MARINE HEALTH CHECK
UPDATE 2009

FLAGSHIP SPECIES REVISITED

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The *Marine Health Check* – Update 2009 was prepared by the Marine Life Information Network *(MarLIN)* at the Marine Biological Association of the UK.

The Marine Biological Association (MBA) of the UK promotes scientific research into all aspects of the sea and disseminates to the public the knowledge gained. MarLIN is an initiative of the MBA that aims to improve access to marine information in order to better our understanding and awareness of our seas and coasts.

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FOREWARD

The WWF *Marine Health Check* series, published in 2000 and 2005, aims to provide an evolving overview of the well-being, including any change in status, of flagship habitats and species that live in the seas around the UK. This 2009 update provides a snapshot of six of the marine life features covered in the 2005 report. The findings reveal mixed fortunes, but clearly highlight the fact that much of our marine biodiversity resource remains under threat from a multitude of human-induced activities including fishing, oil and gas exploitation and renewable energy work, and emerging threats such as the impacts of climate change.

Decline in status or degradation to the quality of marine life is generally something that can be checked and reversed, but experience informs us that political will and stakeholder engagement are key ingredients for success. The last five years have seen development of several key tools that could provide a real opportunity to secure the health of our marine life. These include a scientifically robust and ecologically coherent and representative network of Marine Protected Areas (MPAs) combined with effectively designed and executed marine spatial plans developed as part of an ecosystem-based approach to management.

WWF has been campaigning for a Marine Act and, where relevant, devolved legislation for more than a decade. It is important that such legislation is able to improve marine nature conservation and provide a basis for the sustainable management of the seas around the UK. For example, the designation of MPAs (Marine Conservation Zones in the UK Marine and Coastal Access Bill) including strictly protected and multi-use MPAs; strengthening the remit and scope for inshore sea fisheries management; and ensuring that the numerous activities in our seas are strategically and appropriately agreed through marine spatial plans overseen by a robust Marine Management Organisation.

As we near the milestone of the UK Marine and Coastal Access Bill receiving Royal Assent and as the Scottish Marine Bill progresses through Parliament, it is imperative that this new legislation, including any secondary legislation and associated policy guidance, provides positive and measurable gains for a healthy marine environment and biodiversity upon which we all depend. It is also vital that complementary legislation is urgently brought forward in Northern Ireland.

EXECUTIVE SUMMARY

The 2009 update of WWF-UK's *Marine Health Check* comes at a timely moment in the development of marine policy in the UK, Europe and globally. Marine policy is now focused on the need to develop networks of Marine Protected Areas (MPAs) and a growing demand for better planning in the marine environment and the development of approaches to marine spatial planning, to be delivered in the UK by the enactment of the UK Marine and Coastal Access Bill (MCAB) and the Scottish Marine Bill, currently progressing through the respective Parliaments.

The MCAB includes provisions to set up a series of MPAs, called Marine Conservation Zones, to protect marine biodiversity, to develop an integrated marine spatial planning process (MSP) and set up a single agency – the Marine Management Organisation (MMO) – to oversee planning in the marine environment for UK and England waters. The approach to implementing marine planning is likely to involve outlining the goals and objectives in terms of conservation and different sectoral users of marine areas, identify the issues and collect the relevant information, then evaluate plans which allow the efficient, sustainable use and protection of marine resources. It is therefore important that the correct information on species and habitat locations, distribution and vulnerability to specific threats are known and understood, in order to feed into this process from the beginning. Devolved responsibilities in UK waters means that Marine Conservation Zones (MCZs) will be identified through three distinct but coordinated projects:

- MCZs in English inshore waters and all UK offshore waters apart from those adjacent to Scotland will be identified through the Marine Conservation Zone Project;
- MCZs in Welsh inshore waters will be identified through a project which will be implemented by the Welsh Assembly Government; and
- the Scottish government will introduce MPAs in Scottish inshore waters and is the appropriate authority for MCZ designation in UK offshore waters adjacent to Scotland, where they will be known as MPAs.

The Northern Ireland Government has committed to some parts of the UK MCAB, including the development of a UK-wide Marine Policy Statement (MPS) and the development of high-level marine objectives, but not sections on marine nature conservation and fisheries, which will be dealt with separately by the Northern Ireland Administration.

Here we examine the current status of six 'flagship' species and habitats relative to 2005 and how the UK Marine and Coastal Access Bill may influence their future status.

FLAGSHIP SPECIES

Atlantic salmon
*(Salmo salar)***:**
Numbers entering UK rivers continue to fall.

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Restoration efforts in the UK have been widespread and extensive but have primarily concentrated on freshwater life stages. It appears that the major cause of present continued declines is mortality at sea, which is the focus of much current research. While locally some populations appear to have stabilised or even increased, declines are still prevalent in many areas, and the UK-wide population is considered unstable. Even in areas which have shown some recovery in the past three years, the numbers of salmon returning to British rivers are still a fraction of populations 30 years ago.

Integrated marine spatial planning and management outlined in the MCAB could improve the siting of fish farms away from migration routes of wild salmon stocks to minimise adverse impacts on wild fish (including disease transmission and interbreeding). The new MCAB legislation could be used to increase the level of protection for salmon in estuaries through the designation of MCZs and improved integration of coastal and estuary management. This integration could help minimise the cumulative pressures on migrating salmon in the areas.

Pink sea fan
(Eunicella verrucosa):
Populations were considered to be 'Stable' over most of the range but in 'Severe decline' at Lundy (because of disease) and in Lyme Bay (because of scallop dredging). There is no evidence of recovery of previously degraded sites.

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In 2005, two major problems were causing a decline of the species: heavy mobile fishing gear being used on the reefs where pink sea fans occurred (especially in Lyme Bay) and a mystery disease which was severely affecting populations in south-west England and especially at Lundy, England's only Marine Nature Reserve. New information on sea fan disease, and the start of genetic studies that will help to understand how isolated different populations are, will shed light on this charismatic species. The start of monitoring after closure of an area in Lyme Bay to damaging fishing practices should offer an indication of the impact of and recovery from scallop dredging. In addition, the new Inshore Fisheries Conservation Authorities to be set-up following enactment of the MCAB should see improvements to managing fish stocks in a sustainable manner. The introduction of MCZs provides an opportunity to adapt the level of protection within them so that areas where there are concentrations of long-lived, fragile, sessile species such as the pink sea fan can be protected from damaging activities such as mobile demersal fishing gear (similar to Lyme Bay). As a species which has recently been shown to succumb to natural disease events, it will be important to replicate viable sites for the pink sea fan within the network of MCZs, in order to protect different populations and secure the survival of this species and those it supports.

Harbour porpoise *(Phocoena phocoena)*: This continues to be threatened by human activities.

© Ian Birks/Sea Watch Foundation

Populations in the North Sea appear to have a stable abundance, despite the dynamic distribution of the harbour porpoise in space and time. The most pressing threat to *Phocoena phocoena* is still fisheries bycatch, and conservation action is required to ensure its protection from this danger.

Despite the highly mobile nature of this species, specific areas of habitat have been identified as important, where high local abundance of *Phocoena phocoena* is recorded. Urgent action is required by the UK to designate Special Areas of Conservation (SACs) under the EU Habitats Directive where the harbour porpoise is not only coincidentally present, but is also protected as a qualifying feature. Although the EU Habitats Directive contains only a limited list of species and habitats, the harbour porpoise is listed as an Annex II species and can therefore be protected through the designation of European Marine Sites.

Integrated marine spatial planning and management set out in the MCAB offers an opportunity to manage areas important to the harbour porpoise alongside human activities. In addition, MCZs could be designated with varying levels of protection, which potentially could vary to account for the different uses of certain areas by the porpoises at different times of the year. It should be possible to establish seasonal closures for different types of gear and activities to minimise the impacts on the species on a broad scale. In addition, the EU Common Fisheries Policy outlines efforts to reduce bycatch, including acoustic deterrent devices and bans on drift-netting (also agreed under ASCOBANS). Reducing the impact of fisheries on sensitive top predators is likely to be an element of the future CFP reform.

Seagrass *(Zostera spp)* **beds:** These have continued to be of concern in the past few years.

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Seagrass beds are rich habitats for marine life and important sources of food for wading birds and there is new research into their value as a spawning and nursery habitat, most recently for seahorses in Studland Bay, Dorset, and as a habitat for stalked jellyfish – new to the UK Biodiversity Action Plan (BAP) species list. Although seagrass beds have still not recovered from the wasting disease of the 1930s, and are unlikely to do so, there have been some improvements in water quality that have, and will, reduce pressures on this habitat, making it less susceptible to another disease event.

The protection of this habitat from direct physical damage and loss is still inadequate and lacks both legal and voluntary backing in many areas (both in terms of bylaws and codes of conduct). Failings in the consenting process (piecemeal sectoral approach, ambiguous terminology) and the lack of clarity of features to be protected (as a sub-feature seagrass is not always given adequate consideration) mean that even European Marine Site designation does not necessarily result in protection for seagrass.

The MCAB offers an opportunity to address these issues, with the increasing recognition of seagrass as a habitat under threat and decline (OSPAR Convention and the Marine Bill White Paper). MCZ designation through the MCAB is not limited to habitats listed under the European Habitats Directive and therefore gives an opportunity to provide protection to other important species and habitats such as seagrass. Designation of MCZs for the protection of seagrass could specifically address the protection of the functioning of the seagrass bed as a habitat and not just the protection of the plant or meadow (which shows very dynamic natural cycles). The creation of the MMO, and devolved equivalents, will result in the integration of some of the consenting process in UK offshore, and English and Welsh inshore waters and create a strategic marine spatial planning system that should provide a multi-sectoral basis to manage the diverse activities which threaten this habitat.

Deep-water coral *(Lophelia pertusa)* **reefs**: These continue to be in significant decline.

© Murray Roberts

More information from surveys is now available, pointing to the location of sites that need to be protected. Unfortunately, very few reefs have been discovered that have not already suffered some form of degradation due to human impacts, primarily from fishing. More than 1,300 species associated with *Lophelia pertusa* reefs have been found living in the North Atlantic, confirming their value as a habitat to marine biodiversity. The microbial communities of cold-water corals are also likely to contain novel organisms, which could also be a source of pharmaceuticals.

Lophelia reefs occur in deep water, either inside the UK's Exclusive Fisheries Zone (EFZ) or in international waters, which require cooperative measures. The North-East Atlantic Fisheries Commission (NEAFC) has banned bottom trawling on four seamounts on the North-East Atlantic ridge. Within the OSPAR region there are currently 24 closed areas, covering 578,000sq km(2). Four areas containing *Lophelia* have been closed to fishing in the Irish EEZ, and the Darwin Mounds was the first area to be designated as an offshore SAC for cold-water coral reefs. North-west Rockall Bank has been proposed as a draft SAC.

Replication of sites is required to ensure the survival of the habitat. Although the closure of the Darwin Mounds is a success in many respects, it also highlights the division between marine nature conservation and fisheries management in the European Union – a legal and political issue that will require resolution in the near future. It also highlighted the fact that care must taken in managing protection because, after the announcement of the closure of the Darwin Mounds but during the lag period before the closure came into force, the area was inundated by increased fishing effort that added to the pressure on the habitat(3).

Finally, while demersal trawling impacts are being abated via fisheries exclusions – for example, through the Common Fisheries Policy and NEAFC – damage by oil and gas exploration and seabed mining will not be regulated through marine spatial planning under the MCAB. Instead this will continue to be licensed by the Department of Energy and Climate Change and the Crown Estate. Large infrastructure projects such as renewables development will be licensed by the Infrastructure Planning Commission (IPC) established under the Planning Act. With the MCAB and Planning Bill being developed in close proximity, it is hoped that the MMO and IPC will work very closely together on marine projects(4). The MMO should have a strong IPC advisory role on conditions that should be imposed to mitigate any adverse impact a development may have on the marine environment or other uses of the sea. Deep-water coral reefs will be at risk from any failures in the liaison between the MMO and IPC.

Horse mussel *(Modiolus modiolus)* **beds**: These were shown to have been extensively damaged by mobile fishing gear and some of them had been lost.

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There was no sign of recovery in damaged areas. The situation was particularly serious in Strangford Lough where research by Queen's University Belfast found a significant (3.7 sq km) loss of horse mussel beds since 1993 and identified disturbance by mobile fishing gear as the most likely cause of the initial damage(5). A temporary ban on all trawling and dredging activity in the Lough announced in December 2003 has been extended indefinitely.

Following the threat of infraction proceedings against the UK, the Department of Agriculture and Rural Development in Northern Ireland and the Department of Environment Northern Ireland commissioned the Marine Research Station of Queens University, Belfast, to carry out a restoration programme in Strangford Lough which will cost approximately £2 million.

Horse mussel beds have been listed by OSPAR in its *List of Threatened and/ or Declining Species and Habitats*. The citation noted the sensitivity, particularly to physical disturbance, of this biogenic habitat and its low resilience which results from the long life span of individuals coupled with erratic recruitment that is most successful among pre-existing beds. Badging an area as an SAC is not always enough to protect the full range of wildlife – so regulations and robust and effective management measures, such as the use of highly protected areas closed to extractive activities, are needed to protect fragile species such as horse mussel beds.

Like the pink sea fan, horse mussel beds are restricted to specific locations and are under threat from direct physical disturbance (such as fishing, dredging and coastal development), so the opportunity within MCZs to adapt the level of protection to restrict damaging activities is vital. The recruitment of horse mussels is sensitive to temperature changes, so in light of climate change impacts, the replication of sites across the biogeographical range of the species (and specifically at the northern limits) should be addressed when designating additional sites as MCZs for this species.

RECOMMENDATIONS

This review of the current status of six flagship species and habitats, together with recent developments in marine policy, gives rise to the following set of recommendations.

- Marine Conservation Zones (MCZs) must be identified using sound scientific criteria alone. The socio-economic consequences of designation should only be considered where the desirability of designating two or more areas is equal and will not compromise the ability to achieve an ecologically coherent network of sites.
- MCZs should have different levels of protection to address the variation in threats to and conservation of species and habitats. Highly protected MCZs are needed for especially vulnerable, sensitive or threatened species and habitats.
- The Bill must not include a blanket defence for sea fishing if it causes damage to an MCZ. Sea fishing must be compliant with the requirements of the MCZ because it can be one of the most common causes of harm to marine wildlife.
- In order to adapt to changes in effectiveness and the impacts of climate change, the boundaries of MCZs may need to remain flexible.
- Conservation objectives for MCZs need to be explicit, and the species and/or habitats protected clearly stated, as ambiguity can lead to ineffective protection and failure to meet objectives. Robust management plans provide a key mechanism to achieve this and should be produced for all MCZs.
- The Marine Management Organisation (MMO) and equivalent devolved bodies should be adequately resourced and should have a proactive role in our seas, with a remit to ‘further’ sustainable development.
- The MMO must also be a statutory advisor to the Infrastructure Planning Commission (IPC) when considering developments that impact the marine and coastal environment.
- The MMO and equivalent devolved bodies must deliver a consistent and coordinated approach across borders and between the land–sea boundary. Marine plans should be based on ecosystems, not administrative boundaries and should be produced for all UK seas.
- Inshore fisheries management in England and Wales should ensure sustainable fisheries management and reduce bycatch.
- The MCAB, and especially marine spatial planning, should be integrated with EU legislation including the EU Common Fisheries Policy (CFP), and the EU Marine Strategy Framework Directive.

Harvey Tyler-Walters, Olivia Langmead, Catherine Wilding, Keith Hiscock and Emma Jackson

INTRODUCTION

WWF-UK's *Marine Health Check* 2005[6] reviewed the health of the UK's marine life and provided a snapshot of the existing threats to 16 flagship species and habitats that could taxonomically (species) and geographically (species and habitats) exemplify the sorts of trends of change occurring in UK seas. The report built on WWF-UK's *Marine Health Check* in 2000 to assess the status of these species and habitats, to gauge if they were in decline or had improved.

The 2009 update comes at a crucial moment in the development of marine policy in the UK, Europe and globally, with recognition that we need to improve how we manage and, in particular, how we use our seas. One of the major tools that has risen in importance in the last five years is the need to develop networks of marine protected areas. Another is the growing demand for better planning in the marine environment and the development of approaches to marine spatial planning.

This update looks at how these current and future tools, which will be implemented in the UK following enactment of the UK Marine and Coastal Access Bill and the Scottish Marine Bill, might influence the current status of six 'flagship' species and habitats and, in doing so, examines their status relative to 2005.

NEW DEVELOPMENTS IN MARINE PROTECTED AREAS

The UK Marine and Coastal Access Bill (MCAB), introduced in December 2008, and the Scottish Marine Bill, introduced in April 2009, outline the creation of a network of Marine Protected Areas (MPAs) that will include both new MPAs and the existing network of European marine sites – Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) with marine components. This is in response to the UK's international obligations to establish an MPA network:

- Under the OSPAR Convention, the UK should develop an ecologically coherent network of well-managed MPAs by 2010.
- The UK's commitment at the World Summit for Sustainable Development (WSSD) to establish a representative network of MPAs by 2012.
- The Convention on Biological Diversity agreed a target to establish a network of well-managed MPAs by 2012 to enable delivery of WSSD targets.
- The Habitats and Birds Directives require that a coherent European ecological network of SACs and SPAs shall be set up under the title *Natura 2000*, encompassing both the terrestrial and marine environments.
- The Marine Strategy Framework Directive requires European member states to put measures in place to achieve or maintain Good Environmental Status (GES) in their waters by 2020. The Directive refers to MPAs as an important contribution to achievement of GES, and that a coherent and representative network of MPAs should be created by 2016.

The new national MPAs are called Marine Conservation Zones (MCZs) in English and Welsh territorial waters and UK offshore waters out to 200 nautical miles, with the exception of UK offshore waters adjacent to Scotland. Designation of MCZs will aim to halt the decline in biodiversity by protecting areas where there are rare, threatened and representative species and habitats, and features of geological or geomorphological interest. Devolved responsibilities in UK waters means that MCZs will be identified through three distinct but coordinated projects.

- The Marine Conservation Zone Project will identify MCZs in English territorial waters and all UK offshore waters apart from those adjacent to Scotland;
- MCZs in Welsh territorial waters will be identified through a project which will be implemented by the Welsh Assembly Government; and
- The Scottish Government is the appropriate authority for MCZ designation in UK offshore waters adjacent to Scotland, where they will be known as MPAs.

Northern Ireland has not yet identified potential MCZs (June 2009).

Marine Protected Areas and the Scottish Marine Bill

The Scottish Marine Bill provides for the designation of new MPAs for the purposes of conserving marine habitats, flora or fauna and features of geomorphological and geological interest (seascape is not included). There will be three different types: nature conservation, demonstration and research, and historic. MPAs will be designated and then managed by schemes similar to marine *Natura 2000* sites (Special Areas of Conservation and Special Protection Areas).

Marine Protected Areas and a Marine Bill for Northern Ireland

The Northern Ireland Government has committed to some parts of the UK MCAB including the development of a UK-wide Marine Policy Statement (MPS) and the development of high-level marine objectives, offshore marine planning and reformed marine licensing insofar as it relates to the Food and Environment Protection Act 1985 and marine aggregates extraction. However, the sections on marine nature conservation and fisheries will not be applied in Northern Ireland. Instead the Northern Ireland Environment Minister intends to take forward a Northern Ireland Marine Bill to address these gaps, with the exception of coastal access, which is not being considered in Northern Ireland at this time, and marine fisheries management which is a matter for the Minister of Agriculture and Rural Development.

APPROACHES TO MARINE SPATIAL PLANNING

Marine Spatial Planning is gaining global momentum with international policies and guidance starting to be implemented nationally. These include OSPAR, the International Maritime Organisation, the UN Convention on the Law of the Sea, the EU's Integrated Maritime Policy and the road map on maritime spatial planning.

As part of the UK government's Marine Stewardship initiative, the Department for Environment, Food and Rural Affairs (Defra) commissioned a consortium to research options for developing, implementing and managing marine spatial planning (MSP) in the UK. The final report published in 2006, which described the outcomes of the pilot MSP in the Irish Sea, highlighted the importance of an integrated approach both in terms of devolved administrations' responsibilities and regulatory systems, terrestrial planning and river basin and coastal zone management[7]. The report made eight key recommendations, including the importance of creating a Marine Management Organisation (MMO), to be set up under the MCAB, as the guardian of the planning and management process, and the need to plan 20 years ahead with five-yearly reviews.

The MCAB contains provisions for a marine planning system that will clarify marine objectives and priorities for the future. The approach is basically to outline the goals and objectives in terms of conservation and different sectoral users of marine areas (as outlined in policy documentation), identify the issues and collect the relevant information, and then evaluate plans which allow the efficient, sustainable use and protection of marine resources. It is therefore important that the correct information on species and habitat locations, distribution and vulnerability to specific threats are known and understood, in order to feed into this process from the beginning.

FLAGSHIP SPECIES AND HABITATS

In this 2009 update, we have selected just six species and habitats from 2005 where there have been significant changes in their status or where new scientific studies have helped to explain reasons for change. We have tried to maintain a taxonomic and geographical spread as well as including exploited and unexploited species for the six case studies.

Atlantic salmon *(Salmo salar)*: Numbers entering UK rivers continue to fall. New research may change our view on reasons for decline. Is climate change part of the reason for decline?

Pink sea fan *(Eunicella verrucosa)*: New information on sea fan disease, the start of monitoring after closure of an area in Lyme Bay to damaging fishing practices, and the start of genetic studies that will help to understand how 'isolated' different populations are, will shed new light on the biology of this charismatic species relevant to conservation.

Harbour porpoise *(Phocoena phocoena)*: This continues to be threatened by human activities. It was thought there were no resident groups, but there seem to be hotspots of occurrence and more is becoming known about their location.

Seagrass *(Zostera spp.)* **beds**: These have continued to be of concern in the past few years. There are still no signs of recovery from the wasting disease of the 1930s and beds are being damaged by anchoring and by trawling for cuttlefish. Nevertheless, there is good news, such as finding a breeding population of sea horses in the seagrass at Studland Bay, and an 'outburst' of stalked jellyfish, new to the BAP species list, there.

Deep water coral *(Lophelia pertusa)* **reefs**: In 2005, we were fortunate to be able to use pre-publication information from early surveys of these reefs. Much more information from surveys is now available, pointing to the location of sites that need to be protected from fishing.

Horse mussel *(Modiolus modiolus)* **beds**: These had been devastated by mobile fishing gear in Strangford Lough and are threatened elsewhere. Ongoing work will discover if, as hoped, there are signs of recovery in Strangford Lough.

PROTECTION OF NON-FLAGSHIP SPECIES

It should be noted that in addition to the new information on these flagship species, there are species and habitats that were not included in the 2005 Health Check but which have been added to the UK BAP list or for which new information is available. The crawfish, Palinurus elephas, which we now know has two distinctive populations in the UK[(8)], is continuing to decline despite a significant recruitment event in around 2006[(9)]; and the common dolphin *Delphinus delphis*, which suffered significant mortality in 2008, most likely as a result of navy sonar. Stalked jellyfish are also new to the BAP lists and used to be a common feature of seashores in the south-west – so where are they today?

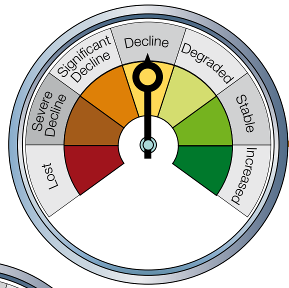
Molecular studies of species are helping to understand the degree of isolation of populations between different locations. Recent work on the sunset cup coral, *Leptopsammia pruvoti* (which has been in severe decline at Lundy since the mid-1980s) indicates that populations most likely reproduce asexually and most of the population may be clones of each other with little or no recruitment from one location to another. The discovery of a population on a wreck in Brittany suggests that establishment of new populations occurs from time to time.

As part of Defra's Review of Marine Nature Conservation (RMNC), criteria for identifying Nationally Important Marine Features (NIMF), species, habitats and marine landscapes) were developed and tested[(10)]. The rationale behind identifying threatened, rare or otherwise exceptional features for priority conservation attention is that, unless urgent action is taken, such features could be driven to extinction or suffer severe decline. Our improving knowledge helps us identify species and habitats that need protection via the criteria for NIMF, and structured approaches are available for the selection of Marine Conservation Zones and the level of protection required. However, current efforts to map species and habitats to be used in the selection of MCZs[1] are considering only species and habitats we are currently committed to protect under BAP and OSPAR. A better understanding of gaps in representativity and replication of habitats, and of the likelihood of connectivity between separate MCZs for species dispersal, is available and should be used to help plan the MCZ network in an ecologically coherent way.

