Charting Progress 2

Feeder Report: Productive Seas

United Kingdom Marine Monitoring & Assessment Strategy

UKMMAS

Charting Progress 2

Feeder Report: Productive Seas

Preface

Charting Progress 2 seeks to show the extent to which the UK Government and the Devolved Administrations are making progress towards their vision of achieving clean, healthy, safe, productive and biologically diverse oceans and seas as set out in *Safeguarding our Seas*, in 2002. It builds on *Charting Progress*, the first assessment of the UK Seas, published in 2005, and its delivery is the responsibility of the United Kingdom Marine Monitoring and Assessment Strategy community (UKMMAS) community which was set up in response to a recommendation in *Charting Progress* to provide a more coordinated approach to the assessment and monitoring of the state of the UK marine environment. UKMMAS created four evidence groups (the Healthy and Biologically Diverse Seas Evidence Group – HBDSEG; the Clean and Safe Seas Evidence Group – CSSEG; the Productive Seas Evidence Group – PSEG; and the Ocean Processes Evidence Group – OPEG) to collect the evidence needed to assess progress towards achieving the vision. Each evidence group has a broad membership across the academic and research communities as well as experts in government agencies and non-governmental organisations, and was tasked to produce a 'Feeder Report' assessing all the evidence available under its remit which could be used as source material for the evidence chapters in the main *Charting Progress 2* report.

This Feeder Report forms the PSEG contribution to *Charting Progress 2* and provides an assessment of the productive use of UK seas. Key contributors are listed at Pages 432 and 433.

The authors of this report are responsible for all the information, including all data, technical information and graphic material, contained within this report, including the referencing, correct use and accuracy of such information.

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Executive Summary

This is the first time that a comprehensive assessment of the productive use of the UK seas has been carried out. We found that our seas are economically productive and there are strong policy drivers to increase this productivity. Most activities are highly regulated in order to limit impacts on the marine environment and, aside from fisheries, have localised pressure footprints. Although we have begun measurements of sustainability we do not yet know how sustainable our use of the seas is overall.

Key findings

- Oil and gas make the highest annual contribution to the economy of any activity in the marine environment, with a gross value added of £37 billion in 2008. Maritime transport and telecommunications provide vital links within the UK and to the rest of the world offering significant economic benefit. Expenditure related to leisure and recreation activities is high and likely to be underestimated given current limitations in sourcing data for this sector. Expenditure on military defence activities provides additional benefits to the economies surrounding the main naval bases. Fisheries and aquaculture within the UK continue to supply food nationally and abroad and support local fishing communities.
- During the past ten years, fishing mortality (mortality caused by fisheries) has declined significantly in 67% of assessed fish stocks in UK waters. Out of 20 indicator fin-fish stocks in UK waters, the proportion being harvested sustainably and at full reproductive capacity has risen from around 10% in the early 1990s to around 25% in 2007. The proportion of these stocks being harvested sustainably has risen from 10% to around 40% over the same time period. However, the large majority of scientifically assessed stocks continue to be fished at rates well above the values expected to provide the highest long-term yield.
- Renewable energy projects and work on flood and coastal defences have more than doubled since *Charting Progress* and will continue to increase. For marine renewable energy, the target is to increase installed capacity from 0.7 GW (as at the start of 2010) to at least 33 GW by 2020. Most of this additional capacity is expected to come from new offshore wind farms.
- Many socio-economic activities put varying degrees of pressure on the marine environment, notably damage and loss of habitat on the seabed from fishing and the presence of physical structures; pollution and other chemical changes from land and marine-based sources; introduction of invasive species from shipping and mariculture; noise from construction and operational activities; and litter from a wide range of sources. Stricter controls in a number of evolving UK, European and international policies have reduced some of these pressures since *Charting Progress* and most industries now have sustainable development strategies.

Improvements in assessment methodology and future requirements

We cannot yet determine whether we are using the seas sustainably, largely because we are not in a position to assess the cumulative impacts of all activities such as fisheries and leisure and recreation. Assessing sustainable use will be an important focus for the coming years.

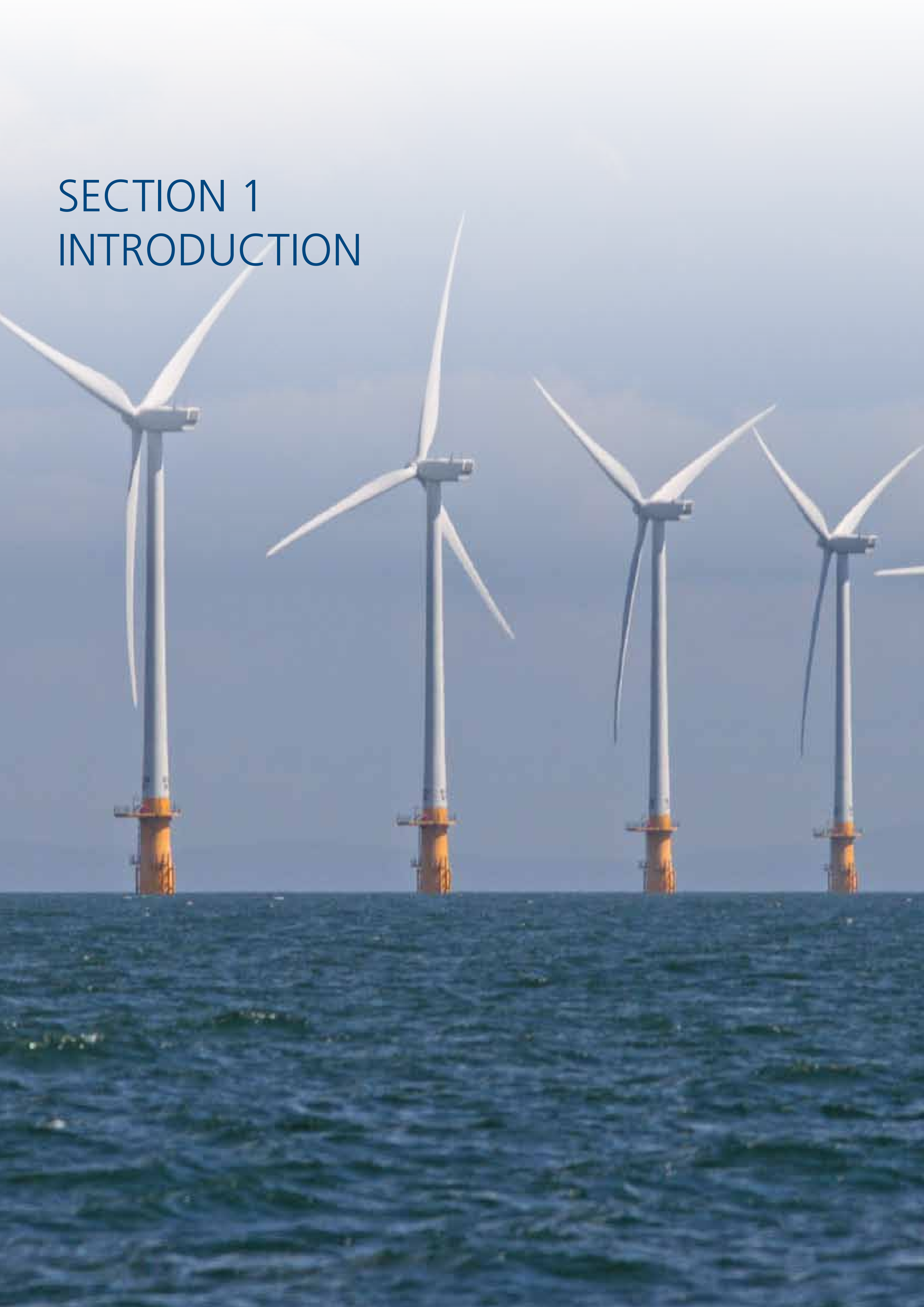
We need a better way to establish a market value for some activities, including leisure and recreation, waste disposal, telecommunications and power transmission, and pipelines, as well as future activities such as carbon capture and storage. We also need a way to evaluate the contribution that marine activities make to social values, such as upholding cultural traditions in local fishing communities. As yet there is little primary research on the economic value of ecosystem goods and services and the non-use value of the marine environment. We need to agree a methodology on how to spatially allocate socio-economic data to support regional assessments.

Future assessments would greatly benefit from a more coordinated and centralised collation of data on the distribution of pressures associated with aquaculture, with leisure and recreation, and with temporal and size aspects of shipping density.

Gaps in knowledge

We also need to know more about the nature and extent of many pressures arising from productive use of the seas, notably the spatial and temporal distribution of noise sources, litter and invasive species and to agree on the methodology used to assess them. We do not yet know the extent of the environmental pressures that will arise from increasing activity in renewable energy, coastal defence and gas storage. We also need tools to take account of the fact that some industries, which may cause impacts while they are being constructed, can then act as areas for species to settle once they are established.

SECTION 1
INTRODUCTION



1.1 Overview

The first Marine Stewardship Report *Safeguarding our Seas* (Defra, 2002) set out the UK Government's and Devolved Administration's vision for clean, healthy, safe, productive, and biologically diverse oceans and seas.

It is the Government's policy that stewardship of the marine environment must be informed by the best available scientific information. *Safeguarding our Seas* outlined plans for developing a more sustainable and integrated approach to the management, conservation and use of the marine environment. Furthermore, an 'ecosystem approach' was detailed as being important in achieving this and for assessments of the quality status of the North-East Atlantic by the OSPAR Commission (e.g. OSPAR, 2000).

In light of these initiatives, an initial assessment was made of the various pressures and impacts of human activities in the marine environment and was published in the report *Charting Progress* (Defra, 2005a). *Charting Progress* took an ecosystem approach by focusing on the various components of marine ecosystems and assessing these according to biogeographic regions rather than geo-political boundaries. The report highlighted a number of areas for improvement in order to enhance the evidence available for policy development. As a result of *Charting Progress* the UK Marine Monitoring and Assessment Strategy (UKMMAS) was established and the Marine Climate Change Impacts Partnership (MCCIP) and the Marine Environmental Data Information Network (MEDIN) were formed.

Charting Progress did not include wide-ranging assessments of socio-economic activity. Under UKMMAS, a number of evidence groups have formed. The Productive Seas Evidence Group (PSEG) is responsible for providing the evidence base on the impacts and benefits of human uses of the seas and for providing the assessment of these to underpin the development of effective policies for achieving the sustainable and productive use of the seas around the UK.

Since the formation of UKMMAS and the associated evidence groups, the Marine and Coastal Access Act 2009, the Marine (Scotland) Act 2010 and proposals for similar marine legislation in Northern Ireland have been developed with the aim of taking the marine management agenda forward. There are also objectives to achieve good environmental status under the EU Marine Strategy Framework Directive (MSFD). The need for information to support the development of these policies and the assessments required under the MSFD has influenced the focus of this report.

Evidence that has been gathered since *Charting Progress* has been updated and presented here. Specifically it will inform policy-making for the marine environment, and help to identify priorities for the Marine Acts to be taken forward by the UK Government and Devolved Administrations.

1.2 Objective

The aim of the PSEG Feeder Report is to provide a comprehensive assessment of the socio-economic activities occurring in the marine environment in the UK and their associated trends and impacts (both positive and negative). No such assessment was made in *Charting Progress*.

This has been achieved through the following objectives:

- To provide a sectoral and regional (where practicable) assessment of the value and sustainability of socio-economic activities occurring in the marine environment in the UK
- To assess the pressures, positive, negative and cumulative (where practicable), in terms of distribution, intensity and frequency (where possible) of socio-economic activities occurring in the marine environment in the UK
- To highlight any new, changing or emerging socio-economic or regulatory activities in the marine environment
- To identify significant gaps in knowledge in order to define priorities for further scientific, economic and/ or social investigations, particularly including those needed to support further application of an ecosystem approach to the management of human activities
- To identify any priorities for regulatory action.

This Feeder Report provides the evidence for *Charting Progress 2*; a summary report pulling together all the evidence on the state of the UK seas.

1.3 Approach

This section describes the general approach taken in preparing the PSEG Feeder Report, including clarifying key definitions of 'productive seas' and 'economic activity' and outlines the structure and content of the report. More specific aspects of methodology are described in Annex 1 to this report. Overall, this report builds upon the work undertaken in *Scotland's Seas: Towards Understanding their State* (Baxter et al., 2008) and Pugh's report for The Crown Estate on the socio-economic value of relevant marine activities in the UK (Pugh, 2008), supported by relevant industry reports and analyses.

1.3.1 Definition of 'productive seas'

Gross Domestic Product (GDP) is defined by the Office for National Statistics (ONS) as the sum of all economic activity, taking place in UK territory (ONS, 2007a) and economic production in general may be defined as *...activity carried out under the control of an institutional unit that uses inputs of labour or capital and goods and services to produce outputs of other goods and services*. The ONS goes on to specify activities where an output is owned and produced by an institutional unit, for which payment or other compensation has to be made to enable a change of ownership to take place.

In relation to the marine environment, 'productive seas' implies those socio-economic activities that *use* the marine environment's natural goods and services to produce outputs of other goods and services that are owned and can be exchanged for payment. This definition becomes important in identifying principal economic activity (see Section 1.3.2).

It is important to note that not all activities that occur in the marine environment necessarily use it or its resources to produce a product or service that is owned, that is, do not relate to productivity. For example, the disposal of waste uses ecosystem goods and services (e.g. chemical cycling for waste assimilation) but does not provide an additional good or service that is owned and can be transferred as a result, that is, does not relate to productivity.

However, to feed into the overall aims of *Charting Progress 2* and those of the other evidence groups, it is important that the working definition of 'productive seas' ensures that all marine-related activities are assessed that present a pressure on the marine environment and potentially result in impacts. Therefore, the scope of this study also considers those activities that fall within the full remit of PSEG and includes activities related to management and support of economic activities.

It should be noted that, in focussing on productive use, the report does not provide a full economic assessment of marine ecosystem goods and services following the Total Economic Valuation (TEV) framework promoted by Defra (2007a). This would require application of the assessment methodology in the reporting among all evidence groups. However, the report does develop the information base on which such assessments could be made by identifying the ecosystem components that activities are dependent on and also impact on (see Annex 1 for a full description of the methodology).

1.3.2 Definition of 'economic activity'

The UK Standard Industrial Classification (SIC) of Economic Activities 2007 (ONS, 2007b) states that ...*an economic activity takes place when resources such as capital goods, labour, manufacturing techniques or intermediary products are combined to produce specific goods or services. Thus, an economic activity is characterised by an input of resources, a production process and an output of products (goods or services).*

In the estimate of national GDP, the decision as to whether to include a particular activity within the production boundary takes into account the following:

- Does the activity produce a useful output?
- Is the product or activity marketable and does it have a market value?
- If the product does not have a meaningful market value can a market value be assigned (i.e. can a value be imputed)?
- Would inclusion (or exclusion) of the product of the activity make comparisons between countries or over time more meaningful?

These questions guided the scope of the PSEG Feeder Report, that is, assessing what activities are included.

Economic activities can be further sub-divided into three levels: principal, ancillary and secondary. The ONS (2007b) provides some useful definitions of these levels (see Table 1.1) and these have been interpreted in relation to the scope of marine productivity to provide a working definition for this project.

Ancillary activities are often referred to as upstream activities while secondary activities are commonly known as downstream activities. There are some difficulties in defining ancillary and secondary activities as they often overlap with those from other principal activities. For example, the secondary activity of fish processing is dependent on fish from both sea fisheries (SIC 03.11) and fish farming

(SIC 03.21). As there are no separately reported values of these two inputs into fish processing a number of assumptions are required to differentiate them. In addition, it is difficult to know where to draw the end point of the upstream and downstream chains.

1.3.3 Socio-economic activities considered

Based on the working definitions in Table 1.1, all economic activities associated with the marine environment and that fall within GDP have been allocated as indicated in Table 1.2.

The PSEG Feeder Report includes an assessment of each of these activities under the heading of the principal activity (see Section 3). All of the activities are very different from each other, for example, oil and gas has complex economic structures and downstream industries, fisheries includes a wide range of activities with different interactions with the marine environment, others such as telecommunications have a direct relationship solely with the seabed but are difficult to place a value on. Furthermore, the level of understanding about the activities (economic and environmental) varies widely. As a result, the same level of detail for each activity has not been possible nor, in some cases, appropriate (e.g. where activities and relationships with the marine environment are quite simple). However, consistent headings are used throughout to assist ease of comparison and navigation.

In addition, a principal activity as a whole may not be entirely marine, with a proportion of the activity occurring on land, such as education, renewable energy, waste disposal. Where economic data are only available for the sector as a whole, assumptions are presented in each activity assessment in Section 3 on the proportion that is marine related.

Table 1.1 Classification of the types of economic activity related to the marine environment.

	SIC 2007 definition	*Our working definition*
Principal	The activity that *...contributes most to the total value added of that unit.*	Those activities that directly use marine ecosystem goods and services to provide a marketable good or service.
Ancillary	Ancillary activities *...exist solely to support the principal or secondary economic activities of a unit, by providing goods or services for the use of that unit only.*	Those activities that exist solely to support (or manage) the activities of the principal activities, particularly those that fall within the management remit of PSEG
Secondary	*…any other activity of the unit, whose outputs are goods or services suitable for delivery to third parties.*	Those that use the outputs of the principal activity to produce a secondary product or service.

1.3.4 Issues considered for each activity

To help meet the objectives of this assessment (see Section 1.2) a number of consistent headings have been used for each principal activity as follows:

- Key points – which summarise the main conclusions from the report within both bullet points and summary headings
- Introduction – a description of activity and management systems
- Use values – an assessment of principal, ancillary and secondary activities
- Regional distribution of value – among the eight CP2 reporting regions
- Trends – past trends in economic value and production

- Socio-economic pressures – interactions with other socio-economic activities
- Environmental pressures and impacts
- Climate change – both impacts on and impacts from climate change
- Industry stability and sustainability
- Forward look

Different data that can measure economic 'value' are available for the different sectors studied in this report. Economic value is fully described as 'Total Economic Value' which has three main components: use values, option values and non-use values. This report is primarily concerned with use values, as reflected in market activity. Market prices are used to measure this activity, but this still gives rise to a number of different measures of economic activity that have been used in this report:

- Turnover is the total market value of goods or services sold – it measures output.
- Investment is the spending on assets that will produce goods or services in the future (e.g. investment in flood defences research and development secures the benefits of flood defences from such information in the future). It is a minimum measure of expected future benefits – because if this benefit was less than the investment, it would not be a rational choice.
- Expenditure is the total market value of goods and services purchased. It is a proxy for turnover, because if it was greater than turnover, an activity would not be economically viable.
- Gross Value Added (GVA) is the added value of outputs of goods and services from an activity compared to inputs. GVA figures are available for some activities, or can be estimated as a proportion of Turnover based on sector-specific, or generic, ratios. Being net of the value of inputs means that GVA can be summed from different sectors without risk of double counting and is used to represent the contribution to Gross Domestic Product (GDP).

Given the difficulties in measuring indirect social and economic impacts there is a paucity of information on this subject area. Although available reports and data have been used where relevant (e.g. figures on employment), the methodology relies on economic data to form a proxy for more social impacts.

While the focus of the report is on describing environmental pressures, a summary is given of potential impacts and reference provided to more detailed assessments of impacts in the two complementary feeder reports: those produced by the Healthy and Biologically Diverse Seas Evidence Group (HBDSEG) and the Clean and Safe Seas Evidence Group (CSSEG).

The study also investigates socio-economic pressures from each activity, that is, how it may influence other social and economic uses in either positive or negative ways. However, as a status report, it does not attempt to assess the inter-sectoral nature of activities and analyse alternative uses of sea areas. To clarify, it is not the role of the PSEG Feeder Report to provide advice on what activities should be given priority in each CP2 Region as this will be addressed by marine planning initiatives under the various Marine Acts and regional policies.

1.3.5 Case studies

Case studies are included throughout the report in relevant sections to help to clarify some of the complex issues involved for individual activities and overall marine management. Case studies and the sections where they can be found are as follows:

Case Study 1	Managed realignment as a soft coastal defence measure (Section 3.2: Coastal Defence)
Case Study 2	Multi-annual fishery management plan for herring off the north west coast of Scotland (Section 3.5: Fisheries)
Case Study 3	HMS *Scylla* – regional socio-economic benefits of diving related activity (Section 3.6: Leisure and Recreation)
Case Study 4	Non-native species (Section 3.7: Maritime Transport)
Case Study 5	Improved understanding of marine archaeology from sharing of information by industry: North Sea Palaeolandscapes Project (Section 3.8: Mineral Extraction)
Case Study 6	Making green energy greener (Section 3.12: Renewable Energy)
Case Study 7	Towards a system of marine planning in the UK (Section 4)

1.3.6 Structure

The PSEG Feeder Report is structured as follows:

1. Introduction (this section)
2. Overall assessment (which forms the basis for Chapter 5 in *Charting Progress 2* – this summarises the activity assessments in Section 3 and incorporates a forward look and regional seas statement)
3. Activity assessments
    - 3.1 Aquaculture
    - 3.2 Coastal Defence
    - 3.3 Defence - Military
    - 3.4 Education
    - 3.5 Fisheries
    - 3.6 Leisure and Recreation
    - 3.7 Maritime Transport
    - 3.8 Mineral Extraction
    - 3.9 Oil and Gas
    - 3.10 Pipelines
    - 3.11 Power Transmission
    - 3.12 Renewable Energy
    - 3.13 Research and Development
    - 3.14 Storage (of Gases)
    - 3.15 Telecommunications
    - 3.16 Waste Disposal
    - 3.17 Water Abstraction
    - 3.18 General Management and Regulation
4. Management (including objectives and indicators of state)

Annex 1 – Assessment Methodology

Table 1.2 Identification of socio-economic activities occurring in the marine environment separated according to principal, ancillary and secondary activities. The relevant SIC 2007 numbers are given in brackets.

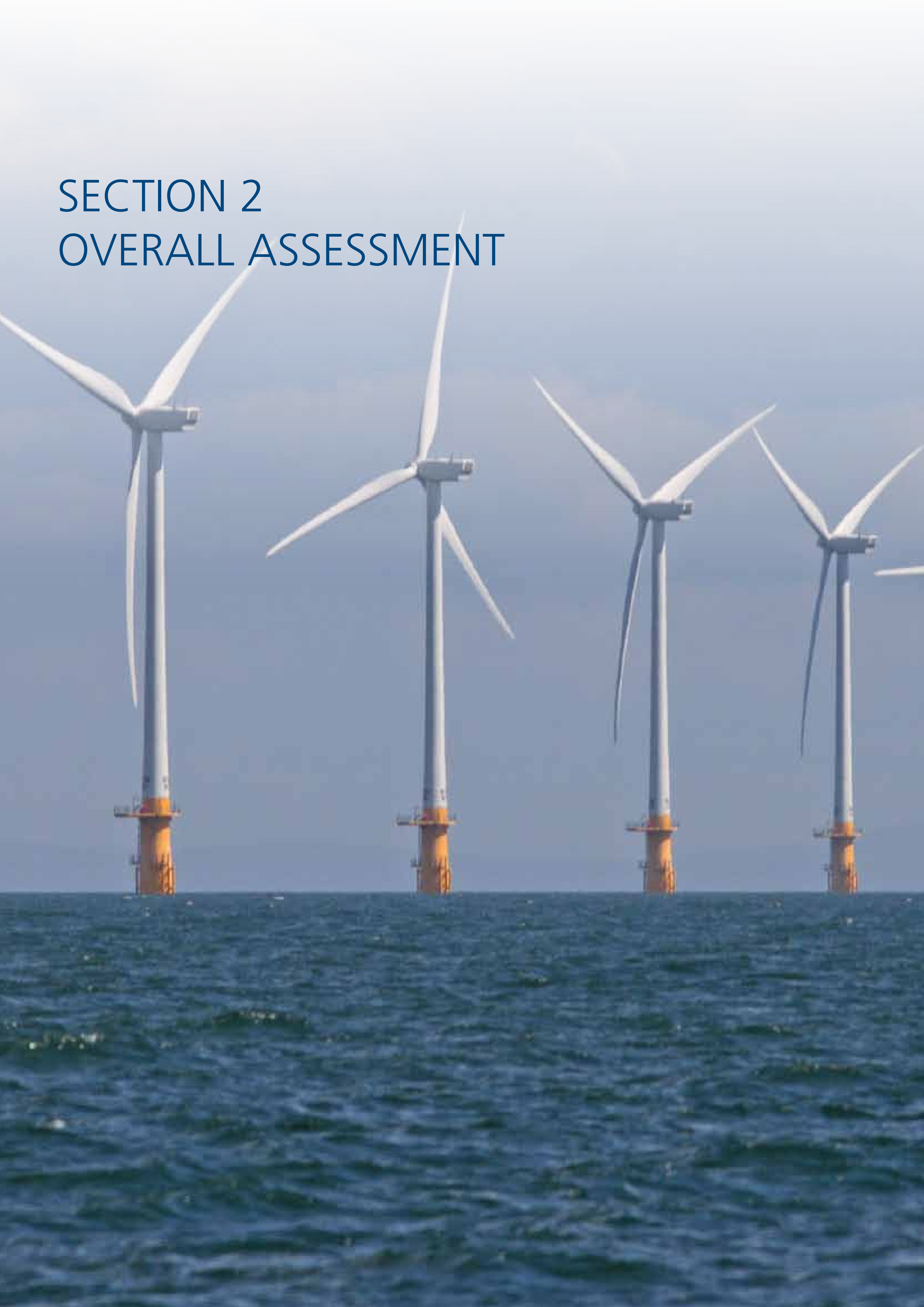
Principal	*Ancillary*	*Secondary*	*Excluded*
Aquaculture (SIC 03.21) Fish farming in seawater; Culture of crustaceans, bivalves, other molluscs and other aquatic animals in sea water; Production of fry, fingerlings and spat; Growing of laver and other edible seaweeds	Manufacture of prepared feed for farms (SIC 10.91); Specialised construction (SIC 43.99/9), installation (SIC 33.2) and decommissioning of fish farms	Fish processing (SIC 10.20); Sale of fish etc for food (SIC 46.38, 47.23); Agents involved in the sale of products (46.17) - Fishmongers and fish retailers	None identified
Coastal Defence (SIC 42.91) including beach replenishment	Construction (SIC 42.91) Research and Development	None identified	None identified
Defence – Military (SIC 84.22) Part Commander-in-Chief Fleet;	Second Sea Lord / Commander-in-Chief Naval Home Command and Central Services; Training; Ship building and maintenance	No known secondary form of productivity from military activities	None identified
Education (SIC 85)[a] Higher Education (85.4); Technical and vocational training, e.g. for commercial (85.32) and non-commercial (85.53) pilotage	Construction of marine structures associated with educational facilities, e.g. slipways and wharves (part SIC 42)	None identified	None identified
Fisheries (SIC 03.11) Inshore and offshore commercial fishing; Taking of crustaceans and molluscs; Taking of other marine organisms, e.g. algae sponges, seaweeds	Activities of fisheries enforcement agencies (SIC 84.24)	Fish processing (SIC 10.20) Secondary sale of fish etc for food (SIC 46.38, 47.23) – supermarket fishmongers and fish retailers	Recreational sea-angling – included under Leisure and Recreation (SIC 93.19)
Leisure and Recreation (SIC 93)[a] Water sports activities and recreation (SIC 93), e.g. diving activities, sailing; Recreational and sport fishing (93.19); Renting and leasing of recreational and sports goods (SIC 77.21); Tourism; Renting of boats for fishing cruises (Part SIC 50.10).	Building of pleasure and sporting boats (SIC 30.12); Manufacture of sports goods (SIC 32.30); Repair and maintenance of boats (SIC 33.15); Construction of artificial surf reefs (SIC 42.9); Operation of sports clubs (93.12); Operation of beach facilities and marinas (93.29)	Tourism accommodation and other services	Cruising (SIC 50.10) – included under Maritime Transport

Principal	*Ancillary*	*Secondary*	*Excluded*
Maritime Transport of passengers (50.10) and of freight (SIC 50.20)	Shipbuilding (SIC 30.11); Repair and maintenance of ships (SIC 33.15); Hazardous waste collection (SIC 38.12) – e.g. waste oil from ships, ballast water; Salvage and dismantling of wrecks (SIC 38.31); Construction of ports and marinas (SIC 42.91); Service activities incidental to water transportation (SIC 52.22) - e.g. operation of ports and piers; navigation, pilotage and berthing; lighthouse activities; capital and maintenance dredging of harbours and navigation channels; Storage of freight (SIC 52.10/1); Cargo handling and stevedoring (SIC 52.24/1); Publication of Admiralty charts – hydrographic office activities (SIC 58); Renting and leasing of water transport equipment (SIC 77.34); Travel agency and tour operators (SIC 79.1); Activities of the Maritime and Coastguard Agency (MCA), Royal National Lifeboats Institution (RNLI) and Health and Safety Executive (HSE) (SIC 84.24); Manufacture of parts of boats and ships, e.g. sails, anchors, engines, navigation equipment; Shipbroking – agents that arrange the ocean transport of goods and commodities by sea (52.29), the employment of a vessel or buy and sell ships on behalf of a client (46.14); Dry bulk chartering; Second-hand tonnage	None identified	None identified
Mineral Extraction Aggregate extraction (08.12); Potash extraction (08.91); Sea salt extraction (08.93)	Support activities – e.g. exploration services (SIC 09.90)	Processing of aggregate at wharf (SIC 08.12); Manufacture of products, e.g. cement (SIC 23) Agents involved in the sale of aggregates (SIC 46.12)	Ship building/ repair (see Maritime Transport)
Oil and Gas Extraction of crude petroleum (SIC 06.10) and natural gas (SIC 06.20)	Support activities – e.g. exploration services and dismantling (SIC 09.10); Utility and pipeline construction (SIC 42.21) and operation (SIC 49.50)	Manufacture of refined petroleum products (SIC 19.20); and industrial gases (SIC 20.11)	Sale of oil and gas (SIC 46.12, 46.71)
Pipelines Pipeline transport: e.g. oil and gas interconnectors from overseas (SIC 49.50) and other substances	Support activities – e.g. exploration services and dismantling (SIC 09.10), Manufacture of pipeline products and machinery; Pipeline construction (SIC, 42.21)	None identified	Pipelines related to domestic oil and gas (see Oil and Gas)

Principal	*Ancillary*	*Secondary*	*Excluded*
Power Transmission (SIC 35.12)	Construction of utility projects (SIC 42.22); Manufacture of electricity distribution and control apparatus (SIC 27.12)	None identified	Distribution of electricity (SIC 35.13); Trade of electricity (SIC 35.14)
Renewable Energy Production of electricity from wind, wave and tidal energy (SIC 35.11)	Construction of marine energy installations Decommissioning of structures	None identified	Transmission of electricity to distribution system (SIC 35.12 – see Power Transmission; Trade of electricity (SIC 35.14)
Research and Development (SIC 72.1) – largely bioprospecting [a]	Activities of research institutes	Use of information for further understanding	Industry related research and development (R&D) (see relevant sections)
Storage (of Gases): (No SIC number) Natural gas storage Carbon capture and storage (Part SIC 06.10 and 06.20)	Support activities – e.g. surveying and prospecting (SIC 09.10), engineering design (SIC 71.12/1)	None identified	None identified
Telecommunications Operation of submarine telecommunications facilities (SIC 61.10)	Construction of utility projects (part SIC 42.22)	None identified	None identified
Waste Disposal Discharges of wastewater (SIC 37 – urban and industrial wastewater, stormwater); disposal of non-hazardous waste (SIC 38.21) and hazardous waste (SIC 38.22 – including dredge material)	Construction of sewer systems and disposal plants and pumping stations (SIC 42.21) Remediation activities – cleanup of sites and oil spills (SIC 39)	None identified	None identified
Water Abstraction for e.g. cooling water (SIC 36 – Water collection, treatment and supply)	Construction of utility projects (SIC 42.22)	Ancillary uses of water for aquaculture	None identified
General - ancillary activities (i.e. regulatory and management activities) supporting all of the principal activities above	Research & Development; Public administration (activities of the conservation agencies – Joint Nature Conservation Committee, Natural England, Countryside Council for Wales, Scottish Natural Heritage, Scottish Environment Protection Agency, Environment Agency, National Trust -SIC 84); Business Services: Employment in Ship finance (SIC 64), Insurance underwriting (SIC 65), Legal and accounting activities (SIC 69); Licence and Rental (SIC 68.2)	None identified	None identified

[a] Only those activities that specifically use the sea to provide a direct product or service that have a market value.

SECTION 2
OVERALL ASSESSMENT



2.1 Introduction

This report summarises the evidence in relation to the productive use of UK seas following the UK Government's vision for clean, healthy, safe, productive, and biologically diverse oceans and seas. This report describes the various industries that use the marine environment's natural goods and services directly or indirectly to generate wealth and provide jobs. These industries also create pressures on the marine environment, for example through pollution, or by disturbing and exploiting habitats and species.

This is the first time that a dedicated report on the productive use of the UK seas has been compiled as part of the evidence base for *Charting Progress*. The evidence for this report has been prepared by the Productive Seas Evidence Group (PSEG) which formed following *Charting Progress* under the UK Marine Monitoring and Assessment Strategy (UKMMAS). PSEG is responsible for providing a robust evidence base on the impacts and benefits of human uses of the seas and supporting the assessment of these to underpin the development of effective policies for achieving the sustainable and productive use of the seas around the UK.

For the purposes of this report, we have defined 'Productive Seas' as consisting of socio-economic activities that *use* the marine environment's natural goods and services to produce outputs of other goods and services that are owned and can be exchanged for payment. The report provides a comprehensive assessment of the economic value of these activities in the UK and their associated trends and pressures (both positive and negative). It highlights regulatory issues and significant gaps in knowledge to help inform policy-making and identify priorities for the Marine Acts to be taken forward by the UK Government and Devolved Administrations.

2.2 Approach

Economic production in general has been defined following the approach taken in the national accounts, that is, as any *...activity carried out under the control of an institutional unit that uses inputs of labour or capital and goods and services to produce outputs of other goods and services* (ONS, 2007a).

We have categorised activities in the marine environment into principal, secondary and ancillary activities. Principal activities use marine ecosystem goods and services directly to provide a marketable good or service, such as food, energy or transport. Ancillary activities are those that enable the primary activity to function, such as construction of wind farms or manufacturing of fishing nets, while secondary activities are those that arise as a result of the outputs from the primary activity, for example, fish processing, and manufacturing of petrochemicals from oil and gas.

Information to support the assessments was sourced from key data providers such as the Department for Environment, Food and Rural Affairs (Defra), the Centre for Environment, Fisheries and Aquaculture Science (Cefas), Marine Scotland, environment agencies (Environment Agency, Scottish Environment Protection Agency, Northern Ireland Environment Agency), The Crown Estate (TCE), the Department of Energy and Climate Change (DECC), the Office for National Statistics (ONS) and spatial datasets such as Seazone (see Annex 1 for more information). Industry reports have also been drawn upon and the quality assurance

of such information has largely been achieved through a wide policy and peer review process of the various drafts of this report.

Different data that can measure economic 'value' are available for the different sectors studied in this report. Economic value is fully described as 'Total Economic Value' which has three main components: use values, option values and non-use values. This report is primarily concerned with use values, as reflected in market activity (see Annex 1 for a full description of the methodology). Market prices are used to measure this activity, but this still gives rise to a number of different measures of economic activity that have been used in this report as follows:

- Turnover is the total market value of goods or services sold – it measures output.
- Investment is the spending on assets that will produce goods or services in the future (e.g. investment in research and development secures the benefits from such information in the future). It is a minimum measure of expected future benefits – because if this benefit was less than the investment, it would not be a rational choice.
- Expenditure is the total market value of goods and services purchased. It is a proxy for turnover, because if it was greater than turnover, an activity would not be economically viable.
- Gross Value Added (GVA) is the added value of outputs of goods and services from an activity compared to inputs. GVA figures are available for some activities, or can be estimated as a proportion of Turnover based on sector-specific, or generic, ratios. Being net of the value of inputs means that GVA can be summed from different sectors without risk of double counting and is used to represent the contribution to GDP

There were some difficulties in quantifying the value of ancillary and secondary activities that are discussed in the report and that limited the assessments for some activities. Non-use values of marine ecosystem goods and services are being explored in the National Ecosystem Assessment, which is due to be released in February 2011 summarising existing information on the current state of the environment and identifying reasons for change in the UK's ecosystem services.

While the focus of the report is on describing environmental pressures, a summary is given of potential impacts and reference provided to more detailed assessments of impacts in the other two complementary feeder reports from the Healthy and Biologically Diverse Seas Evidence Group (HBDSEG) and the Clean and Safe Seas Evidence Group (CSSEG).

The study also investigates socio-economic impacts of each activity, that is, how an activity may influence other social and economic uses in either positive or negative ways. However, as a status report, it does not attempt to assess the inter-sectoral nature of activities and analyse alternative uses of sea areas. To clarify, it is not the role of the report to provide advice on what activities should be given priority in each region as this will be addressed by marine planning initiatives under various marine policies at national and regional levels.

2.3 Assessments

This chapter summarises the principal activities occurring in the marine environment (for more information refer to the full assessments in Section 3, see also the summary table at the end of this section). Each full assessment provides the following information:

- How the activity is defined
- How it is managed, by whom and under what legislation
- The economic 'value' of the principal activity and any secondary or ancillary activities
- How this activity (and value) is distributed around the UK and how it has changed over time
- Additional socio-economic pressures from the activity (e.g. employment, HM Treasury revenue through taxes, impacts on other activities)
- Environmental pressures, consequent impacts and management measures (with relevant links to other Feeder Reports)
- The relationship between the activity and climate change
- Industry stability and sustainability
- The future outlook (including key research issues).

2.3.1 Aquaculture

Aquaculture is the farming or culturing of aquatic organisms (fish, molluscs, crustaceans, plants). More than 99% of economic aquaculture activity in the UK is related to fish and shellfish although there is increasing culture of seaweed and marine worms for bait.

The majority (99%) of existing marine-based fin-fish aquaculture activity is located in Scotland although it is increasing in areas of Wales and England. Shellfish production is more evenly spread throughout the UK (Table 2.1). In 2007, the turnover from aquaculture was £350 million providing a GVA of £193 million. In addition, processing of fish from aquaculture provided an estimated £105 million GVA in 2007. Aquaculture revenue within the UK increased by 132% between 2000 and 2006. Development of the industry is closely tied in with changes in wild fisheries, the availability of investment, site availability and environmental carrying capacity.

The main environmental issues relate to: the sustainability of fish feed; the presence of structures that affect habitats and hydrodynamics; operations that disturb the seabed such as harvesting; and outputs such as discharges, escapees from farms and diseases/ parasites. These issues are managed by the relevant regulatory bodies (including Devolved Administrations, environment agencies and local authorities) through the consenting system and are also dealt with through voluntary best practice undertaken within the industry. The licensing system is extremely complex although there are plans to streamline it through the Marine and Coastal Access Act 2009, the Marine (Scotland) Act 2010 and proposals for similar marine legislation in Northern Ireland. A number of new strategies support sustainable development by setting out goals for balancing economic growth with careful management of environmental impacts and support for social development. The overall aim of the 2009 EU Strategy for the Sustainable Growth of European Aquaculture is to encourage growth in the industry while building on the high environmental and quality standards that have been achieved so far.

While we have good information on the location of fish farms there are some uncertainties over the distribution of pressures associated with aquaculture activities, for example the dispersal of waste products and inputs of nitrogen and phosphorus. This is due to the way that information is collected: details are typically specific to individual sites and projects and are described in individual licence applications and are not centrally collated or freely and readily available. It is recommended that this information is collated centrally, for example by the UK Government and Devolved Administrations or their respective environment agencies.

2.3.2 Fisheries

The UK marine fisheries sector comprises all socio-economic activities related to the capture of wild marine fish and shellfish, and the subsequent handling and processing of catches. In 2007, the UK commercial marine fishery landed 611 thousand tonnes of fish and shellfish into the UK and abroad, worth almost £650 million at first sale (Figure 2.1). Of this, £510 million of catch was from the eight UK regions providing a GVA of £204 million. Shellfish and demersal fish species currently contribute around 40% each to the total market value of the catch, with the remaining 20% comprising pelagic species such as mackerel and herring. Secondary activities can be equally important with fish processing from sea fisheries contributing £385 million GVA in 2007.

The North-East Atlantic mackerel stock currently supports the most valuable fin-fish fishery in UK waters, operating mainly from Scotland. In Northern Ireland, Wales and the Channel Islands, the most valuable fisheries are for shellfish, reflecting the relatively higher incidence of

Table 2.1 Production and total value of cultured shellfish species in the UK in 2007.

Species	*Scotland*	*England*	*Wales*	*N Ireland*	*Total*
Pacific oyster	208	576	10.5	374	1169
Native oyster	22	55	0	0	77
Scallop	2	0	–	2	4
Queen scallop	15	–	–	–	15
Mussel	4806	3252	10 016	8039	26 113
Clams	–	12	–	10	22
Cockles	–	10	–	–	10
Total (tonnes)	**5053**	**3905**	**10 027**	**8425**	**27 410**
Total value (£million)	**5.1**	**4.5**	**7.5**	**5.8**	**22.9**
Percentage of the total	**22**	**20**	**33**	**25**	**100**

inshore fishing for crabs, lobsters and other shellfish such as cockles in these areas. The demersal fisheries in the North Sea, west of Scotland and in the Irish Sea have shifted away from offshore fishing for fin-fish species and towards inshore waters for the very valuable Norway lobster (*Nephrops norvegicus*) and other shellfish and mixed demersal species. This shift has resulted partly from long-term declines in many stocks and associated fishing restrictions, particularly those aimed at cod recovery, as well as the perceived economic opportunities in other fisheries. The composition of catch within each administrative area is summarised in Table 2.2.

Seven of the top ten most profitable fleet segments operate in the North Sea and off the west of Scotland. The total profit earned by the UK fleet was around £95 million in 2006 (before interest payments and depreciation). This represented a 24% decline from 2005 despite increased earnings, although 12 out of 27 fleet segments showed increasing profits over this period. Profitability has varied widely in the UK catching sector during the 2000s because of a reduction in catch per unit effort, escalating fuel prices, an increase in quota trading, and increases in first-sale prices following the introduction of Buyers and Sellers regulations in 2006.

Commercial fishing is a particularly important socio-economic activity in remote coastal regions in Scotland, and in coastal regions in Wales, Northern Ireland and the south-west, although it makes a relatively low contribution to overall GDP. It can provide the economic heart in such regions, where the inshore fishery is dominated by small boat activity. The UK catching sector employed almost 13 000 people in 2007, while the processing sector employed over 18 000 people in 2005 (although some of this processing employment is derived from aquaculture products). The dependency of jobs on fishing can be as high as 20% or more in some coastal communities.

Over the past eight years, total fishing effort in the international demersal fisheries has fallen by around 30% or more in the North Sea, west of Scotland and in the Irish Sea. During the same period, North Sea haddock and cod, and northern-shelf saithe have shown significant declines in fishing mortality (the term 'fishing mortality' defines the rate at which fish are removed from the stock by fishing). These trends are likely to be due to a combination of EU controls on total allowable catches (TACs) and effort, and the decommissioning of vessels in the UK and some other countries. The UK demersal trawl fleet was decommissioned by 15% between 1997 and 2007, with a particularly large impact on the Scottish fleet. Fleet capacity is currently (2007) estimated at 213 000 tonnes; 6763 commercial fishing vessels.

The main pressures of fishing on ecosystem services are on productivity and biodiversity. Although there is evidence in a range of ecosystems that fishing can cause a reduction in biodiversity, the evidence is less clearly established than for productivity of individual fish stocks. The direct impact of fishing gears on components of the wider marine ecosystem and habitats may ultimately also impact on the marine resources available to the fishing sector. Generally, there is good information on the distribution and intensity of the use of different gear types.

The International Council for the Exploration of the Sea (ICES) provides scientific assessments on the sustainability of European fish stocks. In addition, various government agencies throughout the UK publish annual statistics on the UK fishing and processing industry. Further data on fish stock abundance and distribution,

Figure 2.1 Trends in landings and first-sale value of shellfish, pelagic and demersal species landed by UK vessels into the UK and abroad. Reproduced from MFA (2008).

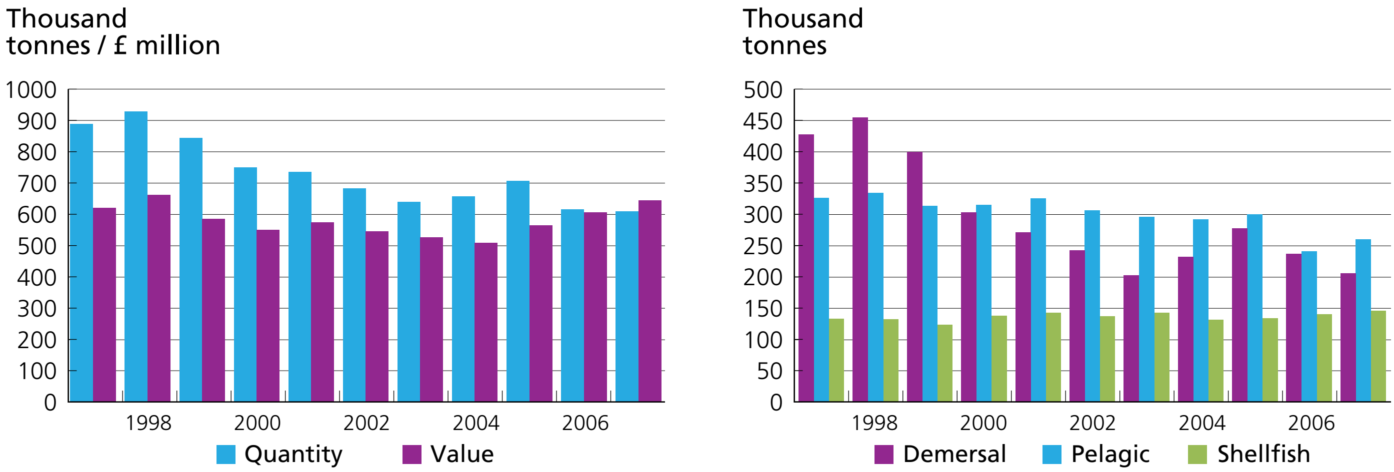


Table 2.2 Percentage composition of total value of catch taken by vessels registered in different parts of the UK in 2007.

	England	*Scotland*	*N Ireland*	*Wales*	*Total UK*
Demersal	45	35	11	21	37
Pelagic	16	23	23	2	20
Shellfish	39	42	66	77	43

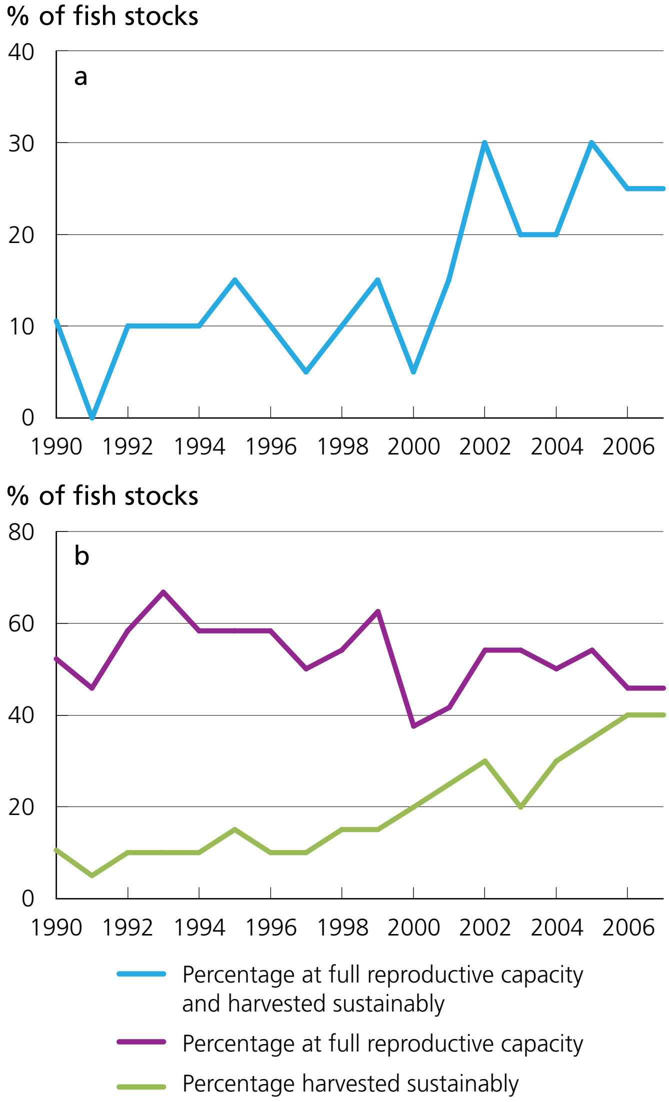
and on aspects of fishing gear design, come from the Fisheries Science Partnership and the Scottish Industry/Science Partnership both of which have developed increasing time-series of data on fish stocks since *Charting Progress*.

Out of 20 indicator fin-fish stocks in UK waters, the proportion of stocks at full reproductive capacity and being harvested sustainably has risen from around 10% in the early 1990s to 25% in 2007 (Figure 2.2a), while the proportion of stocks with full reproductive capacity has changed little since 1990. The proportion of these 20 indicator fin-fish stocks being harvested sustainably has risen from 10% to around 40% over the same time period (Figure 2.2b). The lack of a concomitant increase in reproductive capacity following reductions in fishing mortality may be due to time lags in the recovery of stock biomass, or environmental factors affecting recruitment. Data for 2008 have become available since the Feeder Report was prepared by the Productive Seas Evidence Group and begin to show improvements in spawning stock biomass associated with the progressive reduction in fishing mortality (see data available[1]).

Overall, the large majority of scientifically assessed stocks continue to be fished at rates well above the levels expected to provide the highest

[1] http://www.cefas.co.uk/media/139292/website%20psa%20sustainability%20indicator%20v2.pdf

Figure 2.2 Change in exploitation status of 20 indicator fin-fish stocks around the UK. (a) Percentage of stocks at full reproductive capacity and being harvested sustainably; (b) percentage of stocks where one of the conditions holds each year. Source: Justine Saunders (DEFRA, courtesy of Cefas).



long-term yield. The European Commission is developing multi-annual management plans to recover depleted stocks, and to manage stocks sustainably. They seek to restrict fishing mortality rates to the maximum sustainable yield (MSY) by 2015, as required by the World Summit on Sustainable Development in Johannesburg in 2002. Such management plans were initially focused on cod recovery, but have now been extended to a range of other species.

Since *Charting Progress*, the UK Government and Devolved Administrations have made considerable progress in establishing long-term visions and strategies for sustainable development of the fishing industry and associated activities. This has included further strengthening of the role of the fishing industry in management decisions and collection of data, for example through consultation exercises and fishery science partnerships. The identification of target fishing mortality rates and indicators to monitor progress towards achieving MSY will continue development while revisions to the EU Common Fisheries Policy and implementation of the EU Marine Strategy Framework Directive will increase the focus on management of fisheries within a broader ecosystem framework.

2.3.3 Leisure and recreation

Many different leisure and recreation activities in the UK make use of the marine environment. It is difficult to capture the principal market value obtained from recreational and leisure activities because some activities, such as swimming, do not result in a marketable good or paid-for service. Although this sector is likely to have a high value of economic activity, uncovering the economic contribution is hampered by the number of activities, their wide distribution and the lack of centrally available statistics. Such issues also make it difficult to fully assess spatial pressures.

Some indications of the market value of ancillary activities include a turnover of £1.84 billion for the small commercial marine industry in 2006/07; surfing industry turnover of £200 million in 2001; and total expenditure from recreational fishing of £538 million for England and Wales in 2003 and £141 million for Scotland in 2008. These sources provide a total turnover of £2.74 billion and £1.29 billion GVA.

Expenditure on secondary activities such as coastal tourism, accommodation and food can also be significant with an estimated market value for coastal towns of £4.8 billion in 2005 (GVA £2.26 billion). Other benefits that are potentially substantial include employment and cultural values. A good indication of social value can be provided by the levels of participation: in 2007, 5.4 million people participated in watersports and 0.8 million in sea angling.

Overall, the participation in most marine leisure and recreation activities has stayed relatively stable or increased in recent years. The growth and stability of the marine leisure and recreation market is heavily dependent on the general health of the UK economy, which determines whether people have time and money for leisure pursuits. In addition, trends in sea angling are particularly dependent on advances in fishing technology and catch rates of fish while many watersports are supported by improvements in exposure suits and wet suits.

Environmental pressures as a result of recreational use of the seas may include the removal of marine fauna and flora, physical or visual disturbance of wildlife, pollution from wastewater and litter and alteration of coastlines to facilitate access. They are generally managed through a number of local planning policies and best practice guidance published by organisations such as the Royal Yachting Association.

2.3.4 Mineral extraction

Dredging for marine aggregates is by far the largest activity within this sector, which also includes the extraction of salt.

Eleven companies are generally involved in the production of marine aggregates in the UK. In 2008, these companies landed 19.3 million tonnes of primary aggregate for construction in the UK and abroad representing an estimated landed value (turnover) (before processing and on land sorting) of £116 million and a GVA of £54 million. A further 2 million tonnes were extracted for beach replenishment. Those secondary market values for the marine aggregate dredging industry that could be identified included £80 million GVA from processing and £303 million GVA from sales of concrete products in 2005. Ancillary market values from exploration and transport were more difficult to define in total but indicators include a dredging fleet replacement value of £1 billion.

Marine aggregates mainly come from the eastern and southern coasts of England (Regions 2 and 3) with smaller amounts off Wales and north-west England (Regions 4 and 5). There is currently no dredging within Northern Ireland and Scottish waters due to an adequate land supply of aggregates and lack of suitable and easily accessible resources on the seabed. The maximum depth that dredgers can practically operate in is around 50 m and is limited by available technology and vessel size.

The marine aggregate dredging industry employs about 640 staff, 500 of which are ship crew and the rest provide shore support and administration. A further 600 staff are employed on the wharves that receive UK marine aggregates and about 500 related to the primary delivery of sand/gravel (i.e. from wharves to the point of initial use).

Activity within the sector is driven by the demand for construction material and the availability of land-based aggregates in comparison with marine aggregates. In 2005, marine sand and gravel accounted for 19% of total sand and gravel sales in England and 46% in Wales. Estimates of proven reserves suggest

that there is still a large amount of marine resource available, sufficient for at least 50 years production at current rates of extraction.

A well supported research fund (the Aggregate Levy Sustainability Fund), well developed onboard monitoring systems and regional environmental assessments, mean that there is good understanding of the environmental impacts from marine aggregate extraction and the characterisation of regional aggregate resources and palaeo-landscapes. Pressures from marine aggregate dredging include removal of sand and gravel, damage or disturbance of benthic habitats, and smothering from extraction operations and sorting of sediments. However, the proportion of seabed directly impacted by removal is just 0.007% of the UK continental shelf (UKCS) and impacts are managed through licence-specific environmental impact assessments.

In 2008, the sea salt extraction industry had a combined turnover of about £4 million from the three companies in operation in Cornwall, Anglesey and Essex. Extraction of sea salt is limited by the availability of high quality marine resources and is driven by markets at home and abroad.

2.3.5 Oil and gas

This section summarises all activities associated with oil and gas extraction, transport and storage in the seas around the UK, together with gas storage and storage of carbon dioxide (CO_2) captured from industrial activities.

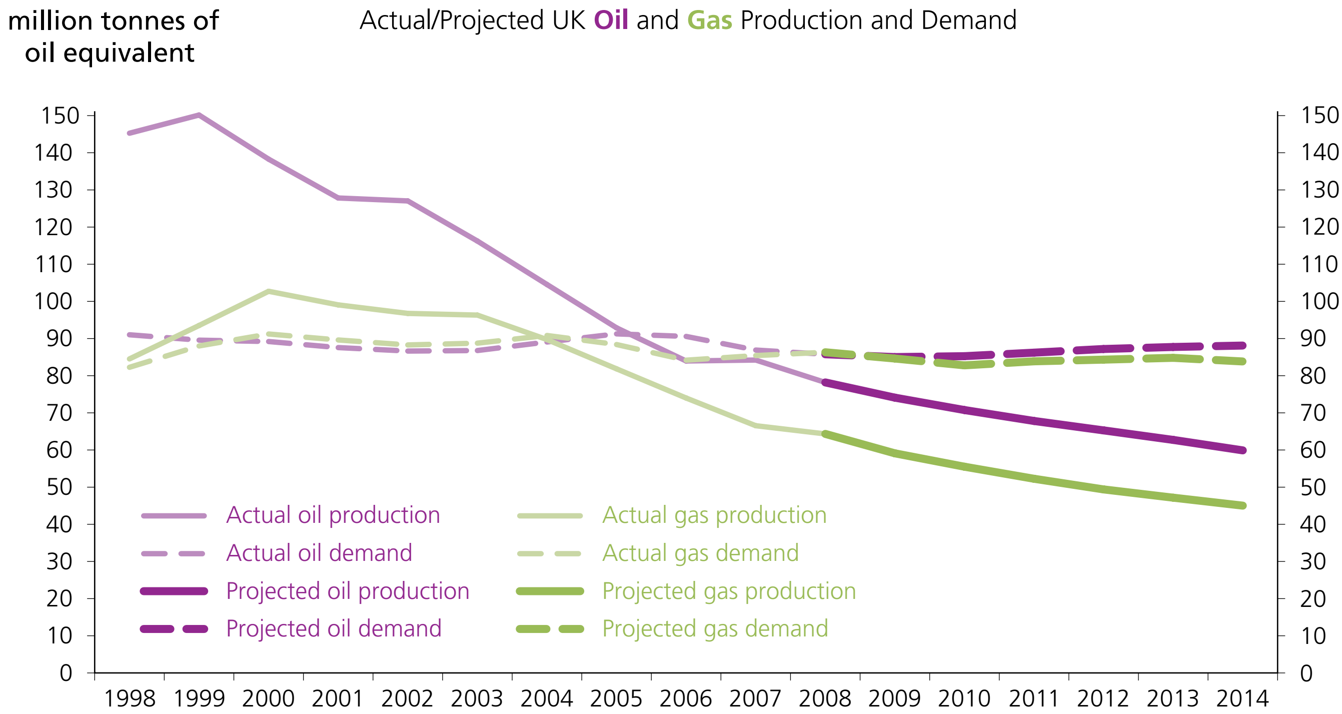
Oil and gas remain the UK's principal sources of fuel and power, meeting more than 75% of demand in 2008. One billion barrels of oil equivalent were extracted from the UKCS in 2008, comprising: 72 million tonnes of oil and natural gas liquids and 68 billion cubic metres of gas. Total UK oil and gas production peaked in 1999 and has been declining since due to decreasing reserves (Figure 2.3). Domestic resources satisfied about two-thirds of UK primary energy demand in 2008 (94% of oil demand and 74% of gas demand) and are projected to satisfy about half of the UK's oil and gas demand in 2020.

The domestic oil and gas extraction industry accounted for £37 billion GVA in 2008 and is one of the largest contributors to GDP. The value of oil and gas is driven by the sale price of oil and gas and the level of production. For example, price per barrel of oil is strongly influenced by volatile energy markets owing to a complicated range of supply and demand factors.

The recovery of remaining oil and gas reserves will require additional investment, both in money and expertise. The distribution of resources is fairly well understood although exploration activities continue in all areas with suitable geology. Around 500 individual structures (including production platforms and tie backs) will be decommissioned over the next three decades.

In 2008, the upstream oil and gas industry invested £4.8 billion in developments, £1.4 billion in exploration and appraisal, and spent £6.8 billion on operations. The extraction of oil and gas is supported by highly specialised 'supply chain' activities and also supports a large downstream manufacturing sector (oil refining: net trade surplus £1 billion; petrochemicals: turnover £50 billion; trade surplus £5 billion), although these use a mix of UK and imported production. In 2008 there were 107 oil platforms, 181 gas platforms, 14 000 km of pipelines, plus 9 crude oil refineries and 3 specialist onshore refineries.

Figure 2.3 Actual and projected UK oil and gas production and demand. Source: DECC as at February 2009.



Additional socio-economic benefits from the oil and gas sector include employment, taxes paid to HM Treasury, export business and energy security. The majority of oil and gas fields on the UKCS are located in the North Sea (Regions 1 and 2) and as a consequence Scotland is the largest region of related employment in the UK. The extraction industry employs 34 000 people; 230 000 in supply chain companies and 214 000 in secondary petrochemical industries.

There are a number of environmental issues associated with oil and gas extraction, the most notable being the risk of oil spills, noise from exploration and production, historical oil-based cuttings piles, and inputs of production chemicals. Oil discharges in produced water have fallen and most oil spills are of less than 1 tonne. Impacts from pipeline installation on habitats are spatially minor with short-term noise and disturbance impacts. The extraction, processing and burning of oil and gas to provide energy is very energy intensive and produces high levels of associated CO_2 emissions causing concern over climate change (see Chapter 6).

