



ENGLISH
NATURE

State of nature

Maritime - getting onto an even keel



working today
for nature tomorrow



Contents

MEHRAs

Marine Environmental High Risk Areas.

Molluscs

Soft-bodied unsegmented invertebrate animals, usually with shells, which include cockles, whelks, limpets, oysters and snails.

Natura 2000

The European Community-wide network of protected sites established under the Birds Directive and the Habitats Directive.

NERC

Natural Environment Research Council.

NGO

Non Governmental Organisation.

NMMP

The National Marine Monitoring Programme.

OSPAR

OSPAR Convention for the Protection of the Marine Environment of the North East Atlantic.

PAHs

Polycyclic Aromatic Hydrocarbons (petrochemicals that originate in oil).

PCBs

Polychlorinated Biphenyls.

Photosynthesis

The biochemical process that utilises radiant energy from sunlight to synthesise carbohydrates from carbon dioxide and water in the presence of chlorophyll and other photopigments.

Plankton

Organisms which drift in the water column and have limited powers of locomotion in comparison with the horizontal water movements. Many benthic animals have planktonic larvae which act as a dispersive phase.

POP

Persistent Organic Pollutant(s).

PPG

Planning Policy Guidance.

QSR

Quality Status Report (OSPAR).

Ramsar site

A site listed under the Convention on Wetlands of International Importance especially as Waterfowl Habitat, which was agreed at Ramsar, Iran.

SAC

Special Area of Conservation.

Salinity

Measure of the concentration of dissolved salts in seawater, normally expressed as parts per thousand (‰). Freshwater is regarded as <0.5 ‰ (limnetic), seawater as > 30 ‰ (euhaline), and brackish water as intermediate.

Scavenger

Any organism that feeds on dead organic material.

SMP

Shoreline Management Plan(s).

SPA

Special Protection Area.

Special Area of Conservation (SAC)

A site of [European] Community importance designated by the [EU] Member States through a statutory, administrative and/or contractual act where the necessary conservation measures are applied for the maintenance or restoration, at a favourable conservation status, of the natural habitats and/or the populations of the species for which the site is designated (Commission of the European Communities 1992). (This status is achieved by sites adopted by the European Commission).

Special Protection Area (SPA)

A site of European Community importance designated under the Wild Birds Directive (Commission of the European Communities Council Directive 79/409/EEC of 2 April 1979 on the Conservation of Wild Birds).

SSSI

Site of Special Scientific Interest.

Sublittoral

The zone of the shore below low water exposed to air only at its upper limit by the lowest spring tides.

Sustainable development

“Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development 1987 (Brundtland Report)).

TAC

Total Allowable Catch(es).

TBT

Tributyltin.

Terrestrial

Living on, or referring to, land.

Turbidity

This is a measure of the attenuation of light in the water column and can be caused by the light adsorption properties of the water, plankton, suspended particulate organic and inorganic matter and dissolved colour.

UK

United Kingdom.

UKBAP

UK Biodiversity Action Plan(s).

UKCIP

UK Climate Impacts Programme.

UWWTD

Urban Waste Water Treatment Directive.

WWF-UK

World Wide Fund for Nature - United Kingdom.

Zonation

The distribution of organisms in distinctive belts on the shore, in the sublittoral, due to gradients in environmental factors.

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Maritime State of Nature Report for England: getting onto an even keel.

Peterborough, English Nature

Foreword

Over the last few years, there has been a growing realisation and acceptance that we need to manage our maritime environment in a more holistic way. Recently, both the UK Government and the European Union have committed themselves to an ecosystem-based approach. This means the management emphasis needs to shift to integrate action to maintain (or restore) healthy ecosystems alongside appropriate human uses, to ensure benefits for both this and future generations. This will require a shift in priorities and a new more integrated approach, both in the way policies are set for the maritime environment and the way it is regulated. Changes to the conduct and extent of some important economic activities may be needed.

To determine what needs to change it is important to be as clear as possible about the state of the maritime environment and its dynamics and how vulnerable or robust our seas and coasts are to the uses being made of them. English Nature, as the Government's statutory adviser on nature conservation, has therefore been reviewing the evidence from the UK and worldwide on these issues. This Report brings the big picture together. We want it to stimulate informed debate and to help people understand why it is important to make changes in the way we use the maritime zone.

We plan to follow up this Report by developing, in consultation with DEFRA and other stakeholders, and through participatory processes, a strategy for England's maritime environment. This will help develop Government's over-arching strategy for the marine environment, recently published in their first marine stewardship report, by developing the changes in policy and practice English Nature believes are needed. We will seek to analyse not only the needs of the environment and biodiversity, but to consider these in the context of the economic, social, political and technological factors that affect the coast and seas and can drive or inhibit beneficial change. English Nature's Maritime Strategy will be published in 2003.

From the evidence we have studied we conclude that, despite the efforts made so far to protect it, the state of marine and coastal biodiversity is not good enough. Much coastal habitat has been lost, and the sea bed has in most places been highly modified, and so less capable of supporting a rich biodiversity. The marine ecosystem is showing signs of significant stress and low resilience to continuing pressure. All this adds up to an alarm call for those who use and manage our coasts and seas and care about the future.

There have been some major initiatives which continue to be crucial in protecting stretches of coast and English Nature values these. There have been important initiatives in the near-shore zone; English Nature has worked closely with many stakeholders to introduce an effective system of well-managed European marine sites. In addition, the UK Government has phased out sewage sludge dumping at sea and made investments to reduce polluting discharges and meet international commitments, along with greater use of strategic and environmental assessment processes. These are essential, but not sufficient to ensure a sustainable future.

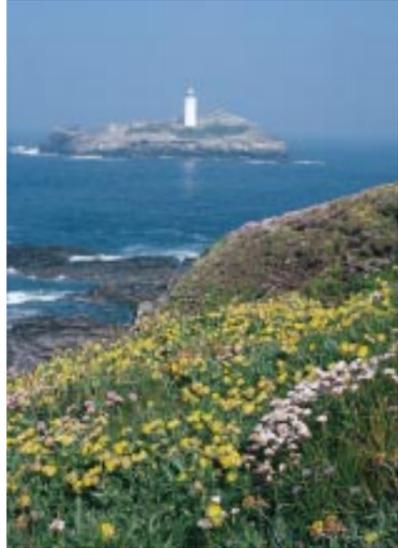
The European Commission's analysis of the need for reform of the Common Fisheries Policy points starkly to the fact that the European fishing fleet is too large and to the urgent need to bring fishing effort down in line with the capacity of the marine resources. English Nature recognises that it is not just a question of protecting healthy coasts and seas. We have a major challenge to get people to recognise that the marine ecosystem is currently degraded and vulnerable, and unless we take some of the pressures off soon it may lose its ability to bounce back and recover. On the coast, we need to stem further losses of high quality habitats and to work with people to find more places where it is feasible to allow coastal processes to operate in a more dynamic fashion.

We invite all who are interested in England's coast and seas to examine the evidence with us, to think about the connections between the different sectoral uses of the maritime zone and their cumulative impacts, and to reflect on the scale and urgency of action required to achieve a more sustainable future.



Sir Martin Doughty
Chair, English Nature

At a glance



Our seas, coasts and maritime history are fundamental to our national and cultural identity. Godrevy Island, Cornwall. Roger Covey/English Nature

Recent progress

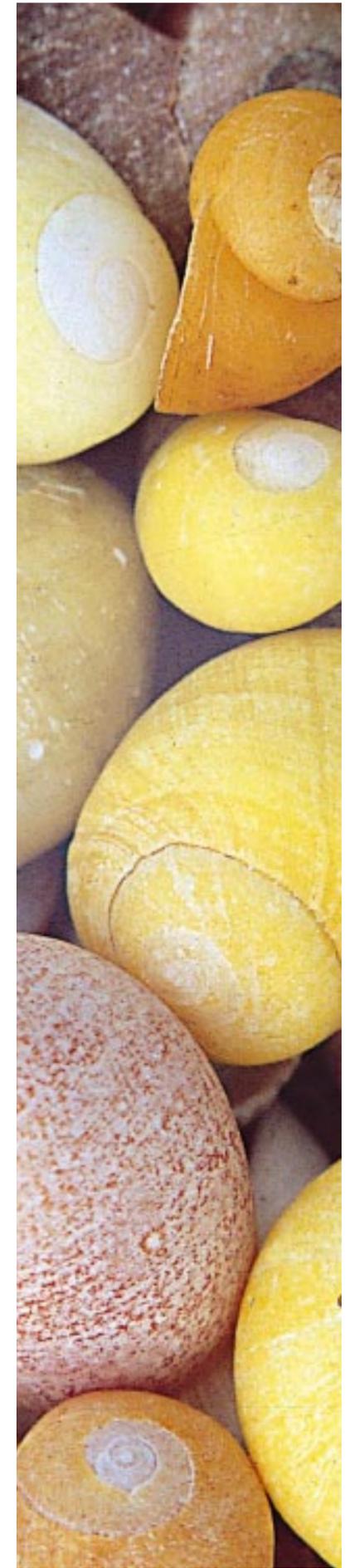
During the 1990s there were a number of important initiatives which improved coastal and marine management including:

- A more environmentally sound approach to coastal defence planning, developed by MAFF, working closely with English Nature, leading to a number of cost effective and more sustainable soft engineering solutions.
- Positive action to integrate environmental protection measures into the oil and gas licensing process by DTI.
- The UK Biodiversity Action Plan (BAP), supported by Government, which includes targets for protection, restoration and enhancement of a number of maritime features.
- A new suite of conservation sites (Special Areas of Conservation), protected under the Habitats Regulations.

The current and precarious state

Despite these, and many other efforts, our maritime ecosystems and their wildlife are being damaged and are in further decline as a result of continuing human impacts and demands:

- Coastal habitats are still being lost rapidly. Past development and fixed/hard coastal defences are fragmenting and squeezing out naturally mobile coastal habitats and their associated wildlife. Only a handful of dune systems are not impacted by development, leisure facilities or artificial sea defences.
- Saltmarsh habitats, many trapped between rising sea-levels and fixed seawalls, are being lost rapidly to 'coastal squeeze'. The loss of saltmarsh nationally is currently estimated at 100 ha each year. In Essex alone one quarter of all the saltmarshes have been lost in the last 25 years. This not only means the loss of valuable wildlife areas, but poses a real challenge in sustaining seawalls that rely on the wave absorbing power of saltmarshes to defend low lying areas.
- Most of Europe's vegetated shingle is in England, including a number of sites such as Dungeness, Chesil Beach and Orfordness, that are globally important both for their biology and geomorphology. Today, nearly 50% of designated shingle habitat is in unfavourable condition as a result of poor coastal management and from activities that damage the fragile plant communities. A major change in the ways these sites are managed will be necessary to maintain their biodiversity.
- Managed realignment should be our main approach to accommodate saltmarshes and mudflats in the face of rising sea-levels. However its use in flood management is still rare, and is failing to offset current losses. Only around 150 hectares of new habitat has been created in the last ten years: far short of the saltmarsh Biodiversity Action Plan target of 140 hectares per year.
- Present agricultural policy is having a double impact. It affects our ability to manage some coastal habitats such as saltmarsh and cliff-top grasslands with appropriate grazing levels or to target areas for habitat restoration. It is also causing deterioration in marine water quality due to nutrient run off from agricultural land. Since 1984 nitrogen inputs to the seas around the UK have increased by around 20%. The Irish Sea has shown steady nutrient increases over the last 30 years, whilst 60% of our internationally important maritime conservation sites (The Habitats Directive Natura 2000 sites) maybe at high risk or are already damaged by water quality problems.
- Plankton, the microscopic plants and animals at the bottom of the marine food chain, are the supporting foundation for all other species. By using and storing carbon dioxide, marine plankton are one of the key regulators of our global climate. A recent report



Periwinkles. Roger Covey/English Nature



In 1998, 51% of people in England visited the seaside. A quality maritime environment is a national asset. Paul Kay/MWPA



stated that in the North Atlantic we have lost 14% of the critical part of the plankton that fixes carbon dioxide from the air within the last 20 years. Global warming has been implicated. Closer to the coast, The National Marine Monitoring Programme believes that pollutants within many of our industrial estuaries have reached levels which may harm the plankton.

- Fishing has taken so many fish out of the seas that the basic structure of marine food chains has altered and is degrading. Between 1880 and 1981 we significantly impacted, and some say halved, the complexity of the North Sea marine food chain. Here, and elsewhere, the rate of deterioration has reportedly increased since the 1980s. Poor water quality and global warming may also be contributing.
- Human pressures have significantly modified the variety of species that would live in the sea, above and beyond changes that might naturally have occurred. As fishing systematically removes the large and slow growing species of fish (and other animals), they are replaced by others that can better cope with the disturbance. In the last hundred years this significant change has been seen in fish populations and also in the populations of animals that live in the seabed. It is believed that discards from fishing have also artificially increased populations of some scavenging seabirds, fish and invertebrate species.
- Most of the large and old fish have been removed from the natural population. Plaice are now just a quarter of the size they were in 1902. Since 1900 the average fish size in the English Channel has declined by more than 15%. Shell middens show that over the last 4,500 years the average size of cod was around 80 to 100 cm. The average cod caught today is around 35 to 40 cm. The estimated total fish stock in the North Sea has declined by approximately 35% in the last 25 years.
- Fishing activity over sandy seabeds has resulted in dramatic changes to their species composition. Over the last century there was a decline in virtually all bivalve molluscs that live in the sediment, whereas scavengers and some predatory species have increased. Physical damage to the seabed and discards from fishing boats are the most likely causes.
- Heavy metals and other chemical pollutants introduced into the maritime environment are difficult to remove, especially when they become locked up in sediment or animal tissue. We have reduced mercury inputs by about 80% since 1985, and since 1987 we have restricted the use of some toxic anti-fouling paints, resulting in a doubling of marine life in some estuaries. However, effects still linger in many estuaries and in some marine species. Accumulations of chemicals in marine mammals, such as seals and porpoises, are believed to reduce their natural immune response, making them more susceptible to death by infectious diseases.



Wave-exposed west coast, Lundy Marine Nature Reserve, Devon. Roger Covey/English Nature

- New, man-made chemicals, discharged into the maritime environment over the last century, are now known to disrupt reproductive processes of fish, such as flounders in estuaries. These chemicals have unknown consequences for predators further up the food chain such as birds.

The economic truth

Losing biodiversity costs us more than sustaining it.

- The World Bank estimates the costs of environmentally sustainable management of the Mediterranean to be half the cost of dealing with the consequences of mismanagement. Prevention is better than cure, and more cost-effective.
- In 1998, 51% of people in England visited the seaside. Many of these visitors will have spent money in the local economy. Recreational anglers are estimated to be spending around £140 million each year in the coastal economies of England and Wales.

The way forward

We want this report to stimulate informed debate and help people understand why it is important to make changes in the way we use the maritime zone, and what those changes may look like. We will, of course, debate our ideas in building our maritime strategy, but we consider the following to be important issues.

- **A Government-led recovery initiative;** recovering our maritime ecosystems, and making best use of all our knowledge about these ecosystems, means that they will be better able to support both wildlife and sustainable exploitation, as well as acting as a natural buffer to chance events, such as storms and floods.
- **Areas free from exploitation** provide a reference by which we could judge our success on managing the impacts on the wider marine environment, and serve as crucial replenishment areas should we destroy or damage the maritime environment elsewhere.
- **New or revised legislation;** as part of the ongoing review of development in marine and coastal waters there would be merit in re-evaluating the 1949 Coast Protection Act with a view to creating a system where sustainable 'coastal management' solutions are also eligible for funding. New legislation is required to protect nationally important elements of marine ecosystems, and to set aside areas from all exploitation for ecosystem recovery, not just fisheries management.
- **The cumulative impacts of our actions;** we must move away from the current sectoral approach that manages activities in isolation from each other, to an approach that puts the emphasis on maintaining the health of ecosystems alongside appropriate human uses.
- **Recovery will take time;** some elements, such as some species of fish, may respond quicker than other parts of the ecosystem, such as habitats, which may take years or decades to re-establish and may be unpredictable. Ecosystems are complex and it is not a case of taking the correct management actions today and seeing a healthy marine environment tomorrow. Not all habitats and species will increase in area or numbers - those that are strongly influenced by human activities or dependent on human activities for sources of food, such as from fishing discards, can be expected to decline over time if management actions are successful.
- **Ecologically meaningful management;** success cannot be achieved by designating a number of isolated wildlife sites with fixed boundaries, while the quality of the wider environment declines. Coastal and marine habitats are dynamic, and this needs to be reflected in how they are managed.
- **Protecting the genetic diversity of our maritime ecosystems;** this includes threats originating from the introduction of organisms (including genetically modified organisms) and non-native species. Greater awareness of such threats is essential, coupled with improved risk management procedures at both national and European levels, linked with risk-assessment processes worldwide.

Introduction

A life support system

"...oceans and seas constitute the major part of the planet that supports life, drive the hydrological cycle, and provide the vital resources to be used to ensure well-being for present and future generations and economic prosperity, to eradicate poverty, to ensure food security and to conserve marine biological diversity and its intrinsic value for maintaining the conditions that support life on earth"

The Commission on Sustainable Development 1999

A social and economic resource

In England, people have a strong sense of identity with the coastal and marine environment, from fish and chips, to a day on the beach, to a link with the rest of the world. Living on an island is fundamental to our national and cultural identity. England has a rich maritime history. Many of the structures that identify our past and current relationship with the sea (such as lighthouses, fishing villages, local harbours and piers) remain intact, as a tangible reminder of our nautical heritage.

The state of the maritime environment should matter to us all. At a global level we rely on the sea to support 'unseen' processes such as those that regulate the global climate. At a local level we depend on our coasts and seas for resources such as fisheries and aggregates. The environment also enriches our quality of life. One in three people live within 10 km of the coast and many people look to our coasts and seas for inspiration and relaxation¹. This 'hidden value' is frequently overlooked in the economic case for development, but it must be recognised that conservation has social and financial benefits, as well as biodiversity gains. For example, in 1998, 51% of people in England visited the seaside². Many of these visitors will have spent money in the local economy. Recreational anglers, who share an interest in a healthy maritime environment, are estimated to be spending around £140 million each year in the coastal economies of England and Wales³. A sustainable approach can also save

Earth, taken by Apollo 17. NASA/FLPA



The sea covers 70% of our planet, supports life on earth, and enriches the quality of life for present and future generations



Children rockpooling, Rosemullion Head SSSI, Cornwall. Roger Covey/English Nature



Coastal habitats such as saltmarsh and sand dunes are important for coastal defence as well as biodiversity. Holkham, North Norfolk. Roger Covey/English Nature

money. For example, an 80-metre broad band of saltmarsh in front of a sea defence soaks up wave energy that would otherwise impact the defence structures. This lowers the standard of defence needed, and can save around £5 million per kilometre⁴. The World Bank estimates the cost of environmentally sustainable management of the Mediterranean to be half the cost of dealing with the consequences of mismanagement⁵. Prevention is better than cure, and more cost effective. Remediation required as a result of poor management is expensive.

A place of diversity

Our coast is spectacular - from the granite coastline of Cornwall, the unique geology of the East Devon and Dorset World Heritage Site, the world famous wetlands, saltmarshes and seabird communities of Norfolk to the hauntingly beautiful sand dunes of the Northumbrian coast. But many people do not realise the diversity and range of our coastal and marine wildlife. England has an important mixture of maritime species and habitats, influenced by the division between colder Arctic and warmer Mediterranean waters around our shores. Dolphins, porpoises, basking sharks and whales can all be seen around the coasts of England. In addition our seas contain around another 40,000 species⁶. This complex of species provides the fundamental character to our marine ecosystems. Most of these species are completely hidden from view and unknown to most people. Given the global, European and national importance of our maritime ecosystems, society as a whole, and Government in particular, must take responsibility to ensure the long-term, wise and sustainable use of this resource. This biodiversity includes groups of animals that are almost entirely restricted to the marine environment such as sponges, hydroids (sea-firs), sea anemones, bryozoans (sea-mats), echinoderms (sea urchins, starfish and their relatives) and



Much of the marine environment is hidden from view and unknown to most people. Our seas contain around 40,000 species, from kelp forests, shown here, to deep sea sediments. JNCC



Mudflats. JNCC

ascidians (seasquirts). In fact, more than twice the number of major animal groups (phyla) are found in England's seas than on the land.

This diversity is largely founded upon the great variation of England's geology and geomorphology. Much of England's coastline is designated wholly, or in part, as Sites of Special Scientific Interest for its geology. These cliff and foreshore sites contain exposures of rocks ranging in age from 480 million years to the recent past (the last 10,000 years), where they provide evidence for understanding change in the past, and indicate what the future might hold.

Recent progress

Over the last couple of decades substantial progress has been made in improving the understanding of the marine and coastal environment. The Department for Environment, Transport and the Regions (DETR), now the Department for Environment, Food and Rural Affairs (DEFRA), was instrumental in bringing together knowledge of nature conservation initiatives as part of the Government's Review of Marine Nature Conservation⁷. This shows, for example, that between 1987 and 1998, the Marine Nature Conservation Review (undertaken by the Nature Conservancy Council and, subsequently, the Joint Nature Conservation Committee) collected and published important baseline information on the distribution of our marine biodiversity^{6,8}. In 1992, English Nature's *Campaign for a Living Coast* substantially raised the profile of the maritime environment⁹. The Government has achieved some real gains in the quality of the environment. These achievements are well reflected in the Government's report, *Safeguarding our Seas*, popularly referred to as the Marine Stewardship Report, published by DEFRA earlier this year¹⁰. For example, throughout the 1990s The Ministry of Agriculture, Fisheries and Food (MAFF), working closely with English Nature, developed a more environmentally sound approach to coastal defence planning. This has led to a number of soft engineering solutions which are both cost effective and more sustainable.

English Nature demonstrated the importance of integrated management with others through the process of developing estuary management plans. The National Trust has continued its essential Enterprise Neptune campaign



(which started in 1965), investing large amounts of money to purchase and manage extensive tracts of coastal land. Huge amounts of money have also been spent on cleaning up industrial and sewage discharges to the environment. In the 1990s DTI took positive action to integrate environmental protection measures into the oil and gas licensing process. In 1994 the Government launched the UK Biodiversity Action Plan (BAP) and the process of publishing agreed habitat and species actions plans was completed in 1999¹¹. The action plans include targets for protection, restoration and enhancement of a suite of maritime features and have wide support from many statutory and non-statutory bodies. At the same time, agri-environment measures have been developed to promote management of, and recently to re-create, coastal habitats. A new suite of conservation sites of European importance (Special Areas of Conservation) has been identified¹² and are being protected under the Habitats Regulations. Management schemes, being delivered by multi-sectoral management groups, are in place for most of these sites. 36 coastal Special Protection Areas (SPAs) have been designated, and these provide protection and management for many species of internationally important birds¹³. Nationally, legislation to protect Sites of Special Scientific Interest (SSSIs) has been strengthened through the Countryside and Rights of Way Act 2000. There has been a lot of Parliamentary interest in extending site protection measures into the marine environment¹⁴. Such issues and the way forward are currently being examined by DEFRA's Review of Marine Nature Conservation. In addition, a biodiversity strategy for England is under preparation. This will be an important document, as it will complement the UK Biodiversity Action Plan, shift the emphasis from UK level to implementation at a country level, and set out a challenging agenda for policy change over the next decade¹⁵. In May 2002 the Government outlined its commitment to better maritime management in its Marine Stewardship Report¹⁰. Meanwhile, the European Commission is drafting a European Marine Strategy¹²³, and seeking fundamental reforms to the Common Fisheries Policy, which incorporate much wider measures for sustaining marine ecosystems.

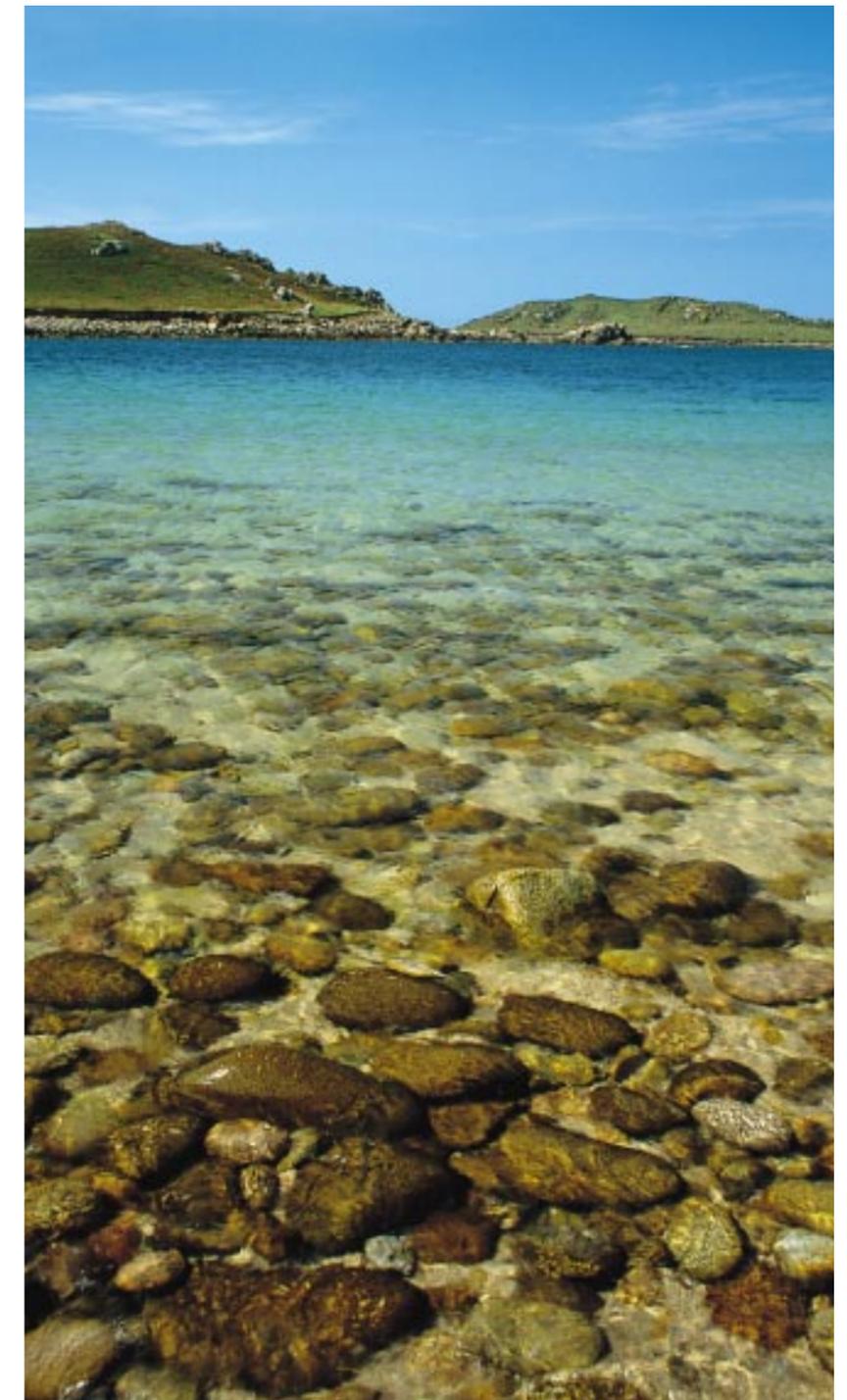
Future challenges

Despite such progress over the last couple of decades, more challenges lie ahead for us all if we are to continue to benefit from the resources of our seas and coasts. A fully representative and ecologically meaningful network of protected conservation areas is essential to conserve sensitive habitats and species. In addition they would have a wider value in raising the profile of the wildlife riches of our seas and coasts. But designated sites alone are not sufficient to ensure the continued survival of biodiversity. For the future well being of maritime wildlife we must move beyond designated sites, or single-issue management, to manage sites within their context and manage the environment in a more holistic way. Our network of protected sites is currently incomplete. It needs to be extended, both in terms of coverage of some habitats and species and in terms of spatial distribution, as the current sites are all near-shore and attached to the coast. Furthermore it will be important to introduce areas which are freed of human pressures, thus joining up fisheries recovery action with nature conservation action, and acting as part of an insurance

for the future. There is evidence that damage and decline has occurred throughout most of our maritime environment, both at local levels and through broad-scale ecosystem changes. It is now increasingly acknowledged, at both national and European levels, that there is a need to take a more integrated approach at the right scale.