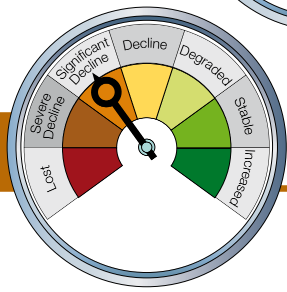
Emma Jackson and Keith Hiscock

1 Defra, 2009, in progress. Accessing and developing the required biophysical datasets and data layers for Marine Protected Areas network planning and wider marine spatial planning.

2009
(varies locally) (Decline)



ATLANTIC SALMON



2005
(Significant decline)

(Salmo salar)

Catherine Wilding and Jack Sewell

The Atlantic salmon is a large, migratory fish that spends its reproductive and nursery phases in freshwater and the majority of its adult life at sea. It can travel extremely long distances, covering numerous national boundaries. The Atlantic salmon's life history makes it vulnerable to a wide range of pressures exerted during its various life stages in both freshwater and the sea. In the UK and Ireland, threats to the species include climate change, pollution, fishing, aquaculture of farm-reared salmon and a number of freshwater impacts. To effectively safeguard the Atlantic salmon, protection is required in freshwater and in the marine environment.

Plate 1: A male (front) and female (behind) Atlantic salmon Salmo salar from the River Avon in Scotland.

Image: © Sue Scott.

NATURAL HISTORY

The Atlantic salmon *Salmo salar* is found throughout Britain and Ireland and the North Atlantic[11]. It can live for up to 13 years and grow to 120-150cm[12]. Atlantic salmon spend most of their adult life at sea, living in freshwater during reproductive and nursery phases[13]. After the first 1–6 years of life in freshwater[12], the fish undergo morphological and physiological adaptations to life in salt water (smolting) and move into the ocean. On leaving their freshwater environment, young salmon are subject to a number of natural and anthropogenic pressures and suffer high levels of mortality. During the marine phase the fish grow rapidly, feeding primarily on marine fish, molluscs and crustaceans. This maturation period lasts 1-4 years[14].

Several North Atlantic feeding areas attract fish from a number of different stocks. Following a tagging session in a feeding area north of the Faroe Islands[15], salmon were recaptured from rivers in nine countries, suggesting that fish from a number of discrete populations came together to feed. Fishing vessels have historically targeted feeding areas like this and fishing in these mixed-stock fisheries can have serious impacts on a number of breeding populations worldwide.

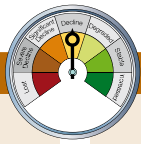
Following maturation, the Atlantic salmon will almost always return to the river where it hatched. Spawning takes place during winter over gravel beds, usually in the upper reaches of suitable rivers. After spawning, most Atlantic salmon die, although some may return to the ocean to recover, migrating back the next season for a second, third or very rarely a fourth spawning[14]. Salmon-bearing rivers are often geographically separated. As a result, populations from individual rivers or even small tributaries in a large river are almost always reproductively distinct[16]. These distinct populations often adapt to local environmental conditions. For example, in some rivers fish may have large fins to move against particularly fast-flowing water, and in acidic rivers, fertilised eggs may have a high tolerance to low pH levels[16]. Unfortunately, this means that any genetic contamination of these populations by accidental or deliberate introduction of artificially reared fish from other localities can reduce survivability by weakening these adaptations.

The salmon has an extremely high commercial value, which is why the species is targeted by commercial fisheries throughout the world. The value of live fish to the recreational fishing industry is also extremely high, with an estimated £1,800 spent locally for every Scottish salmon caught[17]. The Atlantic salmon is also reared in pens in a number of locations worldwide, often causing severe impacts on the surrounding environment and on wild salmon stocks. In the UK, this aquaculture is largely restricted to Scottish sea lochs and river mouths, where conditions are favourable for fish farming.

EXISTING PROTECTION AND MANAGEMENT

- A number of salmon rivers across the UK have been proposed as Special Areas of Conservation under the Habitats Directive. This includes the River Foyle, which crosses the border between the Republic of Ireland and Northern Ireland and is one of the most important salmon systems in Europe. However, the Directive does not enable protection of the marine stage of this species' life cycle.
- In Britain and Ireland, the impact of freshwater angling is regulated and enforced by the relevant environmental authorities. These include restrictive licensing schemes, strategically timed closed seasons, and catch and release schemes where an increasing proportion of caught salmon are released[18]. Throughout the UK there is a ban on the sale of rod-caught salmon, and commercially caught carcasses must be tagged in England, Ireland and Wales[19].
- The Irish net fishery for salmon was closed in 2007[20]. In addition, the effect of a voluntary net buy-out in the River Bush (Northern Ireland) in 2002 reduced mean landings by more than 70%, conserving an estimated 460 fish per year[21].
- The Irish mixed stock salmon fishery, which was estimated to intercept between 30-50% of returning wild salmon[22], was closed in 2006. Despite this, many Irish rivers are expected to fail to meet designated conservation limits[23].
- The Environment Agency has been running a phase-out of mixed-stock fisheries salmon drift nets since 1992. This has included the partial buy-out of the north-east drift net fishery in 2003. As a result, in 2003 16 north-east licensed drift nets were fished, compared with 69 in 2002[24] – a great reduction in fishing effort. Since 2003, these catches have continued to decline, with net catches in 2008 being 30.4 t (8,768 fish) – a decrease of 7.5 t on 2007[18].
- The 'Salmon at Sea' (SALSEA) project began marine monitoring and tracking in 2008, to investigate the continuing declines of smolt at sea.
- The North Atlantic Salmon Conservation Organisation (NASCO) was established under the Convention for the Conservation of Salmon in the North Atlantic Ocean in 1983. It is responsible for the conservation of salmon stocks worldwide and is primarily involved in the acquisition, interpretation and dissemination of scientific information pertaining to North Atlantic salmon stocks, and has recently produced guidelines for restoring stocks.
- The North Atlantic Salmon Fund (NASF) is a private fund that has so far been used to buy out salmon fisheries in Iceland and Greenland. In 2002, a voluntary agreement was reached between Greenland fishermen and NASF that suspended all commercial salmon fishing and allows only an annual subsistence take that will be strictly limited.

STATUS



Degree of decline

Despite buy-out schemes, catch reductions and some improvements in water quality, salmon stocks have continued to decline over the past 30 years, with North Atlantic catches falling by 80% between 1970 and 2000[25]. It appears that survival during the marine life stages is key[21, 26], and the number of smolt returning to freshwater in the UK has reduced by half in the last 30 years[20].

Worldwide, around 90% of the world's known healthy Atlantic salmon population exists in only four countries – Scotland, Ireland, Iceland and Norway[25]. In the remainder of their range, 85% of the wild Atlantic salmon populations are considered vulnerable, endangered or critical[25]. Catches of salmon in the North Atlantic dropped by more than 80% between 1970 and the end of the 20th century[25], and salmon stocks continue to decline throughout their global range[26, 27, 28].

Populations in some areas continue to diminish. In Northern Ireland, the number of salmon returning to rivers is thought to be unsustainable[29]. Of the 148 Irish rivers where salmon are found, only 43 are considered to have healthy populations, and the Irish salmon population has declined by 75% in recent years[30].

In Scotland, coastal net catches are now less than 10% of what they were 50 years ago, and apparent stability in numbers of fish caught by rod and line reflects a reduction in netting catch. This suggests overall populations are still declining[31].

In 2008, almost half of the 64 salmon rivers in England and Wales were classified as 'probably not at risk' or better. This shows a continual improvement since 2004, and an increased probability that these rivers will reach their conservation limit objectives[18].

Nevertheless, in 2008 the spawning escapement was the highest yet recorded, being above the conservation limit in 41 of the 64 principal salmon rivers in England and Wales[18].

Natural re-colonisation of rivers is possible, as has occurred in the Tweed where a weir which closed the river system to salmon was replaced with a salmon run. But this process has taken almost 60 years[19].

Case study: River Frome

"Recent intensive restoration programmes, including gravel bed cleaning and the construction of fish passes, have resulted in a slight increase in returning salmon numbers in the past three years. The gross return of salmon in 2008 was 1,296 – an increase from 2005 returns of 655 fish. But populations are still a fraction of their state prior to the 1990s, as the average number of returning fish was 2,620 annually between 1973 and 1990" – William Beaumont, Game and Wildlife Conservation Trust.

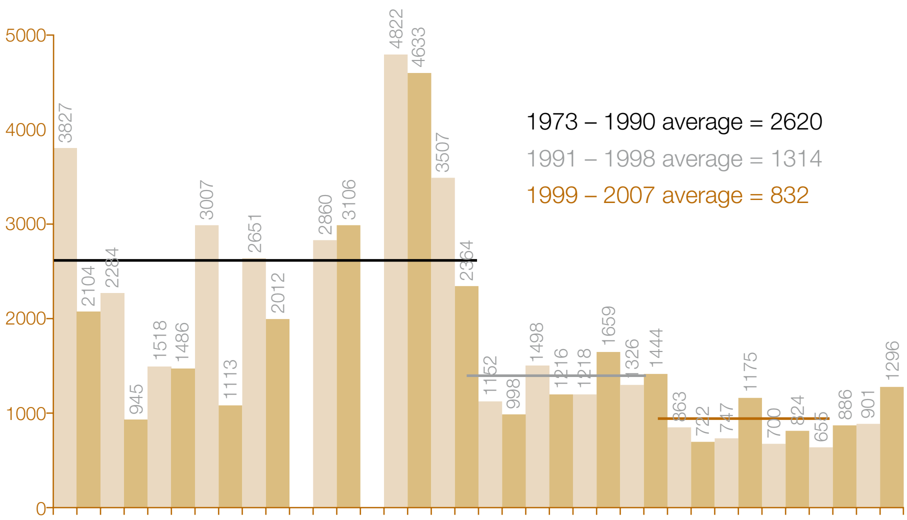
CHANGE IN STATUS SINCE 2005

The status of salmon stocks in the UK is locally variable. Recent water quality improvements and reintroduction efforts in the UK have allowed rivers such as the Clyde, Lagan, Taff and Tyne[32], among others, to become naturally repopulated by salmon. The number of returning adult salmon has recently increased in some rivers (Tees, Fowey, Lune and Kent), remained stable in others (Dee, Test and Caldew), but declined in others (Itchen, Frome, Tamar and Thames)[18].

In many areas of the UK, stocks appear to have been low but stable for the past three years. However, fisheries data indicates that stocks in Great Britain are still in decline[24, 33, 34] with the North Atlantic commercial catches for 2007 being at their lowest since 1960[21, 35]. In 2007, the Joint Nature Conservation Committee (JNCC) assessed the status of UK salmon stocks as 'unfavourable-inadequate'[36].

As well as declining in abundance, the condition of salmon is currently a cause for concern. Grilse (salmon returning from the sea for the first time) have shown reduced body size, with 2003-2006 fish being in the poorest condition in 40 years[19]. This means these fish will have lower energy reserves for spawning.

Gross Salmon Numbers
1973 – 2008



Graph 1: East Stoke salmon counter records from the River Frome, 1973 – 2008.[37]

Plate 2: Farmed Atlantic salmon held in a Scottish loch.
Image: © Sue Scott.

ONGOING ISSUES/THREATS

Salmon farming: The production of farmed salmon in the North Atlantic is 600,000 tonnes annually – 300 times greater than the annual catch of wild salmon[25] – and farmed salmon production for 2007 was the highest yet recorded[21]. However, aquaculture can have severe impacts on the environment, in particular on wild salmon populations.

Farmed fish may facilitate the spread and development of parasites such as the salmon lice *Lepeophtheirus salmonis*, bacterial infection *furunculosis*, and spread infection to wild populations via transport of farmed fish and/or escapees[25]. The escape of farmed salmon and subsequent interbreeding with wild populations can result in the transfer of non-adaptive traits, reducing survivability and recruitment levels of wild fish[16, 25] [38, 39].

Plate 3: Sea lice on a farmed salmon. Salmon pens can act as a source of lice that then infect wild salmon.
Image: © Sue Scott.

Marine and coastal fishing: Over the past decade, buy-out schemes have reduced the impact of coastal salmon fisheries around the UK. The migratory behaviour of salmon means multi-stock fisheries, particularly in North Atlantic feeding areas such as those off the Faroe Isles and Greenland, can diminish stocks from all over the world. Fishing in these areas represents probably the greatest single threat to Atlantic salmon.

Freshwater angling: The Atlantic salmon is fished where it occurs in UK and Irish rivers for food and for its sporting qualities. In Scottish salmon fisheries, the proportion released following capture has increased steadily since the early 1990s and in 2003 almost 60% of rod-caught salmon were returned alive(33). There is evidence that salmon have a high chance of survival following catch and release(40, 41) and can go on to spawn successfully(40). However, studies have shown that if further stress is inflicted after release – for example, by high water temperatures – fish have an increased chance of delayed post-angling mortality(41). This indicates that not all returned fish will survive and the rate of survival depends on environmental conditions.

Obstacles such as dams can prevent migration upstream and may change the hydrology which degrades or causes loss of habitat. Gravel extraction leads to loss of spawning habitat.

Pollution: Salmon are often exposed to freshwater contaminants such as pesticides(42) and herbicides(25), and reduced water quality leads to declines in reproductive success – which in extreme cases has led to extinction from some UK rivers(13). Contamination from the improper disposal of sheep dips kills freshwater invertebrates over several kilometres(43), leaving no food available for young salmon(43). Nutrient enrichment and eutrophication also have an impact.

Adult salmon are predatory, so can potentially accumulate large amounts of persistent chemicals over time. The accumulation of these contaminants can have negative effects on the health and reproductive capabilities of the fish.

Climate change: Sea surface temperatures affect the ability of young salmon to survive at sea(27, 44-46). Warm summers may also inhibit spawning migrations of adult salmon into freshwater by causing unfavourable river conditions for the survival of adult and juvenile fish(47).

NEW / EMERGING THREATS

Disease: A new threat to wild salmon is Red Vent Syndrome. This is characterised by swollen and bleeding vents and has been linked to the presence of a nematode worm, *Anisakis simplex*. First noted in 2005, the disease is apparent throughout the UK and Ireland, and in the River Bush (Northern Ireland) it affects 50-60% of early run fish. The effect on survival is unknown, although early indications suggest it is not severe(21). In 2008 the disease was less prevalent, and lower numbers of salmon were affected than in 2007. Even so, 2008 levels are still above those recorded in 2005 and 2006(18).

SPECIES UNDER SIMILAR THREATS

Sea trout *Salmo trutta*, Allis shad *Alosa alosa*, Twaite shad *Alosa fallax*.

HOW THE MARINE AND COASTAL ACCESS BILL CAN HELP

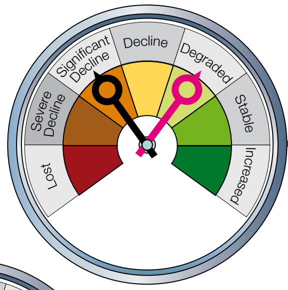
Integrated marine spatial planning and management outlined in the MCAB could improve the siting of fish farms away from migration routes of wild salmon stocks to minimise adverse impacts on wild fish (including disease transmission and interbreeding). MCAB could be used to increase the level of protection for salmon in estuaries, not only through the designation of MCZs, but also through the integration of the currently piecemeal coastal and estuary management (a key area covered by the Bill). This integration could help minimise the cumulative pressures on migrating salmon in the areas.

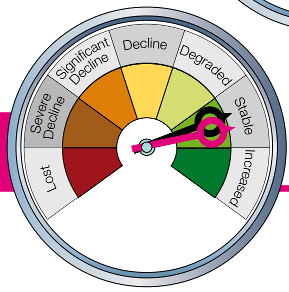
Other legislation measures that improve water quality in transitional water bodies used by salmon migrating to spawning habitat include the EU Water Framework Directive (WFD), Urban Waste Water Treatment Directive, and the Nitrates Directive. There has been a move to include salmon rivers in SACs under the Habitats Directive. However, this Directive does not enable protection at the marine stages of this species' lifecycle.

Because the main pressure on Atlantic salmon is from offshore multi-stock fisheries, particularly in the North Atlantic feeding areas, protection of this species requires international cooperation – for example through the reform of the EU Common Fisheries Policy. Inshore, localised closures and phasing out of mixed stock fisheries and coastal drift netting should help stocks recover.


© ISTOCK

Lundy and Lyme Bay
2005 **2009**





Rest of the Britain and Ireland
2005 **2009**

PINK SEA FAN

(Eunicella verrucosa)

Keith Hiscock, Emma Jackson and Olivia Langmead

The pink sea fan *Eunicella verrucosa* is one of the most exotic of our seabed species. It thrives only in the south-west of Britain where, at a few locations, it can occur in 'forests'. In 2001 sea fans in the south-west suffered from a mystery disease that ravaged the population. Furthermore, a species of warm-water barnacle, until recently unknown in Britain, now infests a portion of the population. Recent studies have shed light on the causes. The major threat from fishing activities continues, but the recent closure of reef areas in Lyme Bay promises to protect local populations and provide further information on population recovery. This will inform its protection nationally.

Plate 4: Eunicella verrucosa is normally pink, but white varieties are sometimes seen. Image: © Keith Hiscock.

NATURAL HISTORY

Sea fans are a type of horny coral that grow as branching flat fans oriented at right angles to the prevailing current. This ensures that the anemone-like polyps arranged along the branches catch as much suspended food as possible. Sea fans normally live deeper than the algal-dominated shallow rocks, usually in depths greater than 15m. *Eunicella verrucosa* occurs from the eastern Mediterranean to south-west Britain as far north as Pembrokeshire and as far east as Portland. Nineteenth century records suggest that the species occurred in the English Channel as far as the Thames Estuary at Margate[48, 49].

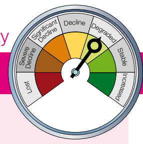
Studies of growth rates in the pink sea fan[50] suggest that the branches grow at about 1cm in length each year, although rates vary. Some sea fans are 50cm high, suggesting great longevity. Sea fans may be swept off the rock by storms or caught in fishing gear such as set nets. In 2003 and 2004, observations were made of reproduction in pink sea fans for the first time[50]. Eggs are produced and, if fertilised, become swimming planulae larvae that can live for several days. This suggests an ability to colonise locations distant from the parent colony.

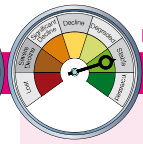
The nationally rare sea fan anemone *Amphianthus dohrnii* lives almost exclusively on sea fans. The sea slug *Tritonia nilsohdneri* and the 'poached egg shell' *Simnia patula* feed on sea fans and both are camouflaged to look like the species they predate. A species that is very similar to, but slimmer than, *Simnia patula* and lives on sea fans is almost certainly a species new to science[51]. In 1994, *Solidobalanus fallax*, a species of barnacle previously unrecorded in Britain (but native in the North-east Atlantic) was found growing on *Eunicella verrucosa*. *Solidobalanus fallax* is now widely distributed on sea fans in south-west England, and in a few cases may dominate them [52].

EXISTING PROTECTION AND MANAGEMENT

Listed on Schedule 5 of the Wildlife and Countryside Act 1981 and included in the UK Biodiversity Action Plan.

Lundy and Lyme Bay





Rest of the Britain and Ireland

STATUS

Degree of decline

Although sea fans are abundant, in generally good condition over much of their range and are no longer in 'Decline', populations are considered to be 'Degraded' as a result of past and continuing damaging activities. It remains important to protect areas inhabited by pink sea fans from mobile fishing gear – not only for their own protection but also because these areas are generally colonised by a rich variety of often sensitive species. Of course, unpredictable events that may be entirely natural, such as the bacterial infection that killed or damaged many sea fans, are likely to happen again.

Plate 5: *Dredged area in Lyme Bay.*
Image: © Keith Hiscock.

CHANGE IN STATUS SINCE 2005

When we looked at pink sea fans in 2005, two major problems resulting in the decline of the species were identified: heavy mobile fishing gear being used on the reefs where pink sea fans occurred (especially in Lyme Bay) and a mystery disease which was severely affecting populations in south-west England and especially at Lundy, England's only Marine Nature Reserve. Populations were considered to be 'Stable' over most of the range but in 'Severe decline' at Lundy (because of disease) and in Lyme Bay (because of scallop dredging).

Plate 6: *Healthy populations of sea fans and other species at an un-dredged site in Lyme Bay.* *Image: © Keith Hiscock.*

ONGOING ISSUES/THREATS

Fishing: Dredging for scallops may be deliberate in reef areas where the dredge can 'hop' the reefs and catch scallops in the sandy patches between. But sea fans will also be removed, and can be detached in nets that are set on the seabed to catch crawfish, or in lost nets that continue to 'ghost fish'. Anglers may also snag and detach sea fans.

In March and April 2007, the University of Bangor conducted towed video surveys in Lyme Bay to compare areas that had been protected ('reserves') from scallop dredging though a voluntary agreement, with those still subject to dredging[53]. The report found a significantly higher abundance of pink sea fans and greater size in areas closed to fishing[53]. Much of the evidence of damage to sea fan populations (and other species) was conspicuous, as Plates 5 and 6 show. Indeed, the images – and the obvious fact that heavy fishing gear and delicate attached species did not mix – was compelling and the proposal to close the reefs to mobile fishing gear achieved great public and scientific support.

On 11 July 2008, 60sq nm of Lyme Bay were closed to scallop dredges and heavy demersal trawls in order to protect marine ecosystems. Following the closure, the Department for Environment, Food and Rural Affairs (Defra) has contracted a consortium of laboratories to monitor the economic, social and ecological impacts of the closed area. Prospects for recovery are good, although sea fans may not recruit every year (HMS Scylla, sunk to become an artificial reef in 2004, was colonised by sea fans only in its fourth year on the seabed) and the species will take several years to reach a large size (Plate 7).

Nutrient enrichment: High seawater temperatures in summer, and possibly nutrient enrichment, were the most likely reasons for a mortality event that included sea fans in the eastern part of the western Mediterranean in 1999[54]. High nutrient levels also encourage algal growth that may smother sea fans. It is possible that high nutrient levels in the Bristol Channel may have been implicated in the adverse effects on Lundy sea fans in 2001[55].

Climate change: The warm-water barnacle *Solidobalanus fallax* is now colonising sea fans in south-west England and will most likely spread to populations in Pembrokeshire. Although the barnacle is unlikely to dominate healthy parts of the sea fan colony, bare skeleton brought about by abrasion (by, for instance, disease or entanglement in fishing lines) will allow settlement which may then extend beyond the original point of attachment.

Pink sea fans are a warmer water species that, in Britain, extend northwards to Pembrokeshire where they are sparse. Seawater warming should increase the success of recruitment and therefore abundance.

The occurrence of a very small proportion of white *Eunicella verrucosa* is a curiosity, especially as the proportion of white individuals increases with distance south along the Atlantic coast of Europe. Finds of several half-in-half white and pink individuals (Plate 8) in recent years suggests that the reason may be environmental and possibly due to sea water temperature. If temperature does determine colour, an increase in the proportion of white sea fans off the British coast can be expected in the next few decades.

Plate 7: Recruitment in pink sea fans may be irregular. This image, taken 15 months after the first individuals were seen on HMS Scylla in July 2007, demonstrates that initial growth can be quite fast (the largest were 16cm high), although normal growth is just over 10mm a year.

Image: © Keith Hiscock.

Plate 8: Pink and white sea fans are sometimes seen, suggesting that the colour may be environmentally determined – perhaps as a result of water temperature.

Image: © Keith Hiscock.

NEW / EMERGING THREATS

Disease: Work by Dr Jason Hall-Spencer and others has investigated the disease that killed or partially destroyed pink sea fans in about 2001-2004 in south-west England, especially at Lundy[56]. The bacterium was identified as a Vibrio species. It has also become clear that such events may occur naturally from time to time. The report in the *Plymouth Marine Fauna*[57] is important: "In the latter half of August and first half of September 1924, Captain Lord reported that a great amount of *Eunicella* brought up was dead; many colonies brought in were partially dead, none in such good condition as in the previous July". It therefore seems probable that episodic declines in abundance due probably to natural factors occur from time to time. Although the heavily fouled skeletons of some sea fans are still attached to the seabed in many places, signs of the disease have not been seen since around 2005.