As a result of increasing dependence on imported fuels the UK will have a growing need for gas storage. The use of geological structures in the sub-sea marine environment for the storage of gas is therefore receiving increasing focus. Structures can include depleted oil and gas fields or artificially created salt caverns and they have been used to store natural gas in Europe and the UK for over 30 years, although there is only one offshore gas storage facility currently in operation in the UK: the *Rough 47/8 Alpha* facility.

As an indicator of economic potential, the Department for Trade and Industry – now the Department of Energy and Climate Change – estimated in 2007 that £10 billion of investment in new gas storage and import facilities was in place or planned over the next few years. Use

of existing storage features and infrastructure is likely to have negligible environmental impacts although the release of hypersaline water in the production of salt caverns may have some localised effects.

There have also been proposals to store CO_2 released from power generation and industrial processes, a process known as Carbon Capture and Storage (CCS). CO_2 can be stored in depleted hydrocarbon fields or aquifers. Given that CCS is a fledgling industry, there is considerable uncertainty surrounding future rates of development, specific location of developments, investment, cost-efficiency of construction, financial incentives and total economic contribution of the industry.

2.3.6 Renewable energy

he UK has among the highest density of exploitable renewable energy resources in the world, and has the potential to become a global leader in both engineering development and energy production. The resources include wind (on both coasts); wave (mostly on the west coast); tidal stream (focussed inshore around headlands and in sounds such as Pentland Firth) and tidal range (particularly in the Severn and Mersey estuaries).

The estimated direct turnover for the industry from current generating capacity is £165 million and GVA is £50 million with additional indirect turnover from manufacturing and installation. Although the location of wind, wave and tidal resources is well understood, the location of economically viable renewable energy projects is constrained by a number of other technical factors, such as the capacity of national grid networks, sea conditions and other existing sea users like fisheries and shipping.

Wave and tidal power in particular are fledgling industries with enormous potential and strong government support, aimed at helping prove these technologies and overcoming uncertainty around limited long-term investments in the current economic climate. They are being supported by test facilities such as the European Marine Energy Centre in Orkney and the New and Renewable Energy Centre in north-eastern England. There is also some uncertainty around environmental pressures such as hydrodynamic changes, construction noise, and collisions by birds or marine mammals with devices that tend to be device and site-specific. However, these are being addressed by detailed monitoring programmes and coordinated research initiatives.

The rapid growth of this sector has been aided by governmental support for energy generation from renewables, involving financial investment and planning and policy initiatives that help to encourage much-needed private investment. The main driver is the EU 2008 integrated energy and climate change policy, according to which the UK must obtain at least 15% of its total energy needs from renewable energy sources by 2020. Targets are much higher than this in some parts of the UK, with Scotland aiming for 20% by 2020 and Northern Ireland 40% by 2025. The Welsh Assembly Government's energy policy statement details the potential to produce more than twice as much renewable electricity as Wales consumes as a nation today by 2025. The extraction of energy from renewable sources lessens UK dependence on fossil fuel energy, which has much higher associated CO_2 emissions, and improves energy security by increasing the diversity of electricity supply.

By December 2009, there were ten offshore wind farms operating 228 turbines with a total installed capacity of 0.7 GW of electricity (two are small demonstrator projects). A further

1.7 GW of capacity was under construction; 4.9 GW had been consented, and about 9.9 GW was in planning and pre-planning processes across the UK. The total installed capacity from all these wind farms will be over 14 GW. This does not include Round 3 wind farms which may add more than 30 GW additional generating capacity (see Figure 2.4). There are strong targets to increase total capacity to 33 GW by 2020. Financial incentives such as the Renewables Obligation Certificates, the Scottish Government's Saltire Prize and the Marine Renewables Deployment and Proving Funds will continue to provide support for the industry over this period.

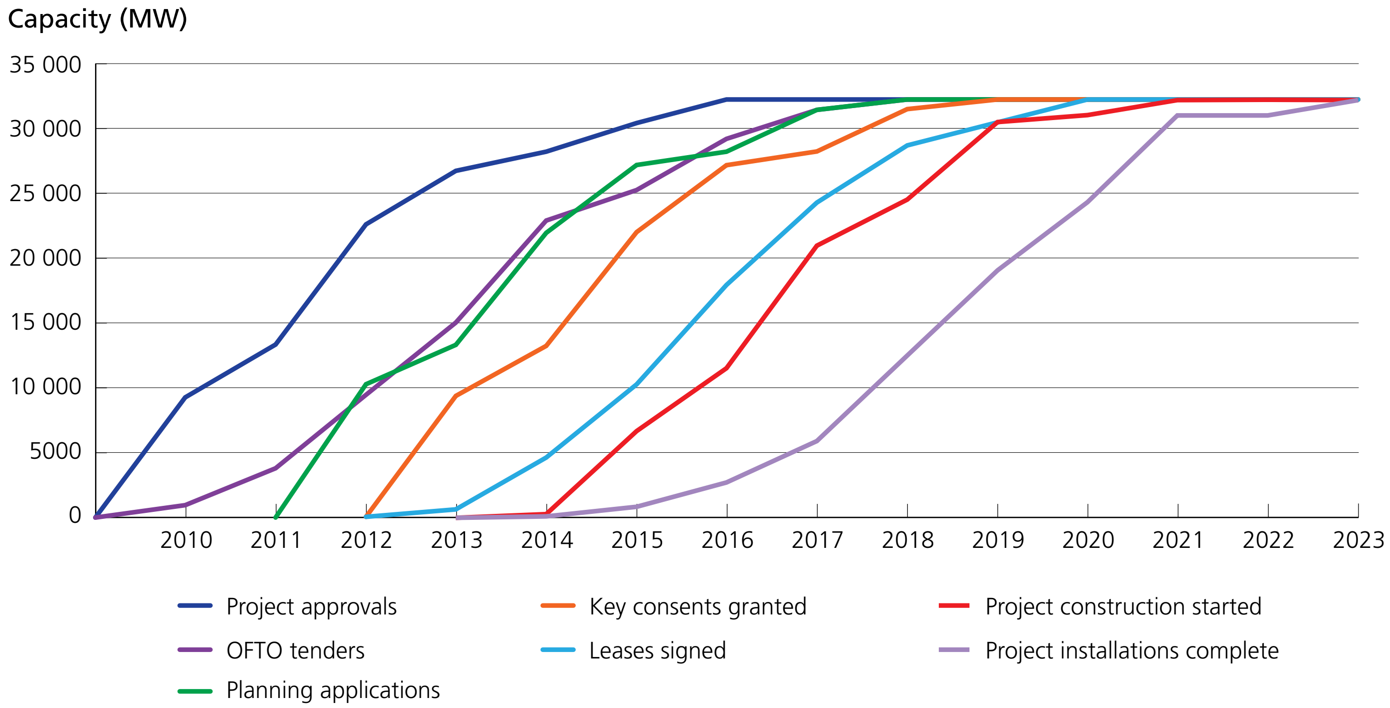
2.3.7 Telecom and power cables

This sector involves the transfer of telecommunications (telecom) and power between the UK and other countries and among the islands of the UK through subsea cables.

There are some 18 000 km of telecommunication cable and 2368 km of power cable on the UKCS. The overwhelming majority of international communication transmissions are through fibre optic submarine cables with the highest proportion (43%) passing through Region 4 (Western Channel and Celtic Sea). The only international power cable link is currently with France. Remaining cables provide links among the islands of the UK, for example, mainland UK with the Isle of Man and the Scottish Isles.

An indicative GVA of £2.7 billion was estimated for telecom cables based on the number of international phone calls. However, this figure does not include the value of internet and data capacity which are now the primary commodity and which are increasing. The true value of telecommunication cables should incorporate both the value of the traffic which is carried and the significance held by the UK as a key strategic location for international systems looking to

Figure 2.4 Projected delivery dates and capacity from Round 3 wind farm projects. Source: R3 Developer Programmes, as of December 2009 – The Crown Estate.



reach markets in America, Europe, Africa and Asia. These are difficult to capture in market value terms but are significant. The capacity from the main interconnecting power cables, which is currently 2540 MW from 212 km of cable, may be used as an indicator of the scale of the activity.

Impacts from cable installation on the seabed are short term and spatially minor. Although there is potential for the electromagnetic fields associated with high voltage power cables to impact on animals that are sensitive to such fields, considerable research suggests that the spatial extent is small and, if the cables are buried to more than 1 m, the impact will not be significant.

The deployment of power cables has been steadily increasing due to increasing demand within the UK and demand for improved security and stability in electricity supply. Deployment of power cables is likely to increase as we develop more offshore renewable energy installations.

The UK telecommunications sector went through a period of correction from 2002 to 2006 following the growth and downturn associated with the Dotcom bubble, but major domestic and international systems are now being installed. Future developments in this sector are focused on extending the global reach of the sub-marine networks, investing in higher capacity circuits and increasing resilience by operating networks over a number of different cables.

2.3.8 Maritime Transport

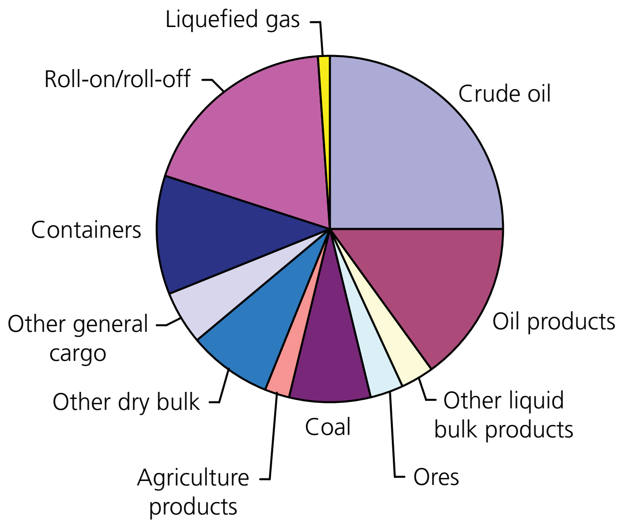
This section encompasses the transport of both freight and passengers by sea. Maritime transport is supported by a diverse range of ancillary activities including shipbuilding, the construction of ports and marinas and activities associated with navigation including dredging and the production of charts.

In 2007, the turnover of UK shipping (freight, passenger and charter services) was £9.5 billion with a direct contribution to GDP of £4.7 billion GVA. In 2007, there were 24.8 million passengers making international sea journeys and 424.42 million domestic sea passengers. UK ports handled 582 million tonnes of freight traffic, although the number of freight passages is unknown due to the commercial sensitivity of shipping data. The type of freight transported is shown in Figure 2.5.

A total GVA of £7.8 billion was calculated for those ancillary activities for which such information was available (e.g. port activities, shipbuilding and navigation activities). However, the value to the economy from other service activities such as construction of ports is less certain, so this is likely to be an underestimate.

In total there are more than 650 ports in the UK for which statutory harbour authorities have been established; of these 120 are commercially active. Values to the economy were assigned to reporting regions based on the proportion of freight tonnage handled by major coastal ports in each region. The majority of value to the economy (> £1 billion each) is located in Region 2 (Southern North Sea; which includes major ports in the Thames connecting with London), Region 1 (Northern North Sea; linking with the northern European mainland), Region 5 (Irish Sea; linking Scotland, the Republic of Ireland, Northern Ireland, England and Wales), and Region 3 (Eastern Channel; with key routes to Europe and North Africa). This pattern is also likely to be a fair reflection on the distribution of pressures from shipping among the regions.

Figure 2.5 UK major port traffic by cargo type in 2007. Source: Justine Saunders, Oxford Economics (2009).



Key pressures relate to pollution (from oil spills, loss of cargo and leaching of antifoulants), introduction and spread of non-native species (through ships' hulls and ballast water), noise impacts from ship movement and habitat damage (for example from port development, maintenance dredging and disposal of dredge material). While shipping is generally a very carbon efficient form of transport, continued growth in the sector will increase global emissions which currently account for around 3.3% of global CO_2 emissions. Most of the shipping impacts are managed through the International Maritime Organization. Impacts from local development are managed through local planning policies and conservation objectives where they apply. While records are kept of vessel movements and shipping densities, this information is currently not easily and freely accessible, hampering an assessment of pressures. To be useful for assessments, collated information should include the size of ships and temporal data such as when and how often they sail.

The long-term trend is for sustained growth of 3% to 4% on average per year in the container and roll-on/roll-off sectors. The Ports Policy review in 2007 proposed no substantive change to the regulatory framework although the recommendation for Master Plans by major ports may help to refine the operating framework for ports.

2.3.9 Defence – Military

UK military defence spending is the third largest area of public government expenditure. For 2007/08 the total expenditure was £1.8 billion for the principal activity with a GVA of £468 million, and £1 billion for ancillary activities. A large amount of public expenditure has recently been directed towards building of new warships with £1150 million spent on shipbuilding and repair in 2006/07. Activities and hence the location of the value to the economy are mainly related to the location of the naval bases and exercise areas. The Navy employs 38 600 people and 5200 civilians and local economies also benefit from activities associated with the naval bases.

Military defence activities in the marine environment largely involve training, surveillance and monitoring, and transport. Designated exercise areas can be very large, and given the need for a certain amount of security there are uncertainties on the exact location and frequency of training activities within these areas. This hampers a spatial and temporal assessment of environmental pressures within the sector. Key pressures are likely to include noise from sonar and underwater explosions, habitat damage and introduction of marine litter and contaminants.

A sustainable development strategy was published by the Ministry of Defence in 2008 and provides a number of objectives, measures and targets for changing the way that activities are carried out in order to reduce pressure on the marine environment, climate and communities.

2.3.10 Waste disposal

Disposal of waste material into the marine environment includes the regulated discharge of wastewater and the disposal of hazardous and non-hazardous waste. Solid wastes include disposal of dredged material from capital and maintenance dredging.

The environment agencies throughout the UK impose strict regulations and controls on discharges to the sea. Although there are around 215 marine disposal sites for dredged material in the UK, only about 100 are in use at any one time. The amount of material disposed of (as wet weight tonnages) has remained relatively constant in England, Scotland, Wales and Northern Ireland over time. Environmental pressures are well documented and monitored by the relevant agencies and can include organic enrichment and the introduction of contaminants and smothering from waste disposal.

Waste disposal is dependent on the sea's ability to assimilate wastes. We used the income generated through licensing of discharges and disposal as an indicator of investment and therefore economic value: income from licensing includes about £0.3 million for waste disposal (2007 data) and £9.1 million for water discharges (2007/08 data).

The disposal of waste also has a positive economic benefit to communities where it allows industries to function. The maritime transport sector, for example, is reliant on shipping access to the coastline and without dredging of navigational channels (supported by disposal) this sector would either be limited or face costly alternative means of disposal. In 2007/08, employment in the licensing of water discharges provided an estimated £6.0 million GVA in the UK, reflecting additional social benefits from the activity.

It is unlikely that demand for disposal will decrease. However, there is increasing pressure from the various environment agencies to minimise disposal into the marine environment. An Environment Agency Technical Advisory Group is attempting to produce a protocol to allow beneficial uses of dredged material, such as use in contract fill and for constructing soft and hard flood defences, rather than classifying all material as waste.

2.3.11 Water abstraction

The majority of water abstractions in the UK are from surface freshwaters and groundwater for use in public water supply, with relatively few from estuarine and coastal waters.

The major saline abstractions provide cooling water for power stations. A large power station may abstract up to 40 cubic metres per second or more during peak load. Other types of saline abstraction include fish farms and fish processing factories, passive and pumped navigation abstractions (to maintain water levels in impounded docks), ballast water abstractions and abstractions associated with certain dredging activities, such as hydraulic dredging.

The various environment agencies throughout the UK license abstractions from inland waters and groundwater. This includes some saline abstractions as inland waters include estuaries, embayments and arms of the sea. Historically,

navigation abstractions and abstractions associated with dredging activities in saline waters have been exempt from licensing. Some modifications to these exemptions are being proposed as part of the implementation of the abstraction provisions of the Water Act 2003 but such activities will remain largely exempt.

Environmental concerns relate to the impingement of fish, invertebrates and algae. Risk assessments made under the EU Water Framework Directive indicate that no water bodies are considered to be 'at risk' of failing the Directive in this respect, although nine sites are 'probably at risk'.

It is difficult to calculate the contribution to the economy associated with saline abstractions, although it is clear that they are fundamental to sustaining several major economic activities. The annual market value of electricity sales from coastal power stations is in the region of £5 billion to £10 billion. Coastal power stations with 'once through' cooling water systems have an energy efficiency advantage over air-cooled power stations, of the order of 2%. On this basis it could be argued that the specific value to the economy of coastal power generation was of the order of £100 million to £200 million per annum. No indicative values were identified for ancillary or secondary activities.

The amount of water abstracted for industrial purposes has remained relatively constant over time and it is likely that the requirement for coastal water abstraction will continue at the same levels. While many coastal power stations are due to be decommissioned over the next two decades, a series of new coastal nuclear power stations may be developed.

2.3.12 Coastal defence

This sector includes coastal defence measures used to prevent or reduce flood risk and coastal erosion. Defences may involve hard structures such as concrete seawalls, and soft engineering such as beach replenishment and managed realignment. Around 44% of the England and Wales coastline is defended and 6% of Scotland's coastline. The investment in coastal defence and flood protection in 2007 was £358 million. The investment in beach replenishment in England and Wales in 2007/08 was £11 million. Ancillary market values include £60 million (2007/08) for construction of defences in England and Wales. Data for Scotland and Northern Ireland are difficult to source as responsibility lies with several different departments and agencies.

The investment and hence activity within this sector in England and Wales has doubled over the past ten years due to the vulnerability of the coast to potential flooding and coastal erosion associated with climate change. However, investment and employment figures alone do not capture the entire value to the economy of coastal defences, as there are significant indirect social and economic benefits that are difficult to quantify.

Flood and coastal erosion risk management projects often have substantial impacts on the coastal environment, for example from construction, physical footprint, changes in geomorphology and coastal squeeze, as well as other forms of habitat degradation and loss. All schemes are therefore subject to appraisal by the relevant regulatory authorities and agencies which take account of the social, economic and environmental impacts as part of the consenting and funding processes.

Projections are that current spending on coastal defences will need to double by 2080. The use of managed realignment (a measure often undertaken as a compensatory measure for coastal works, that may provide additional 'soft' flood and coastal defence benefits) and other forms of soft coastal defence measures are likely to increase.

2.3.13 Other activities

Other activities occurring on the UKCS that may contribute economic productivity and/or support existing activities include research and development (R&D), education and general management and regulation.

Internationally, the UK is a leading provider for marine tertiary education, which directly contributes to productivity through the use of the marine environment for field studies. Education in turn underpins a number of other principal activities, such as providing support for leisure, maritime transport, and R&D activities. Likewise, R&D activities may provide support for other marine industries. General management and regulation, rather than producing a marketable product, is an ancillary activity that provides support for all activities occurring on the UKCS.

The values of these three sectors are difficult to identify due to the range of institutions involved, the wide distribution of activities and the lack of centrally available statistics that are specifically marine in focus. Funding levels may provide an indicator of the ancillary value of R&D and associated knowledge. The Research Council's spending on marine science in 2006/07 was £67 million. All of the research institutes combined had an average annual income of £76 million (GVA) from 2006 to 2008. The turnover related to education is estimated to be £132 million with a GVA of £95 million. The downstream value to be gained from R&D and education is likely to be significant. The turnover of general management and regulation activities includes income of £109.39 million from public administration, £3.06 billion from business services and £102 million from licence and rental (£42 million from the Crown Estate and £60 million from oil and gas licensing).

Environmental impacts from education and R&D are likely to be minimal due to the benign nature of most activities, however key pressures may include wildlife disturbance, physical disturbance and removal, noise and loss of habitat from construction of coastal facilities.

Trends in this group of activities are driven by high level policy developments and changes in economic activities related to a number of factors including market demand, investment, and technological progress. These in turn indirectly drive cognitive development in the marine environment, funding for R&D and education and the need for regulation and management of activities in the marine environment.

Industry investment in R&D may decrease in the short term due to the current economic situation. The Marine Science Strategy will help us to identify priority areas for future research. Due to an increased focus on the marine environment (within various new marine policies and marine planning initiatives) demand for related marine education programmes and the need for general management and regulation activities is likely to increase.

2.4 Regional seas statement

Where possible the value to the economy from the principal activities has been assigned to the eight CP2 regions. Table 2.3 provides a summary of these regional figures for 17 socio-economic activities (General Management and Regulation being considered an ancillary activity). The activities in Table 2.3 are placed into three groups according to the figures available to describe their value to the UK economy:

1. 'GVA from Marine Activities' are the activities for which GVA figures can be identified.
2. 'Other Monetary Values of Marine Activities' are activities where there is monetary data on their value to the economy, but GVA cannot be calculated.
3. 'Marine Activities without Monetary Values' are activities where the value to the economy has not been quantified in monetary terms.

The division of figures between regions uses different methods depending on available data. For some activities that annually report production levels and economic figures for each individual production site, summaries for regions were easy to derive (e.g. aquaculture, mineral extraction, oil and gas). For others where production figures were not available and indicators of activity were used, the assessments of spatial distribution will be less accurate (e.g. maritime transport which was estimated from shipping densities). Finally, for activities where spatial data on values were not available, nor reliable spatial distribution of the activity, spatial allocation was considered inappropriate. The latter examples were often assessed based on centrally derived funds that were difficult to allocate (e.g. education and training). For other industries such as Pipelines it was difficult to derive a measure of their value to the economy at all.

The sections that follow provide brief regional descriptions of the distribution of key activities within the area. In particular, the regional descriptions provide summaries of those activities for which the value to the economy could not be estimated and hence are not presented in Table 2.3, such as power transmission. However, some recreational activities are undertaken all around the UK coast (e.g. fishing and swimming) and it is difficult to identify any particular regions of importance for these.

In addition, it should be noted that some regions are larger than others and may have higher levels of productivity as a result. The largest region is Region 8 (Atlantic North-West Approaches) followed by Region 1 (Northern North Sea).

In summary, the value to the economy from oil and gas is highest in Regions 1 and 2 where the UK's main hydrocarbon fields are located. Aquaculture is most widespread in Scotland with the highest value to the economy in the western part of Scotland in Regions 6 and 7. Marine aggregate extraction is more significant in England and Wales with the highest economic values identified in Regions 2 and 3 in the sout-east of England. Fisheries bring in the highest total market value of catch in Regions 1 and 7 around the north of Scotland (more than twice the value of other regions).

2.4.1 Northern North Sea (Region 1)

The Northern North Sea is the most economically important region for the oil and gas industry and it provides the greatest economic income in Region 1 due to the presence of large oil

Table 2.3 Regional distribution of economic value for the principal activities[1] £millions.

CP2 Region	*Year*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*Sum*
1. GVA From Marine Activities – where possible to determine										
Oil and Gas[2]	2008	19 000	14 200	0	0	1100	0	2700	0	37 000
Maritime transport	2007	887	1555	651	566	741	75	225	0	4700
Telecom-munications	2005	281	415	111	1085	226	14	193	375	2700
Leisure and recreation	2003-08	179	154	274	263	243	87	88	1	1289
Defence – Military	2007/08	78	20	114	140	42	24	26	24	468
Fisheries	2007	65	9	18	19	21	19	48	5	204
Aquaculture	2007	26	1	1	1	14	88	62	0	193
Water abstraction	2008	35	31	9	22	44	9	0	0	150
Mineral extraction	2008	0	32	17	4	1	0	0	0	54
Renewable energy	2008	2	24	0	0	24	0	0	0	50
Total GVA (£millions)		20 553	16 441	1195	2100	2456	316	3342	405	46 808
GVA thousands per km^2		113	266	54	22	57	10	27	1	53
% Marine GDP		43.9	35.1	2.6	4.5	5.2	0.7	7.1	0.9	
2. Investment Values of Marine Activities where GVA not possible to determine										
Coastal defence	2007/08	29	113	56	46	112	1	1	0	358
Waste disposal	2007/08	2.3	1.1	0.3	0.7	2.0	1.6	1.4	0.0	9.3
3. Marine Activities where Regional and Monetary Values not possible to determine										
Education		Centralised GVA; no specific year; not possible to establish regional figures								95
R&D; general management	I	Centralised investment; not possible to establish regional figures								3624
Power transmission		Not possible to establish monetary value								
Gas storage and pipelines		Not possible to establish monetary value								

Superscripts:
1. Does not include ancillary and secondary market values
2. Excluding values from pipelines and hydrocarbon storage as these could not be established

Note that due to the different economic values used it is inappropriate to provide an overall total

fields and well established marine and land infrastructure. Oil and gas presents a diverse range of environmental pressures including noise impacts from exploration and construction activities through to contamination from operational activities. These pressures tend to be highly localised both spatially and temporally (see Section 3.9.7).

The most valuable fisheries for demersal roundfish and *Nephrops* take place mainly in the Northern North Sea. Pelagic species (herring, mackerel, horse mackerel) are targeted using midwater otter trawls and pelagic pair trawls. Smaller scale inshore fisheries for a variety of shellfish species occur all along the coast while dredging for scallops takes place particularly along the Scottish east coast. The greatest pressure in the region is from the widespread fishing activities with selective extraction impacting on fish stocks and habitat disturbance from mobile fishing gears affecting benthic habitats. The Northern North Sea also supports important fin-fish aquaculture around the eastern parts of Shetland and farming of shellfish in the Highlands.

Shipping activity is high here linking the UK with the northern European mainland from ports in the Moray Firth, Firth of Forth, and the Port of Tees and Hartlepool. The naval base Caledonia supports Ministry of Defence activities including sea training, while ship building occurs elsewhere in the region providing significant direct and indirect economic activity (see Section 3.3). Region 1 also contains a high proportion (20%) of UK waste disposal sites (see Section 3.16.4) most likely related to the high number of ports in the region and the need to dispose of material dredged to maintain navigation channels.

Owing to the presence of a number of nationally important coastal power stations in the region, the value of water abstraction for cooling water is estimated to be significant (see Section 3.17). The region also supports a high proportion of water discharge outlets (see Section 3.16.4) related to the location of dense population centres and industrial activity. Recreation within the region is also economically important with, for example, bird watching on the East Lothian coast (see Section 3.6.3.2), cetacean watching in the Moray Firth and scuba diving at St Abbs-Berwickshire (see Section 3.6.4). Pressures from these activities are likely to be highly localised inshore.

2.4.2 Southern North Sea (Region 2)

The most valuable economic product in the Southern North Sea is gas. In addition, there are important gas pipeline links to Europe and the potential for gas storage in subsea caverns is high. Pressures on the marine environment from gas extraction activities are highly localised. The Southern North Sea has among the best sources of wind energy in the UK with four existing wind farms (Lynn, Inner Dowsing, Scroby Sands, Kentish Flats) and new sites being developed (see Section 3.12). Due to the presence of strategically important coastal power stations in the region, the value of water abstraction for cooling water is estimated to be significant (see Section 3.17).

Two of the busiest UK ports in terms of freight traffic are located within the region, Grimsby and Immingham port in the Humber estuary and London in the Thames Estuary, both benefiting from close proximity to markets in Europe (see Section 3.7.4). Pressures from shipping include noise, risk of oil spills and other forms of contamination, and introductions of non-native species through ballast water. Given the

wide-ranging nature of ships, these pressures are all managed through the International Maritime Organization. Region 2 also contains the highest proportion (26%) of UK waste disposal sites (see Section 3.16.4). These are related to the high number of ports in the region and the need to dispose of material dredged to maintain navigation channels. The region also supports the most significant and strategically important marine aggregate resources in the UK with licensed areas off the Humber and east coast regions and the Thames Estuary, providing almost half of all marine construction aggregate to large population areas, particularly London (see Section 3.8.2.3). Demand for marine aggregate materials in the region could significantly increase – particularly to support large scale infrastructure projects (e.g. nuclear new builds, offshore wind gravity base structures) and coastal defence programmes.

The land adjacent to the Southern North Sea is relatively low-lying and consists of some very dynamic coastlines and important population centres. As a consequence, this region has the highest proportion of coastal defence and flood protection schemes in the UK (31.6% of all coastal defences and 33.4% of all flood defences – see Section 3.2.4). The region also supports a high proportion of water discharge outlets (see Section 3.16.4) related to the location of dense population centres.

Recreationally the region is an important source of income for the leisure boating industry but also supports nationally significant areas for bird watching, for example around Norfolk (see Section 3.6.3.2). The main pressures from leisure and recreation will be concentrated inshore and around large population centres and popular beaches.

Fishing activities are widespread both spatially and temporally resulting in a high level of pressure from mobile fishing gears.

2.4.3 Eastern Channel (Region 3)

The Eastern Channel region has the second highest distribution of marine aggregate resources and is increasing in importance due to its close proximity to a number of high population areas. Associated environmental pressures will also increase, although these are highly localised.

A significant amount of market value is derived from Ministry of Defence activities within the region due to the location of the Portsmouth Naval Base and associated ship building (see Section 3.3). Likewise, the region is important for maritime transport activities with ports in Dover, Portsmouth and Southampton moving container and cargo ships, ferries and cruise ships internationally. Pressures from shipping include noise, risk of oil spills and other forms of contamination, and introductions of non-native species through ballast water. Given the wide-ranging nature of ships, these pressures are all managed through the International Maritime Organization.

There is a high proportion (16%) of coastal defence and flood protection schemes although the region is less vulnerable to coastal erosion and flooding compared to other low-lying regions of the UK (see Section 3.2.4). There is a strategic subsea power cable connecting the UK with France landing ashore at Folkestone although the market value of this is hard to define in traditional economic terms.

Recreation activities are particularly important. Along the Sussex and Dorset coasts the leisure boating industry, recreational fishing and scuba

diving provide significant value (see Section 3.6.4) and any environmental pressures will be localised on inshore habitats and species.

2.4.4 Western Channel and Celtic Sea (Region 4)

The southwest corner of the UK is a key point of landfall for international telecommunication connections from America and Africa, providing significant indirect economic value and presenting negligible levels of environmental pressure from installation and operational activity.

The two most valuable fisheries in Region 4 are beam trawling for demersal fish and cuttlefish, and pot fishing for crabs and lobsters (see Section 3.5.4). The use of mobile fishing gear presents the most significant pressure within the region where it impacts on sensitive benthic communities (see Section 3.5.7).

The region also has important wave resources from which electricity could be generated and is likely to become an important area for the testing of demonstrator devices over the next five years and deployment of commercial scale projects over the longer term. It also includes the Severn Estuary with the greatest potential tidal range energy in the UK and a number of options are being explored to harness this. Pressures from such potential activities range from low for discrete offshore wave devices to high for barrages that present a permanent and unrecoverable impact on entire estuarine ecosystems.

South Wales is particularly dependent on marine-dredged sand due to shortages in local land-won sources and there are currently no realistic alternatives (see Section 3.8.2.3). Demand for marine aggregate materials in the region could significantly increase to support large-scale infrastructure projects such as the Severn tidal power project, new nuclear power stations and coastal defence programmes. Pressures from dredging activities are highly localised and low in magnitude and frequency although they may still result in significant site specific impacts where they interact with sensitive features (see Section 3.8.2.6). There are also two naval bases in the region, at Plymouth and Dartmouth, providing significant direct and indirect economic activity and important ferry services from Swansea, Milford Haven and Pembroke dock linking Wales with Ireland (see Section 3.3).

Region 4 includes some attractive coastline ranging from exposed coasts to sheltered embayments. As a result it is an important region for recreation particularly surfing and scuba diving (see Section 3.6.4) and environmental pressures are present at most beaches throughout the region (see Section 3.6.7).

2.4.5 Irish Sea (Region 5)

The Irish Sea is one of the busiest seas in the UK due to the distribution of a number of large population centres around it and is an important focus for a diverse array of different activities. Although the environmental pressures from each activity are highly localised and discrete at a regional level, the resulting cumulative pressures are likely to be the highest of all the regional seas. Due to the wide-ranging interests and concerns over cumulative pressures it has been a pilot area for several marine planning studies (see Section 4.4.1).

There are a few discrete gas reserves that nevertheless provide significant economic value. In addition, there are important gas pipeline links from England and Scotland to Northern Ireland, the Republic of Ireland and the Isle of Man.

The region has among the best sources of wind energy in the UK with four wind farms operating (North Hoyle, Burbo Bank, Barrow, Robin Rigg) and more proposed developments (see Section 3.12). There are a number of important power and telecommunication links between mainland UK and Northern Ireland, the Republic of Ireland and the Isle of Man (see Sections 3.11 and 3.15). Due to the presence of strategically important coastal power stations in the region, the value of water abstraction for cooling water is estimated to be significant (see Section 3.17).

The largest and most valuable fishery in the Irish Sea is for *Nephrops* with a number of smaller fin-fish and shellfish fisheries. The Irish Sea is a nationally important area for the farming of shellfish; mainly mussels in Northern Ireland and the Menai Straits in Wales and oysters and scallops in the southern part of Strathclyde (see Sections 3.1.3.1 and 3.1.4).

Maritime transport activities in Region 5 primarily comprise freight traffic between Scotland, England, The Isle of Man, Northern Ireland and the Republic of Ireland. The region also has 21% of waste disposal sites in the UK although not all are in use at any one time. The region also supports a high proportion of water discharge outlets (see Section 3.16.4) related to the location of dense population centres and industrial activity.

The Irish Sea has the second highest area of investment in coastal and flood protection (the first being Region 2) due to low-lying land and dynamic coastlines (see Section 3.2.4). There are long lengths of attractive coast within easy reach of the population making recreation activities important. Activities include surfing (e.g. along the Llŷn Peninsula), scuba diving (e.g. Strangford Lough and Anglesey) and cetacean watching (e.g. Cardigan Bay) (see Section 3.6.4).

2.4.6 Minches and Western Scotland (Region 6)

The varied coastline in the Minches and Western Scotland region supports a range of inshore fisheries for shellfish and finfish. Inshore rocky areas support a widespread potting fishery for lobster and crab and there is a significant fishery for *Nephrops* and pelagic fisheries for herring, mackerel, and horse mackerel. As in other regions throughout the UK, fishing presents the highest level pressure due its widespread nature and diverse range of activities; however, fishing effort has decreased dramatically in recent years.

Aquaculture in the region includes fin-fish throughout but also oysters and scallops in the northern part of Strathclyde. The region also supports a high proportion of water discharge licences relating to aquaculture activity and dispersed local population areas. Pressures from these activities are generally highly localised, although collectively they may affect the functioning of the surrounding environment, for example, in assimilating waste matter.

Marine wildlife watching is of particular value in Region 6 providing an annual income of £1.17 million per annum from direct expenditure and £5.1 million per annum in additional tourism income (see Section 3.6.3.2). It is also an important area for scuba diving, particularly around the Inner Hebrides. Such activities may place pressures on the wildlife being observed and these are generally managed through best practice guidance and voluntary codes of conduct.

2.4.7 Scottish Continental Shelf (Region 7)

The Scottish Continental Shelf region contains some of the most remote fishing communities in the UK, and the varied coastlines of northern

Scotland support a range of inshore fisheries for shellfish and fin-fish including the most valuable UK towed-gear fisheries for demersal roundfish and *Nephrops* (see Section 3.5.4). Potting for edible crabs is also now extensive on the northern Scottish Continental Shelf. As in other regions throughout the UK, fishing presents the highest level pressure due its widespread nature and diverse range of activity.

This region is the most important in the UK for marine fin-fish aquaculture (see Section 3.1.4). Pressures from individual marine farms are generally highly localised, although collectively they may affect the functioning of the surrounding environment, for example, in assimilating faecal waste matter.

There are some important oil fields on the Scottish Continental Shelf and there was increased activity in exploration and appraisal drilling in 2007, although the majority was close to existing fields (see Section 3.9). Development of new fields will produce a diverse range of pressures including noise impacts from exploration and construction activities through to contamination from operational activities.

Marine wildlife watching is a particularly important source of income in northern Scotland and the Western Isles, Orkney and Shetland (see Section 3.6.3.2). The region is also particularly important for scuba diving (e.g. Scapa Flow, Orkney) and a number of other coastal tourism activities (see Section 3.6.4). Such activities may place pressures on the marine environment and these are currently managed through best practice guidance and voluntary codes of conduct. The region also supports a number of important telecommunication links between the UK and northern Europe.

2.4.8 Atlantic North-West Approaches (Region 8)

The Atlantic North-West Approaches region is remote from major population centres so there are few economically important activities and consequently fewer pressures. At Rockall, there is a targeted fishery for haddock by Scottish and Irish trawlers (and Russian vessels in adjacent international waters). In the 1990s, some Scottish vessels diverted their activity towards deep-water fisheries including species such as orange roughy, tusk, roundnose grenadier and black scabbard fish but unfavourable quota opportunities in recent times have all but stopped this activity.

The region consists of some diverse seabed features and supports a range of biological communities including internationally important deep-sea corals and carbonate mounds. Due to the increasing activity in deep-sea fisheries it has become an important area for deep-sea research, particularly to understand the environmental pressures that occur in the region and to understand the consequent impacts on unique deep-sea habitats.

The north-west corner of the UK is a key point of landfall for international telecommunication connections from America providing significant indirect economic value.

2.5 UK seas statement

Table 2.4 provides an overall UK Seas level summary of trends in market values, outputs and pressures. The overall aim of *Charting Progress 2* is to review and update the evidence presented in the previous UK-wide assessment, *Charting Progress* (Defra et al., 2005), and to assess significant developments that have occurred since then. *Charting Progress* presented an initial assessment of the various pressures and impacts of human activities in the marine environment. However, it made no assessment of the value and sustainability of socio-economic activities occurring in the marine environment in the UK. As a result, there is no information with which to make a direct comparison. Therefore, we have made an assessment here of the changes in value associated with each socio-economic activity that have occurred since the *time* of *Charting Progress* based on the trends reported in the activity sections. The latest year for which data were likely to be incorporated in *Charting Progress* is assumed to be 2003 (rather than the year that the report was actually published – 2005).

Trends in 'output' are reported for the various indicators that were appropriate for each activity (e.g. aquaculture production, landings values for wild fisheries, barrels of oil produced, capacity of power cables, installed capacity of renewable energy and participation rates in leisure activities).

Economic activities may result in many pressures on the marine environment, including noise, pollution and loss of habitat. Pressure trends provide an overall assessment of the change in extent of pressures (spatial extent, frequency, intensity and temporal extent) related to the activity. Where data do not exist an expert judgement has been made, typically based on production trends. As yet, there is no agreed way to summarise such a range of pressures into a single index for each activity. Hence, a description is simply provided of the spatial and temporal extent of pressures to support the assessment. Figure 2.6 provides a map of the top six activities in terms of market value within each region (as assessed from Table 2.3).

In relation to specific changes since *Charting Progress*, the following conclusions from Table 2.4 can be made:

- Most production levels have either been stable or increased since 2003 and likewise economic value has generally been stable or increased. It should be noted that the changes reflect trends that were occurring before the economic downturn but it is likely that most sectors will recover.
- Trends in economic value do not necessarily follow trends in production. For example, while domestic production of oil and gas has fallen, their market values have been extremely volatile. These patterns reflect the impact of market forces (supply, demand, volume of stockpiled resources, accreditation schemes) in influencing economic value.
- Trends in environmental pressures tend to follow trends in production. Exceptions include the oil and gas industry where production has fallen but pressures are unlikely to have changed and will not start decreasing significantly until more infrastructure is decommissioned. However, it should be noted that the decommissioning of such structures is likely to present other environmental pressures (e.g. habitat damage and loss).
- Decreasing trends in overall environmental pressure may be summarised for fisheries (assessed from information on decreased

fishing effort and improved stock management plans) and waste disposal (from improved waste management).

Overall, our seas are economically productive and there are strong policy drivers to increase this productivity. Most activities are highly regulated to limit impacts on the marine environment and, aside from fisheries, have localised pressure footprints. Although we have begun measurements of sustainability we do not yet know how sustainable our use of the seas is overall. This section provides assessments of overall trends for each activity and summary tables and figures highlighting the main findings.

2.6 Forward look

There are a number of developing policies (international and national) aimed at both marine economic activity and the management of the impacts of those activities that will help to shape the future of economic activity and monitoring on the UKCS. These include Sustainable Development policies; the Marine and Coastal Access Act 2009, the Marine (Scotland) Act 2010 and similar marine legislation under development in Northern Ireland; sectoral policies such as the EU Common Fisheries Policy and various EU Directives (such as the Marine Strategy Framework Directive, the Water Framework Directive and the Habitats and Birds Directives – see Chapter 3 of this report and Chapter 4 (*Marine Management*) of the PSEG Feeder Report for more information).

The increasing use of impact assessment as part of policy development across Government is improving the information base on the economic and social values generated by human activity as well as their environmental costs and benefits. The adoption of an ecosystem goods and services approach to valuation is developing through initiatives such as the National Ecosystem Assessment. Such information is likely to be increasingly influential in informing policy choices and can make a substantial contribution to sustainable development.

Finally, the new Marine Management Organisation (under the Marine and Coastal Access Act 2009), Marine Scotland and marine planning throughout the UK will be important vehicles for coordinating research and collating information to enable a better understanding of the extent of pressures. For example, studies are currently being conducted on the distribution of current and potential economic value in relation to aquaculture, renewable energy and inshore fisheries to help inform planning for the development of Marine Protected Areas.

These policy developments will require a better understanding of market value and the direct causal relationship between impacts, pressures and the environment along with better access to such information. Key future research areas are as follows.

- Greater understanding is required in some areas to support the assessment of Good Environmental Status (GES) for the EU Marine Strategy Framework Directive, for example, knowledge of the distribution and status of seabed features and the spatial and temporal distribution of noise sources, litter and invasive species in the marine environment and their significance to marine ecosystem functioning.
- Summary assessments of pressures related to each activity are based on expert judgement and a range of pressure indicators. In order to improve these assessments we need to better understand cumulative pressures.

Table 2.4 Summary of state (economic productivity) and pressures for the UK seas.

Activity	*Productivity*			*Pressures[1]*
	£ million[2]	*Trend[3]*	*Output*	*Trend[3]*
Oil and Gas	37 000	↑	↓	↔
	Value increased despite decline in production. No change in most activities, recent increase in appraisal drilling. Small localised footprint from structures. Operational long term and year round.			
Maritime Transport	4700	↔	↔	↔
	Overall little change in imports and exports. Widespread pressure footprint. Occurs long term and year round.			
Telecom Cables	2700	↑	↑	↑
	Capacity has increased, several international projects. Small localised footprint from cables that are present long term and operational year round.			
Leisure and Recreation	1289	↑	↑	↑
	Increase participation rates likely in some activities. Widespread pressure footprint. Pressures are seasonal but present long term.			
Defence – Military	468	↔	?	↔
	Large zone of potential activity that is likely to be localised. Unknown temporal nature. Expenditure is stable so assume that extent of activity is as well.			
Fisheries	204	↔	↔	→
	Large and widespread extent of disturbance. Long term pressures mostly occurring year round.			
Aquaculture	193	↑	↔	↑
	Increases in some stocks since 2003. Localised spatial pressures, farms present long-term but seasonal in operation. Few data on spatial extent of pressures.			
Water Abstraction	150	↔	↔	↔
	Little change in the amount abstracted. Small localised footprint of disturbance. Operational long term and year round.			
Mineral Extraction	54	↔	↔	↔
	No change in production overall although tonnage has fluctuated. Small localised footprint of disturbance. Seasonal and medium term in time.			

Activity	*Productivity*			*Pressures[1]*
	£ million[2]	*Trend[3]*	*Output*	*Trend[3]*
Renewable Energy	50	⬆	⬆	⬆
	Large increases in investment and consequent production of energy. Small localised footprint from structures. Operational long term and year round.			
Coastal Defence	358[1]	⬆	⬆	⬆
	Investment has doubled over the past 10 years in east of England. Large and widespread extent of disturbance. Structures are more or less permanent.			
Waste Disposal	9.3[1]	↔	↔	↔
	The amount of material disposed of relatively constant. Small localised footprint of disturbance. Wastewater disposal is operational long term and year round.			
Education	95	↔	↔	↔
	Value calculated from a range of years therefore low confidence in estimate. Participation varies among subject areas but likely to be no overall change.			
R & D	3624[1]	↔	↔	↔
	Centralised investment. R&D likely to have increased in the offshore region.			
Power Transmission	?	↔	↔	↔
	Not possible to establish monetary value. No temporal data, deployment rates likely to have been stable.			
Storage of Gases	?	↔	↔	↔
	Not possible to establish current monetary value. Significant increase in investments. No new development since 2003 but surveys (e.g. seismic) likely to have increased.			

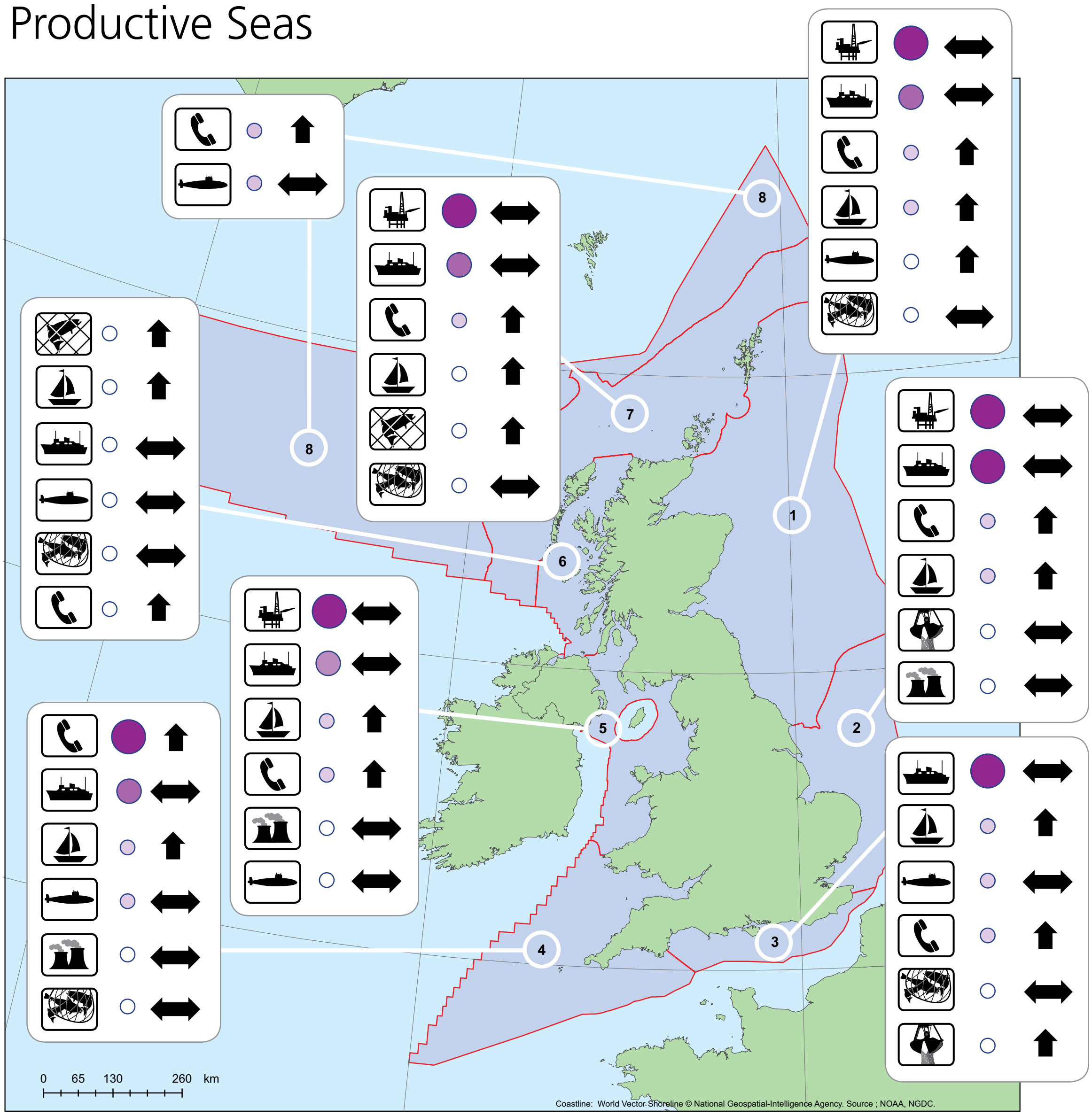
Notes:

1: Measures of pressure reflect both spatial and temporal extent and intensity at the level of the entire UK seas

2: GVA where possible unless otherwise stated as I (investment)

3: Trends are since *Charting Progress* (from 2003 to 2008/9) as follows: ↑ increase, ⬆ large increase, ↓ decrease, ↔ no change at all, → change in type of activity in some areas but no overall difference

Figure 2.6 Contribution to the economy of the main marine activities in each of the eight UK regions and recent trends in the pressures they exert on the marine environment.



Regional sea boundaries

1. Northern North Sea
2. Southern North Sea
3. Eastern Channel
4. Western Channel and Celtic Sea
5. Irish Sea
6. Minches and Western Scotland
7. Scottish Continental Shelf
8. Atlantic North-West Approaches

Oil and gas
Maritime transport
Telecoms
Leisure and recreation
Fisheries
Defence
Water abstraction
Aquaculture
Mineral extraction

Gross Value Added (£)

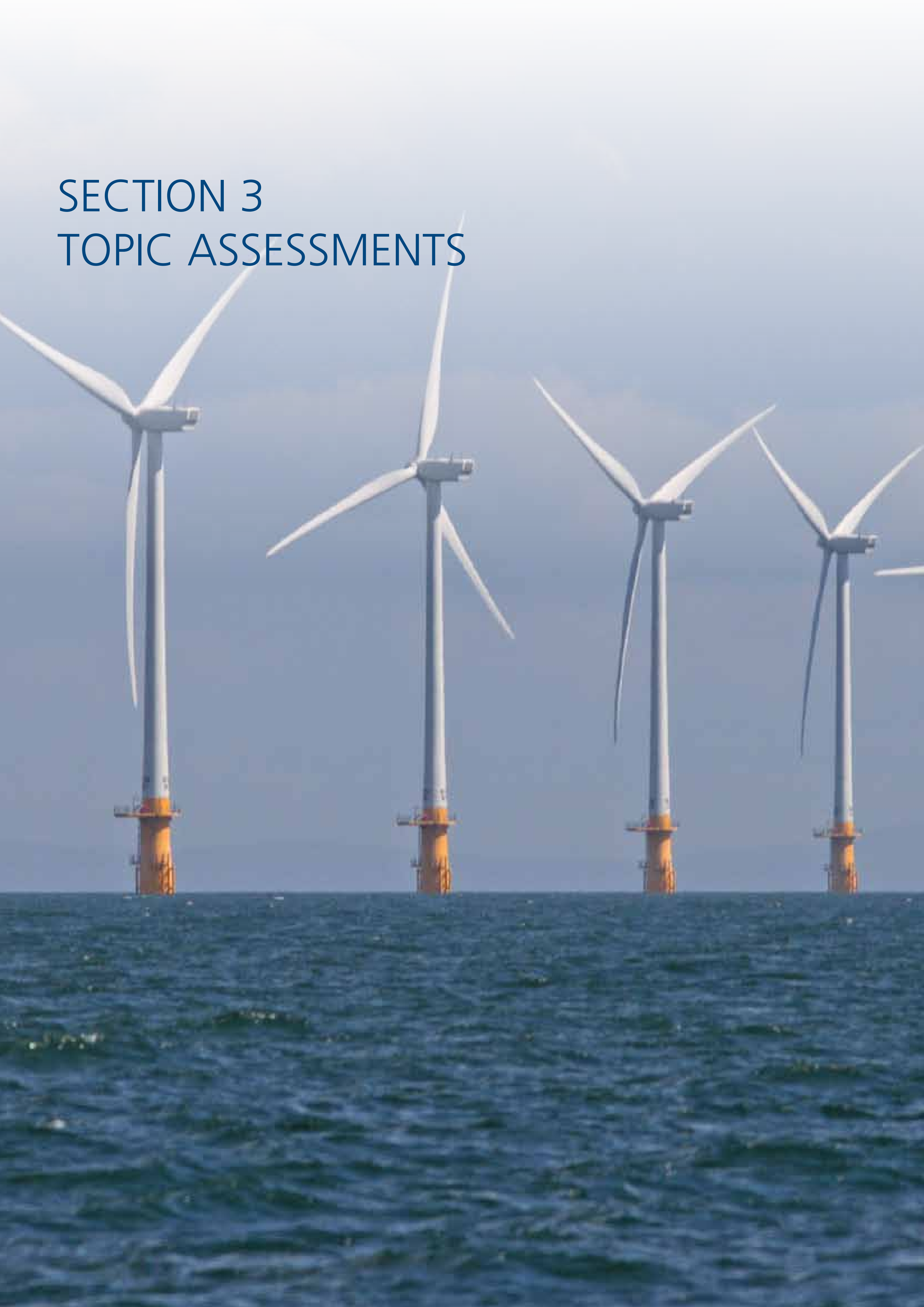
>1bn
500m - 1bn
100 - 500m
10 - 100m

Change in pressure since 2003

Increase
Decrease
No change

- We need better centralised collation of data on the distribution of pressures associated with activities such as aquaculture, leisure and recreation, and shipping.
- We need to agree a methodology on how to spatially allocate socio-economic data to support regional analyses although the assumptions made here have been broadly agreed by industry in reviewing this report.
- Primary research on the economic value of ecosystem goods and services and on understanding the non-use and option values of the marine environment would also be valuable.
- Greater discussion is needed regarding the market value of some activities that to date are poorly quantified, for example, leisure and recreation, waste disposal, telecommunications and power transmission.
- Certain activities and uses of the marine environment have benefits that are hard to quantify. For example, we need a better understanding of the contribution that marine activities make to social values, such as upholding cultural traditions in local fishing communities. Evidence on the cultural and historic values of the marine environment is patchy and to some extent dependent on information from extractive industries.

SECTION 3
TOPIC ASSESSMENTS



3.1 Aquaculture

3.1.1 Key points

- Most aquaculture activity (99%) is related to fish and shellfish
- The majority (99%) of existing finish aquaculture activity is located in Scotland although it is increasing in areas of Wales and England. Shellfish culture is spread more evenly throughout the UK
- In 2007, the turnover from Scottish farmed marine fin-fish was approximately £327 million and from shellfish farming in the UK was about £23 million providing a total of £350 million and a Gross Value Added (GVA) of £193 million
- Processing of fish from mariculture provided an estimated £105 million GVA in 2007
- Environmental issues relate to inputs (e.g. the sustainability of fish feed), presence of structures leading to habitat and hydrodynamic changes, operations that disturb the seabed (e.g. harvesting) and outputs (e.g. discharges, escapees from farms and diseases/parasites)
- Aquaculture within the UK increased by 132% between 2000 and 2006 and despite some recent decreases since, the long-term trend is for continued growth, particularly in other areas such as England and Wales
- A new strategy for European Aquaculture was launched in 2009
- Growth will be constrained by site availability and environmental carrying capacity and the availability of investment

i. Introduction

Aquaculture is the farming or culturing of aquatic organisms (fish, molluscs, crustaceans, plants). More than 99% of economic aquaculture activity in the UK is related to fish and shellfish although there is increasing culture of seaweed and marine worms for bait.

ii. How has the assessment been undertaken?

Economic and spatial data were collated from Marine Scotland and the Centre for Environment, Fisheries and aquaculture (Cefas) and combined in a Geographic Information System (GIS) to provide regional assessments. A number of industry reports were also drawn upon to illustrate other economic and environmental aspects and to describe the future progress of the industry.

iii. Current status of the aquaculture sector and past trends

The majority (99%) of existing marine based fin-fish aquaculture activity is located in Scotland (see Section 3.1.4) although it is increasing in areas of Wales and England. Shellfish production is more evenly spread throughout the UK. In 2007, the turnover from fin-fish farming in Scotland was £327 million and shellfish farming in the UK was £23 million providing a total of £350 million and a GVA of £193 million. In addition, processing of fish from mariculture provided an estimated £105 million GVA in 2007. Aquaculture within the UK increased by 132% between 2000 and 2006 (see Section 3.1.5).

The main environmental issues (see Section 3.1.7) relate to inputs (e.g. sustainability of fish feed), presence of structures that affect habitats and hydrodynamics, operations that disturb

the seabed (e.g. harvesting) and outputs (e.g. discharges, escapees from farms and diseases/parasites). These issues are managed by the relevant regulatory bodies (including Devolved Administrations, Environment Agencies and Local Authorities) through the consenting system and are also dealt with through voluntary best practice undertaken within the industry. The licensing system is extremely complex (see Section 3.1.2) although there are plans to streamline it through the Marine and Coastal Access Act 2009 and similar legislation under development by the Devolved Administrations. A number of new strategies support sustainable development by setting out goals for balancing economic growth with careful management of environmental impacts and support for social development. The overall aim of the latest 2009 overall strategy for European Aquaculture is to encourage growth in the industry while building on the high environmental and quality standards that have been achieved so far.

iv. What is driving change?

Development of the industry is closely tied in with changes in wild fisheries (see Section 3.1.10), site availability and environmental carrying capacity and the availability of investment.

v. What are the uncertainties?

While there is good information on the location of fish farms there are some uncertainties over the distribution of pressures associated with aquaculture activities, for example the dispersal of waste products and inputs of nitrogen and phosphorus. This is due to the way that information is collected; details are typically specific to individual sites and projects and are described in individual licence applications and are not centrally collated or freely and readily available. It is recommended that this information is collated centrally, for example by the UK Government and Devolved Administrations or their respective Environment Agencies.

vi. Forward look

Despite some recent decreases due to the economic downturn, the long-term trend is for continued growth, particularly in areas such as England and Wales.

3.1.2 Introduction

Aquaculture is the farming or culturing of aquatic organisms (fish, molluscs, crustaceans, plants) using techniques designed to increase the production of the organisms in question beyond the natural capacity of the environment, such as through regular stocking, feeding and protection from predators (ONS, 2007b).

More than 99% of marine aquaculture in the UK is related to fish and shellfish farming. Farming of seaweed is a growing part of this sector although there is very little information on this. The sector also includes the production of fry and spat for aquaculture farms and the operation of marine worm farms to produce fishing bait but their contribution to the Gross Domestic Product (GDP) will be small (less than 1%).

Marine aquaculture is particularly important to the economies of the Scottish regions although aquaculture operations occur around the UK.

3.1.2.1 Description of economic activities

The principal economic activity is related to the direct use of the marine seabed and its waters for farming or culture of marine organisms. This activity is supported by a number of ancillary services such as construction and fish feed

production, and in turn supports a number of secondary activities such as downstream processing. The sector can be divided up as indicated in Table 3.1.

3.1.2.2 Description of relevant ecosystem services

The aquaculture sector also relies on various ecosystem services that support its productivity, including: the physical environment; chemical cycling/ water purification; biological productivity (for fish feed and seed stock).

3.1.2.3 Management

Marine aquaculture is managed by a patchwork of different legislation (see Table 3.2) that has evolved over time (Peel and Lloyd, 2008). Statutory planning controls over the development of aquaculture installations were introduced in 2007 in Scotland. This helped to remove a perceived conflict of interest when The Crown Estate (TCE) was both the licensing body and the landlord. However, there has been criticism that this has not provided the simplified, consistent and unified approach to management that was hoped for but has added another layer of regulation (Peel and Lloyd, 2008). Options are currently being explored through the Marine and Coastal Access Act 2009 and the Marine (Scotland) Act 2010 to simplify licensing procedures.

The industry also carries out a considerable amount of self-regulation and self-monitoring, as well as establishing voluntary codes of practice through various bodies and associations including:

- Scottish Salmon Producers' Organisation (SSPO)
- Association of Salmon Fishery Boards (ASFB)
- Association of Scottish Shellfish Growers (ASSG)
- Federation of Scottish Aquaculture Producers (FSAP)
- Seafish – the seafish industry authority
- Shetland Aquaculture
- British Trout Association (BTA).

Research to support the industry is generally managed by the Scottish Aquaculture Research Forum (SARF) which co-ordinates funding commitments from among its membership. Membership includes the industry bodies above, Fisheries Research Services (FRS) [now Marine Scotland], the Scottish Environment Protection Agency (SEPA), Scottish Natural Heritage (SNH) and TCE.

3.1.3 Direct use value

Mariculture (marine aquaculture) is the largest and most valuable component of aquaculture in the UK with the industry broadly split into two categories – fin-fish farming and shellfish cultivation. Although there is activity in other areas such as seaweed farming and marine worm farms, economic data on these is not available.

3.1.3.1 Principal activities

Fin-fish farming

Scotland supplies almost all the marine fin-fish farmed in the UK with a total value of approximately £327 million in 2007[1]. Of this, £324 million was Atlantic salmon (*Salmo salar*) with a total production of 130 000 tonnes in 2007 (FRS, 2008a). Scotland is the third largest salmon farming nation in the world, currently

1 Updated annually at http://openscotland.gov.uk/Topics/Fisheries/Fish-Shellfish

Table 3.1 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Marine Aquaculture (SIC 03.21) includes: • Fish farming • Culture of crustaceans, bivalves, other molluscs, and other aquatic animals. • Production of bivalve spat, lobsterlings, shrimp post-larvae, fish fry and fingerlings • Growing of laver and other edible seaweeds • Operation of fish hatcheries • Operation of marine worm farms	Production of feed for aquaculture operations (SIC 10.91 and part 10.20); Specialised construction (SIC 43.99/9), installation (SIC 33.2) and decommissioning of fish farms	Processing & preserving of fish, crustaceans and molluscs (10.20); Agents involved in the sale of products (46.17) – Fishmongers and fish retailers	None identified

Table 3.2 Summary of consents and regulations for aquaculture and responsibilities in Scotland.