For some time now Government and operating authorities have been trying to take better account of dynamic coastal processes in a more strategic approach to coastal defence, for example through DEFRA funded Shoreline Management Planning⁷³. The European Union have also recommended that Member States develop "integrated coastal zone management"¹⁶. Government has announced its attention to adopt an "ecosystem-based approach" to the management of the maritime environment¹⁰. An ecosystem-based approach to management represents a more strategic way of thinking. It puts the emphasis on management which maintains the core physical, chemical and biological processes that actually support the ecosystem in question. In this approach, fundamental factors that are essential to the functioning of the ecosystem (such as water quality) or species which are critical to the food chain (eg primary producers such as seagrass beds) are highlighted as the focus of management objectives and strategies. The adoption of an ecosystem-based approach to management ensures that the health of the ecosystem is maintained, and that social values (such as fishing or recreation) can be enjoyed in a sustainable manner. Failure to adopt such an approach can result in the loss or degradation of a critical factor or species, which in turn has a knock-on effect throughout the entire ecosystem. We will be working with Government to

Maintaining the core physical, chemical, and biological processes that support the ecosystem should be the focus of management. Isles of Scilly candidate Special Area of Conservation. Roger Covey/English Nature



increase everybody's understanding of what this means in practice. As a starting point we will be using the description of the ecosystem approach, set out in the box opposite, which was agreed at the Conference of the Parties to the Convention on Biological Diversity in 2000¹⁷. We will be working to apply the principles of the approach summarised on page 16. In making these useful operationally we will be taking account of the following key points:

1. A focus on functional relationships and processes within ecosystems.
2. Enhancing benefit-sharing.
3. Using adaptive management practices.
4. Carrying out management actions at the scale appropriate for the issue being addressed, with decentralisation to the lowest level, as appropriate.
5. Ensuring inter-sectoral co-operation.

This approach, together with more ecologically coherent conservation management and protection, should help to ensure recovery of our maritime wildlife so that it is better able to flourish in the future.



We will need close co-operation between all who use and value our maritime environment to ensure truly sustainable and inclusive management. Plymouth Sound and Estuaries candidate Special Area of Conservation. Roger Covey/English Nature

The next steps

This report focuses on the state of our maritime ecosystems and calls for a debate on how we manage and treat this environment. Details of current maritime initiatives have already been documented in the Government's Marine Stewardship Report. Further detail on the policy and management changes that we believe are needed to recover and sustain our maritime environment will be developed in our Maritime Strategy, through a process of consultation and participation, to be published in 2003. If truly sustainable and inclusive solutions are to be found, the detail of any new approach will need to be developed and understood by all who currently benefit from our coasts and seas - from offshore industries to the public who enjoy quiet recreation on the coast.

The ecosystem-based approach

An ecosystem consists of a community of plants and animals and their physical environment that are inter-dependent and may be best described as a network or web

Conference of the Parties to the Convention on Biological Diversity in 2000¹⁷ agreed the following:

1. The ecosystem-based approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Thus the application of the ecosystem-based approach will help to reach a balance of the three objectives of the Convention [on Biological Diversity]: conservation; sustainable use; and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources.
2. An ecosystem-based approach is based on the application of appropriate scientific methodologies focused on levels of biological organisation, which encompasses the essential structure, processes, functions and interactions among organisms and their environment. It recognises that humans, with their cultural diversity, are an integral component of many ecosystems.
3. This focus on structure, processes, functions and interactions is consistent with the definition of "ecosystem" provided in Article 2 of the Convention on Biological Diversity: "Ecosystem" means a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit." This definition does not specify any particular spatial unit or scale, in contrast to the Convention definition of "habitat". Thus the term "ecosystem" does not necessarily correspond to the terms "biome" or "ecological zone", but can refer to any functioning unit at any scale. Indeed the scale of analysis and action should be determined by the problem being addressed. It could for example be a grain of soil, a pond, a forest, a biome or the entire biosphere.
4. The ecosystem-based approach requires adaptive management to deal with the complex and dynamic nature of ecosystems, and the absence of complete knowledge or understanding of their functioning. Ecosystem processes are often non-linear, and the outcome of such processes often shows time-lags. The result is discontinuities, leading to surprise and uncertainty. Management must be adaptive in order to be able to respond to such uncertainties and contain elements of "learning by doing" or research feedback. Measures may need to be taken even when some cause-and-effect relationships are not yet fully established scientifically.
5. The ecosystem-based approach does not preclude other management and conservation approaches, such as biosphere reserves, protected areas and single-species conservation programmes, as well as other approaches carried out under existing national policy and legislative frameworks, but could, rather, integrate all these approaches and other methodologies to deal with complex situations. There is no single way to implement the ecosystem-based approach, as it depends on local, provincial, national, regional or global conditions. Indeed, there are many ways in which ecosystem-based approaches may be used as the framework for delivering the objectives of the Convention in practice.

Limpets. Roger Covey/English Nature



2. The current state of maritime nature

The 12 principles recommended by the Conference of Parties of the Convention on Biological Diversity in 2000 to guide signatory countries in the practical application of the ecosystem-based approach¹⁹

- The objectives of management of land, water and living resources are a matter of societal choice
- Management should be decentralised to the lowest appropriate level
- The ecosystem approach should be undertaken at the appropriate spatial and temporal scales
- Recognising the varying temporal scales and lag-effects that characterise ecosystem process, objectives for ecosystem management should be set for the long-term
- Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems
- Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should: reduce those market distortions that adversely affect biological diversity; align incentives to promote biodiversity conservation and sustainable use; and internalise costs and benefits in the given ecosystem to the extent feasible
- Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach
- Ecosystems must be managed within the limits of their functioning
- Management must recognise that change is inevitable
- The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity
- The ecosystem approach should consider all forms of relevant information including scientific and indigenous and local knowledge, innovations and practices
- The ecosystem approach should involve all relevant sectors of society and scientific disciplines

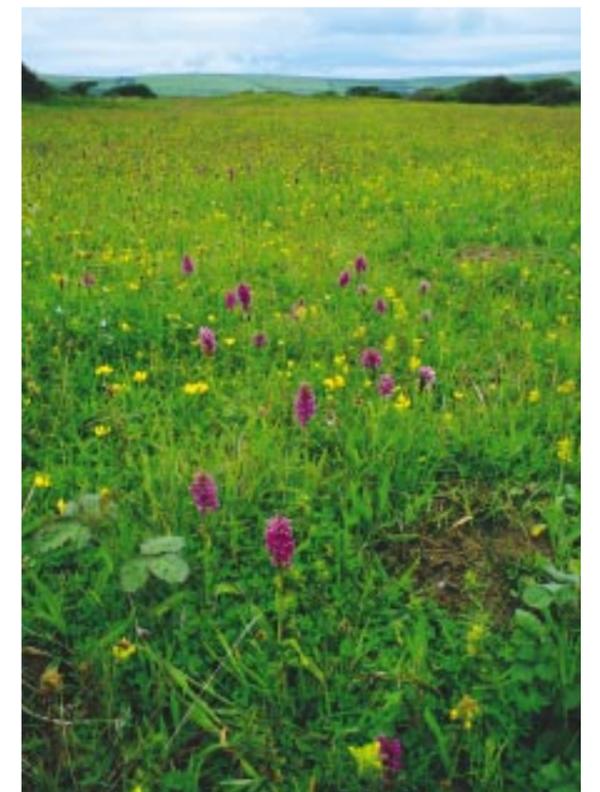
In structuring this report we have organised the information into two broad sections: coastal habitats, including estuaries, sandy and rocky shores; and the open seas, including the seabed. In describing the state of maritime wildlife, it is difficult to avoid using these boundaries to structure the information, but it is equally important to remember the environment is fully interconnected and functions as a whole. For example, steep granite cliffs have inaccessible ledges which are frequently vegetated by sea beet. These plants are fertilised by the droppings of kittiwakes which feed on small marine fish such as herring and sprat, or smaller invertebrates they catch from the sea. In turn, these animals feed on smaller organisms such as microscopic plants and animals (the plankton) which thrive in our coastal waters. In this way, the geology of the land, and the productivity of the sea combine to form the basis of a maritime ecosystem which is dependent on the resources offered by all of its parts. Much of the dynamic interconnection in the coastal zone has been lost through human intervention. There would be value in restoring this in some places.

2.1 Coastal habitats

With a length of around 8,000 km¹⁸, England's coastline is a wonderfully diverse and constantly changing national asset: from the predominantly hard rocky coasts of the south west and north east, to the softer mudflats, saltmarsh and estuaries of East Anglia or the Irish Sea. Much of our soft coastline is dynamic (or should be), either in the short term or over longer timescales. Soft coastlines range from easily eroded mudstone cliffs of Dorset, through the chalk of Kent and Sussex, to extensive areas of salt marsh, sand dunes, shingle or sandy beaches and some of the most environmentally important estuaries in Europe. Variations in the geology, wave exposure and tidal currents, along with the change in climate from south to north, all interact to produce a varied mosaic of habitats, supporting a wide diversity of important wildlife.

Understanding the process of continuous change is essential if we are to work with nature to achieve sustainable coastal management. The erosion of soft cliffs and longshore sediment transport provides material to develop saltmarshes, sandy beaches or sand dunes. These provide a natural coastal defence with benefits for biodiversity and people. The impacts of planning and coastal management decisions, combined with a lack of understanding of, or reference to the geomorphological dynamics of our coastal systems and habitats, are a major reason why our coastal ecosystems are not in good enough condition. We review the state of each of our coastal habitats in the following sections.

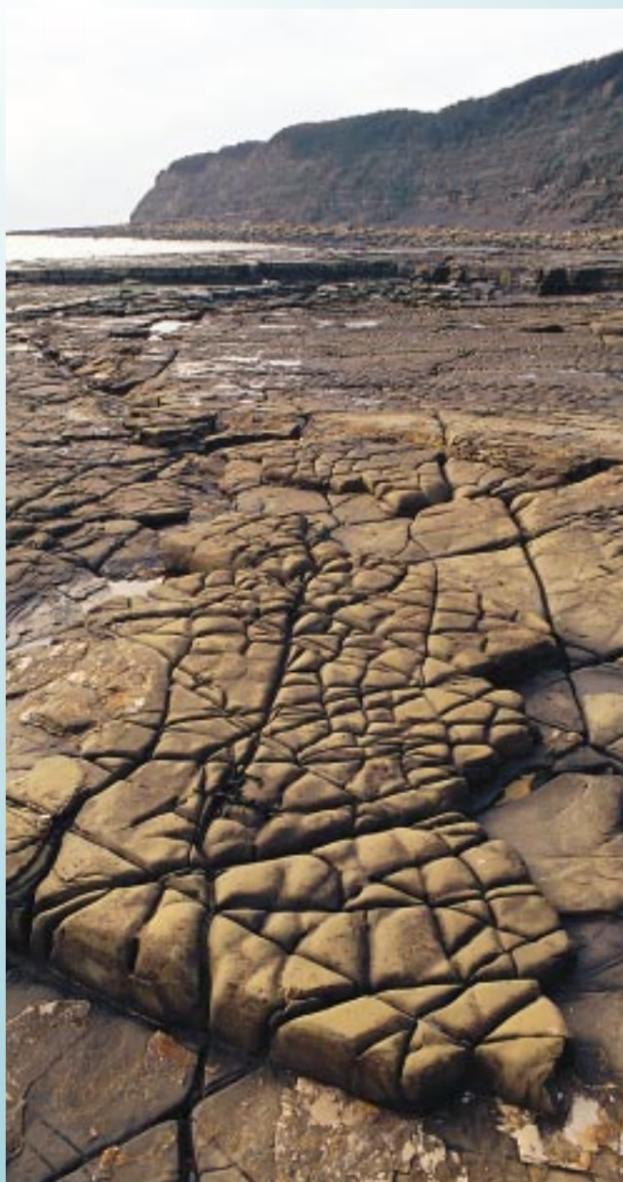
Flower-rich dune slacks rely on the interaction between the sea and the land for their survival. Branton Burrows candidate Special Area of Conservation. Roger Covey/English Nature



2.1.1 Sea cliffs

Around 1,200 km (20%) of England's coastline consists of cliff¹⁹, widely distributed from Northumberland to Land's End and up the west coast to St Bees Head. Although hard cliffs of rocks such as granite, limestone or sandstone are important for wildlife, the cliffs consisting of softer rocks make the greatest contribution to coastal processes through the ease with which they are eroded, thus supplying sediment to beaches and estuaries.

Kimmeridge Bay, part of the Dorset and East Devon World Heritage Site. Peter Wakeley/English Nature 13,066



The Dorset and East Devon World Heritage Site

The importance of the coastal geological and geomorphological sites in England is recognised internationally by the designation of most of the Dorset and East Devon coast by UNESCO as a World Heritage Site²².

This 95 mile stretch of coastline has been hugely influential on the development of the geological sciences, and has inspired many famous geologists over the past 200 years. It is now an international reference site for its geology, and one of the world's richest hunting grounds for fossil marine reptiles. Its dynamic coastal processes are equally important and spectacular, with the coastline including Europe's largest coastal landslide, and classic features such as Chesil Beach and The Fleet Lagoon.

Tourism is a key economic benefit at the coast, and the quality of the biological and geological features are, tangibly or intangibly, the fundamental source of many people's enjoyment. The local authorities in Dorset and East Devon, along with many other local organisations and businesses, have recognised the potential of the World Heritage Site to support and increase sustainable tourism, as well as providing more opportunities to help people appreciate and understand our natural heritage.

Coastal geology and geomorphology: diversity and value

The English coast has a diverse and spectacular geology. Many localities are known across the world as places where geological features or successions of rock were first defined. Coastal areas such as those around Kimmeridge Bay in Dorset have given their name to globally recognised periods of geological time; rocks deposited anywhere in the world between 145 and 154 million years ago are said to be of Kimmeridgian age²⁰. And there are proposals that the coast between St Audrie's Bay and Doniford Bay in Somerset should be considered as the internationally agreed reference section for the base of the Jurassic System²¹. The conservation of such coastal sites is a key priority.

The diversity and splendour of our coastal landscape derives from the complex range and variation in rock formations. Whether they are hard or soft, tilted or horizontal, folded or faulted determines the variety of vertical cliffs, embayments and coastal landslips that we see today. These rock exposures provide a window into the past, and an opportunity to explore (through fossils) a past world of giant and unusual animals, and long-extinct life forms such as dinosaurs and ammonites. The recent declaration of the coast of Dorset and East Devon as a World Heritage Site for its geology and geomorphology recognises the scientific and cultural history and importance of this classic area²².

For over 200 years, important and exciting fossil discoveries have been made in our coastal cliffs and foreshores. These finds, such as the ichthyosaurs and plesiosaurs (marine reptiles), from the cliffs of Lyme Regis and Charmouth in Dorset²³, and from the North Yorkshire coast, help us understand how life on our planet evolved through time. The Isle of Wight cliffs regularly yield dinosaur fossils such as *Iguanodon*, one of the first dinosaurs to be described, and the soft cliffs of London Clay in Essex and Kent are a rich source of fossil shark's teeth. These would not come to light without natural, undefended cliffs, subject to gradual processes of cliff erosion that continually reveal new material.

England's coasts also contain a rich suite of geomorphological (landform) features, including extensive lengths of coast with landforms that have developed in the recent past, and which continue to evolve²⁴. Particularly important are the processes that form and mould the coast, and the need for these processes to continue to operate. These affect the form and evolution of cliffs, spits, estuaries, salt marshes, dunes and landslips, and many other features. Well known sites include the 28 km long barrier beach at Chesil in Dorset, the extensive sand dunes of the Sefton Coast near Liverpool, and the undulating chalk cliffs of the Seven Sisters in Sussex. All these places are of intrinsic scientific and educational importance, and are also much-appreciated features of England's coastline. The dynamic evolution of these processes and landforms provides the foundations for coastal ecosystems and habitats, and underpins the now accepted need to accommodate dynamism in the conservation of coastal systems.

Away from the heavily populated centres of the coast, most geological and geomorphological sites are maintained by natural processes. This is



Folded shales and sandstone at Milllook Haven, Cornwall, formed by mountain building in the past. Mick Murphy/English Nature

the preferred and sustainable option. In the vicinity of developed areas, coastal protection works often impact upon these sites, by obscuring rock sequences seen in cliffs, and modifying coastal processes so that some coastal landforms can no longer evolve naturally.

The scientific, educational and historical importance of the geology and geomorphology of England is reflected in the number of Sites of Special Scientific Interest that are designated for their geological interest. All of these sites were selected through a systematic site assessment exercise known as the Geological Conservation Review, carried out in consultation with acknowledged experts over a period of many years²⁵. The outcome is a series of 1,300 SSSIs¹²⁰ which are notified for their geological or geomorphological interest. Approximately 170 of these are at the coast, where they comprise some 60% by number of coastal SSSIs.

The features in these sites range from intrusions of igneous rocks such as granite, folds and faults produced during past mountain building events, sequences of rocks representative of the long and relatively complete geological record of England, to particularly important fossil sites. These are valuable resources for geological research, and many of the sites are regularly used by schools and universities for this purpose. These sites are also valuable for the story they have to tell. They can enthuse and inspire people, both through these stories, and through the aesthetic qualities that many sites possess. The rich variety of rock type, landform and processes of our coasts are fundamental factors in determining the type of plant and animal communities that colonise these areas, emphasising how important it is for coastal managers to understand the interaction of geological and biological processes.

Key issues for coastal geology and geomorphology: diversity and value

- Coastal protection and sea defence works are the major influence on coastal geological and geomorphological sites, since they can obscure geological features and disrupt natural coastal processes. The integrated approach to coastal management, now a central part of Government policy, is vital to ensure that these issues are considered appropriately



The West Runton elephant. An example of the importance of soft cliff erosion in supplying sediment and revealing important fossil remains. Natalie Bennett/English Nature



Erosion of soft cliffs is essential in maintaining a mosaic of habitats. Norfolk, East Anglia. Roger Tidman NHPA/EN/RT1003200A

Hard rocks form vertical or near-vertical cliffs that are relatively inaccessible to people, enabling seabirds to nest undisturbed and maritime plants to gain a foothold. Ledges and crevices that accumulate soil and humus are the main places where plants such as rock samphire and rock sea-spurrey will grow. The range of plants that occur is often determined as much by the degree of salt spray to which they are exposed, as it is by the nature of the rocks and soils. As a result, vegetation communities exhibit distinct zonation as the influence of salt spray declines. Elsewhere on the rock face, plant communities are dominated by a specialist group of lichens that can survive the effects of salt spray. Hard rock cliffs are important for their populations of breeding seabirds such as razorbill, guillemot and shag. This importance is recognised in the number of cliff sites that are protected for their bird populations. Flamborough Head and Bempton Cliffs Special Protection Area supports England's only, and Britain's largest, mainland gannet colony as well as one of the largest kittiwake colonies in the North Atlantic.

Soft cliffs are formed of poorly consolidated material such as shale or boulder clay, which may be inter-bedded with harder rock layers. They slump as they erode and are easily colonised by vegetation, forming slopes rather than vertical cliffs, often with areas of seepage and standing water. Recently exposed soils, following landslips, develop pioneer plant communities. Longer-lived plant communities dominate older surfaces and eventually lead to scrub and woodland on the most stable slopes. The mosaic of habitat types on soft cliffs provides a range of conditions for plants, such as shore dock, and animals, such as solitary bees, wasps and beetles. These include rare plant species such as the slender centaury, which occurs on limestone cliff slopes and grassland. There are 36 UK Biodiversity Action Plan (BAP) priority species which are primarily associated with cliff slopes, with 59 species in total recorded as using the habitat¹¹. The scarce blackneck moth is an example of a nationally rare species that relies on eroding maritime cliffs. Its food plant (wood vetch) is widespread throughout Britain, but the moth also needs the microclimate afforded by bare ground in a maritime climate²⁷.

The coast between Cuckmere Haven and Holywell in Sussex is the longest undefended section of cliff between the Isle of Wight and The Wash. Roger Covey/English Nature





Kittiwakes *Rissa tridactyla* on maritime cliffs. Seabirds are an important part of our maritime environment. Roger Covey/English Nature

Seabirds and maritime cliffs

The British Isles, due to their geographic location on the eastern seaboard of the north Atlantic and the northwest edge of the continent of Europe, are of major importance for many species of birds. In particular, maritime habitats, including cliffs, sand dunes, shingle, lagoons, estuaries, and the productive seas around them, are of great importance for both breeding and migratory birds and are considered to be some of the most important habitats for bird conservation in England.

Globally, England is one of the most important areas for breeding sea birds and non-breeding waterfowl and seabirds²⁶, and has an important role to play in the conservation of European birds. Feeding, nesting and roosting areas are all provided by maritime habitats, and some species may use a coastal location for nesting, whilst feeding at sea. For example, cliff-nesting seabirds such as fulmars, from various locations around England, will cover large areas of sea up to 400 kms from the shore to find food for their young. In winter, these birds will disperse over a wider area of sea. Regular breeding species include a number of species of gulls, terns, and auks as well as fulmars, Manx shearwaters, storm petrels, gannets, cormorants and shags. One of the largest-known nesting colonies of kittiwakes in the North Atlantic is found on Flamborough and Bempton Cliffs, illustrating the significance of the English coast for birds.

Birds are highly mobile, so conservation measures need to address their whole range and life-cycle, within and beyond designated sites.

There are over 60 sea cliff SSSIs in England, covering an area of just under 6,000 ha of which 92% (by area) are in favourable condition. The remaining 8% (420 ha) is in unfavourable condition, due to interference with coastal processes, or inappropriate land management, particularly the lack of grazing on cliff top grasslands. Land use such as farming at the cliff top can have a direct influence on the vegetation on the cliff slope. In low intensity grazing systems, stock grazing maintains the diverse cliff top vegetation that forms the starting point for the development of cliff-slope plant communities. In the post-war drive to intensify agriculture, most cliff top maritime grassland has been ploughed, resulting in fewer plant species. In contrast, more steeply sloping ground is no longer grazed by stock, resulting in overgrown scrub at the expense of flower rich open grasslands.

Buildings near cliff tops lead to greater pressure to build defence structures to slow the erosion of dynamic cliffs, as the cliff edge recedes towards the development. Climate change is predicted to increase rates of erosion due to increased winter rainfall, and increased storminess²⁸. Hard engineering solutions to reduce the risk of erosion on soft cliffs are costly, difficult and unlikely to be sustainable.

Continual landslips and coastal movement are key factors in maintaining the range of wildlife on soft cliffs and providing a supply of sediment to adjacent or more distant coastlines. Many soft cliffs have been stabilised by coast protection or sown with commercial grass species in an effort to stabilise the cliff slopes. In 1992 it was estimated²⁹ that only 255 km of soft cliffs in England remained unaffected by coastal defences. Research by English Nature³⁰ has also established that the 9.5 km stretch of chalk cliffs between Cuckmere Haven and Holywell in Sussex is the longest section of continuously undefended cliff between the Isle of Wight and The Wash! Stabilisation results in changes to the mosaic of cliff habitats, with bare ground and pioneer vegetation being progressively overgrown. Equally important, this may cause sediment starvation and increased erosion at adjacent beaches. Sediment input to the marine environment from cliffs may have declined by as much as 50% over the past 100 years because of protection works³¹.

The UK Biodiversity Action Plan includes a commitment to a policy of 'no net loss' of maritime cliff and slope habitats¹¹. Under the current legislative and policy framework this is unlikely to be achieved, as future demand for coast protection is predicted to exceed the availability of sites where defences could be removed or abandoned to re-instate cliff recession and habitat restoration³¹.