SPECIES UNDER SIMILAR THREATS

Observations of species associated especially with pink sea fans (the sea fan anemone *Amphianthus dohrnii* and the sea fan sea slug *Tritonia nilshodneri*) suggest that their occurrence is quite variable from year to year and, the case of the sea fan anemone, from location to location. Although recent numbers have been lower than some in other years, there is no suggestion of a downward trend.

While pink sea fans are very widely distributed and are a characteristic feature of most south-west reefs, it must be made clear, from a biodiversity conservation point of view, that the habitats in which they thrive are often also habitats for rare, scarce and sensitive species (Plate 9). Pink sea fans are therefore a 'signpost' species. There have been no reports of mobile fishing gear or disease affecting the northern sea fan .

Plate 9: Sensitive species that live on low reefs adjacent to sediment are threatened by mobile fishing gear. Here, axinellid sponges, including the nationally rare Adreus fascicularis, are present *Image: © Keith Hiscock.*

Plate 10: This species, similar to the 'poached egg shell' Simnia patula, is thought to be a species new to science, and appears to live only on sea fans *Image: © Keith Hiscock.*

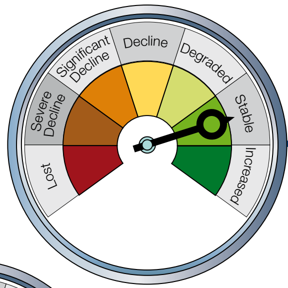
ASSOCIATED FEATURES THAT MAY BE AFFORDED PROTECTION

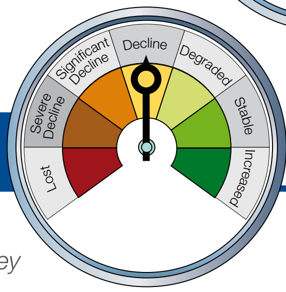
Protection of areas colonised by pink sea fans will also protect other erect attached species, many of which are slow growing and fragile and are therefore threatened by mobile fishing gear. They include axinellid branching sponges, cushion sponges and some hydroids. Furthermore, the structural complexity of reef habitats, which can be degraded by heavy mobile fishing gear, will be protected by the sort of measures put in place in Lyme Bay.

HOW THE MARINE AND COASTAL ACCESS BILL CAN HELP

The introduction of MCZs presents an opportunity to adapt the level of protection within them so that areas where there are concentrations of long-lived, fragile, sessile species such as the pink sea fan can be protected from damaging activities such as mobile demersal fishing gear. One area has been closed for this reason in the last four years (Lyme Bay 60 sq nm fisheries exclusion zone, July 2008). Such areas can also be used to study the recovery of vulnerable species and help identify other areas that would benefit from similar measures. As a species which has recently been shown to succumb to natural disease events, replication of viable sites for the pink sea fan within the network of MCZs is important, in order to protect different populations and secure the survival of this species and those it supports.

2009
(Stable in wide ranging areas.
Decline in some local areas
e.g. Moray Firth)





2005
(Decline)

HARBOUR PORPOISE

(Phocoena phocoena)

Catherine Wilding, Emma Jackson, Olivia Langmead and Judith Oakley

The harbour porpoise *Phocoena phocoena* is the smallest and most numerous of the cetaceans found around the UK. It is also the most heavily protected, being listed in 23 directives, statutes and conventions. Incidental capture or bycatch in certain fisheries continues to be the most significant threat to this species, and may have contributed to its continued decline.

Plate 11: Harbour porpoise

Image: © Ian Birks/Sea Watch Foundation.

NATURAL HISTORY

The harbour porpoise has a small rotund body with a short blunt head, no beak and a small triangular dorsal fin. The back and dorsal fin may be seen briefly at the surface, but the animal rarely leaves the water entirely. Harbour porpoises live for up to 20 years in the wild and usually occur in small groups of up to three, but large aggregations may be seen occasionally. During late summer, porpoises are more social. The main mating season is the summer, with calves born 11 months later[58-60]. Adult harbour porpoises reach a maximum length of 1.8m[61].

Harbour porpoises do not usually approach boats or bow ride.
They can dive underwater for as long as six minutes before surfacing for breath. Their diet comprises a wide variety of small shoaling fish such as herring, as well as cephalopods and crustaceans[58-60].

Harbour porpoises are widely distributed in coastal and offshore waters but generally show a preference for areas close to the coast where water depth exceeds 20-60m[62, 63]. They are considered a coastal shelf species[63] with a tendency to avoid very deep water[64], and their greatest abundance appears to be concentrated along frontal areas with high water mixing[63]. Through the main parts of their range, harbour porpoises are recorded throughout the year, although peaks in numbers occur during summer months[62, 65]. In the UK, locally high densities occur in south-west Wales and off the west coast of Scotland[58, 66]. It is thought that subpopulations exist, with possibly separate populations in the Irish Sea, northern North Sea and southern North Sea[67]. There is some indication of an offshore movement between May and June, possibly associated with calving[66], although calving also regularly occurs nearshore[68].

EXISTING PROTECTION AND MANAGEMENT

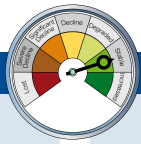
The harbour porpoise is protected by many international agreements and regulations, including:

- The EU Habitats Directive – Article 3 requires member states to designate Special Areas of Conservation (SACs) for the harbour porpoise. In the UK, none has yet been designated. Ireland has designated two sites, with one more forthcoming. However, these sites do not accurately represent protection over the wide range of the species in Irish waters[69].
- Many European countries have designated protected areas for this species. In the UK, the harbour porpoise is a qualifying feature for the designation of the North Sea Dogger Banks as a draft offshore SAC, and other important areas have been identified[66, 70].
- Twenty three sites have been suggested for designation to protect *Phocoena phocoena* in the UK[69]. The EC had expected to complete the SAC designation process by 2010, but further research may be required to identify more suitable areas[69] such as important breeding and feeding regions[62]. It has been argued that low-resolution abundance data (e.g. SCANs II) is insufficient for local management purposes[62], but waiting for further data will create more delays in the designation process. Meanwhile, the species remains at risk and may be further threatened by approval of new human developments or activities if protection is not urgently put into place. Current broad-scale information[64] should be sufficient to identify large areas and potentially seasonal closures to protect *Phocoena phocoena*.
- Under Article 12.4 of the Habitats Directive, EU member states are obliged "to establish a system to monitor the incidental capture and killing of all animals listed in Annex IV" (which includes cetaceans) and to take conservation measures to ensure that incidental capture and killing does not have a significant impact on the species concerned. To reduce bycatch, under the Common Fisheries Policy (CFP) acoustic deterrent devices (pingers) have been mandatory in bottom set gillnet fisheries in the North and Baltic Seas since 2005[71] and in the English Channel since 2007[72].
- Drift nets are banned under EC law but there are widespread problems with non-compliance[73].
- The United Nations Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), of which the UK is a contracting party, has set targets to reduce total North Sea bycatch[70].

The harbour porpoise is also listed under the following legislation:

- Appendix II of the Convention on International Trade in Endangered Species (CITES);
- Appendix II of the Convention on Migratory Species (Bonn Convention);
- IUCN Red List of Threatened Species – species of Least Concern;
- Candidate Nationally Important Marine Feature for the UK;
- The OSPAR Convention, as the harbour porpoise occurs in all OPSAR regions[74];
- Appendix II of the Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention), which gives special protection to vulnerable or endangered species and is implemented in the UK through the Wildlife and Countryside Act 1981; and
- The UK Biodiversity Action Plan – part of the UK's response to the Convention on Biological Diversity.

STATUS



Local scale decline, e.g. Moray Firth

Degree of decline

The harbour porpoise has been recorded around all British coasts[58, 66] but has declined in abundance since the 1940s – most recently in the southern North Sea and the English Channel[75]. In the Baltic Sea the species has almost disappeared[76]. Changes in abundance and distribution may result from changes in prey distribution[77], habitat utilisation for calving, avoidance of other cetaceans[78], or a migration between inshore and offshore waters[62].

The population estimate for the area covered by the SCANS survey (which includes the North Sea, Celtic Sea and English Channel) in 2005 was 315,027 – a similar figure to the original survey in 1994[64], indicating that populations are stable. However, numbers of porpoises present in UK waters vary seasonally and more animals are likely to pass through than are present at any one time.

The harbour porpoise was the most commonly reported stranded cetacean species in the UK in 2006 and 2007[79, 80]. However, increases in strandings may reflect local increases in population abundance[81] and not an increase in mortality rate.

In 2008, OSPAR listed the harbour porpoise as under threat/in decline in two OSPAR regions: the Greater North Sea and the Celtic Sea[74]. Even so, it continues to be the most frequently observed and stranded cetacean in British and Irish waters[66]. Throughout its range, the harbour porpoise is under threat from incidental capture in certain fishing gear, in particular bottom set and drift gill nets.

Phocoena phocoena is the cetacean species most frequently affected by bycatch in the European Atlantic[64]; indeed, 20% of harbour porpoise strandings in the UK are attributed to bycatch[82]. Addressing bycatch is the highest priority in the ASCOBANS Conservation Plan for Harbour Porpoises[83].

Changing attitudes towards hotspots

It was originally thought that marine SACs for the harbour porpoise would be ineffective because this species is so wide-ranging. However, better knowledge has revealed ‘hot spots’[66, 69, 84] – areas which may be important at certain times for breeding[65] or feeding, such as coastal fronts and areas of high water movement[63, 85]. For example, the shallow sand banks at Dogger Bank are important for *Phocoena phocoena*[86, 87] – so much so that this site is the first in the region to be proposed as a draft offshore SAC for the harbour porpoise[86]. This may also result in the protection of seabirds and major prey species for *Phocoena phocoena*, such as the sand eel *Ammodytes marinus*.

Other regions with potentially high population density include eastern Ireland, the western English Channel and the Celtic Sea[69]. Hotspots have been identified in south-west Wales, the outer Bristol Channel, Dogger Bank, the west coast of Scotland and the Shetland Islands.

In addition to spatial protection, temporal protection may also be considered. In Dutch waters, the highest frequency of harbour porpoise drowning and bycatch deaths occurs between December and April[81], and in the UK most bycatch mortalities also occur during winter[79, 88]. It may be possible to protect the harbour porpoise during breeding times. The German Baltic is an important breeding ground[65] and in Aberdeenshire between June and September, 35% of porpoise groups contain calves, indicating that this area is a nursery[62]. Calves in Aberdeenshire comprised 3.2% of porpoise recordings, a proportion which is representative of the area. This indicates that although utilised by juveniles, it is not a preferred calving ground[62]. Further surveys may indicate nursery areas that require protection.

A recent Dutch study showed that bycatch may be seasonal for some fishing methods[81]. This may suggest that temporal closures could provide protection for the porpoise. The use of resonant acoustic reflectors to make nets more ‘acoustically visible’ could be more successful than the more expensive ‘pingers’[89]. The employment of conventional ‘pingers’ is currently under review because they may have adverse effects on porpoises[83].

CHANGE IN STATUS SINCE 2005

Change in the status of harbour porpoise populations is difficult to assess, as any marine mammal census requires extensive survey and the IUCN describes the global population trend as 'unknown'. Although on a wide scale the population appears to be stable[64], declines have been observed in certain areas such as the Moray Firth in Scotland[90]. Regional populations may be of greater conservation concern than the global population.

Other reasons why population assessments are difficult are the highly mobile nature of this species, and density variations with space and time. Since 2005 densities have declined in the northern North Sea, and increased in the southern North Sea. For example, in the southern North Sea in 1995 there were an estimated 98,564 individuals, compared with 47,970 in 2008[64, 83]. This is thought to be due to a redistribution of animals, as the abundance for the North Sea on the whole has not significantly changed.

An estimated 315,027 individuals were recorded in the UK in 2005[64], and new data suggests that the population is relatively stable, at around 328,200 in 2009[69].

Since 2005, no SACs have been designated in the UK to protect the harbour porpoise. Although *Phocoena phocoena* has been recorded in several SACs (for example in Cardigan Bay, Pembrokeshire Marine, the Lleyn Peninsula and the Sarnau SAC in Wales[91] very little protection is afforded because the species is not listed as a qualifying feature.

ONGOING ISSUES/THREATS

Fishing: Entanglement in fishing nets (leading to drowning) is the largest cause of cetacean mortality[89], and strandings post mortems have found bycatch to be the most frequent cause of harbour porpoise mortality[81, 92]. A 2007 report shows that harbour porpoises continue to be affected by bycatch[88]. Each year, around 7,000 are thought to be killed in EU fisheries in the North Sea – most in bottom set gill nets[93]. This exceeds 2% of the North Sea population, and in the Celtic Sea bycatch removes 6.2% of the population[94, 95]. These levels are above the sustainable mortality limit[72, 95, 96]) as cetacean populations can only withstand bycatch levels of up to 1.7% (or less in more threatened populations).

Pollution: Pollution from chemicals such as polychlorinated biphenyls (PCBs)[97], perfluorochemicals[98] and mercury affect cetaceans because they act as immuno-suppressants/ depressants or affect reproduction and development. As a top predator, the harbour porpoise accumulates high levels of these toxic contaminants in its tissues. Cetacean prey is also under threat from contamination, raising the possibility of reduced food availability and bioaccumulation/biomagnification of pollutants in the porpoise

Ship strikes: Fast ferries may be a threat to small cetaceans.

Plate 12: Harbour porpoise showing gill net entanglement marks around the mouth, head and fins.

Image: © Cornwall Wildlife Trust.

Noise pollution: Noise from ships, seismic surveys, seal scrammers (an acoustic seal deterrent) and possibly wind farms[84] are thought to cause local distribution changes. There is also growing evidence that physical injury and mortality can be inflicted on the mammal by high-frequency sonar waves[99].

Hydrocarbon exploration and mineral extraction are likely to disturb porpoises.

Prey depletion: Population declines may be the result of overfishing of prey species such as the sand eel *Ammodytes marinus*[83, 90, 100].

Natural threats: Individual harbour porpoises are sometimes attacked by bottlenose dolphins *Tursiops truncatus*, which may result in porpoises avoiding areas where bottlenoses are present[78]. Instances have been recorded in Cardigan Bay and the Moray Firth, although the reason for these sometimes fatal attacks is unknown[94].

Climate change: Monitoring programmes have shown a recent increase in southern cetacean species which may compete aggressively with the harbour porpoise.

SPECIES UNDER SIMILAR THREAT

Common dolphin *Delphinus delp* his, bottlenose dolphin Tursiops truncatus, basking shark *Cetorhinus maximus* and the sand eel *Ammodytes marinus*.

Plate 13: Cetacean watching has become very popular in Britain. This environmental tourism benefits local economies and protects cetacean populations. Image: © Colin Speedie

HOW THE MARINE AND COASTAL ACCESS BILL WILL HELP

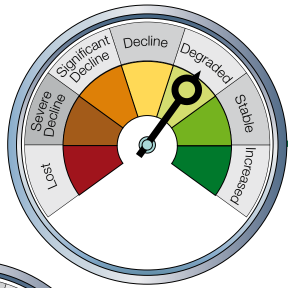
The EU Habitats Directive (92/43/EEC) requires all cetacean species to be strictly protected, including the harbour porpoise (which is listed in Annex II of the directive). However, to date no SACs have been designated specifically for the protection of the harbour porpoise in the UK. This is because it has proved difficult to identify important sites due to the ranging nature of this species, although certain feeding grounds do attract large numbers of porpoise. New information identifying porpoise hotspots means that the data now exists to designate sites, but only at broad spatial scales. New SACs have been proposed, including the Dogger Bank draft offshore SAC with the porpoise as a qualifying feature. The Habitats Directive would continue to be the main legislative measure responsible for the protection of this species. However, additional MCZs could be designated under the MCAB.

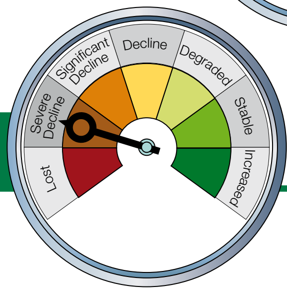
Integrated marine spatial planning and management set out in the MCAB presents an opportunity to manage areas important to the harbour porpoise alongside human activities. MCZs could also be designated with varying levels of protection, which could vary seasonally to account for the different uses of certain areas by the porpoise at different times of the year. By examining spatio-temporal data, it should be possible to establish seasonal closures for different types of gear and activities to minimise the impacts on the species on a broad scale.

In addition, the CFP outlines efforts to reduce bycatch including acoustic deterrent devices and bans on drift-netting (also agreed under ASCOBANS). Reducing the impact of fisheries on sensitive top predators is likely to be an element of future CFP reform.

SEAGRASS BEDS

2009
(Degraded)





2005
(Severe decline)

(Zostera spp)

Cat Wilding, Emma Jackson, Olivia Langmead and Judith Oakley

Seagrass beds are not only rich habitats for marine life and important sources of food for wading birds, but there is also new research into their value as a spawning and nursery habitat. Although beds have still not recovered from the wasting disease of the 1930s, and are unlikely to do so, policy has to some extent instigated water quality improvements that will make them less susceptible to another disease event. However, the protection of this habitat from direct physical damage and loss is still inadequate and lacks both legal and voluntary backing in many areas (in terms of bylaws and codes of conduct).

Plate 14: Eelgrass Zostera marina in Salcombe Harbour.
Image: © Keith Hiscock.

NATURAL HISTORY

Seagrass beds develop in intertidal and shallow subtidal areas on sand and mud sheltered from strong wave action. They are often found near freshwater inputs. Seagrasses are the only flowering plants (angiosperms) that are truly marine, with some 60 species found worldwide[101]. Two distinct species are found in the UK: dwarf eelgrass *(Zostera noltii)* found highest on the shore, and eelgrass *(Zostera marina)* found mainly in the sublittoral. There is also narrow-leaved eelgrass (*Zostera marina* var. *angustifolia*), a variety found on the mid to lower shore[102].

Common eelgrass *(Zostera marina)* has long, narrow dark green leaves which shoot from a sediment binding rhizome. Growth of seagrasses can be vegetative, by rhizome extension and rafting of detached reproductive shoots, or may spread sexually on currents or after seeds are ingested by wildfowl[103-105].

Eelgrass beds are considered an important nursery habitat for many species, including those of commercial importance. The complex structure of seagrass habitats creates many diverse microhabitats which provide refuge for numerous species and a surface for attachment of ephiphytes. Stalked jellyfish, snails and hydroids colonise the leaves, while some species of pipefish and algae are almost exclusively found in this habitat[106]. Seahorses shelter in the canopy and cuttlefish lay their eggs on *Zostera* leaves. It has frequently been demonstrated that infaunal diversity within the root rhizome complex of seagrass beds is significantly higher than for unvegetated sands. Meadows also directly provide an important food source for over-wintering wildfowl which preferentially feed on seagrasses[107].

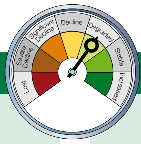
Seagrass beds provide a variety of goods and services. The rhizomes bind and stabilise sediments, increasing deposition of suspended material and inhibiting erosion[108]. In some areas the presence of seagrass beds protects the adjacent coastline, reducing coastal erosion[109]. Seagrasses support high biodiversity and are therefore likely to be important in the resilience and stability of the wider ecosystem. As potentially important nursery, spawning and feeding areas for commercially important species and/or their prey, seagrass beds may contribute significantly to fishery resources.

The sensitivity, conservation and management requirements of Zostera spp. have been documented as part of the UK Marine SACs Project and eelgrass condition assessment monitoring advice for SACs has been produced[110]. In addition, seagrasses are now present in a dozen or more UK Habitat Action Plans and at a local scale the increased awareness of the importance of the habitat is resulting in local bylaws and codes of conduct being implemented.

Plate 15: *A stalked jellyfish Lucernariopsis campanulata growing on eelgrass leaves in the Isles of Scilly.*
Image: © Keith Hiscock.

Plate 16: *Dwarf eelgrass Zostera noltii on a mud flat with laver spire shells Hydrobia ulvae.*
Image: © Keith Hiscock.

STATUS



Degree of decline

Seagrass continues to be under threat and has been classified as degraded in this report. Although turbidity and nutrient loading have been identified as the primary cause of seagrass decline globally, improvements in water quality through better sewerage treatment and national regulations resulting from the Urban Waste Water Treatment Directive and Water Framework Directive are starting to negate these pressures. Even so, continued direct physical pressures on seagrass beds are increasingly resulting in fragmentation and even losses of many beds.

With loss and fragmentation of large patches of seagrass, epifaunal diversity and density decreases[113].

Despite this, even very small patches of seagrass support a far greater abundance and diversity of infauna than bare sand. Therefore *Zostera* habitats, whatever their size, have conservation value[114]. But for larger organisms such as fish, the effects of fragmentation are likely to be magnified, and show more dependence on patch size[115].

Finally, repeated outbreaks of wasting disease led to further losses in the Solent during the 1990s[116] and despite slow recovery in some areas, UK eelgrass beds have still not recovered to their pre-1920s extent, due to significant changes in the sediment dynamics after the loss of the seagrass.

"As well as protection through conservation designation processes, various other management options are available. These may include boat mooring and anchoring restrictions, either statutory or through voluntary codes of conduct, agreements with local fishermen and bait diggers, improved awareness-raising campaigns and restoration of degraded *Zostera* beds. Restoration through transplantation of plants has had varying levels of success depending on the methods adopted. Transplanting plants rather than attempting to re-seed areas seems to be the most successful but may only work with subtidal populations. Ensuring conditions in the site to be restored are suitable for *Zostera* growth is problematic but vital" – Chesworth et al, Hampshire and Isle of Wight Wildlife Trust[116].

Plate 17: Eggs of the cuttlefish Sepia officianalis laid on Zostera marina leaves.

Image: © Paul Naylor.

EXISTING PROTECTION AND MANAGEMENT

Statutory site designation plays an important part in the conservation of seagrass habitats and many of the best examples have been designated Sites of Special Scientific Interest (SSSIs), marine Special Areas of Conservation (as a sub feature), Areas of Special Scientific Interest (ASSIs), Ramsar sites, Special Protection Areas (SPAs), National Nature Reserves (NNRs) and voluntary marine protected areas[111].

- A Habitat Action Plan exists for seagrass beds, aiming to maintain their extent and distribution in UK waters and assess the feasibility of restoring those that are damaged or degraded. This requires baseline information not currently available for some meadows.
- Under Annex I of the EU Habitats Directive, seagrasses are recognised as a characterising feature of two habitats and a component feature of a further two. Zostera habitats are also listed by OSPAR.
- Special Area of Conservation (SAC) eelgrass condition assessment monitoring advice has been produced[110]. However, most monitoring is still in the phase of mapping the current extent of beds[112] and assessments are in most cases being carried out on a six-yearly cycle to fit with reporting, which may limit a fast response to loss or degradation.
- Seagrass is named under Annex V (Biodiversity Strategy) of the OSPAR Convention on the initial list of threatened and declining species, due to adverse impacts from human activities.

CHANGE IN STATUS SINCE 2005

In the absence of adequate monitoring, an assessment of the status of seagrass in 2005 was assumed to be similar to the wider European and global situation, which was that there was a general negative trend and that seagrass beds were in severe decline. In the UK *Zostera marina* was identified as nationally scarce.

From the few monitoring studies and examples of loss that have been reported in the UK and the rest of Europe, it appears that the negative trend has continued[117], although in the last four years a greater awareness of these habitats and their inclusion in conservation management objectives may have reduced the decline. For example, the current spatial distribution of seagrass in the Solent appears to be consistent with records from the 1980s[112]. An increase in distribution of seagrass (due to increased recording effort) could mean that this species may no longer be classified as nationally scarce – but historical records would need to be re-examined to confirm this.

In the last four years, the importance of seagrass as a habitat for seahorses (protected under the Wildlife and Countryside Act) has been reconfirmed through the discovery of breeding populations of both species of seahorses – spiny and short-snouted – in Studland Bay seagrass meadows.