Function/legislation	*Underlying aim*	*Responsibility*
Planning permission	Control of fish farm siting/development	Local Authorities for new developments. Scottish Government for existing approvals; see Scottish Planning Policy (SPP) 22 Planning for Fish Farming.
Lease	Management of seabed rights	The Crown Estate
Coast Protection Act (CPA) Part I	To install structures or deposit any materials on the seabed	Scottish Government: Environment – policy and Local Authority-led schemes. Local Authorities: private-led schemes
CPA Part II	For any works that are likely to obstruct or cause a danger to navigation	Scottish Government: Transport
Food & Environment Protection Act (FEPA) Part I	Food safety	Food Standards Agency (Scotland). SEPA enforces area closures
FEPA Part II	Protection of marine environment (though oil and gas, telecoms etc are reserved)	Marine Scotland (was Fisheries Research Services (FRS) and Scottish Government Marine Directorate (SGMD))
Water Environment/ Water Services Act 2003 and Controlled Activities Regulations 2005 in Scotland (CAR)	Protection of water (incl. marine environment <3 nm)	SEPA/Scottish Government: Environment
Aquaculture and Fisheries (Scotland) Act 2007	Control of parasites (sea lice) and escapees	Marine Scotland
Animal Health Directive	Maintain good fish health through disease control	Marine Scotland
Environmental Impact Assessment (Scotland) Regulations 1999	Required for development to manage all stages of activity.	Local Authorities
Wildlife (e.g. European protected species) licences	Regulates activities likely to affect protected species etc.	Split between SNH and Scottish Government (Environment and Marine)
Conservation of Seals Act 1970	Regulates the control of seals having an impact on a fishery	Marine Scotland – may be extended to fish farms

producing some 10% of global farmed Atlantic salmon (Ernst and Young, 2005). The remainder of the marine fin-fish farming in Scotland consists of cod (*Gadus morhua*) and halibut (*Hippoglossus hippoglossus*) amounting to 1258 tonnes in 2007 (FRS, 2008a). The Scottish fish farming sector now accounts for around 50% of all Scottish food exports after secondary processing. A small amount of fin-fish farming is undertaken in Northern Ireland (about 999 tonnes in 2007 at a value of £1.85 million[2]). The total fin-fish production in the UK in 2007 was approximately 139 000 tonnes.

The UK also produces about 13 000 tonnes of various trout species with a £20 million per annum turnover but these are primarily farmed in freshwater habitats and therefore not taken into account in this analysis (Defra, 2008d; Pugh, 2008).

Shellfish cultivation

Total shellfish cultivation for the UK was valued at about £23 million in 2007 (Cefas, 2008, see Table 3.3). Shellfish cultivation in England was worth £4.5 million in 2007, which is mainly mussel (*Mytilus edulis*), with small quantities of Pacific oyster (*Crassostrea gigas*), native oyster (*Ostrea edulis*) and very small quantities of clam (e.g. *Venerupis semi-decussata* in Northern Ireland) and cockle (*Cerastoderma edule*).

In Wales, the production is almost entirely mussels derived from re-laying and on growing in the Menai Straits worth £7.5 million in 2007 (Seafish, 2006; Cefas, 2008). In Northern Ireland, shellfish production is also dominated by mussels with some oyster and clam production worth £5.8 million in 2007 (Cefas, 2008). The total value at first sale for all species was estimated to be in the region of £5 million in Scotland consisting mainly of mussels with some oyster and scallop cultivation (FRS, 2008b).

It should be noted that the value differs according to the species farmed and that these values also fluctuate from year to year. An example is provided in Table 3.4 of the differences in prices among different species in Scotland. It is therefore important to assess production trends in both tonnes and pounds Sterling.

An increase in the commercial exploitation of species where cultivation is in its infancy, such as lobster (e.g. *Homarus gammarus*) and cockle, is likely to further increase the value of this sector.

Fin-fish farming and shellfish cultivation provide a total first sale value of £350 million. Assuming a value added factor of 0.55 (as used by Pugh and Skinner, 2002) gives £193 million GVA for the principal production process.

3.1.3.2 Secondary activities

The main secondary activity is fish processing. Marine aquaculture contributes 21.4%[3] of the fish (fin-fish and shellfish) supplied to the fish processing sector. Provisional data released by the Office for National Statistics for 2007 shows that total sales (turnover) by the UK processing sector were £2567 million compared with total inputs of £2077 million[4] resulting in a GVA of £490 million in 2007. Using the same proportion it is estimated that £105 million of this was related to aquaculture.

2 http://www.dardni.gov.uk/index/fisheries-farming-and-food/fisheries/aquaculture/aqua-info.htm

3 Based on a ratio of total aquaculture production of 166 500 tonnes to total fisheries production of 611 000 tonnes.

4 www.statistics.gov.uk/abi/downloads/Subsection_DA.xls

Table 3.3 Production and total value of shellfish species in the UK in 2007 (Cefas, 2008; FRS, 2008b).

Species	*Scotland*	*England*	*Wales*	*N Ireland*	*Total*
Pacific oyster	208	576	10.5	374	1169
Native oyster	22	55	0	0	77
Scallop	2	0	-	2	4
Queen scallop	15	-	-	-	15
Mussel	4806	3252	10 016	8039	26 113
Clams	-	12	-	10	22
Cockles	-	10	-	-	10
Total (tonnes)	**5053**	**3905**	**10 027**	**8425**	**27 410**
Total value (£million)	**5.1**	**4.5**	**7.5**	**5.8**	**22.9**
Percentage of the total	22	20	33	25	100

Table 3.4 Total value at first sale of shellfish species in Scotland in 2007 (FRS, 2008b).

Species	*Value, £ million*	*Price*
Mussel (*Mytilus edulis*)	4.3	£800 – £900 per tonne
Pacific oyster (*Crassostrea gigas*)	0.7	£0.22 – 0.30 per shell
Native oyster (*Ostrea edulis*)	0.1	£0.38 per shell
Scallop (*Pecten maximus*)	0.02	£1.00 per shell
Queen scallop (*Chlamys opercularis*)	0.02	£0.06 per shell
Total	**5.1**	

3.1.4 Regional distribution of value

Although information on regional value is limited, the distribution of production is more widely available (and is a good indicator of value). Fin-fish production in the UK is almost exclusively Scottish salmon farming (see above). Production of salmon is highest in Shetland and the North West region of Scotland (Table 3.5). The location of these salmon farms can be seen in Figure 3.1.

The industry is currently constrained by the need for relatively deep and sheltered waters of high environmental quality with appropriate marine and terrestrial access to the farms and their onshore support services. Within Scotland alone there are 280 registered active fin-fish sites (excluding trout species) and 336 registered active shellfish sites (FRS, 2008a,b).

The most widely available information on the regional distribution of shellfish is from Scotland, where production is highest in Strathclyde (Table 3.6).

Based on the distribution of aquaculture sites and total values quoted in Section 3.1.3, it is possible to make a broad assessment of how value is distributed through the different CP2 Regions (Table 3.7).

Figure 3.1 Location of aquaculture sites.

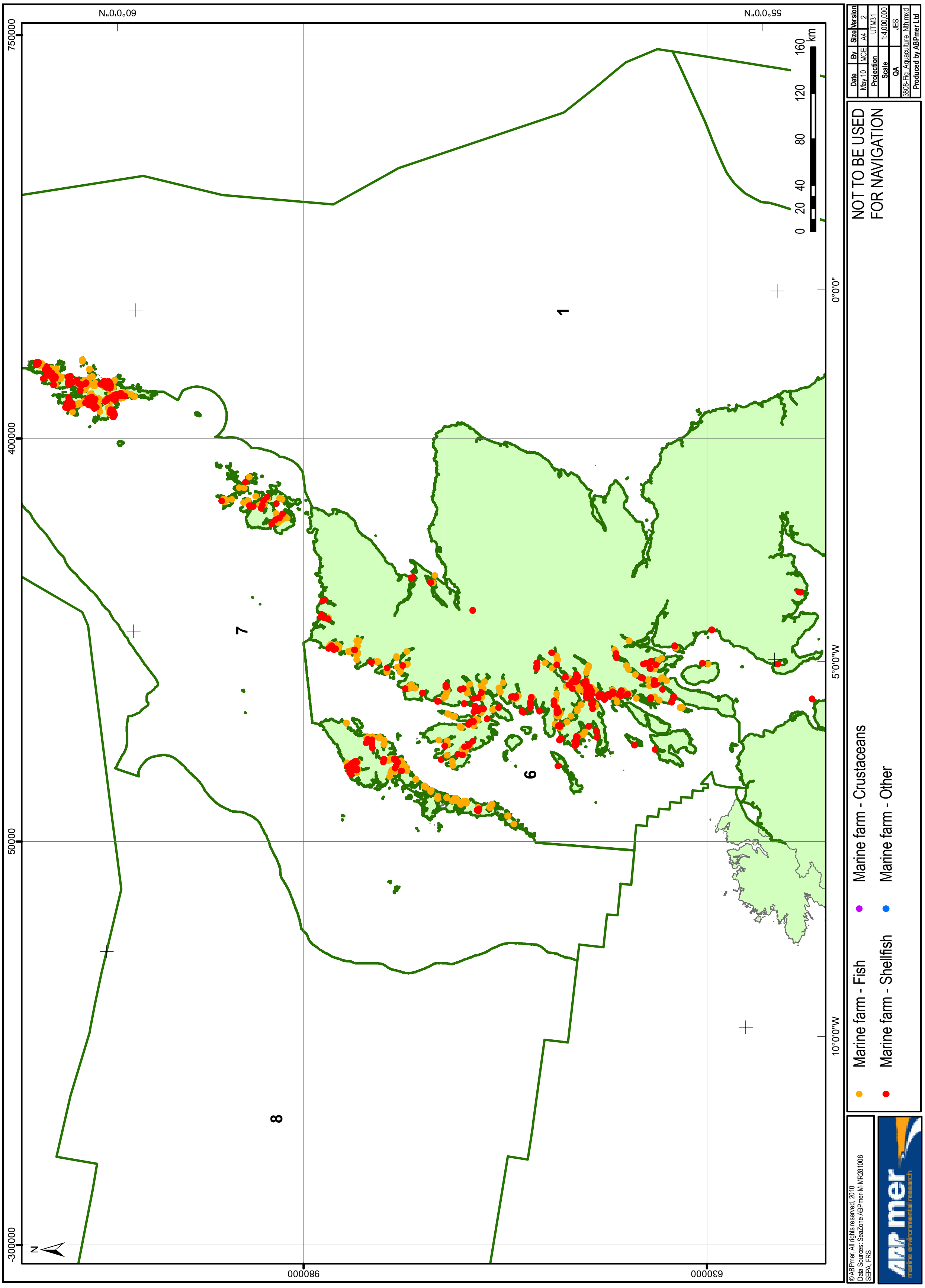


Figure 3.1 continued

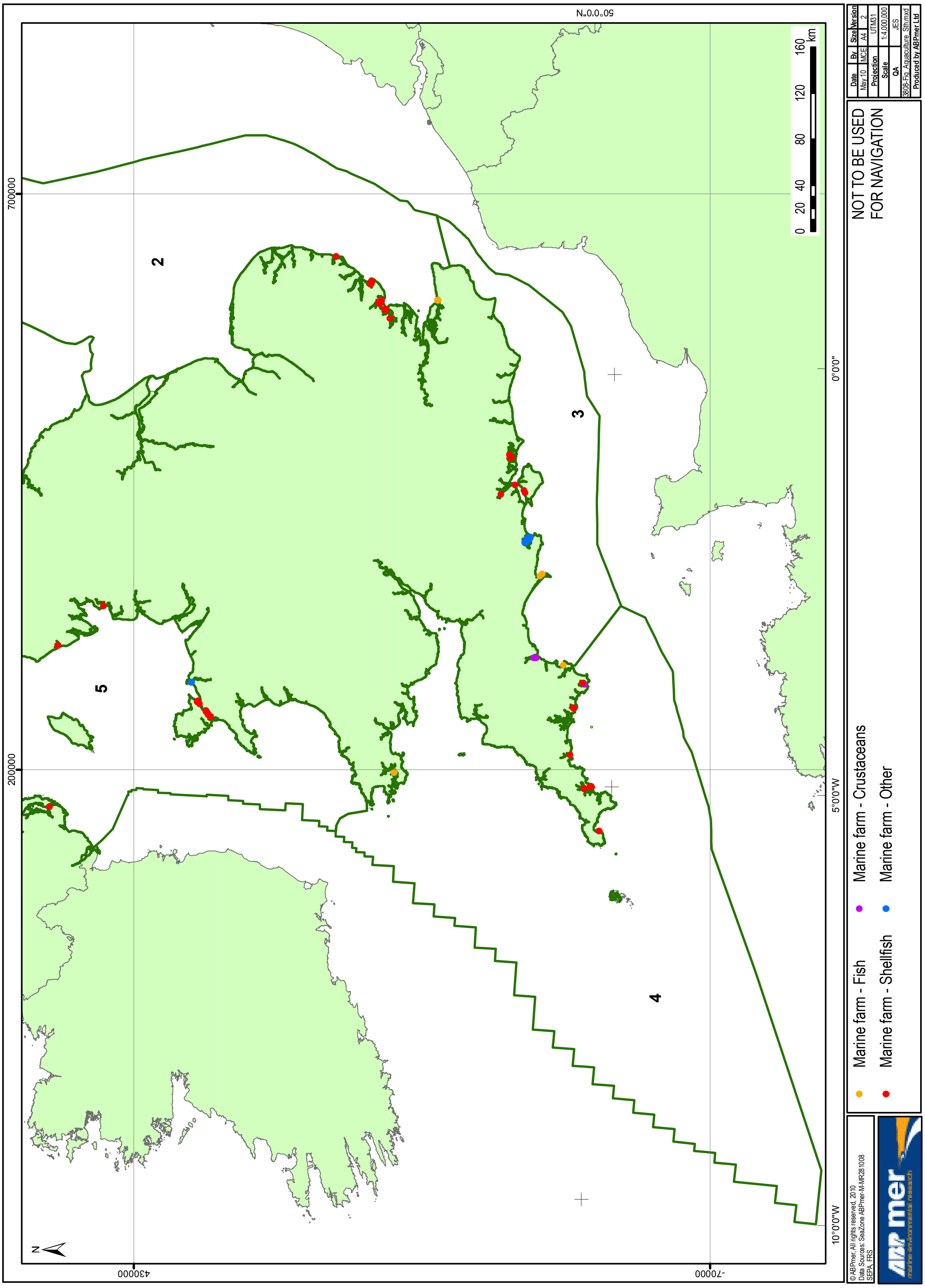


Table 3.5 Annual production of farmed Atlantic salmon by area (FRS, 2008a).

CP2 Region	*Area of Scotland*	*Annual production in 2007, tonnes*	*Annual production in 2006, tonnes*
1	North West	33 541	40 219
7	Orkney	4 432	3 724
1, 7	Shetland	40 795	39 278
5, 6	South West	31 353	25 460
6, 7	Western Isles	19 809	23 166
	Total	**129 930**	**131 847**

Table 3.6 Scottish shellfish production by area, 2007 (FRS, 2008b). Based on sales for direct human consumption.

CP2 Region	*Area of Scotland*	*Companies*	*Mussel, tonnes*	*Pacific oyster, thousands*	*Native oyster, thousands*	*Queen scallop, thousands*	*Scallop, thousands*
1	Highland	51	451	175	0	7	15
7	Orkney	11	3	10	0	0	0
1, 7	Shetland	37	2605	<1	0	0	0
5, 6	Strathclyde	55	1288	2417	273	377	<1
6, 7	Western Isles	16	459	<1	0	0	0
	Total	**170**	**4806**	**2603**	**273**	**384**	**15**

Table 3.7 The distribution of value in 2007 (£million) per Region.

CP2 Region	*Region*	*Fin-fish farming value, £ million*	*Shellfish farming value, £ million*	*Total GVA*
1	Northern North Sea	46.0	0.7	25.7
2	Southern North Sea	0	1.4	0.8
3	Eastern Channel	0	2.3	1.3
4	Western Channel and Celtic Sea	0	1.0	0.6
5	Irish Sea	17.9	7.4	13.9
6	Minches and Western Scotland	153.3	7.5	88.4
7	Scottish Continental Shelf	109.8	2.6	61.8
8	Atlantic North-West Approaches	0	0	0
Total		**327**	**22.9**	**193**

3.1.5 Trends

The UK aquaculture sector has increased dramatically in recent years with the economic contribution from fish and shellfish farming alone increasing by 132% over the period 2000 to 2006 (Defra, 2008d). Trends in Scottish salmon production from 1998 to 2008 can be seen in Figure 3.2. The largest variation in salmon production occurred between 2002 and 2005 and was due mainly to a large smolt placement in 2000, 2001 and 2002. The change was also affected by an increased average weight giving a higher yield per smolt put to sea between 2002 and 2003 and by a reduction in the number of smolts being put to sea from 2003-2005.

Trends in Scottish shellfish cultivation from 1998 to 2007 can be seen in Figure 3.3. The large reduction in queen scallop from 1998 to 2002 and again in 2006 can be attributed to poor results in spat recruitment and a decrease in the production of farmed scallops as a result of environmental influences which caused area closures and prevented sales for human consumption.

3.1.6 Socio-economic pressures and impacts

There are 431 fish and shellfish farming businesses in the UK (Defra, 2008d). In 2004, UK employment for shellfish cultivation was estimated at around 416 full-time and 418 part-time staff. Employment in the fin-fish sector totals an estimated 1396 full-time and 268 part-time staff. Converting this to full-time equivalent (FTE) levels[5] gives a combined total of 2163 for the aquaculture production sector in the UK.

5 Based on an average over all industry categories of 18.9 hours part time and 37.5 hours full time (ONS, 2008c).

Figure 3.2 Annual production of Atlantic salmon in Scotland. Source: FRS (2008a).

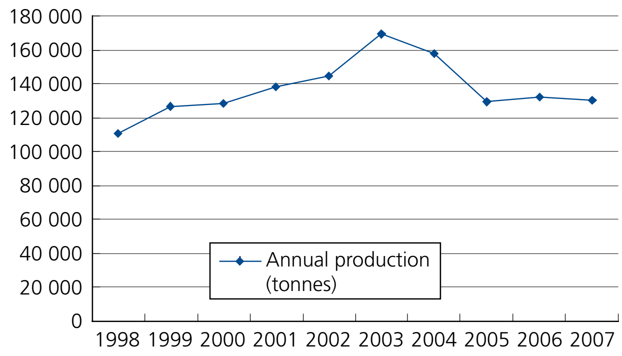
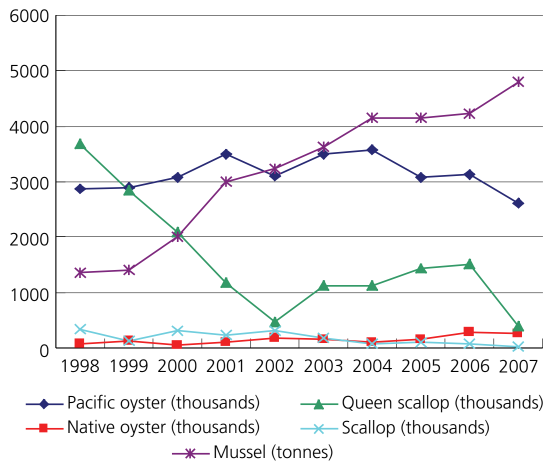


Figure 3.3 Annual production of shellfish in Scotland. Source: FRS (2008b).



Scotland has around two thirds of the overall staff employed in aquaculture, followed by England (28%), Northern Ireland and finally Wales. Within England, the highest proportion of staff is within the South East, with very few staff employed in the London area (Lantra, 2007). Jobs in aquaculture are particularly important for rural coastal communities (e.g. Shetland) which are heavily reliant on the fish industry for employment (AB Associates Ltd, 2008). In Scotland for example around half the people employed in aquaculture live in remote rural areas (Poseidon, 2004).

In recent times, the number of companies involved in aquaculture has reduced due to the rationalisation of the industry, company consolidations, mergers and acquisition, alongside the decline of smaller (and often independently owned) companies (Ekos Ltd, 2006).

3.1.7 Environmental pressures and impacts

Key environmental pressures and impacts associated with aquaculture are described in Table 3.8. The ecosystem services that these pressures impact and the relative significance of these impacts are identified in Table 3.9. See Annex 1 for assessment methodology.

The development and operation of aquaculture facilities is regulated by a number of consents, regulations and voluntary procedures, as discussed in Section 3.1.2. There has recently been a move towards basing regulatory decisions on assessments of the carrying capacity of a system to support aquaculture. Examples include the model developed by SEPA AutoDepomod and the management plan for Sustainable Mariculture in northern Irish Lough Ecosystems (SMILE). AutoDepomod is a software package used for consenting biomass and chemotherapeutants for fin-fish farms in Scotland. It incorporates Depomod which is a particle-tracking model used for predicting the sinking and resuspension flux of particulate waste material (and special components such as medicines) from fish farms and the benthic community impact of that flux (Cromey, 2008). SMILE aims to develop dynamic ecosystem-level carrying capacity models for the five sea lough systems in Northern Ireland (Ferreira et al., 2007).

3.1.8 Climate change

3.1.8.1 Impacts of climate change on the aquaculture industry

Given the current projections, climate change is unlikely to have a significant effect on UK mariculture over the next decade. Further into the future however, the forecast changes are likely to result in noticeable effects (MCCIP, 2008).

Scotland (where 99% of the UK's cultured marine fin-fish is produced) is projected to experience rises in annual and seasonal mean water temperature of up to 2.5°C by 2080. Similar projections are expected for England and Wales in the same time period.

Rising average water temperatures could result in faster growth rates for some species which are more tolerant of higher temperatures (e.g. Atlantic salmon, mussels, oysters) but prolonged periods of warmer summer temperatures may well adversely affect some cold-water species (e.g. cod, Atlantic halibut) and intertidal shellfish (oysters) as the thermal optima for the animals physiology may be exceeded for long periods of time. This could make some sheltered, warmer sites unsuitable for those species during the summer months. The culture of species which are currently of marginal (but growing) value to UK market but which thrive in warmer conditions such as sea bass, sea bream and hake could be a positive new opportunity caused by climate change (MCCIP, 2008).

Disease of mariculture species through bacterial, viral, parasitic and fungal infection will be affected by a changing thermal regime, but in a largely unpredictable manner which is poorly understood. Stresses induced by changes in thermal conditions are likely to make cultured species more susceptible to disease. Warmer

conditions may also allow the establishment of exotic diseases, while diseases such as cold water vibriosis, may become much rarer.

Rising temperatures may also extend the season and infective pressure of sea lice on salmonid species. The possibility of increased storminess (higher frequency of strong wind speeds) projected for certain seasons in some regions could increase the risk of escapes through equipment failure and may necessitate site relocation or changes to equipment design.

The projected increase in the frequency of harmful algal and jellyfish blooms (associated with an increase in warmer waters with calmer, drier summer months) could potentially cause more fish kills and closures of shellfish harvesting areas, but the forecast reduction in summer precipitation may benefit classification of shellfish growing areas (MCCIP, 2008).

An increase in ocean acidification is another factor caused by anthropogenic carbon dioxide (CO_2) dissolving in the ocean which could impact on aquaculture species in the future. Experiments designed to test the impacts of acidification on Pacific oyster and mussels found that oysters have a higher tolerance to ocean acidification than mussels. It was shown that mussels exhibited a decrease in shell formation of 30% with raised pH levels that are likely to be reached during this century (Fernand and Brewer, 2008). One reason for this difference in tolerance is the composition of the shells; approximately 50% of a mussel shell is made from aragonite which dissolves more easily than calcite, which constitutes most of the oyster shells (Fernand and Brewer, 2008).

Adaptation measures

Potential measures that may be employed to minimise future impacts on the industry include:

- Relocation of aquaculture sites to areas which are at more suitable temperatures for the growing of that particular species (e.g. further north or into deeper colder water)
- Relocation of sites to areas which are less sensitive to the possibility of intense storms or harmful algal blooms
- An increase in the protection of cages against a possible increase in the storminess of seas
- A shift to the farming of species which thrive better in warmer conditions
- A shift to the farming of shellfish species with a higher tolerance of acidification (i.e. a higher proportion of calcite in their shells).

3.1.8.2 Impacts of the aquaculture industry on climate change

The three main sources of CO_2 from aquaculture are: (1) energy use for the running of an aquaculture farm, such as for artificial lighting, temperature control in smolt and egg production, powering generators; (2) emissions associated with transportation of both adults and juveniles at different phases of their lifecycle to different sites (e.g. broodstock, smolt and adult phases) as well as transportation of fish for processing and the wholesalers; and (3) emissions associated with transportation of staff and the transportation and production of supplies e.g. fishmeal and equipment.

No data quantifying the CO_2 emissions of the aquaculture industry could be sourced.

Table 3.8 Key environmental pressures and impacts associated with aquaculture. Information based on: Kelso and Service (2000); Naylor et al. (2000); Edwards and Cook (2001); Scottish Executive Central Research Unit (2002); Gubbins et al. (2003); Poseidon (2004); Royal Commission on Environmental Pollution (2004); Gillibrand et al. (2006); Greathead et al. (2006); Wilding et al. (2006); Black et al. (2008); Burridge et al. (2008).

Pressure	**Sustainability of fish feed**
Impact	Feeding carnivorous aquaculture species capture-caught (wild-caught) fish from a lower trophic level. This 'fishing down and farming up' the food web can deplete wild stocks (usually pelagic species such as sandeel, herring, anchovy). Removal of pelagic species may also have consequences for breeding success of piscivorous water birds (kittiwake, puffins). The UK aquaculture sector accounts for 4% of total worldwide fish-oil consumption.
Description of environmental change (intensity, spatial extent, frequency, duration)	Around 95% of feeds used by the Scottish industry are manufactured by three companies, all with feed mills in or near Scotland. Current fishmeal consumption by these plants for aquaculture use is around 105 000 tonnes per annum and is sourced from the UK (24%), Iceland (22%), Norway (16%), Denmark (12%), Chile (10%) and Peru (9%). Of the 50 000 tonnes of oil used for Scottish fish feeds, the majority is from Iceland with some from South American sources and 20% is of Irish and UK origin. The domestic (UK) production destined for aquaculture feeds in Scotland consists of herring and mackerel offal, blue whiting, sandeel and whitefish trimmings.
Existing management measures	In EU countries fisheries are controlled under the Common Fisheries Policy. Total Allowable Catches, closed areas and seasons and mesh size limits are in place for fishmeal target species such as scad, mackerel and sandeel. The Sandeel Box in the Firth of Forth, for example, was introduced to protect sandeels as a source of food for local predators, including seabirds. Monitoring via the International Council for the Exploration of the Sea through its working groups and independent scientists.

Pressure	**Organic enrichment**
Impact	Deposition of particulate waste (faecal material and uneaten fish food) beneath fish cages may result in de-oxygenation of seabed sediments. Shellfish species such as mussels can also produce large quantities of faeces and pseudofaeces. This waste accumulates as 'mussel mud' beneath suspended mussel cultures. These waste products may result in de-oxygenation of seabed sediments and changes in the benthic invertebrate assemblage, characteristically a reduction in diversity and increase in opportunistic species.
Description of environmental change (intensity, spatial extent, frequency, duration)	The distribution of waste particles (feed and faeces) depends on several variables including depth and current speed: the greater the depth and the greater the current speed, the larger the impacted area but the lower the degree of impact. In some circumstances effects on sediment chemistry and faunal composition are limited to the seabed directly underlying the fish cages, and out to a distance of only ~15 m from them (Brown et al., 1987). In contrast, Weston (1990) found detectable effects on sediment chemistry out to 45 m from a fish farm, while benthic community effects were found to at least 150 m away. It is now generally accepted that feed losses from fish farms have been reduced to less than 5% in well-run farms. In general, for shellfish cultivation any changes to the benthos will generally be directly below and in the close vicinity of the culture. The extent of any impact from shellfish faecal waste will also be dependent on the hydrodynamic conditions of an area. In high energy environments any impact on benthos will be minimal due to high dispersion rates of particles. It can take several years after cessation of cultivation for the benthos to return to an assemblage similar to pre- cultivation.

Existing management measures	SEPA sets limits for the biomass of fish which can be grown at a particular site. These limits are designed to match the environment's carrying capacity and prevent the accumulation of wastes. The limits are determined by a detailed modelling process to ensure that the biomass of fish on site and the unit load of waste per area of seabed are within acceptable limits for that area of sea. Where seabed quality standards have been breached SEPA will require operators to rectify the situation. Under the EU Habitats Directive, shellfish cultivation sites in European Marine Sites will be subject to an Appropriate Assessment to test their compatibility with the designated nature conservation objectives, based on concerns about physical and biological impacts.

Pressure	**Reduction in plankton levels**
Impact	Overstocking of shellfish in certain areas can lead to a reduction in the standing stock of phytoplankton.
Description of environmental change (intensity, spatial extent, frequency, duration)	Dependent on the carrying capacity of the area.
Existing management measures	See discussions at Section 3.17 concerning AutoDepomod and SMILE.

Pressure	**Input of nitrogen and phosphorus**
Impact	Fish excretory products and decaying food release ammonia and salts of nitrate and phosphate into the water column. This can increase phytoplankton/algae levels contributing to eutrophication and may be a contributing factor to harmful algal blooms.
Description of environmental change (intensity, spatial extent, frequency, duration)	Greathead et al. (2006) used modelling to investigate the contribution in 104 lochs/voes of nitrogen inputs from tidal exchange, freshwater run-off and fish farming. While tidal exchange was found to be the dominant source of nutrient nitrogen in lochs/voes there were about 20 to 25 lochs/voes in which aquaculture provides more than 10% of the nitrogen, during the second summer of an aquaculture cycle. Gubbins et al. (2003) applied a predictive model to determine the Equilibrium Concentration Enhancement (ECE) of nutrient nitrogen in 110 sea lochs in Scottish coastal waters supporting aquaculture. The results of the model were used to select potential aquaculture 'hotspot' areas where predicted ECE was high (>1.0 µmol/l) in comparison to the majority of lochs modelled. These 'hotspot' areas were mainly located around Shetland. The maximum nutrient inputs from aquaculture occur during the summer when temperatures and feeding rates are high and the biomass on site is at a maximum.
Existing management measures	SEPA sets limits for the biomass of fish which can be grown at a particular site. SEPA uses Locational Guidelines (Scottish Executive, 1999) to assist with the licensing process to ensure that nutrient levels are maintained within Environmental Quality Standards (EQS) limits.

Table 3.8 continued

Pressure	**Introduction or spread of non-indigenous species and translocations (competition)/ interbreeding of escaped farmed species with wild stocks ('genetic pollution')**
Impact	Escapees from fish farms interbreeding with wild populations resulting in losses of genetic variability, including loss of naturally selected adaptations, leading to reduced fitness and performance in the marine environment. Species introduced as mariculture species or in association with mariculture species (e.g. in with shellfish seed) can cause habitat modification and trophic competition with commercial species.
Description of environmental change (intensity, spatial extent, frequency, duration)	The level of reported escapes are usually between 100 000 and 400 000 fish a year (which is up to four times the entire Scottish commercial and rod fishery wild salmon catch). For the combined years of 2003 and 2004 a total of 189 000 salmon escaped from Scottish fish farms of which 31% were from Shetland, 27% Orkney, 14% Western Isles, 3% South west and 25% North West (Walker et al., 2006). Escapee salmon are recorded at relatively low frequencies in wild salmon fisheries in regions with fish farms (typically <5%). In regions of the British Isles without salmon farms their occurrence is irregular and low (typically at frequencies <0.5%). In the 1800s, the slipper limpet (*Crepidula fornicata*) was accidentally introduced to Britain with imports of bivalve seed. This species has been responsible for substantial modification of the sea floor in certain areas as well as for trophic competition with commercial bivalve species. The hard-shell clam (*Merceneria mercenaria*) was successfully introduced from the USA into Southampton Water in 1925 and now has limited distribution around the south coast of England, Pembrokeshire and Loch Sunart, Scotland. Approximately 50% of non-native marine algae are believed to have been introduced with mariculture species, for example, *Sargassum muticum.*
Existing management measures	The North Atlantic Salmon Conservation Organization (NASCO) is a forum for international co-operation for the management of wild salmon in the North Atlantic. NASCO members adopted the Oslo Resolution on minimising impacts from salmon aquaculture in 1997. Article 2 of the Resolution, *Measures to Minimise Genetic and other Biological Interactions* requires signatories to take steps to minimise escapes of farmed salmon. The Aquaculture and Fisheries (Scotland) Act 2007 came into force in August 2007 and allows the inspection of fin-fish farms to assess whether satisfactory measures are in place to contain farmed fish and prevent escapes. Improved containment is one of the five key themes in *A Fresh Start, The renewed Strategic Framework for Scottish Aquaculture* (Scottish Government, 2008b). The movement of non-native mollusc species to and within Europe is restricted through EUregulations (EU Directive 95/70/EC) and in the UK the release of non-native species into the wild is only permissible under the Wildlife and Countryside Act (1981). Council Regulation (EC) No 708/2007 concerns the use of alien and locally absent species in aquaculture and will establish a new system for assessment and management of the risks associated with the introduction of new organisms for aquaculture.

Pressure	**Increased densities of larval sea lice**
Impact	Infection of wild salmonids by sea lice which can include those released from farmed fish.
Description of environmental change (intensity, spatial extent, frequency, duration)	Wild salmon and sea trout can be exposed to increased sea lice infection pressure through the release to the sea of larval sea lice from fish farms. Canadian and Norwegian studies suggest that salmon smolts are most at risk in long fjordic systems where they have to pass several farms during their migration to sea.
Existing management measures	Medicines used to treat fish diseases are licensed by the Veterinary Medicines Directorate under the Marketing Authorisations for Veterinary Medicinal Products Regulations 1994. There is considerable scientific debate within this area.

Pressure	**Increased numbers of sea lice**
Impact	Transference of sea lice from farmed fish to wild fish.
Description of environmental change (intensity, spatial extent, frequency, duration)	Wild salmon and sea trout are at risk from infective larval sea lice that may be associated with marine salmon farms. Salmon are most at risk in long fjordic systems where they have to pass several farms during their migration to sea.
Existing management measures	Medicines used to treat fish diseases are licensed by the Veterinary Medicines Directorate under the Marketing Authorisations for Veterinary Medicinal Products Regulations 1994.

Pressure	**Synthetic compound contamination (e.g. disinfectants antibiotics).**
Impact	Since much fin-fish farming takes place in open net pens, chemicals can be dispersed into the surrounding water by a variety of routes including through treatment, spills, waste food and faecal matter. These discharges have the potential to be toxic to benthic species.
Description of environmental change (intensity, spatial extent, frequency, duration)	A range of sea lice treatments are used. Antibiotic use in Scottish fish farms in 2006 for the three major compounds used (Oxytetracycline Hydrochloride, Florfenicol and Amoxicillin) was 5500 kg. In Scotland a range of disinfectant products are used. The products fall into three general classes: iodophors, 1-alkyl-1, 5 diazapentane and chlorine containing products (Burridge et al., 2008). In Scotland the total quantity of disinfectant used in 2006 was 3901 kg.
Existing management measures	In Scotland a medicine or chemical agent cannot be discharged from a fish farm installation unless formal consent under the Water Environment (Controlled Activities) (Scotland) Regulations 2005 has been granted to the farm concerned by SEPA. SEPA also requires reporting of therapeutant use from each site. Medicines used to treat fish diseases are licensed by the Veterinary Medicines Directorate under the Marketing Authorisations for Veterinary Medicinal Products Regulations 1994.

Pressure	**Non-synthetic compound contamination – Heavy metals**
Impact	Of the metals present in fish farm sediments, elevated concentrations of copper and zinc have been reported in Scotland and Canada. The principal sources of these metals are antifoulant paints and fish feed. Discharges of chemical compounds have the potential to be toxic to benthic species.
Description of environmental change (intensity, spatial extent, frequency, duration)	Copper oxide is the active ingredient in all antifoulant paints currently used in Scotland. Copper oxide use in Scottish fish farms in 2005 totalled 34 000 to 84 123 kg. Analysis of sediments under and around many Scottish fish farms was performed by Dean et al. (2007). Maximum level of copper in surface sediments was 805 µg/g. In contrast, the Sediment Quality Criterion for copper in Scotland is 270 µg/g, which would indicate adverse impacts are very likely. Pore water copper concentrations were 0.1 to 0.2 µg/l. Levels decreased with distance from the cages, and background levels were found in sediments about 300 m away from the farm centre.
Existing management measures	Antifouling net treatments which are used to clean the nets used in fish farms are classed as pesticides, and their use has to be licensed under the Control of Pesticides Regulations 1986. Registration of antifouling products is co-ordinated by the Health and Safety Executive. Heavy metal concentrations are monitored by SEPA.

Table 3.8 continued

Pressure	**De-oxygenation (in the water column)**
Impact	The breakdown of organic matter from fish farms (e.g. uneaten food) can create a chemical and biochemical oxygen demand (COD and BOD), which can lower oxygen levels in the sediment and water column.
Description of environmental change (intensity, spatial extent, frequency, duration)	Gillibrand et al. (2006) investigated the risk of de-oxygenation in Scottish sea lochs with isolated deep water. The research found that a number of sea loch basins (between 5 and 38 out of 135 basins) may be at risk of routinely developing hypoxic bottom water conditions, mostly caused by natural processes. The research also found that carbon fluxes from fish farming may contribute significantly to a predicted hypoxia risk in a small number of sea loch basins (about four), although the risk itself may be overestimated.
Existing management measures	De-oxygenation is routinely monitored by SEPA.

Pressure	**Litter**
Impact	Marine litter from aquaculture farms such as broken net, plastic pipes and metals can impact on marine species through ingestion, entanglement and smothering.
Description of environmental change (intensity, spatial extent, frequency, duration)	Not known.
Existing management measures	None identified.

Pressure	**Introduction of microbial pathogens (disease)**
Impact	Parasites and diseases are part of the natural biology and functioning of ecosystems, but if fish are raised under crowded and stressful conditions they can be more prone to disease. Disease can move in both directions between farmed and wild fish. Cage farms may cause ecological effects stemming from the release of parasites and pathogens.
Description of environmental change (intensity, spatial extent, frequency, duration)	Since the first major outbreak of Infectious Salmonid Anaemia (ISA) in several Scottish fish farms in 1998 there have been claims of a threat to wild populations. The potential exists for transfer of infectious diseases to wild stocks but the real level of risk is not quantifiable given present knowledge.
Existing management measures	Under fish health legislation, restrictions may be imposed on fish movements by fish farmers to prevent the spread of disease. Certain diseases of fish are notifiable and Marine Scotland must be informed of any outbreaks. Marine Scotland also has responsibilities under EUfish health legislation to prevent the introduction and spread of serious diseases of fish that may affect wild and farmed stocks.

Pressure	**Water flow (tidal currents) rate changes – local**
Impact	Infrastructure around the fish farm (e.g. fish pens and floats) has the potential to alter water flow rates.
Description of environmental change (intensity, spatial extent, frequency, duration)	Localised around farms.
Existing management measures	Environmental Impact Assessment (EIA) is also required as part of the process for considering applications for marine fish farm leases. The EU Directive on EIA 85/337/EC as amended by Directive 97/11/EC seeks to ensure that where a development is likely to have significant environmental effects, they are addressed in a formal environmental statement. The Environmental Impact Assessment (Scotland) Regulations 1999 implement this legislation in the UK, and apply to proposed fish farm developments in sensitive areas, those designed to hold a biomass of 100 tonnes or more, or that cover an area in excess of 0.1 hectares.

Pressure	**Wave exposure changes – local**
Impact	Infrastructure found around aquaculture sites (e.g. fish pens, floats, shellfish rafts) has the potential to alter water flow rates.
Description of environmental change (intensity, spatial extent, frequency, duration)	The extent of impact will be dependent on the size and type of the farm, the design of the farm (e.g. arrangement of cages), the water depth of the farm and distance from shore. This information is unknown.
Existing management measures	Environmental Impact Assessment (EIA) is also required as part of the process for considering applications for marine fish farm leases. The EU Directive on EIA 85/337/EC as amended by Directive 97/11/EC seeks to ensure that where a development is likely to have significant environmental effects, they are addressed in a formal environmental statement. The Environmental Impact Assessment (Scotland) Regulations 1999 implement this legislation in the UK, and apply to proposed fish farm developments in sensitive areas, those designed to hold a biomass of 100 tonnes or more, or that cover an area in excess of 0.1 hectares.

Pressure	**Habitat structure changes – abrasion and other physical damage**
Impact	Some aquaculture sites require extensive underwater infrastructure capable of abrading surrounding surfaces. Bed disturbance during harvesting operations (e.g. seed harvesting, dredging for oysters, mussels) can cause physical damage to benthic habitats.
Description of environmental change (intensity, spatial extent, frequency, duration)	The magnitude of impact will be dependent on the size and type of farm.
Existing management measures	Environmental Impact Assessment (EIA) is also required as part of the process for considering applications for marine fish farm leases. The EU Directive on EIA 85/337/EC as amended by Directive 97/11/EC seeks to ensure that where a development is likely to have significant environmental effects, they are addressed in a formal environmental statement. The Environmental Impact Assessment (Scotland) Regulations 1999 implement this legislation in the UK, and apply to proposed fish farm developments in sensitive areas, those designed to hold a biomass of 100 tonnes or more, or that cover an area in excess of 0.1 hectares.

Table 3.8 continued

Pressure	**Habitat change (to another substratum)**
Impact	Some aquaculture sites require underwater infrastructure which could have changed or covered surrounding habitat. The use of materials such as broken bivalve shells, crushed concrete and limestone as cultch to encourage settlement of oysters can also cause a habitat change on the seabed.
Description of environmental change (intensity, spatial extent, frequency, duration)	The spatial extent of such pressure is not known.
Existing management measures	Environmental Impact Assessment (EIA) is also required as part of the process for considering applications for marine fish farm leases. The EU Directive on EIA 85/337/EC as amended by Directive 97/11/EC seeks to ensure that where a development is likely to have significant environmental effects, they are addressed in a formal environmental statement. The Environmental Impact Assessment (Scotland) Regulations 1999 implement this legislation in the UK, and apply to proposed fish farm developments in sensitive areas, those designed to hold a biomass of 100 tonnes or more, or that cover an area in excess of 0.1 hectares.

Pressure	**Settlement of cultivated species outside aquaculture sites.**
Impact	Shellfish larvae produced by species on aquacultures sites 'overspilling' and settling in the surrounding environment. This can create new habitat and make increased biomass available for coastal waterbird species to feed on.
Description of environmental change (intensity, spatial extent, frequency, duration)	The spatial extent of such pressure is not known.
Existing management measures	Unlike the risks associated with escapees and introductions of non-native species which are highly managed, 'overspilling' of the spat from native species is generally not considered a problem. The Aquaculture and Fisheries (Scotland) Act 2007 allows the inspection of fin-fish farms to assess whether satisfactory measures are in place to contain farmed fish and prevent all escapes.

Pressure	**Management of other species that impact on aquaculture**
Impact	Management action is largely related to salmon farming and may include the 'taking or killing' of seals to protect stocks and prevent damage to aquaculture cages.
Description of environmental change (intensity, spatial extent, frequency, duration)	In relation to the total number of seals killed, a 2008 survey of fish farms, salmon netsmen and local district salmon fisheries boards provided a very rough estimate of about 1000 seals killed annually.
Existing management measures	Management of seals is currently dealt with under the Conservation of Seals Act 1970 and various Conservation Orders. All shootings under licence (within the closed season) are reported to Marine Scotland. One of the options under the proposed Scottish Marine Bill includes extending the licensing system for salmon fisheries to fish farms, allowing farmers with an appropriate licence to shoot seals in defence of farms and stock (otherwise known as the 'netsmen's defence).

Table 3.9 Environmental pressures on ecosystem services associated with aquaculture.

Ecosystem service	*Significance of impact*	*Confidence in understanding the relationship = information gaps*
Physical environment	**Low.** Farms preclude other uses of the physical environment, but the installations have a small footprint within the water column and on the seabed. In aggregate the footprint of fish farms and re-seeding/stocking/modification of natural beds within wider coastal systems is likely to be relatively small.	**Moderate**. Most impacts on habitats are understood.
Biological productivity	**Low – High.** Pressures possible from direct genetic impacts, invasive species and/or indirect chemical impacts. Some aquaculture operations have been associated with 'dead zones' in the immediately surrounding seabed. However, this depends on the intensity of farming activity in a local area, and good management can address this.	**Low**. Impacts variable and current practices may mitigate impacts. Impacts on biological systems through escaped invasive species (e.g. competition, pathogens, genetic change) are less well understood.
Biodiversity provision	**Low** – **High.** Pressures possible from the supply of fish feed, direct genetic impacts, invasive species and/or indirect chemical impacts. However, good management can address each of these impacts. Impacts on specific species may be irreversible (high significance). Possible impacts on wider biodiversity and wild commercial species can be significant, either because catch for fish feed involves significant volumes, or because extensive impacts are possible from a small number of escaped individuals.	**Low**. Impacts are variable and the latest practices may mitigate impacts. Impacts on wider biodiversity poorly understood. Genetic/invasive impacts can be very hard to reverse.

Mitigation measures

Increased energy efficiency and the sourcing of energy from renewable sources could reduce the greenhouse gas emissions of the aquaculture industry. Given the location of the aquaculture industry within the marine environment, it is possible that power could be sourced from marine renewables. Supply chains could also be shortened when sourcing supplies and exporting products.

3.1.8.3 Summary

Table 3.10 summarises the climate change pressures and impacts discussed in this section and indicates the likely significance of the impacts, the level of confidence in the assessment and measures that might be employed to manage the impacts (see Annex 1 for a discussion of the assessment methodology).

3.1.9 Industry stability and sustainability

3.1.9.1 Objectives, targets and indicators

In recognition of the importance of the developing aquaculture sector to the Scottish economy and the potential significance of environmental effects associated with large scale development, the Scottish Government published a Strategic Framework for Scottish Aquaculture in 2003 (Scottish Government, 2003) with the following key objectives:

- To achieve an internationally competitive and economically viable industry.
- To maximise the value to the Scottish economy of the aquaculture industry and its products, both in terms of jobs and investment.
- To operate within the biological, assimilative and visual carrying capacity of the environment.

Table 3.10 Summary of climate change implications of aquaculture.

Climate change pressure	*Impacts of climate change on Aquaculture*	*Confidence/ significance*	*Adaptation measures*
Rising sea temperature	Changes in the suitability of species	High confidence / medium significance	Change to species more suited to the climate. Relocation of site
	Prevalence of illness and parasites may increase	Medium confidence / high significance	Change to species less susceptible to parasites or illness. Relocation of site
	Increase in the frequency of harmful algal and jellyfish blooms	Medium confidence / medium significance	Relocation of site
Possible increase in stormy conditions (waves, winds etc.)	Increase in the risk of escapes through equipment failure and nets breaking	Medium confidence / medium significance	Increase in the protection of cages against a possible increase in the storminess of seas, relocation to a more sheltered area.
Ocean acidification	Increases in ocean acidification lead to the unsuitability of some shellfish species.	High confidence / medium significance	Experimental data indicate that a switch to species with a higher proportion of calcite in their shells may reduce the impacts of acidification

Impacts of Aquaculture on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
Transport and manufacture of supplies and materials	CO_2 emissions	Low confidence / unknown significance	Supply chains could be shortened when sourcing supplies and exporting products
Heating lighting and other power requirements	CO_2 emissions	Low confidence / unknown significance	The sourcing of energy from renewable sources; the location of the aquaculture industry within the marine environment means that it could be possible that power could be sourced from marine renewables

- To ensure that the impact of the industry on the biodiversity, landscape, cultural heritage and recreational uses of the sea and coast is minimised and significant impacts avoided.
- To ensure that communities are involved in the development of, and benefit both socially and economically from, aquaculture.
- To encourage more people to benefit from Scotland's healthy, nutritious aquaculture products.
- To adopt sound welfare conditions in the management of farmed stock.
- To adopt best practice in the management and control of disease and pathogens and best environmental practice.
- To provide appropriate regulating support and infrastructure.
- To encourage the industry to manage its operations in pursuance of these objectives, rather than relying on regulation alone to set operational boundaries.
- To demonstrate a responsible approach through continual improvement.

In May 2009, the Scottish Government launched *A Fresh Start*, the renewed strategic framework for Scottish Aquaculture. The renewed framework is focused on the following five outcomes:

- A secure long-term future for the industry by protecting the asset through adoption of disease-control strategies that also contribute to minimising impacts on the environment.
- Development of the right sites in the right places by the right people through transparent, streamlined and proportionate regulation/processes to minimise impacts on other users of the marine and freshwater environment.
- Containment improved by adopting best practice to reduce stock loss, improve profitability and secure the future and credibility of the industry while minimising adverse environmental impacts and preventing conflict with others' interests.
- Maximised profitability for commodity and niche market producers by promotion of a positive image of the industry and making best use of the Scottish quality brand to secure markets home and abroad and provide sustainable employment opportunities.
- An investment climate which supports and underpins the long-term future and competitiveness of the sector with investment in best practice and new technologies.

In 2001, The Northern Ireland Executive published the Shellfish Aquaculture Management Plan for Northern Ireland and an Aquaculture Strategy is also under development[6].

More recently, on 8th April 2009, a new *Strategy for the Sustainable Development of European Aquaculture* was released by the European Commission (EC, 2009a; updating that released in 2002). While improvements have been made in ensuring environmental sustainability, safety and quality of EU aquaculture production, growth within the industry has been lagging behind that of the rest of the world reducing its competitiveness. The overall aim of the 2009 strategy is therefore to encourage growth in the industry while building on the high environmental and quality standards that have been achieved. It also aims to enable coherence with other EU strategies such as the Common Fisheries Policy and the European Strategy for Sustainable Development. The strategy provides key support for:

- Promotion of current know-how and capability internationally
- Setting of standards and certification processes at EU and international level
- Research and technical development
- Promotion of aquaculture within marine planning and integrated coastal zone management initiatives
- Ongoing monitoring and assessment of environmental impacts
- Developments in animal welfare
- Improving the sector's image and governance.

3.1.10 Forward look

Aquaculture production in the UK has been projected to increase by 116% compared to current levels in the next decade (Wilding et al., 2006). Cod and halibut farming (which are both currently only farmed on a relatively small scale) were predicted to grow. The British Marine Finfish Association envisaged in 2007 that within

6 www.niseafood.co.uk/industry/aquaculturedev.asp

the next decade the UK could produce annually up to 10 000 tonnes of halibut, up to 25 000 tonnes of cod and 5000 tonnes of haddock, creating 2000 jobs and a first sale value of £100 million (Pugh, 2008). Other emerging aquaculture species such as tilapia, barramundi, bass and bream along with the growing organic fin-fish sector may also increase the size of the UK fin-fish aquaculture market (Defra, 2008d).

However, cod farming is now seen as a less attractive option due to recent increases in North Sea cod catch quotas. In addition, owing to a shortage of available investment there is now no commercial cod production and only one halibut producer. For example, *No Catch*, Britain's only supplier of sustainable organic cod went into administration in early 2008.

In recent years a number of worm farms (for bait) have also opened and production would be expected to increase further as bait collection becomes less practiced due to the associated environmental impacts.

However, meeting the aspirations for the industry will require greater levels of investment in working capital and future developments are very dependent on site availability and environmental carrying capacity.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the aquaculture industry will need to manage further its activities. For example, GES descriptor 8 states that *...Concentrations of contaminants are at levels not giving rise to pollution effects*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.2 Coastal Defence

3.2.1 Key points

- Defences may involve hard structures (e.g. concrete seawalls), beach replenishment and soft engineering (i.e. managed realignment) to prevent or reduce flood risk and coastal erosion
- Approximately 44% of the England and Wales coastline is defended and 6% of the Scottish coastline
- Investments in coastal defence have doubled over the past ten years due to concerns over climate change impacts on the coast
- The investment in coastal defence in 2007 totalled £358 million while investment in beach replenishment in England and Wales in 2007/08 was £11 million
- Ancillary market values include £60 million (2007/08) for construction of defences in England and Wales
- Projections are that spending on coastal defences will need to double by 2080
- Although coastal defences may themselves have an impact on the marine environment, the social, economic and environmental benefits are considered to outweigh the environmental costs in most cases

i. Introduction

This sector includes coastal defence measures used to prevent or reduce flood risk and coastal erosion. Defences may involve hard structures (e.g. concrete seawalls), beach replenishment and soft engineering (i.e. managed realignment). The principal economic activity is therefore defined here as the direct use of the seabed to provide a substratum for construction. The economic value of defences in protecting terrestrial assets is considered as an additional economic, social and environmental benefit.

ii. How has the assessment been undertaken?

Information regarding coastal defences including location data, spending and employment was provided by the respective environment agencies in England and Wales (Environment Agency; EA), Northern Ireland (the Rivers Agency of the Department of Agriculture and Rural Development; DARD) and Scotland (Scottish Environment Protection Agency; SEPA).

iii. Current status of the coastal defence sector and past trends

Approximately 44% of the England and Wales coast is defended (Geological Society, 2001) and 6% of the Scottish Coast (Ritchie, 2001). The investment in coastal defence in 2007 was £358 million. The investment in beach replenishment in England and Wales in 2007/08 was £11 million. Ancillary market values include £60 million (2007/08) for construction of defences in England and Wales. No secondary values were calculated but a number of additional uses of coastal defences are identified. Data for Scotland and Northern Ireland are difficult to source as responsibility lies within several different departments and agencies.

The investment and hence activity within this sector in England and Wales has doubled over the past ten years. However, investment and employment figures alone do not capture the entire value to the economy of the activity, as there are significant indirect social and economic benefits that are difficult to quantify. While coastal defences may themselves have an impact on the environment, for example from construction, physical footprint, changes in

hydrography and coastal squeeze, all schemes are subject to detailed appraisal by the relevant regulatory agencies and the social, economic and environmental benefits are considered to outweigh the environmental costs in most cases.

iv. What is driving change?

The investment and hence activity within this sector in England and Wales has doubled over the past ten years due to the vulnerability of the coast to potential flooding and coastal erosion associated with climate change.

v. What are the uncertainties?

Information on spatial extent and investments is more readily available for England and Wales, due to central co-ordination of activities. In Scotland and Northern Ireland, responsibility for coastal protection is allocated across different agencies. This means that for these countries there was less information available to support this sector assessment.

vi. Forward look

Projections are that current spending on coastal defences will need to double by 2080. The use of managed realignment and other forms of soft coastal defence measures are likely to increase.

3.2.2 Introduction

This sector includes coastal defence measures used to prevent or reduce flood risk and coastal erosion. These take a variety of forms including the use of concrete seawalls, rock armour (rip-rap), the addition of materials to beaches (beach replenishment) and the use of soft defences (managed realignment). Coastal erosion is occurring along 17% of the UK coastline (30% of England's coastline, 23% Wales, 20% Northern Ireland, 12% Scotland) (MCCIP, 2008). Sea-level rise and the potential for increasingly severe storm events due to climate change will increase the economic importance of this sector.

3.2.2.1 Description of economic activities

The principal economic activity is related to the direct use of the seabed to provide a substratum for construction (Table 3.11). The easiest way of defining the economic value is as the value of the construction itself, i.e. the value of the coastal defence. The principal activity is supported by construction activities. Research and development activities are implemented to assess the effectiveness of defences.

3.2.2.2 Description of relevant ecosystem services

The construction of coastal defences also relies on various ecosystem services that support its productivity, including: the physical environment (on which to construct defences) and erosion-deposition cycles (of sediment – for beach replenishment).

3.2.2.3 Management

In England and Wales the Department for Environment, Food and Rural Affairs (Defra) has national policy responsibility for flood and coastal erosion risk management and provides funding in grant-in-aid to the Environment Agency, which also administers grant for capital projects to Local Authorities and Internal Drainage boards. The EA is the lead organisation for sea flooding risk management although Local Authorities remain the lead organisations for coastal erosion risk management.

In Scotland, the Flood Risk Management (Scotland) Act 2009 created new roles and responsibilities for flood risk management. These included placing Local Authorities,

Table 3.11 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Coastal Defence including beach replenishment	Construction (SIC 42.91) Research & Development	None identified	None identified

SEPA, Scottish Water, and Scottish Ministers under a new duty to act with a view to reduce overall flood risk and a duty to act with a view to achieving the objectives set out in flood risk management plans. Funding for flood prevention and coast protection is included in the local government finance settlement for 2008 to 2011. It is for the authorities to allocate the total financial resources available to it on the basis of local needs and priorities having first fulfilled its statutory obligations and its Single Outcome Agreement with the Scottish Government. Western Isles Council is the only authority which intends to take forward the construction of coast protection schemes in this period but Renfrewshire, Falkirk and North Ayrshire Councils have schemes addressing coastal flooding under construction. The Scottish Government through the Scottish Flood Defence Asset Database (SFDAD) provides some information on fluvial and coastal flood prevention schemes installed since 1961 (Scottish Executive, 2007b).

In Northern Ireland, responsibility for dealing with coastal erosion lies with several departments. This means that information on distribution, expenditure and employment is not centrally collected for this sector. Coastal defences that reduce the risk of flooding on extensive areas of farmland, residential or commercial areas is the responsibility of the Rivers Agency of DARD. The Rivers Agency maintains 26 km of sea defences to avoid the flooding of low-lying coastal lands. Where infrastructure is vulnerable to coastal erosion the relevant authority is responsible for maintaining defences, for example defences that protect roads are the responsibility of the Roads Service. Otherwise individual landowners are responsible for their own coastline (DOENI, 2006).

3.2.3 Direct use value

3.2.3.1 Principal activities

Coastal defence

Approximately 44% of the England and Wales coast is defended (Geological Society, 2001) and 6% of the Scottish Coast (Ritchie, 2001). In 2007, central and local government expenditure on flooding and coastal erosion in England and Wales was £600 million. Pugh (2008) assumed that half of the UK Government investment in flood defences was directly marine related and then scaled this up by a factor of 10% to include works in Scotland and Northern Ireland. This gives a total sum of £357.5 million for the UK for 2007.

The number of licences issued can also provide an indicator of activity. Between 2005 and 2009, 30 FEPA (Food and Environment Protection Act) licences were issued for England and Wales, for coast protection schemes (source: Centre for Environment, Fisheries and Aquatic Science; Cefas). An additional 19 licences were issued for scour protection and 15 licences were issued relating to sea and flood defence. From 2005 to 2009 17 Scottish FEPA licences were issued relating to coastal protection (source: Fisheries Research Services; FRS). In Northern Ireland 3

licences were issued between 2007 and 2009 for projects including sea defences and breakwaters. This works out at approximately 18 licences per year for the whole of the UK.

Beach replenishment

In 2007/08 the EA spent £11.1 million on beach recharge schemes (excluding staff costs) (Environment Agency, 2008a). In 2007, around 2.09 million tonnes of landed UK marine aggregates were used for contract fill activity and beach replenishment (Pugh, 2008). The regional values of this are discussed in Section 3.8 (Mineral Extraction).

Between 2005 and 2009 in England and Wales 75 FEPA licences were issued for beach nourishment schemes.

3.2.3.2 Ancillary activities

Construction

Expenditure on capital coastal defence works is given in Table 3.12, although these activities cannot all be allocated to a purely marine component. These are funded through Grant in Aid supplied by Defra. These figures refer to coastal works only, not tidal and are for capital construction work only. They do not therefore include maintenance work or studies. These estimates are based on forecasts at mid-year. In addition, a further £10 million of staff costs relating to Capital Works Expensed in Year (CWEIY) projects are not included in the analysis by the EA as they cannot be related to specific projects. CWEIY projects are categorised as follows:

- Repair and refurbishment – carrying out works to ensure the condition of the flood defences are retained in the appropriate condition and repaired and restored to that condition as necessary
- Rock groynes and sea walls – defences built as part of sea and coastal defences and often used in conjunction with beach recharge activity to prevent sea flooding. Normally the responsibility for maintenance resides with the local authority
- Flood risk management strategies – strategies developed to provide long-term flood risk options to cover a large area
- Beach recharge – sand and shingle replacement on beaches to maintain the integrity of a sea defence
- Flood mapping – the development of multi-layered maps to provide information on flooding from rivers and the sea for England and Wales

If it is assumed (as above for the value of Principal Activities) that half of the capital works related to flood defences (see note in Table 3.12) are marine, then the total for England and Wales for 2007/08 is approximately £60 million.

Research and development.