The scarce blackneck moth *Lygephila cracca* relies on wood vetch *Vicia sylvatica* growing on unstable maritime cliffs. Blackneck moth. G.E Hyder/FLPA/46180-00001-190 Wood vetch in flower. Ian Rose/FLPA 58664-00002-186

Key issues for sea cliffs

- Inappropriate stabilisation, leading to loss of biodiversity and geological interest
- Poor use of cliff-top land, reducing potential biodiversity
- Inappropriate coastal development in areas of high natural cliff mobility
- Reduction in sediment inputs to coastal systems

2.1.2 Sand dunes

Sand dune systems are naturally dynamic. Sand moves, plant communities change, and whole dune systems migrate in response to various climate factors. The shape and size of dunes depends on the supply of sand and the strength and direction of the prevailing wind. Dunes first form where blown sand is trapped on the strandline by debris or salt tolerant plants. Trapped sand and vegetation will progress to a more stable and persistent habitat, with more fixed vegetation. As the plant cover increases, and other dunes form in front, the sand supply is gradually cut off, resulting in the development of 'fixed dunes' which are naturally stable. However, 'blow outs' may still occur if the vegetation cover becomes broken. When this happens the wind can act on the exposed bare sand, moving it elsewhere within the dune system, often re-starting the plant succession process. A typical dune system will have a zonation from mobile, young dunes on the foreshore, leading into more mature dunes with grassland where the dunes are older. Where human activities cause excessive erosion the whole dune system can degrade.

The UK Biodiversity Action Plan for sand dunes¹¹ has targets to protect existing sand dunes from losses due to human activities, and encouraging new dunes to establish to offset natural losses (expected to be around 2% or 237 ha over the next 20 years). A range of priority BAP species have significant populations on sand dunes, including plants such as the dune gentian, fen orchid, mosses, and insects such as the bright wave moth. Some dune sites are important for reptiles and amphibians. The natterjack



Blakeney Dunes, Norfolk.
Peter Wakely/English Nature 18,330

toad uses seasonally wet dune slacks for breeding, and is now restricted to a small number of coastal sites. Sand lizards are also associated strongly with dune habitats. For both of these species, action is underway as part of the UK Biodiversity Action Plan to restore populations to their previous range. In addition, recent studies on the Sefton coast have shown that great crested newts also make use of dune pools and dune grassland³². Pilot projects have restored dune areas (previously converted to agriculture) to orchid rich grassland within 10 years³³, although the current rate of restoration will not offset predicted losses.

Sandscale Haws, Cumbria.
Peter Wakely/English Nature 13,595



Embryo dunes. Roger Covey/English Nature



Dune gentian *Gentianella uliginosa* in flower.
N A Callow/NHPA/FL/NCA00046A

In England, much of the 11,897 ha of sand dunes are concentrated into a small number of key locations around Northumberland, Lincolnshire, Norfolk, Kent, Dorset, Devon, Cornwall, Lancashire and Cumbria. There are around 50 sand dune SSSIs, covering over 10,000 ha. Of these, 70% are in favourable condition, whilst the remaining 3,000 ha are in unfavourable condition because of inappropriate management, lack of sediment supply due to coastal defence, and development.

Coastal sand dunes can be affected by anything that changes the natural rate of erosion and deposition of sand. The seaward edge of sand dunes can be highly mobile, which is important in the exchange of sediment between the beach and the dune system. The rate of erosion and accretion of sand at the top of the beach can be changed by beach management such as artificial cleaning of the strandline. Sea defence and dune stabilisation work can also affect sediment supply and sediment exchange. Artificial stabilisation of dunes is particularly a problem of developed coastlines, where shifting sand is seen as a threat to urban or holiday developments. Golf courses, for example, can prevent sand dunes from migrating inland, and their ability to respond naturally to environmental change. Although stabilisation can help to counteract severe erosion, man-made defence systems generally result in lower dune diversity by inhibiting the natural mobility of dune systems, and may result in sediment starvation elsewhere.

English dune systems, landward movement of mobile shifting dunes, where it occurs, is at the expense of older fixed dunes, which are unable to re-establish further inland because of development, or improved agricultural land. The dune system becomes squeezed between the eroding coastline and development or agricultural land. In individual sites this loss can be considerable. Of the 121 dune sites in England, 55% are in retreat, 17% are advancing and 28% are stable³⁴. Too much stabilisation prevents a dune system from responding to climatic influences.



Recreational facilities such as golf courses can fragment or artificially stabilise dune systems. English Nature



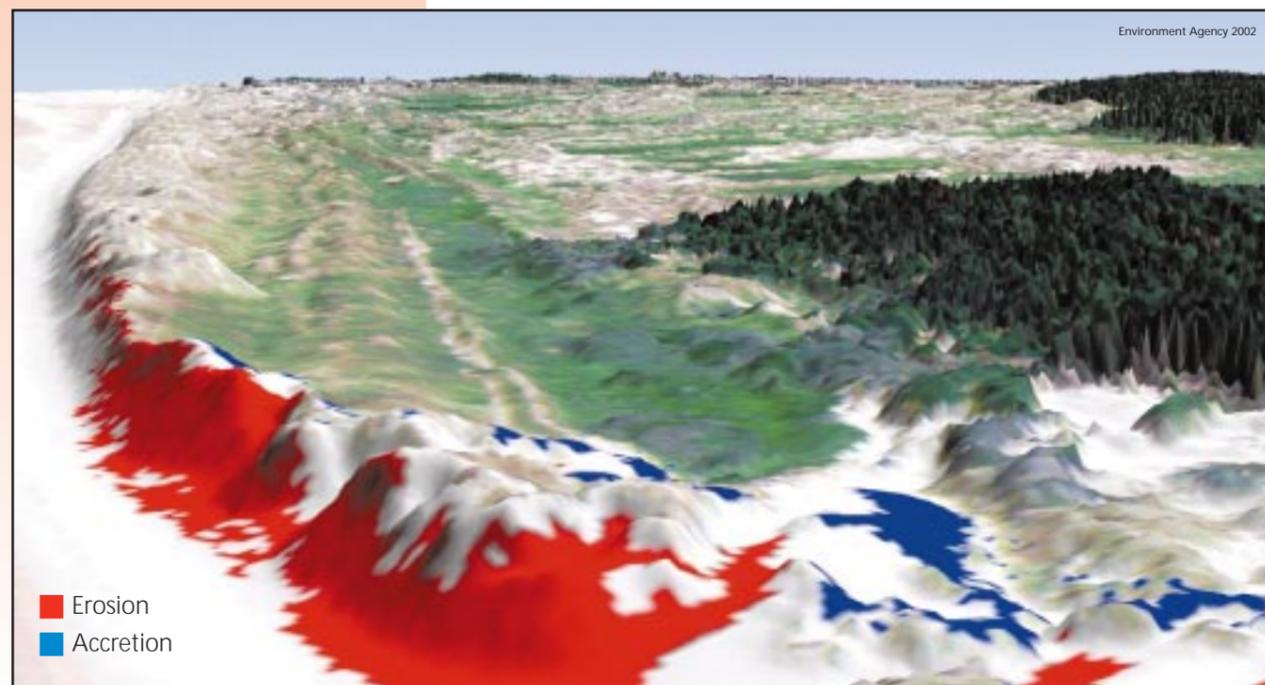
Coastal defences in front of sand dunes. Peter Wakely/English Nature

Sand dune systems are often close to popular tourist beaches. There is extensive human use of dune systems on foot, by motorcycle and four-wheel drive, and there may also be facilities such as car-parking and golf courses. Limited pressure by pedestrians may actually help increase the diversity of sand dune plant communities. High pedestrian pressure, however, such as on heavily-used beach access paths, or vehicle damage, has caused unacceptable erosion of many dune sites. Beach cleaning on key recreational beaches is important, but mechanical beach cleaning reduces the opportunity for new dunes to develop. The development of new golf courses, car parks and other recreational features also causes fragmentation of dune sites, upsetting the natural equilibrium of erosion and deposition. Such developments within the dune system also artificially stabilise the dunes, causing further loss of biodiversity.

Water extraction or drainage, or inappropriate grazing, lowers the water table and dries out damp dune slacks, causing a loss of the wildlife, and reducing the diversity of the dune system.

The loss of sand dune areas is not just a problem for wildlife. Fully functioning dune systems have the capacity to contribute to cost effective coastal defences, absorbing wave energy on the front dune face, and naturally moving, eroding and re-establishing in response to coastal processes.

A 3D visualisation used to highlight where morphological changes are taking place in the sand dune system at Ainsdale Sands, Lancashire.



Very few dune systems in England are in a natural equilibrium, where erosion is balanced by deposition. Most are eroding, mainly due to lack of sediment supply through over-stabilisation of the front dune-face, or through loss of beach sediments¹¹. In a natural environment, dunes are free to erode and migrate in response to natural events. However, in most

Key issues for sand dunes

- Inappropriate stabilisation and loss of sediment supply
- Coastal development
- High recreational pressure in some locations
- Insufficient space to allow dunes to migrate landwards due to development or agriculture



England has a significant proportion of Europe's vegetated shingle, with the largest site being Dungeness in Kent.
Peter Wakely/English Nature

2.1.3 Shingle

Shingle accounts for some 30% of the English and Welsh coastline¹¹. In its most common form, it occurs as a narrow band of beach material that supports strandline plant communities such as sea kale and Babington's orache, which are adapted to the harsh salty conditions and limited water supply. Occasionally, shingle builds to form major structures such as the barrier beach at Chesil, the cusped foreland at Dungeness, and the spit at Orfordness.

Of the 5,130 ha of shingle habitat in the UK, some 4,350 ha occur in England. Around 1,600 ha occur at Dungeness on the Kent coast, the largest English site, whilst only five other sites are larger than 100 ha. The main areas of vegetated shingle are in East Anglia, the English Channel coast, and north-west England. England has a significant proportion of the total amount of vegetated shingle in Europe. Elsewhere in Europe this habitat is largely confined to northern France, Germany and the Scandinavian countries.

Major shingle structures are rare geomorphological features that are of national and international importance, and those that occur in England support much of the European vegetated shingle resource. Shingle is sorted by wave action and thrown up to form a series of ridges and hollows that give it a characteristic appearance, often with vegetation on the ridges and bare ground in the hollows. In the most advanced forms such as at Dungeness, distinct vegetation transitions can be discerned as the ridges age, accumulate humus and improve their water-holding potential. Initial colonisers include yellow horned-poppy and sea pea, followed by grassland and herb-rich communities including sea campion and shepherd's cress. Later still, lichens and mosses often become characteristic.



In addition to their vegetation, shingle coasts are important for seabirds such as little tern *Sterna albifrons*.
E. A. Janes/BI/EAJ04699A

The condition of shingle features depends on the maintenance of a continuing supply of material, generally as a result of movement and re-cycling of the existing shingle resource. The origin and supply of shingle depends on the location. In southern England it is mostly composed of flint arising mainly from reworked Quaternary (ice-age) material transported by long shore drift. In the north west, shingle comes from glacial material transported by rivers. Many of our best shingle sites exist as 'relict' features that have no external shingle supply and rely on re-working; this leads to a gradual loss of the existing material and a reduction in the extent of the shingle feature. However, where coastal processes are allowed to continue, the process of erosion and re-deposition means that the feature is maintained, albeit in a slightly different form and location. Some landward transitional habitats have been destroyed by agricultural improvements and by aggregate extraction, such as the extensive working of shingle at Dungeness in Kent.

In addition to its considerable geomorphological and botanical interest, shingle is important for seabird colonies at Orford Ness, Blakeney Point and Dungeness. England supports 10% of the world's population of sandwich terns, whilst over 60% of Britain's roseate terns occur within just four English SPAs. Furthermore, shingle exhibits unusual thermal regimes that include elevated daytime temperatures and colder night-time temperatures, not dissimilar to desert conditions. As a consequence, the invertebrate communities of some vegetated shingle systems are of considerable importance, and include species such as the Sussex emerald moth, which are at the northern extreme of their European range. Some species, such as bumblebees, rely on both shingle vegetation and adjacent clover-rich grasslands, many of which have been lost as agriculture shifts from pasture to arable.

Currently there are 26 shingle SSSIs, covering an area of just over 3,000 ha. Over half of these by area are in favourable condition, but the remaining 48% of these are in unfavourable and declining condition. This is due to interference with natural shingle movement, or disturbance to plant communities. In recognition of their special plant communities, nine sites have been put forward as Special Areas of Conservation. The UK Biodiversity Action Plan for shingle emphasises the need to manage the existing resource appropriately, and prevent further human damage.

Key issues for shingle

- Manipulation or extraction of material, leading to unnatural and unsustainable shingle structures and loss of geomorphological features
- Disturbance of vegetation and seabird communities through inappropriate activities
- Inappropriate coastal development, leading to costly demands for more coast defence
- Loss of adjacent grasslands to changing agricultural practices

Shingle features are rarely stable in the long term. Many shingle structures, although formed by longshore drift, have adjusted their shape so that drift is now minimal, and some are entering a breakdown phase in the absence of new shingle. During storm events shingle is rolled over the top of the ridge, often covering low lying features, such as lagoons, behind the shingle ridge. Lagoons will disappear as the shingle moves, with new lagoons created in other locations if coastal processes are allowed to operate. With the predicted increase in storminess and sea-level rise due to climate change this natural landward movement is likely to increase. This natural mobility has often been ignored in the past, with industry, power stations, coastal defences and housing being built on shingle structures. They have also been seen as a convenient source of aggregates, and subjected to varying degrees of extraction, disrupting the equilibrium of shingle supply and damaging the internal structure, natural morphology and vegetation. Damage has been caused to shingle structures by moving and re-profiling shingle ridges for flood defence. This makes them prone to catastrophic breaching by storm events. Vegetation is easily damaged by vehicle and pedestrian access, and this can also cause disturbance to nesting and feeding birds with very specialised habitat requirements.

2.1.4 Saline lagoons

Saline lagoons are natural or artificial pools of salt water, partially separated from the adjacent sea. They retain sea water at low tide which may be diluted by freshwater input, or concentrated by evaporation. Lagoonal plants and animals have to be able to adapt to these changes. Lagoons have a restricted distribution in Europe and are relatively uncommon in the UK. England supports four of the five lagoon types found in the UK. Those formed behind shingle ridges (percolation lagoons) are particularly rare elsewhere in Europe. Of the 177 lagoonal sites in England (covering around 1,200 ha) just over half are within existing SSSIs. By area, around 11% of these SSSI's are in unfavourable condition.

The largest saline lagoon in England, The Fleet in Dorset (480 ha), shows many of the characteristics common to other saline lagoons. It is separated from the sea by a shingle bank through which some seawater is exchanged by percolation. Most seawater exchange takes place through a narrow channel at the eastern end of the lagoon. Here salinity is close to that of seawater and reduces to brackish conditions towards the western end, where freshwater influence is greatest. Daily, seasonal and spatial changes in salinity are tough to cope with, often leading to low numbers of species, but those that survive include specialists found nowhere else but saline lagoons³⁵. The latter include a variety of priority UK BAP, Red Data Book and protected species such as several stoneworts (species of aquatic plants), the lagoon sand shrimp, and the starlet sea anemone. Because these species rely on lagoons, their survival is threatened by habitat loss. Lagoons are an important habitat for certain birds, particularly the avocet.

Many saline lagoons in England, particularly those associated with mobile sediments, may be regarded as short-lived (on a geological timescale). The natural process of loss and re-establishment is an important feature in maintaining a mosaic of coastal habitats, but makes it difficult for saline lagoon plants and animals to move from one lagoon to another. Animals and plants can disperse through seawater, but shingle barriers often have a filtering effect on larvae. Alternatively they may be transferred by, for example, birds moving between lagoons. How dispersal takes place is still something of mystery, but chance events may well account for the variation in the communities present in apparently similar lagoons.

The existence and quality of saline lagoons are threatened by a number of coastal activities, not least the interference with coastal processes that



Lagoon formed by a shingle barrier. Shingle Street, Suffolk. Sandy Downie/English Nature



Re-profiling shingle with a bulldozer. Peter Wakely/English Nature

Key issues for lagoons

- Loss of existing lagoons through coastal squeeze
- Lack of lagoon creation through interruption of natural coastal processes
- Poor water and sediment quality as a result of diffuse pollution and/or disrupted water exchange

have moved, destroyed and recreated saline lagoons over time. Some coastal defence works prevent sediment movement, leading to a gradual loss of coastal structures in which lagoons occur, or interfere with crucial water exchange. Conversely, some lagoons have been formed, or protected, by coastal flood defence activities. Sea level rise, although likely to lead to a loss of saline lagoons, may also provide opportunities for creating new lagoons where the sea inundates freshwater areas or low-lying land. It is important to ensure that such opportunities are promoted in shoreline management planning. Communities of plants and animals in lagoons depend on a delicate balance of seawater and freshwater supply. If these are disrupted, the water quality in the lagoon changes and the characteristic plants and animals will not survive. Water quality is another key aspect. Because of their restricted water exchange lagoons are particularly susceptible to build up of nutrients, or other chemical pollutants.

Lagoons are often naturally rich in nutrients, since their limited connection with the open sea encourages the retention of dissolved nutrients. However, relatively low inputs of more nutrients from surrounding land, or the adjacent sea, can cause eutrophication (nutrient enrichment leading to biological change, often undesirable, such as increased growth of algae). This can reduce the light availability to submerged seagrasses and stoneworts, and increased phytoplankton blooms which can produce toxins, or result in oxygen depletion when they decay.

When nutrients enter a lagoon or estuarine system, they can be stored in the sediment. Then starts a cycle of algal growth, based on nutrients from the sediments, algal death, and decomposition putting the nutrients back into the sediments. In such cases the impacts of poor water quality can continue for some time, or become self-perpetuating. Once a certain level of nutrient is reached, detrimental impacts can continue without any further increase in nutrient inputs. The box below gives an example from Australia³⁶; concern has been expressed that a similar process may be occurring in The Fleet³⁷. It is important, therefore, to identify water quality impacts within lagoons as early as possible, and take a precautionary approach to interpreting and acting on suspected impacts.

Nutrients in sediments – the ticking bomb?

Two shallow coastal lagoons in Western Australia suffered excessive growth and accumulation of green algae, and phytoplankton blooms. These were attributed to the use of phosphorous-based fertilisers in the catchment. High winter rainfall caused an influx of nutrients, and water exchange with the adjacent sea was limited.

Low temperatures and light levels limited algal growth during winter, but the nutrients were retained in the system by diatom growth and recycled to the sediment to become available for the benthic algae and phytoplankton in the summer. Modifying fertiliser use in the catchment was unable to restore the lagoon within an appropriate timescale, so a new connection with the sea had to be created to flush the nutrients out of the system. Late recognition of the problem led to a need for more radical and expensive management measures.



Saltmarsh with sea-lavender and glasswort.
Blakeney Point, Norfolk.
E A Janes/NHPA EC/EAJO4850A

2.1.5 Saltmarsh

Saltmarshes form on the upper parts of intertidal mudflats on sheltered coastlines where fine sediment is deposited by the sea. They are occupied by plants that can tolerate periodic covering by seawater. Saltmarshes are typically found on sheltered coasts such as estuaries, inlets and behind barriers such as islands or shingle spits. Most of England's saltmarshes are concentrated in the major estuaries of eastern and north-west England, with smaller areas in the estuaries of the south coast. Because of variation in the sediment type, saltmarshes of the muddier east coast tend to be made up of different species from those of the sandy sediments more characteristic of the west coast. In saltmarshes that are used for seasonal grazing, the species composition may also be affected by the grazing regime.

Saltmarshes change naturally as they develop. Marsh vegetation grows as far as the upper limit of high tide, where it is still periodically covered by saltwater. As tidal water covers the saltmarsh it deposits silt around plant stems and roots, which increases the height of the ground. As more silt is deposited, the marsh is less frequently covered by the sea. Different species of saltmarsh plant have different tolerances to saltwater. As sediment accumulates, the marsh becomes higher, and the vegetation at a certain location will change reflecting the zonation of saltmarsh, typically in four



Saltmarsh forms in estuaries and behind barrier islands such as here at Scott Head National Nature Reserve in north Norfolk. Peter Wakely/English Nature 9,362

main zones: pioneer, lower, middle and upper saltmarsh. The upper saltmarsh zones include species that produce colourful displays of flowers, such as sea-lavender, thrift and sea aster, as well as nationally rare species such as matted sea-lavender or sea-heath.

In 1999, England had 71% of the total saltmarsh area of the UK¹¹, some 32,500 ha, the majority of which is within SSSIs. Some of these sites have been recognised as being of international importance, and have been submitted to the European Commission as candidate Special Areas of Conservation for their saltmarsh communities. In addition, many sites are included within Special Protection Areas because of their importance for birds, as roosting, feeding or nesting areas.

Around one quarter of the saltmarsh (by area) in these designated sites is in unfavourable condition. The reasons for this decline range from coastal defence works, to erosion as a result of rising sea level. If losses continue at present rates, without further re-creation, the targets agreed in the UK Biodiversity Action Plan for saltmarsh will not be met.

Natural events can affect the development of saltmarsh. For example, storms may change the wave exposure of an inlet by removing offshore barriers, resulting in saltmarsh erosion. Long-term changes in the deposition of sediments in an estuary may erode saltmarsh from one area, while marsh development takes place in another.

In addition to these natural changes, where they occur, are changes caused by human activities. The natural succession of saltmarsh is affected by changes to sediment supply (for example by the effects of dredging and dumping of dredge spoil), damage from grazing, changes in wave action (for example by coastal defence work) or more directly by reclamation for development or agriculture. Alongside these are the changes caused by changes in sea level, resulting in the erosion of saltmarsh, often with limited potential for the marsh to migrate landward because of sea defences - a situation known as coastal squeeze.

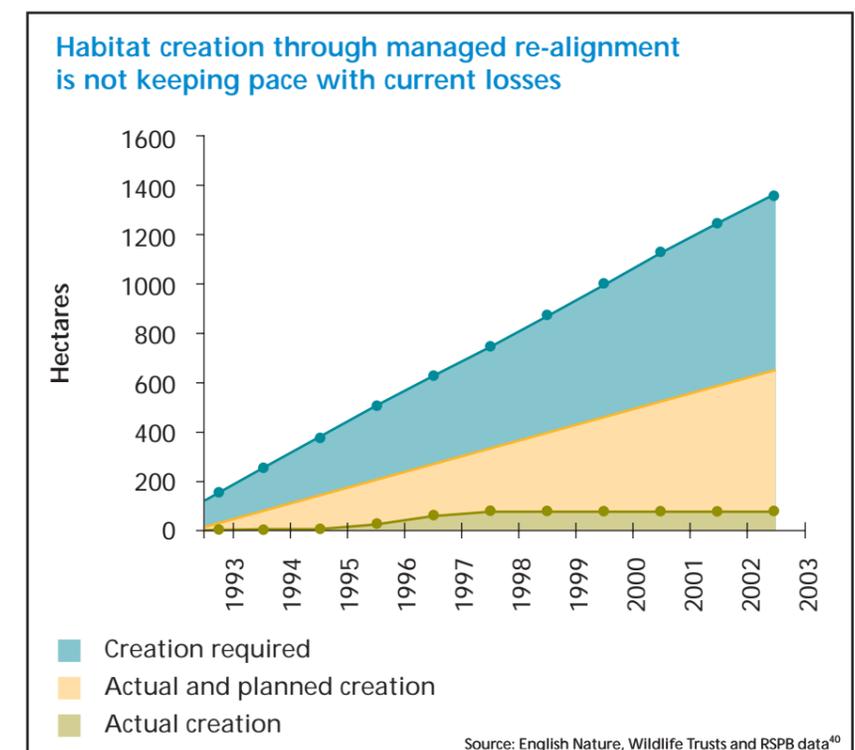
Historic losses of saltmarsh have been massive, although in some areas there have been gains, particularly where the hybrid cordgrass *Spartina anglica* has colonised. Monocultures of *S. anglica* have long been perceived to be a problem where it invades over mudflats. In such situations it may reduce the extent of intertidal mudflat available to feeding wading birds. Control measures have usually been unsuccessful. There is some evidence from recent survey work carried out for English Nature and the Countryside Council for Wales, on the Dee and Severn estuaries, that previously extensive areas of *S. anglica* have undergone succession to other forms of saltmarsh, demonstrating its role as a pioneer species³⁸. In other areas *S. anglica* has been dying back, although the causes of this are not understood.

Saltmarshes have been claimed for agricultural land since the Middle Ages, being enclosed and drained for use as grazing marsh. However, since the 1940s most grazing marshes have been improved for arable crops, so that many saltmarshes are now directly next to arable farmland, and the upper and transitional saltmarsh communities have been lost. Over 800 ha of saltmarsh were converted to agricultural use in The Wash between 1970 and 1980¹¹. Although large-scale land claim for agriculture use is now rare, smaller scale losses such as for port developments or industry continue to have a cumulative effect, along with losses due to sea level rise and interference with natural coastal processes. Saltmarsh loss between 1973 and 1998 has been calculated for a number of East Anglian estuaries. These figures show that in some estuaries the rate of loss increased through the 1990s, compared to the period 1973 to 1988. Of these losses, around 5% (around 19 ha) can be attributed to reclamation, primarily for port developments, whilst the remaining 95% are due to erosion³⁹, most likely as a result of coastal squeeze and loss of estuarine sediment.

Creation of new habitat by realigning sea defences and allowing sea water to flood historic areas of land claim is not keeping pace with current losses. The UK Biodiversity Action Plan for saltmarsh suggests that creation of around 100 ha per year is needed to keep pace with current losses, with a further 40 ha per year for fifteen years to replace the 600 ha lost between 1992 and 1998. In total, since 1992 around 150 ha of managed realignment has taken place⁴⁰, with plans for a further 700 ha of which only a proportion may become saltmarsh in the future, and will take time to achieve the quality of habitat to merit SSSI designation. The gap between habitat re-created and the action needed is growing, so there is a need for more determined action.