Finally, a number of important research projects have been initiated to examine the habitat functioning of seagrasses, including a project to tag seahorses in Studland Bay and an examination of the influence of mooring and anchor damage on the habitat functioning there, and an assessment of the relative value of seagrass as a nursery and spawning habitat for cuttlefish in the English Channel. Such research is invaluable in providing an evidence base for protecting seagrass beds as habitats.

Plate 18: Anchor damage to a seagrass bed. The 'scar' of bare sediment is clearly visible where the underground rhizome network has been damaged and lost. Image: © Steve Trewhella.

ONGOING ISSUES/THREATS

In many systems, patches of seagrass are naturally dynamic, often showing cyclic variability in growth and extent[118-120] driven by internal regulatory mechanisms, external demographic events and environmental factors. Hence, in order to discriminate between human impacts and natural landscape patterns and dynamics, a thorough understanding of the habitat is required and some measurement of the level of threats is important. Threats to seagrass beds in the UK include:

Disease: *Zostera marina* populations have not recovered since the 1930s, when they were ravaged by a slime mould protist (*Labyrinthula* sp.).

Alien species: competition for light and space from introduced species such as *Spartina anglica* and *Sargassum muticum*. In 2008 it was reported that Sargassum was able to attach to the root rhizome complex of seagrasses[121].

Direct physical disturbance by dredging[122], bottom trawling, coastal development, trampling and hand raking for bivalves[91]. Repeated disturbance by anchors, moorings and propellers can cause permanent damage[123, 124].

Indirect physical disturbance due to hydrology changes destabilising the sediment and increasing turbidity after coastal development and land reclamation.

Nutrient enrichment: This causes a decline in *Zostera* biomass[125-127] and promotes epiphyte growth and phytoplankton blooms, which reduces light penetration. Declines are observed even at low levels of enrichment[128], and globally the most severe declines since the 1930s wasting disease appear to result from this factor[126].

Pollution: Tributyl-tin (TBT), other metals and organic pollutants from antifouling and herbicides may reduce nitrogen fixation. Different mixes of contaminants may interact synergistically to reduce photosynthesis in *Zostera marina*[129].

Climate change and associated extreme weather events have been found to negatively impact on seagrass populations. In Portugal, the biomass of *Zostera noltii* declined as a result of salinity changes due to drought events[130]. Increased sea water temperature was thought to have exacerbated *Labyrinthula* infestations, resulting in the wasting disease epidemic in the 1930s[131], by stressing the plant and increasing microbial activity. In the longer term, changes to the chemistry of the marine environment due to an increase in dissolved CO_2 (ocean acidification) may have a positive effect on the seagrass environment due to increased availability of carbon and reduced calcareous epiphytes[132].

HABITATS UNDER SIMILAR THREAT

Saltmarsh, mudflats, saline lagoons.

ASSOCIATED SPECIES

Spiny and short-snouted seahorses *Hippocampus hippocampus* and *Hippocampus guttulatus* respectively); *Laomedea angulata* a colonial hydroid that has only been recorded on *Zostera marina* leaves; cuttlefish *(Sepia officianalis)* spawn directly on seagrass leaves; stalked jellyfish such as *Haliclystus auricula* use the seagrass leaves as a substrate, and pipefish such as *Syngnathus typhle* use the seagrass beds for foraging and protection.

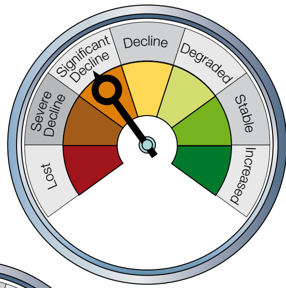
HOW THE MARINE AND COASTAL ACCESS BILL WILL HELP

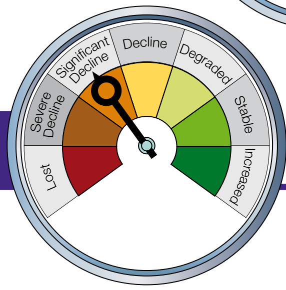
Important policy drivers for the conservation of Zostera include the EU Water Framework Directive (WFD, 2000/60/EC). This requires all inland and coastal waters to reach 'good ecological status' by 2015 and will establish ecological targets for surface waters. Under Annex V, marine angiosperms (seagrasses) are described as one of the biological quality elements to be used in defining the ecological status of a transitional or coastal water body. A number of quality metrics for seagrasses have been proposed[128], although these do not assess the habitat qualities of the seagrass. The WFD and other water quality-related Directives and Bills should help to protect seagrass from pollution. This has already resulted in a shift in the importance of pressures to more localised direct impacts (for example the physical disturbance caused by coastal development, anchoring, moorings and mobile fishing gear), which will require spatial protection of particularly vulnerable beds – protection that is currently inadequate.

European Marine Site designation does not necessarily result in protection for seagrass. For example, at South Hook (within the Pembrokeshire Marine SAC, of which *Zostera* habitats are a key qualifying sub-feature) development was permitted which caused damage to the seagrass habitat[133]. Primarily the failings are due to problems with the consenting process (a piecemeal sectoral approach and ambiguous terminology) and the clarity of features to be protected (as a sub-feature, seagrass is not always given adequate consideration)[91].

The MCAB offers an opportunity to address these issues, with the increasing recognition of seagrass as a habitat under threat and decline (OSPAR Convention and Marine Bill White Paper). MCZ designation through the MCAB is not limited to habitats listed under the Habitats Directive and therefore gives an opportunity to provide protection to other important species and habitats such as seagrass. Designation of MCZs for the protection of seagrass could specifically address the protection of the functioning of the seagrass bed as a habitat and not just the protection of the plant or meadow (which show very dynamic natural cycles). The streamlining of the licensing system in the MCAB will result in the integration of some of the consenting process in English and Welsh waters, and the creation of a strategic marine spatial planning system will provide a multi-sectoral basis to manage the diverse activities that threaten this habitat. In addition, IFCAs should be given stronger powers and explicit duties to manage for conservation purposes.

2009
(Significant Decline)





2005
(Significant decline)

DEEP-WATER CORAL REEFS

(Lophelia pertusa)

Catherine Wilding, Emma Jackson and Olivia Langmead

Deep-water coral reefs occur worldwide. They are generally present at depths in excess of 200m beyond the reaches of surface light. The basic structure of the reef is usually stony coral, especially *Lophelia pertusa*. The reef structure provides shelter for a wide range of species and the hard surface is an attachment point for sessile species. For many years, deep-water trawlers have been fishing long-lived and slow growing fish from the area of these reefs, often destroying the reefs in the process. New areas of cold-water coral habitat continue to be discovered, and recent improvements in understanding their biology and ecology have been made in the last five years. However, very few reefs have been discovered that have not already suffered some form of degradation due to human impacts.

Plate 19: *The coral Lophelia pertusa is the main reef-forming species.*

Image: © Murray Roberts.

NATURAL HISTORY

Recent technological developments allowing *in situ* study have greatly improved our understanding of deep-water coral reefs. The stony coral *Lophelia pertusa* is usually the dominant species in the North-east Atlantic, providing a framework that alters sediment deposition, provides complex structural habitat, and is subject to the processes of growth and (bio) erosion[134]. In addition to the main reef-building species *Lophelia pertusa*, other hard corals such as *Madrepora oculata* and *Solenosmilia variabilis* are found[135].

Lophelia pertusa colonises hard substrata in areas with high water movement and stable temperature[136], and feeds on plankton and detritus falling from productive surface waters[134, 137, 138]. The corals use aragonite (a form of calcium) to build their skeleton structure[139].

Lophelia is gonochoristic, so colonies are single sex[140] and growth is slow, estimated at around 26mm per year[141]. They also live to several hundred years old, and reefs may persist for millennia, reaching 30m high and covering 100sq km(139). Stresses to *Lophelia* can inhibit reproduction, and stress due to trawling appears to prevent sexual reproduction[142].

More than 1,300 species associated with *Lophelia pertusa* reefs have been found in the North Atlantic[136].

The biodiversity found on cold-water coral reefs may be comparable with that of tropical coral reefs[136], and infaunal diversity may be three times that of the surrounding sediment[143]. Because *Lophelia* reefs are often found on isolated features such a seamounts, there is likely to be a high level of endemism among species utilising the reef habitats[136]. Successive growth periods of cold-water, reef-forming corals result in the formation of coral carbonate mound habitats.

Cod and monkfish are found in these habitats, and 68% of fish species (82% of the abundance) recorded from *Lophelia* reefs are of commercial interest[144]; the reefs may act as nursery grounds. Around reefs, 92% of fish species have been found in association with *Lophelia* rather than the surrounding seabed[144], and a multitude of invertebrates live in these habitats, including many species new to science (for examples see[143, 145]. The microbial communities of cold-water corals are also likely to contain novel organisms, which will not only increase our understanding of microbial diversity but could also be a source of new bioactive products such as enzymes and pharmaceuticals[146].

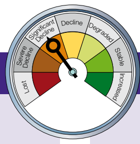
Plate 20: Crinoids Koehlermetra porrecta on Lophelia pertusa at Hatton Bank. Image: © BERR/Defra/JNCC.

Plate 21: Numerous species are found in these rich habitats. This picture shows a gorgonian (Callogorgia sp.), stony corals Madrepora oculata and Lophelia pertusa, several smaller stylasterid corals (Pliobothrus sp.) and many hermit crabs.
Image: © BERR/Defra/JNCC.

EXISTING PROTECTION AND MANAGEMENT

- The North Atlantic Ocean is a key region in the worldwide distribution of *Lophelia pertusa*[134], and 92% of global records of *Lophelia pertusa* occur within the OSPAR area[2].
- The species *Lophelia pertusa* is listed by CITES, and the habitat is included under Annex I of the EC Habitats Directive[147].
- The Darwin Mounds was the first area to be designated an offshore SAC for cold-water coral reefs[148], and the North-west Rockall Bank has been proposed as a draft SAC[149]. Four areas containing *Lophelia* have been closed to fishing in the Irish EEZ, protected by the EC Regulation No 850/98 of the Common Fisheries Policy[2]. Nevertheless, current coverage is still regarded as insufficient[69].
- The North-east Atlantic Fisheries Commission (NEAFC) has banned bottom trawling on four seamounts on the North-east Atlantic ridge. Within the OSPAR region there are currently 24 closed areas, covering 578,000sq km, where *Lophelia pertusa* is known to occur.

STATUS



Degree of decline

Cold-water coral habitats continue to be discovered, and are likely to be more widespread than previously thought[144]. Recent evidence has found new colonies of *Lophelia pertusa* growing on oil and gas platforms in the North Sea[141].

Lophelia reef habitats are considered to be under threat or in decline in all OSPAR regions[2], and given the extent of deep sea fishing it is likely that currently unknown reefs are sustaining damage before they have been discovered.

Throughout their range, cold-water coral habitats are declining in extent due to physical damage by trawling[150-153]. Around the UK smaller patch reefs have declined in extent more severely than larger reefs, because smaller patches present less of an obstacle to fishing gear(150, 154). This is corroborated by reports that trawlers avoid large reefs to prevent damage to their gear[2].

Static fishing gear (gill and tangle nets) and lost gear have been observed from Irish *Lophelia* reefs[155], and these may impact on the fauna through 'ghost fishing'. Further anecdotal reports claim some fishing practices involve the deliberate destruction of coral habitats to clear an area before fishing begins[156]. Damage from fishing is predicted to remain a threat to these habitats throughout the next decade[2].

Scottish reefs are 'significantly impacted'[155], and in Norway and Sweden an estimated 50% of the habitat has been impacted in the last 10 years[156]. Between 2005 and 2007 intense trawling has taken place in known areas of *Lophelia pertusa* occurrence[2]. Fishermen have reported significantly lower catches in areas where reefs have been damaged[156].

Plate 22: Deep-water corals provide a complex habitat for other species to colonise. *Image: © Murray Roberts.*

CHANGE IN STATUS SINCE 2005

New areas of cold-water coral habitat continue to be discovered, and improvements in understanding the corals and their associated fauna are being made[157]. However, very few reefs have been discovered that have not already suffered some form of degradation due to human impacts. Recent research and predictive mapping could help inform the development of a network of MPAs to protect these habitats, as protection is urgently required[158, 159]. Projects investigating *Lophelia* habitats include HERMES (Hotspot Ecosystem Research on the Margins of European Seas) superseded in April 2009 by HERMIONE (Hotspot Ecosystem Research and Man's Impact on European seas)[160].

ONGOING ISSUES/THREATS

Demersal trawling: This causes habitat destruction on a scale that can impact entire coral mounds[150]. Trawling reduces the structural complexity of habitats and causes sediment re-suspension which may smother nearby fauna. Because *Lophelia* corals are so slow-growing, they are vulnerable to trawling[161] and recovery will be extremely slow, or may not occur at all[162]. All evidence of a reduction in the condition of reefs in the past decade has been attributed to demersal fishing[2].

Oil and gas exploration and seabed mining: Drill cutting discharges and mud can smother reef fauna, causing mortality in localised areas[141].

NEW / EMERGING THREATS

Ocean acidification is likely to lead to a reduction in oceanic aragonite concentration. Under these conditions *Lophelia* is unlikely to calcify, and its skeletal structures may dissolve[139]. Some 70% of known global cold-water coral locations could become under-saturated with aragonite by 2099[163]. Cold-water corals are even more vulnerable to the effects of ocean acidification than tropical corals, and ocean acidification is predicted to show the greatest increase in 300 million years[164].

SPECIES UNDER SIMILAR THREATS

Other corals, such as *Madrepora oculata*, gorgonians and antipatharians, form important structural habitats that face similar conservation threats to those facing *L. pertusa* reefs in the North-east Atlantic.

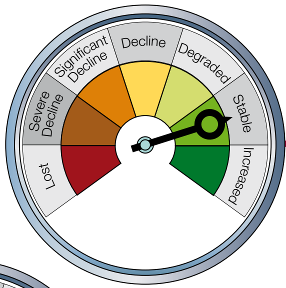
HOW THE MARINE AND COASTAL ACCESS BILL CAN HELP

Lophelia reefs generally occur in deep water, either inside the UK EFZ or in international waters, which require cooperative measures. The North-east Atlantic Fisheries Commission (NEAFC) has banned bottom trawling on four seamounts on the North-east Atlantic ridge. Within the OSPAR region there are currently 24 closed areas, covering 578,000sq km[2]. Four areas containing Lophelia have been closed to fishing in the Irish EEZ and the Darwin Mounds was the first area to be designated an offshore SAC for cold-water coral reefs. The North-west Rockall Bank has been proposed as a draft SAC. Much more information from surveys is now available, pointing to the location of other sites that need protection from fishing and oil and gas exploration. Replication of sites is required to ensure the survival of the habitat through ecologically meaningful representation of the reefs.

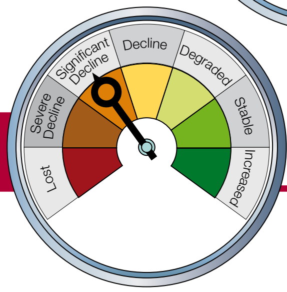
Although the closure of the Darwin Mounds is a success in many respects, it also highlights the division between marine nature conservation and fisheries management in the European Union – a legal and political issue that will require resolution in the near future. It also highlights the fact that care must taken in managing protection – after the announcement of the closure of the Darwin Mounds, but during the lag period before the closure came into force, the area was inundated by increased fishing effort which added to the pressure on the habitat[3].

Finally, while demersal trawling impacts are being abated via fisheries exclusions (i.e. CFP, NEAFC), damage by oil and gas exploration and seabed mining will not be regulated through marine spatial planning under the MCAB. Instead this will continue to be licensed by the Department of Energy and Climate Change and the Crown Estate. Large infrastructure projects such as renewables development will be licensed by the Infrastructure Planning Commission (IPC) established under the Planning Act. The Marine and Coastal Access and Planning Bills have been developed in parallel and it is proposed that the MMO and IPC work very closely together on marine projects[4]. The MMO should have a strong IPC advisory role on conditions that should be imposed to mitigate any adverse impacts a development may have on the marine environment or other uses of the sea. Deep-water coral reefs will be at risk from any failures in the liaison between the MMO and IPC.

2009
(Stable, but no sign of recovery in damaged areas such as Strangford Lough)



HORSE MUSSEL BEDS



2005
(Significant decline)

(Modiolus modiolus)
Keith Hiscock

Horse mussel beds act as biogenic (living) reefs and provide a habitat and refuge for up to 100 other species. Queen scallops often occur in association with horse mussel beds and are a targeted fishery. However, the dredges used to gather the 'queenies' have caused extensive damage, and in some areas – for example, Strangford Lough – have resulted in loss of the beds. Horse mussels are slow to settle and grow, so recovery may take a long time or not occur at all (a fact reinforced by recent studies). Nevertheless, a project to examine restoration of the population in Strangford Lough, and the adoption of OSPAR recommendations, are positive steps.

Plate 23: Horse mussel beds can grow several metres above the seabed and cover hundreds of hectares. This dense reef is off the Shetland Islands.
Image: © Keith Hiscock.

NATURAL HISTORY

Although the horse mussel *Modiolus modiolus* is widely distributed around most of Britain and Ireland, horse mussel beds are restricted to northern waters. These beds occur in areas with moderate levels of tidal current exposure, particularly tide-swept channels in Scottish and Irish sea lochs (loughs) but also in open sea areas such as in the Irish Sea around the Isle of Man and off the Lleyn Peninsula. Beds are most common in depths of between 5m and 70m(165). Smaller beds or clumps are found on rocky surfaces in some Scottish sea lochs(165), while larger beds are usually found over softer mixed sediment. Where beds occur on softer sediments, the mussels are often partially buried.

Horse mussels are held together and to rocky substrata by strong byssal threads produced by the mussel. When large numbers of these mussels anchor in close proximity, extensive and complex networks of threads are formed. These trap sediment, pseudofaeces, stones and shell to form reef structures that may be raised several metres above the seabed and can extend over hundreds of hectares.

Horse mussel beds support a diverse assemblage of suspension feeders, including barnacles, tube worms, hydroids, soft corals, sea mats, sea squirts and brittlestars. Shallow reefs support foliose and crustose seaweeds (166-168). Without human interference, horse mussel beds are extremely long-lasting, stable structures. However, due to their poor rate of recruitment, beds are very slow to recover from any damage. It is possible that they may never recover from severe damage, particularly that caused by trawling.

EXISTING PROTECTION AND MANAGEMENT

- Horse mussel beds can be protected as a 'Reef' under the Habitats Directive and can also occur in 'Shallow inlets or bays', giving them further potential protection.
- *Modiolus modiolus* beds are listed as a habitat under the UK Biodiversity Action Plan(165).
- In Strangford Lough, trawling and dredging were banned in December 2003 to protect horse mussel reefs. But this was too late, as much of the damage had already been done.
- In May 2008, the Welsh Assembly Government approved a Sea Fisheries Committee bylaw prohibiting the use of bottom towed fishing gear in an area off the Lleyn Peninsula to protect the horse mussel beds there.
- *Modiolus modiolus* beds are listed under OSPAR Annex V list of threatened and/or declining species and habitats published most recently in 2008.

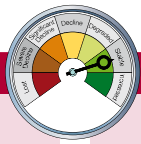
The OSPAR citation noted the sensitivity, particularly to physical disturbance, of this biogenic habitat and its low resilience which results from the long lifespan of individuals coupled with erratic recruitment.

Summary of actions proposed in the OSPAR assessment[1]

1. Habitat survey and mapping: Contracting Parties should be encouraged to complete habitat surveys of their sea areas. ….
2. Communication: OSPAR should ask the EU and other fishery management authorities to review the effectiveness of VMS [Vessel Monitoring Systems] for monitoring compliance with closures of small areas of sensitive habitat.
3. Adapt the habitat definition: Recognising that at present the parts of the EUNIS classification concerned with *Modiolus* beds do not cover the full spectrum of *Modiolus* biotopes and their descriptions, these parts of the classification should be revised. ….
4. Improve assessment: Consideration should be given to bringing together a specialist working group... [to assess the overall extent of *Modiolus* beds in the OSPAR area]. ….
5. Assess measures: assess whether existing management measures for the protection of *Modiolus* beds are effective, and what further measures, if any, might be needed to assess the key threats.
6. Targeted MPA designation and management: recommend that Contracting Parties intensify their work to identify, select and effectively manage sites where *Modiolus* beds are known to exist as OSPAR Marine Protected Areas and to ensure management plans for existing protected sites (e.g. SACs) are not leading to further deterioration of the habitat.

Plate 24: Horse mussel Modiolus modiolus beds provide a valuable refuge for a multitude of species including tube worms, anemones, brittle stars and sea urchins.
Image: © Keith Hiscock

STATUS



No sign of recovery in damaged areas such as Strangford Lough.

Degree of decline

Improved information

As a part of OSPAR's work to establish status, a review has been prepared that shows historic and recent records for the North Atlantic and, in more detail, for Britain and Ireland[169]. In Wales, surveys have revealed further locations for horse mussels and the Countryside Council for Wales has undertaken significant surveys in established monitoring programmes [170-172]. The horse mussel bed off the north of the Lleyn Peninsula is becoming particularly well surveyed.

Following the threat of infraction proceedings against the UK, a programme of restoration in Strangford Lough, which includes further survey and experimental studies to investigate breeding, has been started at the Marine Research Station of Queens University, Belfast. Research on spawning of *Modiolus* has already led to successful laboratory rearing of spat to 8-9 weeks (for more information, see Restoration below).

The SPLASH (Special Protection and Local Action for Species and Habitats) project[173] added significantly to our knowledge of the biology of *Modiolus modiolus*. It found that the youngest specimens from the Isle of Man were 13 years old and from Strangford Lough 19 years old, suggesting a lack of successful recruitment in these populations in recent decades. Growth rates were calculated for specimens from Pen Llyn a'r Sarnau in Cardigan Bay and were between 3mm and 8mm per year, reaching a length of around 80mm after 20 years of age. These results are not encouraging in terms of recovery of damaged populations, including those in Strangford Lough. Furthermore, studies suggested that populations were significantly differentiated genetically.

This implies that *Modiolus* beds should not be restocked from different locations, and that culturing techniques from local stocks are more appropriate for restocking the beds.

Restoration

Northern Ireland's Department of Agriculture and Rural Development and the Department of Environment commissioned a restoration programme in Strangford Lough in 2008. The three elements of the programme, being undertaken by Queens University, Belfast, are:

- Mapping the occurrence, extent and density of populations;
- monitoring temporal trends in abundance; and
- piloting restoration measures.

Areas where *Modiolus* occurs or once occurred are being monitored using transects and quadrats *in situ*. Additionally, there are proposals for two no-disturbance areas where reefs still persist or were present. Recruitment of spat has been evident. Original research on spawning of *Modiolus* has led to successful laboratory rearing of spat to 8-9 weeks.

CHANGE IN STATUS SINCE 2005

A Queen's University Belfast survey found a significant (3.7 sq km) loss of horse mussel beds since 1991 and identified disturbance by mobile fishing gear as the most likely cause of the initial damage[5]. There was no sign of recovery in damaged areas. The situation was particularly serious in Strangford Lough, where it was eventually agreed that dredging for scallops had resulted in wholesale removal of horse mussel beds; now, the temporary ban on all trawling and dredging activity in the Lough announced in December 2003 has been extended indefinitely. Other possible threats still include increased nutrients and climate change (horse mussels are a northern species). Disagreement on the cause of decline and, indeed, whether decline was occurring at all, delayed action when the adoption of the precautionary approach would have been advisable.

ONGOING ISSUES/THREATS

Fishing: The most significant threat to horse mussel beds is the use of heavy towed gear.

Coastal development and dredging: Horse mussel beds are likely to be vulnerable to smothering from dumping of sediment and from changes in water flow caused by dredging and development.

Climate change: *Modiolus modiolus* is a northern species and the furthest southern beds in the British Isles are in west Wales. Sea water temperature is almost certainly the factor limiting recruitment, and increasing temperatures may mean no significant recruitment for many decades. However, a long-lived species protected from damage requires only the occasional good recruitment to survive in an area. The likelihood of recruitment events being less frequent as sea water temperatures rise makes it more important to ensure that existing reefs are protected.