Defra and the Environment Agency have a Joint Flood & Coastal Erosion Risk Management & Research Development Programme, and between 2007 and 2008 this programme spent nearly £4.1 million on research related to flooding and coastal defence (Defra and EA, 2008).

The Scottish Government, Scottish Natural Heritage (SNH) and SEPA fund research to improve flood and coastal erosion risk management but spending related specifically to the coastal zone is indistinguishable from that concerned with flooding inland. A Scottish Government report published in 2007 identified 26 000 properties at risk from coastal flooding (Scottish Executive, 2007a). The Scottish Government is supporting research into coastal

Table 3.12 Actual expenditure on Capital Works Expensed in Year (CWEIY) 2006/07 and 2007/08. Source: Environment Agency (2007).

Capital works	*2006/07, £ million*	*2007/08, £ million*
Repair and refurbishment [a]	56.0	33.3
Rock groynes and sea walls	18.8	21.1
Flood risk management strategies [a]	15.8	15.6
Beach recharge	17.0	11.0
Flood mapping [a]	7.0	6.2
Total	**114.6**	**87.2**

[a] Not specifically marine.

flooding and erosion issues in the Western Isles and Angus. In collaboration with the Scotland & Northern Ireland Forum for Environmental Research (SNIFFER), SEPA and SNH, a report on coastal flooding in Scotland was published in September 2008, which will inform the future research agenda (SNIFFER, 2008).

Other sources of research funding include The National Trust which commissioned a report which examined how climate change was likely to affect its properties (National Trust, 2005). The National Trust owns nearly 10% of the UK coastline (England, Wales, Scotland, Northern Ireland).

3.2.4 Regional distribution of value

3.2.4.1 Coastal defences

Coastal defences are generally located in or adjacent to intertidal areas and therefore their extent is limited to a narrow margin around the UK coastline. The demand for coastal defences is not uniform around the UK: England proportionally has the greatest amount of coast at risk from erosion.

The rise in sea level relative to the land will be greater than the global average in southern and eastern England because the land is sinking. Around the Scottish coastline this increase in global sea-level rise is offset in some areas by the isostatic rise in the Scottish landmass, which has continued since the melting of the ice sheets at the end of the last ice age (Dawson et al., 2001). Long-term tide gauge measurements at Aberdeen show a rising trend over the last 100 years of around 0.7 mm/year (MCCIP, 2008). In contrast, a tide gauge in Lerwick (Shetland Islands) has recorded a fall in relative sea level since 1957 (Baxter et al., 2008).

In Scotland, between 1969 and 1981, the Department of Geography at Aberdeen University mapped and described all 647 sandy beaches over 100 m in length. Of these, around 40% of beaches were found to be eroding, 22% were stable, 11% were advancing, 8% showed evidence of both advance and retreat and 9% were protected or backed by some other stable feature such as rocks.

Predicted global sea-level rise and a possible increased risk of storm surges are likely to place increased pressure on coastal infrastructure and habitats in the future through coastal squeeze (Kindleysides et al., 2003). The loss of saltmarsh and mudflat now totals over 100 hectares a year in Britain (Pilcher and Burston, 2002). Shoreline Management Plans (SMPs) provide a large-scale assessment of the risks associated with coastal processes and present a long-term policy framework to reduce these risks.

Data supplied by the Environment Agency give an indication of the forecast expenditure on capital works in 2008/09 around different coastal regions of England (Table 3.13). Less information is available for expenditure in Northern Ireland and Scotland. Ritchie (2001)

Table 3.13 Forecast expenditure on significant capital works in 2008/09 among English coastal regions.

Coastal region	*Expenditure, £ thousand*
Anglian	30 888
Midlands	0
North East	1 091
North West	21 937
South West	16 768
Southern	14 210
Thames	0
Total	**84 894**

found that 6% of the Scottish mainland coastline (307 km) was defended. The Scottish Flood Defence Asset Database shows that approximately 19 flood protection schemes are coastal, and the average costs of each flood defence work, at present day values, was estimated at £2.1 million (Scottish Executive, 2007b).

In some areas decisions will need to be made either to use coastal defences or to allow erosion to continue. Some habitats will require protection to preserve interest but the issues are complex so decisions must be made on a case-by-case basis (Lee, 2001). Within the Jurassic Coast World Heritage Site (East Devon and Dorset), for example, there are large areas that may be subject to sudden mass movements, such as when part of the Black Venn landslip failed in 2008. Part of the scientific interest in this site lies in the study of erosional processes that also expose new layers of fossiliferous strata. The towns along the stretch of coast are not part of the World Heritage Site however and require protection that has regard for the management of the scientific interest in the adjacent sites. Cooper and McKenna (2008) point out that erosion is a valuable natural process occurring in coastal ecosystems, that is important for the functioning of the ecosystem, and that it is only in relation to threats to coastal settlements that it appears undesirable. Coastal defences that affect this normal functioning have numerous impacts on local and adjacent habitats.

Summary of regional distribution and value

The total value of coastal defences was estimated at about £357.5 million. Data on coastal defences were not available for Scotland and Northern Ireland so this value was allocated to CP2 Regions based on the proportion of coastal defences that are located in each Region (see Table 3.14 and Figure 3.4).

3.2.4.2 Beach replenishment

Over the past ten years, beach replenishment schemes have mainly been located on the Lincolnshire and north Norfolk coasts, which are most at risk from erosion. Other schemes have taken place in Northumberland (Newbiggin-by-the-Sea), East Anglia (Suffolk and Essex) and at various sites along the south coast. In most cases, beach replenishment material will be sourced from existing permitted licence areas for marine aggregate extraction. However, on occasion, schemes may take advantage of the availability of maintenance or capital dredgings to replenish shores opportunistically. In this case replenishment is a route to dispose of the waste arising from maintenance dredging beneficially (see Section 3.16: Waste Disposal). According to the British Marine Aggregate Producers Association (BMAPA) there are no regular landings of marine aggregate in Scotland or Northern Ireland. However, several beaches in Scotland have been replenished including Portobello and the beach adjacent to the GlaxoSmithKline plant at Montrose. A beach replenishment scheme carried out in Scotland,

Table 3.14 Regional distribution of coastal defence.

CP2 Region	*Coastal defence length, km*[a]	*Coastal defences, % of total length*	*Flood defences total length, km*[b]	*Flood defences, % of total length*	*Estimated value based on coastal defences, £ million*
1	34.1	8.2	27.7	1.3	29.3
2	131.0	31.6	691.2	33.4	113.0
3	64.7	15.6	251.7	12.2	55.8
4	53.6	12.9	852.1	41.2	46.1
5	129.9	31.3	244.7	11.8	111.9
6	0.8	0.2	No data	-	0.7
7	0.7	0.2	No data	-	0.7
8	0	0	No data	-	0
Total	**414.85**		**2067.4**		**357.5**

[a] Seazone (UK); [b] Environment Agency (England and Wales).

at Aberdeen in 2006, utilised maintenance dredgings from Montrose Harbour. The amount of marine aggregates used regionally for beach recharge material is given in Table 3.15 while the value is discussed in Section 3.8 (Mineral Extraction).

3.2.5 Trends

From 1996 to 2007 central and local government expenditure on flood and coastal erosion risk management has doubled in cash terms. A recent report estimates that spending on coastal defences will need to double again to £1 billion by the year 2035 just to maintain current standards of flood protection in England (Environment Agency, 2009).

Beach nourishment schemes may cost more in the long-term than the use of hard coastal defences, as they need to be maintained through the addition of new material every few years (Speybroek et al., 2006).

Table 3.15 Summary of regional landing statistics for marine dredged secondary aggregates used for beach nourishment and contract fill for 2007. Source: The Crown Estate (2008a).

CP2 Region	*Location*	*Tonnage*
2	Skegness	887 057
2	Newbiggin-by-the-Sea	412 500
2	Pevensey Bay	33 816
3	Bournemouth	765 141
Total		**2098 514**

Figure 3.4 Location of coastal defences.

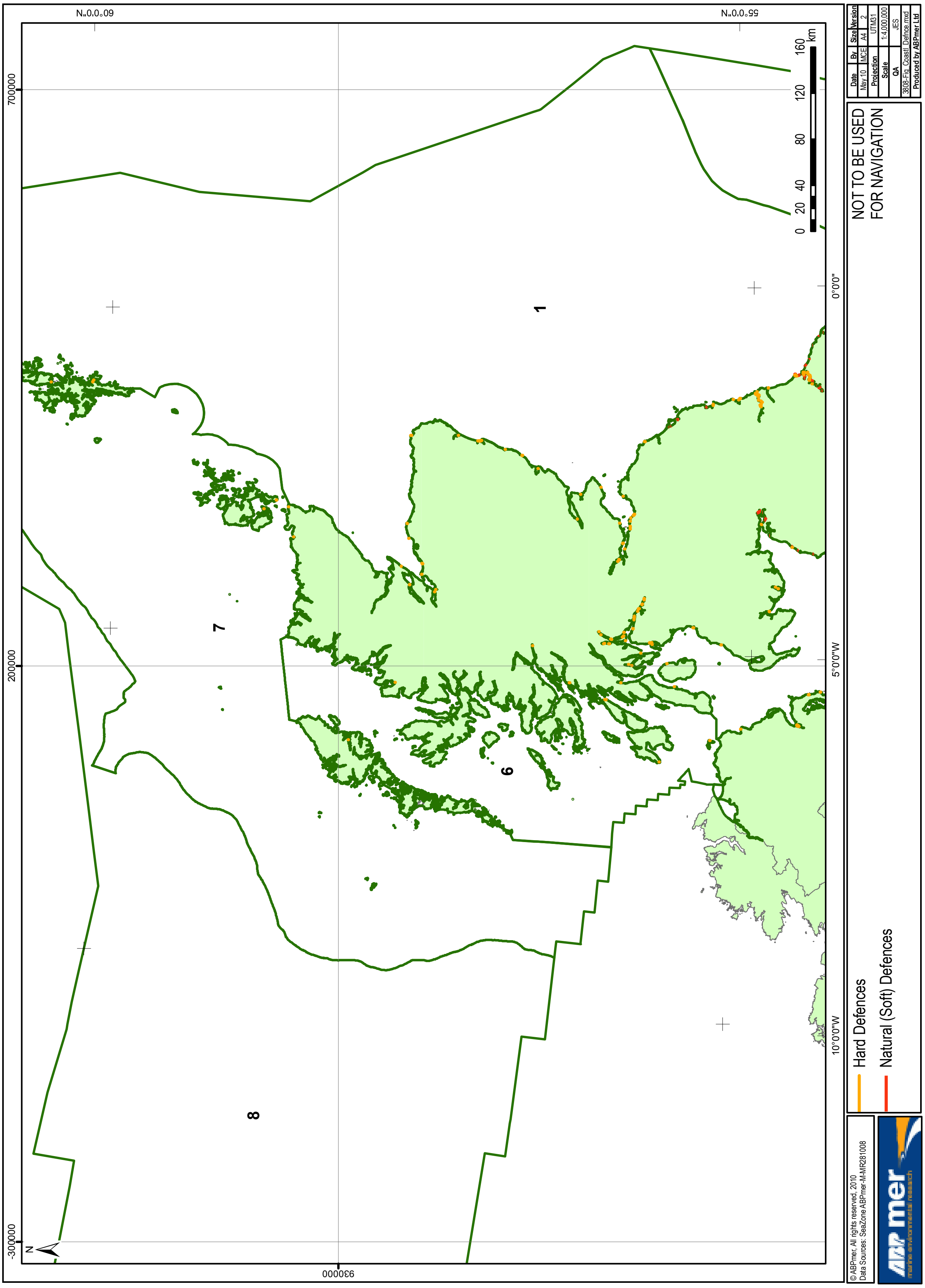
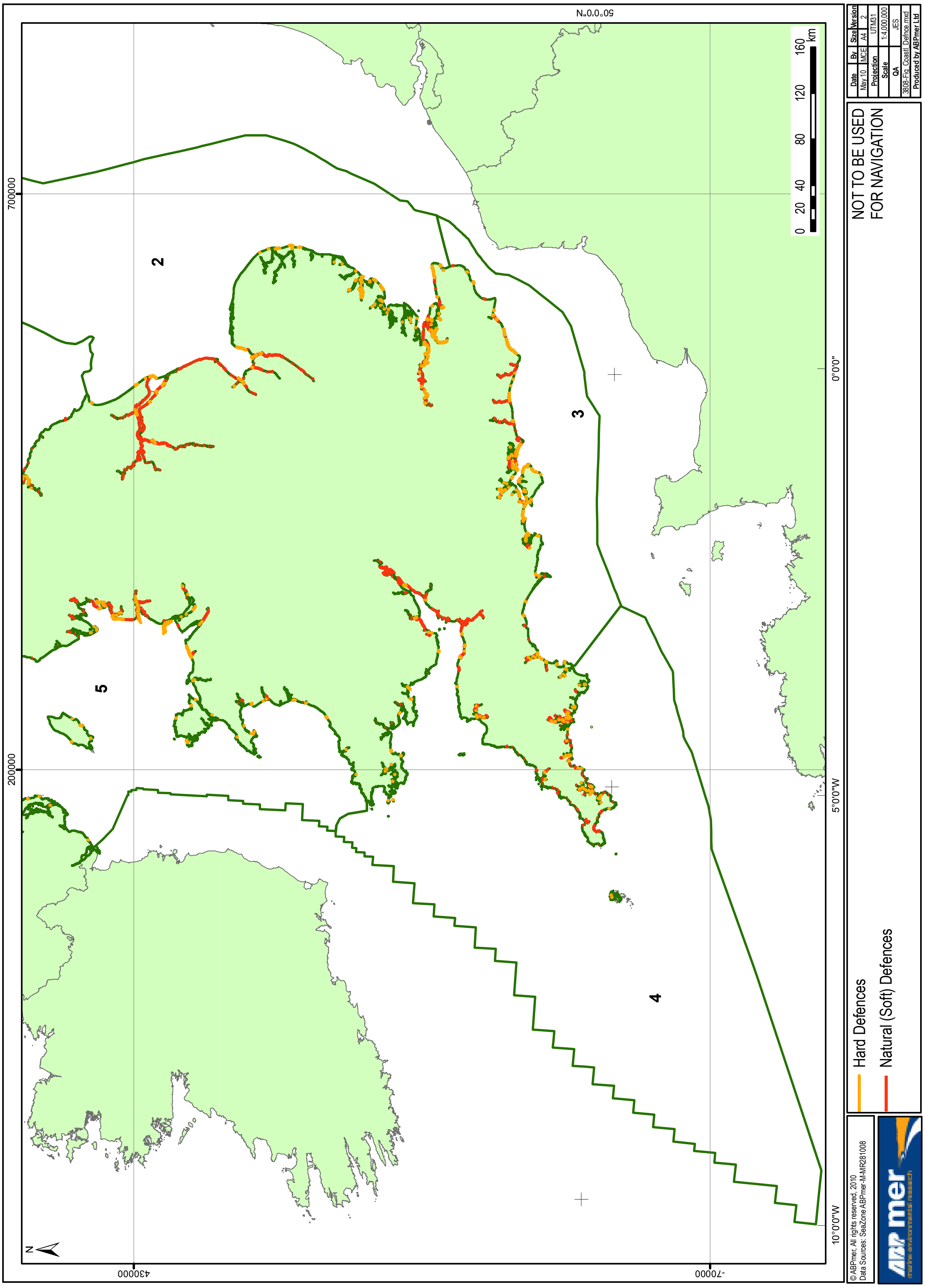


Figure 3.4 continued



3.2.6 Socio-economic pressures and impacts (positive and negative)

3.2.6.1 Coastal defences

The protection of property by preventing erosion and also by providing flood protection conserves economic value and provides local residents with reassurance. In Scotland, where a higher proportion of the population lives close to the coastline, the indirect value of protecting properties from the sea is immense (SCF, 2004). However there are concerns about the long-term sustainability of development in coastal flood plains. Increasingly policy seeks to address this by limiting coastal development to those activities dependent on a coastal location.

Another social benefit from coastal defence schemes is the provision of employment, in associated industries such as construction, marine aggregate dredging and environmental consultancy and advice. A report commissioned by Defra (2006a), on coastal defence work in Local Authorities estimated that in England 62 FTE (full-time equivalent) engineering staff were engaged on capital schemes and 89 FTE engineering staff were employed on work related to operations and licensing. Within the Environment Agency 40% of staff are estimated to work on flood defence work although this figure also includes those working on in-land defences. Due to the lack of centrally available data and commissioned reports, similar figures are not available for Scotland, Northern Ireland and Wales.

Coastal defences may protect or increase local tourist trade by conserving or enhancing amenity values. However, some case studies have shown that defences can reduce amenity value. For example, coastal defences in Italy were colonised by extensive beds of mussels and green ephemeral algae. The growth of the green algae was a major problem for local beach tourism, as they washed up on the shore after storms. The beach had to be cleaned and the amenity value of the beach was reduced (Airoldi et al., 2005).

Transport of material may pose problems, for example, transporting large loads of rocks by lorries may impact tourist trade and cause congestion. In some places these impacts have been mitigated, such as in West Somerset by using rail transport to reduce road haulage. This scheme also reused material from old defences to reduce the need to excavate and move material which reduced the carbon footprint of the defences (Brampton et al., 2007).

3.2.6.2 Beach replenishment

Beach replenishment can protect the coastline from erosion, including the reduction of storm damage. Compared to other ‘hard’ forms of coastal defence beach nourishment may be seen as a ‘softer’ option with fewer adverse ecological consequences (Speybroek et al., 2006). By maintaining beaches, nourishment schemes can protect or increase local tourist trade by conserving or enhancing amenity values.

Beach replenishment supports employment, including associated industries such as marine aggregate dredging and environmental consultancy and advice. Material can be deposited from vessels by ‘rainbowing’ or using a pipeline to pump material on to the shore. These methods reduce transport and traffic issues. Alternately material may be trucked on to the shore and may require mechanical spreading.

One drawback may be that by mitigating and/or preventing erosion, replenishment schemes may encourage coastal development with associated environmental impacts.

Case Study 1 provides a description of managed realignment, a measure often undertaken as a compensatory measure for coastal works, which may provide additional 'soft' flood and coastal defence benefits.

3.2.7 Environmental pressures and impacts (positive and negative)

Major environmental pressures and impacts associated with coastal defence and beach replenishment are shown in Tables 3.16 and 3.17. The ecosystem services that these pressures impact on and their significance are identified in Table 3.18.

The environmental impacts of beach replenishment partly relate to the removal of material from the marine environment (aggregate dredging), the impacts of this sector are outlined in Section 3.8 (Mineral Extraction). Before re-depositing the material, it must be analysed to ensure that it is suitable for the beaches on which it is to be used and that it is a close match to existing materials. Material from maintenance dredging of ports etc. is tested for chemical contamination to reduce unintended environmental damage.

3.2.8 Climate change

3.2.8.1 Impacts of climate change on coastal defence activities

Currently the UK is estimated to have around 2400 km of artificially protected coast, the longest in Europe (Eurosion, 2004). Increases in sea level along with changes in the wave regime are likely to lead to increased coastal erosion. In addition changes in patterns of rainfall and storm surge could lead to increases in coastal flooding. A response to these threats, where realignment is not feasible or economically viable could be an increase in the construction and the upgrading of coastal defences. Coastal defence construction can either be a hard defence such as groynes or walls, or soft defence such as beach recharge or re-nourishment where appropriate. One impact of this will be an increase in demand for aggregates and timber for construction. Coastal defences and structures currently being constructed allow for climate change within the design through guidelines issued by Defra (2006b).

It has been calculated that in terms of economic losses in the future the potential effects of coastal erosion on its own are minor compared to flooding and represent only 2% to 6% of total potential losses (Halcrow, 2001; Hall et al., 2006). However, coastal erosion in the context of other coastal issues and the viability of property and infrastructure on eroding coastlines still merits serious attention (Hall et al., 2006).

Figures are only available for river and coastal combined and are not available exclusively for the coastal zone. Engineering to address future flood risk could amount to between £22 and £75 billion by the 2080s depending on the scenario. As an example, in 20 years time the annual cost of flood and coastal defences would need to be between £700 million and £1.1 billion per year (Defra, 2004a). It is important to remember that the costs are for flooding on both rivers and the coast.

An assessment of coastal erosion defence costs was undertaken by Defra (2004b) and showed that the cost of maintaining all defences at the current standard amounted to £2.9 billion over the next 100 years at present value. Areas under the greatest threat from future erosion will be along major estuaries and the east coast (Foresight, 2004). Present levels of expenditure on coastal defence will not keep pace with

Case Study 1:
Managed realignment as a soft coastal defence measure

Managed realignment (MR) and regulated tidal exchange (RTE) schemes are the two key methods that are used for creating coastal intertidal habitats on existing, and usually reclaimed, land that lies within the flood plain. They are often undertaken with habitat creation as one of their primary aims and often as specific compensation measures that are required under the EU Habitats Directive to offset losses of equivalent, and internationally designated, habitats that have occurred as a consequence of separate plans or projects. In almost all cases, they are also designed to perform an important coastal flood defence function and to provide a mechanism for adapting to sea-level rise. Indeed, the sites selected for such schemes are usually identified through Shoreline Management Planning or other strategic coastal protection initiatives (e.g. Coast Habitat Management Plans, Estuary Flood Management Strategies).

The term 'managed realignment' is most commonly understood to involve a deliberate breaching, or removal, of existing seawalls, embankments or dykes in order to allow the waters of adjacent coasts, estuaries or rivers to inundate the land behind (e.g. Leggett et al., 2004; Environment Agency, 2007). In most instances the newly flooded land is low-lying coastal flood plain and therefore a new seawall is needed to clearly define the inundated area and protect the hinterland behind. However, on areas with rising ground either no new line of defences or only a partial counterwall is required. In contrast to MR, RTE encompasses a range of techniques for intertidal habitat creation other than full breaching of the existing seawall, whereby the seawall remains in situ. These include the use of sluice gates, weirs or pipes to control regular tidal inundation (e.g. Sharpe et al., 2002). It is distinct from MR because a high degree of control is retained in terms of the rate of water exchange with the adjacent tidal waters, with the tidal range then becoming restricted within the site and the old defence line tending to require continued maintenance. At some sites (e.g. Abbotts Hall, Essex) an RTE scheme can be adopted as a precursor to a MR project.

Although these sites can have, and should have multiple objectives wherever possible, habitat creation and coastal protection remain the principle drivers. The coastal defence function that these schemes provide includes:

- Improving the quality of the defences locally. These projects are often undertaken at locations where there is a weakened defence and a risk of unmanaged flooding and therefore the new counterwall that is built provides a greater level of coastal defence protection than the wall it replaces.
- Providing accommodation space for tidal waters and thus offsetting the effects of marine transgression and coastal squeeze and, in so doing, enhancing the long-term sustainability of estuary and coastal environments.
- Acting as a storage area for tidal waters especially on bigger spring tides and especially on storm surges to alleviate flood risk at adjacent and upstream locations. RTEs are particularly useful for trapping, and then slowly releasing, large volumes of water in this manner. However, large, and appropriately located, MRs such as at Alkborough on the Humber Estuary also act to reduce tidal heights in upstream areas by diverting large water volumes.

Since they were first implemented in Europe in the late 1980s, some 91 MR and RTE schemes have been undertaken across North-West Europe employing a variety of techniques and creating a range of habitats. Of these, there have been 30 MR and 11 RTE schemes in the UK alone. The first MR in the UK occurred at Northey Island (Blackwater Estuary) in 1989 but it was not until the mid-1990s that the next schemes were implemented (e.g. Orplands, Tollesbury). The lessons learned from these early projects and those that succeeded them have provided coastal managers with increasing confidence about the effectiveness of such measures. These projects have also been useful for communicating the rationale and benefits of such schemes to the general public and, as a consequence of this learning process, steady improvements have been made in the quality and quantity of MR and RTE schemes.

The pattern across North-West Europe as a whole is that such schemes have often evolved from *ad hoc* initiatives, to a new generation of sophisticated projects which are meticulously planned, consulted on and monitored. They have also increased in size so that while less than 500 hectares had been created in the UK by 2005, three large schemes undertaken in 2006 (at Alkborough, Wallasea and Chowder Ness) had increased this to around 1000 hectares in a single year, and by early 2009 a total of 1250 hectares had been created.

MRs are also increasingly being seen as a mechanism for delivering multiple functions beyond their core habitat creation and flood project objectives by, for example, providing recreational, fisheries and nutrient/carbon processing benefits. Further details on these schemes can be found in the ABPmer online database which collates case-specific information on MR and RTE projects across Northern European.

A wide range of factors need to be considered to determine the potential suitability of a site for MR, including its possible effects on the wider coastal or estuarine environment/ system. The past decade has seen the publication of many peer-reviewed articles focussing on individual or small sets of parameters. Cooper (2003) stated that the design of a successful MR scheme depends largely upon the creation of appropriate physical conditions and morphological responses within the scheme and adjacent natural environment.

Table 3.16 Key environmental pressures and impacts associated with coastal defence. Based on: Airoldi et al. (2005); Moschella et al. (2005); Cooper and Pontee (2006); Moreira et al. (2006).

Pressure	**Physical presence of structure**
Impact	Coastal defences can have significant impacts on habitats, including loss, reduction and replacement by other types of habitats.
Description of environmental change (intensity, spatial extent, frequency, duration)	Barrier defences such as seawalls prevent landward transgression of intertidal habitats in response to sea level rise. This may result in changes to intertidal habitats and a narrowing of intertidal zones. This loss of habitat is referred to as 'coastal squeeze'. Ultimately this may lead to the complete loss of a beach (Pilkey and Dixon, 1996).
Existing management measures	Shoreline Management Plans (SMPs) guide management in England and Wales. The EA is committed to offsetting impacts of coastal squeeze through its habitat creation programme. Some Scottish Local Authorities have developed SMPs as a management tool.

Pressure	**Hydrographic change from the presence of the structures**
Impact	Increased erosion.
Description of environmental change (intensity, spatial extent, frequency, duration)	Reduction of wave energy may alter depositional processes and lead to changes in the characteristics of soft-bottom sediments including changes in grain size, organic matter content and Redox conditions. If water flow through structures is much reduced, habitat on the landward side may be severely modified because of the creation of sheltered conditions which will favour deposition of fine and organically enriched sediments. This will alter the structure of the biological assemblage through changes in composition and/or abundance (Airoldi et al., 2005). The change in sedimentation pattern may lead to erosion/ sedimentation processes in adjacent areas. Erosion prevention may reduce the amount of sedimentary material entering the system and reduce accretion in nearby shores so that these habitats erode over time. Coastal defences may also lead to accelerated erosion of the inter-tidal area in front of the defences (Cooper and Pontee, 2006). Almost two-thirds of the intertidal profiles in England and Wales have steepened over the past 100 years, this is particularly prevalent on coasts protected by hard engineering structures (46% of England's coastline, 28% of Wales, 20% Northern Ireland and 7% Scotland).
Existing management measures	Design of coastal defences takes account of their effect on natural processes. The potential for such impacts is carefully assessed as part of any environmental impact analysis (EIA). Negative impacts of schemes are offset through EA's habitat creation programme.

Pressure	**Introduction of noise and visual cues**
Impact	Disturbance and changes to behaviour.
Description of environmental change (intensity, spatial extent, frequency, duration)	Noise related to construction activities has the potential to cause some disturbance to birds and fish. Sensitivity to noise is species dependent (Nedwell et al., 2003).
Existing management measures	Construction impacts are managed where necessary. Works can be timed to avoid key feeding or migratory periods. Most likely impacts are to birds and fish. Impacts to marine mammals are unlikely except at seal haul out sites.

Pressure	**Footprint of structure**
Impact	Hard coastal defences fragment and replace sedimentary habitats. This leads to habitat changes (loss and introduction of new habitat) and species level pressures.
Description of environmental change (intensity, spatial extent, frequency, duration)	Although they provide a new, artificial surface for epibiota, studies have found that hard coastal defences such as seawalls are not equivalent to natural rocky habitats. Epibiotic assemblages on artificial structures have been found to be less diverse and less abundant than those on nearby natural surfaces (Moschella et al., 2005). A study of natural rocky shores and artificial seawalls found that organisms present at similar densities did not perform in the same way, so that artificial substrates may not provide a good replacement for natural habitats (Moreira et al., 2006).
Existing management measures	Consideration is given to material types as part of scheme design. Increasing concentration on soft-engineering schemes where these can be effective.

Pressure	**Footprint of structure**
Impact	Species level pressures: Barriers to movement.
Description of environmental change (intensity, spatial extent, frequency, duration)	Studies have shown that costal defence structures can affect regional species diversity. Removal of isolating barriers favours the spread of non-native species (Airoldi et al. 2005).
Existing management measures	Under the requirements of the EU Water Framework Directive measures to improve connectivity may be put in place where appropriate.

future coastal erosion resulting in around one third of coastal defences being destroyed in the coming decades (Foresight, 2004).

It has been reported that almost two-thirds of intertidal profiles in England and Wales have steepened over the past hundred years and that this trend is particularly apparent on coastlines protected by hard defences and structures (MCCIP, 2008). This steepening is expected to increase in the future due to the sea level rise and changes to the wave conditions (Masselink and Russell, 2008).

Adaptation measures

Coastal and flood defences are, in themselves, an adaptation to climate change impacts. However, there is scope for improvement in design to increase the durability of constructions. In addition, managed realignment (see Case Study 1) is increasingly being taken up as a soft flood and coastal defence option.

3.2.8.2 Impacts of coastal defence activities on climate change

The construction and raw materials will have an impact on carbon dioxide (CO_2) emissions although this cannot be quantified at the present time. However, a study by Defra is underway entitled: *Understanding the Impact of Flood and Coastal Erosion Risk Management on the causes of Climate Change* which aims to determine the impacts of coastal defence on climate change.

Mitigation measures

Mitigation measures include sourcing of sustainable, low carbon materials and use of renewable or low carbon energy sources during construction and manufacture.

Table 3.17 Key environmental pressures and impacts associated with beach replenishment. Based on: Menn et al. (2003); Nedwell et al. (2003); Speybroek et al. (2006).

Pressure	**Beach replenishment/ nourishment to mitigate erosion**
Impact	Habitat changes.
Description of environmental change (intensity, spatial extent, frequency, duration)	Removal of material will cause impacts on the seabed (see Section 3.8: Mineral Extraction, Table 3.60 for details). Habitat changes can result where the composition of the deposited material is different from normal beach material. If the material is shelly it may prevent wind erosion on the beach, which is important for maintaining dunes. Changes in sediment characteristics can alter infaunal assemblages by altering suitability for burrowing species, food supply (including to shorebirds, by altering penetrability). Coarser material may slow down vegetation successions enhancing habitat value for nesting shore birds. Nourishment can result in changes in beach morphology. The replenishment material may contain contaminants such as heavy metals, organotins and persistent organic pollutants. Rainbow spraying can increase the chance of an elevated flux of salt towards coastal dunes and this can damage vegetation. This method of beach replenishment occurs very rarely as it is dependent on fine wet sediments such as silts. Most techniques for coarser sands involve pumping material ashore.
Existing management measures	Requirement to ensure that material is a close match. Testing of sediment contamination. Timing of application can limit impacts on organisms. Winter can mitigate impacts on benthos and birds.

Pressure	**Beach replenishment/ nourishment to mitigate erosion**
Impact	Change in beach profile leading to hydrographic changes.
Description of environmental change (intensity, spatial extent, frequency, duration)	Likely to result in only very minor changes to local hydrodynamic regime.
Existing management measures	Potential effects on coastal processes are evaluated as part of an EIA and mitigation measures introduced if necessary.

Pressure	**Introduction of noise and visual cues**
Impact	Noise and visual disturbance.
Description of environmental change (intensity, spatial extent, frequency, duration)	Noise and sediment addition may cause disturbance to foraging birds. Noise generated by shipping of fill material is likely to cause some minor disturbance to fish (Nedwell et al., 2003).
Existing management measures	Seasonal restrictions can avoid sensitive periods for birds and fish where necessary.

Pressure	**Footprint of structure**
Impact	Species level pressures
Description of environmental change (intensity, spatial extent, frequency, duration)	The application of a layer of sediment will smother organisms on application. If application results in the erosion of fines (fine particles) the increased turbidity can alter primary productivity within subtidal areas and alter visual predation rates. Nourished beaches have less diverse assemblages than natural beaches (Speybroek et al., 2006) with reductions in dominant macroinvertebrate species (Menn et al., 2003). Alteration of prey availability can result in decreased shorebird populations.
Existing management measures	Changes in invertebrate populations occur in response to natural conditions, such as storm events, and these may be more severe than the changes caused by nourishment (Menn et al., 2003).

Table 3.18 Environmental pressures on ecosystem services associated with coastal defence.

Ecosystem service	*Significance of impact*	*Confidence in understanding the relationship = information gaps*
Erosion-deposition cycles (of sediment)	**Low – Moderate**. Coastal defence activities can work counter to sediment processes, intensity of pressure dependent on extent of interventions, but relates to a subset of marine sediment movements (e.g. in the North Sea).	**Low**. Can be difficult to distinguish from impacts of other marine sedimentation processes on coast.
Biological productivity (supporting service)	**Moderate**. Inter-tidal habitats provide nutrient cycling and fish nursery functions, extensive areas of inter-tidal habitat have been lost from the UK coastline, and loss is continuing due to coastal squeeze.	**Moderate**. Impacts dependent on sediment types and other biological cycles, which can vary between different coastal environments.
Biodiversity provision	**High**. Impacts on inter-tidal habitat are a significant factor in the conservation of a range of species and habitats. The UK Biodiversity Action Plan (www.ukbap.org.uk/UKPlans.aspx?ID=33) identifies that *...saltmarshes are being 'squeezed' between an eroding seaward edge and fixed flood defence walls. This is most pronounced in south-east England, where, for example, it is estimated that 20% of the saltmarsh resource in Kent and Essex was lost between 1973 and 1988. The best available information suggests that saltmarshes in the UK are being lost to erosion at a rate of 100 ha a year.*	**High**. Biodiversity impacts in inter-tidal habitats are monitored and subject to detailed management plans.
Cultural values	**Low – Moderate**. Coastal defence activity can dominate coastal landscape. Coastal defence is one significant factor in loss of inter-tidal landscapes. However, evidence that this is significant in cultural terms is very difficult to assess.	**Low**. Variable and subjective

3.2.8.3 Summary

Table 3.19 summarises the climate change pressures and impacts discussed in this section and indicates the likely significance of the impacts, the level of confidence in the assessment and measures that might be employed to manage the impacts (see Annex 1 for a discussion of the assessment methodology).

3.2.9 Industry stability and sustainability

3.2.9.1 Objectives, targets and indicators

Defra has set out its strategy for managing flood and coastal erosion risk in England (Defra, 2004a). The overall aims of the strategy are:

- To manage the risks from flooding and coastal erosion by employing an integrated portfolio of approaches which reflect both national and local priorities, so as:
  - to reduce the threat to people and their property
  - to deliver the greatest environmental, social and economic benefit, consistent with the Government's sustainable development principles

Table 3.19 Summary of climate change implications

Climate change pressure	*Impacts of climate change on Coastal Defence*	*Confidence/ significance*	*Adaptation measures*
Increase in sea level	Overtopping of existing coastal and flood defences	High confidence / high significance	Some defences may need to be increased in height. Use of MR
Possible increase in stormy conditions	Overtopping of existing coastal defences during storm events	High confidence / high significance	Some defences may need to be increased in height. Use of MR
	Erosion of coastal defences	High confidence / medium significance	Coastal defences will need to be strengthened to prevent erosion

Impacts of Coastal Defence on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
Although not yet quantified, the construction and raw materials will have an impact on CO_2 emissions	CO_2 emissions	Low confidence / unknown significance (work underway)	Sourcing of sustainable, low carbon materials and use of renewable or low carbon energy sources during construction and manufacture

- To secure efficient and reliable funding mechanisms that deliver the levels of investment required to achieve the vision of this strategy.

In Scotland, the Scottish Government consulted on its flood risk management strategy in 2008 (Scottish Government, 2008a) linked to the Flood Risk Management (Scotland) Bill which was introduced to the Scottish Parliament in September 2008 and will establish a framework within which sustainable flood risk management, including the management of coastal flooding, will operate more effectively. The Flooding Issues Advisory Committee (FIAC) has proposed the following overall objective of sustainable flood management in Scotland:

- Meet needs for flood resilience.

And that to meet this overall objective it must be integrated with four further objectives:

- A social objective to enhance community benefit with fair access for everyone
- An environmental objective to protect and work with the environment, with respect for all species, habitats, landscapes and built heritage
- An economic objective to deliver resilience at affordable cost with fair economic outcomes
- A future generation's objective to allow for future adaptability, with a fair balance between meeting present needs and those of future generations.

Planning Policy Statement 25 (*Development and Flood Risk*) contains further detailed policies in relation to flood risk. Equivalent provisions are contained in Scottish Planning Policy 7 *Planning and Flooding* and National Planning Policy Guidance 13 *Coastal Planning* (both Scotland),

Technical Advice Note 15 *Development and Flood Risk* (Wales) and Planning Policy Statement 15 *Planning and Flood Risk* (Northern Ireland).

In April 2005, Defra issued six high level targets for Operating Authorities who included the Environment Agency, Internal Drainage Boards, Local Authorities and Maritime Local Authorities, all being responsible for providing coastal defence. The high level targets are primarily focused on measures of activity, although some of the biodiversity targets relate to outcomes.

1. Maintain current and publicly available Policy Delivery Statements and update as necessary.
2. Record relevant information on the National Flood and Coastal Defence Database (NFCDD).
3. Produce second generation Shoreline Management Plans in accordance with revised Defra guidance by March 2010.
4. Ensure the maintenance of biodiversity through a range of sub-targets, for example, to ensure no net loss to habitats covered by Biodiversity Action Plans and seek opportunities for environmental enhancements.
5. Assess developments in areas at risk of flooding and coastal erosion.
6. Report to Defra on progress in implementing previously issued guidance on Internal Drainage Board (IDB) amalgamations, consortia and membership.

As part of its strategy for managing flood and coastal erosion risk in England, Defra (2004a) developed nine outcome measures for flood and coastal erosion risk management in England. Measures relate to issues such as:

- Overall benefits – this will show the benefits of flood and coastal erosion risk management activities in monetary terms. Where possible, aspects of the natural and historic environment and social benefits will be included. In time the costs and benefits of protecting properties, infrastructure, transport links, the environment and so forth will be identified separately as well as the total benefits.
- UK Biodiversity Action Plan habitats – flood and coastal erosion risk should improve the natural environment as well as reducing the risks to people and property. This measure will record the overall increase in Biodiversity Action Plan habitat achieved through flood and coastal erosion risk management activities.
- Long-term policies and action plans – for the next few years this measure will ensure that sustainable, high-level plans for managing flood and coastal erosion risks are developed. It will show the percentage of Catchment Flood Management Plans and Shoreline Management Plans that have been signed off by Environment Agency Regional Directors.

Reporting on such targets and measures will assist in further analysis of the socio-economic and environmental values of coastal defences.

3.2.10 Forward look

The need for coastal defences is dependent on the stability of beaches and the impacts of flooding and coastal erosion on human activities along the coast. Climate change, predicted to

lead to a rise in sea levels, possible increased storminess and changes to wave conditions (MCCIP 2008), may alter erosion rates, the incidence and severity of flooding events, and increased steepening of intertidal profiles, resulting in increased demand for coastal defences.

The expenditure on flood and coastal defences is set to increase from £600 million in 2007 to £650 million in 2008/09 and £700 million in 2009/10 (Defra, 2008b).

The aggregate dredging industry predicts that known marine reserves of aggregates will provide a supply for at least another 50 years, based on the extent of present reserves. The resource potential, however, is extensive and alternate sources of replenishment material (particularly sand) are likely to be available. An example highlighted in this assessment is the beneficial re-use of maintenance dredgings as a source of such material. Clear drivers on the need for construction and beach replenishment material and the actual amounts required will help to direct the marine aggregate and maintenance dredging industries and inform their long-term strategies.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the activities associated with coastal defence will need further management. For example, GES descriptor 7 states that ...*Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.3 Defence – Military

3.3.1 Key points

- For 2007/08 the total expenditure on marine-related military defence activities was £1.8 billion for principal activities with a Gross Value Added (GVA) of £468 million and £1 billion for ancillary activities
- A large amount of spending has recently been directed towards building of new warships (£1150 million in 2006/07)
- There are additional socio-economic benefits with respect to employment and the local economies associated with Naval bases
- Naval bases include the Clyde (Region 5), Portsmouth (Region 3), Devonport (Region 4) and Caledonia (Region 1)
- Owing to the confidential nature of military defence activities it is difficult to assess the extent and frequency of activity in the marine environment and future trends
- A sustainable development strategy was released in 2008
- Relevant appraisals and environmental assessments are conducted by the Ministry of Defence for a wide range of military defence activities

i. Introduction

Military defence activities in the marine environment largely involve training, surveillance and monitoring, and transport.

ii. How has the assessment been undertaken?

Most of the economic data were sourced from the Ministry of Defence (MOD) and Defence Analytical Services and Advice (DASA) webpages. Data on the spatial distribution of defence-related activities were obtained from SeaZone, the MOD and the Health and Safety Executive.

iii. Current status of military defence activities and past trends

UK military defence spending overall is the third largest area of public government expenditure (after Health and Children, Schools and Families). For 2007/08 the total expenditure was £1.8 billion for the principal activity with a GVA of £468 million and £1 billion for ancillary activities. A large amount of public expenditure has recently been directed towards building of new warships with £1150 million spent on shipbuilding and repair in 2006/07. Activities and hence the location of the value to the economy are mainly related to the location of the Naval bases and exercise areas. The Navy employs 38 600 people and 5200 civilians and local economies also benefit from activities associated with the Naval bases. A sustainable development strategy was published by the MOD in 2008 and provides a number of objectives, measures and targets for changing the way that activities are carried out in order to reduce pressure on the marine environment, climate and communities. Key pressures are likely to include noise from sonar and underwater explosions, habitat damage and introduction of marine litter and contaminants.

iv. What is driving change?

Change (e.g. in relation to sea training activities and ship building) is driven by home defence policies (e.g. surveillance and monitoring of UK waters) and military activities abroad.

v. What are the uncertainties?

There are uncertainties on the exact location of training activities within designated exercise areas (which can be very large) and the frequency of use of those areas given the need for a certain amount of security in the information provided. This hampers a spatial and temporal assessment of environmental pressures within the sector. Given that military defence is a public sector there is good information on spending but it is not presented on a regional basis.

vi. Forward look

Owing to the confidential nature of military defence activities it is difficult to assess future plans. However, it is likely that training, surveillance and monitoring will continue at a similar level. Furthermore, new sustainable development strategies may change the way that activities are carried out, resulting in reduced pressure on the marine environment and climate.

3.3.2 Introduction

The military defence sector (largely the Royal Navy) makes use of the marine environment to provide security and protection of people and assets in the UK. The majority of activities within UK waters are for training purposes to support military activities abroad. Surveillance and monitoring of UK waters to detect and respond to potential threats are also undertaken, especially against fishing and offshore energy interests.

The defence sector was included as a marine related activity contributing to the UK economy by Pugh (2008) and as 'Military activities', in the OSPAR Quality Status Reports. All data are sourced from the MOD and Defence Analytical Services and Advice (DASA) webpages except where otherwise noted.

3.3.2.1 Description of economic activity

Principal and ancillary activities associated with MOD activities are listed in Table 3.20. No secondary activities could be identified. Principal activities in the marine environment include sea transport by naval vessels and sea training. Ancillary activities include home command services and ship building.

3.3.2.2 Description of relevant ecosystem services

The military defence sector relies on various ecosystem services that support its productivity, including: the physical environment, and chemical cycling/ water purification (to assimilate wastes).

3.3.2.3 Management

Military defence activities in the marine environment are managed by a number of MOD departments. The Commander-in-Chief (C-in-C) Fleet is responsible for the operation, resourcing, and personnel training of ships, submarines and aircraft. The Second Sea Lord (2SL) and Commander-in-Chief Naval Home Command (NHC) were merged in 1994. 2SL/NHC is responsible for the shore-based establishments and manpower of the Royal Navy. The C-in-C Fleet and 2SL/NHC were merged on 1 April 2006 to form the Fleet Joint TLB (Top Level Budget). Central Services will also have some responsibilities for the management of marine related activities. Military defence activities are subject to planning and environmental regulations as detailed in Section 3.3.7.

Table 3.20 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Defence (SIC 84.22) Part Commander-in-Chief Fleet; Training	Second Sea Lord / Commander-in-Chief Naval Home Command and Central Services; Ship Building and maintenance	No known secondary form of productivity from military activities	None identified

3.3.3 Direct use value

3.3.3.1 Principal activities

UK military defence spending in 2007/08 totalled £37.4 billion and is the third largest area of public government expenditure (after Health and Children, Schools and Families).

Navy resource outturns show that the C-in-C Fleet received a budget of £2185 million of Resource Departmental Expenditure Limits (DEL) in 2007/08. It has been assumed that the majority is for the operation of marine activity. Since 2006/07 the C-in-C Fleet has been combined with C-in-C Naval Home Command which manages shore-based support. The average proportion allocated to the latter over the past five years was 17.7%. Extracting this same proportion from the combined expenditure provides an estimate of £1797 million for the operation of marine activities. GVA is estimated to be £468 million.

Maritime transport

Activities related to maritime transport are mainly associated with the Naval Bases (HMNB). These include:

- HMNB Clyde (at Faslane) – Region 5
- HMNB Portsmouth – Region 3
- HMNB Devonport – Region 4
- HMS Caledonia – Region 1.

Sea training

Sea training is carried out within defined military practice and exercise (PEXA) training areas. Land support comes from training establishments based at:

- Britannia Royal Naval College (BRNC) Dartmouth, Devon – Region 3
- HMS *Raleigh* – Torpoint, Cornwall – Region 4
- HMS *Excellent* – Portsmouth, Hampshire – Region 3
- HMS *Collingwood* – Fareham, Hampshire – Region 3
- HMS *Sultan* – Gosport, Hampshire – Region 3
- HMS *Temeraire* – Portsmouth, Hampshire – Region 3.

Flag Officer Sea Training (FOST)

The Naval bases at Plymouth, the Clyde in Scotland and a small team at Northwood in Middlesex, provide Operational Sea Training (OST) for all surface ships and submarines, together with land and air units and with increasing numbers of NATO and foreign participants conducting training under its guidance. Over 100 ships and submarines from the Royal Navy and navies of NATO and allied nations benefit from FOST's training expertise each year.

Tier 1 training focuses on unit level training – where ships have tailored programmes to suit their individual operational needs. The larger surface units are trained at Devonport, with the waters of the South West Approaches totalling some 10 000 square miles. The submarine focus is mainly at Faslane. Having completed their initial training packages at Plymouth and Faslane, the ships and submarines of the Royal Navy then graduate to more complex Tier 2 training.

Tier 2 focuses on 'Joint' training courses with the RAF and Army and takes place three times a year. The Joint Maritime Courses (JMC) are conducted off the North West of Scotland which provides an ideal environment for training both in the littoral and deep ocean, with inclement weather often adding another dimension. The Cape Wrath firing range is extensively used for Naval Gunfire Support. Each JMC is two weeks long.

3.3.3.2 Ancillary activities

Economic activity that supports the MOD's activities in the marine environment can be estimated from expenditure formerly allocated to the Naval Home Command (£388 million, see Section 3.3.3.1), capital Departmental Expenditure Limits (£29 million) and, following the methodology of Pugh (2008), 25% of the total expenditure (resource and capital) allocated to central services (£590 million). This provides a total estimate of approx £1 billion in expenditure.

The Royal Navy is a significant source of income in certain regions. For example, the Naval base at Devonport (Plymouth) generates about 10% of income for Plymouth, employs 2500 people, and creates business opportunities for around 400 firms. Defence contributes £500 million annually to the south Hampshire economy, forming 5.2% of the region's Gross Domestic Product (GDP). It has been assumed that much of this revenue is related to ancillary activities such as supply of products and support of personnel. Further data related to employment are given in Section 3.3.6. Ancillary activities from ship-building are detailed below.

Shipbuilding

In 2006/07 the MOD spent £1150 million on shipbuilding and repair. This is part of the new Defence Equipment and Support Department which reported a total expenditure of £16 billion in 2007/08.

The biggest and most capable warships ever to be built for the Royal Navy – the aircraft carriers HMS *Queen Elizabeth* and HMS *Prince of Wales* – will be based at Portsmouth. The ships are estimated to be worth £3.8 billion each. Hull sections will be constructed at Rosyth, Barrow-in-Furness and Portsmouth and assembled at Rosyth.

All six of the new Daring-class destroyers currently on order will be based in Portsmouth. They will be much larger and more capable than any previous escort warship built for the Royal Navy. The first – HMS *Daring* – was formally handed over to the MOD in December 2008 and was finally commissioned on 23 July 2009. One-third of each of the ships – the forward section and the mast – was built by Vosper Thornycroft in Portsmouth.

Work has also started at Hunterston in Ayrshire on the £135 million Vallant Jetty project, a new floating jetty which will provide the HMNB Clyde with state of the art facilities for the maintenance of the new Astute class of attack submarines.

The first three Astute Class submarines are under construction at BAE Systems in Barrow-in-Furness with the Government retaining an option on three more. The first, HMS *Astute*, will enter service in 2010 (it was being prepared for sea trials late 2009) and will be followed by HMS *Ambush* and HMS *Artful*. The Astutes will be the largest and most sophisticated attack submarines ever built for the Royal Navy.

The UK's nuclear deterrent consists of four *Vanguard* class ballistic missile submarines (SSBNs) based at HMNB Clyde, armed with Trident missiles. The explosives handling jetty is nearby at Coulport in Argyll and Bute, Scotland. On 4 December 2006, the Government announced plans for a new class of nuclear missile submarines. The procurement costs of these new submarines, and associated equipment and infrastructure, were estimated to be £15 to £20 billion at 2006/07 prices. The full detail of the plans was outlined in the Ministry of Defence White Paper (MOD, 2003). BAE Systems Submarine Solutions and Rolls-Royce Marine Power Operations are undertaking design studies for the new SSBNs. Investment is also planned for the *Vanguard* 5-year life extension (£250 million) and decommissioning programme (the first *Vanguard* class submarine will end its extended service life in 2022).

3.3.4 Regional distribution of value

Figure 3.5 indicates the areas designated for military practice and exercise (PEXA) and historical dumping grounds for munitions. In addition, the waters off the west coast of Scotland and the Inner Hebrides are the Royal Navy's Scottish Exercise Areas (SXAs), which are routinely patrolled and used for operational sea training and exercises. The figures also indicate the location of Royal Navy docks including Naval bases and ports licensed by the Health and Safety Executive (HSE) to allow the storage of explosives.

Assessing the spatial distribution of expenditure associated with MOD activity is difficult. Expenditure among individual bases is not publicly available therefore total expenditure needs to be assigned to CP2 Regions based on assumptions made about the regional distribution of activity. The locations of both Naval bases and PEXA were included in the analysis of the spatial distribution of principal activity to capture areas of current marine activity and use.

Table 3.21 indicates that the majority of principal value is located in Regions 3 and 4 where there are large Naval bases and where a large proportion of training is allocated. Ancillary values will be spread throughout the UK but will largely be associated with the location of the four main Naval bases in Regions 1, 3, 4 and 5.

3.3.5 Trends

It is difficult to report on trends due to various changes and mergers in the departments within the MOD. Table 3.22 therefore shows the changes in total resource expenditure (DEL) in providing military defence capability over the five years since 2003 and some departmental examples. If inflation is taken into account, expenditure has generally remained stable over time.

Figure 3.5 Areas designated for military practice and exercise, historical dumping grounds for munitions, Naval bases, and ports licensed by the Health and Safety Executive for storage of explosives.

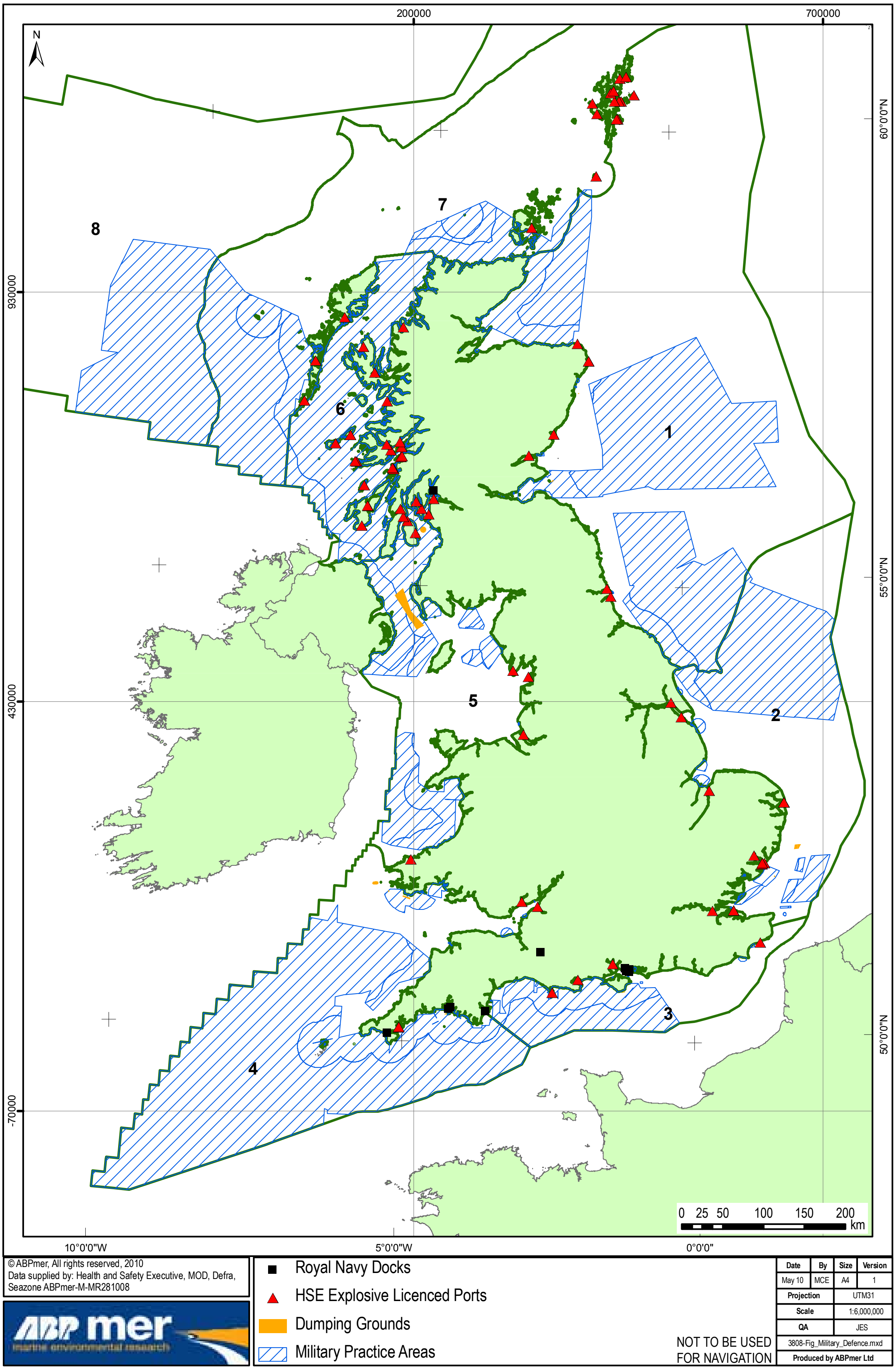


Table 3.21 Regional distribution of value.

CP2 Region	*Percentage of CP2 Region*	*Principal value, £ million*
1	7.73	299
2	4.81	75
3	18.26	437
4	23.93	538
5	34.52	163
6	3.56	91
7	3.76	101
8	3.42	92
Total	**100.00**	**1797**

3.3.6 Socio-economic pressures and impacts (positive and negative)

3.3.6.1 Positive

Employment and local economy

In 2008, the Royal Navy directly supported 4600 FTE (full-time equivalent) civilian jobs (C-in-C Fleet) and 38 600 service personnel (DASA, 2008). However, as the following examples illustrate, the indirect employment benefits can be much larger and are closely associated with supporting the Naval bases.

HMNB Clyde (at Faslane) is the largest single site employer in Scotland with an integrated workforce of 6500 personnel – drawn from the Royal Navy, MOD civilians, Babcock Naval Services (the MOD's industrial partner at the Base) and external contractors. A further 3000 Scottish jobs are supported indirectly by HM Naval Base Clyde and more than £250 million is spent in Scotland on wages and contracts awarded each year, directly related to the base.

HMNB Portsmouth is a major employer in the Portsmouth area, with 17 200 people working at peak times and supporting the local community. It is home to almost two thirds of the Royal Navy's surface ships (50 ships including three aircraft carriers). Defence contributes £500 million annually to the south Hampshire economy, forming 5.2% of the region's GDP. Ship movements in Portsmouth Harbour and the Solent approaches to Portsmouth and Southampton are controlled by the Queen's Harbour Master, a serving Naval officer with his headquarters and staff of 26 in Portsmouth Naval Base.

HMNB Devonport is supported by 2500 civilian and service personnel. It estimated that the base generates about 10% of the income for Plymouth and creates business opportunities for 400 local firms.

Specific projects may also provide significant employment opportunities. With respect to the future aircraft carriers (see Section 3.3.3.2), building the hull sections and outfitting the vessels will provide work for about 10 000 people, including 3500 at the two Clyde yards and 1600 at Rosyth at the project's peak.

Defence

There is an indirect value obtained from the surveillance and monitoring that is carried out by the Royal Navy and others for military defence purposes. In particular, defence provides economic stability through the indirect protection of industry activities and assets.

It has been suggested that there are also unquantifiable benefits for law enforcement, i.e. incentive for fishers and other marine environment users to comply with existing laws. However, there are no statistics or reports to illustrate this role, particularly in the marine

Table 3.22 Example of trends in Resource and Capital expenditure (£million).

	2003/04	2004/05	2005/06	2006/07	2007/08
Total Resource DEL	**35 681**	**37 211**	**38 484**	**38 858**	**40 622**
Commander in Chief Fleet	3 242	3 569	3 548	2 148	2 185
2SL/NHC	693	763	778	[a]	[a]
Chief Defence Logistics	7 758	7 452	7 588	12 788	[b]
Defence Procurement Agency	2 850	2 568	2 272	2 321	[b]
Defence Equipment & Support					16 236
Total Capital DEL	**65**	**40**	**18**	**14**	**29**
Commander in Chief Fleet	37	17	7	14	29
2nd Sea Lord/Commander-in-Chief Naval Home Command	28	23	11	[a]	[a]

[a] Since combined with the Commander in Chief Fleet; [b] Since combined to form Defence Equipment & Support.

environment. The jurisdiction of the Ministry of Defence Police (MDP) is limited to the UK and is governed by the Ministry of Defence Police Act 1987 (MOD, 2006a). Under section 2 of the 1987 Act the MDP may assist other civilian police forces and may in an emergency exercise the powers of local civilian police. They also have general jurisdiction in relation to defence land, property (including ships) and personnel.

Summary

The socio-economic benefits from military defence activities range from local employment through to indirect benefits of protection and are summarised in Table 3.23.

3.3.6.2 Negative

Military defence activity and exclusion zones may impact on other productive uses of the marine environment, such as fisheries, aggregates, and construction and social activities related to leisure and recreation. This section provides two examples of how issues have been or are being managed.

Historical dumping of munitions at sea, in particular in a region known as Beaufort's Dyke, has posed issues for the laying of cables and pipelines. The Dyke is a long narrow trough situated in the North Channel between County Down, Northern Ireland and the south-west coast of Scotland in Region 5 (MOD, 2006b and Figure 3.5). It is 50 km long, 3.5 km wide and 200 to 300 m deep. Disposal of munitions was restricted to the area in and around Beaufort's Dyke as defined by Notice to Mariners No 4095 issued in 1945. Dumping operations ceased in 1972 when agreements were reached within two International Conventions: the London Convention (Dumping of Wastes at Sea) and the Oslo Convention (for the prevention of Marine Pollution by Dumping from Ships and Aircraft). Laying of the Scottish Northern Ireland Pipeline (SNIP) slightly to the north of the defined area in 1995 coincided with munitions washing up on surrounding beaches. Subsequent side-scan sonar surveys by Fisheries Research Services (FRS) mapped the distribution of munitions both within and around Beaufort's Dyke

Table 3.23 Socio-economic benefits. Sources: UK Defence Statistics (2008); Royal Navy website.