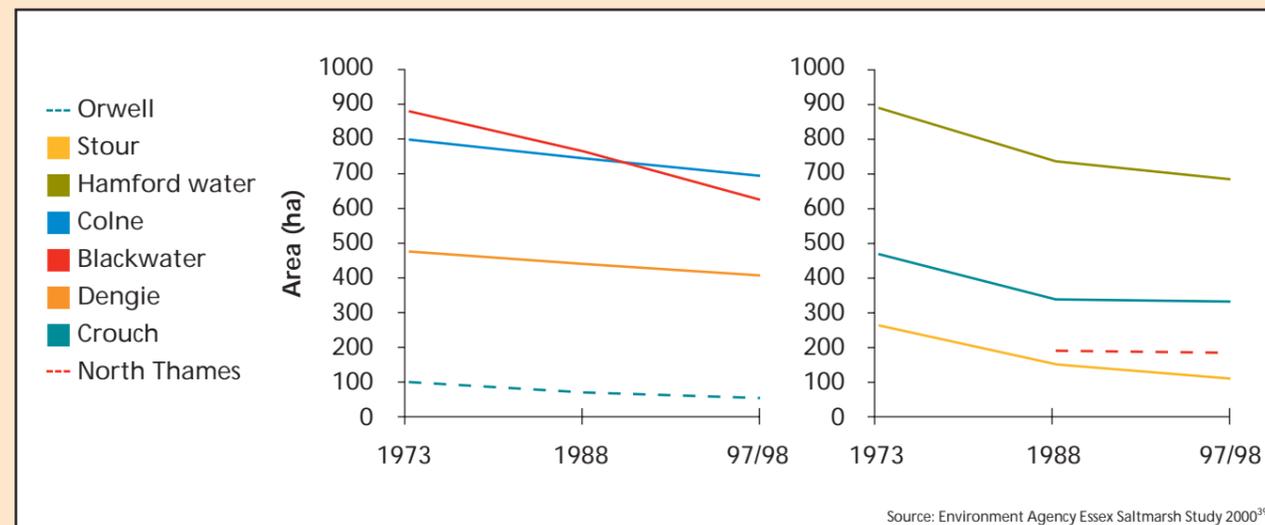


Managed re-alignment is starting to restore saltmarsh and mudflats. But current rates of habitat creation are not keeping up with losses. Tollesbury, Essex. Carol Reid/English Nature



The declining area of saltmarsh in Essex estuaries³⁹

	Area (hectares)			Area (and percentage) lost	
	1973	1988	1997/8	1973 to 97/8	1988 to 97/8
Orwell	100	70	54	46 (46%)	16 (23%)
Stour	264	148	107	157 (59%)	41(28%)
Hamford Water	876	765	621	255 (29%)	144 (19%)
Colne	792	744	695	97 (12%)	50 (7%)
Blackwater	880	739	684	5197 (22%)	5 (7%)
Dengie	474	437	410	64 (14%)	27 (6%)
Crouch	467	347	308	159 (34%)	40 (11%)
North Thames	No data	197	181	No 1973 data	16 (8%)
TOTAL	No data	3447	3060	No data	339 (10%)



Key issues for saltmarsh

- Loss due to coastal squeeze against sea defences
- Loss due to land claim for development
- Low level of habitat re-creation to offset previous and current losses



Estuaries are an important coastal habitat, with high conservation value even adjacent to industrial areas. Mersey Estuary. David Woodfall/NHPA EC/DW004169A

2.1.6 Estuaries

Estuaries are the largest coastal habitat resource in England, covering nearly 400,000 ha. For many, estuaries represent the last wilderness areas around our coast - tranquil, mysterious places where the cries of wildfowl penetrate early morning mist rising off the mudflats exposed by the low tide. In reality estuaries, and the wildlife they support, are amongst our most threatened maritime habitats. Where they are relatively undeveloped, they are seen as the last remaining source of development land for extensive port developments, storage areas and industry. It is estimated that around one third of the estuarine habitat in Britain has been land-claimed since Roman times, and the loss has continued, due to large developments, and the cumulative effects of numerous small scale projects. Some estuaries, such as the Tees Estuary in north-east England, have lost up to 90% of their intertidal mudflat, saltmarsh and brackish/freshwater marsh habitats⁴¹. This is made worse by changes in sea level, causing further loss of intertidal habitat. Also, estuaries are conduits from rivers to the sea, receiving contaminants from the land, along with pollutants from adjacent industries, which are deposited in soft sediments.

Although England's estuaries have been extensively changed by human activities, they still remain productive habitats, with a diverse range of wildlife. The challenge now is to keep the pressures manageable, avoid new pressures, and seek to restore some estuaries where damage has occurred.

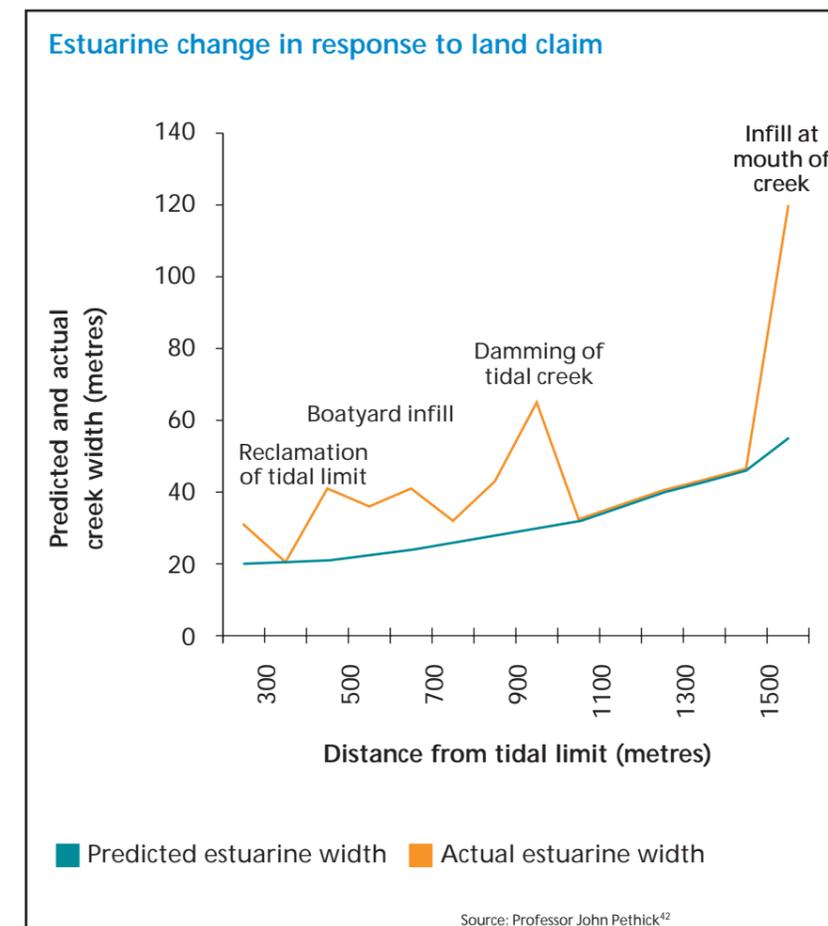
The most important features of an estuary are the change from fresh to saltwater, the presence of a range of brackish/freshwater interfaces in the adjacent marshlands, and the low wave energy, which allows the development of extensive and productive mudflats and saltmarshes. At the top of a natural estuary, most of which have now been truncated by land-claim or sluices, the water is mostly riverine. Plants and animals find this area extremely difficult to inhabit - at one time they may be living in freshwater, six hours later they may be in saltwater. Nearer the sea, estuaries normally become wider, with a shallow central channel, with more extensive mudflats on either side. These mudflats are highly productive, with large numbers of worms, shrimps and molluscs (invertebrates) providing abundant food for wading birds. On particularly rich mudflats the food available to wading birds in a square metre of mud is estimated to provide the same energy as contained in a Mars bar. When the tide is in, and the mudflats are covered by seawater, they form an important food source for fish, which are able to feed on the invertebrates that emerge from the mud to feed. Many fish pass through estuaries on their way between river and sea, including rare species such as shad. Estuaries are also important nursery grounds for many commercial fish. At their mouth, estuaries typically broaden, and the influence of the sea is greatest, so that only fully marine plants and animals can survive.

Waders feeding on sandbanks and mudflats, Liverpool Bay.
Alan Williams/NHPA/BI/AWI001490A



In England, estuaries may be divided into four physiographic types: rias, coastal plain estuaries, bar-built estuaries, and complex estuaries. Of all estuary types, bar-built and coastal plain estuaries are the most common, making up around 74% of the number of estuaries in England⁴¹.

The shape and dimensions of an estuary evolve over a long time in equilibrium with the amount of water entering the estuary at high tide. All estuaries are constantly changing. Estuarine equilibrium has been likened to a water bed: push down on one end, and the water rises in the other. In the case of estuaries, building on the estuary in one place will make it try to expand in another, resulting in erosion of mudflats or salt marsh and leading to pressure for coastal defences.



An unpublished study into the morphology of Polbathic Creek⁴² (part of the Lynher estuary in Cornwall) shows the effect of infill on estuarine areas. Where there is no infill, the estuary conforms to a predicted width, but where infill has occurred, the estuary has eroded adjacent areas in order to compensate for the volume lost to the infill. In populated areas, infill and consequent erosion may lead to pressure for coastal defence or an increased risk of flooding during surge tides.

There are 46 estuarine SSSIs, covering 100,000 hectares of estuarine habitat, predominantly mudflat, although including some saltmarsh. By area 24% of these SSSIs are in unfavourable condition, due to issues ranging from water quality and development, to erosion as a result of sea level rise.

England has nearly 20% of Europe's Atlantic and North Sea estuaries, giving us a clear international responsibility to conserve estuarine habitats. There are currently eight estuarine candidate Special Areas of Conservation, and 32 Special Protection Areas which include estuarine habitat, with further proposed SACs and SPAs under consideration.

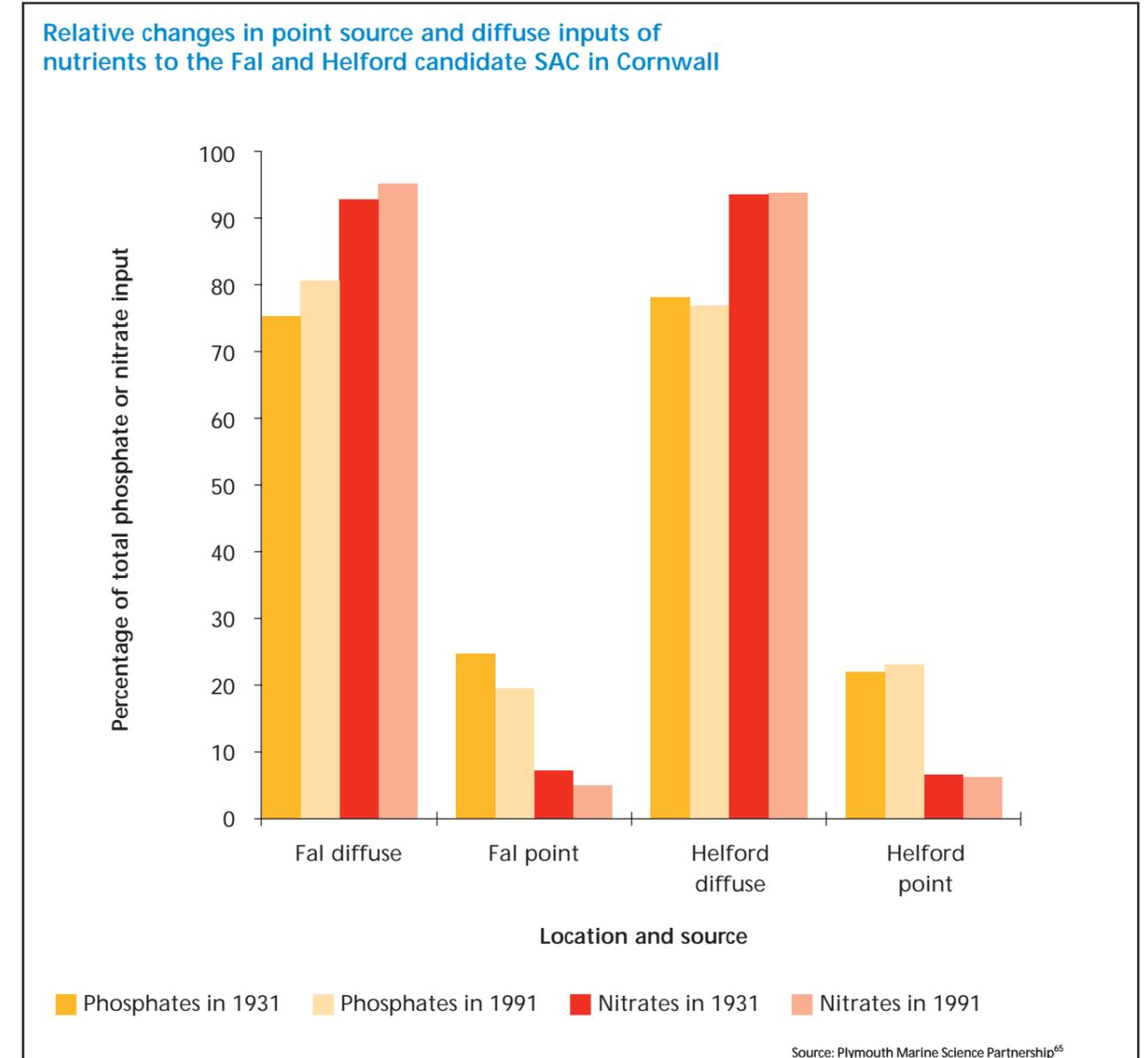
Estuaries are a finite national wildlife asset that is still being lost. There are direct losses due to development, and more wide-ranging impacts caused by constraining a dynamic feature with inappropriate hard sea-defences. For example, in Essex alone, 'coastal squeeze' of the intertidal zone between rising sea level and the inflexible sea defence line has caused the loss of 1,000 ha of saltmarsh in the last quarter of the twentieth century - 25% of the previous total area³⁹. Any long-term management must halt and reverse the current rate of direct loss, and allow estuarine geomorphological processes to function as naturally as possible, if sustainable coastal and flood defence solutions are to be found. This will include halting losses caused by sediment starvation as a result of unsustainable maintenance dredging of shipping channels, and inappropriate coastal defence that inhibits or stops the natural sediment supply.

Managed realignment provides an opportunity to recreate saltmarsh and mudflat habitat by removing sea walls, allowing an estuary to return to a more natural form. However, we should recognise that this does not create additional new habitat, but starts to compensate for some of the previous losses. Additionally, whilst retreat sites show that it is possible to restore intertidal mudflat and saltmarsh communities, the physical characteristics and environmental value of restored habitats are likely to be different from adjacent, naturally occurring, habitats. English Nature in partnership with others is studying the value of habitats created during managed realignment of coastal defences to assess their contribution to maintaining biodiversity⁴³.

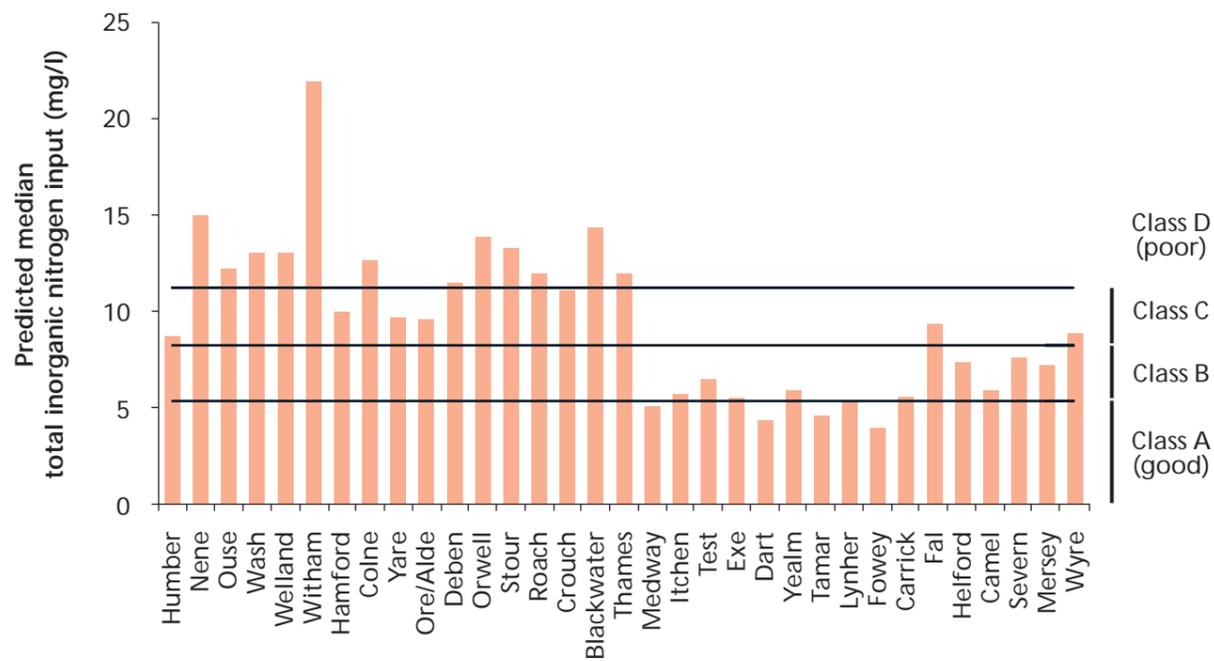
The UK Biodiversity Action Plan commits to the production of sufficient mudflat habitat to offset losses due to rising sea levels. This will require the restoration of around 1,000 ha/per year of mudflat over the next decade in England. Innovative measures for encouraging habitat creation will be needed if the UK is to reverse past losses, as well as keep pace with losses due to rising sea level.

Water quality is a concern in many estuaries⁴⁴. In general, water quality is improving due to more stringent controls on point source discharges. However, there are increasing problems from diffuse sources of pollution such as nutrients, and there are still problems in estuaries with an industrial past from contaminants within the sediment. These may be

stirred up during development or dredging operations, or because of changing patterns of sediment deposition and erosion. Run-off from land within the catchment delivers a cocktail of chemicals (principally nutrients from agricultural fertilisers and manure⁴⁵, but also pesticide and herbicide residues) to estuarine waters. The National Marine Monitoring Programme concluded that many industrial estuaries appear to be polluted to an extent which could be harmful to plankton, which form the basis of the marine food chain and an important life stage for many species of conservation and economic importance. They suggested that it was likely the effects were due to several contaminants acting together⁴⁶. More effort will be needed to address all sources of contamination, including changes in farming practices and urban drainage, and research into the safest way of dealing with sediment contaminants.



Nitrate classification of selected estuaries (from Cole et al 1999)⁴⁵



Key issues for estuaries

- Poor water and sediment quality from diffuse and some point source inputs
- Loss of habitats due to coastal squeeze against sea defences
- Loss of habitats due to inappropriate development and land claim
- Maintenance dredging, removing sediment and disrupting estuarine equilibrium



Activities such as bait digging can be detrimental to wildlife at certain times of the year, or in popular areas. Paul Kay/MWPA

Unsustainable recreational activities, or exploitation such as wildfowling or bait digging, are a cause for concern in some estuaries. At low levels, these activities are unlikely to have a detrimental impact on wildlife, but at high levels, such as persistent bait digging, or collection of crabs over large areas of an estuary on consecutive low tides, disturbance and habitat damage can cause a long-term decline in a range of wildlife. At certain critical times, such as during cold weather, or breeding seasons, even low levels of disturbance can have a serious impact.

2.1.7 Sandy and muddy seashores

Outside estuaries there are muddy sediments wherever there is sufficient shelter from wave action, such as behind islands or towards the top of extensive intertidal flats. At first glance, sandy or muddy shores appear relatively devoid of marine life. However, beneath the surface are animals adapted to life in the sediment.

Mudflats support rich invertebrate communities, which provide an important food source for wading birds and fish. Surface plants such as sea grass or seaweeds such as gutweed *Enteromorpha* spp, help to stabilise the sediment, reduce erosion, and provide food for large numbers of birds such as Brent geese.

Sandy beaches are characteristic of much of the coast of England, either covering the whole beach, or as a limited area of the shore alongside other habitats such as shingle or rock. Sand, rather than mud, is deposited where there is greater wave exposure, or lack of fine sediment input, so that only the larger sediment grains are deposited on the shore. Many sandy beaches are highly mobile, with sand being removed by winter storms, and re-deposited in early summer. Some changes can take place over longer timescales: for example sand can appear one year, disappear for a while, then reappear some years later. Plants are unable to survive on highly mobile sandy beaches. However a specialised community of sand hoppers can survive on the upper shore, while surf clams, razor shells and heart urchins can thrive towards the bottom of the shore⁴⁷. Towards the top of the shore, the coarse grained sediment dries quickly as the tide goes out, making it a difficult place for marine animals to survive. However, the dry sand may be blown to develop sand dunes above the high tide mark.

With increasing shelter, finer sediments are deposited, consisting of a mixture of sand and mud. These mixed muddy-sand sediments contain probably the most varied marine sediment communities, with the most diverse being in muddy gravels, although the sheer number of individuals is higher on mudflats. Muddy sands are characterised by diverse communities of worms such as lugworm and ragworm, along with shells such as Baltic tellins.



Sand blowing along beach. Paul Glendell/English Nature 24,182

Key issues for sandy and muddy seashores

- Loss of habitat through coastal squeeze and interference with natural coastal processes
- Sediment extraction in some locations
- Poor water and sediment quality

Muddy and sandy beaches are subject to a range of threats and disturbances. On specific sites activities such as bait digging, if carried out at critical times, or to a great extent, can cause major disturbance and damage to wildlife. Similarly, disturbance by recreational walkers or dogs at critical times can disturb bird populations, forcing them to feed in other locations or at other times of the day which are less favourable. Shifting patterns in recreational activity, such as an increase in kite flying or buggy riding, will increase this disturbance.

Mobile coarse sand beaches are less prone to damage and disturbance as they are naturally disturbed by wave action. Large changes to beach structure and sediment supply can result from coastal defence works, or sediment extraction elsewhere. Solid coastal defence structures at the top of sandy beaches may cause wave energy to be reflected back onto the beach, eroding sediment and lowering beach levels. This leads to even more wave energy reaching the sea defences, more energy being reflected back, and further lowering of beach levels until in many cases the sea defences are undermined, or the sand disappears from the beach entirely. Sand extraction continues at a number of beaches, such as the Ribble Estuary in north-west England.

Lugworm *Arenicola marina* mounds in sand.
Roger Covey/English Nature



Coastal defences on chalk shore, Thanet, north-east Kent. Much of the chalk cliffs of Kent and Sussex have been modified by coastal works that prevent coastal processes from operating, and destroy the communities of plants and animals.
Chris Pater/English Nature

2.1.8 Rocky shores

The nature of rocky shores depends greatly on their geology and wave exposure. Hard rocks such as granite erode slowly and have fewer crevices and pools than rocky shores of slate or shale. Chalk shores occur around Flamborough, Norfolk, Kent, Sussex, the Isle of Wight and Dorset, and are extremely rare throughout Europe. England has around 57% of the European coastal chalk¹¹, and contains many of the best examples of chalk shore habitats. Because chalk is soft and erodes easily, it supports an unusual collection of plants and animals, including shells and sponges that bore into the rock, and green seaweeds that are found on no other rock types⁴⁸.



Rocky shores show a zonation of plants and animals. Fal and Helford candidate Special Area of Conservation.
Roger Covey/English Nature

All rocky shores show a zonation of plant and animal communities. At the top of the shore, only plants and animals that can cope with drying for up to 10 hours survive. These include maritime lichens, seaweeds such as channelled wrack, and animals such as the small periwinkle, which can hide away in crevices. Lower on the shore, plants and animals are not uncovered for such a long time at low tide, so a wider range of species are present including bladder wrack, egg wrack, anemones, limpets and a range of periwinkles and topshells. Towards the bottom of the shore, which the tide only exposes for around two hours at a time, plants and animals more typical of the shallow underwater environment can gain a foothold. These include the kelps, a range of sponges and seasquirts, and often fish such as blennies and gobies under boulders or within crevices. The typical zonation pattern can be changed by a number of factors. Rockpools allow different plants and animals to colonise the shore, crevices and fissures provide damp hiding places, and the under surfaces of boulders can be colonised by a range of starfish, urchins, seasquirts and sponges.



Rocky shores are generally robust, and suffer little from human activities such as recreation or disturbance. Some heavily visited sites suffer disturbance from excessive rockpooling, or turning of boulders to search for marine life⁴⁹. Such high levels of disturbance are a cause for concern at some locations.

More concerning is the destruction of particular rocky shore communities by developments such as coastal defences, or intertidal structures such as slipways and jetties. Many of the specialised upper shore and splash zone seaweed communities on chalk shores have been covered by concrete sea defence structures. Elsewhere, a proliferation of small-scale developments are resulting in a continual loss of natural foreshore⁵⁰. Rocky shores adjacent to ports, harbours and marinas are still impacted by tributyltin (TBT) antifouling paint, with dogwhelks being either completely absent, or reduced to extremely low numbers⁵¹.

Rocky shores have been shown to be very sensitive to climate change⁵², with a balance between northern (cold water) or southern (warm water) species of barnacles, limpets and topshells. Monitoring of these changes, is being undertaken by MarClim, a four year consortium-funded project led by the Marine Biological Association of the UK, which will give a measure of the way climate change is affecting marine wildlife.

2.2 Marine habitats and species

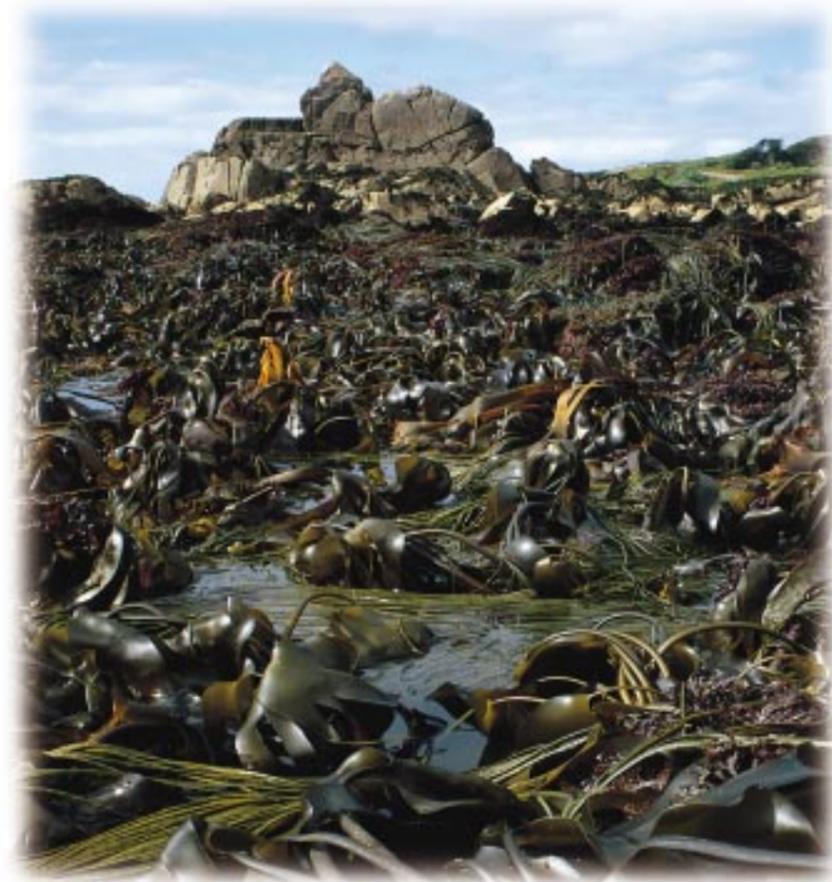
Out of sight and out of mind, the sea around England is a valuable resource that we have taken for granted, in spite of the fact that we use marine habitats to provide food, for recreation and building materials. We also rely on it to help regulate our maritime climate.