HABITATS UNDER SIMILAR THREAT

Biogenic reefs are endangered by physical disturbance and mobile fishing gear is the most likely source of that disturbance. Reefs of the tube worm Serpula vermicularis are, like horse mussel reefs, places where a high diversity of species live and are also threatened by physical disturbance. Mussel *(Mytilus edulis)* reefs are commercially exploited by dredging and recruit/recover rapidly, often with help from laying spat in mussel beds. They are not therefore under the same level of threat as *Modiolus* reefs. Low reef habitats near sediment are also under threat from mobile fishing gear: species are likely to be removed and the rock itself may be significantly damaged. The loss or degradation of rock reefs may result in loss of diversity (structural complexity is important to reef species).

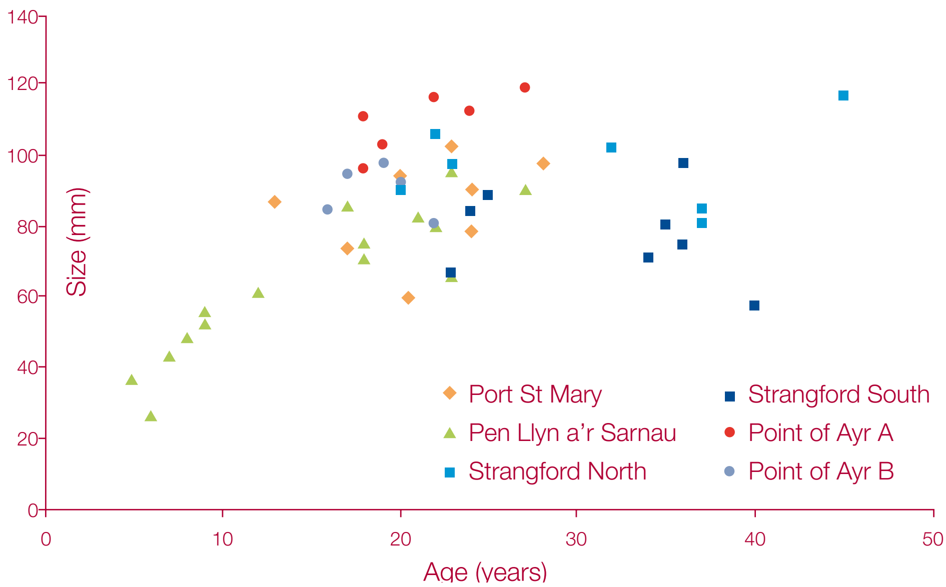


Figure 1: Graph showing ages and sizes of Modiolus from different locations (from the SPLASH project10).

CONCLUSION

Further physical damage to horse mussel reefs has been prevented by banning mobile fishing gear in some areas where reefs exist or existed. Such prohibitions are necessary to protect a wide range of species in all marine protected areas. The likelihood of natural recovery, particularly at the southern limit of range for *Modiolus modiolus*, is low, so experimental work to rear mussels for placement in the wild is welcomed.

HOW THE MARINE BILL MAY HELP

Badging an area as a Special Area of Conservation (SAC) is not always enough to protect its wildlife – which is why regulations and robust management measures, such as highly protected areas being closed to extractive activities, are needed to protect fragile species such as horse mussel beds. Although regulations may occur when a site is designated, they are often only initiated when damage to the relevant feature is identified. The inadequate protection of the Strangford Lough SAC led to a formal written warning from the European Commission in November 2005. The ban on trawling that had been issued in 2004 was extended indefinitely and a restoration programme was initiated. New work points to the beginnings of recovery in the Lough.

Like the pink sea fan, *Modiolus* beds are restricted to specific locations under threat from direct physical disturbance (such as fishing, dredging and coastal development) so the ability within MCZs to adapt the level of protection to restrict damaging activities is vital. The recruitment of horse mussels is sensitive to temperature changes and therefore replication of sites across the biogeographical range of the species (and specifically at the northern limits) should be addressed when designating additional sites as MCZs for this species.

However, with sections on marine nature conservation and fisheries of the MCAB not applied in Northern Ireland, additional protection for this species in this important location will rely on the Northern Ireland Marine Bill.

MAPS OF THE CURRENT DISTRIBUTION IN THE UK

The following maps of current distribution have been compiled from numerous data sources (see acknowledgements). They represent the current status of knowledge on the recorded distribution of the species and habitats in question. It should be remembered that our knowledge is still incomplete, and further records are likely to become available over time.

Atlantic salmon

(Salmo salar)

The data for *Salmo salar* was collated from the Joint Nature Conservation Committee (JNCC), the Countryside Council for Wales (CCW) and the NBN Gateway. The distribution of the confirmed records should only be taken as indicative based on the data available at the time. Data was unavailable for Northern Ireland and the offshore region. As most of the data comprised records from freshwater systems and inshore waters, the expected offshore distribution was plotted using the *Fishes of the North-eastern Atlantic and the Mediterranean Volume* 1[(11)] to indicate where this species is expected to be found. The Atlantic salmon is not listed as an interest feature in any marine Special Area of Conservation (SAC) and none has been displayed on the map.

Pink sea fan

(Eunicella verrucosa)

The data used to plot the distribution of *Eunicella verrucosa* was sourced from CCW, JNCC and the Data Archive Centre for Marine Species and Habitats (DASSH). The data was plotted against the relevant marine SACs. Only those SACs containing the interest feature 'Reefs' have been displayed. These include Plymouth Sound and Estuaries, Fal and Helford, Lundy, Pembrokeshire Marine, and the Isles of Scilly Complex.

Harbour porpoise

(Phocoena phocoena)

Data used to show the distribution of *Phocoena phocoena* was sourced from JNCC, CCW, DASSH and the Small Cetaceans in the European Atlantic and North Sea (SCANS-II) programme. The SCANS-II data was provided in the form of effort-based sightings from boat and aerial surveys. SCANs sightings are plotted along the lines of survey effort. This map should be considered an update of the 2005 Marine Heath Check map, which is why pre-2005 data has been excluded. These surveys are only indicative of distribution, so may not fully represent the entire distribution of this highly mobile species. The data has been plotted alongside the relevant marine SACs (including offshore candidate, draft and possible SACs). Only SACs with *Phocoena phocoena* listed within the interest features have been included: Berwickshire and North Northumberland, Isles of Scilly Complex, Luce Bay and Sands, Moray Firth, Pembrokeshire Marine, Lleyn Peninsula and the Sarnau, and Plymouth Sound and Estuaries SACs; and Dogger Bank and North-west Rockall Bank (listed as a non-qualifying feature) offshore dSACs.

Seagrass *(Zostera spp.)* beds

The distribution of the seagrasses *Zostera marina* and *Zostera noltii* were collated from data provided by Scottish Natural Heritage, JNCC, the Countryside Council for Wales, the NBN Gateway, DASSH and the Devon and Dorset *Zostera* Inventory. The distribution is plotted alongside those SACs which have the relevant interest features (mudflats and sandflats not covered by seawater at low tide, sandbanks which are slightly covered by sea water all the time, estuaries, coastal lagoons or large shallow inlets and bays), along with SACs in which seagrasses occur but are not listed under the interest features.

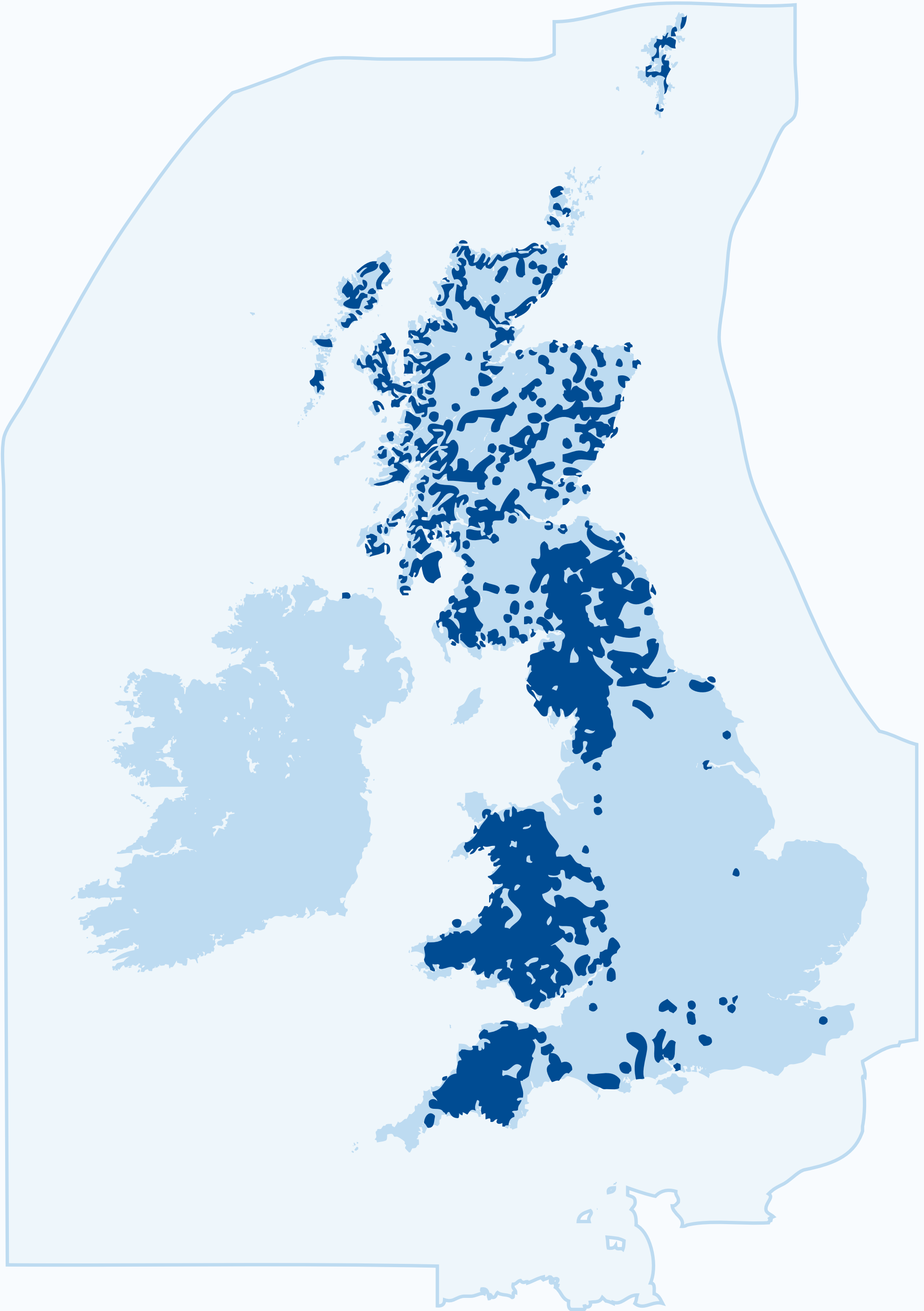
These include Solway Firth, Morecambe Bay, Severn Estuary, Plymouth Sound and Estuaries, Fal and Helford, Pembrokeshire Marine, Lleyn Peninsula and the Sarnau, Essex Estuaries, the Isles of Scilly Complex, Murlough, Strangford Lough, the Vadills, Loch nam Madadh, Berwickshire and North Northumberland coast, the Wash and North Norfolk coast, Chesil and the Fleet, Obain Loch Euphoirt, Sound of Arisaig, Sunart, Dornoch Firth and Morrich More, Moray Firth, the North Norfolk coast, Mòine Mhór, Carmarthen Bay and Estuaries, the Anglesey coast, Saltmarsh, Solent Maritime, South Wight Maritime, Sanday, the Humber Estuary, Menai Strait and Conway Bay, and Firth of Tay and Eden Estuary with qualifying features, and Isle of Portland to Studland Cliffs, South-east Islay Skerries, and Loch Creran with non-qualifying features.

Deep-water coral *(Lophelia pertusa)* reefs

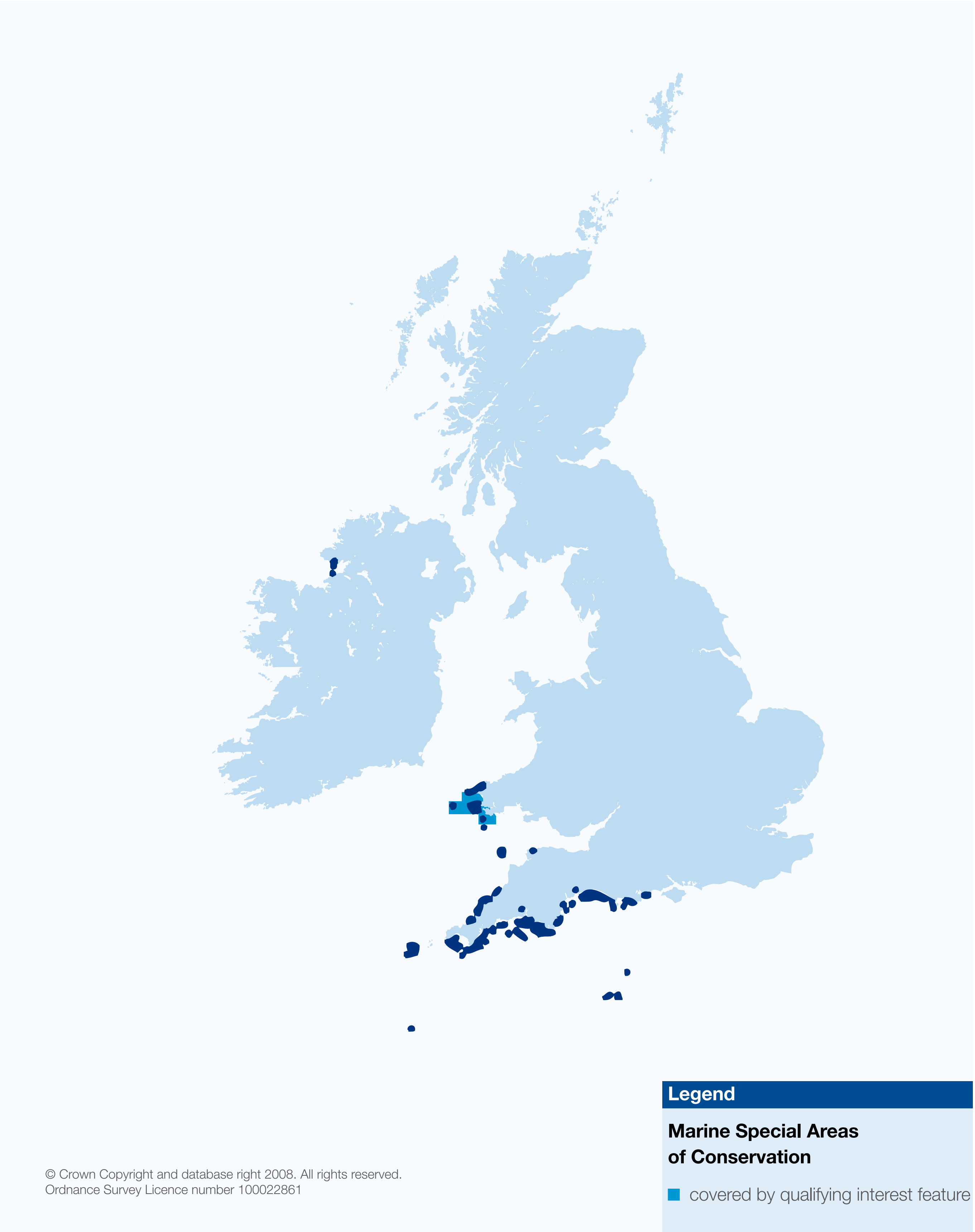
The data used to produce this was sourced from OSPAR's distribution maps of *Initial OSPAR List of Threatened and/or Declining Species and Habitats,* downloaded via the NBN Gateway. The map displays both certain and uncertain records of the presence of *Lophelia pertusa* reefs. These have been plotted alongside the relevant marine SAC (including offshore candidate, draft and possible SACs and Irish offshore candidate SACs). Only those SACs which have 'Reefs' listed as an interest feature, and in which *Lophelia pertusa* reefs occur, have been displayed. These include Stanton Banks and Darwin Mounds offshore cSACs, Wyville Thomson Ridge offshore pSAC and North-west Rockall Bank and Hatton Bank offshore dSACs.

Horse mussel *(Modiolus modiolus)* beds

The distribution map for *Modiolus modiolus* beds was produced using data collated from CCW, JNCC, SNH and OSPAR[1]. The data has been plotted alongside the relevant marine SACs. Only those SACs which have reefs or large shallow inlets or bays listed as interest features, and in which *Modiolus modiolus* beds occur, have been displayed. These include Flamborough Head, Lleyn Peninsula and the Sarnau, Strangford Lough, Lochs Duich, Long and Alsh Reefs, Sunart, Moray Firth, Sanday, Loch Creran, Loch Laxford, Menai Strait and Conway Bay, and Sullom Voe.

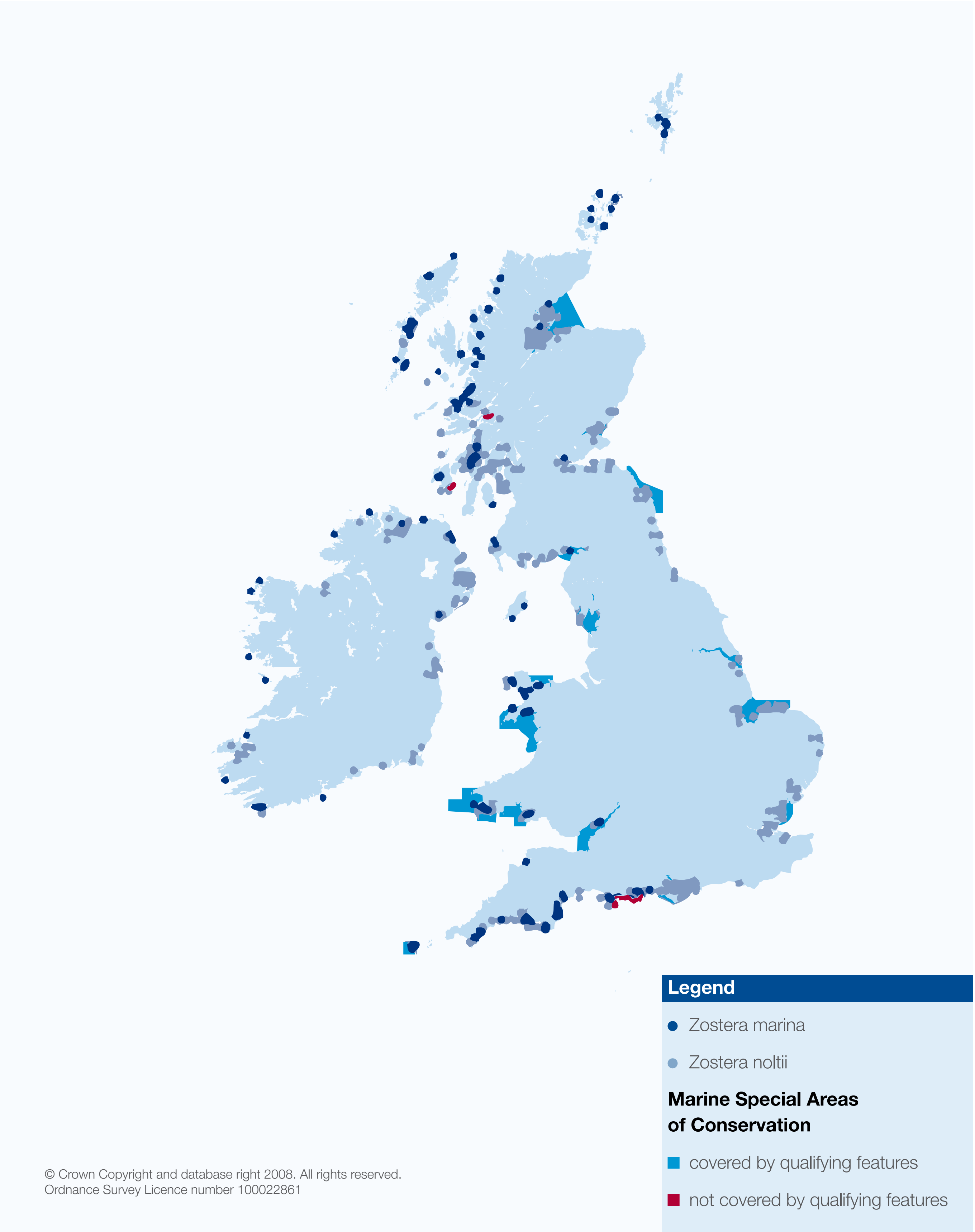


Map 1: Current distribution of the Atlantic salmon (Salmo salar). See map details on page 43.

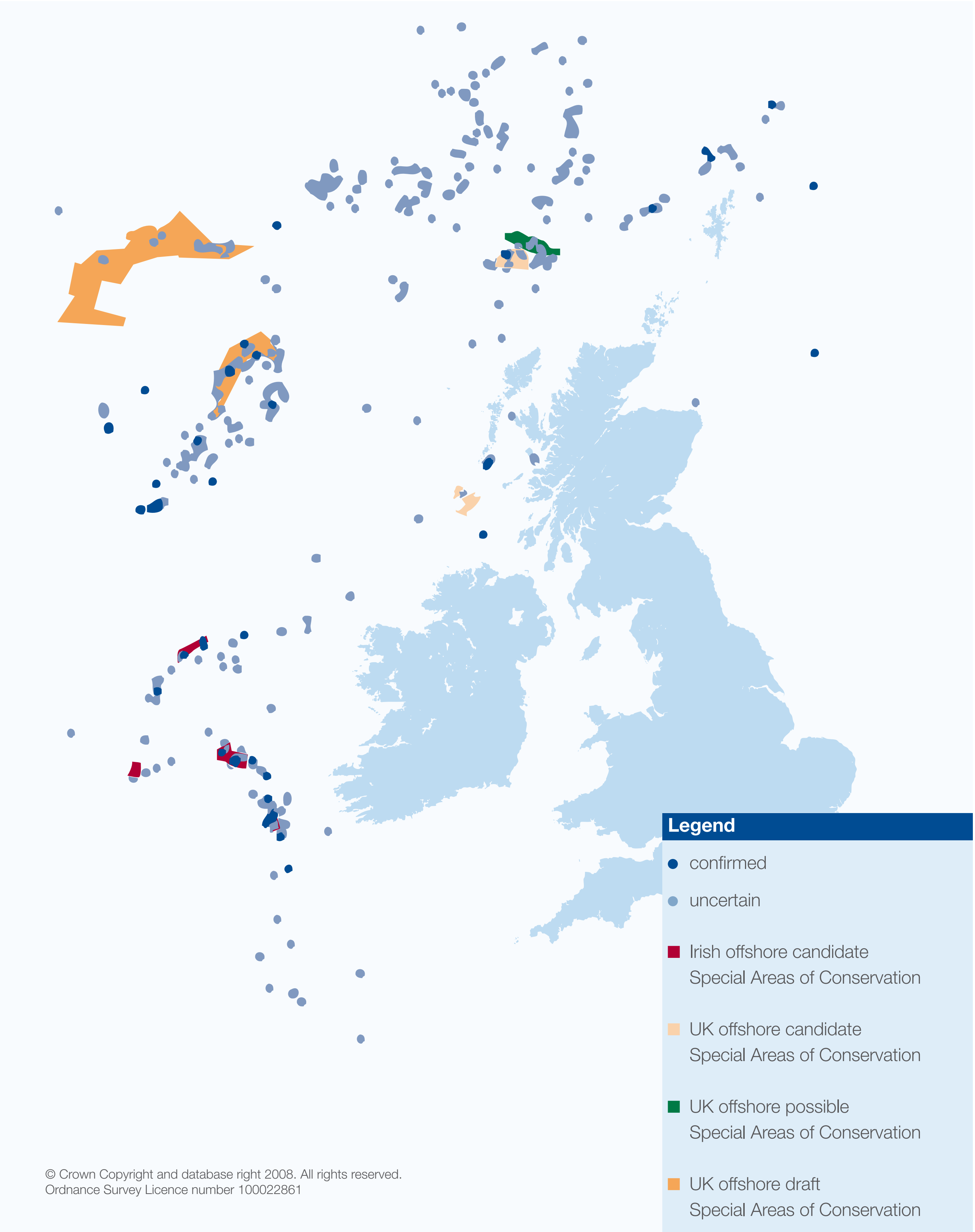


Map 2: Current distribution of the pink sea fan (Eunicella verrucosa). See map details on page 43.