Benefit	*Description*
Employment	In 2008 the Naval Service as a whole comprised approximately 38 600 service personnel and the Commander of Chief Fleet employed 4600 civilian personnel. Wider indirect benefits can flow on into the surrounding regional community.
Local economies	Benefits are related to the areas surrounding the HMNBs, e.g. Regions 1, 3, 4 and 5. HMNB Portsmouth contributes £500 million annually to the south Hampshire economy, forming 5.2% of the region's GDP; HMNB Devonport generates about 10% of the income for Plymouth and creates business opportunities for 400 local firms.
Defence	Economic stability through the indirect protection of industry activities and assets; surveillance and monitoring.
Other	Although the primary role of military Search and Rescue (SAR) units is to recover military aircrew from crashed aircraft, the vast majority of callouts are to provide emergency relief for the general public. Much of this is via helicopters and specialised aircraft. There have been no ship callouts since 1998.

thereby assisting the later planning of routes for electricity and telecommunications cables crossing the area (FRS, 2004).

Broad Bench reef at Kimmeridge in Dorset (Region 3) is a favoured spot for surfers but it lies within the defence training estate (DTE) Bovington and Lulworth's sea danger area (SDA) for training (Access Broad Bench Association, 2009). The primary purpose of the DTE Bovington and Lulworth training area is to provide facilities for live fire training, including operational pre-deployment training to British service personnel. Access via the sea to Broad Bench is available daily when firing on the range is completed. Land access is available to the public on approximately 137 days per annum; that is all but six weekends a year and on bank holidays and main school holidays. However, this doesn't take into account that recreational activities are general restricted to summer time and day light hours.

The MOD has a system of managed recreational access for some terrestrial areas along the coast and, although there are no examples for the marine environment, it is likely that such management systems may also be considered.

3.3.7 Environmental pressures and impacts (positive and negative)

The ecological pressures from military defence activities are, to some extent, similar to that of coastal construction activities and maritime transport (see Sections 3.2: Coastal Defence and 3.7: Maritime Transport). Additional pressures such as noise damage to marine animals from sonar and the use of explosives are listed in Table 3.24. The ecosystem services that these pressures impact and the relative significance of these impacts are identified in Table 3.25.

In order to reduce the impacts of military defence on the environment, the Secretary of State for Defence's policy statement (8 December 2008) on Safety, Health, Environmental Protection and Sustainable Development in the MOD requires that the Department *...carry out sustainability appraisals and environmental assessments, as appropriate, for new or revised policies, programmes (including acquisition programmes) office relocations, new projects and training activities*.

Table 3.24 Key environmental pressures and impacts associated with military defence activities.

Pressure	**Introduction of noise from sonar activity and the use of live explosives for training purposes**
Impact	Biological disturbance, disturbance of behaviour, damage to hearing, worst-case fatality.
Description of environmental change (intensity, spatial extent, frequency, duration)	Given the confidential nature of the MOD activities in the marine environment it is very difficult to assess the spatial and temporal extent and intensity.
Existing management measures	EIAs. The MOD has also developed an Environmental Risk Management Capability known as Sonar 2117, which is designed to be used in support of the in-service tactical active sonar capability. Sonar 2117, which was accepted into service in March 2006, provides a robust, repeatable and transparent method of assessing the environmental risk to, and impact on, marine life caused by sonar activity, and managing this impact by providing advice on mitigation measures.

Pressure	**Introduction of moving objects (ships, missiles)**
Impact	Death or injury by collision.
Description of environmental change (intensity, spatial extent, frequency, duration)	There are 75 000 military and commercial ship movements a year in Portsmouth harbour (including 18 Continental ferry movements a day) and 5000 in HMNB Devonport. See reports on collision in Section 3.7 (Maritime Transport).
Existing management measures	See Section 3.7 (Maritime Transport).

Pressure	**Abrasion**
Impact	Habitat structure changes – abrasion and other physical damage.
Description of environmental change (intensity, spatial extent, frequency, duration)	Given the confidential nature of MOD activities in the marine environment it is very difficult to assess the spatial and temporal extent and intensity.
Existing management measures	

Pressure	**Introduction of structures into the marine environment**
Impact	Habitat loss from the development of defence ports and other coastal infrastructure.
Description of environmental change (intensity, spatial extent, frequency, duration)	Devonport is the largest Naval base in Western Europe. It covers over 650 acres and has 15 dry docks, four miles of waterfront, 25 tidal berths and 5 basins.
Existing management measures	See Section 3.7 (Maritime Transport) for further assessment.

Pressure	**Introduction of marine litter from spent shells and explosives**
Impact	
Description of environmental change (intensity, spatial extent, frequency, duration)	There is very little information on the incidence of marine litter from defence activities within exercise areas.
Existing management measures	

Pressure	**Introduction of non-synthetic substances and compounds – heavy metals**
Impact	Contamination by hazardous substances from munitions.
Description of environmental change (intensity, spatial extent, frequency, duration)	As sea disposal of munitions has ceased, impacts relate to historical sites, i.e. Beaufort's Dyke (see Section 3.3.6.2). Surviving records from 1945-46 record munitions such as various types of bombs, mortar bombs, rockets, small arms ammunition, hand grenades. By the 1970s, the annual dumping of munitions had decreased to less than 10 000 tons per annum. Surveys by FRS in 1995-96 concluded that the dumping had not resulted in contamination of seabed sediments or of commercially exploited fish or shellfish (FRS, 2004).
Existing management measures	Sea disposal of surplus munitions began in 1945 and continued until 1972 when the adoption of the London and Oslo Conventions ended sea dumping of munitions on the UK continental shelf and restricted dumping to an area some 400 miles south west of Land's End (see Section 3.3.6.2). In September 1992, the UK signed the Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention). This prohibits the disposal of all substances at sea with only minor exemptions, for example dredged material from ports and harbours.

Pressure	**Introduction of radionuclides**
Impact	Radionuclide contamination from uranium or plutonium – deliberate or accidental.
Description of environmental change (intensity, spatial extent, frequency, duration)	Disposal of low to intermediate level radioactive waste in the 1950s also occurred in Beaufort's Dyke from non military sources. Monitoring of radioactivity levels in Beaufort's Dyke has never detected any localised increase in radioactivity (MOD, 2006b). The potential for accidental contamination arises if a nuclear-powered naval ship or ship/submarine with nuclear weapons is involved in an accident or terrorist threat. The risk of this occurring has not currently been assessed.
Existing management measures	Deliberate sea disposal of radioactive wastes is no longer permitted.

Table 3.25 Environmental pressures on ecosystem services associated with military defence.

Ecosystem service	*Significance of impact*	*Confidence in understanding of the relationship = information gaps*
Erosion-deposition cycles (of sediment)	**Minimal – Low.** A small proportion of dredging activity is due to defence uses of ports. But dredging can be significant and necessitate compensatory habitat measures.	**Low.** Can be difficult to distinguish from other impacts on sedimentation processes on coast (e.g. protection against coastal erosion).
Biological productivity	**Minimal.** Pressures on biological productivity services possible from habitat disruption and channel dredging associated with ports, but defence activities are a minor part of overall port activity. Potential impacts of pollution from vessels and invasive species introduced /spread by international vessel movements difficult to counteract.	**Low.** Impacts on biological systems through escaped invasive species not well understood.
Biodiversity provision	**Low – High.** Moderate to high impacts from noise (seismic activity and sonar, explosives testing); low pressures possible from invasive species, channel dredging, port development and/or vessel pollution associated with ports - defence activities are minor part of overall port activity.	**Low.** Cumulative impacts of noise and collisions less well understood.

Relevant appraisals and assessments are conducted by the MOD for a wide range of military defence activities, including those which may impact on the marine environment. For example, environmental impact assessments (EIAs) are undertaken by the MOD prior to the deployment of military sonar. These sonar EIAs cover the marine habitats and species in the operating areas concerned. The EIAs ensure that potentially damaging environmental effects are identified during the planning stage of the exercise and any impact is reduced to an absolute minimum. Planning policies, such as EMP04 (MOD 2007a) and EMP05 (MOD, 2007b) produced in November 2007, provide guidance on procedures for EIAs. The MOD also published a Sustainable Development Strategy in 2008 that gives an overview of the MOD's obligations relating to designated sites, protected species and biodiversity (see Section 3.3.9).

3.3.8 Climate change

The MOD's Sustainable Development Strategy (SDS) (MOD, 2008) outlines a number of objectives that the Defence sector aims to meet in relation to climate change. These are described in the following sections.

3.3.8.1 Impacts of climate change on military defence activities

The impacts of climate change on military defence activity are likely to be complex and far reaching due to the large scope of activities. A five-year programme of work was begun in September 2007 by the Hadley Centre to determine these impacts on the MOD. The effects of climate change from maritime transport activities are outlined in Section 3.7 (Maritime Transport).

Adaptation measures

Climate change objective B of the SDS (MOD, 2008) is to ...*agree and implement an effective process to enable Defence activities to continually adapt to a changing climate, such*

that Defence capability is not compromised and any potential benefits from the future climate are realised. The strategy outlined three key areas in which Defence will adapt:

- Adapting our estate – Ensuring that the Defence Estate is resilient to changes in weather patterns and increased frequency of extreme events, both in the UK and abroad
- Adapting our equipment – Ensuring that equipment and services being developed and procured now will be able to meet the challenges of the future climate in which defence forces will operate
- Adapting our planning – Understanding the impact that climate change will have on global security and factoring it into our planning of force structure and training as well as taking an active role in cross-Government and International Climate Security planning.

3.3.8.2 Impacts of military defence activities on climate change

The SDS (MOD, 2008) noted the following data on climate change impacts from Defence operations:

- In 2007/08 the MOD emitted approximately 1.9 million tonnes of carbon dioxide (CO_2) from energy use on the Estate[7]
- The MOD is currently responsible for approximately 1% of the UK's total CO_2 emissions from its use of energy, fuel and transport
- Emissions from the MOD Estate account for approximately 70% of those from the Central Government estate.

7 This figure contrasts with higher estimates made by Barnett (2001) of approximately 17 million tonnes of CO_2 emitted in the UK from defence. Barnett calculated the proportion of the UK's GNP spent on defence and applied the same proportion to estimates of total UK emissions. This approach assumes that military emissions per unit of gross national product (GNP) are the same as the national mean of emissions per unit of GNP.

These calculations include emissions from all military activities rather than just marine related activities in the UK.

Mitigation measures

Climate change objective A of the SDS (MOD, 2008) is to ...*ensure that the emissions of the GHGs* [greenhouse gases] *that result from defence activities are continually reduced, such that Defence will eventually not be a significant contributor to the causes of climate change*.

The SDS identifies the following key areas of work in order to achieve this (not all are directly related to the marine environment):

- Reducing emissions from motive fuels (aviation, marine and land)
- Reducing emissions from Defence business related travel
- Continued improvements to energy management and energy reduction on the Defence Estate
- Renewable energy development/ procurement on the defence estate
- Reducing emissions from Information Technology (IT)
- Preparing for UK-wide changes to technology, fossil fuel use and energy availability as the UK becomes a low-carbon economy
- Pursuing a sustainable consumption and production strategy
- Examining the possibility of using aviation fuel made from sustainable non-crude oil sources
- Addressing the energy efficiency behaviour of MOD staff
- Ensuring that Defence policies support the delivery of the MOD's Climate Change Strategy.

Full details of their greenhouse gas emission reduction targets and intended course of action to achieve these targets are set out within the MOD's Climate Change Strategy (MOD, 2009). The need to ensure operational capability makes it difficult to set targets for some areas. However, there are potentially large reductions in emissions to be made in relation to the use of marine fuels.

3.3.8.3 Summary

Table 3.26 summarises the climate change pressures, impacts and mitigation measures discussed in this section and indicates the likely significance of the impacts and the level of confidence in the assessment.

3.3.9 Industry stability and sustainability

3.3.9.1 Objectives, targets and indicators

The Defence White Paper (MOD, 2003) seeks to deliver security for the people of the United Kingdom and the Overseas Territories by defending them, including against terrorism; and to act as a force for good by strengthening international peace and stability. The White Paper outlines the current military defence situation and the need for flexibility in order to deliver security in an ever changing world. For the maritime area the emphasis is increasingly on delivering support from the sea onto land bases, on securing access to operations and protecting the crucial sea lines of communication from the home base. It also highlights that the strategy is dependent on well trained personnel.

The SDS (MOD, 2008) outlines the context for the Defence sector against the overall UK strategy (HM Government, 2005). The overall aim of the MOD strategy is ...*To ensure that the MOD becomes a national leader in sustainable development...* with a vision to embed the principles of sustainable development into all areas of Defence business. Specific areas where objectives and targets have been set include:

- Sustainable consumption and production
- Climate change and energy (see Section 3.3.8)
- Natural resource protection and environmental enhancement
- Sustainable communities and fairer world
- Delivering the strategy.

3.3.10 Forward look

Owing to the confidential nature of military defence activities it is difficult to assess future plans. However, it is likely that training, surveillance and monitoring will continue at a similar level. Furthermore, a number of strategies are planned for implementation in relation to sustainable development and this may change the way that activities are carried out, resulting in reduced pressure on the marine environment and climate.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the military defence sector will need to manage further its activities. For example, GES descriptor 11 states that ...*Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

Table 3.26 Summary of climate change implications.

Climate change pressure	*Impacts of climate change on Military Defence*	*Confidence/ significance*	*Adaptation measures*
See Section 3.7 (Maritime Transport)			

Impacts of Military Defence on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
Motive fuels from travel	CO_2 emissions	Medium / High	Reduced travel; sustainable fuel sources
Use of heat and electricity fuels on Defence Estate	CO_2 emissions	Medium / High	Improvements to energy management and energy reduction; use of renewable energy and more efficient ship design; sustainable consumption and production strategies

3.4 Education

3.4.1 Key points

- Turnover is estimated to be £132 million with a Gross Added Value (GVA) of £95 million
- This is likely to be an underestimate due to difficulties in sourcing data from all marine-related education and training establishments
- There are significant social and cognitive values related to education that are difficult to quantify
- The sector is fairly stable overall although specific areas have changed and are likely to change over time

i. Introduction

This sector relates to education and training undertaken in the marine environment and underpins a number of other principal activities in providing support for leisure, maritime transport, research and development.

ii. How has the assessment been undertaken?

Values were taken from assessments made by Pugh (2008) of the Higher Education Institutes and values from the Field Studies Council, British Marine Federation and the Sector Skills Council for Science, Engineering and Manufacturing Technologies. There are also unquantified cognitive values that are discussed in Section 3.13 (Research and Development).

iii. Current status of the education sector and past trends

The turnover related to education and training is estimated to be £132 million with a Gross Value Added (GVA) of £95 million. The sector is fairly stable although specific areas of interest have changed over time. Environmental impacts are likely to be minimal due to the benign nature of most activities, however key pressures may include wildlife disturbance, physical disturbance and removal, noise and loss of habitat from construction of coastal facilities.

iv. What is driving change?

Change in the marine education sector is driven by high level policy developments and changes in economic activities that support cognitive development in the marine environment and in turn drive funding.

v. What are the uncertainties?

Given the difficulties in sourcing data from all marine-related education and training establishments, the estimate of turnover is likely to be an underestimate. There are also significant social and cognitive values related to education that are difficult to quantify. Due to the diverse range of activities and participants, the impacts from education on the marine environment and climate are difficult to quantify.

vi. Forward look

Owing to an increased focus on the marine environment (various Marine Acts and marine planning initiatives) demand for related marine education programmes is likely to increase.

3.4.2 Introduction

The sector 'education' potentially includes Higher Education Institutions (HEI) such as universities, technical and vocational training (e.g. commercial pilotage) and leisure training classes (e.g. non-commercial sailing). The Higher Education sector was partially assessed by Pugh (2008). Vocational and leisure training could be considered as an ancillary activity relevant to the marine sector but is assessed here for consistency.

3.4.2.1 Description of economic activities

Use of the marine environment for education is largely associated with higher education and vocational or leisure training (Table 3.27). Education and training is also supported by some ancillary activities such as construction of coastal facilities.

3.4.2.2 Description of relevant ecosystem services

The education sector is generally dependent on clean and safe seas in which to operate and, for some activities, biologically healthy and diverse marine populations to study. As such its productivity is reliant on the following ecosystem services: the physical environment, biological productivity, water purification and waste treatment, and biodiversity.

3.4.2.3 Management

Management of educational and training activities in the marine environment depends largely on the nature of the activity and the degree of impact on the marine environment. Maritime transport activities are governed by the Maritime and Coastguard Agency (MCA). The construction of marine educational facilities is governed via local planning policies and permits and EIA (environmental impact assessment) processes for larger facilities.

3.4.3 Direct use value

Although this sector is likely to have a low economic value in relation to activities such as oil and gas exploration and production, it is regarded as an important activity that is dependent on the marine environment. However, uncovering the economic contribution is hampered by the number of activities and courses delivered by a wide range of organisations, the wide distribution of the activity and the lack of available central statistics. It is even more difficult to identify the upstream contribution from construction and other ancillary activities. Therefore only the direct use value of the principal activity is assessed here and has been broadly split into three areas: environment education, leisure training, and technical and vocational training.

3.4.3.1 Environmental education

Education and academic study which relates to the marine environment is mainly through outdoor education centres (catering for schools, higher education and professional groups) and through universities independently. The largest area of turnover comes from the HEIs.

In the higher education sector there are many academic courses which are marine based including marine biology, oceanography and marine engineering. UCAS (Universities & Colleges Admissions Service) listed 110 different marine related courses at UK universities in 2009. Costs are difficult to isolate from Research and Development as HEIs perform both activities. A turnover of £73 million was estimated by Pugh (2008). Applying the value added factor for the whole education sector of 0.72 gives a gross value added (GVA) of £52 million.

Table 3.27 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Education & Training (SIC 85) Higher Education (85.4); Technical and vocational training, e.g. commercial pilotage (85.32); Non-commercial sailing, pilotage training etc. (85.53)	Construction of marine structures associated with educational facilities, e.g. slipways and wharves (part SIC 42)	None identified	None identified

The Field Studies Council (FSC) is an environmental education charity committed to helping people understand and be inspired by the natural world. The council has 17 centres across the UK and is one of the major environmental education providers. The FSC has three centres, all located in Region 4, that are very marine orientated and use coastal sites regularly, Dale Fort and Orielton in Pembrokeshire, Wales and Slapton Ley in Devon. This suggests that at least 15% of FSC's turnover (£1.7 million) is dependent on access to coastal teaching sites. This equates to £255 000 (Steve Tilling, Field Studies Council, pers. comm. 2009).

3.4.3.2 Leisure training

The British Marine Federation is the trade association for the leisure and small commercial marine industry. The federation produces annual statistics which relate to all craft up to 50 m in length (not including traditional ship building) including kayaks, personal watercraft, sail, motor and also windsurfing. The trade association estimates that revenue from sailing/watersport schools is around £30 million (BMF, 2007b).

3.4.3.3 Technical and vocational training

SEMPTA (the Sector Skills Council for Science, Engineering and Manufacturing Technologies) is the organisation responsible for technical and vocational training in shipbuilding and ship-repair (including submarines, boatbuilding, boat repair and marine equipment). SEMPTA estimates that almost £29 million per annum is being spent by companies, government and individuals in this marine sector on education and training.

3.4.3.4 Summary of commercial value

Taking the values above and applying the value added factor for the whole education sector of 0.72 gives a total GVA of £95 million (Table 3.28). See also Section 3.13 for discussion on the cognitive values of Research and Development.

3.4.4 Regional distribution of value

The major higher education establishments that offer a range of marine related courses include: Southampton University (and associated National Oceanography Centre), Southampton Solent, Newcastle University, University of Plymouth, Bangor University, University of Aberdeen, University of Hull, University of Liverpool, and the University of York.

Sailing schools and outdoor education centres are widely distributed around the country. The location of Royal Yachting Association (RYA) sailing schools and marine training centres can be seen in Figure 3.6. Activity is spread across the CP2 Regions.

Table 3.28 Summary of direct use value from marine related education and training.

	Organisation	*Turnover, £*	*GVA, £ at 0.72*
Environmental education	HEI	73 000 000	52 560 000
	FSC	255 000	184 000
Leisure training		30 000 000	21 600 000
Technical and vocational training	SEMPTA	29 000 000	20 880 000
Total		**£132 million**	**£95 million**

3.4.5 Trends

Information on the number of people undertaking specific marine related higher education courses is limited. Data from UCAS in the broader subject areas of engineering, biological sciences and physical sciences showing the number of university applicants from 2003 to 2007 can be seen in Figure 3.7. In all three disciplines, numbers of applicants have stayed relatively stable.

There has been a significant increase in the number of marine engineers in work based learning and further education; in 2002/03 the number was more than double that in 1998/89 (SEMPTA, 2006). The FSC (2002) suggests that biology fieldwork (which will include marine and coastal work) is declining in schools despite the very clear educational and personal development strengths that it offers.

Any trends over time in the marine education sector are likely to be due to high level policy developments and changes in economic activities that support cognitive development in the marine environment (e.g. new developments in renewable energy, marine planning and leisure and recreation pursuits). These will in turn drive the funding and demand that supports educational institutes.

3.4.6 Socio-economic pressures and impacts (positive and negative)

Marine based education and training provide a number of benefits to society which are difficult to value economically. Training provision provides employment for skilled workers in a range of fields and the wages they earn will support the local and national economy. The BMF (2007b) estimated that there are about 664 people employed in sailing/ watersports schools in the UK. The number of staff employed in marine related higher education was estimated by Pugh (2008) at 336. This estimate was based on 1999/00 data on employment levels of academics and technicians and assumed that there had been no growth (or decrease) in the sector and that 50% of academic staff time and 20% of technician time was related to teaching (the rest is related to research). However, according to data from the Office for National Statistics website (www.nomisweb.co.uk) between 1999/00 and 2007/08, employment in the overall education sector increased by 18%. If this level is adjusted by assuming even growth throughout the education sector this suggests an employment level of 396 involved in teaching.

Training results in a more skilled workforce supporting industrial sectors and this can sustain economic growth. Training can also lead to innovation within industrial sectors and provides

Figure 3.6 Location of sites associated with education and training.

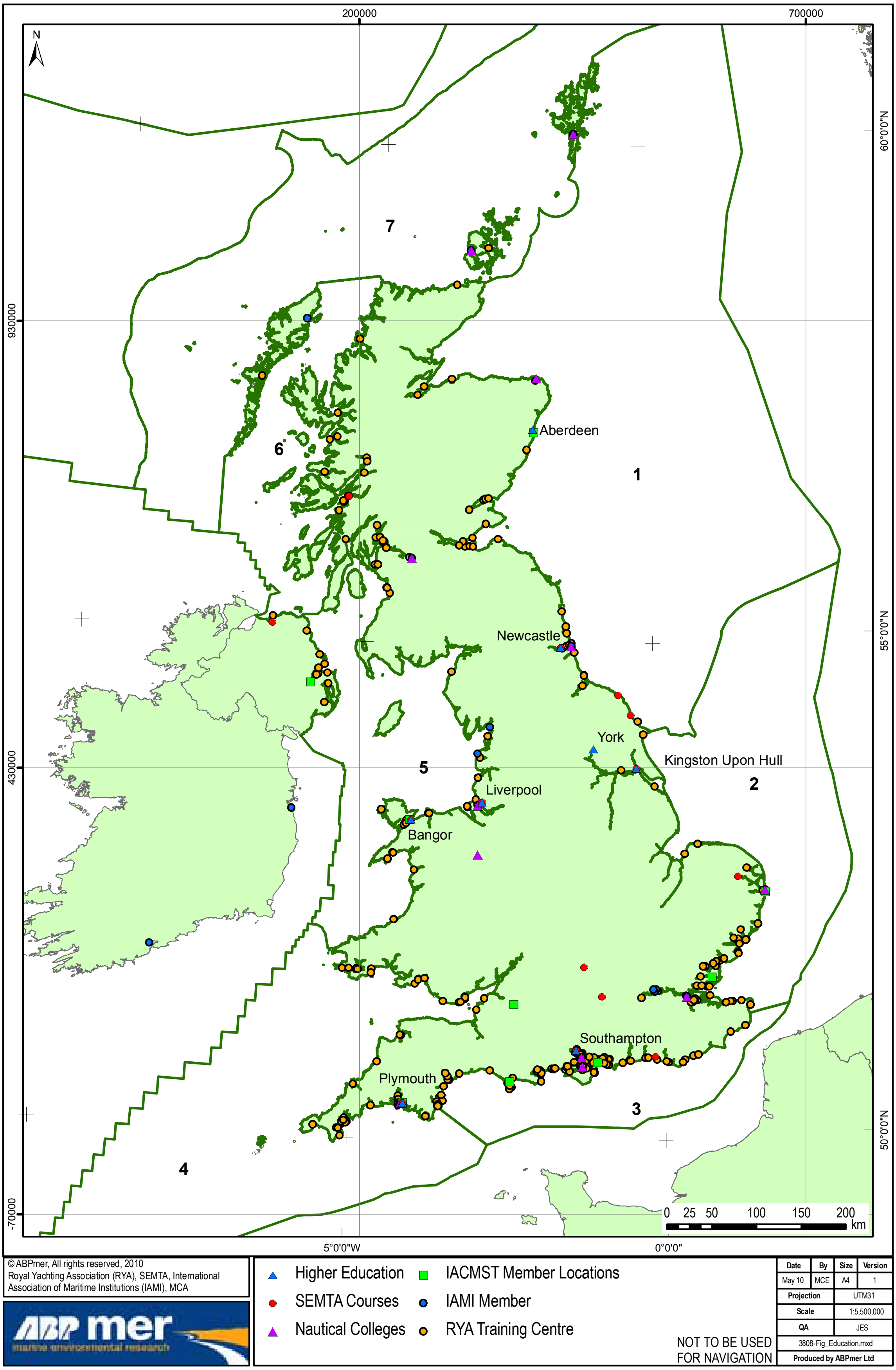
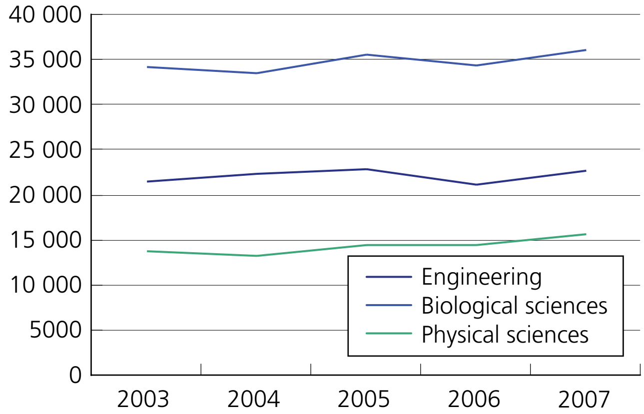


Figure 3.7 Number of university applicants between 2003 and 2007 undertaking engineering, biological sciences and physical sciences. Source: Universities & Colleges Admissions Service.



the skills to utilise, manage and maintain marine resources.

Training and education also have benefits for the individual providing opportunities and enhancing well-being. Fieldwork and outdoor education undertaken around the UK coast has a range of social benefits such as connecting learners with their environment, their community, their society and themselves. It engages and motivates learners through first-hand experiences which demonstrate the relevance of knowledge and understanding (e.g. see www.ltscotland.org.uk/takinglearningoutdoors/about/about.asp).

3.4.7 Environmental pressures and impacts (positive and negative)

Environmental pressures associated with education and training can arise from the development of educational facilities (wharves etc.) and undertaking fieldwork and other courses in the marine environment. While the impacts of construction in the coastal marine environment are fairly well understood (see Section 3.7: Maritime Transport) limited data exist on quantifying field study impacts. A brief overview of environmental pressures and impacts associated with education and training can be seen in Table 3.29. The ecosystem services that these pressures impact and the relative significance of these impacts are identified in Table 3.30.

3.4.8 Climate change

There are currently no published data relating to climate change and education. However, Table 3.31 summarises potential impacts from Education activities on climate change and potential impacts on Education from climate pressures. It also assesses the level of confidence in the impact assessment, the significance of the impacts and measures that might be employed to manage the impacts.

3.4.9 Industry stability and forward look

SEMPTA (2006) reported that over 68% of training providers surveyed expect demand for marine engineering courses to increase in the future. Over 40% of companies in shipbuilding and repair and 27% of companies in the boatbuilding sector, including several large organisations that account for the majority of employment, also said that their training budget is due to increase.

The FSC (2002) suggests that biology fieldwork is declining in schools despite the very clear educational and personal development strengths that it offers. This is happening at a time when there is increasing demand for students with the skills and confidence to practise outdoor biology and to be aware of their impacts on the world around them.

Table 3.29 Key impacts and pressures associated with education and training. Based on: Lyngs (1994); Evans (1998); UK CEED (2000); Ronconi and St Clair (2002); Zakaia and Chadwick-Furman (2002); Woods-Ballard et al. (2003); Barker and Roberts (2004); Kelly et al. (2004); Pinn, and Rodgers (2005); Tyler-Walters (2005); Davenport and Davenport (2006); Defra (2007b); JNCC (2008a); RYA Green Blue (www.thegreenblue.org.uk).

Pressure	**Marine wildlife disturbance (visual and acoustic)**
Impact	Disturbance caused by an external influence can cause animals to stop feeding, resting or travelling and socialising with possible long-term effects of repeated disturbance including loss of weight, condition and a reduction in reproductive success.
Description of environmental change (intensity, spatial extent, frequency, duration)	Difficult to quantify as few spatial data exist on this issue due to a low level of official reporting and a high level of heterogeneity in where incidents are recorded. Intensity is likely to be small compared to disturbance associated with Leisure and Recreation (see Section 3.6). Likely to be highest around sailing schools and marine training centres (Figure 3.6).
Existing management measures	The Countryside and Rights of Way Act 2000 makes it an offence to cause 'reckless or intentional disturbance' to basking sharks, cetaceans and some bird species. Difficult to enforce although a number of codes of conducts have been implemented to help reduce this type of disturbance such as the 'WiSe' scheme, the Pembrokeshire Marine Code and the Scottish Marine Wildlife Watchers Code.

Pressure	**Physical disturbance of seabed substrata and alterations to the local benthic habitat**
Impact	Trampling, clambering, smothering and other physical disturbance of marine benthic habitats.
Description of environmental change (intensity, spatial extent, frequency, duration)	Comprehensive spatial data on subject is limited. Highest impacts will be around popular field study locations. Pinn and Rodgers (2005) investigated the influence of visitors on intertidal biodiversity at Kimmeridge Bay. The research found reduction in the larger, branching species of algae and an increase in ephemeral and crustose species in the more heavily utilized areas. The amount of physical disturbance will be dependent on the popularity of a site by water users and the structure of the habitat. In most cases the extent of the 'footprint' will be relatively localised.
Existing management measures	Voluntary codes of conduct are in place at various marine reserves and popular dive areas to try and limit the level of physical disturbance such as at Wembury, Devon and St Abbs, Berwickshire. Various bait collectors codes exist such as the National Federation of Sea Anglers (NFSA) and the Solent European Marine Site (SEMS) code.

Pressure	**Sewage discharge**
Impact	Sewage discharge causing health problems and nutrient enrichment of coastal areas.
Description of environmental change (intensity, spatial extent, frequency, duration)	Mainly around coastal resorts and ports but difficult to quantify the contribution specifically from education and training (although likely to be very small).
Existing management measures	Discharge of boat sewage to coastal waters is regulated through the International Convention on the Prevention of Pollution by Ships (MARPOL7 3/78). This does not apply to small craft carrying fewer than 15 passengers. Disposal at sea is therefore a value judgement but accepted convention is that holding tanks should not be emptied less than three miles offshore. Since 2006, The Recreational Craft Directive has applied to newly built vessels and requires provision to be made for a holding tank to be fitted.

Pressure	**Erosion and increase in suspended sediments**
Impact	Increase in the erosion of soft sediment features and an increase in suspended sediments caused by scouring from boats wake/wash.
Description of environmental change (intensity, spatial extent, frequency, duration)	Mainly around coastal resorts and ports but difficult to quantify the contribution specifically from education and training (although likely to be very small).
Existing management measures	A number of management approaches are available for controlling boat wash. Non statutory approaches through zoning, speed restrictions and no wake zones can be implemented and these are very common in inland waterways. Navigation, Harbour and Local Authorities have the power to enforce byelaws for zoning and speed restrictions if necessary. An example is Poole Harbour 'Watch your Wash!' programme, which enforces byelaws with speed restrictions in place.

Pressure	**Litter**
Impact	Includes plastic, polystyrene, rubber, metals and glass. Litter can impact on marine species through ingestion, entanglement and smothering.
Description of environmental change (intensity, spatial extent, frequency, duration)	Mainly around coastal resorts and ports but difficult to quantify the contribution specifically from education and training (although likely to be very small).
Existing management measures	Dropping litter is an offence under the Environmental Protection Act 1990. Education through various leaflets and codes such as the Marine Conservation Society 'seashore code'.

Table 3.30 Environmental pressures on ecosystem services associated with education and training.

Ecosystem service	*Significance of impact*	*Confidence in understanding of the relationship = information gaps*
Physical environment	**Low**. Physical disturbance can be severe in areas that are popular study sites, but is generally localized in those areas and researchers usually attempt to reduce their impact. Disturbance can also be caused by scouring from a boat's wake/wash, which increases erosion on a wider scale, but with a less intense impact at any one point.	**High**. Impacts on benthic marine environment well understood.
Biological productivity	**Low**. Extraction for educational purposes is unlikely to occur at any level that is threatening to fish stocks. Visual and acoustic disturbance can have an impact on marine wildlife, but severity is dependent on craft/equipment type and how it is used.	**Low**. Neither extraction nor disturbance is well reported.
Biodiversity provision	**Minimal – Low**. Impacts on biodiversity are likely to result from visual and acoustic disturbance, sewage discharge and litter. However, the pressure from education and training are likely to be minimal to low.	**Moderate**. Difficult to quantify disturbance, but effects are understood.
Water purification and waste treatment	**Minimal**. Although education may affect water quality, the effect is likely small and localised.	**Moderate**. Education and training contribution to water quality issues not well studied, but effects and desired level of water quality understood.

Table 3.31 Summary of climate change implications.

Climate change pressure	*Impacts of climate change on Education*	*Confidence/ significance*	*Adaptation measures*
All	Increased provision of courses that train people to deal with climate change. This could occur in all sectors of education.	Low confidence / unknown significance	Provision of training and education targeting climate change issues

Impacts of Education on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
CO_2 emissions could arise from sources such as field trips and research cruises.	CO_2 emissions	Low confidence / unknown significance	Efficient boat and ship design (see Section 3.7: Maritime Transport) for research cruises and field work.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether marine-related education and training establishments will need to further manage their activities. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.5 Fisheries

3.5.1. Key points

- In 2007, the first sale value (turnover) of fish and shellfish taken by UK vessels in UK waters was £510 million with an estimated Gross Value Added (GVA) of £204 million
- Shellfish and demersal fish species currently contribute around 40% each to the total market value of catch, with the remaining 20% comprising pelagic species such as mackerel and herring
- Fishing is a particularly important socio-economic activity in remote coastal regions in Scotland and south-west England
- Fish processing from sea fisheries provided a GVA of £385 million in 2007
- In Northern Ireland, Wales and the Channel Islands, the most valuable fisheries are for shellfish, reflecting the relatively higher incidence of inshore fishing for crabs, lobsters and other shellfish in these areas
- The demersal fisheries in the North Sea, west of Scotland and Irish Sea have shifted towards inshore waters for the valuable Norway lobster (*Nephrops norvegicus*) and other shellfish and mixed demersal species
- Changes result from long-term declines in many stocks and associated fishing restrictions and perceived economic opportunities in other fisheries
- Changes in profitability are related to escalating fuel prices, an increase in quota trading, and increases in first-sale prices
- EU controls on Total Allowable Catches (TACs) and fishing effort, and decommissioning of vessels in the UK and other countries are likely to have contributed to reductions in total fishing effort in the international demersal fisheries of around 30% or more over the past eight years in the North Sea, west of Scotland and the Irish Sea
- The UK whitefish demersal trawl fleet was reduced by around 15% in size by the two decommissioning schemes in 2001 and 2003, with a particularly large impact on the Scottish fleet
- The capacity of the UK fleet is currently (2007) estimated at 213 thousand tonnes and 6763 commercial fishing vessels
- The UK currently has a very large inshore fleet of under-10 m vessels, distributed widely along the coastline
- During the past ten years, fishing mortality estimates have declined significantly in 67% of assessed fish stocks in UK waters, including important stocks such as North Sea haddock and cod, and northern shelf saithe
- Out of 20 indicator fin-fish stocks in UK waters the proportion being harvested sustainably has risen from around 10% in the early 1990s to around 40% in 2007, while the proportion of stocks with full reproductive capacity has changed little since 1990

- The large majority of scientifically assessed stocks continue to be fished at rates well above the levels expected to provide the highest long-term yield
- The European Commission is developing multi-annual management plans to recover depleted stocks and to manage sustainably-exploited stocks
- From 2003 onwards, multi-annual management plans for cod have impacted a wide range of UK demersal fisheries
- Fishing activity presents the most widespread human pressure in UK waters

i. Introduction

The UK marine fisheries sector comprises all socio-economic activities related to the capture of wild marine organisms (fish and shellfish), and the subsequent handling and processing of catches.

ii. How has the assessment been undertaken?

The International Council for the Exploration of the Sea (ICES) provides scientific assessments on the sustainability of European fish stocks. In addition, various government agencies throughout the UK publish annual statistics on the UK fishing and processing industry. Further data on fish stock abundance and distribution, and on aspects of fishing gear design, come from the Fisheries Science Partnership and the Scottish Industry/Science Partnership both of which have developed increasing time-series of data on fish stocks since *Charting Progress* (Defra, 2005a).

iii. Current and likely future status of the fisheries sector

Catches of fish and shellfish by UK vessels in the CP2 Regions achieved a first-sale value (turnover) of £510 million in 2007 and a GVA of £204[8] million. Shellfish and demersal fish species currently contribute around 40% each to the total market value of catch, with the remaining 20% comprising pelagic species such as mackerel and herring. Secondary activities can be equally important with fish processing from sea fisheries contributing £385 million GVA in 2007.

The NE Atlantic mackerel stock currently supports the most valuable fin-fish fishery in UK waters, operating mainly from Scotland. In Northern Ireland, Wales and the Channel Islands, the most valuable fisheries are for shellfish, reflecting the relatively higher incidence of inshore fishing for crabs, lobsters and other shellfish in these areas.

Seven of the top ten most profitable fleet segments operate in the North Sea and off the west of Scotland. The total profit earned by the UK fleet was around £95 million in 2006 (before interest payments and depreciation). This represented a 24% decline from 2005 despite increased earnings, although 12 out of 27 fleet segments showed increasing profits over this period.

Although commercial fishing makes a relative low contribution to overall Gross Domestic Product (GDP) it is a particularly important socio-economic activity in remote coastal regions in Scotland and south-west England and Wales. The UK catching sector employed almost 13 000 people in 2007 while the processing sector

8 This figure is tentatively based on the value added factor for 2006 due to lack of financial information for 2007.

employed over 18 000 people in 2005. The dependency of jobs on fishing can be as high as 20% or more in some coastal communities.

Substantial declines in the UK fishing industry since the 1990s were largely halted by the early 2000s. Total fishery landings, and employment in the fishing industry, have been fairly stable since then. In particular, the trends in catch composition and catch value for UK fisheries since 2004 indicate a small growth in the shellfish sector, but reduced landings in the pelagic sector. Over the past eight years, the total fishing effort in the international demersal fisheries has fallen by around 30% or more in the North Sea, west of Scotland and the Irish Sea. During the same period, North Sea haddock and cod, and northern-shelf saithe have shown significant declines in fishing mortality. These trends are likely to be due to a combination of EU controls on TACs and effort, and the decommissioning of vessels in the UK and some other countries.

The UK whitefish demersal trawl fleet was reduced by around 15% in size by the two decommissioning schemes in 2001 and 2003, with a particularly large impact on the Scottish fleet. Fleet capacity is currently estimated at 213 thousand tonnes; 6763 commercial fishing vessels (2007).

Out of 20 indicator fin-fish stocks in UK waters, the proportion of stocks being harvested sustainably has risen from around 10% in the early 1990s to around 40% in 2007, while the proportion of stocks with full reproductive capacity has changed little since 1990. Despite a reduction in fishing mortality, the lack of a concomitant increase in reproductive capacity may be due to time lags in the recovery of stock biomass, or environmental factors affecting recruitment.

Overall, the large majority of scientifically assessed stocks continue to be fished at rates well above the levels expected to provide the highest long term yield. The European Commission is developing multi-annual management plans to recover depleted stocks, and to manage stocks sustainably. They seek to restrict fishing mortality rates to the maximum sustainable yield (MSY) by 2015, as required by the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002. Such management plans were initially focused on cod recovery, but have now been extended to a range of other species.

iv. What is driving change?

Profitability has varied widely in the UK catching sector during the 2000s because of a reduction in catch per unit effort, escalating fuel prices, an increase in quota trading, and increases in first-sale prices following the introduction of Buyers and Sellers regulations in 2006.

The demersal fisheries in the North Sea, west of Scotland and the Irish Sea have shifted away from offshore fishing for fin-fish species and towards inshore waters for the very valuable Norway lobster (*Nephrops norvegicus*) and other shellfish and mixed demersal species. This shift has resulted partly from long-term declines in many stocks and associated fishing restrictions, particularly those aimed at cod recovery, as well as the perceived economic opportunities in other fisheries.

v. What are the uncertainties?

ICES Working Groups provide information on a further 23 fin-fish stocks (excluding sharks and skates) harvested by UK fisheries in waters around the UK, but for which it has not been possible to determine stock status relative to

any precautionary reference points. The absence of quantitative advice is due to a number of reasons:

- There are no or currently insufficient assessment data to indicate stock trends (e.g. Rockall cod and whiting, West of Scotland megrim and sandeel, Channel sprat, northern anglerfish).
- The data are inadequate to define the current status relative to precautionary reference points (or no reference points are available) although trends indicate low or declining stock size (e.g. North Sea, Irish Sea and Celtic Sea whiting, west of Scotland herring stocks, Celtic Sea herring, Shetland sandeel).
- The data are inadequate to define current stock status although trends indicate stock size is either stable or has recently been relatively high (e.g. Irish Sea and Celtic Sea haddock, Irish Sea herring, North Sea sprat, Eastern Channel plaice, western anglerfish stocks, western megrim).

vi. Forward look

Since *Charting Progress*, the UK Government and Devolved Administrations have made considerable progress in establishing long-term visions and strategies for sustainable development of the fishing industry and associated activities. This has included further strengthening of the role of the fishing industry in management decisions and collection of data for example through consultation exercises and fishery science partnerships. The identification of target fishing mortality rates and indicators to monitor progress towards MSY will continue development while revisions to the EU Common Fisheries Policy (CFP) will increase the focus on management of fisheries within a broader ecosystem framework.

3.5.2 Introduction

This section provides an overall description of the principal, ancillary and secondary activities of the UK marine fisheries sector, followed by brief descriptions of the management of UK fishing fleets and the types of commercial fishing activity carried out by the UK in the different regional seas covered by *Charting Progress* (Defra, 2005a).

3.5.2.1 Description of economic activities

The UK marine fisheries sector comprises all socio-economic activities related to the capture of wild marine organisms (fish and shellfish), and the subsequent handling and processing of catches (Table 3.32). The principal activity is commercial fishing at sea and on the foreshore by licensed operators. Ancillary activities include businesses directly dependent upon such activities, such as fishing boat construction and maintenance, and the manufacturing and repair of fishing gear. Secondary activities include the processing of catches for human consumption or animal feed, and the retailing of the products. The UK aquaculture sector is described in a Section 3.1 (Aquaculture).

3.5.2.2 Management of the fisheries

The main tool for the management of marine fisheries in European waters is the CFP (ec.europa.eu/fisheries/cfp_en.htm) first introduced in 1983 with a major reform in 2002 and another expected to take effect from 2013 (EC, 2009b). Management policies and measures are described in more detail in Section 3.5.9, including multi-annual management plans for specific stocks. Responsibility for administering and delivering the CFP varies throughout the UK. Fisheries in Scottish territorial waters are managed by Marine Scotland; those in Welsh territorial waters are managed by the Welsh

Table 3.32 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
(SIC 03.11): Inshore and offshore commercial fishing Taking of crustaceans and molluscs Taking of other marine organisms, e.g. algae, sponges, seaweeds	Activities of fisheries enforcement agencies (SIC 84.24) Boat building (SIC 30.12) and maintenance (SIC 33.15) Fishing gear manufacturing, e.g. net makers (SIC13.94) Repair of fishing nets (SIC 33.19)	Fish processing (SIC 10.20) Sale of fish etc. for food (SIC 46.38, 47.23) – fishmongers and fish retailers, supermarkets and other retail outlets	Recreational fishing and associated businesses (see Section 3.6: Leisure and Recreation).

Assembly Government (WAG); those in Northern Ireland are managed within the Executive by the Department of Agriculture and Rural Development (DARD) and those in English inshore waters and other UK offshore waters are managed by the Department for Environment, Food and Rural Affairs (Defra). In Wales, The Marine and Coastal Act will make provisions for the establishment of the 'Welsh Fishing Zone' which will extend from the existing 12 nm Territorial Waters to the Median Line.

Data management

The UK currently has well-developed long-standing programmes of data collection and research to provide the evidence base for effective international and national management of fish and shellfish stocks supporting the UK fishing industry.

These include a wide range of trawl surveys to monitor abundance of commercial and non-commercial demersal species, often carried out collaboratively with other Member States. Other survey methods include the use of hydro-acoustics for herring, egg surveys for mackerel and horse mackerel, and underwater camera surveys for *Nephrops* stocks. In addition, there are extensive programmes of data collection at landing sites and at sea to determine the length and age composition of commercial catches, and the quantities of fish and shellfish discarded at sea. Other sampling programmes are aimed at determining the biological characteristics of stocks such as growth rates and length or age at maturity. The cost of collecting the survey and fishery data has been subsidised by the European Commission since 2002, initially through the EU Data Collection Regulation (DCR; Council Regulation (EC) 1543/2000 and Commission Regulations 1639/2001 and 1581/2004) and from 2009 onwards through the Data Collection Framework (DCF; Commission Regulation (EC) No 665/2008 and Council Decision 2008/949/EC). The DCR and DCF specify the type, amount and quality standards of data that Member States are legally required to collect to ensure an adequate evidence base for implementation of the CFP. In doing so, the new DCF strengthens the collection of socio-economic data on the catching, processing and aquaculture sectors, to provide more highly-resolved catch composition and length frequency data for different components of Member States' fishing fleets, and to collect data to evaluate the impacts of fishing on the ecosystem (www.mfa.gov.uk/statistics/dcf.htm).

Additional data on fish stock abundance and distribution, and on aspects of fishing gear design, come from the Fisheries Science Partnership and the Scottish Industry/Science Partnership both of which have developed increasing time-series of data on fish stocks since *Charting Progress* (Defra, 2005a).

Statistics on the UK fishing and processing industry are published annually by the Marine and Fisheries Agency (MFA) in the *United Kingdom Sea Fisheries Statistics* or released via the statistics section of their web-site (www.mfa.gov.uk/statistics). More detailed information on Scottish fisheries is provided in Scottish Sea Fisheries Statistics 2007 (Scottish Government, 2007) and additional information on Northern Ireland Fisheries is available from DARD. The data on fishing fleets given in MFA's reports are based on the fleet of vessels as registered with the Register of Shipping and Seamen, part of the Maritime and Coastguard Agency, an executive agency of the Department of Transport. The Register of UK commercial fishing vessels can be considered as exhaustive as it is a requirement for a commercial fishing vessel to be registered before it can be active. In addition, with effect from 1993, when vessel licensing in the UK was extended to include those of overall length (LOA) of 10 m and under, all commercial fishing vessels must be both registered and licensed before they can be active. The National Shellfish Licensing Scheme, which came into effect in 2006, requires vessels fishing for crabs and lobsters to be licensed, and a scallop licence was introduced in 1999 for vessels of over 10 m. Vessels fishing for salmon and migratory trout are included under a separate licensing scheme. Descriptions of regional commercial fishing fleets and their activities are made by drawing on a range of additional information, including UK fleet activity databases, Vessel Monitoring System (VMS) data and local knowledge.

The scientific assessment of European stocks is carried out primarily by ICES. The EC also has its own advisory body, the Scientific, Technical and Economic Committee for Fisheries (STECF) whose members (highly qualified scientific personnel particularly in the fields of marine biology, marine ecology, fisheries science, fishing gear technology and fishery economics) are nominated by the Commission based on their competence in their respective field. The STECF reviews ICES advice and conducts specific analyses requested by the Commission. UK scientists are strongly represented in ICES and STECF. Short-term advice on stocks and advice on longer-term management options are based largely on analysis of long time series of fishery and survey data that are now collected within the framework of the EU DCR and DCF, taking into account improvements in understanding obtained through related research and development projects. All the Devolved Administrations support programmes of research and development in areas of marine science that can support both the short-term and longer term development of UK and EU fisheries policy. Programmes of research supporting the CFP are also funded through the EU Framework and Studies programmes, both of which have extensive involvement of UK scientists.

3.5.3 Direct use value

3.5.3.1 Principal activity – catching sector

Pugh (2008) reports that sea fishing is a small and slowly declining part of the UK economy. In 2005 it was about 3.4% of the larger 'agriculture, forestry and fishing' sector, which in turn was about 1% of the total UK economy. However, with a fishing fleet consisting of 12 729 full and part time fishermen (MFA, 2008), fishing remains an important socio-

economic activity for many coastal communities, particularly in the more remote parts of Scotland.

In 2007, the UK commercial marine fishery landed 611 thousand tonnes of fish and shellfish into the UK and abroad, worth almost £650 million at first sale. Of this, £510 million of catch was from the eight CP2 Regions, as determined from the breakdown of catch statistics by ICES rectangles (£133 million came from non-UK waters). Shellfish provide the highest catch values for vessels registered in Wales and Northern Ireland and the Islands, reflecting the relatively higher incidence of inshore fishing for crabs, lobsters and other shellfish and the high proportion of *Nephrops* trawlers in Northern Ireland (Table 3.33). In terms of price fetched per unit weight, shellfish fetched an average first-sale price of £1900 per tonne in 2007 in the UK, compared with £1350 per tonne for demersal fish and £500 per tonne for pelagic fish. The high economic value of shellfish, and the dependency of many remote communities on shellfish fisheries such as for *Nephrops*, crabs, lobsters, scallops and other molluscs, implies that non-sustainable harvesting of these species would have strong economic impacts on many local communities.

The breakdown of the landings by country of vessel registration was Scotland (61%), England (31%), Northern Ireland (6%), Wales (2%) and the Islands (Jersey, Guernsey and the Isle of Man) (<1%). The composition of the UK catch also varied regionally (see Section 3.5.4 for more details).

The collection of economic data on the active UK fishing fleet is carried out by Seafish (The Sea Fish Industry Authority) on behalf of UK Fisheries Administrations. The latest results available from Seafish (Curtis et al., 2009) suggest that despite increases in vessel earnings across a number of segments, rising operating costs and reduced fishing opportunities meant that achieving profitability was still a major challenge for most of the UK fishing fleet in 2007. The following bullet points on the economic performance of the UK catching sector are drawn largely from the Executive Summary and sectoral analyses of the 2009 Seafish report with other trends from the 2008 Report (Anderson et al., 2008). Other sections of the Seafish report should be consulted for detailed performance statistics for individual fleet sectors.

- The total turnover of the UK fishing fleet in 2007 was £645 million, a 6% increase from 2006. This figure comprises landings at home and abroad (from CP2 Regions and all other sea areas fished). Increased earnings since 2006 have been due to increases in prices fetched for catches following the UK-wide introduction of the Registration of Buyers and Sellers (RBS) legislation in January 2006, which helped tackle the issue of under-reported landings.
- Vessel earnings have increased across a number of fleet segments due to improvements in fish availability and prices as well as in development of business management and marketing skills.
- However, most segments of the UK fishing fleet achieved lower average operating profits in 2007 than in 2006. Notable exceptions were the Area VII scallop dredge segment and the North Sea and West of Scotland demersal twin-rig trawl. The fall in operating profit in 2007 relative to 2006 reflects the increase in costs incurred by most segments in 2007.

Table 3.33 Percentage composition of total value of catch taken by vessels registered in different parts of the UK in 2007. Source: MFA (2008). Includes all sea areas.

	England	*Scotland*	*Northern Ireland*	*Wales*	*Islands*	*Total UK*
Demersal	45	35	11	22	24	**37**
Pelagic	16	23	23	2	0	**20**
Shellfish	39	42	66	76	76	**43**

- The total profit generated by the UK fishing fleet was around £95 million in 2006[9] (24% lower than in 2005). Although overall profits declined by 24% between 2005 and 2006, the surveys carried out by Seafish indicated that profits increased between 2005 and 2006 in 12 out of 27 fleet segments. Seven of the top ten most profitable fleet segments operate in the North Sea and West of Scotland.
- The total GVA[10] generated by the UK fishing fleet was estimated to be around £241 million in 2006 (27% less than in 2005)[11].
- The over-40 m UK pelagic fleet targeting species such as mackerel and herring produced the highest average earnings per vessel in 2006 at £4.1 million, and the highest average profit per vessel at £1.57 million.
- North Sea and West of Scotland demersal trawlers (over-24 m vessel length) produced average vessel earnings of £1.2 million in 2007. However profits in this sector declined sharply in 2007 from £163 000 in 2006 to £99 500 in 2007.
- Prior to 2006, Irish Sea demersal trawlers experienced a steady deterioration in earnings, primarily due to cod recovery effort restrictions. Earnings have since increased by 8%.
- North Sea over-10 m *Nephrops* trawlers earned more on average than equivalent West-of-Scotland vessels, which in turn earned more than Irish Sea vessels.
- Beam trawlers target high value species such as sole, but have high running costs. Vessels in the over-300 kW segment of the North Sea beam trawl fleet (the majority of which is foreign-owned) earned on average £1003 700 in 2007, a significant increase of 17% from 2006. In contrast, vessels in the South West beam trawl fleet (over-221 kW and over-30 m segment) experienced a significant decrease in average earnings during the same period, from £747 500 in 2006 to £592 700 in 2007 dropping to levels lower than in 2005 and 2004. This segment had moved from making considerable losses in 2005 to profits in 2006, thanks mainly to improved market prices for key flatfish species.
- Key factors affecting the level of profits are fuel costs and the cost of access to fishing opportunities (e.g. cost of leasing additional quota). During the fuel crisis in 2008, the cost of fuel to fishermen (excluding duty) escalated from 40p per litre to around 60p per litre by July, resulting in the European Commission

9 Before deducting interest and depreciation. No total figure was available for 2007 due to lack of financial information in some sectors.

10 GVA = sum of remuneration of labour (crew share) and profit.

11 The 2006 figures provide a value added factor of almost 40%. If this is applied to 2007 landings values from the CP2 Regions, a rough estimate of £204 million GVA can be provided.

agreeing in principle on the contents of an emergency package of measures to tackle the fuel crisis in the fisheries sector (Seafish, 2008). The total amount spent by the UK fishing fleet on quota leasing in 2007 was around £8 million, with some of the larger vessels spending over £50 000 each.

- Average expenditure increased both in absolute terms and as a proportion of earnings for most segments in 2007. Total expenses as a proportion of earnings varies significantly by segment, ranging from 46% of earnings to more than 100% of earnings, which indicates that some vessels were operating at a loss.
- Vessels using more fuel-intensive fishing methods, such as the otter-trawl and beam trawl segments, experienced the biggest increases in fuel expenditure between 2006 and 2007, while the less fuel-intensive methods, such as seining and passive gear segments, experienced relatively modest increases. In 2007, the proportion of earnings spent on fuel ranged from 26% for large trawlers to 7% for smaller vessels. In 2006, the increase in fuel price and the volatility of fuel price changes had a significant impact on the daily fishing decisions made by skippers, such as where to land, and how often to go to sea. As a result many skippers and vessel owners took positive steps to improve their fuel efficiency, such as gear modifications and reduced towing speeds.
- Quota trading has emerged as an economic activity allowing vessel owners to carry on fishing beyond their existing quota allowance. Since 2001-2002, many vessel owners have increasingly needed either to purchase or to lease additional quota to remain in business. Active vessels usually lease additional quota from owners of inactive vessels. The total amount spent by the UK on quota leasing in 2007 was around £8 million, with some of the larger vessels spending over £50 000 each. The increased expenditure on quota leasing has been particularly acute in the North Sea and west of Scotland demersal trawl fisheries for fin-fish.
- Following the UK-wide introduction of days at sea (DAS) regulations in 2003, which restricted the activities of vessels with certain gear types in the cod recovery zone, a market for the purchase of DAS rapidly developed. While prices for DAS are not set and are simply a reflection of agreements made between fishermen, it is important to note that the price of transferring days is extremely variable due to the demand for particular gear types and the amount of quota allocation held by the vessel. Seafish estimated that the total number of days traded in 2006 was approximately 5500, a decrease of 5% when compared with 2005. The total cost of these transactions to the UK fishing fleet was estimated to be in the region of £1 million, with owners of some vessels in the North Sea and West of Scotland demersal segments spending up to £20 000 on purchasing days at sea in 2006. The average price for a day at sea in 2006 was 35p per kW day.

The certification of sustainable fisheries by the Marine Stewardship Council (MSC) may bring marketing advantages in a climate of increasing public and commercial awareness of sustainability issues, and where there is a desire to source fish and shellfish from environmentally responsible businesses. Currently, there are eight UK fisheries in UK waters with MSC accreditation, including five pelagic fisheries for herring or mackerel, a bass fishery, a *Nephrops* creel fishery, and a cockle fishery. Several fisheries are also undergoing evaluation in the

scheme including the North Sea haddock and *Nephrops* fisheries. Further details are available on the MSC website.

3.5.3.2 Ancillary activities

Ship building

In 2007, the UK had the second largest fishing fleet capacity in the European Union, at 213 thousand tonnes (gross tonnage, GT). The fleet contains vessels that range in size from large pelagic trawlers in the 50 to 80 m length range to the very large fleet of under-10 m inshore vessels. Spain has the largest fleet with 468 thousand GT in 2007. In terms of vessel numbers, the UK is the sixth highest in the EU with 6763 commercial fishing vessels in 2007 compared with the largest EU fleet of 17 600 vessels in Greece. The number and gross tonnage of vessels in the UK fleets has declined by 20% since 1997. From 2004 to 2007, the decline was relatively small at around 4%. England has the largest number of vessels, accounting for almost half of the total UK fleet, while a third of UK vessels are Scottish. However, Scotland has the highest share of capacity (GT), 56%, and power (kW), 47%, compared with 33% and 39%respectively in England. This reflects the larger proportion of the English fleet comprising under-10 m vessels (82%) compared with Scotland (69%; MFA, 2008).

Despite the relatively large size of the UK fleet, the ship-building sector in the UK has declined substantially over time (see Section 3.7: Maritime Transport, and Pugh, 2008), and the majority of large fishing vessels over 20 m long, and part of the under-20 m fleet, are now built in other European countries. Fishing vessels up to around 20 m continue to be built in the UK, mainly in Scotland but also in some other large ports in the UK such as Whitby. Specialised enterprises building a range of small fishing vessels, and maintaining existing fishing vessels, occur all round the UK coast and have a strong local value.

Provision of marine equipment and supplies

The provision of marine equipment and supplies is also a vital industry servicing commercial fishing, although it is difficult to partition the activities and value of this sector between the different marine use sectors (Pugh, 2008).

3.5.3.3. Secondary activities

Processing sector

Processing factories in the UK are widely dispersed around the coast, usually close to landing sites. The largest processors are near major fishing ports in Scotland and Humberside. Provisional data released by the Office for National Statistics (ONS, 2008a) shows that total sales (turnover) by the UK processing sector in 2007 were £2567 million compared with total inputs of £2077 million. These provisional results for the industry indicate a GVA of £490 million. Marine aquaculture contributes 21.4% of the fish (fin and shellfish) supplied to the fish processing sector[12]. Subtracting this proportion provides a total GVA related to sea fisheries of £385 million. In comparison, the GVA for the catching sector in 2006 was estimated by Anderson et al. (2008) to have been £241 million. The latest information on sales indicates that total exports by the fish processing industry in 2007 were worth £601 million, of which nearly 80% were exports to other EU countries.

12 Based on a ratio of total aquaculture production of 166 500 tonnes to total fisheries production of 611 000 tonnes.

3.5.4 Regional distribution

This section provides an initial description of the different activities in the CP2 Regions with a final summary of the catch value obtained in each Region.