The richness of marine life around our shores is frequently overlooked by a population fed colourful images of tropical reefs by the media. Because our northern waters are not clear, shallow and warm, our underwater life is less visible to people. Around England, diving is a specialist sport, whereas in warmer waters it is a more popular leisure activity. Thus most people do not realise we have our own soft and hard corals, dense forests of kelp, and extensive areas of seabed sediments. Our underwater biodiversity is equally as important and colourful as that of warmer waters. Only since the invention of the aqualung have we begun to study the seabed in the same way as terrestrial ecologists have studied the land. This recent start partly accounts for our ignorance of many to the riches of our seas, and of the damage we have done to them. Our knowledge is increasing. Projects such as JNCC's Marine Nature Conservation Review have described the distribution and conservation importance of habitats and species in our inshore waters⁶. The UK Marine SACs project developed our understanding of how these habitats should be managed to improve the prospects for biodiversity⁵³.

Because our knowledge of the underwater environment is less detailed compared to our knowledge of coastal maritime habitats, we describe the environment in broader terms. Underwater sediments, which by area cover the largest proportion of the seabed. Underwater rock, which typically fringes the coastline, extending offshore to varying degrees, particularly around rocky islands such as the Farne Islands in the north-east of England. And finally the open sea, home to wide-ranging populations of animals such as whales, dolphins and fish, but more importantly, supporting the plankton which drive the whole marine food chain.

Key issues for rocky shores

- Cumulative habitat loss from development or coastal defences
- Poor water quality in a number of locations
- Climate change



Kelp forest at low tide.
Roger Covey/English Nature

Non-native species and novel 'genetically modified' organisms: a threat to the genetic diversity of marine ecosystems

Threats to maritime ecosystems are not limited to the more obvious impacts, such as fishing, pollution or coastal development. Of equal concern are the threats and impacts arising from the introduction of non-native species or novel 'genetically modified' organisms.

Non-native 'introduced' species

Non-native species can reach our waters through activities such as shipping or shellfish cultivation. A recent review conducted by JNCC described 14 species of marine algae, five diatoms, one angiosperm and 30 invertebrate species that established themselves in the seas around the UK between 1889 and 1996⁵⁴. The threats they pose to maritime ecosystems are due to the risk of interbreeding with native species (eg *Spartina anglica* in saltmarshes), their potential for smothering or displacement of native species, possible predation of native species, or because they adversely affect the resilience and functioning of ecosystems by reducing biodiversity. So far in the UK, the effects of introductions have not been as detrimental as elsewhere in the world. The International Maritime Organisation is developing mechanisms to try and prevent further introductions arising from ship ballast waters.

Despite such efforts, recent introductions reaching our coasts include:

- Japanese kelp, first recorded from the Hamble estuary in 1994, probably introduced on ship's hulls. This species has now spread along the south coast. The predominant effect it can have is to displace native species⁵⁴.
- An introduced species of seasquirt, first recorded in Plymouth Sound in 1999, has now spread east to The Fleet and west to Milford Haven.
- A Pacific species of jellyfish, believed to have been transported on ships hulls, was responsible for the destruction of £3m worth of Scottish farmed salmon in summer 2002.⁵⁵

Novel 'genetically modified' organisms

The creation and release of novel 'genetically modified' organisms poses a serious threat to our maritime biodiversity. Genetically engineered salmon, which grow quicker and larger, are currently found in North America. Efforts at modifying other organisms could now go far beyond that, but are still at an experimental level. Over the next few years developments are likely to include genetic modifications to fish for increased pest and disease resistance, increased tolerance to low temperatures, and tolerance to saltwater. Carp, for example, could then be farmed in marine waters; and low water temperatures would no longer restrict salmon growth. Research efforts globally are focusing on introducing salt and drought tolerance into grasses and trees so they can be used in harsh estuarine and marine environments. Such developments could increase the disruption of maritime ecosystems unless rigorously regulated to high worldwide standards.

Protecting genetic diversity: awareness and risk assessment

Two principal actions are required to safeguard the genetic diversity of our maritime ecosystems.

- Awareness. Without good knowledge of likely problems it is difficult to develop effective strategies to tackle them. There is almost certainly greater awareness of the possible impacts of non-native species than developments in genetically modified organisms, and yet the latter have the potential in the near future to threaten maritime biodiversity.
- Comprehensive and consistent risk assessment on the introduction of novel genetically modified organisms and non-native species into the seas around our coasts. Given the inherent linked nature of the seas, risk assessment needs to operate both at a national and European level. The independent Advisory Committee for Releases to the Environment (ACRE) needs to develop its role in promoting awareness, and become more proactive in safeguarding the maritime environment from such potential threats.



Seagrass grows in shallow water sediments, stabilising sand and providing an important habitat for other species. JNCC

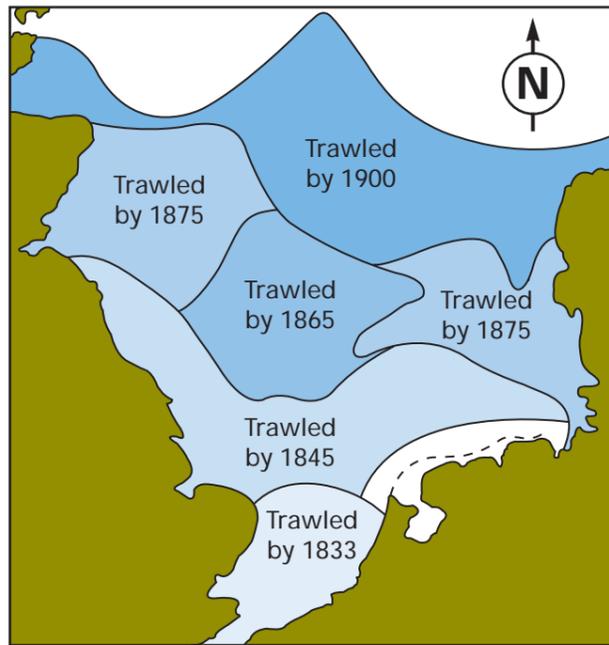
2.2.1 Underwater sediments

Much of the seabed around England consists of sediments, varying from coarse gravel and sand in areas of high current speed or wave action, through to soft mud where there is little natural disturbance. Much of the material arises either from glacial deposits, reworked by wave or tidal action, or inputs from rivers which are redistributed by waves, tides and currents.

Communities living in sediments depend largely on the nature and stability of the seabed, which in turn is affected by depth, wave action and tidal streams. Extensive areas of gravel are found around south-eastern coasts and in the English Channel. These areas are generally stable, with tidal currents preventing the deposition of fine sediments and keeping the gravel surface clear. Because of this lack of surface sedimentation, and the presence of larger pebbles, a range of plants and animals can get a foothold on the seabed. These include plant-like animals such as hydroids and anemones, and in shallow water, seaweeds such as the sea oak. Between the stones are worms such as the peacock fan worm, and the sand mason worm. The seabed may be further stabilised by 'ross worm' *Sabellaria spinulosa* forming low reefs or crusts of sandy tubes, which 'cement' stones and gravel together. Moving around on the sediment surface are commercially important species such as crabs and scallops. Sandier and muddy seabeds lack the larger material for hydroids and seaweeds to settle, apart from isolated empty shells. Surface life is therefore limited, but a range of animals burrow into the sand, such as burrowing anemones and worms, shells and sea urchins. On the sediment surface are mobile animals such as starfish, crabs and scallops and a range of fish such as plaice and sole.

Plaice *Pleuronectes platessa* camouflaged on sea bed. Roy Waller/NHPA/FIRWA00321A





Map showing the expansion of trawling effort into the North Sea, demonstrating that habitat disturbance has existed since 1900 over all parts of the North Sea⁵⁹

Source: Redrawn from Jennings, Kaiser & Reynolds, 2001. Marine Fisheries Ecology. By permission of Blackwell Science



Larger boats and more powerful engines mean heavier fishing gear, such as these scallop dredges, can be hauled over the seabed. Paul Knapman/English Nature

In shallow sandy sediments, beds of seagrass (the only truly marine flowering plant) can exist, stabilising the sediment, increasing species richness and providing a nursery ground for spawning and juvenile animals⁶⁶. With increasing depth, there is a decrease in the effect of wave action and fine muddy sediments predominate, forming a very soft seabed. Into this soft mud burrow a range of creatures such as the Dublin Bay prawn, which is trawled to provide scampi, other shrimps, and a wide range of worms and molluscs.

There are many human impacts on seabed sediments⁴⁷. England, particularly the south-east, relies on a constant

supply of marine sand and gravel from licensed extraction areas in the nearshore coastal zone, primarily off East Anglia, Kent and Sussex. In spite of increases in the efficiency of aggregate use (efficiency has increased by around 30% over the past ten years) there is still a need for around 250 million tonnes of aggregate per year, of which 50 million tonnes comes from recycled sources, and around 23 million tonnes from marine sources. Around half of this marine aggregate is used for the construction industry, with the remainder used for beach nourishment or exported to adjacent areas of Europe.

Large-scale extraction of marine aggregates is a relatively recent activity, developing as new technology has enabled the resources to be exploited. In the past five years, the area licensed for extraction 0-12 miles offshore has reduced, whilst the area licensed for extraction beyond 12 miles offshore has increased⁵⁷. These changes reflect the fact that inshore areas have mostly been exploited, and areas further offshore are now being targeted. Currently around 7-10 years' aggregate supply is left in inshore areas around East Anglia and in the Thames estuary, prompting investigations into extraction further offshore in the mid-eastern English Channel area.

Despite evolving and improved management, it is inevitable that aggregate extraction will have an impact on the seabed and its wildlife, although efforts are made to minimise this as much as possible. Such localised effects include the temporary and perhaps permanent loss of some aspects of marine biodiversity within the extraction area, coupled with physical changes to the seabed that may last for some time. Further research into the effects of extraction are being undertaken by the British Marine Aggregate Producers Association and The Crown Estate, as part of a rolling review of the areas licensed for marine aggregate extraction.

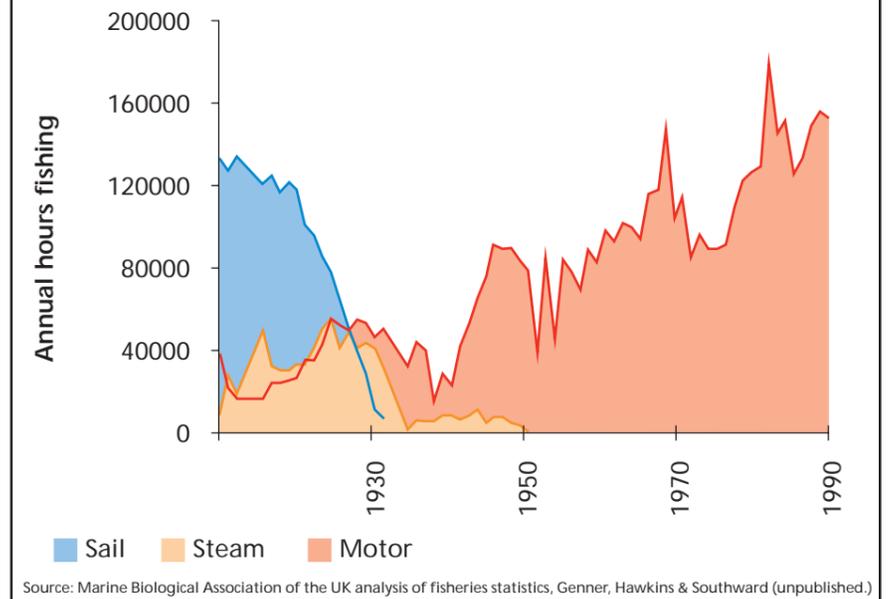
Fisheries have widespread effects on seabed sediments, with many types of towed fishing gear designed to scrape the surface of the seabed during fishing. The seabed and animals that live there are disturbed, damaged or killed⁵⁸. Fishing gears that are designed to drag on the seabed can remove animals that provide food, or damage areas that form refuges for many species. Different fishing gears cause differing degrees of damage to the seabed⁵⁸. Beam trawls and scallop dredges are designed to scrape through

the surface layers of the sediment. Beam trawls' 'tickler' chains ensure that fish swim up from the bottom to be scooped up by the net, and help to keep the trawl on the sea bed whilst it is being towed. Beam trawling effort in the North Sea is very patchily distributed as fishermen concentrate their effort in grounds that yield good catches. Some areas are visited over 400 times per year, while others are never fished^{60,61}. Within intensively fished areas there may be long-term changes in the benthic community, but attributing change to fishing activities, rather than other natural processes and human activities, is problematic for all but the most obvious cases.⁶² It is likely that most of the North Sea sediment communities are now characterised by fast-growing opportunistic species which can survive repeated disturbance, or fast moving scavengers which feed on the damaged animals left behind after the passage of fishing gear. As can be seen in the accompanying illustrations, such impacts from fishing gear have been a feature of much of the North Sea (as well as the English Channel) since the beginning of the twentieth century⁵⁹, with the intensity of fishing effort noticeably increasing with the advent of motor trawling since the 1940s. With this historic level of fishing, it is difficult to find baseline data to demonstrate how the North Sea looked without fisheries impacts, although we can gain useful data from historic records and preserved laboratory samples.

The other widespread impact on seabed sediments is the effect of contaminants which can become bound up with mud and sand. Historic inputs of persistent substances such as heavy metals and organic compounds have left a legacy of contaminants. Many of these contaminants have been transported long distances from their original source or concentrated due to natural sediment transport mechanisms⁶³. Some inshore areas of underwater sediments contain heavy metals such as cadmium, lead, mercury and copper, particularly areas adjacent to previous discharge and disposal sites⁶⁴. Improved standards have reduced or removed inputs of some of these chemicals, but there are still effects from cocktails of contaminants, or new substances whose effects are as yet poorly understood. Sometimes even measures to improve the environment can have unforeseen side effects on recovery, for example where improving water quality leads to sediment contaminants being drawn back into solution⁶⁵. Improved prediction of the likelihood of such effects will allow remedial action to be taken.

Long term data from the Irish Sea shows that there are early signs of eutrophication, most likely as a result of nutrient inputs from rivers and industrial discharges⁶⁶.

Fishing effort by demersal trawlers in the English Channel 1919-1990, showing increase in fishing effort



Source: Marine Biological Association of the UK analysis of fisheries statistics, Genner, Hawkins & Southward (unpublished.)

Key issues for underwater sediments

- Fishery disturbance to populations and seabed habitats
- Poor water quality, leading to sediment contaminant loading
- Aggregate extraction



In shallow water, rock surfaces are covered by kelp. Deeper, where there is less light, animals such as dead man's fingers cover the rock. JNCC

2.2.2 Underwater rock

Rocky cliffs and shores fringe much of our coast, and extend to varying degrees underwater. On some coasts, such as around the south-west or the north-east, the rocky reefs extend deep underwater, and the submerged scenery can be every bit as dramatic as that above water, with rocky pinnacles coming to the surface, deep canyons, and open rocky surfaces. Elsewhere, for example off the East Anglian coast, underwater rock exposures are extremely rare, and the seabed is typically made up of sand or mud. Although rocky reefs can appear robust and resilient, the communities which live on them can be delicate, particularly in areas which are sheltered from strong wave action.

Rock communities underwater vary with depth (due to light intensity), wave exposure, currents and rock type. Typically, rock surfaces in shallow water are dominated by leafy seaweeds such as kelps⁶⁷. In deeper water (since there is less light) there are fewer seaweeds, and rock surfaces are covered by encrusting animals such as anemones, sponges and hydroids⁶⁸. Wave exposure affects the plant and animal communities that are present. High levels of exposure lead to a change in the types of seaweeds and a reduction in the variety present. In deeper water, communities are less affected by wave action but are strongly influenced by the strength of tidal currents. Most animals are fixed to the rock surface, so they rely on the movement of the sea to bring them a constant supply of food, mostly small particles of organic debris, and microscopic plants and animals. Tidal currents represent a predictable conveyor belt, into which animals can extend tentacles, or funnel-like filters to collect passing food.

If current speed increases beyond a certain level, fewer organisms are able to keep a foothold on the rock, and communities become characterised by fewer more resilient species.

Around the coast of England we straddle a change in sea water conditions, with colder northern waters giving way to warmer southern waters. These changes are often marked by transition zones, for example the front off Flamborough Head in the North Sea, and along the English Channel. Because of these changes in seawater character, some species have an extremely limited distribution around our coasts. These include species such as the pink seafan, more characteristic of Mediterranean waters, which is found off south-west England, and others such as the bottlebrush hydroid, more typical of cold northern waters and found on the east coast as far south as Flamborough Head.

The presence and continued well-being of these species are important indicators of the general health of the rocky seabed. The pink seafan is large and easily damaged by modern commercial fishing gear (including so-called rock-hopper trawls), which is able to fish rocky ground that previously would have been inaccessible. This fishing breaks down the reef structure and reduces habitat diversity.⁵⁸ This in turn can reduce the suitability of the reef for other commercial species such as crabs and lobsters. In addition to their use as indicators of general health of the environment, the relative abundance of northern cooler water species and southern warmer water species will change as sea temperatures vary with climate change. It will be important to ensure that management and protection mechanisms account for movement of species due to climate change over time.

Key issues for rocky seabed

- Fishery pressure on some rocky reefs and delicate plant and animal communities
- Climate change

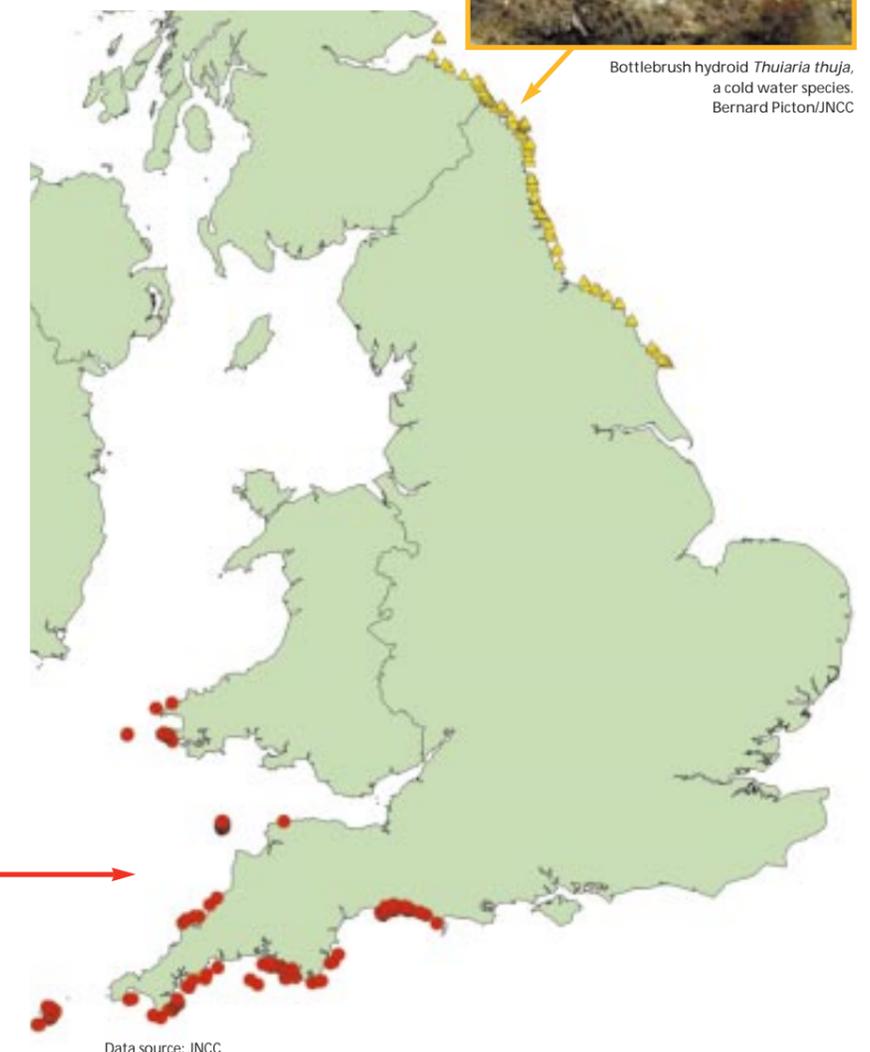


Bottlebrush hydroid *Thuiaria thuja*, a cold water species. Bernard Picton/JNCC

Distribution map of pink seafan and bottlebrush hydroid

- Pink seafan
- ▲ Bottlebrush hydroid

Pink seafan *Eunicella verrucosa*. JNCC





Zooplankton under a microscope.
Dr D P Wilson/FLPA/33720-00006-187

2.2.3 The open sea

Of all maritime habitats, we probably know least about the biodiversity of the open sea. Natural migration patterns and the widely dispersed nature of many open water species make them difficult to locate reliably and study systematically.

The fate of the whole ocean food chain rests not on larger animals, but on those at the base: the microscopic phytoplankton. These tiny single-celled plants form the base of a food web, which extends on through microscopic grazing plankton, predatory plankton, fish, and on to marine mammals and man. The composition of the plankton shows daily and seasonal cycles, which reflect night and day, the strength of sunlight, and the amount of nutrients in the water. In winter, plankton populations are at a low ebb. Winter storms mix nutrients from deep down in the water with the surface layers, and rain washes more nutrients into the sea from the land. As the sun's strength increases during spring, and the water column stabilises, the plant plankton (phytoplankton) populations grow massively, until the nutrients are used up. Matching the massive growth in plant plankton is a corresponding increase in grazing zooplankton, which are hunted and eaten by an increasing population of predatory zooplankton. As the available nutrients are used up, plankton numbers reduce dramatically. The spring plankton bloom is over. This mass of productivity drives the food web, feeding animals and fish, which are fed on by larger fish, which are in turn consumed by marine mammals and man. Also in the food web are marine birds, which feed off large and small fish, and species such as the basking shark, which filter-feeds the animal plankton. Basking sharks follow the plankton bloom, swimming around filtering seawater through their open mouths at natural boundaries

between water masses (fronts), where the plankton become more concentrated. These areas with high plankton concentrations result in identifiable 'hot-spots' where basking sharks are present most years. Some of these hot-spots coincide with areas of fishing activity, or shipping movement, resulting in by-catch or ship strike and damage to individuals.

The stability of the marine ecosystem is intimately linked with the plankton. Not only do plankton provide the base of the food web which supports other species including commercial fish stocks, but many animals and plants spend a part of their early life in the

plankton as eggs, spores or small larval stages. At this stage they are vulnerable to predators such as other plankton, or larger fish, and are also affected by pollutants during this critical stage of their development.^{46,69} Since the success of reproduction is largely determined by survival of

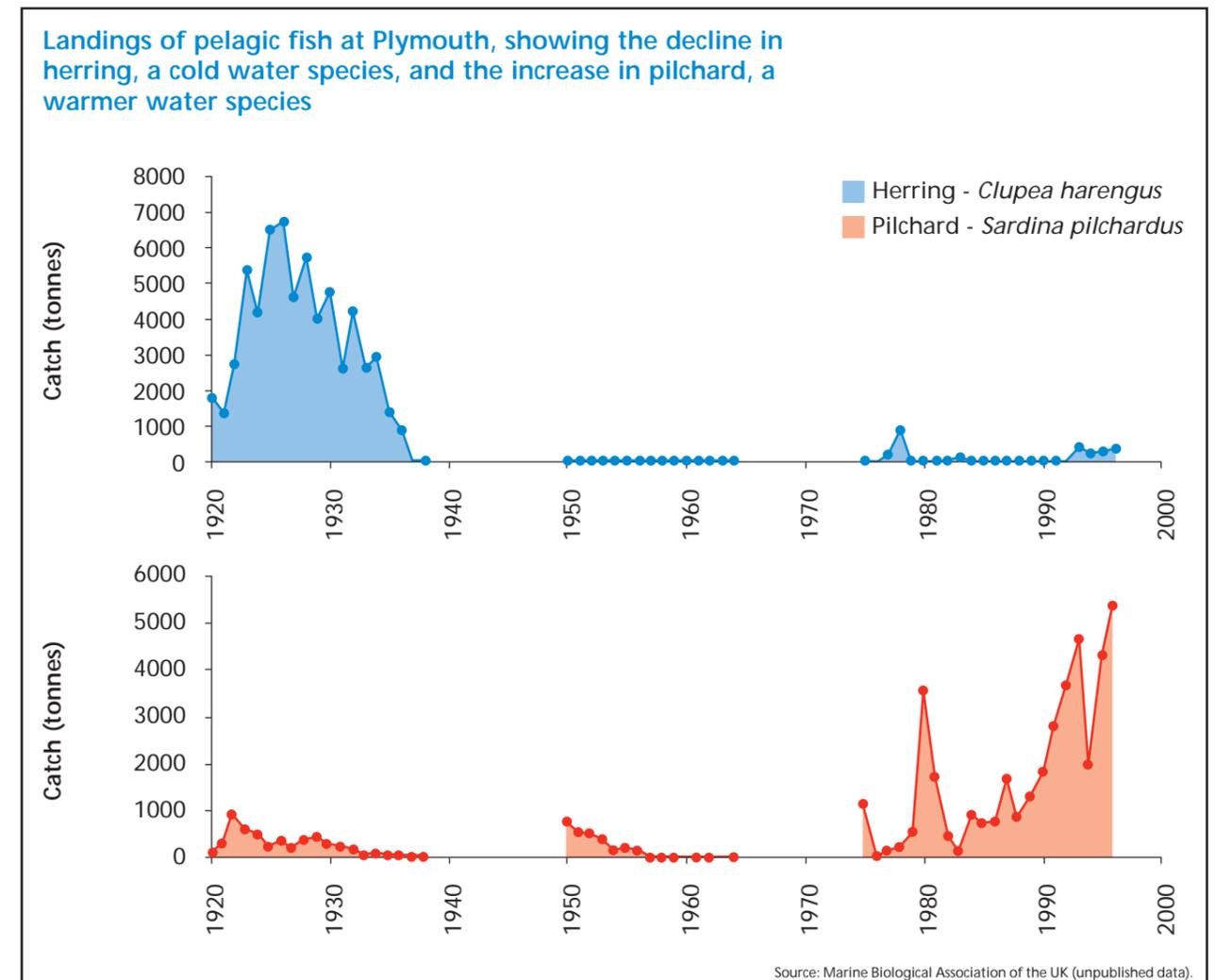
planktonic stages, any actions or pollutants that reduce planktonic survival have a direct effect on fisheries recovery. Changes in the proportions of species of adult fish can affect the numbers of juvenile fish larvae in the plankton. These changes can fundamentally affect the balance between grazers, predators and prey, meaning that fewer fish of particular species survive to reach spawning adulthood.