Map 3: Current distribution of the harbour porpoise (Phocoena phocoena). See map details on page 43.



Map 4: Current distribution of seagrass (Zostera spp.) beds. See map details on page 43-44.



Map 5: Current distribution of deep-water (Lophelia pertusa) reefs. *See map details on page 44.*

Map 6: Current distribution of horse mussel (Modiolus modiolus) beds. *See map details on page 44.*

MARINE POLICY OPPORTUNITIES AND LIMITATIONS

The last decade has seen a shift in emphasis for governance in the marine environment from the sectoral management of human activities to encompass sustainable, multi-sectoral use of the sea. Essentially this is the holistic paradigm that underpins the Ecosystem Approach – a framework for looking at whole ecosystems in decision-making, and for valuing the services they provide to ensure that we maintain a healthy and resilient natural environment for future generations.

The Ecosystem Approach has been widely adopted in environmental policy originating from the World Summit on Sustainable Development (WSSD) and the Convention on Biological Diversity (CBD) and, more recently, the Oslo-Paris Convention for Protection of the Marine Environment of the North East Atlantic Convention (OSPAR), and the EU Marine Strategy Framework Directive (MSFD)[174]. The intention is to implement the Ecosystem Approach in the 2012 Common Fisheries Policy reforms[175].

One element of the Ecosystem Approach is the need to understand the 'value' of the goods and services afforded by marine ecosystems. This 'valuation' is relatively straightforward for goods with a market value such as fish, but much harder to determine for less tangible benefits such as the resilience of ecosystems from natural and human-induced change. However, this latter service is vital for the continued delivery of the marine ecosystem services that we all depend on, such as the provision of protein for human consumption, regulation of climate, prevention of storm damage to our coastlines, and waste remediation (among others), against the shifting baseline of a changing climate.

Climate change is altering marine habitats, species distribution and phenology, and is impacting on predator fish stocks and seabird populations. In addition, sea surface layers have become more acidic by about 0.1 pH units. Such ocean acidification will have major negative impacts on some shell/skeleton-forming organisms – the foundation of marine food webs – this century[176]. For marine ecosystems to adapt to climate change, they must be protected across their range and connectivity between populations must not be compromised. Diversity (species richness, functioning) increases resilience to climatic variability, compounding the need to protect marine ecosystems from human-induced degradation.

Humankind has depended on the sea for food and transport for centuries, possibly even millennia. Today, our coastal waters and oceans are subject to continued use (and sometimes abuse) by a variety of industrial sectors such as oil and gas, shipping, recreation and fisheries. A large proportion of the world's population lives within the coastal zone. Pollution, while much improved, remains a local, regional and global issue, especially as new chemicals such as biocides and pharmaceuticals are developed. Yet we continue to look to the sea for our future – not least in the development of renewable energy resources such as wave and tidal and sites for wind farms.

As a result, marine species and habitats continue to be exploited, stressed or threatened by human activities. The need to manage our multi-sectoral use of the sea more effectively and sustainably has long been recognised. New policy initiatives such as the MCAB have the potential to improve the management of our seas, if applied effectively.

The UK has various international obligations such as the commitment under the World Summit on Sustainable Development and the Convention on Biological Diversity to achieve a significant reduction in biodiversity loss by 2010, to encourage the application of the ecosystem approach of marine managements, to establish a network of marine protected areas by 2012, and to restore depleted fish stocks by 2015 if possible. The UK also has a commitment under OSPAR to develop ecological quality objectives for the North Sea, and to designate areas of its seas as marine protected areas as part of an 'ecologically coherent' network of well-managed sites. Within the EU context, the most recent initiative – and the one which has the greatest bearing on the provisions in the UK MCAB – is the European Marine Strategy Framework Directive (MSFD), which was introduced in 2008 and must be transposed into domestic legislation by 15 July 2010. This is in addition to obligations under the Habitats, Birds, Shellfish Waters, Urban Waste Water Treatment, Water Framework, Bathing Waters, Environmental Impact Assessment and Strategic Environmental Assessment Directives and the Common Fisheries Policy.

The UK MCAB is a piece of framework legislation to improve the management of our seas and the protection of our marine natural heritage, which should fulfil the above international obligations and ensure the sustainable use of our seas.

THE UK MARINE AND COASTAL ACCESS BILL (MCAB)

The UK MCAB aims to simplify and unify the currently complex and sectorally-based planning and licensing systems, to be overseen by a new strategic delivery body for the marine environment – the Marine Management Organisation (MMO), and devolved equivalents. The MMO is designed to be a centre of expertise to provide a consistent and unified approach to enable management and coordination of the marine area by bringing together a number of separate organisations.

The MCAB will provide opportunities to conserve marine species and habitats and modernise fisheries management. The MCAB introduces a new marine planning system. A UK-wide Marine Policy Statement will set out objectives for sustainable use of the marine environment. A series of marine plans will be developed using information about spatial uses and needs in those areas. The marine licensing system will be improved by a more comprehensive and efficient system that will result in better and more consistent decisions. Marine nature conservation will be addressed through new conservation tools, such as the designation of new Marine Protected Areas (MPAs) called Marine Conservation Zones (see below). Together with existing MPAs (e.g. European Marine Sites), these will form a network of MPAs that aim to halt the deterioration in the state of the UK's marine biodiversity and promote recovery, and support healthy functioning and resilient marine ecosystems (see below). To meet such aims, ecological coherence of the network is crucial and should be fundamental to the implementation of the MCAB.

Finally, fisheries management and marine enforcement will be strengthened by the MCAB so that more effective action can be taken to conserve marine ecosystems and help achieve a sustainable and profitable fisheries sector. As part of modernising inshore fisheries management in England, Sea Fisheries Committees (SFCs) will be replaced with Inshore Fisheries and Conservation Authorities (IFCAs). In Wales, the Welsh Assembly Government will assume full responsibility for inshore fisheries management and enforcement.

MARINE NATURE CONSERVATION AND MCZS

The UK MCAB includes provisions for new national MPAs, called Marine Conservation Zones (MCZs), in English and Welsh territorial waters and UK offshore waters (out to 200 nautical miles) with the exception of UK offshore waters adjacent to Scotland. MCZs aim to halt the decline in biodiversity by protecting areas where there are rare, threatened and representative species and habitats, and features of geological or geomorphological interest. The network of MPAs and MCZs must be both large enough, and close enough together, to support functioning communities of marine wildlife. Seven design principles (based on OSPAR 2003) have been identified to ensure ecological coherence:

- representativity;
- replication;
- viability;
- adequacy;
- connectivity;
- protection; and
- best available evidence.

The UK government and the devolved administrations will be required by the MCAB to lay a statement before the appropriate legislature that identifies the characteristics of the network of MCZs. The OSPAR principles should be used to inform this. The practical interpretation of the MPA network design principles is key to how MCZs are designated. For example, if representativity and replication only consider priority features for which we have international obligations to protect (OSPAR and Biodiversity Action Plan species and habitats), many other functionally important species and habitats would be excluded from the criteria and would not potentially be included in the network of MPAs. This is particularly important since the BAP list is restricted to species and habitats for which quantitative information on their decline exists; this is a major constraint on the number of species and habitats included, since data to support these measures is often not available for many marine species.

Replication is key for the adequate protection of species and habitats across their geographical ranges. This is particularly important at the range edges as well as within the centre of the ranges, and for species such as the pink sea fan that have narrow ranges. The importance of replication of sites for the pink sea fan to counter natural variability has been illustrated by the declines at Lundy during the 1990s. Representation of species and habitats within a network based on records of occurrence alone will not be sufficient to build an ecologically coherent network. The sites within a network should be adequate to ensure the ecological viability and integrity of species and habitats. Ecological processes link the physical and biological environment, and in some cases result in a strong biological response in a confined geographical area which could influence the functioning of specific habitats found there. For example, seagrass beds known to be important for biodiversity or as spawning grounds due to their location, size or 'quality' need to be represented – not just areas where a seagrass bed has been recorded.

To ensure the viability of species and habitats through natural cycles of variation, the network should include self-sustaining, geographically dispersed sites. In particular, a number of the flagship species and habitats reviewed here have shown significant losses due to disease (for example pink sea fan and seagrass), so replication of viable sites for these species will help minimise loss and degradation of these features.

Connectivity – the movement of species and the transport of their offspring from place to place – is vital to achieving ecological coherence. This could be interpreted as protecting larval sources and sinks (for example key spawning habitats such as seagrass beds), juvenile and adult migration routes, and incorporating land/sea connections (especially important for anadromous species such as salmon) – all of which can help maintain connectivity. MPAs can 'inoculate' surrounding areas by acting as a source of recruitment for adjacent fisheries and as a source of biodiversity to neighbouring areas more generally. As larval exchange differs markedly among different species, the MPA networks should aim to maintain the connectivity of larval dispersal for the majority of species within those networks. Instead of trying to ensure the connectivity between individual MPAs (which would be difficult for the reasons outlined above), the emphasis should be on protecting areas with high-quality habitat to ensure a source of recruitment[177].

In contrast to EMSs, where activities are regulated according to their perceived damage to the priority features (habitats and species listed in Annexes I and II respectively of the Habitats Directive) for which each site was designated, MCZs will have differing levels of protection. The government has stated in Parliament that it intends to designate some areas as highly protected MPAs, providing the greatest benefit to biodiversity of any type of MPA. Highly protected MPAs facilitate recovery from past impacts, leading to often rapid increases in abundance, body size, reproductive output and diversity of species within them[178].

The living cover and complexity of habitats on the seabed also increases following protection. Thus the level of protection must be relevant to species and habitats and their function. For example, the pink sea fan, deep-water corals, *Modiolus* and seagrass beds are highly sensitive to physical disturbance, so the use of demersal gear would need to be restricted (or prohibited) in order to preserve these features. By contrast, restricting demersal fishing is likely to have a beneficial effect on the food supply for pelagic species such as harbour porpoises – but other measures such as seasonal closures to trawling on calving grounds would also be needed. In addition, protection will not be restricted solely to Habitats Directive Annex I habitats and Annex II species, but will encompass more priority features.

Finally, while it is important that MCZs will be designated on scientific evidence, it is essential to recognise there are some limitations and accept that use of best available evidence is also vital. This has particular implications for marine ecosystems where much of the evidence is semi-quantitative, anecdotal or entirely lacking. However, expert judgement can be taken into consideration when assessing evidence, as this is often the only information available. There is also a need for this to be an adaptive process, incorporating periodic reviews into the MCZ designation process: as more information becomes available with ongoing research and monitoring, levels of protection within MCZs will need to be adjusted, management plans adapted or even boundaries of sites realigned to ensure continued protection.

FISHERIES MANAGEMENT

Inshore fisheries management will be modernised under the MCAB through Inshore Fisheries and Conservation Authorities (IFCAs) that will replace Sea Fisheries Committees in England. IFCAs have a number of duties, not least seeking to ensure that the exploitation of sea fisheries resources is sustainable. In addition, the authority for an IFC district must seek to ensure that the conservation objectives of any MCZ in the district are furthered. WWF believes that similar duties are also required in Wales in order to ensure that, compared with England, the environment is adequately considered in fisheries management.

The Common Fisheries Policy Green Paper[175] recognises that ecological sustainability is a basic premise for the economic and social future of European fisheries. The importance of a healthy ecosystem to support fisheries, and their continued exploitation and societal benefits, is recognised with suggested measures such as:

- new initiatives to eliminate discards and protect sensitive species and habitats; and
- a continued drive to combat ‘Illegal, Unregulated and Unreported’ fisheries (IUU), in order to prevent such fisheries in European waters and the importing of any products originating from them.

It is hoped that cetacean bycatch will be reduced through efforts to protect sensitive species; this measure, along with that on IUU fishing, should also be beneficial for habitats such as deep-water coral reefs. How this will be implemented is not fully defined but it is possible that the mechanisms will involve decentralisation and regional management solutions implemented by EU member states.

THE DEVOLVED ADMINISTRATIONS

As a result of the current devolution settlements in the UK, not all aspects of the UK MCAB extend to all of the UK's marine area. Different responsibilities are held by each devolved government.

Scotland introduced the Scottish Marine Bill (SMB) in April 2009 for managing its seas out to 12nm, but it is also responsible for nature conservation in offshore waters (12-200nm). The SMB provides for the establishment of Marine Scotland as a government department (equivalent to the MMO) and for a national marine plan (out to 12nm). The key differences between the SMB and the UK MCAB are in the nature conservation provisions. The SMB involves designation of three types of MPA: for nature conservation, demonstration and research, and historic purposes. While the latter two types are not designed for nature conservation, they may act as *de facto* MPAs by restricting damaging activities.

The Welsh Assembly Government will implement licensing in Welsh waters to 12nm and will agree marine plans in conjunction with the UK Secretary of State/MMO for inshore and offshore Welsh waters (0nm to the median line with Ireland), where they include functions reserved to the UK government. Following enactment of the MCAB, Welsh Ministers will create a 'Welsh Fisheries Zone' which will extend to the median line and fisheries management will be delivered from within the Welsh Assembly Government. It is vital that the Welsh Assembly Government works closely with the MMO given the complex mixture of reserved and devolved activities in Welsh waters.

Rather than propose more MPAs – since an area comprising over 40% of Welsh territorial seas is already designated as European Marine Sites (EMSs) as well as intertidal and coastal Sites of Special Scientific Interest (SSSIs)[91] – the emphasis for nature conservation will initially be on increasing the level of protection within the existing network of sites by the creation of highly protected MCZs, where activities will be strictly regulated.

The main issue with this approach is the fulfilment of representativity and replication criteria within the existing network, which has gaps in coverage (91)(since EMSs were designated solely for the protection of features listed in Annexes I and II of the Habitats Directive).

Also, CCW is taking a different approach to defining nationally important biodiversity, including both habitats and species included in the UK Biodiversity Action Plan as revised in 2007, or identified as candidate Nationally Important Marine Features (NIMFs)[179].

Northern Ireland has committed to the development of a UK-wide Marine Policy Statement (MPS); the development of high-level marine objectives; planning offshore; reforming licensing arrangements relating to the Food & Environmental Protection Act 1985; and marine aggregate extraction. However, important sections of the UK Bill, such as marine nature conservation and fisheries, will not be applied in Northern Ireland, but it is expected that these will be covered in a separate Northern Ireland Marine Bill[180].

The devolved administrations have different activities devolved to varying degrees in different parts of the UK marine area. Therefore, there is a need for integration across borders to manage as a whole. However, there is a degree of resonance between clauses in the SMB and the MCAB that should help to facilitate cross-boundary management. Further assurances are required from the UK government, Welsh Assembly Government, and Northern Ireland Executive that they will cooperate on cross-boundary issues.

WWF PRIORITIES FOR THE UK MCAB

The UK MCAB is a key milestone but may take some years to be implemented fully. Priorities for WWF during this phase and its implementation are:

- to create an ecologically coherent network of marine protected areas, based on sound scientific criteria, that protect marine wildlife and habitats (with a range of MPA management options – from Highly Protected Marine Reserve (HPMR) to multi-use);
- to ensure the new Marine Management Organisation (MMO) – a proposed 'centre of marine expertise' – is a strong, effective body that will have a clear overview of all activities taking place at sea;
- to establish a comprehensive planning system that covers the whole of UK seas, not just selected areas;
- to ensure an 'ecosystem approach' to managing our seas, which means respecting ecologically meaningful boundaries, not simply administrative borders;
- to sustainably manage fish stocks and the marine environment; and
- to ensure coordination and cooperation across borders, and consistency between the UK MCAB and devolved marine legislation.

CLIMATE CHANGE IMPACTS ON THE MARINE ENVIRONMENT AND NEED FOR ADAPTATION

Climate change is already having an impact on our seas, with warmer sea temperatures and increasing acidification accompanied by changes in productivity, species reproduction and abundance, shifts in distributions of marine organisms and particularly in plankton communities. These show regional variability, with complex patterns of species movement and responses to climate drivers.

Climate change can be expected to result in further changes in the length of the growing season, community composition and species ranges. Trophic disruption is likely as a result of changes to timing of biological processes, and may have serious impacts throughout the food chain. Coastal ecosystems are expected to change in response to increased storminess and rises in sea levels (e.g. erosion of existing coastal habitats). This stress is in addition to the multiple directly anthropogenic stresses caused by pollution, nutrient enrichment, loss of coastal habitats and over-fishing, which have already rendered marine ecosystems more vulnerable to climate change and thus less capable of adapting.

There are a number of ways that an ecologically coherent MPA network can help build resilience in marine ecosystems to climate change. Sufficient replication of protected sites through the geographic range (and especially near the limits) of a species will allow range extensions and ensure that designated sites are not obsolete in the future. Replication of sites is also important under conditions of predicted increasing climatic variability (such as the frequency and intensity of storms) to ensure population viability if one site becomes degraded through an extreme event. Finally, ecosystems with high biodiversity and functional integrity are widely argued to be more resistant to both climatic disturbances and invasion by alien species[181], and this resistance can be enhanced by reducing or removing additional human pressures burdening them.

CONCLUSION

The last five years have seen major shifts in marine policy, with a growing appreciation of the need to protect our marine species and habitats, and the ecosystem goods and services they provide to the wider environment of which we are part. Marine ecosystems may have some inherent stability and resilience, but we are now realising that the provision of goods and services from these ecosystems, which are important for human survival and well-being, are increasingly vulnerable to our activities.

And yet, of the six flagship species and habitats examined in this Update, seagrass beds remain degraded, the Atlantic salmon continues to decline, and deep-water coral reefs have suffered a significant decline. Pink sea fan and harbour porpoise populations and horse mussel beds are probably stable but pink sea fan has shown no recovery in previously impacted sites, and continued damage to horse mussel beds in Strangford Lough resulted in their loss.

The six flagship species and habitats are all protected in some way, such as designation under national regulation, EU Directive or international convention. Yet they continue to be threatened by human activities. New threats have emerged in the last four years. These include Red Vent Syndrome in the Atlantic salmon and, of course, new aspects of climate change that can potentially affect all marine life – such as ocean acidification, which is likely to directly threaten all species with calcareous skeletons such as deep-water corals (e.g. *Lophelia*) and horse mussel beds, but also with potentially significant changes to the ecosystem as a whole, which are difficult to predict.

It is clear that the current multi-sectoral management of the seas leads to ineffective protection in many cases. For example, although technically protected within European Marine Sites (EMSs), seagrass beds received no effective protection due to a multi-sectoral approach to planning, ambiguous terminology, and lack of clear guidance. In Strangford Lough, horse mussel beds were destroyed even after protection measures were put in place. Similarly, the EMSs on their own are not appropriate to protect wide-ranging species such as the harbour porpoise. Equally, Atlantic salmon populations continue to decline in spite of considerable improvements in water quality and management of our rivers, probably because of less well-managed activities in the marine environment.

It is also clear from the maps of current distribution that a relatively small proportion of records of these priority and nominally protected species and habitats are included in designated areas at present. The harbour porpoise is only included in one draft SAC, while the Atlantic salmon is not listed in any marine site.

The UK Marine and Coastal Access Bill and forthcoming devolved legislation are a timely and long-awaited step forward. The creation of the MMO, and devolved equivalents, as an overarching agency to oversee the management of our seas and improvements to licensing and the planning framework within our coasts and seas (as suggested by the House of Commons Select Committee on Coastal Zone Management in 1995) has the potential to markedly improve the cost-effectiveness and integration of marine planning. The suggested network of MPAs (the MCZs) could result in a world class system of MPAs and vastly improve how we protect our marine biodiversity, while providing a platform for further study and understanding of the structure and functioning of marine ecosystems. Yet, as we have seen in this report, designation and protection are not the same thing. The network of MPAs, the new planning system (MSP) and the MMO itself depend on the political and societal will to protect our marine biodiversity, the ability to enforce that will (through appropriate licensing, regulation and enforcement), the clarity of the guidance to support planning and enforcement, and (ultimately) the budgetary resources placed behind it.

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RECOMMENDATIONS

This review of the current status of six flagship species and habitats, together with recent developments in marine policy, gives rise to the following set of recommendations:

- Marine Conservation Zones must be identified using sound scientific criteria alone. The socio-economic consequences of designation should only be considered where the desirability of designating two or more areas is equal and will not compromise the ability to achieve an ecologically coherent network of sites.
- MCZs should have different levels of protection to address the variation in threats to and conservation of species and habitats. Highly protected MCZs are needed for especially vulnerable, sensitive or threatened species and habitats.
- The Bill must not include a blanket defence for sea fishing if it causes damage to an MCZ. Sea fishing must be compliant with the requirements of the MCZ because it can be one of the most common causes of harm to marine wildlife.
- In order to adapt to changes in effectiveness and the impacts of climate change, the boundaries of MCZs may need to remain flexible.
- Conservation objectives for MCZs need to be explicit, and the species and/or habitats protected clearly stated, as ambiguity can lead to ineffective protection and failure to meet objectives. Robust management plans provide a key mechanism to achieve this and should be produced for all MCZs.
- The Marine Management Organisation (MMO) and equivalent devolved bodies – should be adequately resourced and should have a proactive role in our seas, with a remit to 'further' sustainable development.
- The MMO must also be a statutory advisor to the Infrastructure Planning Commission (IPC) when considering developments that impact the marine and coastal environment.
- The MMO and equivalent devolved bodies must deliver a consistent and coordinated approach across borders and between the land–sea boundary. Marine plans should be based on ecosystems, not administrative boundaries and should be produced for all UK seas.
- Inshore fisheries management in England and Wales should ensure sustainable fisheries management and reduce bycatch.
- The MCAB, and especially marine spatial planning, should be integrated with EU legislation including the EU Common Fisheries Policy (CFP), and the EU Marine Strategy Framework Directive.

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ACKNOWLEDGEMENTS

The authors thank the following for their assistance and expertise in the compilation of this report:

Atlantic salmon: William Beaumont (Game and Wildlife Conservation Trust), Kirsteen MacKenzie (Ocean and Earth Sciences National Oceanography Centre Southampton) and Sonja Brown.

Pink sea fan: Dr Jason Hall-Spencer (University of Plymouth Marine Institute). Harbour porpoise: Phil Hammond (SCANS II, Sea Mammal Research Unit), Jim Reid, Lisa Goodwin (Wildlife Trust), Sonja Eisfeld (WDCS) and Colin Speedie.

Seagrass beds: Gavin Black (Natural England), Steve Trewhella, Nigel Mortimer (South Devon AONB Unit), and Neil Garrick-Maidment (The Seahorse Trust).

Horse mussel beds: Joe Breen and Huw Edwards (DoENI) and James Strong (Queens University Belfast).

Deep water coral reefs: Dr Jason Hall-Spencer and Maria Campbell (University of Plymouth Marine Institute) and Dr Murray Roberts (SAMS).

IMAGE PROVIDERS

The images used in this report were supplied by I Birks (Sea Watch Foundation), Cornwall Wildlife Trust, Keith Hiscock, Kerry Howell (University of Plymouth Marine Institute), Paul Naylor, Murray Roberts, Sue Scott, Juliet Shrimpton (HWDT), Colin Speedie and Steve Trewhella.

DATA PROVIDERS

Biological survey data and records were supplied by the following:

Harbour porpoise

- Small Cetaceans of the European Atlantic and North Sea (SCANS-II) project supported by the EU LIFE Nature programme under project LIFE04NAT/GB/000245 and by the governments of Belgium, Denmark, France, Germany, Ireland, The Netherlands, Norway, Poland, Portugal, Spain, Sweden and the UK.
- MarLIN
- Joint Nature Conservation Committee (JNCC)
- Countryside Council for Wales (CCW)

Atlantic salmon

- NBN. The information used here was sourced through the NBN Gateway website and included the following resources: Biological Records Centre. “Database for the Atlas of Freshwater Fishes”. Updated 26/10/2004. <*http://data.nbn.org.uk/*> (Accessed 12/05/2009). The data providers and the NBN Trust bear no responsibility for the further analysis or interpretation of this material, data and/or information.
- JNCC
- CCW

Pink sea fan

- MarLIN
- Scottish Natural Heritage (SNH)
- CCW

Seagrass beds

- CCW
- MarLIN
- SNH
- JNCC
- Devon and Dorset *Zostera* Inventory

Horse mussel beds

- CCW
- JNCC
- SNH
- OSPAR report data permission pending

Deep water coral reefs

- The information used here was sourced through the NBN Gateway website and included the following resources: Joint Nature Conservation Committee. “The distribution of *Lophelia pertusa* reefs within the OSPAR region”. Updated 17/09/2008. <*http://data.nbn.org.uk*> Interactive map of the OSPAR habitat *Lophelia pertusa* reefs (accessed 12/05/2009). The data providers and NBN Trust bear no responsibility for the further analysis or interpretation of this material, data and/or information.