3.5.4.1 Regional fisheries descriptions

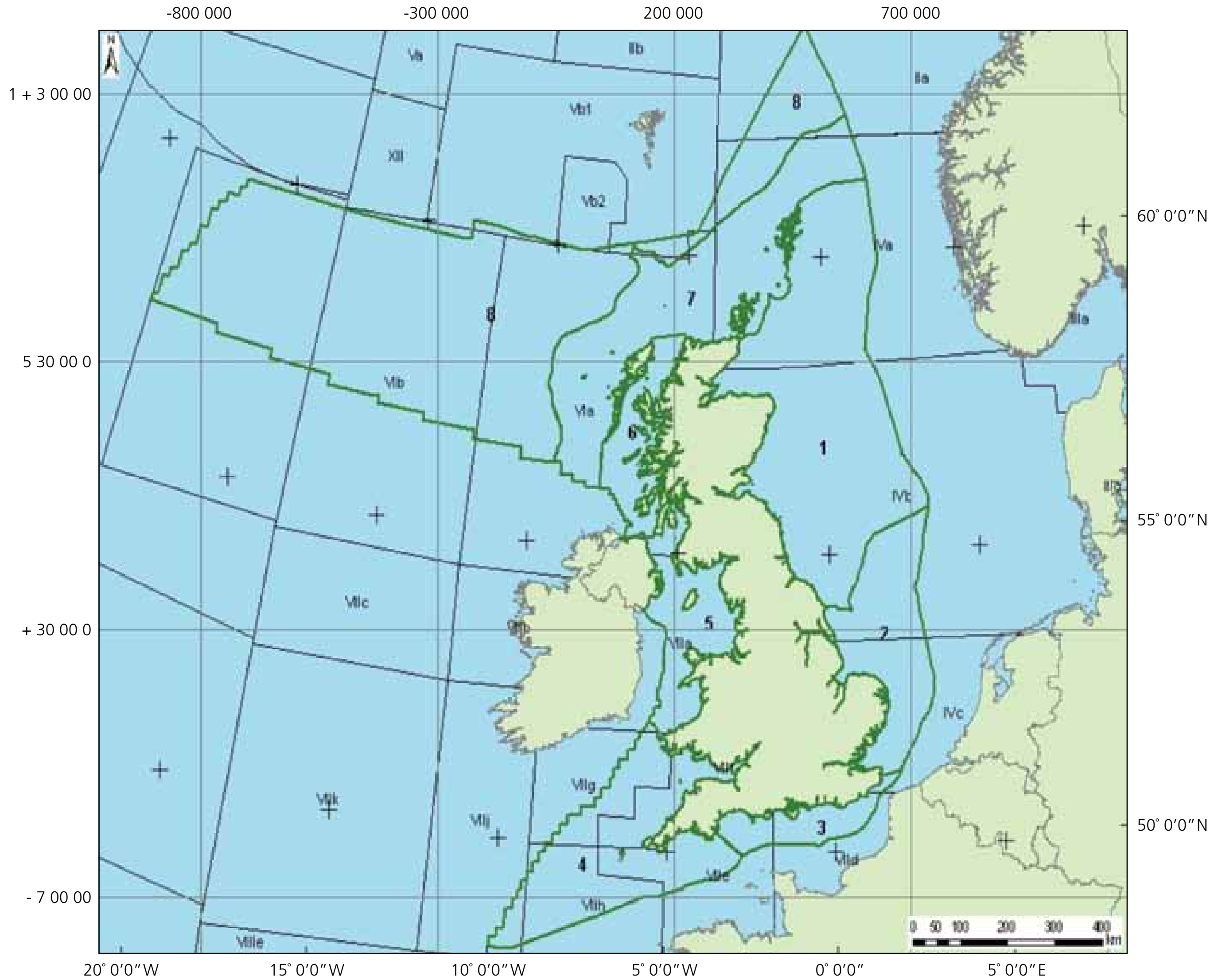
Within the EU Common Fisheries Programme stocks are defined and managed in discrete sea areas based on combinations of ICES divisions. The relationship between CP2 Regions and ICES Areas and Divisions is shown in Figure 3.8. Descriptions of the fisheries are provided below and are principally based on the ICES Areas and Divisions, with an indication of how these relate to the CP2 Regions. Information is provided only for fisheries managed by the UK. Pressures on stocks are generated by fisheries from all Member States operating in each CP2 Region, but given the difficulty of obtaining data on activities of different types of foreign fishing vessels operating inside and outside of UK waters, their activities in CP2 Regions are not covered in the fishery descriptions given below. More detailed descriptions of the fisheries operating from each port in England and Wales are given by Pawson et al. (2002) and Walmsley and Pawsen (2008).

Regions 1, 2, 7 & 8 (North Sea; ICES area IV)

The UK fisheries of the North Sea in Regions 1, 7 & 8 (ICES Divisions IVa and IVb to the north of the Dogger Bank), are mainly conducted by Scottish vessels operating out of ports on the NE and NW coasts, by English vessels operating out of ports on the NE coast of England, and by visiting Northern Ireland vessels. The most valuable UK towed-gear fisheries for demersal roundfish and *Nephrops* in the North Sea take place mainly in the Northern North Sea and Scottish Continental Shelf (Regions 1 & 7). These include bottom otter trawl fisheries using +80 mm mesh mainly for *Nephrops*, and bottom otter trawls, pair trawls, multirig otter trawls and seine nets using +120 mm mesh for demersal fin-fish such as haddock, cod, saithe, whiting, anglerfish, plaice and lemon sole. *Nephrops* support one of the most valuable UK fisheries, and the North Sea fishing grounds for this species are in the Moray Firth and Fladen grounds in ICES Division IVa, and the Firth of Forth and Farn Deeps in IVb (Figure 3.9). Pelagic species (herring, mackerel and horse mackerel) are targeted in the Northern North Sea using midwater otter trawls and pelagic pair trawls. Dredging for scallops takes place along the Scottish east coast, whilst potting for edible crabs is now extensive on the Scottish Continental Shelf (Region 7). Smaller scale inshore fisheries for a variety of shellfish species occur all around the northern parts of UK North Sea coast.

In the shallower Southern North Sea (Region 2), the majority of UK fishing effort is by English vessels and 'flag vessels' from other Member States operating under UK quotas. A UK beam trawl fishery for sole in the Southern North Sea using +100 mm meshes involves Anglo-Dutch vessels landing mainly into the Netherlands, while English beam trawlers typically using 80 mm mesh land into the UK. A small UK fishery for brown shrimp (*Crangon* species) takes place as a component of a larger international fishery in the Southern North Sea using fine mesh beam trawls which also take a by catch of small demersal roundfish and flatfish. A fleet of vessels including many under-10 m vessels deploys a variety of gears including otter trawls, gillnets, trammel nets and longlines to target sole, bass, cod, rays, anglerfish and other demersal species according to target species, season and area fished. Seasonal fisheries for herring take place, including in the Thames

Figure 3.8 UK Continental Shelf with CP2 Regions and ICES Areas and Divisions. Region 1: Northern North Sea; Region 2: Southern North Sea; Region 3: Eastern Channel; Region 4: Western Channel and Celtic Sea; Region 5: Irish Sea; Region 6: Minches and Western Scotland; Region 7: Scottish Continental Shelf; Region 8: Atlantic North-West Approaches.

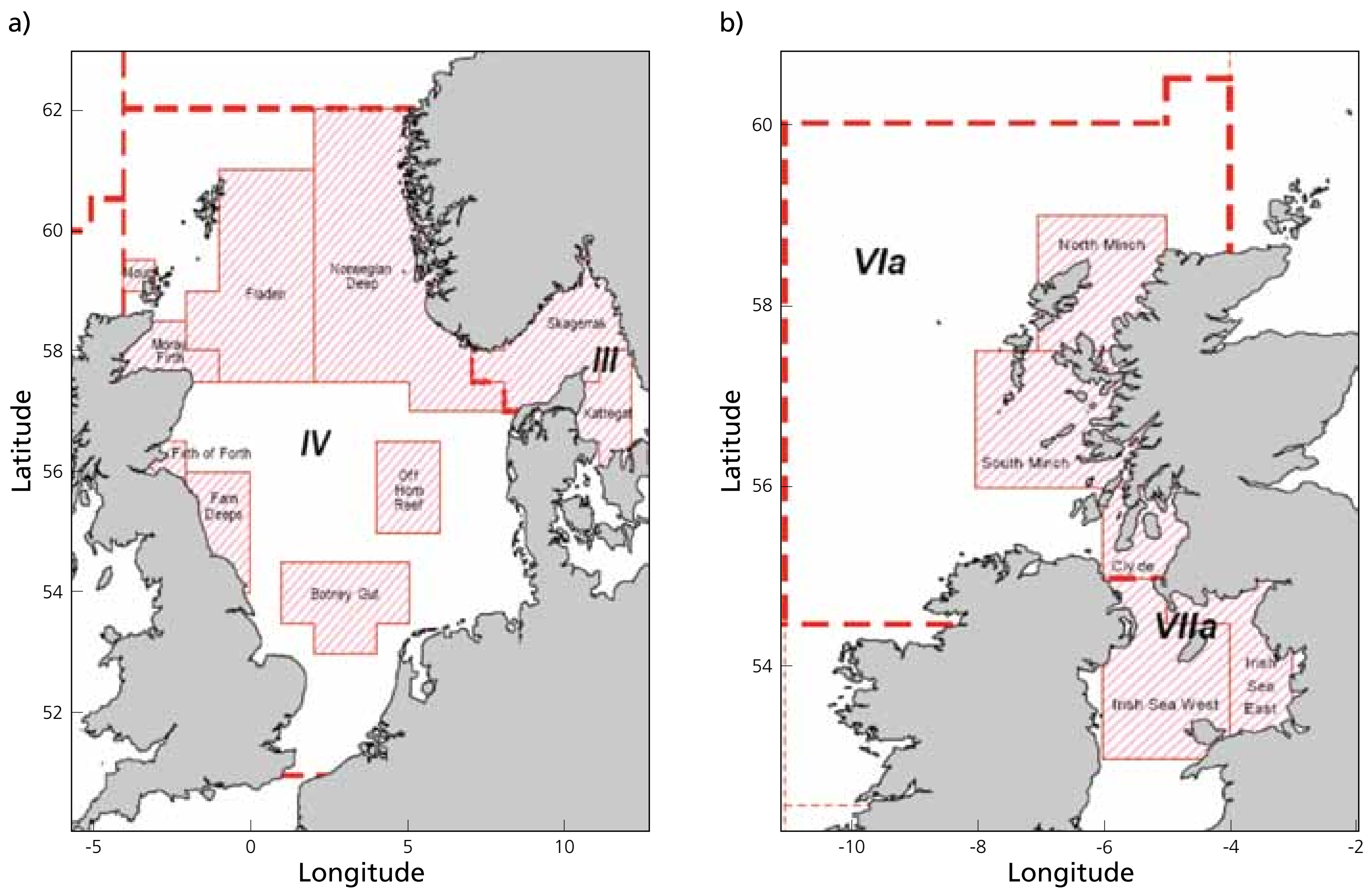


Estuary. Pot fisheries for crabs and lobsters occur along the coastline and offshore, and specialist inshore fisheries for cockles and other bivalves occur in the Wash and Thames estuary.

Region 3 (Eastern Channel; ICES Division VIId and part of VIIe)

In the Eastern Channel (VIId) the main UK fisheries are small-scale fisheries working within the coastal zone (0 to 12 nautical miles), and include many under-10 m vessels. Beam trawl fisheries target sole and take a plaice by-catch; trammel nets and otter trawls are also used to catch sole. Cod are caught by bottom otter

Figure 3.9 Distribution of Nephrops *stocks in (a) the North Sea, and (b) to the west of Scotland and in the Irish Sea. Source: ICES (2008a,b).*



trawlers and inshore gill-netters. Whiting are also caught. During the winter there is a pelagic fishery for herring. There are also longline fisheries for dogfish, conger eel, bass and ling; a dredge fishery for scallops and pot fisheries for whelks, cuttlefish, crabs and lobsters. Shellfish form an important part of the inshore fishery catches throughout the English Channel. Specialist inshore fisheries in this Region include dredge fisheries for oysters and various clams in the Solent and Poole Harbour (which lies on the border of VIId and VIIe).

Region 4 (Western Channel and Celtic Sea; ICES Division VIIe, f, g and h)

The two most valuable UK fisheries in VIIe are beam trawling for demersal fish and cuttlefish, and pot fishing for crabs and lobsters. The main target for beam trawlers from Brixham and Plymouth is sole, however there is a high diversity of species caught with very significant contributions from cuttlefish, lemon sole, anglerfish, scallops and smaller quantities of high value species such as John Dory, brill and turbot. Cuttlefish are caught mainly in winter.

A beam trawl fishery from Newlyn in VIIe-h targets megrim and anglerfish with by-catches of sole. Bottom otter trawlers using 70 to 89 mm

mesh nets target squid and cuttlefish mainly during autumn and winter and lemon sole in winter to spring, but also land a wide variety of demersal species, including bass and John Dory. A number of these vessels can change over to scallop dredging if the availability/ price of scallops is advantageous. There are also pelagic trawl fisheries for mackerel, sprat and bass, a ring-net fishery for pilchards and a dredge fishery for scallops and clams. A variety of set gillnets are deployed to catch spider crabs, pollack, anglerfish, ling, rays and other mixed demersal fish. Individual vessels may deploy a variety of gillnets during a trip. Handline fisheries target mainly mackerel and bass. Specialist inshore shellfisheries fisheries are relatively limited, although a non-powered (oars or sail power only) fishery for oysters in the Fal estuary provides part-time employment for a number of licence holders.

As in the Western Channel, the two most valuable UK fisheries in the Celtic Sea (VIIf, g and h) are beam trawling for demersal fish, and pot fishing for crabs, lobsters and whelks. Three ICES rectangles covering the cod spawning grounds in Divisions VIIf and g are closed to fishing during February and March. This also impacts the Dover Sole fishery which mainly takes place in spring in this area. Inshore in the Celtic Sea, there are a wide variety of fisheries for shellfish including crabs, lobsters, cockles, whelks and razor clams. These tend to be pot or creel based fisheries. Only one vessel occasionally fishes for razor clams. A component of the UK beam trawl fleet targets anglerfish, megrim and other benthic fish species in offshore waters, and also catches sole. Bottom otter trawls using 70 to 89 mm and +100 mm nets target, rays and other mixed demersal species including squid when seasonally available. Some trawling for bass also takes place. A small fleet of midwater otter trawl and pair trawl vessels target mackerel and horse mackerel in areas outside the mackerel box, an area with high abundances of juvenile mackerel that is closed to all forms of mackerel fishing using towed gears.

A variety of set gillnets are shot in the Celtic Sea by individual vessels near wrecks, reefs and other grounds to catch pollack, hake, anglerfish, ling, spider crabs, cod, rays and other mixed demersal fish. There is an important summer fishery for turbot using tangle gear. The hand and pole fishery for fin-fish is mainly a fishery for mackerel, and also for bass and pollack.

Region 5 (Irish Sea; ICES Division VIIa)

The largest and most valuable fishery in the Irish Sea is for *Nephrops* and is prosecuted by a fleet using single and twin trawls with 70 to 99 mm mesh. This fishery occurs predominantly in the muddy area west of the Isle of Man, with a smaller fishery taking place off the coast of Cumbria in the eastern Irish Sea. The *Nephrops* fishery also takes by-catches of whiting, haddock, cod and plaice. Most whiting are discarded due to size and low market value. Landings of whiting have declined precipitously since the 1980s and now amount to only a few hundred tonnes per year throughout the Irish Sea. Some bottom otter trawl vessels target plaice and other small demersal fish using 70 to 99 mm mesh during summer.

Vessels using midwater otter trawls with +100 mm mesh were an important part of the Northern Ireland fleet in the 1980s and 1990s, and seasonally targeted cod, hake and haddock particularly in the North Channel and the deeper waters of the Irish Sea. This fleet has declined substantially in recent years due to reduced cod catches, restrictions on activities caused by the cod recovery plan, and switching of vessels into the more valuable *Nephrops* fishery. A large part of the western Irish Sea is closed to demersal

whitefish trawling from 15 February to the end of April, to help conserve cod. This closure commenced in 2000, and also included part of the eastern Irish Sea in that year.

The Irish Sea beam trawl fishery for sole is currently of minor interest for UK vessels and is prosecuted mainly by Belgian and Irish beam trawlers. Inshore, gillnets and tangle nets are used to catch cod, bass, grey mullet, sole and plaice. Valuable pot fisheries for crab, lobster and whelk take place inshore and there are small-scale fisheries for shrimps. There are also hydraulic dredge fisheries for razor clams and dredge fisheries for scallops and shore-based fisheries for cockles which can be economically very significant at the national level in some years. On a UK level, cockles were estimated to be worth 6.7 million in 2007 (MFA, 2008, see Box 3.1 for an example of the Burry Inlet cockle fishery). The main pelagic fishery in the Irish Sea is for herring and involves mainly pair trawlers from Northern Ireland. The number of such vessels has declined to very low levels in recent years. A small drift net fishery for spawning herring takes place intermittently off the Mourne coast.

Regions 6, 7 & 8 (ICES Sub-Area VI and Division Vb)

Regions 6, 7 & 8 contain some of the most remote fishing communities in the UK, and the varied coastlines of Scotland and Northern Ireland support a range of inshore fisheries for shellfish and fin-fish. Inshore waters of this region also support the bulk of the UK's aquaculture industry, consisting predominantly of salmon and shellfish farms (mainly mussels). Inshore rocky areas support a widespread crustacean (lobster and crab) potting fishery – mainly fished by under-10 m boats. The majority of UK vessels in the demersal fisheries are locally-based Scottish bottom trawlers. The main trawl fisheries have traditionally taken a mixture of species including gadoids (e.g. cod, haddock and whiting) plus anglerfish, megrim and *Nephrops*. Some saithe and lemon sole are also taken. Although seine netting, mainly targeting haddock, was an important Scottish fishery in the past, most of the seiners have converted to otter trawl (single or twin rig) and have moved to deeper waters to target anglerfish with a by-catch of megrim, ling and tusk. Along the shelf edge, anglerfish, megrim and hake are the subject of more specialised targeted fisheries by the largest whitefish vessels fishing with 120 mm mesh sizes.

The *Nephrops* fishery in the North and South Minches and in the Clyde is conducted by vessels using 80 to 99 mm mesh size, and includes under-10 m vessels fishing in coastal waters. There is also a significant static gear (creel) fishery for *Nephrops*. Pelagic fisheries for herring, mackerel and horse mackerel take place using pelagic pair trawl or single boat mid-water trawl. A deeper-water fishery for blue whiting takes place along the edge of the continental shelf.

At Rockall, there is a targeted fishery for haddock by Scottish and Irish trawlers (and Russian vessels in adjacent international waters). In the 1990s, some Scottish vessels diverted their activity towards deep-water fisheries including species such as orange roughy (*Hoplostethus atlanticus*), tusk, roundnose grenadier (*Coryphaenoides rupestris*) and black scabbardfish (*Aphanopus carbo*) but unfavourable quota opportunities in recent times have all but stopped this activity.

Box 3.1:
Burry Inlet Shellfishery

Location and history

Burry Inlet Estuary is located in South Wales near the towns of Llanelli and Swansea. The Burry Inlet Cockle Fishery has provided a traditional source of food and employment for the local area since Roman and Mediaeval times. Traditionally women collected around 100 to 150 kg per day using donkeys to transport the cockles to shore. In the 1920s horse-drawn carts enabled gatherers to collect up to 500 kg per day. In 1921, the South Wales Sea Fisheries Committee (SWSFC) introduced a minimum landing size to protect spawning stocks.

Assessment of stock status

The cockle stock within the Burry Inlet is considered a discrete self-recruiting management unit and the status of the stock is monitored by the Cefas Shellfish Resource team, which conducts biannual (November and April/May) surveys to assess stock status and fishable biomass. During these surveys cockle numbers, weight, length and age are recorded along permanent transects; additional transects can be conducted in other areas where cockles are considered to have settled. The results of these surveys are used to set quotas which represent around 30% of the fishable biomass, with the broad aim of ensuring that enough cockles remain to act as a spawning stock, to provide food for oystercatchers and other wading birds and to support the Burry Inlet ecosystem.

Recent status

In recent years, including 2008, there have been high levels of mortality of adult cockles during the summer. The cause of the high mortality is not certain but contributing factors may include high parasite loadings, substantial leakage of sewage into the estuary, high temperatures and exceptionally high densities of cockles.

In 2004, the amount of shellfish harvested fell to 1469 tonnes (compared to an average of around 3200 tonnes between 1993 and 2003 – calculated from landing statistics on the SWSFC website) and between February and March 2005, the fishery was closed due to low availability of adult cockles. High cockle mortality in June and July 2005 resulted in over 80% of an estimated 15 000 tonnes of stock being lost[13]. Landing statistics from the SWSFC website show that 1077 tonnes and 688 tonnes were landed in 2006 and 2007 respectively (www.swsfc.org.uk/home.htm, accessed 4 August 2009).

Management

The SWSFC is responsible for administering the Burry Inlet Cockle Fishery which has been controlled since the 1960s through the application of the Burry Inlet Cockle Order 1965. This Regulating Order, established under the 1967 Sea Fisheries (Shellfish) Act, allows the SWSFC to regulate commercial gathering through a licensing system and daily quotas. Since 1965, the number of licences has varied between 43 and 67 and quotas are set as a daily weight limit per gatherer and can be up to 300 kg in winter and 850 kg in summer (based on the results of the stock assessments) (Moody Marine Ltd, 2009). Management advice is implemented through adjustment of the daily quota per gatherer, changes to the minimum mesh size and through closure of all, or selected zones, of the fishery, while ongoing management is informed by feedback from gatherers, landings and fisheries officers.

13 http://online.carmarthenshire.gov.uk/agendas/eng/SJSC20070112/REP04_01.HTM

The cockles are gathered by hand, using rakes for the collection of the cockles and 'riddling' on mesh of specified size to ensure retention of cockles above the minimum landing size. Compliance with the minimum landing size is checked by SWSFC enforcement officers.

Local byelaws within the SWSFC district enable the following controls:

- Commercial gathering of cockles by licence holders only
- Hand-gathering only
- Minimum landing size (normally 19 mm but sometimes reduced to 17.5 mm to allow harvest of undersize cockles on dense beds to promote growth and avoid density-dependent mortality)
- Prohibition of gathering at night and on Sundays
- Limiting gathering to one low tide per day when required
- Re-deposition of illegally taken cockles
- Temporary closure of cockle beds for management purposes
- Limitations of use of vehicles on the shore (prior permission required).

The Burry Inlet cockle fishery received Marine Stewardship Council accreditation as a sustainable fishery in April 2001 and was re-certified in February 2007.

3.5.4.2 Regional distribution of economic value

Table 3.34 summarises the regional catch by gear type in 2007. The catches by UK vessels in the Northern North Sea (Region 1), the Minches and Western Scotland (Region 6) and the northern Scottish Continental Shelf (Region 7) totalled £332 million; 65% of the total first-sale value of fish and shellfish caught by UK vessels. The Southern North Sea (Region 2) and Eastern Channel (Regions 2 & 3) together provided 13% of the total catch value, while the Irish Sea (Region 5) and Western Sea and Celtic Sea (Region 4) provided 10% and 9% respectively.

Towed nets and seines pull in the greatest first-sale value in each Region contributing 70% overall. Fishing sectors using pots and traps (mainly for crabs and lobsters) provide the second highest overall economic return. Dredges and pumps are used primarily for molluscs such as scallops and cockles, and provided about 7% of the total UK first-sale value in 2007. Fixed nets and various types of fishing with lines provided around 5%, and were relatively most important in the English Channel, Celtic Sea, off the north of Scotland and in areas beyond the CP2 Regions.

A more highly resolved image of spatial variations in catch value is given by Dunstone (2008) using spatial effort data based on Vessel Monitoring System (VMS) position data for vessels over 15 m long, and reported ICES rectangle positions for non-VMS vessels under 15 m long, and catch value by rectangle (Figure 3.10).

Figure 3.10 shows the very patchy distribution of catch value which tends to be relatively high in coastal areas around the mainland and offshore islands where there are valuable fisheries for shellfish such as crabs, lobsters, *Nephrops* and

Figure 3.10a Spatial distribution of the annual mean value of all UK fish landings in 2004-2007 based on VMS position data and ICES rectangle data on catch value for VMS vessels.

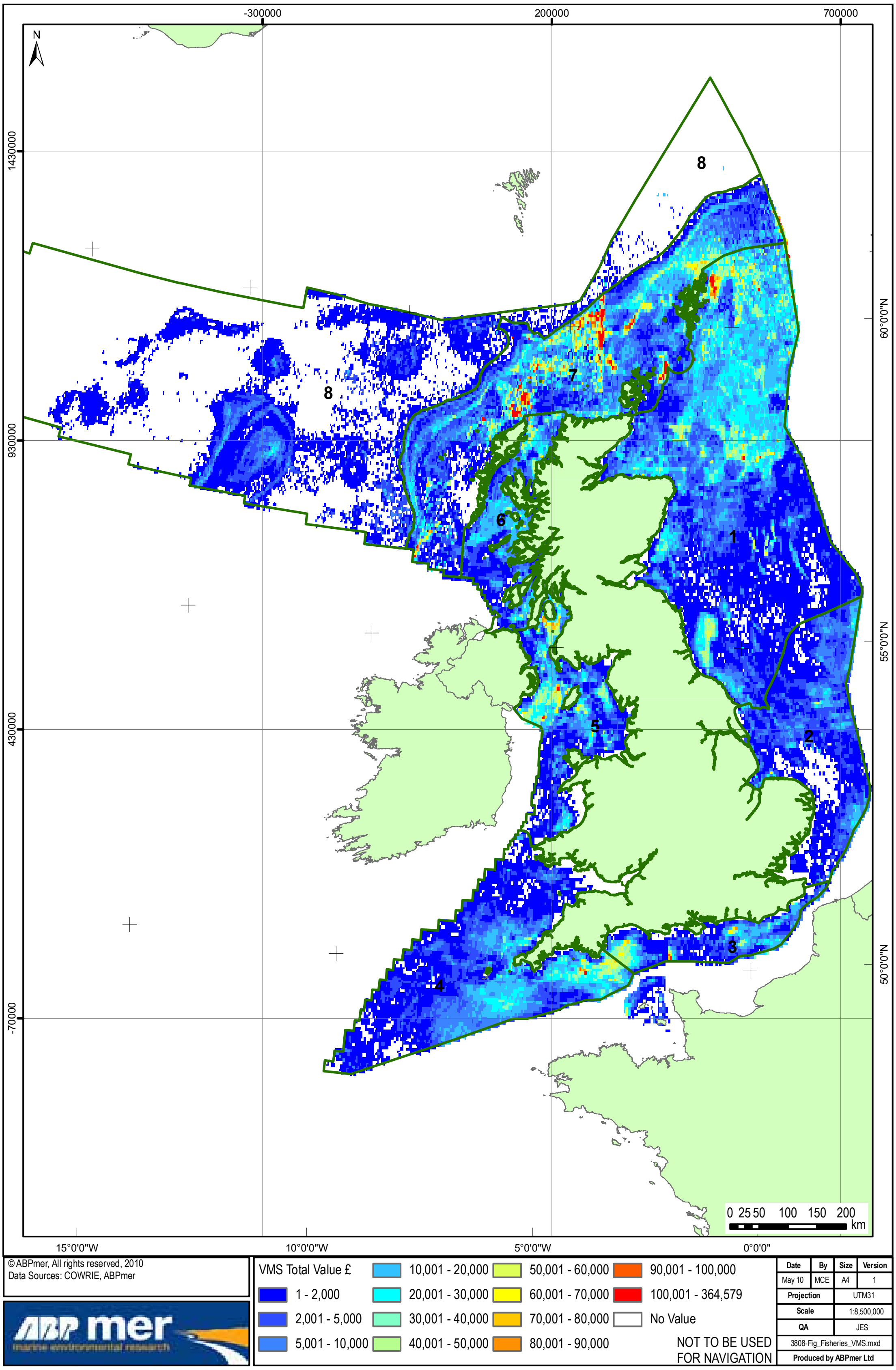


Figure 3.10b Spatial distribution of the annual mean value of all UK fish landings in 2004-2007 for non-VMS vessels, based on ICES rectangle data on catch value.

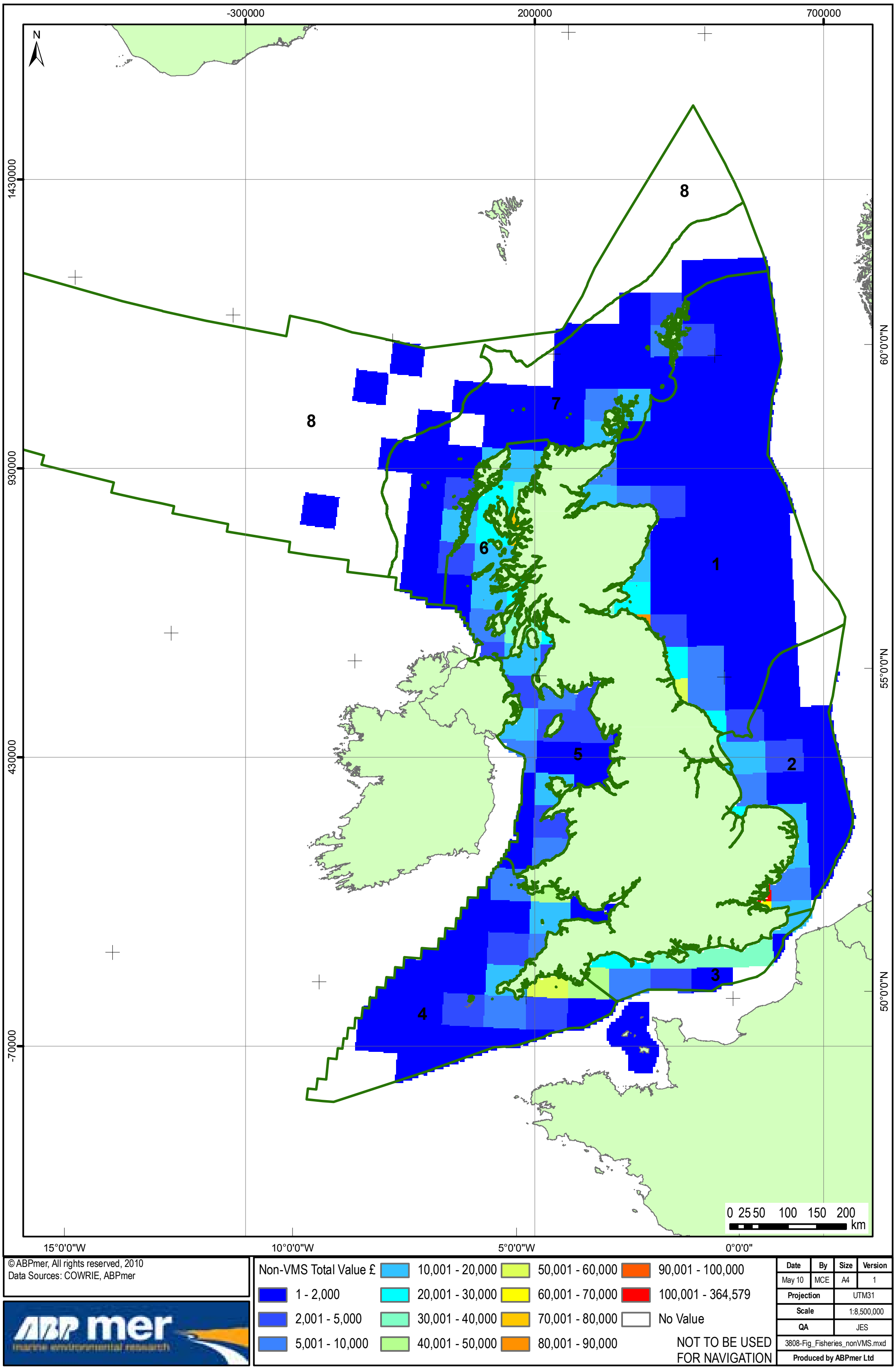


Table 3.34 First-sale value of fish and shellfish landings into the UK and abroad by UK vessels in 2007, by CP2 Region and type of fishing gear.

CP2 Region (source of catch)	*Towed nets and seines*	*Pots and traps*	*Dredge, pumps*	*Fixed nets; lines*	*other gears*	**Total**
First-sale value, £ million						
Northern North Sea	140.3	13.7	8.8	0.5	0.04	**163.3**
Southern North Sea	12	8.3	0.4	1.8	0	**22.5**
Eastern Channel	18.6	10.9	8.5	5.6	0.2	**43.8**
Western Channel and Celtic Sea	24.4	11.6	3.2	8.3	0.63	**48.1**
Irish Sea	31.3	10.2	10.5	0.4	0.3	**52.7**
Minches and Western Scotland	24.5	20.6	3.2	0.1	0.77	**49.2**
Scottish Continental Shelf	97.9	14.9	2.2	4.4	0.49	**119.9**
Atlantic North-West Approaches	9.2	0.4	0	0.7	0	**10.3**
Total	**358.2**	**90.6**	**36.8**	**21.8**	**2.43**	**509.8**
First-sale value, percentage[a]						
Northern North Sea	27.5	2.7	1.7	0.1	0	**32.0**
Southern North Sea	2.4	1.6	0.1	0.4	0	**4.4**
Eastern Channel	3.6	2.1	1.7	1.1	0	**8.6**
Western Channel and Celtic Sea	4.8	2.3	0.6	1.6	0.1	**9.4**
Irish Sea	6.1	2.0	2.1	0.1	0.1	**10.3**
Minches and Western Scotland	4.8	4.0	0.6	0	0.2	**9.6**
Scottish Continental Shelf	19.2	2.9	0.4	0.9	0.1	**23.5**
Atlantic North-West Approaches	1.8	0.1	0	0.1	0	**2.0**
Total	**70.3**	**17.8**	**7.2**	**4.3**	**0.5**	**100.0**

[a] Source: UK IFISH 2 database.

scallops, and fisheries for high-value species such as sole in the Western Channel and outer Thames Estuary. Other patterns of catch value are evident, including elevated values along the shelf edge in Region 7 (Scottish Continental Shelf) where valuable trawl fisheries for anglerfish and other demersal species take place, and generally elevated values in the northern half of Region 1 (Northern North Sea) where predominantly Scottish trawl fisheries for *Nephrops*, haddock and other demersal species take place.

As a further example, stocks of the burrowing decapod crustacean *Nephrops norvegicus* in the North Sea, west of Scotland and Irish Sea (Regions 1, 5 & 6) support some of the most valuable UK towed-gear fisheries as well as some localised creel fisheries. The distribution of the main stocks is shown in Figure 3.9.

3.5.5 Trends

3.5.5.1 Management trends

Significant developments have occurred in European fisheries management since *Charting Progress*, with increasing development of recovery plans and management plans within the CFP, and improved enforcement of fisheries regulations. The development of multi-annual management plans is in line with European commitments to the World Summit on Sustainable Development in 2002, which requires restoring fish stocks to levels giving maximum sustainable yield by 2015. The CFP is currently undergoing a review following the previous review in 2002.

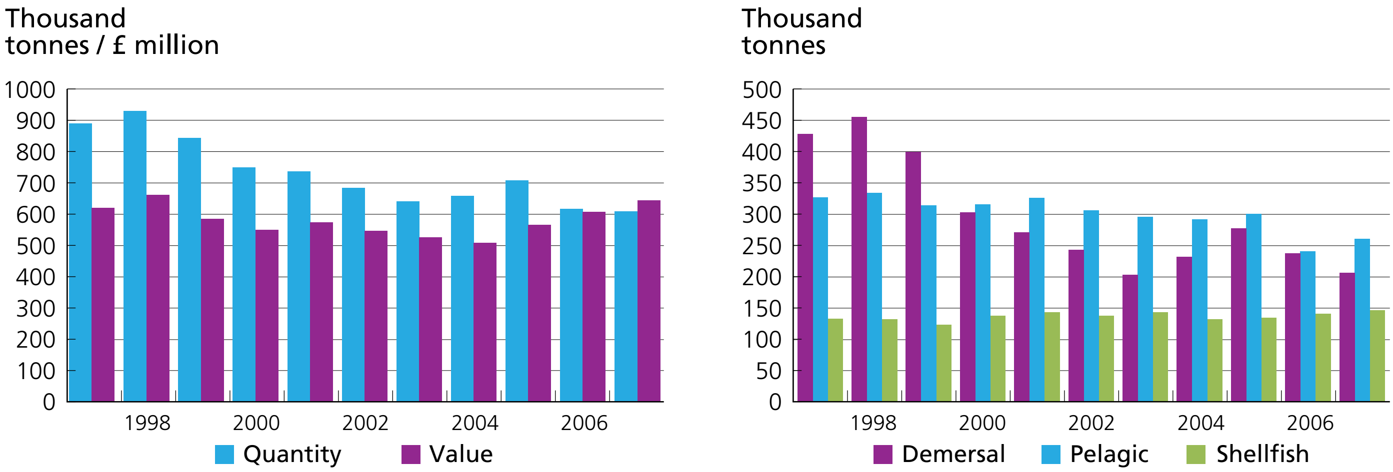
Within the UK, the Devolved Administrations have made considerable progress since *Charting Progress* in establishing long-term visions and strategies for sustainable development of the UK fishing industry and associated activities. This has included further strengthening of the role of the fishing industry in management decisions and collection of data. There have been several important schemes initiated or developed in collaboration with fishermen since *Charting Progress*, such as the Scottish Conservation Credits Scheme, which aims to improve conservation of cod while reducing socio-economic impacts of EU regulations, and the Environmentally Responsible Fishing (ERF) pilot project in England and the Irish Sea Data Enhancement Pilot Project which aim to improve the evidence base for developing more targeted management measures. Collaborative programmes between fishermen and scientists are continuing to develop fishing gear designs to improve selectivity and reduce catches of critical species such as cod, and some important advances have occurred since *Charting Progress*. An example is the trials in the North Sea of the US-designed 'Eliminator' trawl carried out on UK vessels in 2007 and 2008, which demonstrated substantial reductions in cod catch while maintaining similar catch rates of haddock compared to a standard control trawl (Revill and Doran, 2008).

3.5.5.2 Trends in landings and economic value

Total landings by UK vessels into the UK and abroad have declined by a third since the late 1990s, although first-sale value declined from around £650 million in 1998 to around £500 million in 2004 before recovering to over £600 million by 2007 (Figure 3.11). Shellfish landings have been stable since the late 1980s, whereas landings of demersal species declined by around 50% between 1998 and 2003.

The Cabinet Office (2004) concluded that the pelagic fishing sector at that time was in good health while the whitefish sector was suffering greatly. In contrast, the over-10 m fixed and mobile gear shellfish sector was strong, catching high-value species such as *Nephrops*, scallops and crabs. The picture for the inshore/under-10 m sector, which contains the bulk of employment in the fishing industry, was more varied. Profitability appeared mixed, but the sector had the advantage of the ability to provide fresh produce to local consumers, and, in line with the shellfish sector, there was greater economic flexibility with lower levels of invested capital, less requirement on crew labour, and lower fixed costs (Cabinet Office, 2004). The trends in catch composition and catch value for UK fisheries since 2004 indicate a small growth in the shellfish sector, but reduced landings in the pelagic sector (Figure 3.11).

Figure 3.11 Trends in landings and first-sale value of shellfish, pelagic and demersal species landed by UK vessels into the UK and abroad. Reproduced from MFA (2008).



3.5.5.3 Trends in fishing effort

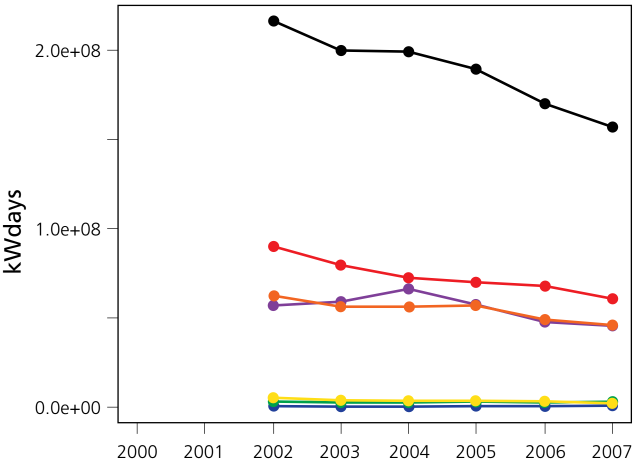
The impact of fishing on fish stocks should be related to the amount of fishing taking place in each CP2 Region, as well as the efficiency and selectivity of the gear and the species targeting patterns. Data compiled by STECF (2008) provide a comprehensive picture of effort by EU Member States operating in the various regional seas. Some care is required when interpreting apparent short-term changes (e.g. in Figure 3.12 the sharp drop in the unidentified 'none' category between 2002 and 2003 arises from an inability to fully partition Irish effort by mesh-band prior to 2003). However the information is useful for showing gross changes over time.

In the North Sea and Eastern Channel (Regions 1, 2 & 3, and Eastern parts of 7 & 8), the total fishing effort (kW days) of the international fishing fleets has declined by around 27% since 2002 (Figure 3.12). The bulk of this decline is attributed to otter trawls targeting fish such as cod and haddock. Declines in overall fishing effort have also been observed in the Irish Sea and to the West of Scotland where the drop is particularly large. In contrast, fishing effort in the Western Channel (components of Regions 3 & 4) and Celtic Sea (Region 4) appears to have increased since 2000.

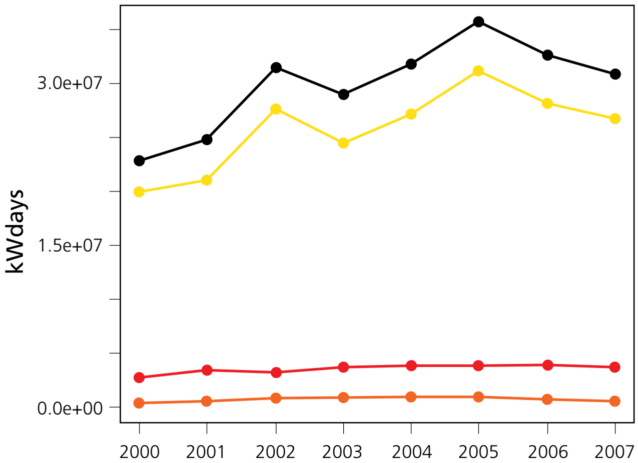
The UK has been a leading European player in carrying out schemes to reduce fleet capacity through decommissioning of vessels. From 1997 to 2007, 380 vessels totalling 127 067 kW of power and 40 452 gross tonnes of vessel capacity were removed from the UK fishing fleet by decommissioning exercises, representing 12% and 15% respectively of the UK total fleet capacity. While earlier exercises were targeted to achieve a general reduction of fleet capacity, exercises carried out in 2003 were targeted to achieve reductions in the UK demersal fleets whose activities were a major contributor to cod mortality. To illustrate this, the 2003 exercise resulted in the removal of 45 000 kW and 16 700 gross tonnes of capacity from the UK fleet, of which over 70% was from the Scottish offshore demersal fleet. The decommissioning of Scottish trawlers has been the most likely cause of a substantial reduction in fishing mortality on North Sea haddock, a stock exploited mainly

Figure 3.12 Trends in fishing effort by CP2 Region. Source: STECF (2008).

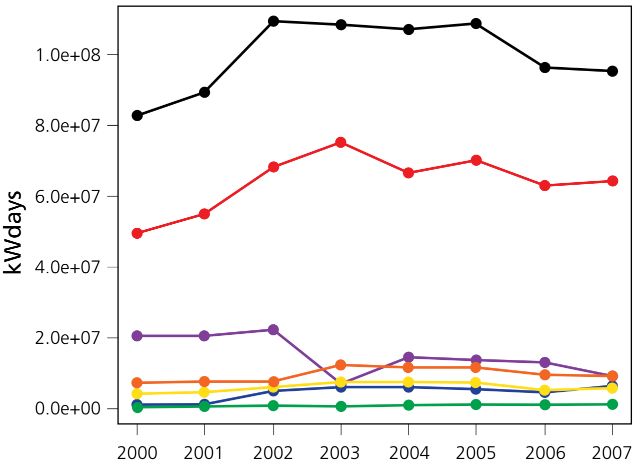
a) North Sea & Eastern Channel (Regions 1, 2, 3; eastern parts of 7 & 8)



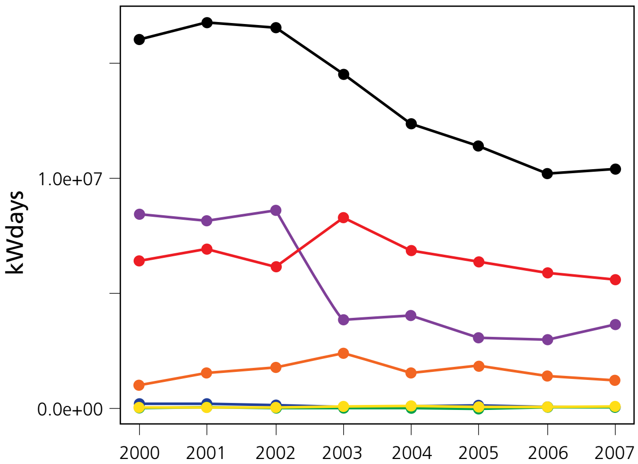
b) Western Channel (parts of Regions 3 & 4)



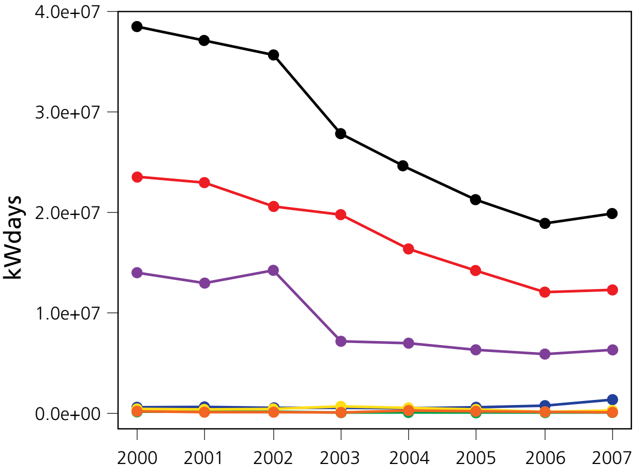
c) Celtic Sea (part of Region 4)



d) Irish Sea (Region 5)



e) West Scotland (Region 6, and western parts of 7 & 8)



KEY

- Total
- Trawls, seines and similar (including dredges)
- Beam trawls
- Gillnets or entangling nets
- Trammel nets
- Longlines
- none

Note: Irish effort data up to 2002 are not split by mesh size and are included in the category "none".

by Scotland. This stock is currently being fished close to the long-term EU-Norway target for sustainable fishing mortality.

Since 2003 there have been two separate decommissioning exercises. In 2007, an exercise was carried out to remove beam trawl effort associated with the Western Channel (ICES Area VIIe) sole fishery as part of the UK response to the introduction of the EU management plan for this stock. This resulted in the removal of a further eight vessels representing 1578 gross tonnes and 6787 kW of capacity from the English beam trawl fleet. An exercise was being carried out in 2009 to decommission vessels from the English inshore fleet (i.e. those fishing vessels of 10 m and under overall length) in response to pressures of limited quota availability for these vessels in certain fisheries. It was estimated that the £5 million of funding available for this scheme could result in approximately 60 to 70 vessels being removed from the UK fleet. Over the seven-year period from 1992 to 1998, there were six decommissioning rounds in Northern Ireland. These removed 56 vessels from the fleet traditionally associated with *Nephrops* fishing, leaving a fleet of 174 vessels at the end of December 1998. Further fleet reductions left 108 vessels of over 10 m in overall length in 2005 capable of fishing for *Nephrops* of which roughly 50 work twin trawls for part of the year.

3.5.5.4 Trends in fish stock abundance and fishing mortality

The annual advice on stock trends and status provided by ICES to the European Commission is mainly based, where data permit, on a combined analysis of survey and fishery data, and includes information on trends in catches, spawning stock biomass (SSB), recruitment of young fish, and fishing mortality. Full analytical assessments, including trends in SSB and fishing mortality in relation to precautionary and limit reference points, is available for around 20 fish stocks in UK waters, and these are plotted in Figures 3.13, 3.14, 3.15 and 3.16 for assessments conducted in 2008. Less comprehensive information is available for other stocks depending on the type of data available, and the trends in some other stocks are considered by ICES to be unreliable due to difficulties encountered in determining stock status based on available data.

Several stocks with full analytical assessments have shown marked long-term declines in fishing mortality such as North Sea haddock (Figure 3.13), west Scotland and North Sea saithe (Figure 3.14) and Irish Sea plaice (Figure 3.15). Fishing effort in these fisheries has declined significantly – in the case of North Sea haddock which is fished mainly by Scotland, the substantial decommissioning of Scottish trawlers is likely to have had a large impact. In the Irish Sea, a long-term decline in the English trawl fleet is likely to have been a major factor in the substantial reduction in fishing mortality on plaice. Recent declines in estimates of fishing mortality are apparent for a number of other stocks, including cod in the North Sea and Celtic Sea (Figures 3.13 and 3.15), haddock at Rockall (Figure 3.14) and sole in the Celtic Sea (Figure 3.15). Recent trends in fishing mortality are technically difficult to determine accurately, and future assessments may revise the trends observed in some stocks (see full assessment results on the ICES website). A recently introduced process of bench-marking of ICES stock assessments, which commenced for selected stocks in 2009, could lead to changes in perceived stock status through revisions to input data, model assumptions or biological reference points.

Figure 3.13 Long-term trends in spawning stock biomass (SSB) and fishing mortality (F) for five North Sea and Eastern Channel (Regions 1, 2, 3, 7 & 8) fish stocks. The precautionary reference point for SSB (Bpa) and fishing mortality (Fpa) is shown as a horizontal red line. Source: ICES.

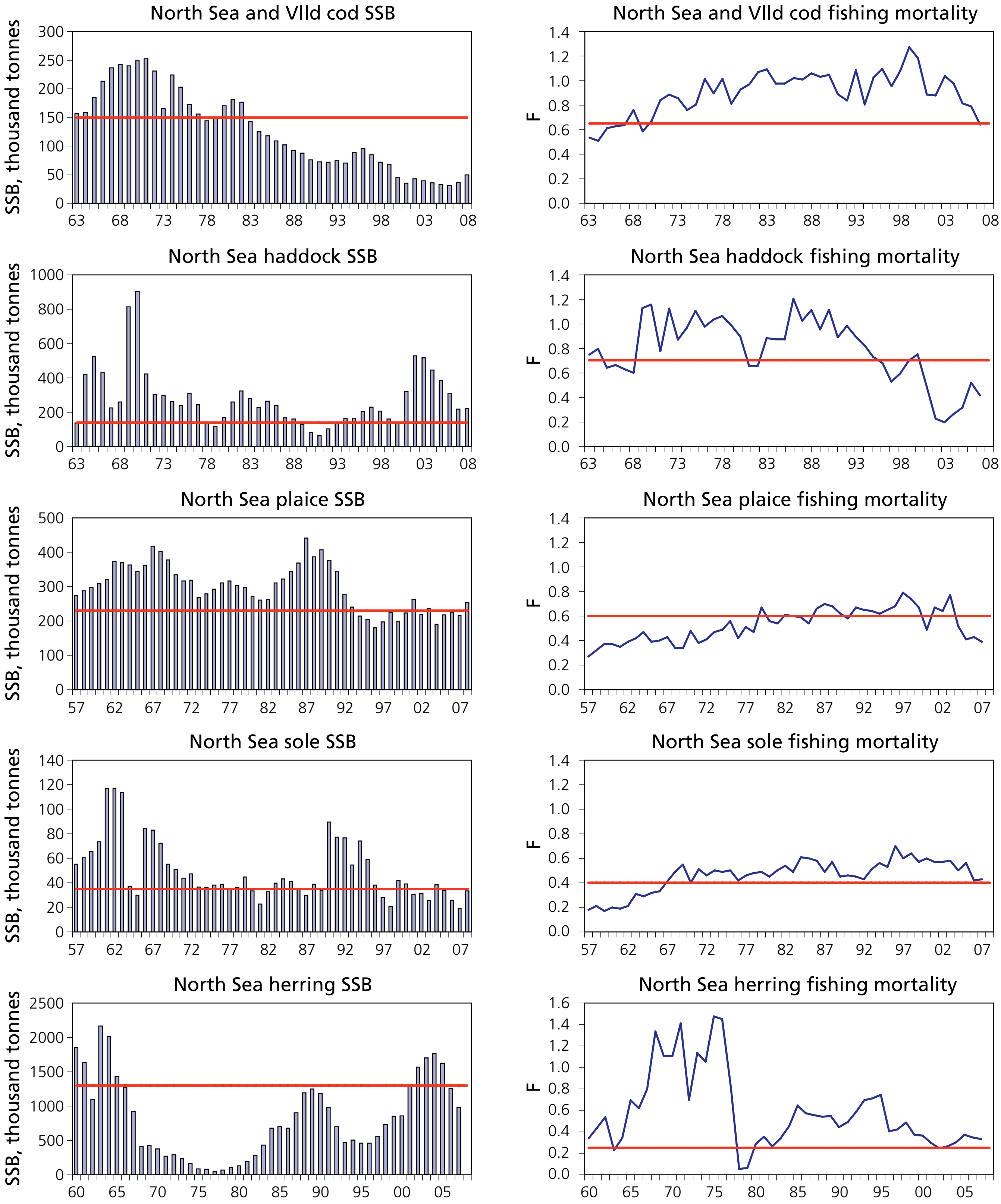


Figure 3.14 Long-term trends in spawning stock biomass (SSB) and fishing mortality (F) for three fish stocks to the West of Scotland (Regions 6, 7 & 8) and two more widely dispersed stocks (saithe – Regions 1, 2, 6, 7 & 8 and blue whiting – Regions 1, 2, 3, 4, 5, 6, 7 & 8). The precautionary reference point for SSB (Bpa) and fishing mortality (Fpa) is shown as a horizontal red line. Source: ICES.

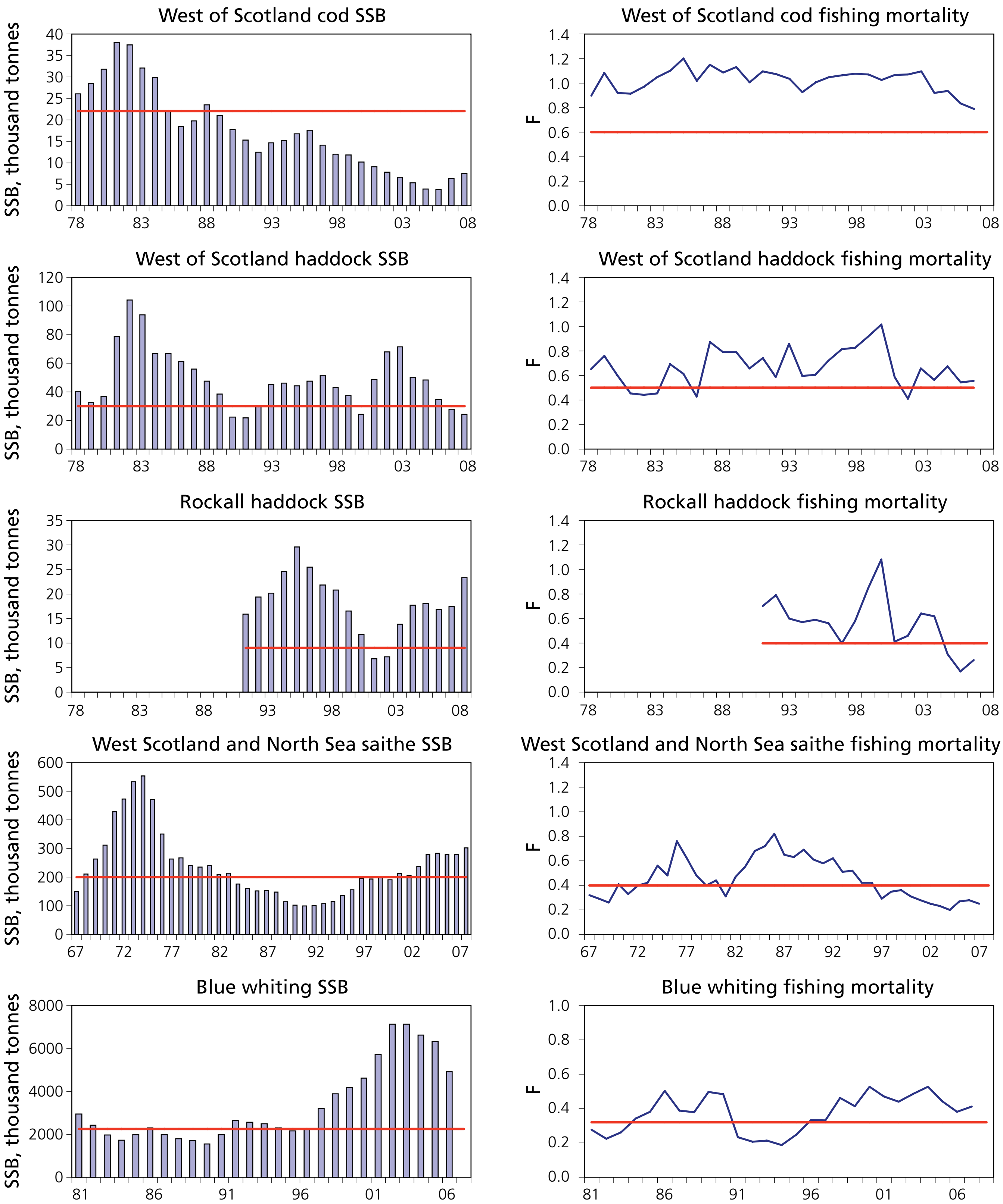


Figure 3.15 Long-term trends in spawning stock biomass (SSB) and fishing mortality (F) for three fish stocks in the Irish Sea (Region 5) and two in the Celtic Sea (Region 4). The Celtic Sea cod stock covers ICES Divisions VIIe–k. The precautionary reference point for SSB (Bpa) and fishing mortality (Fpa) is shown as a horizontal red line. Source: ICES.