Plankton are also affected directly by climate change, both in terms of temperature changes in the surface water layers, and more dramatically by changes in ocean currents, which affect the characteristics of coastal water⁵².

Long-term climate cycles, such as the North Atlantic Oscillation, have an important bearing on the abundance of fish stocks, due to oceanographic fluctuations affecting plankton distribution and productivity. Better understanding of these cycles could improve fish stock management, and also provide the context to changes observed in any marine monitoring programme. For example, the changing fortunes of cold water herring, compared with warmer water pilchards.



The second largest fish in the world, the basking shark *Cetorhinus maximus*, feeds directly on the plankton, filtering them through its open mouth.
Linda Pitkin/NHPA/FI/LBP00004A





Bottlenose dolphin *Tursiops truncatus*. Andy Rouse/NHPA/MA/AR003729C

3. A review of key issues

This section summarises some of the key issues that are affecting our maritime biodiversity. The major challenge is to recognise the extent of the pressures on the maritime environment and the fact that the stress they are putting on the system is too great. The cumulative effect of all sectoral impacts is lowering the resilience of the maritime ecosystem and leaving it dangerously vulnerable to expected future pressures. The coastal ecosystem continues to be squeezed, and the marine ecosystem shows evidence of damage and degradation and needs a period for recovery. An ecosystem-based approach, which recognises interconnections and dependencies and promotes more integrated approaches across all sectors is a fundamental requirement, along with better application of the precautionary approach.

Summary of key issues by habitat type

	Inappropriate stabilisation	Coastal defences and development	Adjacent land use	Recreation	Water quality	Lack of habitat creation	Extraction, dredging & aggregates	Climate change	Fishing pressure	Maritime litter
Sea cliffs	•	•	•							
Sand dunes	•	•	•	•						
Shingle		•	•	•						
Saline lagoons		•			•					
Saltmarsh		•				•				
Estuaries		•			•		•			
Sandy and muddy shores		•			•		•			
Rocky shores		•			•			•		
Underwater sediments					•		•		•	
Underwater rock								•	•	
The open sea					•				•	•

Key issues for the open sea

- Poor water quality, particularly affecting top predators, and planktonic stages of a range of species
- Marine litter
- Fishery pressure on target and non-target species

Larger marine fauna such as cetaceans (dolphins, porpoises and whales) and turtles are vital features of the open sea. These larger marine animals arouse great interest, demonstrated by the rapid increase in popularity of whale watching around the world and concern over dolphin deaths in the English Channel, probably associated with the pelagic trawling for bass in this area. Feeding in the same area as dense shoals of bass brings these mammals into conflict with current fishing practices. Aside from the winter bass fishery mortality, the annual by-catch of harbour porpoise in the North Sea is calculated to be around 2.6% of the population.⁷⁰ Research has shown that mortality above 1.7% of the population will result in a decline and eventual loss⁷⁰. Recently, in some winters, up to 600 cetaceans have been washed up on the beaches of the western Channel, which are believed to have died in mid-water trawls⁷¹. Allowing for the fact that many cetacean carcasses never reach the beach to be recorded, the actual mortality is likely to be much higher, and almost certainly in excess of the 1.7% maximum set by the ASCOBANS treaty. Such a level of by-catch is not sustainable and is considered contrary to the aims of European Directives to protect these species. Research into less harmful fishing methods is currently being undertaken by DEFRA.

The stranding of turtles on the coast of England is often met with surprise, and the suggestion that these individuals have been swept off course. However, leatherback turtles in particular are a constant part of our marine fauna, as they are able to maintain their body temperature above that of the surrounding seawater, and come into cooler northern waters in their search for their jellyfish prey. Unfortunately they frequently mistake plastic bags or other marine litter for jellyfish. Many turtles die after eating plastic or drown after becoming entangled in fishing gear, particularly lobster and crab pot lines.

There are many human impacts that alter maritime ecosystems, but this section focuses on just three: coastal development and management; marine and land-based pollution; and fisheries. This is because we consider that they are currently the most significant

human factors that directly contribute to the overall decline in the quality of our coasts and seas, and where improvements in management could have the greatest economic and biodiversity benefits.

Cutting across these issues is the need for integration between the various management measures and activities. This is particularly demonstrated in the UK's approach to managing our coastlines, but applies equally offshore, where different activities continue to be managed in isolation from other issues, or the overall health of the ecosystem.

In the future, other issues will become increasingly significant. These need to be predicted and planned for if they are to be

managed effectively and with sufficient environmental precaution. These include the actual or potential effects of the introduction or invasion of both non-native species and 'novel' genetically modified species. The effects of these on genetic diversity and on the gene pool of maritime ecosystems need to be considered.

3.1 Coastal development and management

Managing the coast is complicated by a range of factors: it is dynamic and there is a complex and wide range of institutions and different legislation involved, with insufficient integration¹⁰. Coastal development above Mean Low Water is controlled by the Town and Country Planning Act, guided by various Planning Policy Guidance (PPG) Notes, including PPG 20 which specifically deals with Coastal Planning.¹⁸ Below Mean High Water, other controls include the Food and Environmental Protection Act and the Coast Protection Act (administered by the joint Marine Consents and Environment Unit of DEFRA and Department for Transport), along with licensing for other activities such as aggregate extraction, or oil exploration.

The future approach to maritime management must look at the issues more holistically, to ensure joined up and co-ordinated regulation and consider the need for a new legislative framework. It must also ensure better use of evidence and effective learning from experience, to avoid repeating mistakes.

The most recent estimates of the extent of climate change come from UKCIP02 report²⁸. The predictions (under high emissions scenario) suggest:

- Temperature increases of up to 5°C by the 2080
- Increases in winter rainfall over the whole country, with a decrease in summer rainfall over southern England
- Sea level rise by as much as 86cm by 2080 in the south east of England

These predictions do not account for possible changes due to marine variables such as extreme storms, ocean circulation and wave climates

It is expected at the very least that extreme storms will increase in frequency, and wave heights will also increase

Planning for these changes must allow wildlife to move in response to coastal evolution, and temperature change

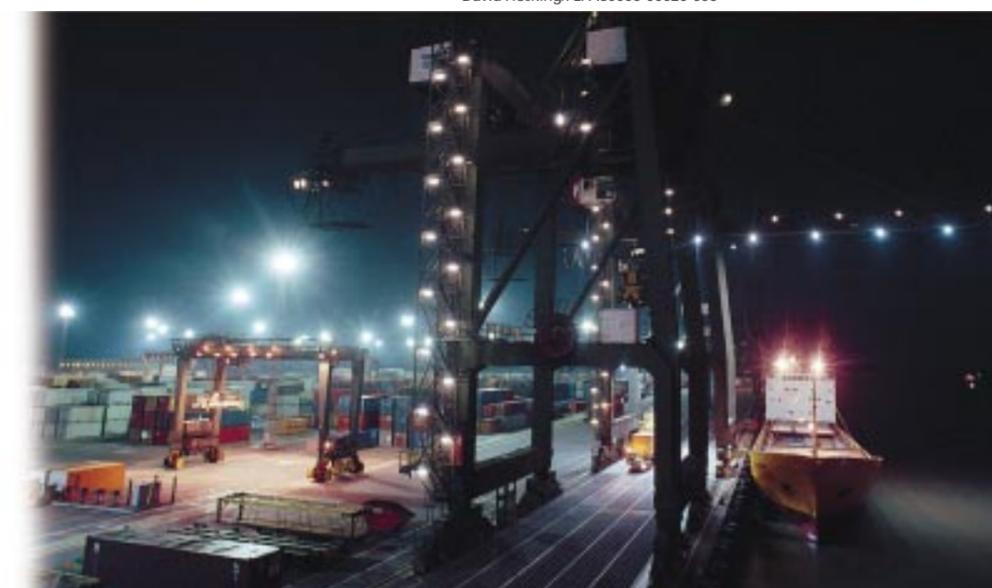


High value assets have been built on mobile coastlines. Sandbanks, Poole Harbour. Kitchenham Ltd.

Currently around 30% of England's coastline is developed¹⁸, with one in three people living within 10 km of the coast¹⁰. The number of households in the UK is projected to grow to 24 million by 2021. To meet this growth, there will inevitably be development pressure in some coastal locations, and it will be of paramount importance to ensure that there is no unsustainable development that leads to future demands for costly coastal protection and compromises the ability to meet conservation targets such as those under UK BAP. Planning Policy Guidance Note 20, Coastal Planning, advocates that only those uses that are dependent on a coastal or foreshore location are granted planning permission in such areas. Despite this, in 2000 research confirmed that some development, mainly housing, continues to be planned and permitted in coastal locations⁷². In the past, coastal towns and villages often extended out into the water, reclaiming areas for development or agriculture. These areas are now at risk from coastal erosion, increases in sea level and increased storminess leading to pressures for protection by man-made defences. Difficult management decisions will need to be made as the coastline responds to natural events and climate change⁷³. Protection of all built, farmland or environmental assets *in situ* is unlikely to be an option, and the costs of insuring against increasingly frequent flooding or erosion events are likely to escalate.

Sea level rise

Sea-level rise will inundate intertidal areas and saltmarshes and will affect the shape of estuaries, particularly in the south-east of England, due to their history of land-claim for agriculture and development. Without changes to current sea defences, it is inevitable that intertidal areas on artificially protected coasts will be lost, as they become squeezed between rising sea level and sea defence structures, with southern and eastern England being the most vulnerable. Predictions of losses and gains have been made by the University of Newcastle⁷⁴ showing that even if 12,500 ha of managed retreat takes place, there will still be an overall loss of 2,049 ha of coastal habitats as a result of sea-level rise over 50 years. Without the creation of intertidal mudflat and saltmarsh through managed realignment, the losses of natural habitats will be much greater. The current rate of habitat creation lags well behind the rate of loss (as shown in the saltmarsh section). A dramatic improvement in the rate of managed retreat will be needed if Biodiversity Action Plan targets for no net loss of coastal habitats are to be met.



Harbour. David Hosking/FLPA80055-00020-056

Predicted losses and gains of coastal habitats in England over the next 50 years as a result of coastal management practices and projected sea level rise⁷⁴

Habitat	Projected loss by 2050 (ha)	Estimated gain (ha)	Balance (ha)
Mudflat and sandflat	11,459	12,991	1,532
Saltmarsh	6,996	7,685	689
Sand dune	504	381	-123
Shingle	238	110	-128
Cliff top	133	0	-133
Reed bed	172	0	-172
Coastal lagoon	530	30	-500
Wet grassland	3,214	0	-3,214
Total	23,246	21,197	-2,049

NOTE

The predicted gains for saltmarsh and mudflat rely on around 12,500 ha of managed realignment. Without this managed realignment the overall losses will be much greater.

These losses due to climate change need to be seen against a background of past losses. Past coastal development has resulted in considerable direct loss of marine and maritime habitats through landclaim and dredging. Around 90% of the Tees Estuary has been lost to landclaim over last 120 years⁴¹, while Holland Haven in Essex has been completely lost by sea wall construction across the mouth of the former estuary⁷⁵. Losses in some estuaries continue due to small-scale developments such as slipways, jetties and seawalls. Larger-scale projects result in major losses which are irreversible. In some circumstances, compensation by creating habitat can offset such losses, but quality may not be comparable. So the natural capital of our maritime environment continues to be lost.

Ports and harbours

Set against losses due to inappropriate coastal development and management are the challenges of maintaining nationally important infrastructure that demands a coastal location, such as ports and harbours. As an island nation, the United Kingdom relies on shipping routes for trade and transport. Over 90% of the UK's overseas trade is

carried by sea, and over 70 million passenger journeys are made from our ports each year⁷⁶. Much of the UK's world status rests on our maritime history. The amount of freight passing through UK ports increased by around 16% over the last decade of the 20th century⁷⁶, and the types of freight carried are changing even more dramatically. The freight carried by bulk carriers (such as aggregates or iron ore), and the oil carried by tankers, have been joined by the rapidly growing container shipping industry, with the tonnage of freight carried by container more than doubling between 1990 and 2000. With world trade steadily increasing, and competition from other countries to attract shipping, the pressures for development in England's ports are immense. The size of vessels has also grown steadily. Until the late 1980s vessel size was limited by the dimensions of the Panama Canal, through which most trading ships passed. However, there are now even larger ships - the so-called 'post Panamax' vessels which are travelling the seas without using the Panama Canal and there are recent proposals for Ultra Large Container ships. With the limit on vessel size now broken, the container shipping industry will probably concentrate on a smaller number of 'hub ports' which will then trans-ship to other destinations by road, rail or smaller vessels. The development of larger vessels, carrying larger amounts of cargo, leads to pressure to dredge deeper navigation channels (new vessels have a draft of 14.5 m) and to provide larger areas of storage space and infrastructure in coastal locations. Usually, the only location for these developments is on the intertidal zone, shallow waters, or low-lying coastal land adjacent to the port. Most of these ports are in environmentally important locations, and so it is critically important to find sustainable development solutions to maintain and enhance trade, whilst conserving and improving biodiversity.

Container vessel unloading at port. David T Grewcock/FLPA90885-123-75

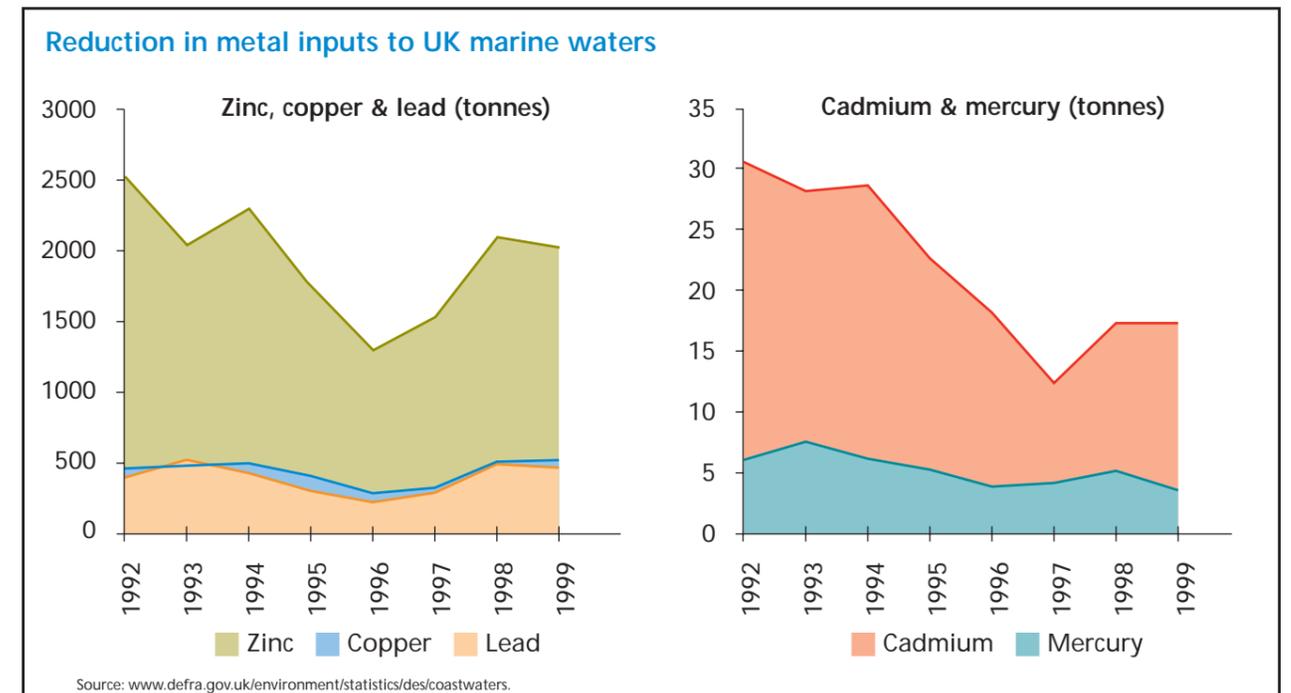


Key messages for coastal development and management

- In spite of guidance to the contrary, ill-conceived developments are still taking place that will result in future pressure for further coastal defences. Coastal processes should, and will, continue to operate, to mould the coastline and to evolve natural landforms such as dunes, saltmarsh and shingle spits. Poorly thought out coastal development has traditionally sought to stop this natural evolution, and fix coastal landforms in place, at high cost both financially and environmentally. In the first instance, guidance needs to be properly implemented (perhaps by being made mandatory). In the current review of development in marine and coastal waters there would be merit in reviewing the 1949 Coast Protection Act to support a shift from coastal defence to coastal management. This would better reflect current policy and understanding of coastal processes
- Ensuring that coastal land is only used in future for development that is dependant on a coastal location. Other forms of development should go elsewhere. Otherwise we will lose valuable coastal habitat and the remaining undeveloped quality coastline for people to enjoy
- Current maritime habitat creation is not keeping pace with losses from piecemeal development or climate change. Habitat creation needs to be better integrated into a much longer term view of coastal planning, and should be strategically planned rather than relying on opportunities as they become available
- In addition, we need a debate about the need for long-term adaptive strategies which include the relocation of existing unsustainable development
- There is a need for government to further strengthen co-ordination of action on the coast. Opportunities exist, such as through the European commitment to Integrated Coastal Zone Management (ICZM)⁷⁷, Department for Transport's review of consents and development in coastal waters, and DEFRA's Review of Marine Nature Conservation
- There is a risk of development of port capacity in excess of need at the cost of important nature conservation assets. A strategic framework is needed to guide those developments that are likely to be consented on the grounds of over-riding public interest and to promote sustainable development solutions

3.2 Marine and land-based pollution

For much of human history the seas have appeared to have a limitless capacity to receive waste. Early assumptions were made that the immense dilution when substances were disposed of to the sea would prevent problems. It has since been realised that certain substances such as heavy metals can accumulate in the environment, and strenuous efforts have been made to reduce these inputs.



The Urban Waste Water Treatment Directive and Bathing Waters Directive have resulted in clear improvements in the quality of coastal and estuarine water. In some cases reductions in organic inputs have been suggested as a reason for a decline in some bird numbers, particularly common and black-backed gulls, and waders and wildfowl such as dark-bellied brent geese, shelduck, wigeon, avocet and black-tailed godwit. There is limited evidence for any large-scale changes to populations, although in some estuaries, the distribution of birds may have altered⁷⁸. However, any decline in bird numbers as a result of improving water quality may need to be seen as acceptable within wider environmental improvements and consistent with obligations for such improvements. English Nature is supporting further research to better understand these interactions.

Diffuse inputs

Whilst controls on pipeline discharges have been brought under more stringent control, diffuse inputs of a range of contaminants have continued, forming an ever larger proportion of the total burden entering the environment. These come from a variety of sources including run-off



David Woodfall/PO/DW 005701A

from agricultural and urban land, atmospheric deposition (particularly combustion products) and small scale unlicensed discharges (for example from shipping). Around 80% of marine pollution comes from land-based sources¹⁰.

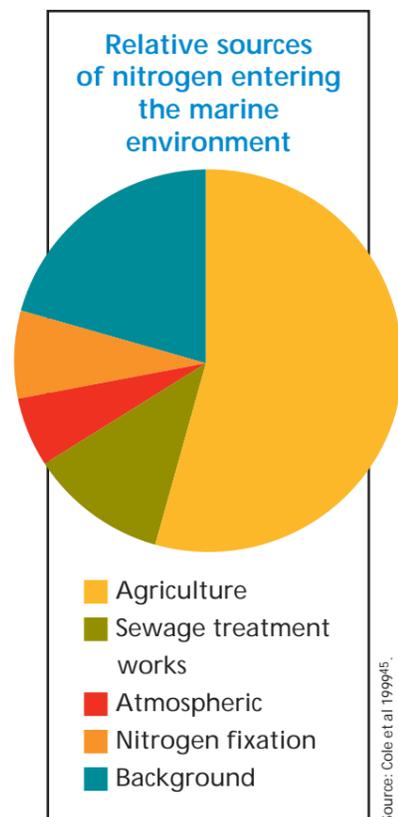
Two major problems hinder understanding of the harmful effects of marine water quality: a lack of data on historic trends; and the fact that many substances have harmful effects at levels that are lower than current detection limits. The latter point is well illustrated in the case history of tributyltin (TBT) which had damaging effects on marine mollusc populations at concentrations below those which could be detected at the time (see box opposite).

Two water quality issues that currently give cause for concern in the maritime environment are eutrophication, and endocrine disruption and other sublethal adverse effects.

Eutrophication

Eutrophication is the over enrichment of the maritime environment with nutrients, leading ultimately to excessive growth of algae, and often reduced oxygen content of the water. Nutrients are naturally present in the environment, but are increased by human activities such as sewage disposal and run-off from agricultural land. Most changes in diffuse inputs result from changes in land use, often from permanent pasture to arable, with an associated increase in fertiliser use, along with increased stock densities on remaining grazing land²¹. Inputs of nitrogen to marine waters have increased steadily since the early 1980s⁷⁹, whilst long-term studies in the Irish Sea have shown a steady rise in nutrient levels over the past 30 or 40 years⁶⁶.

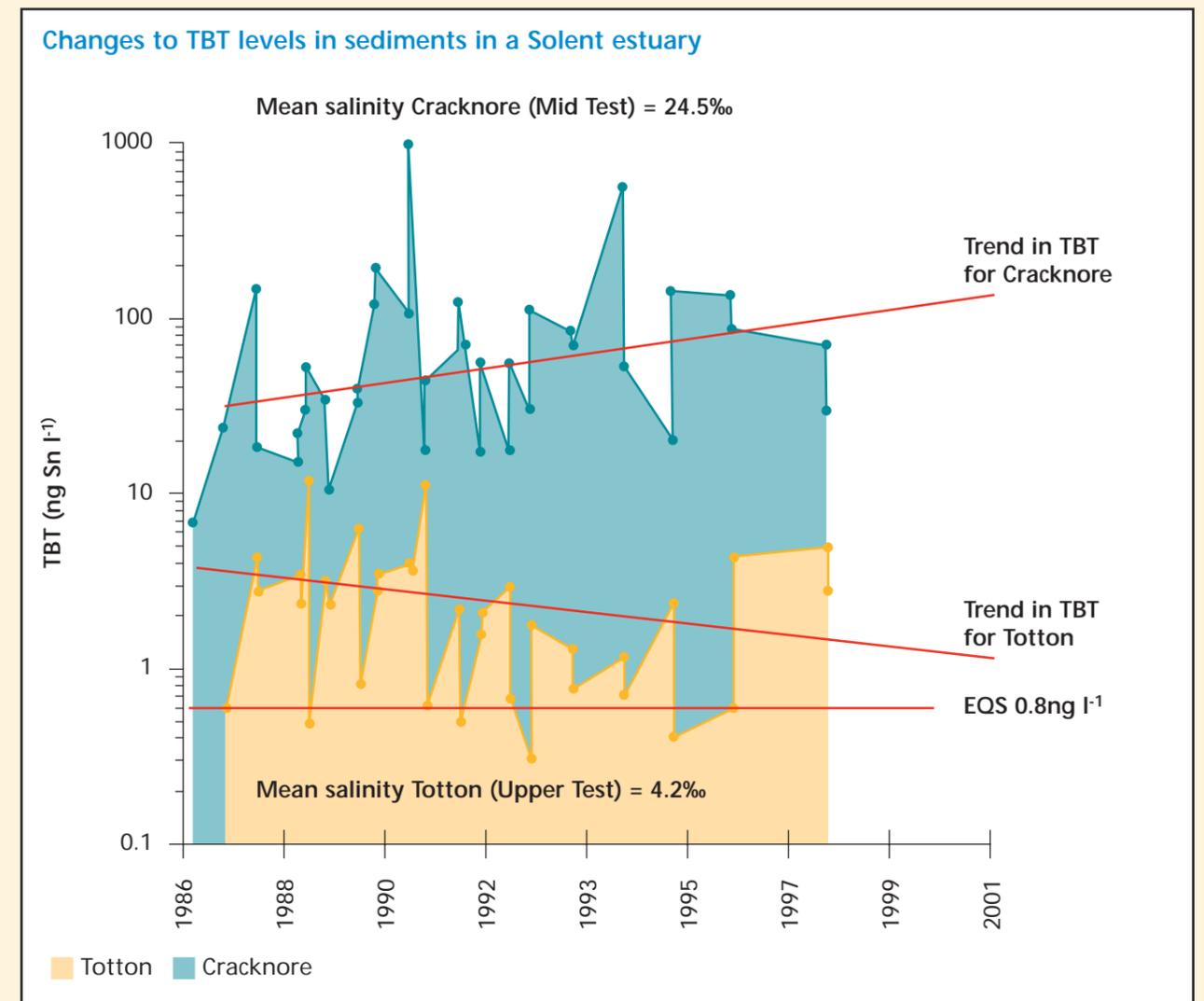
The effects of nutrients on wildlife are varied. They include excessive development of green seaweed mats and more frequent algal blooms in the water column which, as well as reducing biodiversity, can lead to closure of aquaculture operations and reduced amenity value. Studies by English Nature and the Environment Agency show that over half of our most important maritime wildlife sites, designated as SACs or SPAs, may be damaged through eutrophication or are at risk⁴⁴. For example, in the Tees and Cleveland Coast, there is a significant increase in the gutweed *Enteromorpha* covering the intertidal mudflats. It is suggested that these changes are due to a combination of factors, including sediment changes, reduced turbidity, elevated TBT levels and milder winters⁸⁰. In Lindisfarne SPA, gutweed growth has increased over many years, reducing the suitability of the site for some species of feeding birds⁸¹. One factor may be nutrients entering coastal waters from diffuse agricultural run-off into major river systems such as the River Tweed.