REFERENCES

1. Rees, I. (2009). Draft Background Document for *Modiolus modiolus* beds. OSPAR, pp.
2. Hall-Spencer, J.M. and K. Stehfest (2009). Assessment of *Lophelia pertusa* reefs in the OSPAR area and the development of a monitoring program. *Joint Nature Conservation Committee (JNCC), UK,* pp.30.
3. Davies, A.J., J.M. Roberts, and J. Hall-Spencer (2007). Preserving deep-sea natural heritage: Emerging issues in offshore conservation and management. *Biological Conservation*, 138, 299-312.
4. Defra (2008). Managing our marine resources – licensing under the Marine Bill. *Department for Environment, Food and Rural Affairs (Defra)*, pp.20.
5. Roberts, D., C. Davies, A. Mitchell, H. Moore, B. Picton, A. Portig, J. Preston, M. Service, D. Smyth, D. Strong, and S. Vize (2004). Strangford Lough Ecological Change Investigation (SLECI). *Report to Environment and Heritage Service by the Queen's University, Belfast, pp.*
6. Hiscock, K., J. Sewell, and J. Oakley (2005). *Marine Health Check* 2005. A report to gauge the health of the UK's sea-life. *WWF-UK*, pp. 79.
7. MSSP Consortium (2006). Marine Spatial Planning Pilot. *ABPMer*, pp. 56.
8. Palero, F., P. Abelló, E. Macpherson, M. Gristina, and M. Pascual (2008). Phylogeography of the European spiny lobster *(Palinurus elephas)*: Influence of current oceanographical features and historical processes. *Molecular phylogenetics and evolution*, 48, 708-717.
9. Palero, F. and P. M. (2008). Isolation and characterization of microsatellite loci in *Palinurus elephas. Molecular Ecology Resources*, 8, 1477-1479.
10. Hiscock, K. and H. Jones (2004). Testing criteria for assessing 'national importance' of marine species, biotopes (habitats) and landscapes. pp.
11. Whitehead, P.J.P., M.-L. Bauchot, J.-C. Hureau, J. Nielson, and E. Tortonese (1986). Fishes of the North-eastern Atlantic and the Mediterranean. Vol. I, II & III. *United Nations Educational, Scientific and Cultural Organisation (UNESCO)*,
12. FishBase (2004). A global information system on fishes, version 10/2004. Available from: *www.fishbase.org*
13. Hendry, K. and D. Cragg-Hilne (2003). Ecology of the Atlantic salmon. *English Nature*, pp.
14. Wheeler, A. (1969). *The fishes of the British Isles and north-west Europe.* London: Macmillan.
15. Hansen, P.L. and J.A. Jacobsen (2003). Origin and migration of wild and escaped farmed Atlantic salmon *Salmo salar* L., in oceanic areas north of the Faroe Islands. *ICES Journal of Marine Science, 60, 110-119.*
16. Verspoor, E. (1997). Genetic diversity among Atlantic salmon *(Salmo salar L.)* populations. *ICES Journal of Marine Science*, 54, 965-973.
17. TWG (2009), *Tripartite Working Group* Tripartite Working Group
18. Anonymous (2009). Annual Assessment of Salmon Stocks and Fisheries in England and Wales 2008. *Cefas, Environment Agency*, pp. Available from: *http://publications.environment-agency.gov.uk/pdf/GEHO0409BPYY-e-e.pdf*
19. AST (2008). Summer Journal 2008. *Atlantic Salmon Trust Magazine.*
20. AST (2009). Winter Journal 2008/2009. *Atlantic Salmon Trust Magazine.*
21. ICES (2008). Extract of the Report of the Advisory Committee. North Atlantic Salmon Stocks, as reported to the North Atlantic Salmon Conservation Organization. pp. 80 pp.
22. ICES (2008). Report of the Working Group on North Atlantic Salmon (WGNAS). pp. 235.
23. Maoileidigh, N.O., P. Mcginnity, D. Doherty, J. White, D. Mclaughlin, A. Cullen, T. Mcdermott, and N. Bond (2008). Restocking programmes for salmon *(Salmo salar L.)* in Ireland – how successful have they been? *ICES Council Meeting Papers, C.M.2008/N:13,* 16.
24. Agency, E. (2004). Annual assessment of salmon stocks and fisheries in England and Wales, 2003. pp. Available from: *www.environment-agency.gov.uk/commondata/acrobat/ices_report_2003_753412.pdf*
25. WWF (2001). The Status of Wild Atlantic Salmon: A River by River Assessment. *The World Wide Fund for Nature, Canada,* pp.
26. Jonsson, B. and N. Jonsson (2004). Factors affecting marin production of Altantic salmon *(Salmo salar). Canadian Journal of Fisheries and Aquatic Sciences*, 61.
27. Peyronnet, A., K.D. Friedland, and N.O. Maoileidigh (2008). Different ocean and climate factors control the marine survival of wild and hatchery Atlantic salmon *Salmo salar* in the north-east Atlantic Ocean. *Journal of Fish Biology,* 73, 945-962.
28. ICES (2007). Report of the Workshop on the Development and Use of Historical Salmon Tagging Information from oceanic areas (WKDUHSTI). pp. 64.
29. Department of Culture Arts and Leisure Northern Ireland (2008). Salmon and Inland Fisheries Annual Report 2007. *Northern Ireland Assembly,* pp. 28. Available from: *www.dcal-fishingni.gov.uk/salmon_and_inland_fisheries_annual_report_2007.pdf*
30. Anonymous (2008). The Status of EU Protected Habitats and Species in Ireland. Conservation status in Ireland of habitats and species listed in the European Council Directive on the Conservation of Habitats, Flore and fauna 92/43/EEC. *National Parks and Wildlife Service. Department of Environment, Heritage and Local Government,* pp. 136.
31. Fisheries Research Services (2008). Statistical Bulletin. Scottish Salmon and Sea Trout Catches, 2007. *Scottish Government,* pp. Available from: *www.frs-scotland.gov.uk/FRS.Web/Uploads/Documents/SCSB07.pdf*
32. Milner, N., I. Russell, M. Aprahamian, R. Inverarity, J. Shelley, and P. Rippon (2008). The role of stocking in the recovery of the River Tyne salmon fishery. *ICES Council Meeting Papers, C.M.2008/N:05,* 18.
33. Fisheries Research Services (2004), Statistical Bulletin. *Scottish Salmon and Sea Trout Catches, 2003,* in *Report for Scottish Executive, Environment and Rural Affairs Department.* Fisheries Research Services: Aberdeen.
34. Anonymous (2007). Annual Assessment of Salmon Stocks and Fisheries in England and Wales 2007: Preliminary assessment prepared for ICES, April 2008. *Cefas and Environment Agency,* pp. 110.
35. ICES (2008). North Atlantic Salmon Stocks: Report of the ICES Advisory Committee. pp. 62.
36. CASS (2009). Conservation of Atlantic Salmon in Scotland. Laymans report. pp. 10. Available

from: *www.snh.org.uk/salmonlifeproject/pdf/EC_Interim_Report09.pdf*

37. Beaumont, W.R.C., L. Scott, and I. A.T. (2009). The 2008 East Stoke Salmon Counter Records. CEH Report, pp. 11.

38. Jonsson, B.A. (1997). A review of ecological and behavioural interactions between cultured and wild Atlantic salmon. *ICES Journal of Marine Science,* 54, 1031-1039.

39. McGinnity, P., P. Prodöl, A. Ferguson, R. Hynes, Ó. Maoiléidigh, N. Baker, D. Cotter, B. O'Hea, D. Cooke, G. Rogan, J. Taggart, and T. Cross (2003). Fitness reduction and potential extinction of Atlantic salmon, *Salmo salar*, as a result of interactions with escaped farm salmon. *Proceedings of the Royal Society of London B*, 270, 2443-2450.

40. Webb, J.H. (1998). Catch and Release: the survival and behaviour of Atlantic salmon angled and returned to the Aberdeenshire Dee, in spring and early summer. pp.

41. Anderson, W.G., R. Booth, B. T.A., R.S. McKinley, F. B., F. Økland, and D. Scruton (1998). Remote monitoring of heart rate as a measure of recovery in angled Atlantic salmon, *Salmo salar*. *Hydrobiologia*, 371/372, 233-240.

42. Moore, A., N. Lower, I. Mayer, and L. Greenwood (2007). The impact of a pesticide on migratory activity and olfactory function in Atlantic salmon *(Salmo salar L.)* smolts. *Aquaculture*, 273, 350-359.

43. Hendry, K., D. Cragg-Hine, M. O'Grady, H. Sambrook, and A. Stephen (2003). Management of habitat for rehabilitation and enhancement of salmonoid stocks. *Fisheries Research*, 62, 171-192.

44. Friedland, K.D., L.P. Hansen, D. D.A., and M. J.C. (2000). Linkage between ocean climate, post-smolt growth, and survival of Atlantic salmon *(Salmo salar L.)* in the North Sea area. *ICES Journal of Marine Science*, 57, 419-429.

45. Friedland, K.D., G. Chaput, and J.C. Maclean (2005). The emerging role of climate in post-smolt growth of Atlantic salmon. *ICES Journal of Marine Science*, 62, 1338-1349.

46. Todd, C.D., S.L. Hughes, T. Marshall, J.C. McLeans, M.E. Lonergan, and E.M. Biuw (2008). Detrimental effects of recent ocean surface warming on the growth conditions of Atlantic salmon. *Global Change Biology*, 14, 1-13.

47. Solomon, D.J. and H.T. Sambrook (2004). Effects of hot dry summers on the loss of Atlantic salmon, *Salmo salar*, from estuaries in South West England. *Fisheries Management & Ecology*, 11, 353-363.

48. Hiscock, K. (2001). *Eunicella verrucosa*. Pink sea fan. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [online] [cited 05/06/09]; Available from: *www.marlin.ac.uk/species/Eunicellaverrucosa.htm*

49. Manuel, R.L. (1988). *British Anthozoa*. Synopses of the British Fauna (New Series). [Synopses of the British Fauna No. 18.], ed. D.M. Kermack and R.S.K. Barnes. Avon, The Bath Press: The Linnean Society of London.

50. Hiscock, K. *Unpublished research*.

51. Lorenz, F. (2009). Personnal communication to K. Hiscock.

52. Southward, A.J., K. Hiscock, F. Kerckhof, J. Moyse, and A.S. Elfimov (2004). Habitat and distribution of the warm-water barnacle *Solidobalanus fallax* (Crustacea: Cirripedia). *Journal of the Marine Biological Association of the UK,* 84, 1169-1177.

53. Hiddink, J.G., M.J. Kaiser, H. Hinz, and A. Ridgeway (2008). Quantification of epibenthic fauna in areas subjected to different regimes of scallop dredging activity in Lyme Bay, Devon. *School of Ocean Sciences, College of Natural Sciences, Bangor University*, pp.

54. Perez, T., J. Garrabou, S. Sartoretto, J.-G. Harmelin, P. Francour, and J. Vacelet (2000). Mortalité massive d'invertébrés marins: un événement sans précédent en Méditerranée nord-occidentale. *Comptes Rendus de l'Académie des Sciences/Life Sciences*, 323, 853-865.

55. Hiscock, K. (2003). Changes in the marine life at Lundy. *Report of the Lundy Field Society for 2001 and 2002*, 52, 84-93.

56. Hall-Spencer, J.M., J. Pike, and C.B. Munn (2007). Diseases affect cold-water corals too: *Eunicella verrucosa* (Cnidaria:Gorgonacea) necrosis in SW England. Diseases in Aquatic Organisms, 87-97.

57. MBA (Marine Biological Association) (1957). *Plymouth Marine Fauna*. Plymouth: Marine Biological Association of the UK.

58. Reid, J.B., P.G.H. Evans, and S.P. Northridge (2003). *Atlas of Cetacean distribution in north-west European waters.* Peterborough: Joint Nature Conservation Committee.

59. *Greenpeace species fact-file: Harbour porpoise.* Available from: *www.greenpeace.org.uk/contentlookup.cfm?&ucidparam=20021008152320&CF [cited 2005].*

60. Sea Watch Foundation (2004). Species Information Sheet: The harbour porpoise in UK waters. *Sea Watch Foundation*, pp.

61. ASCOBANS (2009). *Small Cetaceans covered by ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas).* [cited 2009 01/06/2009]; Available from: *www.ascobans.org/index0201.html*

62. Weir, C.R., K.A. Stockin, and G.J. Pierce (2007). Spatial and temporal trends in the distribution of harbour porpoises, white-beaked dolphins and minke whales off Aberdeenshire (UK), north-western North Sea. *Journal of the Marine Biological Association of the United Kingdom,* 87, 327-338.

63. Macleod, C.D., C.R. Weir, C. Pierpoint, and E.J. Harland (2007). The habitat preferences of marine mammals west of Scotland (UK). *Journal of the Marine Biological Association of the United Kingdom,* 87, 157-164.

64. SCANS-II (2006). Small Cetaceans in the European Atlantic and North Sea. Final Report. Covering the project activities from 01.04.2004 to 31.12.2006. pp.

65. Verfuß, U.K., C.G. Honnef, A. Meding, M. Dähne, R. Mundry, and H. Benke (2007). Geographical and seasonal variation of harbour porpoise *(Phocoena phocoena)* presence in the German Baltic Sea revealed by passive acoustic monitoring. *Journal of the Marine Biological Association of the United Kingdom,* 87, 165-176.

66. Evans, P.G.H. and J. Wang (2002). Re-examination of distribution data for harbour porpoise around Wales and the UK with a view to site selection for this species. *Seawatch Foundation*, pp.

67. Eisfeld, S.M. and K.-H. Kock (2006). Expert Paper to the ASCOBANS Conservation Plan for Harbour Porpoises *(Phocoena phocoena L.)* in the North Sea. pp. 93.

68. Evans, P.G.H. (2000). Biology of cetaceans of the North East Atlantic (in relation to seismic energy). In *Proceedings of the Seismic and Marine Mammals workshop*. 2000, pp.

69. Berrow, S.D. (2009), *Not Sufficient but not Insufficient !! EU Commission meeting on Atlantic Margins* Confidential report to WWF-UK.

70. House of Commons Environment, F.a.R.A.C. (2004). Third Report of Session 2003-04. Caught in the net: by-catch of dolphins and porpoises off the UK coast. *The Stationery Office Limited*, pp.

71. Hammond, P.S., G. Bearzi, A. Bjørge, K. Forney, L. Karczmarski, T. Kasuya, W.F. Perrin, M.D. Scott, J.Y. Wang, R.S. Wells, and B. Wilson (2008). *Phocoena phocoena*. IUCN Red List of Threatened Species *www.iucnredlist.org* [cited 18 May 2009]; Available from: *www.iucnredlist.org/details/17027*

72. JNCC (2006). *Marine mammal bycatch*. [cited 05/06/09]; Available from: www.jncc.gov.uk/page-1564

73. ASCOBANS (2008). Implementation of the ASCOBANS Triennial Work Plan (2007-2009). *United Nations Environment Programme*, pp. 16. Available from: *www.service-board.de/ascobans_neu/files/ac15-12.pdf*

74. OSPAR Commission (2008). OSPAR List of Threatened and/or Declining Species and Habitats (Reference Number: 2008-6). *OSPAR Convention For The Protection Of The Marine Environment Of The North-East Atlantic* pp. Available from: *www.jncc.gov.uk/pdf/08-06e_OSPAR%20List%20species%20and%20habitats.pdf*

75. OSPAR Commission (2005). Case Reports for the Initial List of Threatened and/or Declining Species and Habitats in the OSPAR Maritime Area. pp. Available from: *www.jncc.gov.uk/PDF/p00198_Case%20reports%20for%20Initial%20list%20of%20species%20and%20habitats%202005%20version.pdf*

76. Koschinski, S. (2002). Current knowledge on harbour porpoises *(Phocoena phocoena)* in the Baltic Sea. Ophelia, 55, 167-197.

77. Eisfeld, S., S. Keith, A. Pope, D. Still, S. Dolman, and m. Simmonds (2009). Outer Moray Firth Cetacean Research 2008. *Whale and Dolphin Conservation Society (WDCS)*, pp. Available from: *www.wdcs.org/submissions_bin/bbc_moray_firth_research.pdf*

78. Thompson, P.M., S. White, and E. Dickson (2004). Co-variation in the probabilities of sighting harbour porpoises and bottlenose dolphins. *Marine Mammal Science*, 20, 322 – 328.

79. Sabin, R.C., E.L. Evans-Jones, P.D.J. Chimonides, C.J.H. Spurrier, M. Perkins, A.A. Cunningham, R.J. Reid, J. Barley, R. Penrose, and R. Law (2006). Annual Report to Defra for the period 1st January – 31st December 2006. pp. 43. Available from: *http://sciencesearch.defra.gov.uk/Document.aspx?Document=WC04022_5279_GEN.pdf*

80. UK Cetacean Stranding Investigation Programme (2007). UK Cetacean Strandings Investigation Programme. Annual Report for the period 1st January – 31st December 2007. *Natural Environment Group Science Division, Defra*, pp. Available from: *www.cwtstrandings.org/MSN_Reports/WC0601_7291_ANN.pdf*

81. Osinga, N., P. Hart, and D. Morick (2008). By-catch and drowning in harbour porpoises *(Phocoena phocoena)* stranded on the northern Dutch coast. *European Journal of Wildlife Research*, 54, 667-674.

82. Sabin, R.C., P.D.J. Chimonides, C.J.H. Spurrier, E.L. Evans-Jones, P.D. Jepson, R. Deaville, R.J. Reid, I.A.P. Patterson, R. Penrose, and R. Law (2006). Trends in cetacean strandings around the UK coastline, cetacean and marine turtle post-mortem investigations 2005. *Consultancy report of the National History Museum*, pp. 47.

83. Reijnders, P.J.H., G.P. Donovan, A. Bjørge, K.-H. Kock, S. Eisfeld, M. Scheidat, and M.L. Tasker (2009). Draft ASCOBANS Conservation Plan for Harbour Porpoises *(Phocoena phocoena L.)* in the North Sea. *United Nations Environment Programme*, pp. 28. Available from: *www.service-board.de/ascobans_neu/files/ac16/AC16_21_ConservationPlanNorthSea_March09.pdf*

84. Gilles, A., M. Scheidat, and U. Siebert (2009). Seasonal distribution of harbour porpoises and possible interference of offshore wind farms in the German North Sea. *Marine Ecology Progress Series*, 383, 295-307.

85. Johnston, D.W., A.J. Westgate, and A.J. Read (2005). Effects of fine-scale oceanographic features on the distribution and movements of harbour porpoises *Phocoena phocoena* in the Bay of Fundy. *Marine Ecology Progress Series*, 295, 279-293.

86. JNCC (2008). Offshore Special Area of Conservation: Dogger Bank SAC Selection Assessment Version 4.0. *Joint Nature Conservation Committee* (JNCC), pp. 30. Available from: *http://jncc.gov.uk/pdf/DoggerBank_SelectionAssessment_4.0.pdf*

87. Hiscock, K. and M. Breckels (2007). Marine Biodiversity Hotspots in the UK. A report identifiying and protecting areas for marine biodiversity. *WWF UK*, pp. 116.

88. Loveridge, J.M. and J.E. Loveridge (2007). Marine Strandings in Cornwall and the Isles of Scilly. *Cornwall Wildlife Trust (Marine Strandings Network*), pp. Available from: *www.cwtstrandings.org/MSN_Reports/CWT_Marine_Strandings_Network_Report_2007.pdf*

89. WWF (2007). *Win for inventor saving porpoises from fishing nets*. [cited 15/05/2009; Available from: *wwf.org.uk/article_search_results.cfm?uNewsID=1567*

90. Clark, N.M., M.J. Tetley, R.M. Culloch, E.G. Mitchelson-Jacob, and K.P. Robinson (2006). Harbour porpoise *(Phocoena phocoena L.)* have declined in the outer southern Moray Firth, NE Scotland – A spatial and temporal view. In *20th Annual Conference of the European Cetacean Society.* 2006. Gdynia, Poland, 3-6 April, pp.

91. Jackson, E.L., O. Langmead, J. Evans, R. Ellis, and H. Tyler-Walters (2008). Protecting nationally important marine Biodiversity in Wales. *Marine Biological Association of the UK*, pp. 76.

92. Pinn, E. (2007). Formal Review of Research and Development of Contract CR0364 –Cetacean Strandings around the UK Coast. *DEFRA*, pp. Available from: *http://sciencesearch.defra.gov.uk/Document.aspx?Document=WC0601_7415_GEN.pdf*

93. JNCC (Joint Nature Conservation Committee) (2006). *Marine mammal bycatch*. [cited 05/06/09]; Available from: *www.jncc.gov.uk/page-1564*

94. Tregenza, N. (1999). *Cornwall Dolphin Report 1998/9 for Cornwall Wildlife Trust*. Available from *www.chelonia.demon.co.uk/cwtreprt.html* [cited.

95. Tregenza, N.J.C., S.D. Berrow, P.S. Hammond, and R. Leaper (1997). Harbour porpoise *(Phocoena phocoena L.)* by-catch in set gillnets in the Celtic Sea. *ICES Journal of Marine Science*, 54, 896-904.

96. Anonymous (1996). Report of the Scientific Committee: review of harbour porpoises in the North Atlantic region. pp. 84-90.

97. Bull, J.C., P.D. Jepson, R.K. Ssuna, R. Deaville, and A. Fenton (2006). The relationship between polychlorinated biphenyls in blubber and levels of nematode infestations in harbour porpoises, *Phocoena phocoena. Parasitology*.

98. Van de Vijver, K.I., P.T. Hoff, W. Van Dongen, E.L. Esmans, U. Siebert, J.M. Bouquegneau, R. Blust, and W.M. De Coen (2004). Baseline study of perfluorochemicals in harbour porpoises *(Phocoena phocoena)* from Northern Europe. *Marine Pollution Bulletin*, 48, 986-1008.

99. Jasny, M., J. Reynolds, C. Horowitz, and A. Wetzler (2005). Sounding the Depths II: The Rising Toll of Sonar, Shipping and Industrial Ocean Noise on Marine Life. *Natural Resources Defense Council*, pp. 76. Available from: *www.nrdc.org/wildlife/marine/sound/sound.pdf*

100. Reeves, R.R., B.D. Smith, E.A. Crespo, and G. Notarbartolo di Sciara (2003). Dolphins, Whales and Porpoises: 2002-2010 Conservation Action Plan for the World's Cetaceans. pp. 139. Available from: *www.scribd.com/doc/5358998/20032010-Conservation-Action-Plan-for-the-Worlds-Cetaceans*

101. Den Hartog, C. (1970). *The Seagrasses of the World*. Amsterdam, North Holland.

102. Black, G. and D. Kochanowska (2004). *Inventory of eelgrass beds in Devon and Dorset:* English Nature, Environment Agency, Devon Biodiversity Records Centre, Devon Environmental Records Centre.

103. Reusch, T.B.H. (2002). Microsatellites reveal high population connectivity in eelgrass *(Zostera marina)* in two contrasting coastal localities. *Limnology & Oceanography*, 47, 78-85.

104. Marbà, N., C.M. Duarte, A. Alexandra, and S. Cabaço (2004). How do seagrasses grow and spread? In *European seagrasses: an introduction to monitoring and management*, J. Borum, T.M. Greve, T. Binzar, and R. Santos, (eds). European Union Project: Monitoring and Managing of European Seagrasses (M&MS). pp. 11-18.