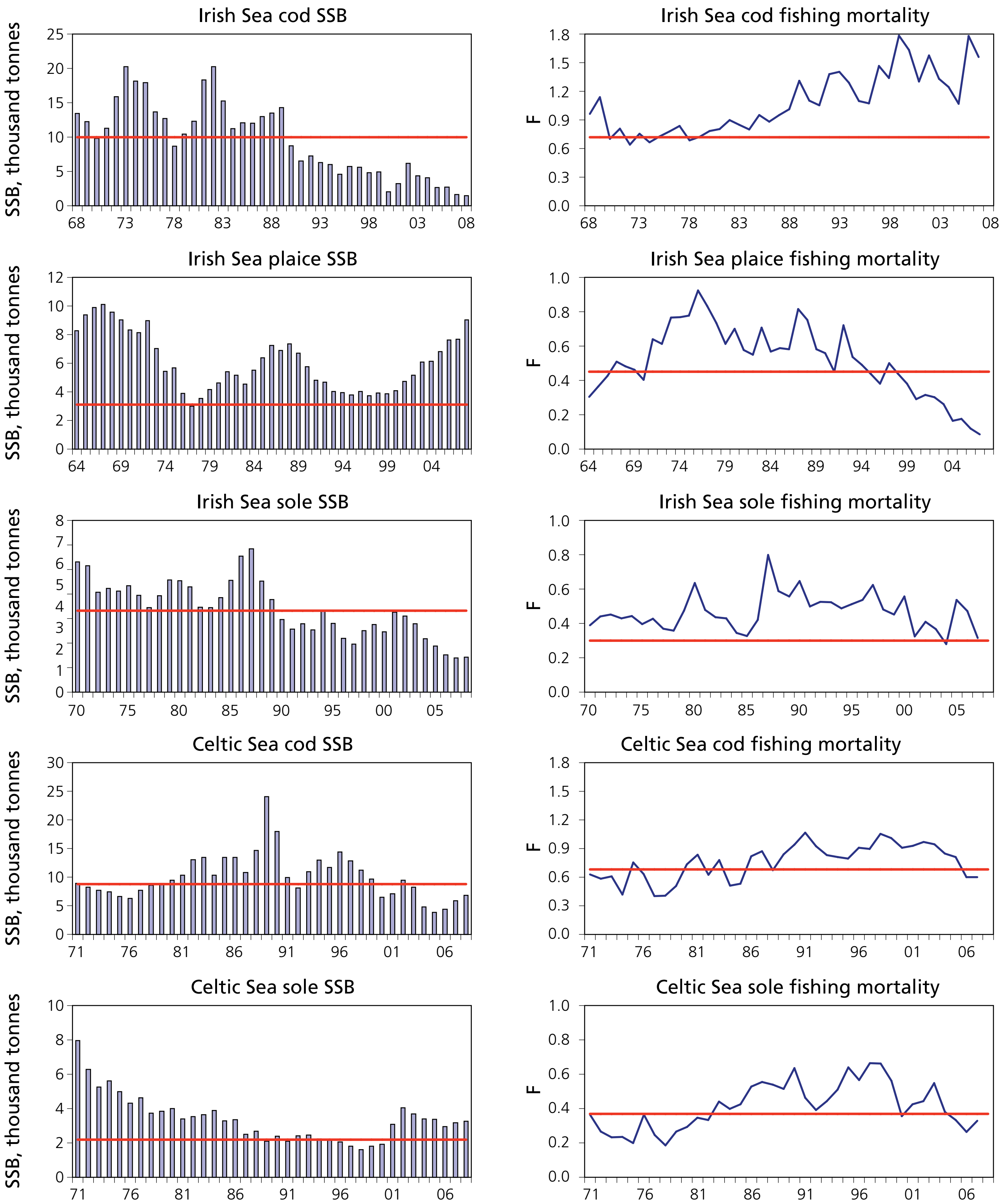
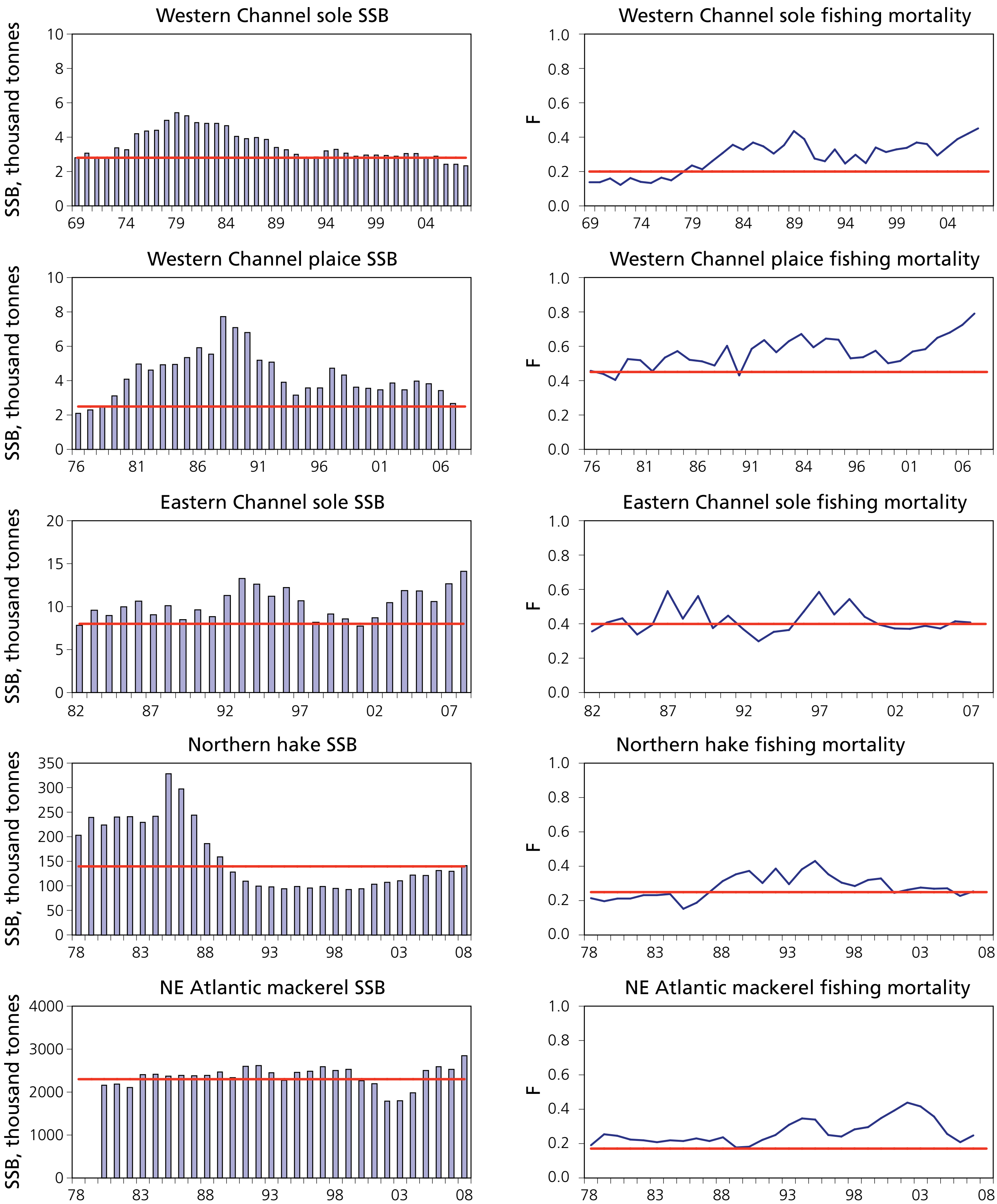


Figure 3.16 Long-term trends in spawning stock biomass (SSB) and fishing mortality (F) for three fish stocks in the Eastern and Western Channel (Regions 3 & 4) and two widely dispersed stocks (hake and mackerel – Regions 1, 2, 3, 4, 5, 6, 7 & 8). The precautionary reference point for SSB (Bpa) and fishing mortality (Fpa) is shown as a horizontal red line. Source: ICES.



The relatively weak response of SSB to reductions in fishing mortality may reflect the time lag in stock recovery following a decrease in mortality, or there may be a negative effect of environmental change on spawning success. An example was the growth of the North Sea cod, haddock and whiting fisheries in the 1970s following several years with very successful spawning - the so-called ‘gadoid outburst’ (Cushing, 1984). Several stocks including North Sea herring and whiting, and Irish Sea and west-of-Scotland cod, have experienced a succession of extremely weak year classes in recent years.

It should be acknowledged that the scientific assessment is often unable to take account of variation between areas. National fish quotas are based on allocation keys established at the commencement of the CFP. This can cause quota management problems if a stock has become depleted overall but effort has become concentrated on fishing grounds supporting national fleets with disproportionately small allocations of the overall TAC. An example is North Sea whiting where the overall stock size appears to have declined over time but effort has become increasingly concentrated along the east coast of England and Scotland where UK fleets subject to relatively small TAC allocations and declining quotas have experienced increasing catch rates in recent years (ICES, 2009c).

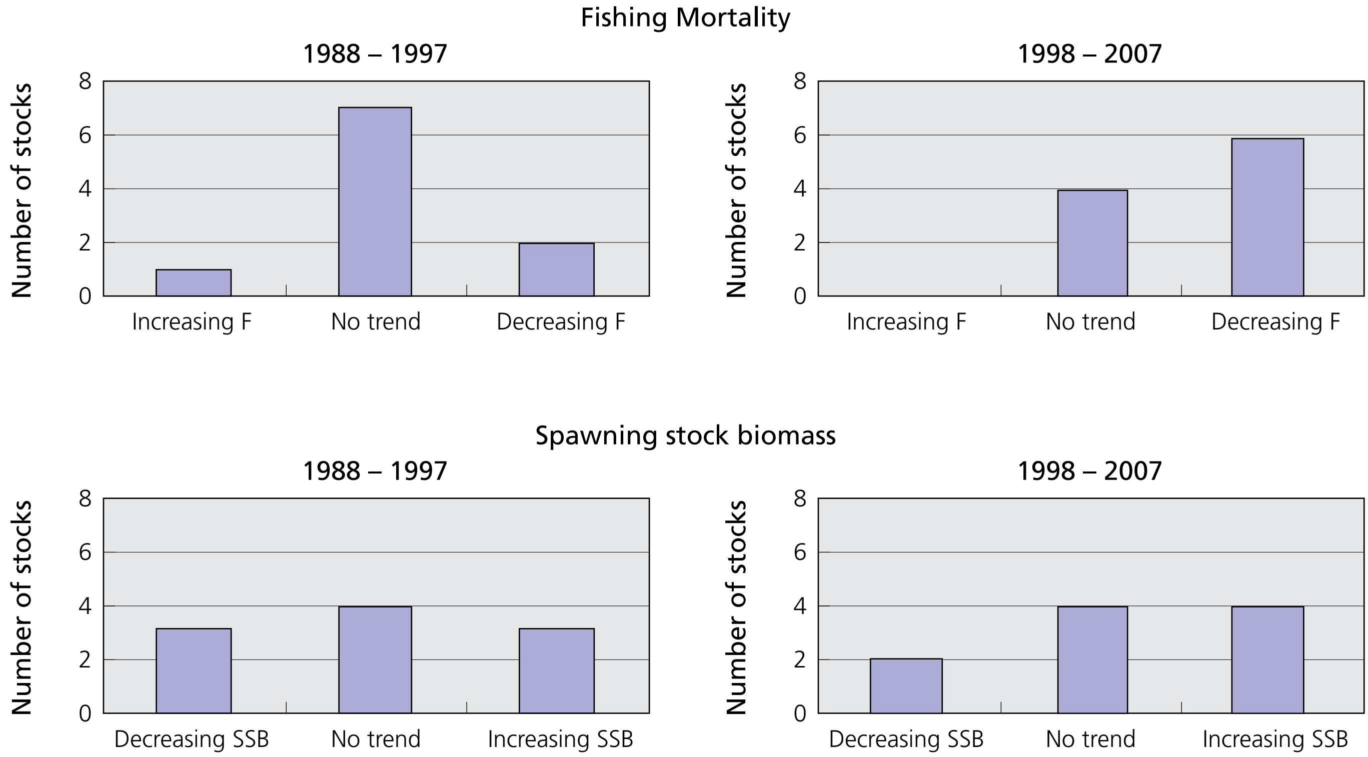
An overall analysis of trends in fishing mortality and SSB is given in Figures 3.17 and 3.18 based on ICES assessments up to 2008. Sufficient data were available to examine two groups of CP2 Regions. Here, the trends in fishing mortality and SSB for a number of stocks assessed by ICES are compared for two time periods (1988–1997 and 1998–2007). Overall, there appears to have been a general improvement (reduction) in fishing mortality over the past decade, although a less marked response in SSB has been observed.

In the North Sea and eastern part of the northern shelf (Regions 1, 2 & 7, 8 east) during 1998–2007, there was a predominance of stocks exhibiting significant decreasing trends in fishing mortality whereas in the previous decade most stocks showed no trend and in some, fishing mortality increased (Figure 3.17). This may reflect the large reductions in fishing capacity of the Scottish offshore fleet following decommissioning. For SSB the picture was less clear. Only a single additional stock showed a significant increase in 1998–2007 compared with the preceding decade.

In the Celtic Seas and western area (Regions 4, 5 & 6), fishing mortality results were similar to the North Sea with a preponderance of stocks in the recent period showing a declining trend (Figure 3.18). In the case of SSB, two additional stocks exhibited increasing trends in 1998–2007 compared with the previous decade and one less showed a declining trend.

There are currently no analytical assessments for *Nephrops* stocks capable of determining interannual trends in SSB relative to reference points for sustainability. However, the UK has successfully deployed underwater television camera (UWTV) surveys to estimate the density of burrows along transects across the mud patches where the populations occur (ICES 2007, 2009a,b). These provide an indicator of trends in abundance of each *Nephrops* stock (Figure 3.19). The UWTV surveys are also being used for estimating absolute abundance after correcting the raw data for several forms of bias that have been quantified (ICES 2009a,b). The absolute estimates for several *Nephrops* populations are also shown on Figure 3.19 (ICES,

Figure 3.17 North Sea and northern shelf (Regions 1, 2 and 7 & 8 east of 4° W). Number of stocks of UK importance (10 stocks) with significant increasing or decreasing trends in fishing (F) mortality and spawning stock biomass (SSB) over two time periods. Spearman rank correlation applied to data obtained from ICES assessments in 2008.

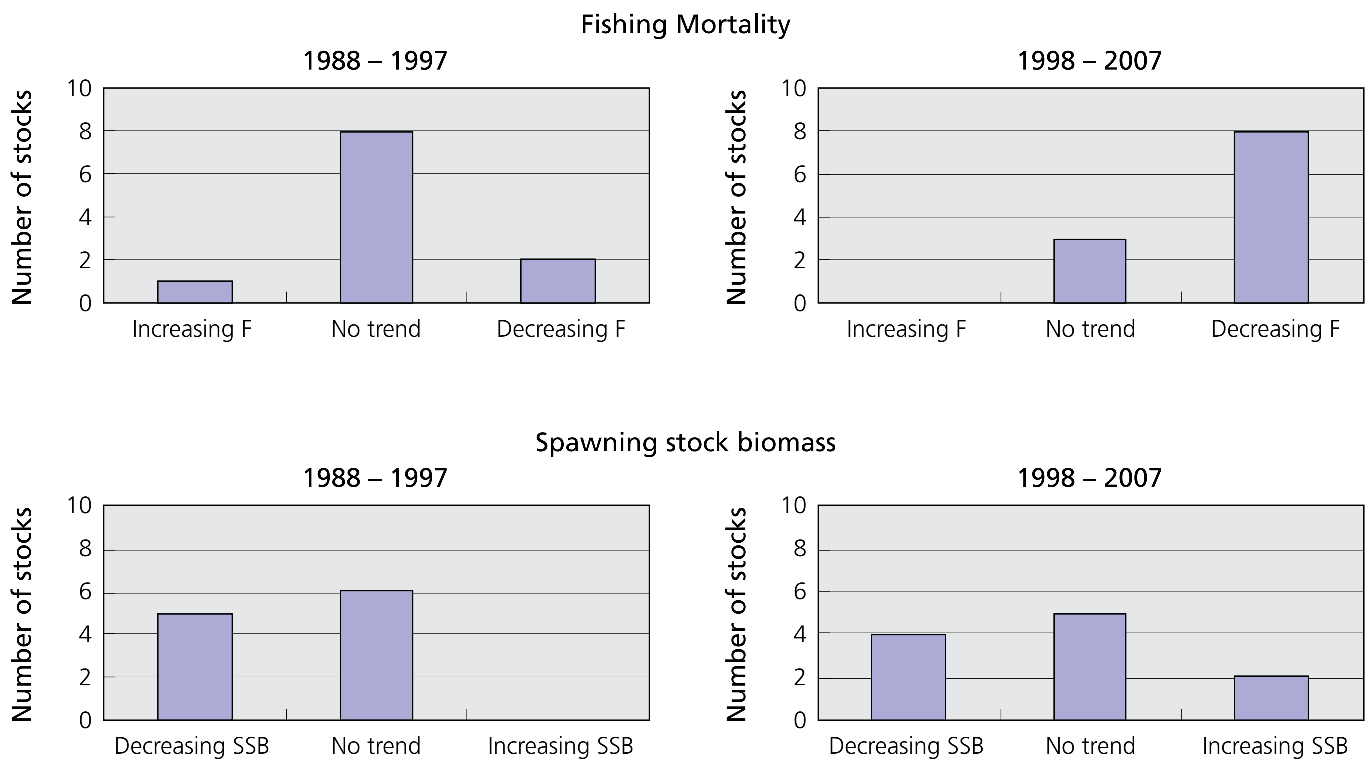


2009c,d). It is possible to calculate, from the bias-corrected burrow count, a level of fishery catch compatible with a fishing mortality rate considered sustainable for each stock. This requires information on the size composition of the population occupying the burrows as well as the selectivity of the fishing gears and the discarding pattern. However, historical *Nephrops* landings data are considered too inaccurate prior to the UK-wide introduction of the Buyers and Sellers regulations in 2006 to calculate time series of fishing mortality relative to any fishing mortality reference points for years with UWTV data (ICES, 2009c,d). However this should be possible for 2006 onwards.

Most of the *Nephrops* stocks in Regions 1 & 6 show a general trend of increasing burrow density from the mid-1990s to the mid-2000s, although the three stocks in Region 6 show a sharp decline in 2007 followed by an increase in 2008 in two of the areas. A general trend of increasing *Nephrops* abundance in the Northern North Sea is also indicated by the North Sea Commission Fisheries Partnership stock survey, which uses a questionnaire approach to determine fishermen's perceptions of year-on-year changes in abundance of *Nephrops* and other commercially important fish stocks (ICES, 2008a).

The UK has relatively limited fisheries for deep water stocks, and catches within the UK Regional Seas would occur in Region 8 (Atlantic North-West Approaches). Most deep-water

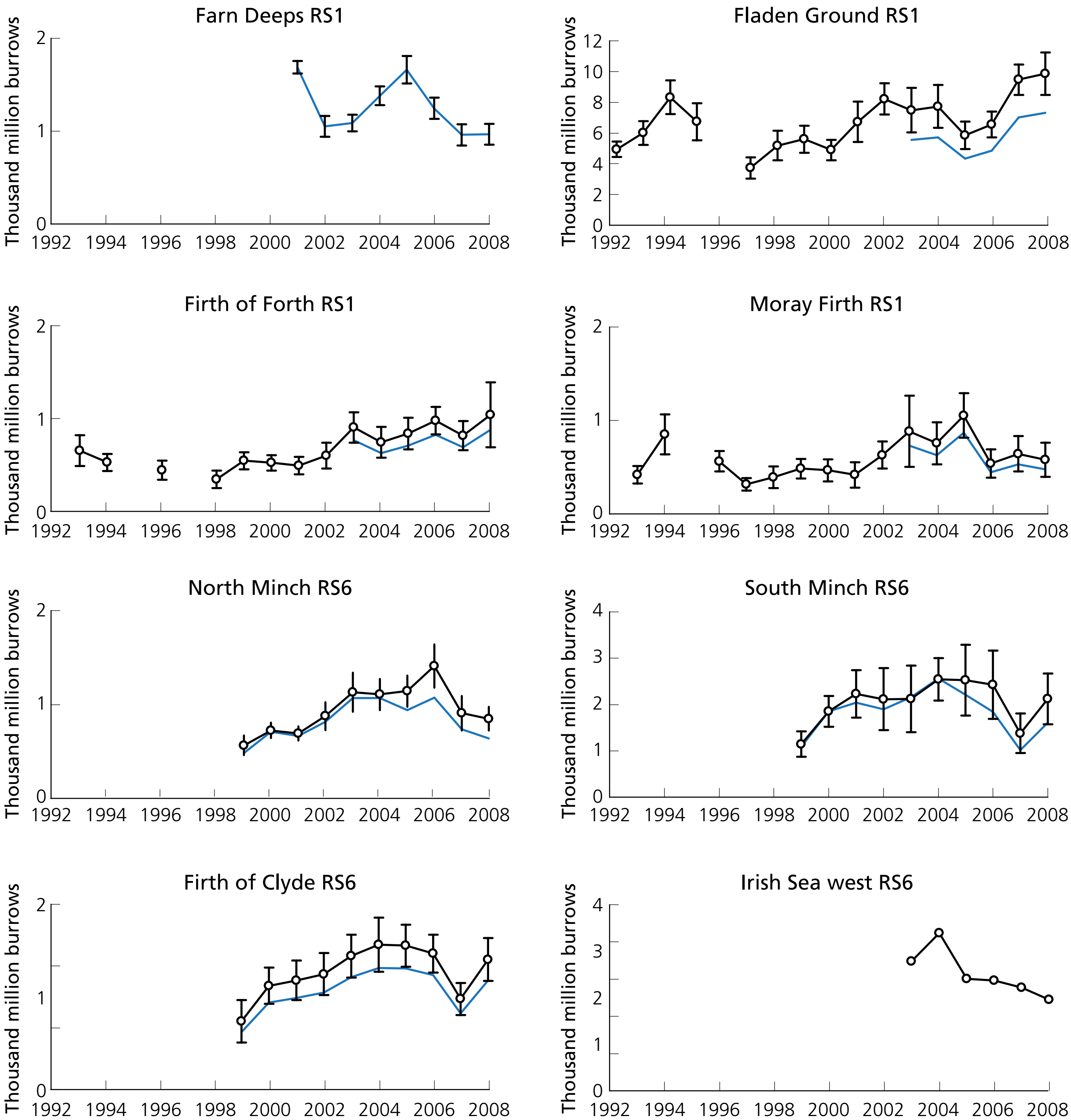
Figure 3.18 Celtic Seas (Regions 4,5, 6 and 7 & 8 west of 4° W) Number of stocks of UK importance (11 stocks) with significant increasing or decreasing trends in fishing mortality (F) and spawning stock biomass (SSB) over two time periods. Spearman rank correlation applied to data obtained from ICES assessments in 2008.



species are straddling stocks occurring in both EU and North East Atlantic Fisheries Commission (NEAFC) waters. ICES advice in 2008 (www.ices.dk/advice/icesadvice.asp) notes that the information base for providing advice on deep-water species in the North-East Atlantic is still considered to be poor, despite initiatives to expand the data sampling and data analyses in recent years.

Deep-water species such as roundnose grenadier, black scabbardfish, blue ling, orange roughy, Portuguese dogfish (*Centroscymnus coelolepis*) and leafscale gulper shark (*Centrophorus squamosus*) show indications of stock declines or continued low abundance (ICES, 2008c,d). Many deep-water stocks are very vulnerable to over-exploitation due to slow growth and tendency of some species to aggregate on seamounts or other features. ICES recommends that fisheries on these species should only be allowed to expand when indicators and reference points for future harvest have been identified and a management strategy, including appropriate monitoring requirements has been decided upon and implemented. For the deep-water species, the state (biomass) and impact (fishing mortality) indicators are difficult to measure. Consequently, ICES recommends that pressure indicators such as effort be used in the management of these stocks.

Figure 3.19 Underwater TV camera survey estimates of burrow density of Nephrops *for the stocks in Regions 1, 5 & 6 shown in Figure 3.9. Source: ICES (2009c,d). Open circles are original burrow counts, with 95% confidence intervals where calculated. The blue line gives absolute estimates after correction for estimation biases.*



3.5.6 Socio-economic pressures and impacts (positive and negative)

3.5.6.1 Employment

In 2007, the UK commercial catching sector employed 12 729 fishermen, a decline from around 18 600 in 1997. The number of fishermen declined rapidly up to 2003 but has declined only slightly since then (MFA, 2008). The proportion of fishermen comprising part-timers in the UK has remained at around 20% over the past ten years. The total therefore represents 11 466 full-time employees (based on an average over all industry categories of 18.9 hours part time and 37.5 hours full time; ONS, 2008b). The decline in number of fishermen since 2007 has been greatest in Wales (43%) compared with 33% in Scotland and Northern Ireland and 28% in England (MFA, 2008).

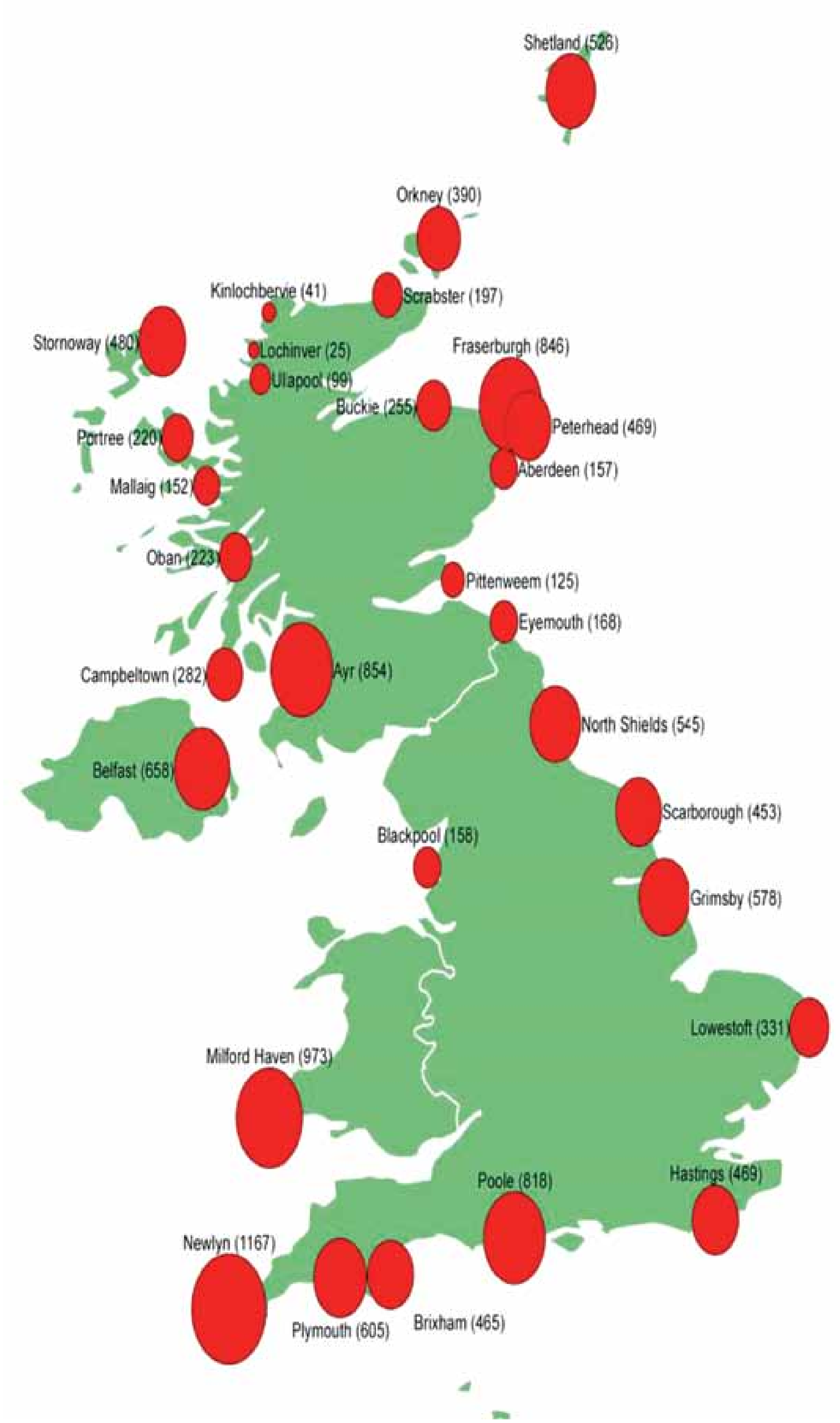
The regional distribution of employment in the catching sector in 2007 was 5589 (England), 5509 (Scotland), 973 (Wales) and 658 (Northern Ireland). The regional distribution of numbers of fishermen within these areas (Figure 3.20) is partly driven by the nature of the fishing fleets in each area. For example, the Scottish Highlands and Islands has roughly the same number of fishermen but only half the value of catch as in the NE Scottish mainland, and this reflects the predominance of inshore fishing on under-10 m boats in the Highlands and Islands (Blackadder et al., 2009). However, the regional patterns are more complicated than that shown in Figure 3.20 because it is possible to have a vessel that is administered in Peterhead Scotland but registered in Cornwall, England.

The UK processing sector comprised 573 businesses and employed 18 180 people in 2005 (Pugh, 2008). In the retail trade, there were 13 000 fishmongers in the UK (including mobile fishmongers and stalls). Supermarkets now provide the bulk of fish to the UK consumer, selling 85% by volume and 80% by value of chilled and frozen fish (not including canned products). The average consumption of fish in the UK in 2004/05 was 185 g (£0.99) per person per week, compared with £4.94 spent on meat per person per week. Total consumption of fish in the UK has increased slightly since then.

The combined employment level in the catching, processing and aquaculture sector in the UK in 2005 was 31 633 people, representing 3.5% of the total employment in all maritime industries in the UK, including leisure and recreation (Pugh, 2008).

Although fishermen represent a small percentage of the national workforce, they are regionally concentrated and make a significant contribution to local economies around the coast. The dependency of communities on fishing, calculated as the proportion of the total number of employees in an area who are involved directly in fishing or processing, or indirectly through dependent businesses, was highest in 2001 around the Scottish coast and in some communities in the south west of England (Cabinet Office, 2004). In particular, a report based on 2005 data, as part of an Axis 4 European Fisheries Fund project, showed that 12% of jobs in Annan and 23% in Fraserburgh were directly related to the fisheries sector (Bob Henderson, Scottish Executive, pers. comm., 2008). In both places the fish processing sector was by far the main contributor to fisheries-related employment. The decline in the industry has been significant over the past two decades. The 2007 workforce in Scotland was approximately half that employed in the early 1970s (Jamieson et al., 2009).

Figure 3.20 Regional distribution of numbers of fishermen by administration port. Reproduced from MFA (2008).



As another example, a socio-economic study of the fishing industry in the south west of England in 2003 (Ekos Consulting (UK) Ltd. and Nautilus Consultants, 2003) showed that out of the 25 community harbours and commercial ports (wards) assessed, the most fishing dependent ward was Penzance South (which mainly covers the port of Newlyn), where fish sector employees (including jobs directly and indirectly involved in fishing) made up 84% of the total workforce. Other wards that were dependent on fishing included Brixham (23% of the workforce), Mevagissey (12% of the workforce), Radipole (covering Weymouth; 13% of the workforce) and Kingswear (covering Dartmouth; 17% of the workforce). The report concluded that the dependent ports were generally characterised by a narrow economic base dominated by tourism related activities and where, as a result, low incomes and part time and seasonal employment prevail. This was particularly apparent in the major landing ports of Brixham and Newlyn where fishing and related industries made up a large proportion of the workforce.

Understanding how the fishing industry responds to fishery management and other bio-economic pressures is critical for developing effective management measures. In the past, the impact of fisheries economists on fisheries management has been highly variable, although their role is likely to increase due to the move towards integrated management of the marine environment (Pascoe, 2006). Hutton et al. (2008) investigated the socio-economic causes of the long-term (50 year+) decline in the English and Welsh fishing fleet, and discussed the contribution of regulations, fleet reduction programmes, increasing fuel costs and associated reductions in investment, and the increasing globalization of fishery markets. They also showed how the economic impacts of fleet reduction programmes can be partially mitigated by increases in fishing vessel efficiency.

Management measures for sustainable development of the fisheries sector need to acknowledge the specific nature of regional fisheries and the social and economic framework in which they operate, so that they achieve their goals whilst mitigating unnecessary impacts. Good governance including consultation and buy-in with fishing communities, and appropriate incentives, is essential (Symes, 2006; Grafton et al., 2006). A notable UK initiative since *Charting Progress* was the establishment of the 'Invest in Fish South West' project, initiated in 2004 and led by stakeholder, non-governmental organisation (NGO) and business groups. This project, involving consultations and bio-economic modelling, has the stated aims to agree the measures needed to best sustain fish stocks within the region (Celtic Sea, English Channel and Western Approaches), considerate of the regional economy, local communities and the wider marine environment (www.investinfishsw.org.uk).

3.5.6.2 Exports and imports

Not all of the fish and shellfish landed into the UK are destined for local consumption, and there is a substantial overseas market. UK exports of fish and shellfish rose from 377 thousand tonnes (£355 million) in 1998 to 480 thousand tonnes (£891 million) in 2003. Exports subsequently declined in weight to 431 thousand tonnes in 2007 although the value increased to £944 million in 2006 before declining to £909 million in 2007. Exports are mainly mackerel, herring and salmon.

The quantity of fish and shellfish imported into the UK (excluding imports of processed fish products) has been increasing since the 1990s.

In 1998, 533 thousand tonnes (£1066 million) were imported, rising to 754 thousand tonnes (£1922 million) in 2006 (MFA, 2008) making the UK a net importer of fish. This affects the UK balance of accounts. Imports declined by 11% by weight and 8% by value in 2007 compared with 2006. The main species imported are cod, haddock, tuna, shrimps and prawns. For some key demersal species such as cod and haddock, imports currently are well in excess of exports, whereas in the pelagic fishing sector, exports of herring and mackerel are larger than imports. Most imports in 2007 were from Iceland (95 thousand tonnes), Denmark (49 thousand tonnes), Norway (42 thousand tonnes) and Germany (40 thousand tonnes). Exports were mainly to the Netherlands (85 thousand tonnes), France (71 thousand tonnes), Russia (52 thousand tonnes) and Spain (39 thousand tonnes). These figures are part of the total landings into the UK.

3.5.7 Environmental pressures and impacts (positive and negative)

The environmental pressures and impacts caused by the fishing sector are directly related to the effects of fishing on the productivity of fish stocks and fish communities, both in terms of the amount of fishing taking place in each regional sea, and the efficiency and selectivity of the fishing gears. The direct impact of fishing gears on components of the wider marine ecosystem and habitats may ultimately also impact on the marine resources available to the fishing sector. The key pressures, impacts and mitigating factors are summarised in Table 3.35. Attaining sustainable rates of fishing, particularly at fishing effort giving maximum sustainable yield for as many species as possible, together with the use of appropriately selective fishing gears and fishing tactics, will go a long way towards achieving the necessary mitigation. A substantial reduction in discarding of target and non-target species is a major goal of fisheries management, particularly for mixed demersal fisheries, and can be achieved through a combination of gear design and avoidance of areas where small fish are most abundant. As fisheries gradually shift towards lower fishing mortality rates implied by achieving maximum economic yields, the size-mix of fish on the grounds will also shift towards larger and more valuable individuals, allowing the fisheries to become even more selective.

The use of temporal and spatial fishery closures is included within CFP regulatory measures to help promote productivity of stocks, divert fishing away from areas where fish are particularly vulnerable to fishing (for example spawning aggregations) or improve fishery selectivity patterns (e.g. closure of fish nursery grounds). Fishery closures in EU legislation were reviewed recently by the EU STECF (STECF, 2007). The STECF report emphasised the need for clearly stated objectives for closures as well as suitable scientific monitoring programmes to determine if they are having the desired effect. Spatial closures can have undesirable side effects if fishing is diverted to areas previously less disturbed by fishing (Dinmore et al., 2003), or to other species or population components for which additional fishing mortality is undesirable. Recent EU Council provisions allowing for the use of cod avoidance measures such as real time closures have been taken up by UK authorities, particularly in Scotland and these should promote productivity of cod by helping to reduce fishing mortality towards the long-term targets.

The main pressures of fishing on ecosystem services are on productivity and biodiversity (Table 3.36). The impacts of fishing on productivity at the regional seas scale are well

understood, although there are additional climatic factors causing changes in fish recruitment patterns and distribution (see Section 3.5.7). Although there is evidence in a range of ecosystems that fishing can cause a reduction in biodiversity, the evidence is less clearly established than for productivity of individual fish stocks. It is well known that non-sustainable fishing can sequentially deplete fish populations according to their vulnerability, starting with the larger, long-lived and least productive species such as skates and working down to the smaller species with high turnover rates such as small pelagic species (Pauly et al., 1998). This results in a progressive reduction in the mean size of individuals within exploited fish communities. The exploitation status of fish communities can therefore be evaluated using multi-species, size-based indicators such as the proportion of large fish in survey catches. The pressures of fishing on the ecosystem, and associated indicators, are discussed in more detail in the HBDSEG Feeder Report.

Generally, there is good information on the distribution and intensity of the use of different gear types. For example, maps of fishing effort for different types of fishing gears used by the international fleets, at the scale of ICES rectangles, show that the main impacts of beam trawling are in the Southern North Sea, English Channel, Celtic Sea and Irish Sea (Regions 2, 3, 4 & 5) where stocks of sole and plaice are most abundant (Figure 3.21). The impacts of otter trawls extend over all the UK regional seas, although effort in the Southern North Sea (Region 2) and Atlantic North-West Approaches (Region 8) is generally lower than in other areas. Finer-scale information on fishing effort is obtainable from VMS data for those vessels required to carrying the equipment. The map of first-sale value of UK fish catches (Figure 3.10) illustrates this.

3.5.8 Climate change

Sea temperature and other climate induced environmental factors have been shown to alter fish community structure through changes in distribution, migration, recruitment and growth. The impact of climate change on commercially important UK fish species has been comprehensively reviewed by Pinnegar et al. (2008). The present report focuses on the implications these changes will have for the fishing industry.

Economically important cold-adapted species such as cod and herring are anticipated to suffer poorer recruitment on average, and changes in growth patterns, in any sea areas around Britain and Ireland where temperatures are increasing beyond the optimum for these species. This is likely to result in a shift in the centre of distribution towards areas with more favourable conditions for the productivity of these species. Drinkwater (2005) reviewed the possible impacts of future climate change on cod, and predicted that stocks in the Celtic and Irish Sea may disappear altogether by 2100, while those in the southern North Sea will decline. It is likely that cod will spread northward in the Barents Sea and along the coasts of Greenland, and may even extend onto some of the continental shelves of the Arctic Ocean. In addition, spawning sites will be established further north than currently is the case, and it is likely that spring migrations will occur earlier and autumn returns will be later. This would mean that UK based fishing boats would have to travel further to target these species, increasing the fuel costs and the number of days at sea.

Any changes in the distribution, migratory routes and spawning of species could also cause populations to move away from (or towards) locations where particular quotas or restrictions

Table 3.35 Key environmental pressures and impacts associated with fishing.

Pressure	**Selective removal of species**
Impact	Individual stock level pressures on distribution and population size. Loss of biological productivity of individual stocks, reduced genetic diversity.
Description of environmental change (intensity, spatial extent, frequency, duration)	Reduction in age diversity, spawning stock biomass, and distributional range. Growth and recruitment overfishing leading to reduced long-term productivity (sustainable yields). Impacts occur at the scale of biological stocks that may have multiple components within regional seas or extend over one or more regional seas. Recovery rates following appropriate reduction in fishing pressures depend on individual stock productivity but may take decades for slow-growing species. Fishing may also result in genetic changes in exploited fish populations. See the HBDSEG Feeder Report, Section X on Fish for impacts on genetic diversity.
Existing management measures	Controls on fishing activities through licensing, EU regulations on Total Allowable Catches, establishment of long-term management plans, direct fishing effort control, fishery closures and other technical measures. New UK initiatives involving avoidance of overexploited species.

Pressure	**Selective removal of species**
Impact	Impacts on non-target species (by-catch) due to non-selective extraction.
Description of environmental change (intensity, spatial extent, frequency, duration)	An estimated annual average of 21 797 tonnes of fish were caught by the English and Welsh fleet in the North Sea, between 2003 and 2006 (Enever et al., 2009). Of this total, 5427 tonnes (25%), were subsequently discarded, including non-target species as well as undersized or high-graded individuals of commercial species. Seasonal patterns in discarding vary according to gear type. Bycatch has declined in the northern and southern North Sea, and the Irish Sea due to a decline in static net fishing and improved net technology (see Section 3.5.5.1). See the HBDSEG Feeder Report, Section X on Fish and Section X on Cetaceans for more details on discards and bycatch.
Existing management measures	EU and additional UK technical measures to improve gear selectivity and reduce discarding. Monitoring programmes to determine the quantity and composition of discarded catches are now in place in most UK fisheries.

Pressure	**Selective removal of species**
Impact	Indirect impacts on community structure and food webs, loss of biological productivity and biodiversity.
Description of environmental change (intensity, spatial extent, frequency, duration)	Depletion of species at different rates according to fishing effort, species targeting, gear selectivity, life history characteristics and associated vulnerability of species. Fishing may remove both predator and prey species from the marine food web. Impacts have been reported at the spatial scale of fish communities within regional seas and spanning one or more regional seas. See the HBDSEG Feeder Report, Section X on Fish for impacts on food webs and a case study on sand eels.
Existing management measures	Controls on fishing activities through licensing, EU regulations on Total Allowable Catches, direct fishing effort control, fishery closures and other technical measures. EU and additional UK technical measures to improve gear selectivity and reduce discarding.

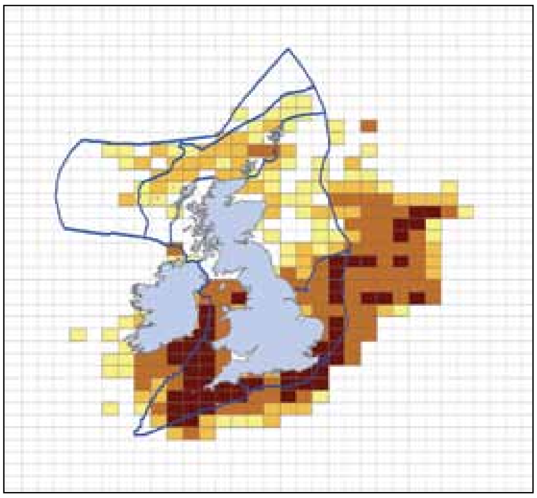
Pressure	**Abrasion due to disturbance from fishing gear**
Impact	Damage to, or loss of habitats.
Description of environmental change (intensity, spatial extent, frequency, duration)	Physical damage to habitats and their associated species caused by fishing gears causes a varying extent of mechanical damage to habitats (Kaiser and de Groot, 2000). The main cause of anthropogenically forced changes to the UK seabed and its habitats is demersal and benthic towed fishing gear, which adversely affects large areas of subtidal sediments and some reef habitat down to 200 m as well as parts of the deeper sea, particularly the continental slope. A greater variety of pressures impact on marine habitats in the southern UK compared to the north where the pressures are mainly associated with fishing activities. Demersal trawling is calculated to affect a minimum of 5.4% of the total area of the seabed rising to a possible maximum of 21.4% in England and Wales and adjacent offshore waters (Eastwood et al., 2007). See the HBDSEG Feeder Report, Section X on Marine Habitats for a detailed assessment.
Existing management measures	EU and additional UK legislation on gear design; closed areas to protect sensitive habitats. A number of sensitive habitats such as deep water corals (Hall-Spencer et al., 2002) are closed to fishing to protect them from damage. Closed areas may however transfer fishing effort to areas previously fished less intensively (e.g. Rijnsdorp et al., 2001; Dinmore et al., 2003).

Pressure	**Introduction of litter, remnants of damaged nets**
Impact	Ghost fishing and entanglement of marine animals.
Description of environmental change (intensity, spatial extent, frequency, duration)	The longevity of ghost fishing from lost gear varies depending on environmental conditions but generally follows a cycle whereby the catch decays, attracts scavengers that eventually clear the net and then may resume 'fishing'. Lost gear can include nets, pots, creels and traps. Of most concern are the latter three as they tend to be more durable. There are few assessments of the extent of ghost-fishing in the UK although the Joint Nature Conservation Committee provides some examples from overseas (http://www.jncc.gov.uk/page-1567). In 2007, fishing litter comprised the second largest component of all litter washed up on UK beaches in five out of the seven CP2 Regions surveyed and was the highest contributor in one Region. See the CSSEG Feeder Report, Section 3.6 on Litter for detailed analysis.
Existing management measures	Escape panels and biodegradable materials are being introduced to reduce losses from ghost fishing in some areas. The Fishing for Litter Scheme, co-ordinated by the UK arm of KIMO (the Local Authorities International Environmental Organisation) and implemented in Shetland, Scotland and south west England, encourages fishermen to bring marine litter caught in fishing nets and gear, back to port for correct disposal.

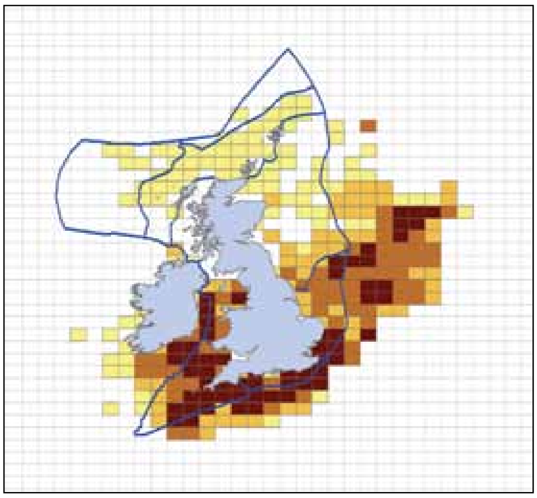
Table 3.36 Environmental pressures on ecosystem services associated with fishing.

Ecosystem service	*Significance of impact*	*Confidence in understanding of the relationship = information gaps*
Biological productivity	**High**. Non-sustainable rates of fishing mortality (related to fishing effort and fishing gear selectivity) cause changes in age structure, spawning stock biomass, species compositions and distribution of impacted fish stocks to an extent that longer-term productivity (sustainable yields) will be reduced for the impacted species. The production of biomass of prey species may increase following depletion of predators, implying a shift in productivity and fishing towards lower trophic levels (Pauly et al., 1998).	**High**. Impacts of fishing on productivity of fish stocks is well understood
Biodiversity provision	**Moderate**. (See the HBDSEG Feeder Report)	**Moderate**. Effects of fishing on biodiversity fairly well understood.

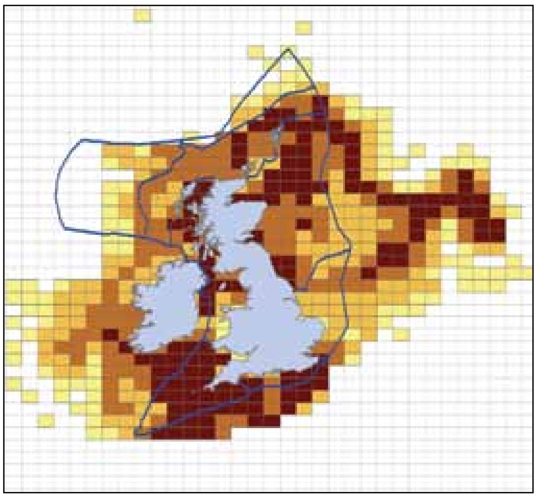
Figure 3.21 Spatial distribution and intensity of international fishing effort (hours fished, calculated from days fishing) using beam trawls and otter trawls in 2003 and 2007. Dark brown represents high effort, yellow represents low effort and medium grades in between.



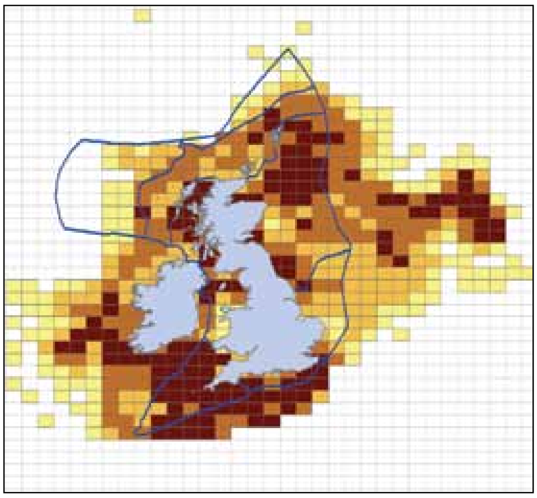
Beam trawl hours 2003



Beam trawl hours 2007



Trawl hours 2003



Trawl hours 2007

are in place, for example, No Take Zones. Populations may also move into colder, deeper water making them more difficult to catch with certain gear types.

Additional opportunities may arise for sustainable commercial and recreational fishing of warmer-water species extending northwards into UK regional seas. Existing more southerly stocks such as red mullet, John Dory, and bass may also experience improved productivity in years with higher average sea temperatures. There have also been marked increases in hake abundance in the Northern North Sea.

Table 3.37 summarises the climate change pressures, impacts and measures discussed in this section and indicates the likely significance

Table 3.37 Summary of climate change implications.

Climate change pressure	*Impacts of climate change on Fisheries*	*Confidence/ significance*	*Adaptation measures*
Rising sea temperatures and associated oceanographic changes	Fisheries will be affected by climate-induced changes in species distribution, productivity and migratory routes. Heavily exploited species are more vulnerable to short-term natural climate variability (O'Brien et al., 2000; Walther et al., 2002; Beaugrand et al., 2003). More southerly (warmer water species) are becoming more prevalent in UK waters (Beare et al., 2004) and this trend is likely to continue if seas become warmer, altering the species composition on UK fishing grounds.	High / High	Reduce fishing mortality to give a broad enough age range of spawners to buffer against weak year classes brought about by climate variations. Adapt fishing patterns and gear design to target new species sustainably. Create new markets for warmer water species that are increasing in catches.
Possible increase in stormy conditions (waves, winds etc.)	The possibility of more intense storms could make conditions more dangerous in certain areas for fishing fleets.	Low / Unknown	Innovative vessel design

Impacts of Fisheries on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
The main impact from fishing on climate change is from carbon dioxide (CO_2) emissions given out by fishing vessels, in transporting fish and in the energy used in fish processing e.g. machinery and fish freezing. Quantification of this is not available.	CO_2 emissions	Low confidence/ significance unknown	Innovative vessel design and improved boat efficiency (discussed in further detail in Section 3.7: Maritime Transport). Improved energy efficiency and consumption at fish processing factories.

of the impacts and the level of confidence in the assessment (see Annex 1 for further methodology).

3.5.9 Industry stability and sustainability

The main drivers affecting the fishing sector are related to balancing both the long-term productivity of the industry and the sustainability of the fishery resources. This section outlines the policies behind these drivers and the management measures, targets and indicators employed to maintain the stability and sustainability of the industry.

3.5.9.1 Economic drivers

Fishing has been an important part of the UK's maritime history for centuries, and many of our coastal communities developed around emerging fishing opportunities such as the growth of the herring fisheries and the distant-water fisheries for cod and other species. Following the Second World War, there was a steady uncontrolled growth of fishing and progressive advances in the design and construction of vessels, deck machinery, fishing gears and electronics (Engelhard, 2008). This resulted in increasing numbers of stocks around the UK being subjected to non-sustainable rates of fishing. This mirrored a world-wide trend.

The progressive depletion of the biomass and age structure of affected stocks impaired their productivity and sustainable yield. The effect is particularly acute for long-lived, slow growing species such as skates (Ellis et al., 2008). In some cases, for example herring stocks around the UK during the 1970s, catastrophic collapses in abundance occurred, requiring closures of the fisheries with severe socio-economic impacts.

Marked regional changes in available fish resources, together with the loss of distant water fisheries following the introduction of 200-mile Exclusive Economic Zones (EEZ) in 1976, had major impacts on local fishing communities all around the UK.

The development of UK fisheries has also been driven by the discovery of new markets. The increasing popularity of 'scampi' since the 1970s fuelled a large growth in the fisheries for Norway Lobster (*Nephrops norvegicus*), and an overseas demand for whole prawns added further value to the fishery in later years. The fisheries for *Nephrops* are now among the most valuable in UK waters.

3.5.9.2 Sustainability drivers

The CFP established a system of TACs allocated to Member States according to 'relative stability keys', and a wide range of technical conservation measures to regulate the configuration of fishing gears (for example mesh size) and fishing activities (closed areas and seasons). During the 1990s, the European Commission responded to the worsening state of EU fish stocks by recommending significant cuts in TACs. However, without any associated measures to reduce fishing effort or fishing capacity in line with the TACs, the measures largely failed to control or reduce the impact of fishing on stocks. Although the CFP had limited success in conservation of fish stocks, it nonetheless introduced important aspects of policy such as the structures policy and the Multi-Annual Guidance Plan for EU fisheries.

A major reform of the CFP during 2002 aimed to achieve more effective long-term management of EU fleets and fisheries towards sustainability. The reform focused on setting long-term objectives for fish stocks, better management of fleet capacity, better enforcement, greater involvement of stakeholders through the formation of Regional Advisory Councils, and measures to limit the environmental impact of fishing. The CFP is currently undergoing another major review with an aim to making it more efficient in ensuring the economic viability of European fleets while conserving fish stocks, integrating with the EU Maritime Policy and providing good quality food to consumers. The reform of the CFP is expected to take effect from 2013.

International political drivers such as the World Summit on Sustainable Development (Johannesburg, 2002) have also influenced European and UK fisheries policies. Member States of the EU committed themselves to maintaining or restoring fish stocks to levels that can produce Maximum Sustainable Yield (MSY) no later than 2015. MSY is the highest yield that may be taken from a fish stock without lowering its productive potential for future years.

EU policy within the CFP reflects the World Summit on Sustainable Development commitment with the development of multi-annual management plans for setting and attaining long-term management objectives for stocks considered sustainable. For mackerel in the North-East Atlantic, coastal states have recently agreed a long-term management plan. For stocks shared between the EU and Norway, such plans have also been agreed for

North Sea haddock, herring and saithe. The EU has also unilaterally established multi-annual management plans for plaice and sole in the North Sea and for herring on the west coast of Scotland. A multi-annual plan for sustainable exploitation of Western Channel sole was established in 2007.

Some stocks are however outside safe biological limits and for these, the multi-annual plans established by the European Commission include harvest control rules aimed at promoting recovery of the stocks. This is the case for the long-term plans for cod stocks and their fisheries which cover stocks in the North Sea, Irish Sea and to the west of Scotland. Associated with the recovery plans for cod stocks has been the development of regulations to control fishing effort, limiting the allowable days at sea for different fleet sectors according to area fished, gear type, mesh size band and species composition of landings. These, and other related technical measures, have had far-reaching socio-economic impacts on the UK demersal fishing industry. In 2008, the EU Council established a revised cod recovery plan (Council Regulation (EC) No 1342/2008) including the associated effort management regime. The revised plan essentially shifts responsibility for much of the detailed fisheries management to Member States. Within the UK this has been accompanied by extensive stakeholder consultation and the establishment of forums to discuss measures cooperatively.

When a recovery plan has achieved its primary goal, a long-term management plan is established to attain longer term goals such as MSY. This has been the case for the Northern hake stock, where the recovery plan established by the European Commission in 2004 has been followed by a Commission proposal (March 2009) establishing a long-term management plan for achieving the fishing mortality giving the MSY attainable under the prevailing oceanographic conditions.

Other international drivers having variable impacts on marine fisheries management around the UK include the OSPAR Convention strategies, and EU directives related to habitats and species. The EU Marine Strategy Framework Directive 'Good Environmental Status' indicator for fish species relates to the objective that ...*Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock*. This form of indicator for marine fish stocks is discussed in Section 3.5.6. The classification of threatened and endangered species by the International Union for Conservation of Nature (IUCN) also influences how the capture of such species should be regulated.

Key UK policy drivers include the Marine and Coastal Access Act 2009 and the Marine (Scotland) Act 2010. Aspects of marine planning including establishment of areas closed to fishing are of particular relevance to the fishing industry. Over the period covered by the *Charting Progress* publications, the Devolved Administrations have made considerable progress in developing fisheries policies and visions for the future sustainability of the UK fishing industry after extensive collaboration with stakeholders. In 2004, the UK Cabinet Office Strategy Unit published *Net Benefits*, which proposed a possible long-term strategy for improving the fortunes of the UK fishing industry and communities which depend on it (Cabinet Office, 2004). A series of subsequent publications have outlined the UK Government strategy for sustainable development of the fishing industry. These include the Devolved Administrations' response to Net Benefits

(*Securing the Benefits*; Defra et al., 2005) and the subsequent publication *Charting a New Course* (Defra, 2005b), which sets out how Defra, working with stakeholders, will deliver the policies in *Securing the Benefits*. Defra's *Fisheries 2027* vision statements (Defra, 2007c) build on current policies to provide a single coherent direction for marine fisheries policy. Within Scotland, the Sea Fisheries Advisory and Reference group (SeaFAR) produced a strategy for sustainable seas (SeaFAR, 2006) and in 2008 produced a States of the Seas report (Baxter et al., 2008). Under the new administration in Scotland a new forum, the Scottish Fisheries Council has been established with the aim of encouraging long-term sustainable fisheries bringing together representatives of the fishing industry, conservation groups and the scientific community (Scottish Government, 2008c). The Scottish government's vision for the seas is contained in the Marine Scotland 2009 Strategy Statement (Scottish Government, 2009a).

All the UK government fisheries policies emphasize the need for stakeholders to contribute effectively to decisions affecting their livelihood. At the European scale, an important development associated with the CFP has been the establishment of Regional Advisory Councils. These provide a mechanism for stakeholders, working where appropriate with scientists and NGOs, to respond collectively to 'non-papers' and other proposals for management procedures issued by the European Commission, and to provide other forms of advice to the Commission. At the national level, fisheries scientists in the UK are working increasingly closely with the fishing industry to develop the evidence base for effective fisheries management and to develop innovative solutions such as more selective fishing gears. Formal collaborative programmes of data collection have been established through the Defra-funded Fisheries Science Partnership in England and Wales and the Scottish Government Marine Directorate-funded Scottish Industry/Science Partnership.

3.5.9.3 Management measures

A key impact of the CFP is how the implementation of its EU-wide regulations affects local fishing industries. Reducing the vessel numbers by decommissioning schemes, and controlling overall fishing effort, unfortunately does not alleviate all management difficulties. The variability in fish stocks over space and time means that individual vessels can experience relatively high catch rates of some TAC species but have only limited quotas available. The options for the vessel are to lease additional quota, move elsewhere or discard over-quota fish.

The introduction of the Registration of Fish Buyers and Sellers and Designation of Fish Auction Sites Regulations, which came into force in Scotland, England and Northern Ireland in September 2005 and in Wales in 2006, requires all buyers of first-sale fish bought directly from fishing vessels, and sellers of first-sale fish sold at a designated auction site operating in their areas, to be registered with the relevant UK Fisheries Departments. All catches must have valid sales notes as required by the EU legislation. This helps to ensure the legitimacy of fish landed in the UK.

The stricter enforcement of regulations and the restrictions on fishing imposed by recovery and management plans have led the UK fishing industry, government and fishery scientists to try to develop innovative management proposals to conserve stocks while avoiding further cuts in fishing effort. Often such schemes originate from proposals by fishermen. The Defra 'Environmentally Responsible Fishing'

project (2008 onwards) involves a wide range of voluntary vessels in the North Sea to quantify all components of the environmental footprint of commercial fishing vessels and angling charter vessels targeting fin-fish in inshore waters. The Irish Sea Data Enhancement Pilot Project has involved a range of fishing vessels voluntarily providing enhanced data on catches and fishing operations, and samples of discarded catch, as well as enhanced observer coverage. In Scotland, the Conservation Credits Scheme implemented from February 2008 used temporary closed areas to move vessels away from concentrations of cod and began trials with gears which reduced catches of cod. For 2009 the scheme has been further developed to include a wider range of cod avoidance tools and includes a greatly enhanced scheme of real time closures (Scottish Government, 2009b, 2010). Participation in such schemes provides some benefits such as additional days-at-sea allowances or exemption from quota regulations (Scottish Government, 2009c).

The most important political decisions affecting the fishing industry are those that control their activities in order to meet targets for conservation of fish stocks. Since 1999, the ICES advice which underpins management of fisheries has been provided within a precautionary approach framework based on the FAO Code of Conduct for Responsible Fisheries (FAO, 1995). The ICES Precautionary Approach is summarised in Box 3.2.

This form of single-stock advice based on the Precautionary Approach rather than agreed management plans can be problematical for management of mixed fisheries and for the viability of fishing businesses that require a degree of stability in catches, particularly when the advice is for zero or very low catches. Furthermore, only 17% of the 137 stocks for

Box 3.2:
The ICES Precautionary Approach

The ICES Precautionary Approach requires, where data permit, the definition of 'limit' and 'precautionary' reference points for spawning stock biomass (SSB: the total weight of mature fish in a stock) and fishing mortality (F: a parameter related to the fraction of a stock killed by fishing each year). If SSB falls below the limit reference point (B_{lim}), there is an elevated probability of the productivity of the stock being impaired due to fewer young fish being produced. If F exceeds the limit reference point (F_{lim}), it is probable that the SSB will remain or become depleted below B_{lim}. Since the values of SSB and F used by fishery managers are estimates based on sampling schemes and stock surveys, and not exact values, ICES advice on catch options is based on forecasts of SSB and F relative to precautionary reference points (B_{pa} and F_{pa}) set sufficiently above B_{lim} or below F_{lim} to provide a margin of safety given the likely imprecision of the forecast values of SSB and F. ICES also provides advice on values of F that are expected to provide high long-term yields and low risk of stock depletion below B_{lim}. However, unless there is an agreed EU management plan that sets TACs based on harvest control rules that ICES has evaluated and found to be precautionary, ICES has continued to give advice based on the Precautionary Approach that in some cases may include advice to reduce catches to zero if any non-zero catches are expected to result in $F > F_{pa}$ or $SSB < B_{pa}$.

which fishery management advice was reported by ICES in 2007 had all the necessary reference points and stock estimates to implement the precautionary approach rules (Cadrin and Pastoors, 2008). The socio-economic issues associated with setting annual fishing opportunities solely on the ICES Precautionary Approach have been important drivers for the European Commission to develop more appropriate recovery or management plans for increasing numbers of stocks, agreed through consultation with stakeholders through the Regional Advisory Councils. These plans typically include constraints on the relative change in TAC from year to year, depending on the state of the stock. An example is given in Case Study 2 for the management plan put in place for herring off the north west of Scotland from 2009 onwards. This plan was evaluated by ICES and found to be in accordance with the Precautionary Approach, and the computer simulations of the plan indicated that a fishing mortality rate of F = 0.25 would be a suitable target for providing the maximum long term yield for this stock.

The productivity and management of UK's fisheries is also affected to a small extent by illegal, unreported and unregulated (IUU) fishing. A report for the Pew Trust in 2008 used a simulation model to evaluate the potential cost of IUU fishing in 14 groups of fish stocks across five large marine ecosystems in the Baltic Sea, North Sea, Celtic–Biscay Shelf, Iberian Coastal and Mediterranean Sea (eftec, 2008). They estimated a minimum total cost to EU Member States of lost catches from 2008 to 2020 averaging about 15% of total fishery value and more than 30% of the value of the fisheries considered, and over 27 800 lost job opportunities in fishing and processing industries (around 13% of total fisheries employment). They concluded that IUU fishing is preventing stock recovery and keeping fisheries locked in low-value states. The European Council recently adopted a regulation to prevent, deter and eliminate IUU fishing (Council Regulation 12083/08).

3.5.9.4 Objectives and indicators of state

A range of indicators of state may be used for indicating sustainability of fishing. Indicators of sustainability of fish stocks around the UK, based on the ICES Precautionary Approach, are described in Box 3.2. Further work on indicators of sustainable development of EU and UK fisheries will include the development of indicators to monitor progress towards long-term objectives such as maximum sustainable yield as specified by the World Summit on Sustainable Development (Johannesburg, 2002). The revised EU Data Collection Framework from 2009 onwards requires the collection of survey data and VMS data by all Member States to calculate indicators of the impacts of fishing on fish stocks (e.g. discard rates, size at maturity, mean maximum length of fish over all stocks) and also the impacts on the environment (e.g. fraction of habitats not disturbed by fishing).