TBT: a lingering example of the need for the precautionary approach

Tributyltin (TBT) antifouling paints were extensively used by leisure and commercial craft from the early 1970s until 1987, when they were banned on boats smaller than 25 m. Concern that TBT might be having an adverse effect on Pacific oysters and dog whelks led to research on the effects, although in many cases TBT levels were below the levels of detection at the time. By the time action was taken, populations of these whelks had disappeared from many estuaries, oyster cultivation had suffered huge losses and TBT had become incorporated into estuarine sediments. Away from commercial shipping, recovery has been slow, but progress is being made. In the Crouch estuary there has been a doubling of seabed species since TBT use on recreational boats was stopped⁹¹. As well as the effects on wildlife, there are commercial implications as heavily contaminated dredge sediments cannot be disposed of to sea but require specialist treatment at much greater expense. This economic burden is preventing maintenance dredging in some estuaries.

Sediments in the Solent adjacent to commercial shipping areas are showing a continuing increase in TBT in spite of the ban on its use on small craft. The worldwide ban on the application of TBT after 2003 and replacement of all existing coatings by 2008 will halt the input, but reductions in sediment loading will be extremely slow. Data source: Dr W Langston, Marine Biological Association of the UK.





Enteromorpha spp.
Dan Laffoley/English Nature

Morecambe Bay cSAC and SPA are at risk of eutrophication resulting from both point and diffuse sources of nutrients entering from rivers and the Irish Sea¹¹⁸.

On the south coast, in Pagham Harbour and Chichester/Langstone Harbours, progressively more extensive annual development of green seaweed mats are considered to be damaging the SPA and SAC features⁴⁴.

Very few marine sites have had sufficient long-term monitoring to determine the effects of long-term nutrient loading. Once nutrients enter estuarine or coastal systems they can become incorporated into the sediments, from where they can continue to cause eutrophication even after nutrient inputs are stopped. This reinforces the need to be precautionary in our approaches to water quality - by the time biological effects of eutrophication become apparent, restoration may be expensive or impossible. Obvious symptoms of eutrophication can be masked by other contaminants. For example diffuse inputs of certain herbicides could potentially inhibit photosynthesis in algae⁸², preventing algal blooms and masking the symptoms of eutrophication, allowing nutrients to build-up unobserved. Conversely, some substances such as TBT are toxic to grazers on algal plankton. In uncontaminated sites, algal blooms may be kept under control by efficient grazing, whilst in contaminated estuaries the algal populations can expand relatively unchecked⁸³. High suspended solid loads can also mask the effects of nutrient enrichment. More pronounced eutrophic effects were noted in the Tees Estuary once the Tees barrage became operational. The barrage is believed to have improved water clarity which may have been a factor in the increased algal growth.

In England, improvements to sewage treatment works are continuing to be delivered through the water companies' Asset Management Plans (AMPs). This is leading to reductions in point sources of nutrients into the environment as required by a number of statutory drivers, including the Urban Waste Water Treatment Directive, the Habitats Directive, and the Government's Public Service Agreement (PSA) target of bringing 95% of SSSIs into favourable condition by 2010. Diffuse sources of nutrients therefore constitute an increasing proportion of the total loading in marine waters. Implementation of initiatives to control diffuse pollution, through the Nitrates Directive, has been relatively slow. In the case of the Nitrates Directive, the initial designation of Nitrate Vulnerable Zones (NVZs) - areas requiring statutory Action Programme Measures to reduce nitrate loss into the water environment - were restricted to waters which were drinking water supplies. In 2002, DEFRA announced a substantial increase in NVZs across England, identifying all surface and ground waters subject to nitrate pollution or having evidence of eutrophication. In 2002, the Government also initiated a strategic review of diffuse water pollution from agriculture in England. This review will need to address the risk of eutrophication in marine waters in order to deliver the Government's current statutory obligations, future obligations under the Water Framework Directive, and also the UK's wider commitments under OSPAR⁸⁴.

Endocrine disruption and other sublethal effects

The endocrine system in organisms controls a range of functions, including behaviour, growth and reproduction. It is now established that some chemicals found in the environment, so called endocrine disruptors, have the ability to adversely change endocrine function in organisms. The European Commission has listed over 500 known and potential endocrine disrupting chemicals, although for some of these substances there is no clear evidence for endocrine disrupting effects⁸⁵. Principal endocrine disruptors include pesticides, TBT, herbicides, alkylphenols, bisphenol A, phthalates, PCBs and other organochlorines, PAHs, natural and synthetic hormones. Cadmium, lead and mercury have also been implicated. Although there is an extensive list of possible endocrine disruptors there is little reliable information on the effects of these substances in the marine environment. In 1999 CEFAS were contracted by English Nature to evaluate the risks of endocrine disruption in biota at marine SACs. Although it was established that there was significant risk of exposure of biota to endocrine disruptors, further work was required in order to better understand the risks of

The effects of tributyltin antifouling paint on dogwhelks are well studied. But there are a range of other endocrine disrupting chemicals whose effects are less understood.
Dan Laffoley/English Nature



effects. Research has concentrated on fish exposed to oestrogen-type substances, with sparse information on other species apart from the effects of TBT on molluscs. It is thought that many endocrine disrupting chemicals arise from domestic sewage. Other sources include industrial effluents, agricultural run-off, and leachate from contaminated land or disposal sites. Studies have shown oestrogenic effects in four species of fish (flounder, viviparous blenny, and two species of sand goby) from a range of industrialised estuaries. Although the full implications of these observations are unknown, it is possible that reproductive performance could be impaired in some cases, and hence populations may be affected⁸⁶.

It should also be acknowledged that endocrine disruption is one of a number of potential sub-lethal effects on organisms through exposure to toxic chemicals. There are developing areas of concern regarding exposure to other organic chemicals, including polybrominated flame retardants, and some chlorinated paraffins. A concern is that many substances suspected of being endocrine disruptors, or having other sub-lethal effects, are persistent in the marine environment and will bioaccumulate, thus exerting possible effects throughout the food chain. Some organochlorines, for example PCBs, are measured in high concentrations in mussels, fish liver, fish-eating birds and marine mammals. High levels of organochlorines have been highlighted as a concern in the Biodiversity Action Plan for the bottlenose dolphin¹¹. Accumulations of chemicals in marine mammals such as seals and porpoises are believed to reduce their natural immune response, making them more susceptible to death from infectious diseases⁸⁷.

Polycyclic aromatic hydrocarbons (PAHs) reach the marine environment from a variety of sources, primarily combustion of fossil fuels, but also from oil spills, emissions from offshore oil and gas installations, and shipping. Some of these inputs are rising (for example the number of reported oil spills from shipping is increasing⁸⁹) whilst others such as the total inputs discharged from offshore installations are declining⁹⁰.

PAHs collect in marine sediments, where they can be a source of diffuse pollution⁸⁸. PAHs can accumulate in shellfish, and they are implicated in high rates of liver tumours in some North Sea flatfish⁸⁸. It is also believed that their breakdown products are more toxic and more persistent, with research showing that exposure to ultraviolet light in the surface water layers can increase the toxicity of PAHs⁹².

The key concern about endocrine disruption and other sub-lethal effects is that many chemicals are implicated, and effects may occur at very low concentrations. Research into endocrine disruption in freshwater fish has shown effects at concentrations of a thousand millionth of a gram in a litre of water. Effects are likely to be hidden in a slow loss of wildlife rather than an obvious catastrophic change. Add to this the possible fact that some chemicals may not cause effects in isolation but may interact with others in the environment, and the complexity of the subject becomes apparent. However, the implications of taking no action, or making the wrong management decisions are huge. Many of these substances are persistent, and will accumulate in sediment. Clean-up

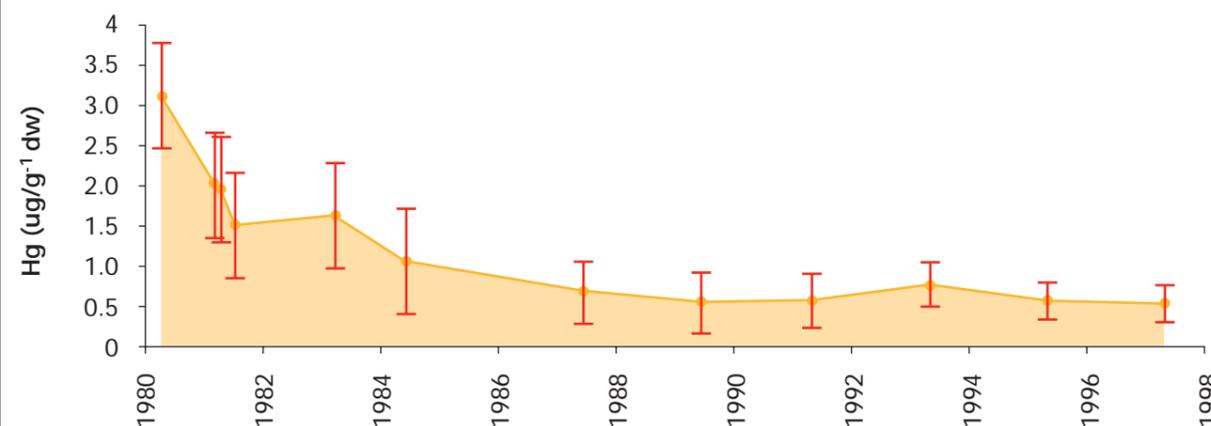
Mercury: a case to show the slow recovery from persistent contaminants

Mercury has long been recognised as a persistent pollutant, and strenuous efforts have been made to reduce inputs to the environment, with some success demonstrated by the reducing load of mercury in mussels in the Mersey⁹⁴ (graph 1).

Declining mercury levels in mussels in the Mersey estuary

Graph 1

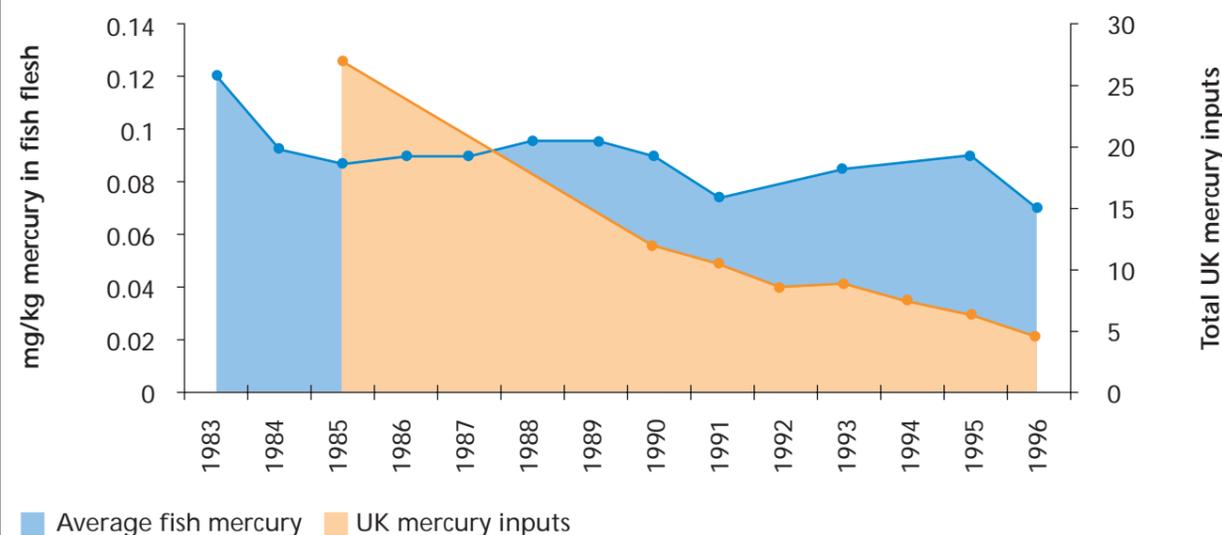
Error bars represent SD of the mean



However, the persistence of substances in the environment is clearly demonstrated in graph 2, where the downward trend in mercury in fish flesh from samples around the UK is much slower than the downward trend in mercury inputs to the environment⁹⁵. In spite of the downward trend in mercury discharges to the environment, and declines in the average mercury levels in fish, long-term monitoring of residues in gannet eggs show inconsistent trends in this contaminant, as well as PCBs, over the period 1988 to 1998, demonstrating the effect of concentration of persistent contaminants via the food chain⁹⁶.

Mercury contamination in fish

Graph 2



becomes prohibitively expensive, or at worst, impossible. This is clearly demonstrated in the case history of TBT, which resulted in a huge economic burden once the effects of contamination were widely apparent. Although the costs of dealing with the early warnings may have appeared unpalatable at the time, they were minor when compared with the subsequent financial losses suffered by shell-fisheries, or the increased costs of dealing with contaminated sediment. The key lessons learned from past water quality problems have been the lack of precautionary action taken when early warning signs became apparent, and the subsequent economic and social costs of dealing with major effects. Early warning signs of the potential impacts of endocrine disruptors in both the marine and freshwater environments are beginning to appear⁸⁶, and some research is underway to examine the more likely effects. In most cases we are unaware of these effects since no effective monitoring is in place. What is needed urgently is increased research to identify the scale of the problem, monitoring to identify trends in the most problematic chemicals, and a precautionary approach to controlling known and suspected sources. The time lag between taking action and delivering change in the marine environment is clearly indicated by improvements in mercury discharges. Once persistent chemicals are released into the environment, recovery may take many decades.

Key messages for marine and land based pollution

- Despite important initiatives, marine and land-based pollution remains a key concern. This is emphasised by the recent World Summit on Sustainable Development⁹⁷
- Eutrophication from diffuse sources has the potential to cause adverse effects in European Marine Sites, and without action is likely to harm the special interest and also prevent achievement of PSA targets for SSSIs. Action now will help achieve reductions in inputs needed to meet OSPAR 2010 requirements and Water Framework Directive 2015 targets
- Waiting for biological symptoms to occur before taking action on eutrophication will be too late. Symptoms may be masked by other contaminants, and may not appear until remedial action is very expensive and difficult
- Endocrine disrupting chemicals are an identified risk factor. These and other sub-lethal effects are poorly understood, but a precautionary control of suspected inputs is urgently needed if we are to avoid storing up greater problems for the future. Further research and monitoring of these, and other chemicals of concern, should be undertaken
- There is a need to develop robust standards, targets and action to protect biodiversity from the adverse effects of contaminated sediments. We need to recognise that there will be a time lag before the environment improves as a result of any measures
- It is important to bring together long-term studies which will enable better informed decisions to be made. We welcome the contribution DEFRA's Marine Environmental Change Network (MECN) and Diffuse Water Pollution from Agriculture Project will make to this

3.3 Fisheries

The complex coastline, with its shallow seas, many bays, estuaries and islands, and a long history of coastal settlement, have combined to ensure a well established and continuing tradition of fishing along England's coast. Approximately 750,000 tonnes of fish were landed by the UK fleet in 2000⁹⁸, with a total value of £550 million. To put this into context, the total value of all UK landings in the UK and abroad in 1997 was £622 million, or one thousandth of the UK's total gross domestic product⁹⁹. Major English fishing ports include Newlyn, Plymouth, Brixham, Hull and Grimsby.

To meet the high consumer demand for particular types of fish, some 60% of the UK's fish (worth approximately £1,300 million) is imported¹⁰⁰. It should be noted that estimates suggest recreational fishing in the inshore waters of England and Wales generates an income of around £140 million for the coastal economy³.

Declining fish stocks

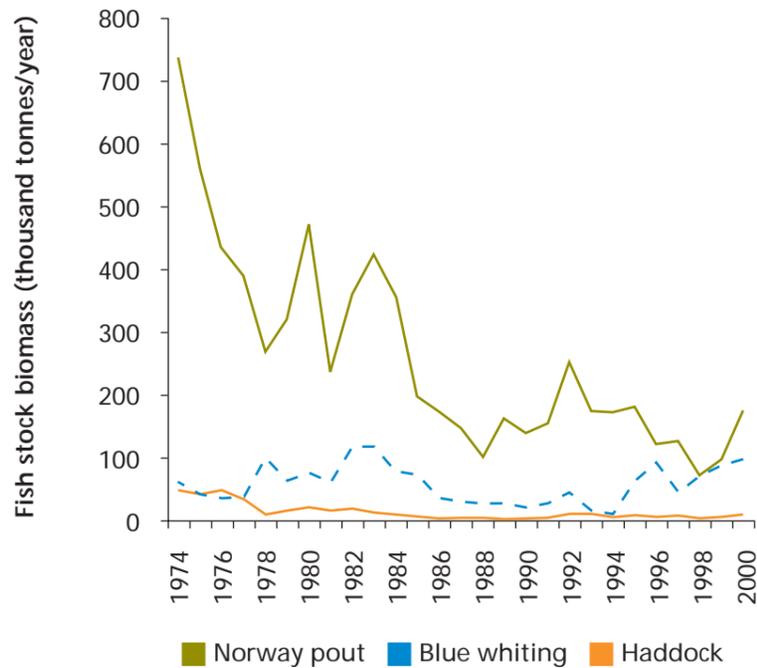
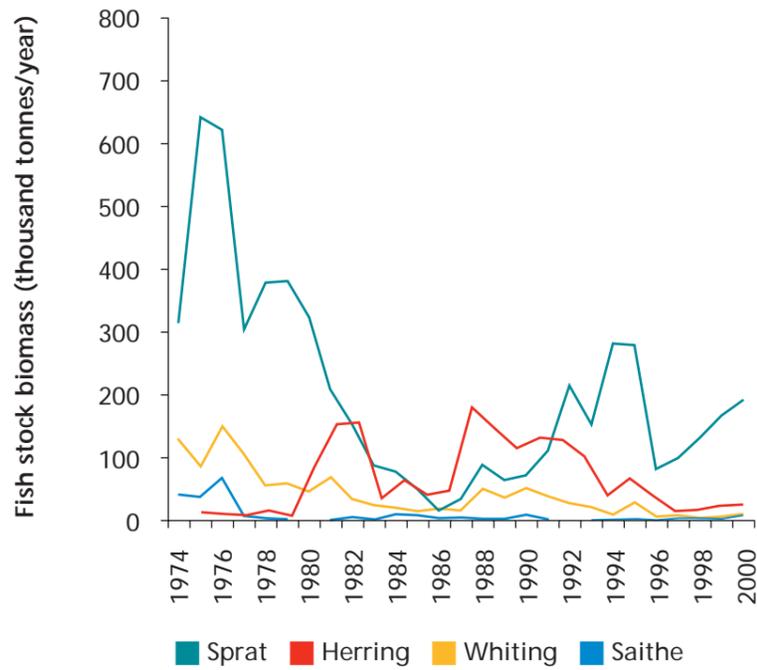
Fish stocks of many important species are at historically low levels, and in most instances outside safe biological limits. At the same time, fishing effort remains above levels which will allow stocks and hence the environment, to recover. As stocks of popular species such as cod and haddock have declined, some fishing effort has been transferred to other species, making them vulnerable to the effects of over-fishing. Fishermen now have to fish longer and use more efficient gear in their attempts to continue to make a living. If left unreformed, current fishing practices will result in permanent or long-term loss of commercial fish stocks, with consequent effects on fishing-related employment. Lack of fish will also affect the processing sector, which currently employs around 22,000 people in the UK.

Fishing has a range of effects on the marine environment, ranging from habitat disturbance and damage through heavy fishing gear dragging across the seabed⁹⁸, to possible genetic changes in fish stocks as a result of sustained fishery pressure¹⁰¹.



English Nature

Estimated fish stock biomass in the North Sea, showing the decline in species since 1974



Source: www.defra.gov.uk/fish

Fishing in the seas around Europe is currently regulated by the Common Fisheries Policy (CFP). Introduced by the EEC in 1983, the CFP aimed to maximise production, employment and efficiency by managing the fish stocks. However, scientific warnings over the last decade or so about the need to reduce effort and capacity in line with available biological resources have been disregarded; indeed, for some fisheries effort has actually increased. At present 64% of the fish stocks in European waters are considered to be over-exploited, or have already collapsed. The remaining 36% are considered to be fully exploited¹⁰². To compensate for this decline consumers have increased reliance on imported fish from outside the European Union. Concerns over the fate of fish stocks as a whole are heightened by a recent analysis of global trends, which now show an overall decline in many stocks¹⁰³.

The number of boats fishing within England's fishery grounds has declined steadily since the early 1980s⁹⁸. However, as the number of boats has declined, so the fishing efficiency has continued to increase; consequently fishing pressure has remained high or even increased. Financially, fishing is also under-performing. Return on capital investment is currently between 0 and 2%¹⁰⁴, with some fisheries showing a negative return. In summer 2002, the biggest fishing fleet on the east coast of England went out of business, resulting in the loss of 90 jobs - there were insufficient fish to keep the business afloat¹⁰⁵.

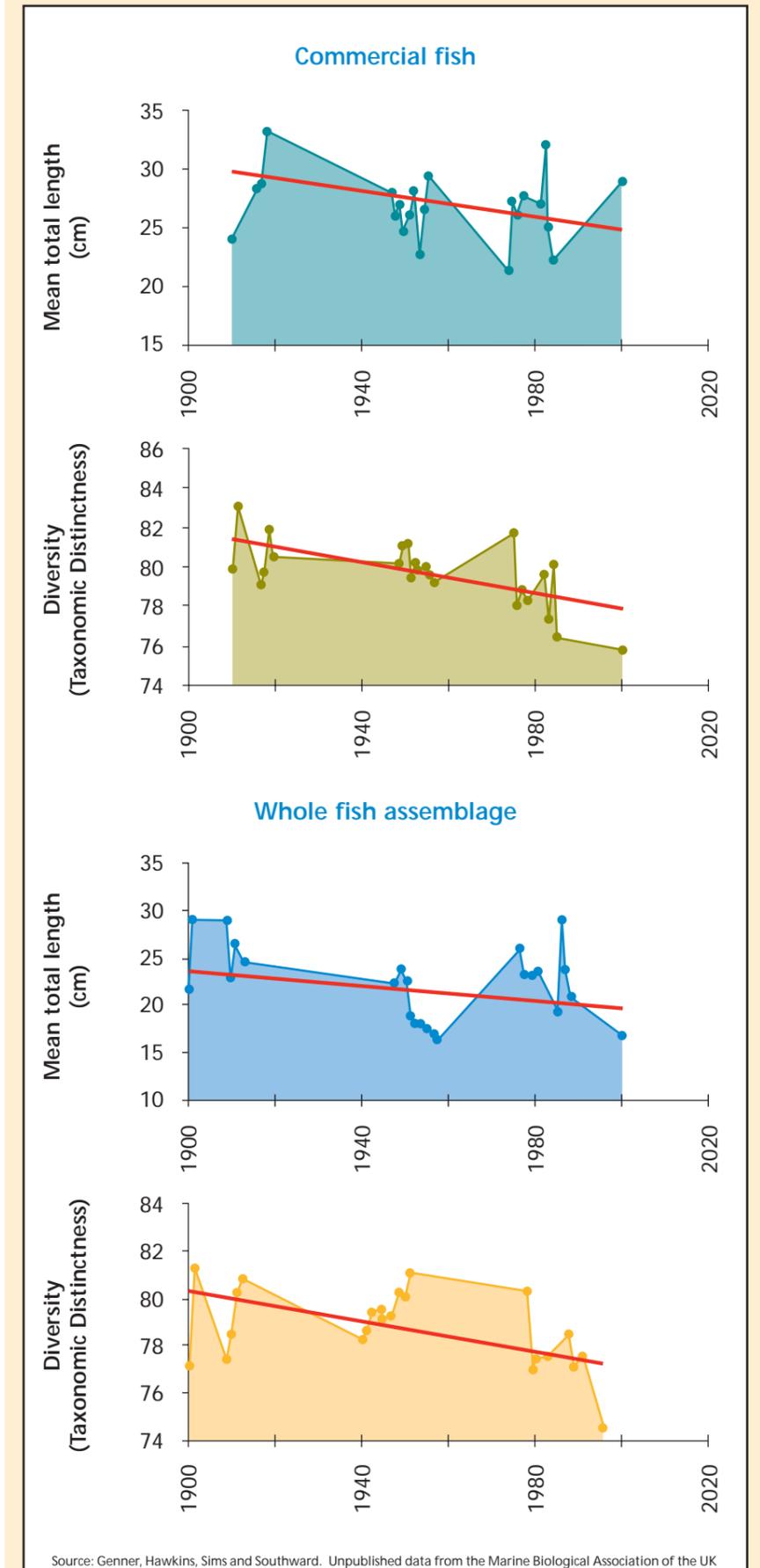
The environmental effects of fishing

As well as reducing fish stocks to dangerously low levels, fishing also has significant effects on other parts of the marine environment⁵⁸. Implementation of the Common Fisheries Policy has failed to protect marine habitats and species. The Commission's current proposals for radical reform seek to bring fishing pressure in line with the resources. They also seek to integrate environmental considerations into fisheries management and develop an ecosystem based approach¹⁰⁶.

Diversity among fish populations is also declining as a result of fishing pressure. Work undertaken by the Marine Biological Association of the UK has demonstrated clear downward trends in diversity of both commercially targeted fish species and non-target fish off Plymouth since 1913¹⁰⁷.

Similar declines have been recorded around England in both seabed wildlife¹⁰⁸, and commercial fish species¹⁰⁹. It has been estimated that for every kilogramme of North Sea sole caught by beam trawl, up to 14 kg of other seabed animals are killed¹¹⁰. Often this includes species of commercial importance which are either below the minimum size for landing, or for which the boat has no quota allowance, and therefore, cannot legally land. In the UK whitefish trawl fishery over two thirds of the discarded catch consists of commercial species, of which undersized fish make up the majority. The estimated cost (in terms of loss of future catch) of this discarding amounts to over 40% of the total annual landed value of the fishery¹¹¹.