105. Coyer, J.A., O.E. Diekmann, E.A. Serrão, G. Procaccini, N. Milchakova, G.A. Pearson, W.T. Stam, and J.L. Olsen (2004). Population genetics of *Zostera noltii* (dwarf eelgrass) throughout its biogeographic range. *Marine Ecology Progress Series* 281 51-62.

106. Anonymous (1995). *Seagrass beds Habitat Action Plan*. Biodiversity: The UK Steering Group Report – Volume II: Action Plans (December 1995, Tranche 1, Vol 2, p262) [cited; Available from: www.ukbap.org.uk/UKPlans.aspx?ID=35

107. Anonymous (2003). Northern Ireland Habitat Action Plan for seagrass beds (part of Northern Ireland Biodiversity Action Plan).

108. Orth, R.J., T.J.B. Carruthers, W.C. Dennison, C.M. Duarte, J.W. Fourqurean, K.L.J. Heck, A.R. Hughes, G.A. Kendrick, W.J. Kenworthy, S. Olyarnik, F.T. Short, M. Waycott, and S.L. Williams (2006). A Global Crisis for Seagrass Ecosystems. *Bioscience*, 56, 987-996

109. Borum, J., Carlos M. Duarte, D. Krause-Jensen, and T.M. Greve, eds (2004). *European seagrasses: an introduction to monitoring and management*. 2004: EU project Monitoring and Managing of European Seagrasses (M&MS). 95 pp.

110. Jackson, E.L. (2006). Special Area of Conservation (SAC) eelgrass condition assessment monitoring advice on attributes to monitor and methodology. *Report to English Nature*, pp. 16.

111. Anonymous (2003). Northern Ireland Habitat Action Plan 2003 for seagrass beds (part of Northern Ireland Biodiversity Action Plan). Available from: *www.ehsni.gov.uk/pubs/*

publications/Seagrass_Beds_web_version_April_03.pdf

112. Lefebvre, A., C.E.L. Thompsona, K.J. Collinsa, and C.L. Amosa (2009). Use of a high-resolution profiling sonar and a towed video camera to map a *Zostera marina* bed, Solent, *UK Estuarine, Coastal and Shelf Science*, 82, 323-334

113. Reed, B.J. and K.A. Hovel (2006). Seagrass habitat disturbance: how loss and fragmentation of eelgrass *Zostera marina* influences epifaunal abundance and diversity. *Marine Ecology Progress Series*, 326, 133-143.

114. Hirst, J.A. and M.J. Attrill (2008). Small is beautiful: an inverted view of habitat fragmentation in seagrass beds. *Estuarine, Coastal and Shelf Science*, 78, 811-818.

115. Scottish Environment LINK (SEL) (2007). Seagrass Beds (Zostera spp). In *Evidence for damage to marine habitats: a literature review*. 2007: Scottish Environment LINK.

116. Chesworth, J.C., D.G. King, and V. Swales (2008). Inventory of eelgrass Beds in Hampshire and the Isle of Wight. *Hampshire and Isle of Wight Wildlife Trust, Hampshire*.

117. Krause-Jensen, D., E.D. Almela, A.H. Cunha, and T.M. Greve (2004). Have seagrass distribution and abundance changed? In *European seagrasses: an introduction to monitoring and management*, J. Borum, C.M. Duarte, D. Krause-Jensen, and T.M. Greve, (eds). The M&MS project. pp. 33-40.

118. Den Hartog, C. (1987). "Wasting disease" and other dynamic phenomena in *Zostera beds. Aquatic Botany*, 27, 3-14.

119. Boström, C., E.L. Jackson, and C.A. Simenstad (2006). Seagrass landscapes and their effects on associated fauna: A review. *Estuarine, Coastal and Shelf Science*, 68, 383-403.

120. Bell, S.S., B.D. Robbins, and S.L. Jensen (1999). Gap dynamics in a seagrass landscape. *Ecosystems*, 2, 493-504.

121. Tweedley, J.R., E.L. Jackson, and M.J. Attrill (2008). *Zostera marina seagrass* beds enhance the attachment of the invasive alga *Sargassum muticum* in soft sediments. *Marine Ecology Progress Series*, 354, 305-309.

122. Erftemeijer, P.L.A. and R.R. Robin Lewis (2006). Environmental impacts of dredging on seagrasses: A review. *Marine Pollution Bulletin*, 52, 1553-1572.

123. Gray, L. (2009), *The UK's largest population of seahorses is in danger of being wiped out, according to conservationists, in Daily Telegraph*.

124. Rhodes, B., E.L. Jackson, R. Moore, A. Foggo, and M. Frost (2006). The impact of swinging boat moorings on Zostera marina beds and associated infaunal macroinvertebrate communities in Salcombe, Devon, UK. *University of Plymouth in collaboration with English Nature, Devon*.

125. Spivak, A.C., E.A. Canuel, J.E. Duffy, J.G. Douglass, and J.P. Richardson (2009). Epifaunal community composition and nutrient addition alter sediment organic matter composition in a natural eelgrass *Zostera marina* bed: a field experiment. *Marine Ecology Progress Series*, 376, 55-67.

126. Coleman, V.L. and J.M. Burkholder (1994). Community structure and productivity of epiphytic microalgae on eelgrass *(Zostera marina L.)* under water-column nitrate enrichment. *Journal of Experimental Marine Biology and Ecology*, 179, 29-48.

127. Burkholder, J.M., K.M. Mason, and H.B. Glasgow (1992). Water column nitrate enrichment promotes decline of eelgrass Zostera marina: evidence from seasonal mesocosm experiments. *Marine Ecology Progress Series*, 81, 163-178.

128. Foden, L. and D.P. Brazier (2007). Angiosperms (seagrass) within the EU water framework directive: A UK perspective. *Marine Pollution Bulletin*, 55, 181-195.

129. Chesworth, J.C., M.E. Donkin, and M.T. Brown (2004). The interactive effects of the antifouling herbicides Irgarol 1051 and Diuron on the seagrass Zostera marina (L.). *Aquatic Toxicology*, 66, 293-305.

130. Cardoso, P.G., D. Raffaelli, and M.A. Pardal (2008). The impact of extreme weather events on the seagrass Zostera noltii and related Hydrobia ulvae population. *Marine Pollution Bulletin*, 56, 483-492.

131. Rasmussen, E. (1977). The wasting disease of eelgrass *(Zostera marina)* and its effects on environmental factors and fauna. In *Seagrass ecosystems; a scientific perspective*, C.P. McRoy and C. Helfferich, (eds). New York: Marcel Dekker. pp. 1-52.

132. Hall-Spencer, J.M., R. Rodolfo-Metalpa, S. Martin, E. Ransome, M. Fine, S.M. Turner, S.J. Rowley, D. Tedesco, and M.C. Buia (2008). Volcanic carbon dioxide vents show ecosystem effects of ocean acidification. *Nature*, 454, 96-99.

133. Camplin, M. (2007), *Lessons from managing marine SACs in Wales, in Coastal Futures 2007*: London, UK.

134. Davies, A.J., M. Wisshak, J.C. Orr, and J.M. Roberts (2008). Predicting suitable habitat for the cold-water coral *Lophelia pertusa* (Scleractinia). *Deep-Sea Research*, 55, 1048-1062.

135. Hill, M.O., D. Moss, and C.E. Davies (2004). EUNIS habitat classification descriptions. *European Topic Centre on Nature Protection and Biodiversity*, pp.

136. Roberts, J.M., A.J. Wheeler, and A. Freiwald (2006). Reefs of the deep: the biology and geology of cold-water coral ecosystems. Science, 213, 543-547.

137. Kiriakoulakis, K., E. Fisher, G.A. Wolff, A. Freiwald, A. Grehan, and J. Murray Roberts (2005). Lipids and nitrogen isotopes of two deep-water corals from the North-East Atlantic: initial results and implications for their nutrition. In Cold-Water Corals and Ecosystems, A. Freiwald and J. Murray Roberts, (eds). Berlin: Springer. pp. 715-729.

138. Thiem, Ø., E. Ravagnan, J.H. Fosså, and J. Berntsen (2006). Food supply mechanisms for cold-water corals along the continental shelf edge. *Journal of Marine Systems*, 60, 207-219.

139. Turley, C.M., J.M. Roberts, and J.M. Guinotte (2007). Corals in deep-water: will the unseen hand of ocean acidification destroy cold-water ecosystems? *Coral Reefs*, 26, 445-448.

140. Waller, R.G. (2005). Deep-water Scleractinia (Cnidaria: Anthozoa): current knowledge of reproductive processes. In *Cold-Water Corals and Ecosystems*, A. Freiwald and J.M. Roberts, (eds). Berlin: Springer. pp. 691–700.

141. Gass, S.E. and J.M. Roberts (2006). The occurrence of the cold-water coral *Lophelia pertusa* (Scleractinia) on oil and gas platforms in the North Sea: Colony growth, recruitment and environmental controls on distribution. *Marine Pollution Bulletin*, 52, 549-559.

142. SAMS (Scottish Association for Marine Sciences) (2009). Reproduction – Lophelia.org. [cited 04/05/09]; Available from: *www.lophelia.org*

143. Henry, L.A. and J.M. Roberts (2007). Biodiversity and ecological composition of macrobenthos on cold-water coral mounds and adjacent off-mound habitat in the bathyal Porcupine Seabight, NE Atlantic. *Deep Sea Research* I, 54, 654-672.

144. Costello, M.J., M. McCrea, A. Freiwald, T. Lundalv, L. Jonsson, B.J. Bett, T. van Weering, H. de Haas, J.M. Roberts, and D. Allen (2005). Role of cold-water *Lophelia pertusa* coral reefs as fish habitat in the NE Atlantic. In *Cold-water corals and ecosystems*, A. Freiwald and J.M. Roberts, (eds). Berlin: Springer. pp. 771-805.

145. Guerra-Garcia, J.M., J.C. Sorbe, and I. Frutos (2008). A new species of Liropus (Crustacea, Amphipoda, Caprellidae) from Le Danois bank (southern Bay of Biscay). *Organisms Diversity & Evolution*, 7, 253-264.

146. Synnes, M. (2007). Bioprospecting of organisms from the deep sea: scientific and environmental aspects. *Clean Technologies and Environmental Policy*, 9, 53-59.

147. Anonymous (1999). *Lophelia pertusa* reefs: habitat Action Plan. pp. 195. Available from: *www.ukbap.org.uk/UKPlans.aspx?ID=45#10*

148. JNCC (2008). Offshore Special Area of Conservation: Darwin Mounds SAC Selection Assessment (Version 4.0). *Joint Nature Conservation Committee (JNCC)*, pp. 14. Available from: *www.jncc.gov.uk/PDF/* DarwinMounds_SelectionAssessment_4.0.pdf

149. JNCC (2009). Offshore Draft SACs. [cited 01/06/2009]; Available from: *www.jncc.gov.uk/default.aspx?page=4537*

150. Wheeler, A.J., B.J. Bett, D.S.M. Billett, D.G. Masson, and D. Mayor (2005). The impact of demersal trawling on Northeast Atlantic deepwater coral habitats: The case of the Darwin Mounds, United Kingdom. In *Benthic*

Habitats and the Effects of Fishing, P.W. Barnes and J.P. Thomas, (eds). Bethesda, MD: American Fisheries Society. pp. 807-817.

151. ICES (2007). Report of the Working Group on Deep-water Ecology. *Marine Biological Association Plymouth*, pp.

152. Rogers, A.D., A. Baco, H. Griffiths, T. Hart, and J.M. Hall-Spencer (2007). Corals on seamounts. In *Seamounts: ecology, fisheries and conservation* T.J. Pitcher, T. Morato, P.J.B. Hart, M.R. Clark, N. Haggan, and R.S. Santos, (eds). Oxford: Blackwell Publishing. pp. 141-169.

153. Rogers, A.D., M.R. Clark, J.M. Hall-Spencer, and K.M. Gjerde (2008). A scientific guide to the FAO draft international guidelines (December 2007) for the management of deep-sea fisheries in the High Seas. IUCN, pp. 48.

154. Davies, A.J., J.M. Roberts, and J. Hall-Spencer (2007). Preserving deep-sea natural heritage: Emerging issues in offshore conservation and management. *Biological Conservation*, 138, 299-312.

155. Grehan, A.J., V. Unnithan, K. Olu-Le Roy, and J. Opderbecke (2005). Fishing impacts on Irish deep-water coral reefs: making the case for coral conservation. In *Benthic habitats and the effects of fishing*, P.W. Barnes and J.P. Thomas, (eds). Bethesda, MD, USA: American Fisheries Society Symposium 41. pp. 819-832.

156. Fosså, J.H., P.B. Mortensen, and D.M. Furevik (2002). The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. *Hydrobiologia*, 471, 1-12.

157. Roberts, J.M., A. Wheeler, A. Friewald, and S. Cairns (2009). *Cold-water corals: the Biology and Geology of Deep-Sea Coral Habitats:* Cambridge University Press.

158. Hall-Spencer, J., A. Rogers, J. Davies, and A. Foggo, eds (2007). *Deep-sea coral distribution on seamounts, oceanic islands, and continental slopes in the Northeast Atlantic*. Conservation and adaptive management of seamount and deep-sea coral ecosystems, ed. R.Y. George and S.D. Cairns. 2007: Rosenstiel School of Marine and Atmospheric Science, University of Miami. 135-146.

159. Tittensor, D.P., A.R. Baco, P.E. Brewin, M.R. Clark, M. Consalvey, J. Hall-Spencer, A.A. Rowden, T. Schlacher, K.I. Stocks, and A.D. Rogers (2009). Predicting global habitat suitability for stony corals on seamounts. *Journal of Biogeography*, 36, 1111-1128.

160. Hourigan, T.F.E., J. Boutillier, M. Clark, J. Hall-Spencer, E. Kenchington, J. Murray Roberts, D. Tracy, and S. Hain (2008). The status of cold-water coral communities of the world: A brief update. In *Status of coral reefs of the world*, C. Wilkinson, (ed). Townsville, Australia: Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre. pp. 57-66.

161. Clark, M.R. and J.A. Koslow (2007). Impacts of fisheries on seamounts. In *Seamounts: ecology, fisheries and conservation*, T.J. Pitcher, T. Morato, P.J.B. Hart, M.R. Clark, N. Haggan, and R.S. Santos, (eds). Oxford: Blackwell Publishing. pp. 413-441.

162. Hall-Spencer, J., V. Allain, and J.H. Fosså (2002). Trawling damage to Northeast Atlantic ancient coral reefs. *Proceedings of the Royal Society of London, Series B*, 269, 507-511.

163. Guinotte, J.M., J.C. Orr, S.D. Cairns, L. Morgan, and R. George (2006). Will human-induced changes in seawater chemistry alter the distribution of deep-sea scleractinian corals? *Frontiers in Ecology and the Environment*, 4, 141-146.

164. Caldeira, K. and M.E. Wickett (2003). Anthropogenic carbon and ocean pH. Nature, 425, 365.

165. UK Biodiversity Group (1999). *Tranche 2 Action Plans Volume V: Maritime species and habitats (October, Tranche 2, Vol V, p67)*. [cited 2005; Available from: *www.ukbap.org.uk/UKPlans.aspx?ID=495*

166. Comely, C.A. (1981). The physical and biological condition of *Modiolus modiolus* (L.) in selected Shetland voes. *Proceedings of the Royal Society of Edinburgh, Series B*, 80, 299-321.

167. Connor, D.W., M.J. Dalkin, T.O. Hill, R.H.F. Holt, and W.G. Sanderson (1997). Marine biotope classification for Britain and Ireland. Vol. 2. Sublittoral biotopes. *Joint Nature Conservation Committee.*

168. Holt, T.J., E.I. Rees, S.J. Hawkins, and R. Seed (1998). Biogenic reefs. *Scottish Association for Marine Science*, pp. 174.

169. OSPAR Commission (2009). Draft Background Document for *Modiolus modiolus* beds. *OSPAR*, pp.

170. Sanderson, W.G., R.H.F. Holt, L. Kay, K. Ramsay, J. Perrins, A.J. McMath, and E.I.S. Rees (2008). Small-scale variation within a *Modiolus modiolus* (Mollusca: Bivalvia) reef in the Irish Sea: II. Epifauna recorded by divers and cameras. *Journal of the Marine Biological Association of the UK*, 88, 143-149.

171. Lindenbaum, C., J.D. Bennell, E.I.S. Rees, D. McClean, W. Cook, W. A.J., and W.G. Sanderson (2008). Small-scale variation within a *Modiolus modiolus* (Mollusca: Bivalvia) reef in the Irish Sea: I. Seabed mapping and reef morphology. *Journal of the Marine Biological Association of the UK*, 88, 133-142.

172. Rees, E.I.S., W.G. Sanderson, A.S.Y. Mackie, and R.H.F. Holt (2008). Small-scale variation within a *Modiolus modiolus* (Mollusca: Bivalvia) reef in the Irish Sea. III. Crevice, sediment infauna and epifauna from targeted cores. Journal of the *Marine Biological Association of the UK*, 88, 151-156.

173. Maggs, C. (2008). Special Protection and Local Action for Species and Habitats (SPLASH) 2004-2008. Final Report. *Quercus Centre for Biodiversity and Conservation Biology Queen's University Belfast*, pp.

174. European Commission (2008), *Marine Strategy Framework Directive*, in *2008/56/EC*. European Commission: Brussels.

175. European Commission (2009), *Green Paper. Reform of the Common Fisheries Policy, in COM(2009)163 final*: Brussels.

176. MCCIP (2008). Marine Climate Change Impacts Annual Report Card 2007-2008, Summary Report. MCCIP, p8.

177. Jones, P.J.S. and A. Carpenter (2009). Crossing the divide: The challenges of designing and ecologically coherent and representative network of MPAs in the UK. *Marine Policy*.

178. Blyth-Skyrme, R.E., M.J. Kaiser, J.G. Hiddink, G. Edwards-Jones, and P.J.B. Hart (2006). Conservation benefits of temperate marine protected areas: variation among fish species. *Conservation Biology*, 20, 811-820.

179. Hiscock, K., R. Harris, and J. Lukey (2006). Nationally Important Marine Features and Biodiversity Action Plan Marine Priority Habitats and Species. Report to the *Joint Nature Conservation Committee from the Marine Biological Association. Marine Biological Association of the UK*, pp.

180. Northern Ireland Marine Task Force (2009). A Northern Ireland Marine Bill. pp. 2. Available from: *www.nienvironmentlink.org/documentbank/uploads/Northern%20Ireland%20Marine%20Bill.pdf*

181. Stachowicz, J.J., H. Fried, R.W. Osman, and R.B. Whitlatch (2002). Biodiversity, invasion resistance, and marine ecosystem function: reconciling pattern and process. Ecology, 83, 2575-2590.

APPENDIX I: CATEGORIES OF DECLINE

For the purposes of this report, we have adopted the following descriptive terms which are based on work undertaken by OSPAR, by *MarLIN* and in the EU 6th Framework project European Lifestyles and Marine Ecosystems (ELME: *www.elme-eu.org*). Reference is made to the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List categories (see: *www.redlist.org/info/categories_criteria2001.html*).

Seabed habitats

Rank	Scenario
Lost	**Extent:** the habitat and its associated community is destroyed or removed. There is no evidence to suggest it still exists. **Degradation**: the 'quality' or 'structure' of the habitat is so severely degraded that it can no longer support its typical community or characteristic species.
Severe decline	**Extent:** over 75% of the spatial extent (or density of key structural[2] or key functional[3] species) of the habitat is lost OR the majority[4] of the habitat has been lost. Where its overall extent remains, the habitat is reduced to small, widely dispersed fragments. **Degradation:** the habitat has experienced a severe reduction (over 75%) in the abundance of associated key structural or key functional species, and the species richness or biodiversity is minimal. Further degradation is likely to result in loss of the habitat.
Significant decline	**Extent:** the spatial extent (or density of key structural or key functional species) of the habitat has declined by 25% to 75% of prior distribution OR the spatial extent (or density) has declined 'considerably'[5]. The habitat has either shrunk in spatial extent or been fragmented. **Degradation:** The population(s) of species important for the structure and/or function of the habitat may be reduced or degraded by the factor under consideration; the habitat may be partially destroyed; or the viability of a species population, species richness and biodiversity, and function of the associated community, may be reduced. Further degradation may result in severe decline (above).

2 Key structural – the species provides a distinct habitat that supports an associated community. Loss/degradation of this species population would result in loss/degradation of the associated community.
3 Key functional – the species maintains community structure and function through interactions with other members of that community (for example, predation, grazing, competition).
Loss/degradation of this species population would result in rapid, cascading changes in the community.
4 The term 'majority' is used to denote a 'major' (or 'mostly') loss, fragmentation or mass mortality.
5 The term 'considerable' is used to denote a change in status that indicated that the habitat is (or was) under threat and action needed. Similar terms might include 'significant', 'much', 'large-scale', and 'a lot'.

Rank	Scenario
Decline	**Extent:** the spatial extent (or density or key structural or functional species) has reduced by 25% or less OR the habitat has suffered a 'minor'[6] but 'noticeable' reduction in spatial extent (or density). The majority of the habitat remains but has either shrunk in extent, exhibits cleared or disturbed patches or shows signs of erosion or encroachment at its edges. **Degradation:** species important for the structure and/or function of the habitat are still present but their abundance is reduced. Especially sensitive, rare or scarce species are missing, especially those sensitive to environmental change and disturbance. The viability of a species population or the biodiversity/functionality in a community is reduced. Further degradation may result in significant decline (above).
Degraded	The spatial extent (or density or key structural or functional species) is not reduced. However, the habitat demonstrates signs of degradation, change in function or stress. Further degradation may result in decline (above). Symptoms will depend on the habitat in question. For example, especially sensitive, rare or scarce species are missing or reduced in abundance, especially those sensitive to environmental change and disturbance. Biodiversity and species richness are reduced. Opportunistic species or those tolerant of disturbance may be increasing in abundance. Key structural or functional species may exhibit disease or reduced viability (growth or reproduction rates).
Stable	No change in status (spatial extent, abundance or community function) reported or expected.
Increased	The spatial extent (or density of key structural or functional species) has increased over that expected or observed due to natural variability.

6 The terms 'minor' or 'noticeable' are used to suggest a measurable change in status that causes concern. Similar terms might include 'chronic change', 'mild', 'some reduction', 'somewhat reduced', 'reduced' and 'smaller than'.

Seabed habitats

Rank	Scenario
Lost	The population of the species is no longer present or there is a high probability that the last individuals have died or moved away, or surveys in the study area have repeatedly failed to record a living specimen.
Severe decline	The population demonstrates a high[7] and rapid[8] decline in numbers in the study area[4], or the species has already disappeared from the major part of its former range in the area, or population numbers are at a severely low level due to a long continuous decline in the past.
Significant decline	The population has undergone a 'considerable'[10] decline in numbers, range, and distribution beyond that expected by natural variability.
Decline	The population has suffered a 'minor'[11] but 'noticeable' reduction in numbers or distribution, or evidence suggests that there is a high probability of significant decline (above) due to reduced recruitment and/or reproductive individuals, or continued unsustainable extraction.
Stable	The population is believed to occur in similar numbers and/or extent, range and distribution to either: **1.** historical times before human activities or natural catastrophes adversely affected populations or, **2.** over a defined time period. (The time period against which the assessment is made is to be stated.)
Increased	The population has undergone an increase in numbers, range and distribution beyond that expected by natural variability. 'Increased' includes recovery towards pre-existing numbers and/or extent.

Application of the scales is undertaken using best available knowledge and expert judgement: precise figures for population size and habitat extent will very rarely be available.

7 'High' might be quantified as an over 70% reduction in the population, using IUCN categories of 'Critically Endangered' and 'Endangered' as a guide.
8 'Rapid' means 'within a year or less'.
9 'Long' in environmental management terms might be quantified as 'more than 10 years'
10 The term 'considerable' is used to denote a change in status that indicated that the habitat is (or was) under threat and action needed. Similar terms might include 'significant', 'much' 'large-scale' or 'a lot'.
11 The terms 'minor' and 'noticeable' are used to suggest a measurable change in status that causes concern. Similar terms might include 'chronic change', 'mild', 'some reduction', 'somewhat reduced', 'reduced' and 'smaller'.

The mission of WWF is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by

- conserving the world's biological diversity
- ensuring that the use of renewable natural resources is sustainable
- reducing pollution and wasteful consumption

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