Decline in size and diversity of commercial and non commercial species in the English Channel showing ecosystem effects of fishing pressure



Source: Genner, Hawkins, Sims and Southward. Unpublished data from the Marine Biological Association of the UK



Roger Covey/English Nature

There is clear evidence, from worldwide studies, of changes in community structure in marine ecosystems as a result of fisheries pressure¹¹². An example of this is the effect of northern cod fisheries on the coast of British Columbia. Reduction in cod stocks is believed to have led to an increase in lobster survival, which caused an increase in fishing effort for lobsters. As these stocks declined, sea urchin survival improved, leading to an explosion in their numbers¹¹³. Similar disruption to the ecosystem could be taking place here. Echinoderm (starfish and urchin) larvae have dominated the North Sea plankton since the early 1980s¹¹⁴. This period of domination coincides with the increase in beam trawling effort, which started in 1970 and continues to the present day. Such a shift could be due to fishery pressure because starfish suffer less mortality during trawling than many other species, so they survive better; fishing may have reduced predation on some species by reducing the abundance of fish predators; and fishing may have provided increased food for scavenging species, increasing their populations¹¹⁴. This is just one example of the major changes which have taken place in our seas - there are doubtless others. The complexity of the ecosystem is being reduced, and with the change from complex food webs to simple food chains, resilience is also lost. It has recently been claimed that the number of levels in the North Sea food chain halved between 1880 and 1981¹¹⁵. Such fundamental changes have happened almost un-noticed, and yet fisheries are probably the most studied of our activities affecting the marine environment.

Key messages for fisheries

- The European fishing fleet is too large and catches too many fish. The amount of fish caught must be reduced to bring fishing effort in to line with resources, and to help fish stocks to recover. Governments at the World Summit on Sustainable Development in August 2002 committed to restore depleted fish stocks to levels that can produce the maximum sustainable yield by 2015 where possible. In so doing, many of the other effects of fishing on the marine environment will be reduced. To achieve this goal transitional aid will be needed
- Many fishing methods damage non-target wildlife. Recovery of the seabed depends on its physical structure and how well adapted to disturbance the plants and animals are. Some areas may take years or may never fully recover
- We need to work with the industry to develop the ecosystem-based approach, including the development of more regional governance and the use of less environmentally damaging fishing methods
- Exploring the scope of both spatial and temporal closures to allow both fish and wildlife to recover
- There is a need for more targeted research into the way that fishing affects the delicate balance of the life in the sea. In areas where we do not know the effects of our actions, we should be more cautious in our management. We cannot afford to continue to take risks in fisheries management that may lead to long-term or irreparable damage to fish stocks and other life in the sea

4. A modern approach to management

The aim of this section is to highlight some key actions that we believe are required and that need to be taken into account by all who are responsible for, or manage the maritime environment.

We need an informed debate about what needs to change and why. Following publication of this dossier of evidence, we plan to stimulate such debate.

We will start a consultation process to develop in more detail ideas on how to tackle the challenges effectively. The results will underpin the development of English Nature's new Maritime Strategy and action plan.

This is due for launch in 2003.

4.1 The need for change

Evidence points to the need for a change in the direction of maritime policy and management:

- Coastal ecosystems, including their underlying geology and geomorphology, are especially vulnerable today because of unsustainable management practices including inappropriate development and coastal defence measures, and the effects of global climate change.
- Marine communities have been substantially altered primarily as a result of consistent fishing pressure over the last century. The link with the significant loss of marine biodiversity can be demonstrated.
- Poor water quality is having a pervasive and chronic effect on some maritime species.
- Contaminants become stored in marine sediments where they can later be liberated or concentrated in the higher levels of the food chain.
- There are significant economic savings to be made over the long term by modifying our present approach to one which is more sustainable.

So why has it taken so long to realise that our coasts and seas are in such a degraded condition? In part it is because problems with the sea are not generally visible to the public, and that changes have occurred slowly but progressively over a long time. Moreover, what we regard as a baseline for judging change is a degraded system, and this makes it difficult to understand what an environment in good condition would look like. A fundamental issue is that those with responsibilities for maritime issues, outside of the conservation sector, have yet to fully embrace values for the conservation of maritime ecosystems and all that they contain. Finally, only recently has

the focus on the maritime environment started to look at ecosystems as a whole, rather than sectoral interests or single issues. Dealing with single issues has led to some notable successes: for example the reduction of mercury inputs to marine waters, the ban on TBT antifouling paints for small craft, and the creation of a number of maritime Special Areas of Conservation. Essential though they are, these successes have not solved the wider problems of declining ecosystem health. Further, now we must tackle the wider and more difficult challenge of recovery.



Successes such as the ban of TBT antifouling paints for small craft are welcome, but wider problems of declining ecosystems remain. Roger Covey/English Nature

4.2 The type of change needed

Maritime management needs to take a much more holistic, precautionary and longer-term view; something the Government is already acknowledging. Current management relies on predicting the effects of single activities, then trying to manage them accordingly. However, our understanding of the maritime environment is incomplete, and regulators are never likely to have sufficient information to be certain of the long term and cumulative impacts, therefore we need to manage risks accordingly. Ecosystems often function in ways that we cannot predict from previous trends. For these reasons we need to build in a much larger safety margin to ensure we are managing within the limits of our knowledge and the capacity and resilience of the ecosystem; at the moment we may well be operating outside these limits.

Any measures we put in place to protect biodiversity need to take into account the inter-relationships within the maritime environment. A network of protected sites will be insufficient if protection measures are inadequate

Commercial species	Age at sexual maturity	Life span
Sand eel	1-2 years	4 years
Plaice	3-5 years	>40 years
Cod	3-6 years	>30 years
Common skate	7-12 years	>40 years
Haddock	2-5 years	>20 years
Saithe	2-10 years	>20 years
Common sole	3-5 years	>20 years
Non commercial species		
Barnacles	1 year	5-10 years
Egg wrack	5 years	10-25 years
Horse mussel	3-8 years	20-100 years
Seafan	?	20-100 years
Maerl	?	700 years
Basking shark	12-20 years	50
Harbour porpoise	4	12

Source: www.marlin.ac.uk & www.fishbase.org

and if the surrounding coasts and seas are in such poor health that species cannot move between them. An interconnected network of protected sites is an essential requirement but must be supplemented by other measures. We need to ensure that protected sites, where some of the environment is maintained free from exploitation, can thrive in a quality ecosystem which links them to achieve maximum effect.

Environmental change takes place over long timescales. Some commercially harvested species of fish could live for several decades, and take a number of years to reach sexual maturity and reproduce. Coastlines move and evolve over decades and hundreds of years. Set against this is the expectation that changes in policy will deliver immediate benefits. It is essential that modern policy should be forward looking, delivering long-term success. Seen in the context of the life spans of maritime species, forward looking takes on a whole new scale!

Current maritime management looks into the future to varying degrees. A review of the first generation of Shoreline Management Plans by DEFRA has recognised the need for a consistent 50-year forward view for coastal management⁷³, with appropriate reviews during this time. This long-term forward view is welcomed and should be seen as a minimum for forward planning in the maritime environment, although shorter-term goals and milestones need to be set and to be consistent with longer-term management needs.

Predicted climate change will need us to plan beyond the next 50 years for the effects of higher sea-levels and increased storminess. This forward planning will be essential if we are to avoid building in places which will be under threat, and if we are to manage the risk to existing developments cost-effectively. For the seas we need to introduce a period of recovery by lessening pressures especially from fishing.

4.3 What this means in practice

In essence we need to be managing coasts, seas, their ecosystems and the wildlife and natural resources they contain and not just individual sectors and their activities. This should help to foster recovery and ensure that the combined effects of these activities do not lead to a long-term decline in the health of the maritime environment.

Because of the current and sustained pressures on the marine environment, we need a period of recovery, to ensure that we can support future demands. Without this recovery period, to get things onto a more even keel, our continuing demands on the marine environment will lead to yet further loss of biodiversity and undermine future economic and social welfare. For the coastal zone, we need a more co-ordinated approach to regulation and management, greater use of soft engineering, more adaptive strategies for dealing with coastal change, and a programme of habitat re-creation. This is essential if we are to meet the needs of this and future generations and ensure the survival of coastal habitats and species and a high quality coastline for all to enjoy.



Even the humble barnacle can live up to ten years, underlining the need for a long term approach to maritime management. Paul Kay/MWPA

4.4 Key elements of a new approach

4.4.1 Targets

A key target of any new approach must be to reverse the declines in biodiversity and improve maritime environmental quality.

4.4.2 Integration

Current maritime policy has evolved over many decades, and has mainly focused on managing access to resources and controlling navigation. There has not been a starting point at which the goals for maritime management were established and explicitly agreed; merely a slow evolution. This piecemeal approach has left us with a range of legislation that fails either to ensure that resources are managed equitably, or that sustainable management is brought about over the longer term. Rationalising the legislation to support the implementation of an ecosystem-based approach and achieve true sustainable management over the whole maritime environment must be a priority.

Policy and legislation can be a vehicle for change or be lacking in flexibility or innovation. There is a clear need for radical and innovative thinking if we are to reverse the current decline in our maritime environment. Consultation and participative processes need to be used to help develop good policies as envisaged in the Government's "Guide to Better Policy Making"¹²². But the way in which consultation is carried out needs care if it is not to hamper innovation. Particular sectors may actively lobby against innovative change, seeing it as a threat to their interests and making it difficult to develop new solutions to long standing problems. Innovative thinking is often limited to new ideas within a particular sector, rather than developing policies for sustainable use over the wider maritime environment. Better co-ordination, co-operation and joined up thinking is needed between Government departments that manage activities in the

maritime environment.

The Marine Consents and Environment Unit is a good first step in this process, co-ordinating decisions under the Coast Protection Act and the Food and Environmental Protection Act. However, there would be merit in re-evaluating the 1949 Coast Protection Act and its integration with current and developing policy.

A more forward-looking step would be the development and application of a Government-led framework (led by a grouping of

'blue' Ministers). This could drive the process forward and deliver practical action on the ground to implement an ecosystem-based approach to our maritime environment, with the participation of departments, agencies and maritime users. We would like to explore the scope for this with stakeholders as we develop our maritime strategy.

4.4.3 An ecosystem-based approach

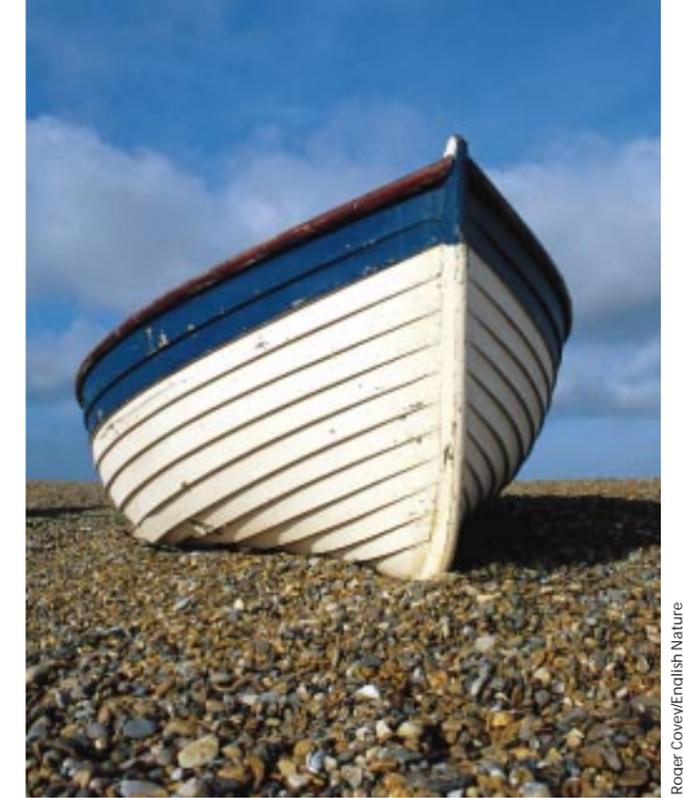
The core of an ecosystem-based approach lies in integrating the range of demands we place on the environment, such that it can indefinitely support these demands without deterioration. This is gaining more credence, particularly with regard to fisheries management^{116,117}, where looking at fish stocks in isolation from their environment, food source and predators is proving detrimental for both fisheries and conservation.

An ecosystem-based approach needs to be adopted by all sectors of the maritime community, from shipping to conservation, fisheries to recreation. This means taking a holistic approach to managing our demands on the maritime environment. Above all it is a sustainable and precautionary approach, seeking to ensure that damage does not occur through a lack of understanding or knowledge. Management of risks needs to be better, and there need to be a wider range of management options available. One innovation we need to trial is to set aside some marine areas free from extraction. These sites would then act as an insurance against damage occurring elsewhere due to a lack of knowledge or over intensive use. They would also act as valuable reference areas against which to judge the sustainability of management in wider seas and coasts.

4.4.4 Improving knowledge collection, management and learning

There are substantial gaps in knowledge and understanding of the maritime environment and we will never have enough information and understanding to predict all eventualities. It will be important to ensure that all maritime management is carried out within the limits of our knowledge, and that, where a critical lack of knowledge is highlighted, it triggers a precautionary approach and appropriate research.

We need to recognise that we have sufficient information right now to start implementing an ecosystem-based approach to management. In many cases however, information is spread between various research institutes where it not easily available to policy makers or managers, and it is sometimes difficult to make links between diverse data sets and so better understand the bigger picture. More needs to be done here.



Roger Covey/English Nature

Dan Laffoley/English Nature





Marine environmental data needs to be made widely available if managers are to be able to make informed decisions.
Roger Covey/English Nature

To support full implementation of an ecosystem-based approach, all maritime managers need to increase their understanding of the range of inter-related effects that their activities can have on the maritime environment. Equally importantly, operators need to recognise where they have insufficient understanding and need to take a more precautionary approach. To inform this approach better science will be needed. Not just new research, but first a gathering together of maritime information to ensure that the best existing work is being effectively used. Links need to be built between maritime managers and key research establishments, so that for example, the latest information on ocean processes is used to inform fish stock recovery programmes, or maritime conservation monitoring.

English Nature supports the Government's commitment, outlined in the Marine Stewardship Report, to developing better integration of marine environmental monitoring and observation. Many initiatives are already underway to improve the accessibility of data, such as on habitats and species by MarLIN - the Marine Life Information Network. This is summarising scientific information in a way that is meaningful for management and making it available on the internet, or the National Biodiversity Network. In future this will supply data for reporting on the state of the maritime environment. We welcome the Government's commitment to ensuring that publicly funded marine environmental data is made as freely available as possible; there is also a need to ensure that privately collected data, where it is not commercially sensitive, is also made more widely available. In addition to the need for improved co-ordination and access to spatial data and mapping of the marine environment, also highlighted in the Marine Stewardship Report, there is a need for similar spatial data co-ordination in the coastal zone, if managers are to be able to take more informed decisions.

Appropriate monitoring will also be important, to check that recovery is taking place, and to ensure that we gain valuable information on the effects of new activities on the maritime environment. Action to follow up and test whether predictions made in environmental impact assessments are borne out in practice is needed. If such monitoring were done and made widely available, it would provide useful information to guide future environmental impact assessments and management plans.

4.5 The next steps

English Nature will be developing its Maritime Strategy in consultation with others over the coming year. The launch of this State of Nature Report is the start of a broad consultation process to develop ideas for practical change that command wide support. Only by working together towards a common goal of sustainable use of the maritime environment can we strive towards a better future for both people and our maritime biodiversity.

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The production of a review of scientific information draws heavily on the body of published and unpublished work that has been undertaken by previous researchers. We are extremely grateful to those who have taken the time to publish such a wealth of information on the state of our maritime environment. We believe that by bringing this evidence together we have made the case stronger for more significant and urgent actions to provide a healthy and productive maritime environment.

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Glossary

Algal bloom

A massive reproduction and growth of algae, often free-floating, in response to the presence of higher than normal levels of nutrients.

Algal mat

A dense mass of green or other algae (e.g. *Enteromorpha* spp., *Ulva* spp.) which blankets the substratum in a littoral or shallow-water environment, often in areas of freshwater influence or where eutrophication occurs.

Annex 1 birds

Bird species listed on Annex 1 of the Birds Directive. These are in danger of extinction, are rare, or are considered vulnerable within the European Union. Those that regularly occur at levels over 1% of the national population meet the SPA qualifying criteria.

Annex I habitat type(s)

A natural habitat(s) listed in Annex I of the Habitats Directive for which Special Areas of Conservation can be selected.

Anthropogenic

The effects imparted by human activity on the form and function of the natural world.

Arctic

Referring to a biogeographical region centred north of the British Isles and influencing the extreme north of the British Isles.

ASCOBANS

Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas.

BAP

Biodiversity Action Plan.

Benthos

Those organisms attached to, or living on, in or near, the seabed, including that part which is exposed by tides.

Bioaccumulation

The ability of organisms to retain and concentrate substances from their environment. The gradual build-up of substances in living tissue, usually used in referring to toxic substances, may result from direct absorption from the environment or through the food chain.

Biodiversity (biological diversity)

“The variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.” (UN Convention on Biological Diversity 1992).

Biogeographic region

A region which is separated from adjacent regions by barriers or a change in environmental conditions which limits the movement of species or prevents their establishment outside their natural geographical range.

Biomass

The total quantity of living organisms in a given area, expressed in terms of living or dry weight or energy value per unit area.

Bloom (algal/planktonic)

- 1) A seasonal increase in the abundance of plankton
- 2) A superabundance of one or more species of planktonic organism, often resulting in a discoloration or opacity of the water, or of macroalgae; can be a consequence of eutrophication.

Brackish

Referring to mixtures of fresh and seawater. Usually regarded as between 0.5 ‰ and 30 ‰ salinity.

CEFAS

Centre for Environment Fisheries and Aquaculture Science

CFP

Common Fisheries Policy.

Chalk

A soft fine-grained sedimentary rock, normally white, consisting almost entirely of calcium carbonate.

CHaMPS

Coastal Habitat Management Plans.

Circalittoral

The subzone of the rocky sublittoral below that dominated by algae (the infralittoral), and dominated by animals. No lower limit is defined, but species composition changes below about 40 m to 80 m depth, depending on depth of the seasonal thermocline. This subzone can be subdivided into the upper circalittoral where foliose algae are present and the lower circalittoral where they are not.

Cliff

Any slope, usually of bedrock but can be clay, steeper than 45°.

Coastal zone

The space in which terrestrial environments influence marine environments and vice versa. The coastal zone is of variable width and may also change in time. Delimitation of zonal boundaries is not normally possible; more often such limits are marked by an environmental gradient or transition. At any one locality the coastal zone may be characterised according to physical, biological or cultural criteria, which need not, and rarely do, coincide.

CPR

Continuous Plankton Recorder.

Crustacea

A class of invertebrates which include crabs, shrimps and barnacles.

DDT

Dichlorodiphenyltrichloroethane.

DEFRA

Department for Environment, Food and Rural Affairs.

DETR

Department for Environment, Transport and the Regions.

Diversity

The state or quality of being different or varied. In relation to species, the degree to which the total number of individual organisms in a given ecosystem, area, community or trophic level is divided evenly over different species, ie a measure of heterogeneity. Species diversity can be expressed by diversity indices, most of which take account of both the number of species and number of individuals per species.

DTI

Department of Trade and Industry.

DfT

Department for Transport.

EA

Environment Agency.

EC

European Commission.

EDMAR

Endocrine Disruption in the Marine.

EEC

European Economic Community.

Epifauna

Animals living on the surface of sediments or hard substrates.

EU

European Union.

European (marine) site

A special area of conservation under the EC Habitats Directive; a site of Community importance drawn from the Member States list by the Commission of the European Communities under the Habitats Directive, or a site not submitted by a Member State but found by the Commission to be hosting a priority habitat type or priority species and subject to consultation; an area classified pursuant of Article 4(1) or (2) of the Wild Birds Directive. (Based on The Conservation (Natural Habitats, &c.) Regulation 1994 and Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora).

Eutrophication

The over-enrichment of an aquatic environment with inorganic nutrients, especially nitrates and phosphates, often anthropogenic (e.g sewage, fertiliser run-off), which may result in stimulation of growth of algae and bacteria, and can reduce the oxygen content of the water.

FEPA

Food and Environmental Protection Act 1985.

Foreshore

The part of the intertidal zone that lies between normal high- and low-water marks. In English law, the landward limit has been defined as the line of medium high tides between the springs and the neaps, while the seaward limit is assumed to be the low-water line of ordinary tides.

Geomorphology

The branch of science concerned with the structure, origin and development of topographical features of the earth's crust.

ICES

International Council for the Exploration of the Sea.

IMO

International Maritime Organisation.

Imposex

An abnormality of the reproductive system in female gastropod molluscs, by which male characteristics are superimposed onto female individuals, resulting in sterility or, in extreme cases, death. This may be caused by hormonal change in response to pollution from organotin, even at low concentrations.

Infauna

Benthic animals which live within the seabed.

Infralittoral

A subzone of the sublittoral in which upward-facing rocks are dominated by erect algae, typically kelps; it can be further subdivided into the upper and lower infralittoral.

Intertidal

The area of the shore between the highest and lowest tides.

IPCC

Intergovernmental Panel on Climate Change.

JNCC

Joint Nature Conservation Committee.

Kelp

A group of large brown algae of the Order Laminariales.

Littoral

The area of the shore that is occupied by marine organisms which are adapted to or need alternating exposure to air and wetting by submersion, splash or spray. Also called intertidal.

Maerl

Twig-like unattached (free-living) calcareous red algae, often a mixture of species and including species which form a spiky cover on loose small stones - 'hedgehog stones'.

MAFF

Ministry of Agriculture, Fisheries and Food.

MarClim

Marine Biodiversity and Climate Study.

Marine protected area

“Any area of intertidal or subtidal terrain, including geological and geomorphological features, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment.” (IUCN definition, as modified by the Marine Protected Area Group, a working group of Wildlife Link's Joint Marine Group).

Maritime

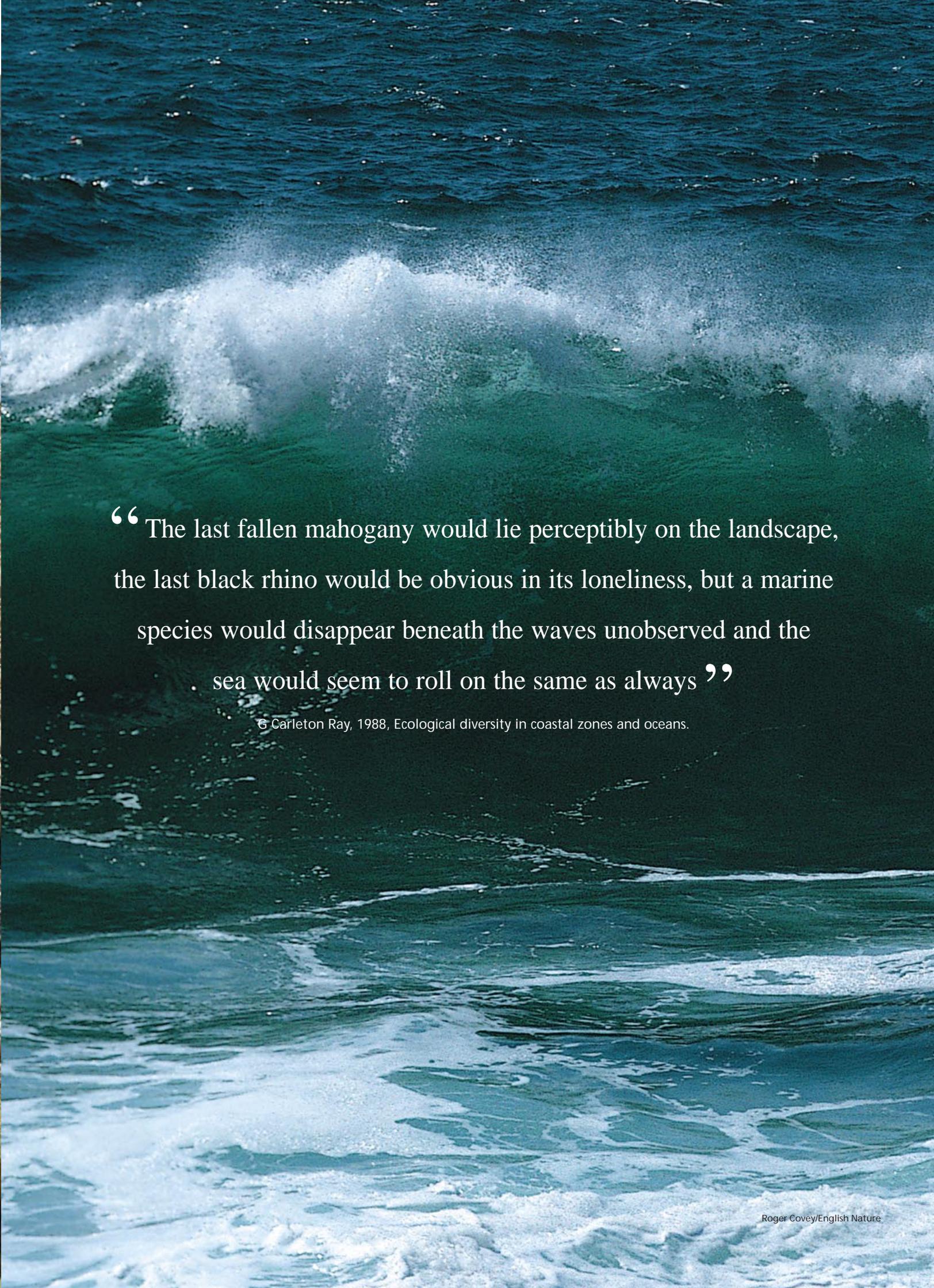
Situated, living or found close to, and having a special affinity with, the sea.

MARPOL

International Convention for the Prevention of Pollution from Ships.

MCEU

Marine Consents & Environment Unit.



“The last fallen mahogany would lie perceptibly on the landscape, the last black rhino would be obvious in its loneliness, but a marine species would disappear beneath the waves unobserved and the sea would seem to roll on the same as always”

© Carleton Ray, 1988, Ecological diversity in coastal zones and oceans.



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