At the UK level, the Marine and Coastal Access Act 2009 and the Marine (Scotland) Act 2010, and the formation of new bodies such as the Marine Management Organisation in England, and Marine Scotland (Scottish Government, 2009a) (which brings together Fisheries Research Services, the Scottish Fisheries Protection Agency and core elements of the Scottish Government Marine Directorate), will include aspects of regional fisheries management and marine planning that will require collection of appropriate supporting data on fisheries (including recreational fishing), fish stocks and habitats. The modernisation of inshore fisheries management in England through the

Case Study 2:
Multi-annual fishery management plan for herring off the northwest coast of Scotland

Council Regulation (EC) No 1300/2008 of 18 December 2008 established a multi-annual fishery management plan for the stock of herring distributed to the west of Scotland (ICES Area VIa(N) and the fisheries exploiting that stock.

Article 4

Setting of TACs

1. Each year, the Council, acting by qualified majority on the basis of a proposal from the Commission, shall fix for the following year the TAC applicable to the herring stock in the area west of Scotland, in accordance with paragraphs 2 to 6.
2. When STECF considers that the spawning stock biomass level will be equal or superior to 75 000 tonnes in the year for which the TAC is to be fixed, the TAC shall be set at a level which, according to the advice of STECF, will result in a fishing mortality rate of 0.25 per year. However, the annual variation in the TAC shall be limited to 20%.
3. When the STECF considers that the spawning stock biomass level will be less than 75 000 tonnes but equal or superior to 50 000 tonnes in the year for which the TAC is to be fixed, the TAC shall be set at a level which, according to the advice of STECF, will result in a fishing mortality rate of 0.2 per year. However, the annual variation of the TAC shall be limited to:
   a) 20% if the spawning stock biomass level is estimated to be equal or superior to 62 500 tonnes but less than 75 000 tonnes;
   b) 25% if the spawning stock biomass level is estimated to be equal or superior to 50 000 tonnes but less than 62 500 tonnes.
4. When STECF considers that the spawning stock biomass level will be less than 50 000 tonnes in the year for which the TAC is to be fixed, the TAC shall be set at 0 tonnes.
5. For the purposes of the calculation to be carried out in accordance with paragraphs 2 and 3, STECF shall assume that the stock experiences a fishing mortality rate of 0.25 in the year prior to the year for which the TAC is to be fixed.
6. By way of derogation from paragraphs 2 or 3, if STECF considers that the herring stock in the area west of Scotland is failing properly to recover, the TAC shall be set at a level lower than that provided for in those paragraphs.

replacement of Sea Fisheries Committees with Inshore Fisheries and Conservation Authorities, will place increasing focus on the need for adequate data and scientific analysis to support management and sustainable development of inshore fisheries and resources.

3.5.9.5 Trends in sustainability of fish stocks around the UK

The UK Government Sustainable Development Strategy *Securing the Future*, launched in 2005 (HM Government, 2005), includes an indicator of sustainability of fish stocks around the UK. This is an indicator of the proportion of fin-

fish stocks around the UK at full reproductive capacity (when spawning stock biomass, SSB, is at or above the ICES-defined precautionary SSB reference point, B_{pa} at the start of each year) and harvested sustainably (fishing mortality, F, is below the precautionary reference point F_{pa} each year). The figures are obtained from the time-series of F and SSB given by the most recent scientific assessment of each stock (see Section 3.5.5.4). The indicator is currently calculated only for 20 fin-fish stocks in UK waters for which ICES gives quantitative advice on sustainability based on age-structured assessment models, and for which estimates of both F and SSB are available up to the most recent fishing year (www.ices.dk/advice). The 20 stocks represent a wide range of different stocks and fisheries including demersal roundfish (cod, haddock, saithe, hake and blue whiting), flatfish (sole, plaice), and pelagic (mackerel, herring). Many of these stocks are extremely valuable or have high conservation profile. A further four stocks (Celtic Sea plaice, western horse mackerel and North sea sandeel and Norway pout) have quantitative ICES advice on stock status relative to B_{pa} only (no F_{pa} specified) and are not included in the sustainability index.

ICES Working Groups also provide information on a further 23 fin-fish stocks (excluding sharks and skates) harvested by UK fisheries in waters around the UK, but for which it has not been possible to determine stock status relative to any precautionary reference points. The absence of quantitative advice is due to the following points:

- There are no or currently insufficient assessment data to indicate stock trends (e.g. Rockall cod and whiting, West of Scotland megrim and sandeel, Channel sprat, northern anglerfish).
- The data are inadequate to define the current status relative to precautionary reference points (or no reference points are available) although trends indicate low or declining stock size (e.g. North Sea, Irish Sea and Celtic Sea whiting; west of Scotland herring stocks, Celtic Sea herring, Shetland sandeel).
- The data are inadequate to define current stock status although trends indicate stock size is either stable or has recently been relatively high (e.g. Irish Sea and Celtic Sea haddock; Irish Sea herring, North Sea sprat, Eastern Channel plaice, western anglerfish stocks, western megrim).

The available information on the stocks with no ICES advice therefore does not suggest that there might be a substantial difference in the proportion of stocks with different status compared with the 20 indicator stocks. The inability of ICES to provide advice for these stocks is generally related to inadequacies in data and modelling, or new data types requiring developmental work and not necessarily related to the state of the stock.

In 2008, ICES also provided advice on a number of elasmobranch species (e.g. sharks and rays). However it is not possible to determine precautionary reference points for both SSB and F for these stocks based on an analytical assessment and they are not included in the sustainability index. However, of a total of 31 stock/area combinations for elasmobranchs in the Celtic Seas and the North Sea, ICES advised in 2008 that 16 were stable or increasing, 7 were depleted or severely depleted (and one extirpated), and 8 were of uncertain status.

Sustainability indices are also given by the Scottish Government Marine Directorate and ICES based only on annual ICES advice on current SSB levels relative to the precautionary

reference point for SSB (B_{pa}). By including the criterion that both F and SSB are within sustainable limits, the Defra index identifies stocks that may temporarily be above B_{pa} due to recent good recruitment, but continue to be harvested unsustainably.

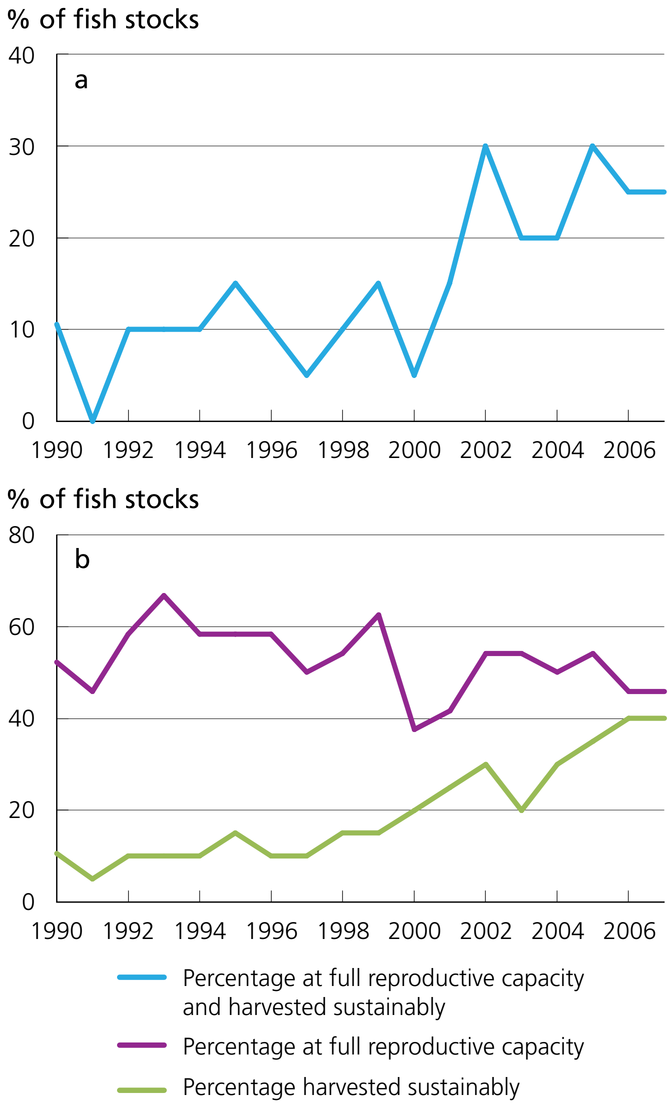
The earliest year for which all 20 stocks have time-series of SSB and F estimates is 1991. From 1982 to 1990, 19 of the stocks had data. In 1980, 17 stocks had data and in 1970 only 10 of the stocks had data. It is therefore only possible to give a sustainability index for all 20 stocks from 1991 onwards. Using the UK Framework baseline year of 1990 results in only 19 stocks for 1990, but this makes only a small difference to the results. The total for UK landings for the 20 stocks in 2007 was over 40% of the total landings of all species landed by UK vessels into the UK and abroad.

The proportion of stocks being harvested sustainably was around 10% in the early 1990s but has increased to around 40% in 2007 (Figure 3.22). This is based on the 20 stocks that have F_{pa} reference points. In contrast, the proportion of stocks with full reproductive capacity has fluctuated with little trend since 1990. Despite a reduction in fishing mortality, the lack of a concomitant increase in reproductive capacity may be due to time lags in the recovery of SSB following reductions in F, or possibly due to environmental factors affecting recruitment.

The proportion of stocks with full reproductive capacity and being harvested sustainably follows a generally similar pattern to the proportion being harvested sustainably although the trend is less steep since the mid-1990s (Figure 3.22).

Since 2002, 20% to 30% of the fish stocks around the UK have been at full reproductive capacity and being harvested sustainably, compared to none in 1991 and 5% to 15%

Figure 3.22 Change in exploitation status of 20 indicator fin-fish stocks around the UK. (a) Percentage of stocks at full reproductive capacity and being harvested sustainably (Defra index: rounded to nearest 5%); (b) percentage of stocks where one of the conditions holds each year (not rounded).Source: Justine Saunders (DEFRA, courtesy of Cefas).



in the years from 1992 to 2001. The trend since the first *Charting Progress* evaluation in 2005 is therefore flat. A 'traffic light' stock-by-stock evaluation of exploitation status since 1970 (Table 3.38) shows that the problems of overexploitation generally worsened around the mid-1980s. Note, however that the amber 'light' signifies that one of two conditions (i.e. either

Table 3.38 Evaluation of the change in exploitation status of 20 indicator fin-fish stocks in UK waters, for which ICES was able to provide quantitative management advice in 2008.

Grouped by species

Species	Stock	Regional sea
Cod	IV, VIId	1,2,3,7,8
Cod	VIa	6,7,8
Cod	VIIa	5
Cod	VIIe-k	4
Haddock	IV	1,2,7,8
Haddock	VIa	6,7,8
Haddock	VIb	8
Saithe	IIIa, IV, VI	1,2,6,7,8
Hake	IIIa, IV,VI, VII, VIIIab	1 to 8
Blue whiting	I-IX, XII, XIV	1 to 9
Plaice	IV	1,2
Plaice	VIIe	3,4
Plaice	VIIa	5
Sole	IV	1,2
Sole	VIId	3
Sole	VIIe	3,4
Sole	VIIfg	4
Sole	VIIa	5
Mackerel	IV, VI, VII	1 to 8
Herring	IV, VIId	1,2,3

Grouped by regional sea

Species	Stock	Regional sea
Cod	IV, VIId	1,2,3,7,8
Haddock	IV	1,2,7,8
Plaice	IV	1,2
Sole	IV	1,2
Herring	IV, VIId	1,2,3
Sole	VIId	3
Sole	VIIe	3,4
Plaice	VIIe	3,4
Sole	VIIfg	4
Cod	VIIe-k	4
Cod	VIIa	5
Plaice	VIIa	5
Sole	VIIa	5
Cod	VIa	6,7,8
Haddock	VIa	6,7,8
Haddock	VIb	8
Saithe	IIIa, IV, VI	1,2,6,7,8
Blue whiting	I-IX, XII, XIV	1 to 9
Mackerel	IV, VI, VII	1 to 8
Hake	IIIa, IV,VI, VII, VIIIab	1 to 8

Assessment

(red)	Stocks not at full reproductive capacity and not harvested sustainably
(yellow)	Stocks either at full reproductive capacity or harvested sustainably
(green)	Stocks at full reproductive capacity and harvested sustainably
(white)	No data

the fishing mortality or the reproductive capacity) is precautionary without showing which this is. In 2007, landings of stocks at full reproductive capacity and being harvested sustainably represented 20% of the total landings for the 20 stocks.

The sustainability indicator does not provide a measure of the broader ecosystem impacts of fishing at particular levels of fishing effort or with different types of fishing gears, for example the impacts of fishing on key predator or prey species. This aspect is covered in the Chapter 3 (*Healthy and Biologically Diverse Seas*) in *Charting Progress 2*.

3.5.10 Forward look

The available evidence on the exploitation status of the fish stocks of importance to the UK indicates that the increases in fishing pressure (as shown by estimates of fishing mortality) that occurred during the 1980s and 1990s have been largely halted and in some cases reversed. A progressively increasing number of stocks are being harvested sustainably, although the proportion remains relatively low at around 40% and the fishing mortality in many stocks remains well above the levels that would provide the largest long-term yield. A number of stocks that supported valuable fisheries historically remain severely depleted, including cod and whiting stocks in the Irish Sea and to the west of Scotland. The commitment of the EU to attaining the World Summit on Sustainable Development target of achieving maximum sustainable yield for fish stocks by 2015, and the progressive development of recovery and management plans to achieve this, should ensure continued reduction in fishing pressures on stocks. While the objective of achieving MSY by 2015 is established, the identification of target fishing mortality rates and indicators to monitor progress towards MSY is still in development.

The generally more encouraging signs relating to sustainable exploitation rates are less evident in the case of spawning stock biomass. The extent to which further reductions in fishing mortality or improved fishing gear selectivity will improve the biomass of the stocks and the sustainable yield, will depend on the combined effect of improved egg production as the age profile of the stocks expands at lower mortality rates, and the effect of trends in environmental conditions affecting survival of young fish and hence the number of fish recruiting to the fishable stock.

Stability of the fishing industry is currently recognised in EU stock recovery and management plans which limit the annual adjustment in TAC to a specified percentage, depending on the status of the stock relative to reference points for sustainability. Declines in fish landings, fleet size and employment observed up to 2003 or 2004 have become less marked in subsequent years, indicating greater stability. However this does not preclude more severe localised fishery management problems and related socio-economic impacts caused by local imbalances between fishing capacity and fish availability. Continued involvement of the fishing industry in developing solutions to local management problems should help to mitigate these problems.

Fisheries management will continue against a backdrop of probable continued climatic change, which is expected in the longer term to alter the mix of species available to marine fisheries in the different Regional Seas around the UK. This will require adaptation of fisheries and fishery management measures to ensure that the fisheries remain sustainable and profitable.

Revisions to the CFP are placing increasing focus on management of fisheries within a broader ecosystem framework, and it is expected that fisheries management decisions will increasingly consider the broader impacts of fishing and the inter-relatedness of species being harvested. The fishing industry itself has increasingly contributed to evaluation of proposed fishery management measures, as well as development of new measures, through the Regional Advisory Councils and national dialogue. It is expected that this process will mature further in the coming years, and that the industry may also play an increasingly collaborative role in collection of the data needed for managing the fisheries for sustainability and profitability.

3.6 Leisure and Recreation

3.6.1 Key points

- A diverse range of leisure and recreation activities in the UK make use of the marine environment
- In 2007, 5.4 million people participated in watersports and 0.8 million in sea angling
- Useful indicators of ancillary value include regular reports by the British Marine Federation of the small commercial marine industry (a turnover of £1.84 billion in 2006/07); surf retail report (£200 million in 2007); and total expenditure from recreational fishing (£538 million for England and Wales in 2003 and £141 million for Scotland in 2008)
- These sources and others provide a total estimated market turnover due to leisure and recreation of £2.74 billion and £1.29 billion Gross Value Added (GVA)
- The estimated income for coastal towns from tourism in the UK is calculated at £4.8 billion, resulting in a GVA of £2.26 billion
- Other benefits that are potentially substantial include employment and cultural values
- Participation within the sector is dependent on the general health of the UK economy and the health of the environment
- Environmental pressures are very difficult to quantify; they may include removal of marine fauna and flora, physical or visual disturbance of wildlife, pollution and alteration of coastlines to facilitate access

i. Introduction

Many different leisure and recreation activities in the UK make use of the marine environment.

ii. How has the assessment been undertaken?

Economic data were collated from a number of sources related to the various activities. Information on the spatial distribution of activities was provided mainly through Seazone and the Royal Yachting Association.

iii. Current status of the leisure and recreation sector and past trends

It is difficult to capture the principal market value obtained from recreational and leisure activities because some activities, such as swimming, do not result in a marketable good or paid-for service. A good indication can be provided by the levels of participation in each activity. In 2007, 5.4 million people participated in watersports and 0.8 million in recreational angling. Useful indicators of the market value of ancillary activities include regular reports by the British Marine Federation of the small commercial marine industry (a turnover of £1.84 billion in 2006/07); surf retail report (£200 million in 2007); and total expenditure from recreational fishing (£538 million for England and Wales in 2003 and £141 million for Scotland in 2008). These sources and others provide a total estimated market turnover due to leisure and recreation of £2.74 billion and £1.29 billion GVA. Secondary value from coastal tourism, accommodation and food can also be significant with an estimated expenditure for coastal towns of £4.8 billion in 2005 (GVA £2.26 billion). Other benefits that are potentially substantial include employment and cultural values. Environmental pressures as a result of recreational use of the seas are very difficult to

quantify due to a lack of spatial and temporal information on levels of activity. Pressures may include the removal of marine fauna and flora, physical or visual disturbance of wildlife, pollution from wastewater and litter and alteration of coastlines to facilitate access.

iv. What is driving change?

The growth and stability of the marine leisure and recreation market is heavily dependent on the general health of the UK economy and the health of the marine environment. Trends in sea angling are particularly dependent on advances in fishing technology and catch rates of fish. Overall, the participation in most marine leisure and recreation activities has stayed relatively stable or showed an increase in recent years.

v. What are the uncertainties?

Although this sector is likely to have a high economic value, uncovering the economic contribution is hampered by the lack of a trade association, the large number and wide distribution of activities, and the lack of centrally available statistics. Such issues also make it difficult to fully assess spatial pressures. It is recommended that such information is centrally collated.

vi. Forward look

As the sector is heavily dependent on the general health of the UK economy (so that participants have more disposable income to engage in leisure and recreation activities) it is likely that there will be some short-term decreases. However, with the infrastructure and technology in place to support such activities it is likely that it will achieve predicted growth rates over the long term.

3.6.2 Introduction

This sector refers to the leisure and recreational use of the marine environment and includes angling, sailing, boating, nature-watching, scuba diving, surfing, kayaking and swimming. Although this sector is likely to have a high economic value, uncovering the economic contribution is hampered by the number of activities, the wide distribution and the lack of available statistics.

3.6.2.1. Description of economic activities

The leisure and recreation sector is characterised by a diverse array of principal activities (Table 3.39). They range from those that interact relatively passively with the marine environment (e.g. whale watching) to those that interact more directly (e.g. recreational fishing). These are supported by an even greater range of ancillary economic activities including construction, manufacturing, and management. Downstream activities that benefit from leisure and recreation include accommodation and other services. Rentals are included as a Principal activity as this is the easiest way to estimate the direct value of leisure-boating activities.

3.6.2.2 Description of relevant ecosystem services

The leisure and recreation sector is generally dependent on clean and safe seas to operate in and, for some, healthy and abundant wildlife to catch and/or observe. This makes the sector reliant on the following ecosystem services to support its productivity: biological productivity; water purification and waste treatment; biodiversity; physical environment.

Table 3.39 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Leisure and Recreation (SIC 93): Tourism; Water sports activities and recreation, for example, diving activities, sailing; Recreational and sport fishing (93.19);	Construction of artificial surf reefs (SIC 42.9), marinas (42.91), moorings, slipways. Manufacture of sports goods (SIC 32.30). Building of pleasure and sporting boats (SIC 30.12). Repair and maintenance of boats (SIC 33.15). Operation of sports clubs (93.12) Operation of recreational transport facilities (marinas, moorings) and beach facilities (93.29) Renting and leasing of recreational and sports goods (SIC 77.21); Renting of boats for fishing cruises – (SIC 50.10)	Tourism accommodation and other services	Cruising (SIC 50.10) – see Section 3.7 (Maritime Transport)

3.6.2.3 Management

Management of leisure and recreational activities in the marine environment depends largely on the nature of the activity and the degree of impact on the marine environment. Activities are generally managed via local planning policies. Water transportation around the UK is governed by the Maritime and Coastguard Agency, an Executive Agency of the Department for Transport and managed by port and harbour authorities. The construction of marine recreational facilities will be subject to planning permits and environmental impact assessment (EIA) processes for larger facilities or those proposed for sensitive areas.

3.6.3 Direct use value

Coastal areas attract large numbers of visitors each year. For example, 80% of Devon's 3.5 million visitors a year go to the coast (i.e. 2.8 million) and Blackpool attracts 17 million visitors a year supporting around 52 000 jobs (Atkins, 2004). The estimated income for coastal towns from tourism in the UK is calculated at £4.8 billion. The proportion of turnover contributing to gross value added has been estimated at 0.47 for the hotel catering and licensed premises section. Using this conversion factor for tourism would suggest a GVA of £2.26 billion from UK seaside tourism as a whole (Pugh, 2008). A problem with seaside tourism values is that it is very difficult to separate which tourist activities are specifically related to the utilisation of the coastal and marine environment and which are more general 'seaside holiday' expenditure values. The main sectors of marine leisure and recreation are therefore discussed individually in more detail in the following sections.

3.6.3.1 Watersports[14]

The marine environment provides the basis for a wide range of popular recreational activities including sailing, power boating, kayaking, scuba diving and surfing. Participation in UK watersports and leisure activities in 2007 was

14 Activities which are undertaken around the coast but do not directly interact with the marine environment, such as general tourism, cliff climbing and coastal walking have been excluded from this analysis as have activities which are focussed inland (i.e. less than 10% of activity on the coast) such as canal boating and rowing. Angling is considered in Section 3.6.3.3. The study did not obtain specific estimates for coasteering.

estimated at about 10.5 million with over 60% taking place around the coast (BMF et al*.* 2007), that is, 6.3 million in marine activities. Of those activities that directly interact with the marine environment (excluding recreational fishing), there is a total participation level in the UK of 5.4 million (Table 3.40). Watersports have been broadly split into leisure-boating and non leisure-boating activities for this analysis.

Leisure-boating activities

Recreational leisure boating is the most valuable aspect of the UK watersports industry. The British Marine Federation (BMF) is the trade association for the marine leisure industry. The majority of its members are small and medium enterprises (SMEs) but a small number of companies operate at the top end of the market and have turnover in excess of several million pounds per annum. The Federation produces annual statistics, which relate to the production of kayaks, personal watercraft, sailing and motorised craft, windsurfers and all craft up to 50 metres in length but do not include traditional ship building.

Total turnover of the UK leisure and small commercial marine industry in 2006/07 was £2.95 billion (Table 3.41) – an increase of 6.5% from 2005/6 (BMF, 2008). The value mainly relates to ancillary activities such as manufacturing, maintenance and leasing. Manufacturing is the most valuable aspect of the sector with an estimated value of £1.32 billion. A proportion of this revenue will have come from inland activities (as seen under 'consumer services'). A comparison of the proportion of value from inland boat hire and marinas to coastal/sea charters and marinas, estimated that 62% of the total value relates to the marine environment, that is, £1.84 billion.

Non leisure-boating activities

Some watersports activities such as surfing, coastal swimming and scuba diving are not included in the BMF economic values (see above – although some overlap in certain sectors such as watersports rental is likely to occur). Information on the economic value of these activities is more limited compared to that found in the leisure-boating sector.

The economic value of the UK surf industry was estimated at £200 million in 2007 and is growing each year with the increasing popularity of the sport. The majority of this value is from retail such as boards, equipment and clothing (Bournemouth Borough Council, 2007).

Ancillary activities related to non-boating watersports activities include the building of artificial surf and diving reefs. Artificial surf reefs amplify existing surf and shape the waves into better quality surfing waves. Europe's first artificial surf reef has been constructed 220 m offshore from Boscombe in Dorset, although some adjustments may be required. The reef cost £3.03 million to build. A Council Economic Impact Assessment has suggested that the reef will provide direct income of up to £3 million per annum. It will also create an image value of £10 million per annum, resulting from a variety of publications and media interest on a national scale. It is hoped the project will generate a huge stimulus for equipment retailing, surf-training schools, accommodation, drink and food and is expected to create an estimated 60 full-time and 30 part-time jobs (Bournemouth Borough Council, 2007).

The sinking of the HMS *Scylla* in April 2004 in Whitsand Bay, Cornwall as an artificial reef for scuba diving is another example of the economic benefits which can be provided by the construction of artificial reefs (see Case Study 3).

Table 3.40 Participation in major UK watersports undertaken around the UK coast. Source: BMF et al. (2007: tables 24 and 34).

Activity	*Number of participants in UK*	*Proportion of activity undertaken at the coast, %*	*Estimated number of participants on the coast, thousands*
Surfing	517 686	100	518
Kayaking	801 895	42	337
Small boat sailing / racing	624 463	58	362
Powerboating	252 777	80	202
Personal watercraft	143 332	64	92
Motor boating/cruising	497 217	45	224
Yacht cruising and racing	439 493	74	326
Scuba diving	270 982	70	190
Outdoor swimming	4768,750	60	2861
Waterski/Wakeboard	235 076	41	96
Windsurfing	169 621	58	98
Kitesurfing	66 553	93	62
Total			**5368**

3.6.3.2 Marine wildlife watching

Marine wildlife tourism is defined as 'any tourist activity with the primary purpose of watching, studying or enjoying marine wildlife' (Masters et al., 1998). The sector includes viewing a range of marine species such as whales, dolphins, basking sharks, seals and seabirds. The sector may be water-based, land-based, or both and may also be formally organised or undertaken independently (META, 2002).

The most popular and economically important sector of marine wildlife tourism is whale and dolphin (cetacean) watching. In 1998, the value of whale and dolphin watching in the UK was estimated at a direct value of £1.4 million and an indirect value of £6.3 million (Hoyt, 2000).

In Scotland, total marine wildlife tourism (of all marine species) was estimated to be worth over £9.3 million in 1998 with indirect revenue resulting from marine wildlife tourism estimated at £57 million (Masters et al., 1998). The direct economic income (i.e. expenditure on excursion tickets) from cetacean tourism activities was estimated to be £1.17 million per annum with associated expenditure (accommodation, travel, food, etc.) from tourists being brought to rural West Scotland solely due to the presence of whales representing £5.1 million in additional tourism income (Hoyt, 2000; Parsons et al., 2003).

However, other estimates of economic value surpass these totals indicating a wide discrepancy in assessments mainly due to the methodology used. Seal watching, another popular tourist activity, was estimated by the International Fund for Animal Welfare to provide at least £36 million to the UK economy in 1996

Table 3.41 Breakdown of UK industry revenue by detailed sector for the leisure and small commercial marine industry, 2006/07. Source: BMF (2008).

Sector	*Description*	*£ million*	*% of UK Total*
Manufacture	Power boat manufacture	697.07	23.6
	Sail boat manufacture	112.59	3.8
	Other boat manufacture	27.46	0.9
	Electronics manufacture	128.06	4.3
	Deckgear / rigging manufacture	135.07	4.6
	Other equipment / accessories manufacture	125.55	4.3
	Engines / systems manufacture	89.88	3.0
	Total	***1315.67***	***44.6***
Distribution	Power boat distribution	194.90	6.6
	Sail boat distribution	84.05	2.8
	Other boat distribution	17.58	0.6
	Electronics distribution	73.01	2.5
	Other equipment / accessories distribution	111.36	3.8
	Engines / systems distribution	149.96	5.1
	Total	***630.85***	***21.4***
Consumer services	Boat repairs / servicing	173.33	5.9
	Coastal / sea charter	121.29	4.1
	Inland boat hire	94.62	3.2
	Watersports rental	24.88	0.8
	Sailing schools	30.17	1.0
	Dealers	125.34	4.2
	Brokerage	61.06	2.1
	Chandleries / marine outlets	83.09	2.8
	Coastal marinas	113.59	3.8
	Inland marinas	47.36	1.6
	Surveyors	24.58	0.8
	Other services	50.13	1.7
	Total	***949.44***	***32.2***
Business services	Business consultants and services	20.52	0.7
	Financial / insurance / legal	12.66	0.4
	Other services	22.56	0.8
	Total	***55.74***	***1.9***
	Total	**2951.70**	**100**

Case Study 3:
HMS Scylla - regional socio-economic benefits of diving related activity

HMS *Scylla* was sunk in April 2004 in Whitsand Bay, Cornwall to form the first artificial reef for diving created from a deliberately scuttled warship in Europe. The wreck lies upright on the seabed at a maximum depth of 27 metres.

The cost of acquiring, preparing and sinking the *Scylla* amounted to £1.25 million although the net economic impact of the *Scylla* in terms of additional expenditure from the first season of diving was estimated at £1374 699 made up of:

- Direct spending of around £9000
- Capital spending by clubs, centres and charter boats of £152 500
- Revenue spending by clubs, centres and charter boats of £275 501 including wage costs
- Diver spending in tourism related businesses of £937 698.

Net additional employment is estimated at 35.46 full-time equivalent (FTE) jobs made up of jobs supporting clubs, centres and charter boat operators as well as tourism related businesses.

The net additional impact on the South West Region is lower than the overall impact as a result of leakages of capital and revenue spending out of the region, and given that a proportion of the divers attracted to the *Scylla* are drawn from within the South West, and their spending may have occurred in any event. Taking account of these factors, the regional impacts during the first year of diving activity are estimated at:

- Net additional spending of £1167 461
- Net additional employment of 27.8 FTE jobs.

It is anticipated that there will be further increases in activity resulting from the wreck as diving clubs add the *Scylla* to their programmes, as clubs return to observe the change over time and as the local diving centres increase their training programmes as they benefit from the increased awareness of the Plymouth/Looe area as a centre for diving.

The *Scylla* project has generated considerable enthusiasm and support from a wide range of stakeholders, diving clubs and local diving and charter boat operators. By providing a new alternative to existing sites, some of which are deteriorating as dive sites, it has helped to underpin existing diving activity in the Plymouth/Looe area, and therefore to protect existing economic activity arising from diving. It has also led to a significant increase in diving activity in the local area with concomitant positive impacts on economic activity.

Source: (Geoff Broom Associates, 2005)

(as cited by Beaumont et al., 2006). Caution is needed if using such indicators of value to assess regional patterns and temporal trends.

Bird watching of coastal and seabirds is undertaken at many spots around the coast attracting large visitor numbers to certain areas. For example, Titchwell Marsh on the north Norfolk coast is one of the Royal Society for the Protection of Birds' most visited reserves with an estimated 92 000 visitors a year and the Scottish Seabird Centre on the east Lothian coast had over 284 000 visitors in 2007.

3.6.3.3 Recreational fishing

Recreational fishing takes place to varying extents all around the UK coastline. This is primarily angling from the shore or on private, chartered or rental boats, but there are also some catches made for personal use by unlicensed operators using a range of nets, lines and pots or traps, or by hand picking on shore (e.g. for shellfish).

Sea angling is a popular recreation activity all around the UK coast. Detailed assessments have been recently made for Scotland (Radford et al., 2009), Northern Ireland (PricewaterhouseCoopers, 2007) and England and Wales (Defra, 2004c).

The total number of participants in Britain involved in sea angling in 2007 was approximately 290 800 from a boat and 480 950 from the shore (BMF et al., 2007). The total expenditure by anglers resident in England and Wales in 2003 was estimated at £538 million, made up of £178 million shore based, £82 million for charter and £278 million for own boat activities (Defra, 2004c).

The recent report for Scotland (Radford et al., 2009) investigated a range of indicators including: overall sea angling activity levels, measured in angler days; the number of home and visiting anglers; the distribution of angler days across shore, private and charter boats; the target species; angler expenditure; the economic contribution of sea angling to regional incomes and employment.

In summary, it is estimated that 125 188 adults and 23 445 children went sea angling in Scotland in 2008 with a total expenditure of £141 million.

The gross expenditure from sea anglers in Northern Ireland was estimated at £7.4 million (PricewaterhouseCoopers, 2007).

This provides a total expenditure of £686 million for the UK. Important sources of expenditure for anglers include equipment, boat charter, accommodation and food. A small number of hotels, for example, specifically cater to anglers providing specialist services such as early morning breakfasts and storage for the fish caught. Bait is another important component of sea anglers' expenditure and bait collection is an important secondary industry. It is often supplied and bought locally, and is likely to make a significant contribution to the region's economy. Estimates of the value of the UK bait market vary considerably ranging from £25 million to £90 million per annum (Nautilus consultants, 2005).

The most popular sea angling species to target is bass, with nearly half of all sea anglers choosing this as their main target species. Cod is also popular, as are mackerel, rays, sharks, conger eels and pollack. The value of the bass sport fishery in 2004 is estimated to be in excess

of £100 million per annum despite severely depleted stocks of larger bass (BASS, 2004; Nautilus consultants, 2005).

3.6.3.4 Summary

Table 3.42 provides a summary of those activities for which an estimate of turnover could be obtained. These sources provide a total estimated market turnover due to leisure and recreation of £2.74 billion. Applying a value added factor from Pugh (2008) of 0.47 for the hotel/catering/pub sector gives £1.29 billion GVA. However, this figure represents a small portion of the total activities identified in Table 3.40 and therefore is likely to be a gross underestimate of market turnover, thereby assigning the figure a low level of confidence.

3.6.4 Regional distribution of value

3.6.4.1 Leisure-boating activities

The regional distribution of value around the UK for the leisure-boating industry can be seen in Table 3.43. The South East dominates with the greatest revenue share of the marine industry (36.1%) followed by the South West (24.1%) and the East of England (12.3%). The location of boat building facilities and sailing areas can be seen in Figure 3.23. In addition there are at least 236 coastal marinas in the UK and Channel Islands, making the coastline accessible to the boating public and providing some 49 000 marina berths. These berths are concentrated in the South East and South West, although the East of England, West coast of Scotland, Wales and the Channel Islands also provide a significant share (BMF, 2007a).

3.6.4.2 Non leisure-boating watersport activities

Figure 3.24 illustrates the distribution of non leisure-boating watersport activities. A number of leisure studies that have been undertaken at a regional scale are also included in the summary figures in Table 3.43. For activities such as angling and marine wildlife watching, data which show a comprehensive breakdown of the regional distribution of value is more limited. However, Table 3.44 describes these activities in more detail providing an indication of key areas where higher economic value is more likely to be realised.

3.6.4.3 Summary

In order to estimate the regional value of all leisure and recreational activities, the total GVA of £1289 million has been allocated according to the distribution of bathing beaches, dive sites (wrecks and reefs), surf sites, RYA marinas, cruising routes, racing areas and sailing areas. This is illustrated in Table 3.45. The level of confidence in this spatialisation is low and could be improved by allocating value for each activity based on the distribution of each activity.

3.6.5 Trends

Overall the participation in most marine leisure and recreation activities has stayed relatively stable or showed an increase in recent years (BMF et al., 2007). Watersports have been seen as an increasingly important aspect of the marine leisure and tourism market in recent years. The popularity of activities such as surfing has increased dramatically in recent years (Bournemouth Borough Council, 2007). Factors such as increasingly active lifestyles, increasing leisure time and affluence have combined to enhance the attractiveness of sports and physical recreation for the tourist (Cornwall Enterprise,

Table 3.42 Summary of participation rates and economic value in marine leisure and recreation activities.

Activity	*Participation*	*Turnover*	*Comment*
Leisure boating	1.2 million (2007)	£1840 million (2006/07)	Turnover
Surfing	0.5 million (2007)	£200 million (2007)	Surf retail only
Marine wildlife watching		£9.3 million (1998)	Scotland
Recreational fishing	0.8 million (2007)	£538 million (2003)	Expenditure – England and Wales
		£141 million (2008)	Expenditure – Scotland
		£7.4 million (2007)	Expenditure – Northern Ireland
Total		**£2736 million**	

2001). Furthermore, ongoing technological improvements in, for example, wetsuit technologies mean that people are now able to utilise marine waters for recreational activities further into the winter months.

The participation in marine wildlife tourism is also continuing to increase. Cetacean watching for example is estimated, by research carried out for the UK Whale and Dolphin Conservation Society, to be growing at 10% a year (META, 2002).

Sea angling activity appears to have stabilised over the past decade. In 1970, sea anglers fished on average 36 times a year falling to about 12 times in 1992 and 11 in 2002. Most anglers have also observed a decrease in fish catches and declines in the size of fish caught over the past 15 years (Defra, 2004c). To some extent anglers have adapted to changing conditions by switching locations, travelling further and using more powerful boats to extend their search.

3.6.6 Socio-economic pressures and impacts (positive and negative)

The leisure and recreation industry (including tourism) is both socially and economically important to the UK and the coast has been a

Table 3.43 Revenue from leisure and small commercial marine activity by Devolved Administration and Regional Development Agency (RDA) areas 2007. Source: BMF (2008).

Devolved Administration and RDA region	*CP2 Region*	*Turnover, £ million*	*Value added, £ million*
Scotland	1, 5, 6, 7	98.9	35.3
North East	1	16.8	6.0
Yorkshire	1, 2	33.6	12.0
East Midlands	2	251.4	89.7
East of England	2	363.6	129.7
London	2	54.5	19.4
South East	2, 3	1064.7	379.9
South West	3, 4	711.6	253.9
Wales	4, 5	77.6	27.7
West Midlands	5	156.4	55.8
North West	5	86.4	30.8
Other UK e.g. Channel Islands	Excluded	14.0	5.0
Northern Ireand	5	22.4	8.0
Total UK		**2952**	**1053**

Table 3.44 Summary of the spatial extent of non leisure-boating activities around the UK coast.

Sector	*Activity*	*Description of activity and spatial distribution*	*Regional studies on economic value of activity*
Recreational and sport fishing		Widespread although participation rates are highest in the South West, South East, North East and Wales (Defra, 2004c). The largest angling charter boat ports in the UK are Weymouth and Poole (Nautilus consultants, 2005). In Northern Ireland popular spots include Portrush, Dunseverick, Ballintoy, Torr Head.	Generates £165 million of expenditure in the South West each year: £110 million from resident anglers and £55 million from visiting anglers (Nautilus consultants, 2005). The value of recreational sea angling in Wales is estimated to be £28 million (Nautilus consultants, 2005) and £141 million in Scotland (Radford et al., 2009). In Scotland, the Firth of Lorne and the Sound of Mull have become the centre for common skate contributing over £15 million per year to the local economy. Lochs Sunart and Etive attract vast numbers of shore and boat anglers seeking spurdog, this fishery is estimated to be worth £15 million per year. Tope are worth about £10 million per year to several communities in Dumfries and Galloway.
Watersports	Surfing	Surfing is undertaken along beaches and reef breaks all around the UK but primarily in Cornwall, Devon and Dorset in England, along the Gower Peninsula, Pembrokeshire and the Llŷn Peninsula in Wales and in the outer Hebrides and Caithness coast in Scotland.	The direct spend of surfers in Cornwall was in the region of £21 million per annum in 2000 (Cornwall Enterprise, 2001).
	Scuba diving	Mainly along rocky coastlines in areas with good water visibility with particularly popular spots including St Abbs-Berwickshire, Weymouth, Plymouth, the Isles of Scilly, Sussex, Scapa Flow (Orkney), the Pembrokeshire islands, the Inner Hebrides and Strangford Lough	The cost of acquiring, preparing and sinking HMS Scylla in Whitsand Bay amounted to £1.25 million although the net economic impact of the Scylla in terms of additional expenditure from the first season of diving was estimated at just under £1.4 million (see Case Study 3)
	Outdoor swimming	Widespread around the UK	No data available
	Coasteering	Coasteering is an activity which combines sea level traversing, scrambling, surf swimming and cliff jumping along a rocky stretch of coastline. The activity is primarily run by outdoor activity centres in Pembrokeshire, Anglesey, Devon and Cornwall.	No data available
Marine wildlife watching		The main areas for marine wildlife tourism are the west coast of Scotland (principally the Isle of Mull and Oban on the mainland), Moray Firth, Pembrokeshire, Cardigan Bay, Cornwall and Strangford Lough.	Estimated at £9.3 million in Scotland in1998 with the indirect revenue resulting from marine wildlife tourism estimated at £57 million.

Figure 3.23 Location of boat building facilities and sailing areas.

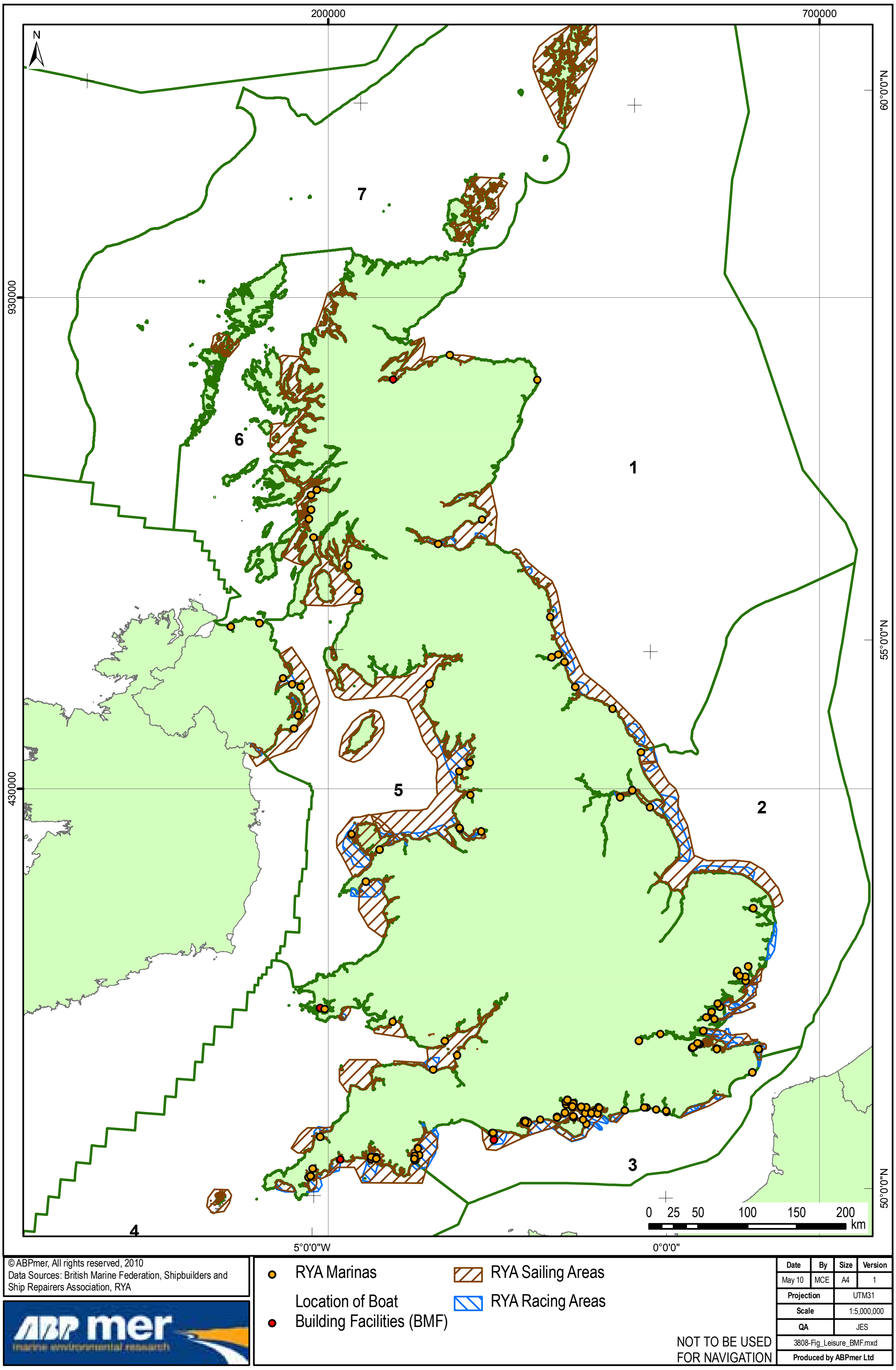


Figure 3.24a Regional distribution of non leisure-boating watersports activities. Regions 1, 6 and 7.

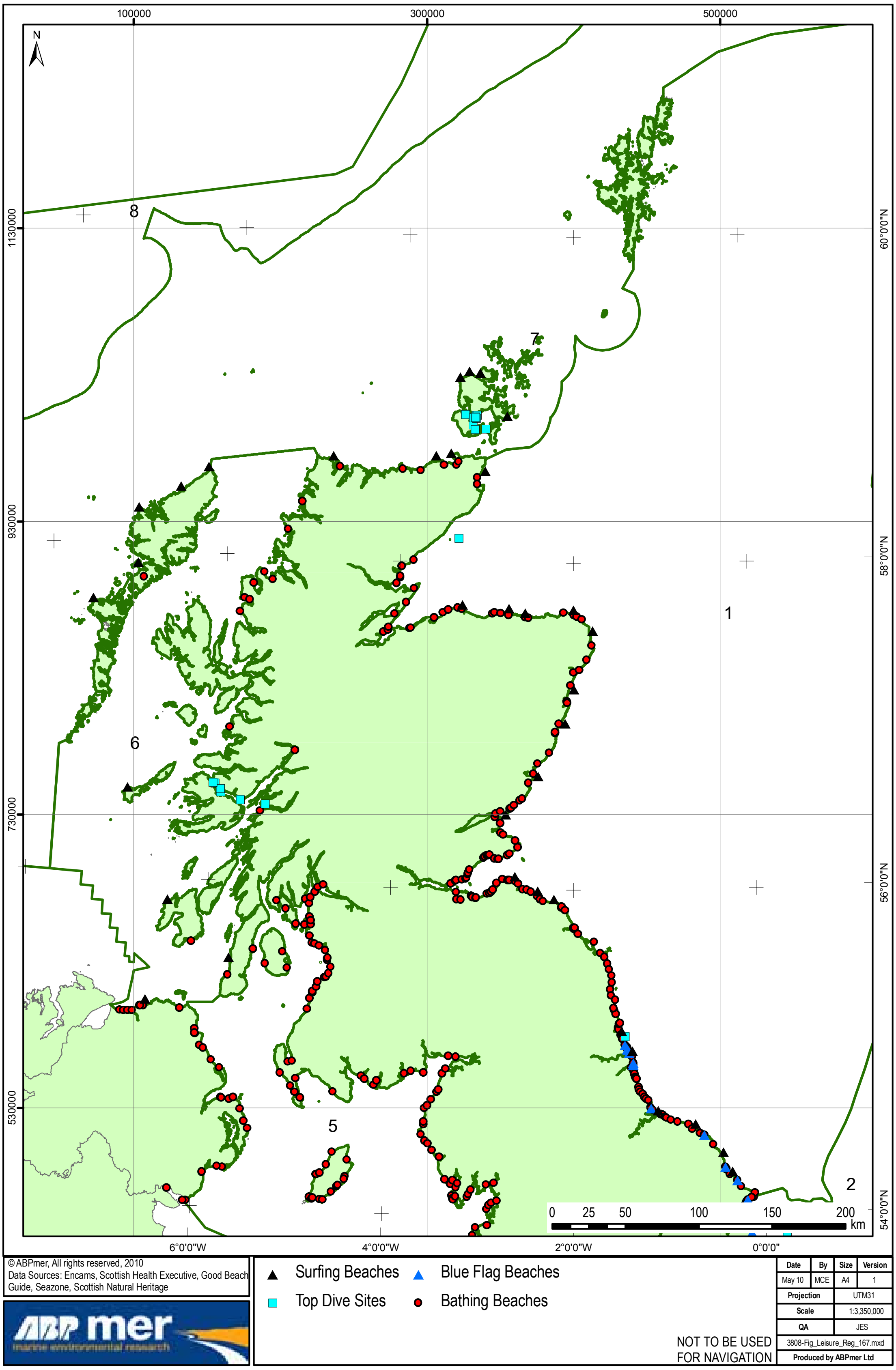
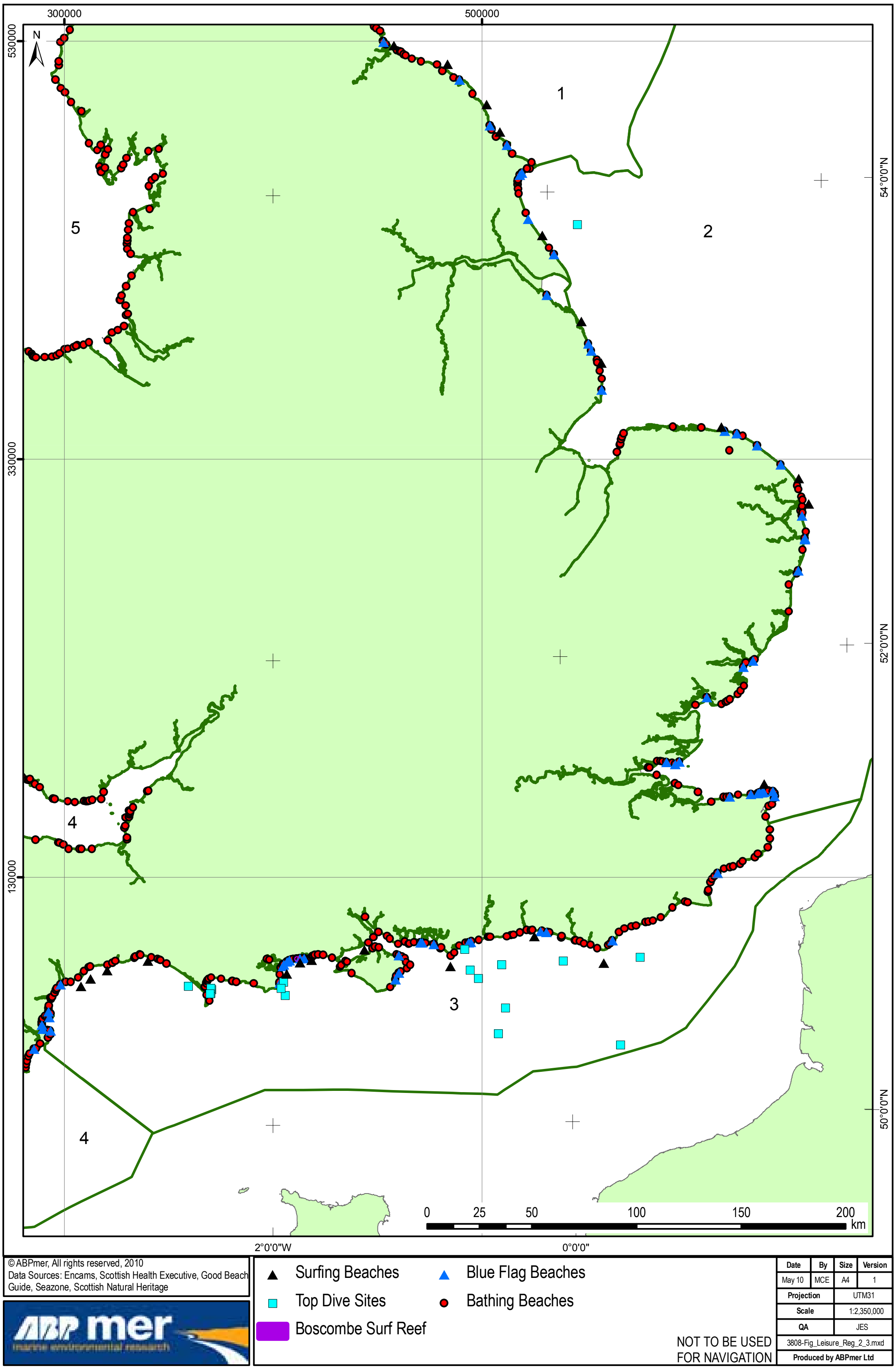


Figure 3.24b Regional distribution of non leisure-boating watersports activities. Regions 2 and 3.



Data Sources: Encams, Scottish Health Executive, Good Beach Guide, Seazone, Scottish Natural Heritage

Figure 3.24c Regional distribution of non leisure-boating watersports activities. Regions 4 and 5.

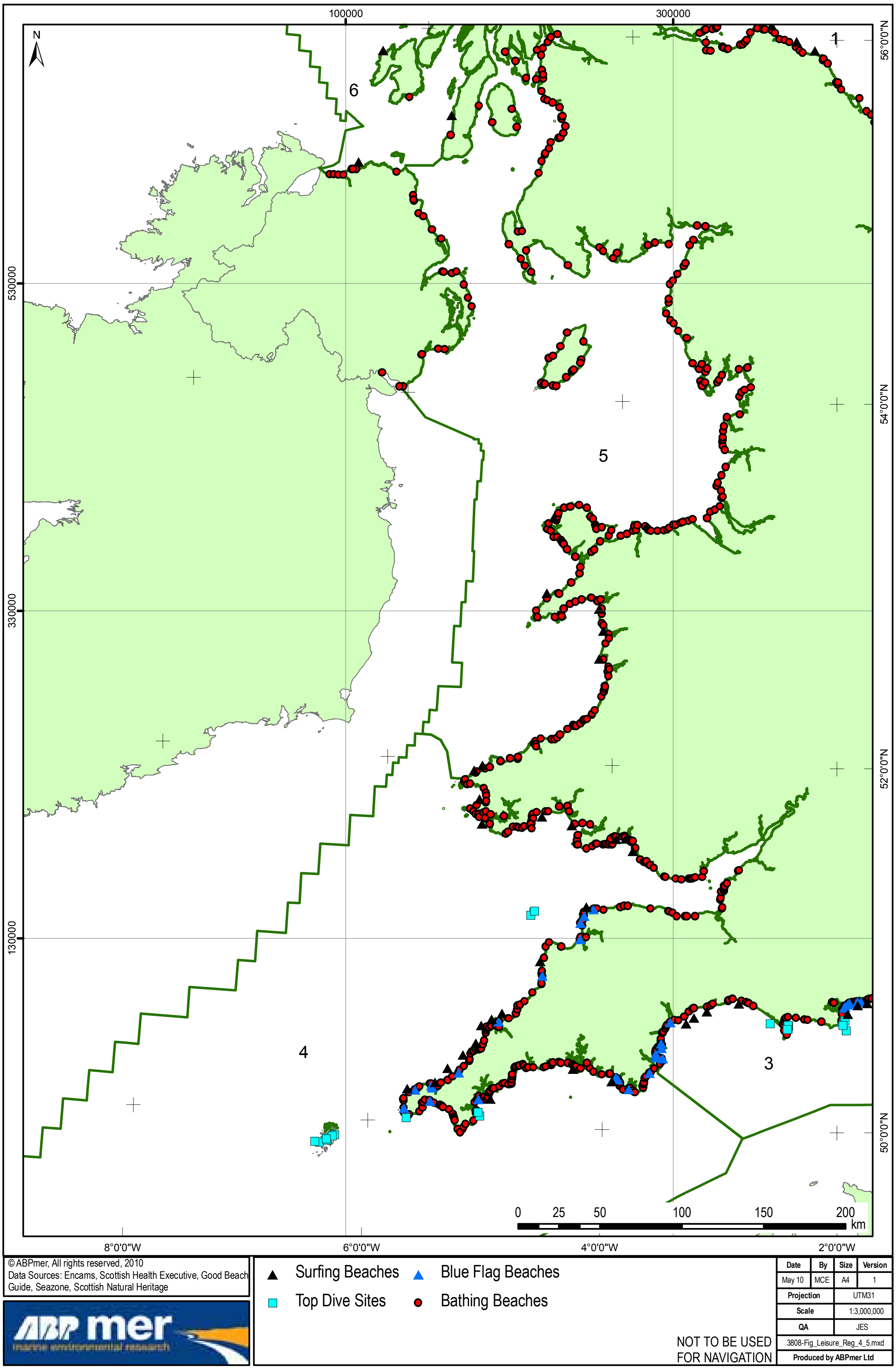


Table 3.45 Regional value of all leisure and recreational activities.

CP2 Region	*% leisure activity*	*Proportion of GVA, £ million*
1	13.90	179
2	11.92	154
3	21.23	274
4	20.45	264
5	18.88	243
6	6.74	87
7	6.81	88
8	0.07	1
Total	**100**	**1289**

major focus for this sector for many years. From large traditional seaside resorts to small-scale coastal activities, this sector makes an important contribution to the local, regional and national character of the coast and surrounding marine environment.

The main area of employment is in marine leisure-boating which employed around 35 680 people across the industry in 2006/07 – an increase of 1.9% on 2005/06 (BMF, 2007a). Many of these jobs are centred around major sailing ports and coastal resorts such as Cowes, Dartmouth, Portsmouth, Plymouth, Poole, Falmouth and Largs. Sea angling is another area of high employment in the leisure and recreation sector with roughly 19 000 related jobs around the UK (Defra, 2004c).

In addition to the revenue from the industry itself, participation in boating activities and holidays generates a range of further national, regional and local economic benefits, for example spending in supermarkets, in hotels, restaurants and pubs, and on travel. Domestic spending associated with leisure boating amounts to at least £2 billion a year, supporting up to an additional 68 000 jobs (BMF, 2007a).

The UK coastal marina sector directly employs 1700 people, with a turnover of £113 million (Table 3.41) and a GVA of £69 million. In addition, the associated marine and hospitality activities of marina operators are estimated to support a further 600 local jobs and £6.5 million of GVA (BMF, 2007a).

Sea angling in Scotland supported 3148 full-time equivalent (FTE) jobs in 2008, representing an income of £69.67 million (Radford et al, 2009). The study estimated that if sea angling were to cease to exist 1675 FTEs with an income of £37 million would be lost.

Activities which are often undertaken along sparsely populated stretches of coastline such as surfing, scuba diving and angling can be important sources of employment to these rural areas, such as in shops, angling charter and scuba diving centres. For example, an estimated 3000 jobs in the south west are linked to sea angling alone (Nautilus consultants, 2005). Marine wildlife tourism is a particularly important area of employment for certain rural coastal areas of Scotland (with over 400 jobs in 1998 in the sector) (Masters et al., 1998). Marine wildlife watching not only has important social implications for the small rural communities in terms of employment but is also important in raising the awareness of local marine wildlife, inspiring the public and teaching a healthy respect for their natural environment (Beaumont et al. 2006). As an example, the Tiree Wave Classic windsurfing event contributed an economic income of £0.36 million in 2004 (SNH, 2008b).

Angling and watersports activities have been shown to contribute towards helping to divert young people away from anti-social behaviour, building relationships and linkages on a cross-border and cross-community basis, and facilitating greater social cohesion (PricewaterhouseCoopers, 2007; University of Brighton, 2008).

3.6.7 Environmental pressures and impacts (positive and negative)

Key environmental pressures and impacts associated with leisure and recreation are presented in Table 3.46. The ecosystem services that these pressures impact and the relative significance of these impacts are identified in Table 3.47. A number of impacts relate to water transport in general including physical impacts from marina construction, slipways and installation of moorings; dredging of the seabed for access routes and introduction of non-native species from boat hulls. These impacts are considered in more detail in Section 3.7 (Maritime Transport).

3.6.8 Climate change

3.6.8.1 Impacts of climate change on the leisure and recreation sector

Coastal tourism

Climate change is increasing the frequency of months when conditions are more comfortable for tourism in NW Europe (MCCIP, 2008). Warmer weather is more likely to attract visitors to coastal locations around the UK, extending the tourist season beyond its traditional limits and opening up new destinations. An increase in the frequency of 'extreme weather' events such as storms and severe rainfall has also been predicted, however, which could discourage tourists and disrupt travel, utilities and marine leisure service provision (Yeoman, 2005; McEvoy et al., 2006; MCCIP, 2008).

Watersports

The temperature of the water has an impact on anyone who enjoys watersports particularly 'full immersion' watersports such as surfing, scuba diving and swimming. Warmer sea conditions and milder air temperatures in the future are likely to increase the extent and level of participation in these activities (particularly through the colder winter months) (Knights, 2007).

Winter precipitation across the UK is predicted to increase by between 10% and 35% by 2080 depending on the region and the greenhouse gas emission scenario used in the projection. As well as more rain predicted in winter, the average intensity of the rainfall is also predicted to increase, possibly by more than 20% in some areas (Hulme et al., 2002). This increase in rainfall means that the likelihood of an overflow of untreated sewage into coastal waters is also predicted to increase (Knights, 2007). Coming into contact with water containing sewage is a serious health risk, especially for those enjoying watersports that result in total immersion, where swallowing of small volumes of water is unavoidable. The amount of pollutants entering coastal waters is also likely to be higher as surface 'run-off' increases. In urban areas, these inputs can include substances such as oil and heavy metals whereas in rural areas, run-off from agricultural land can contain high levels of pesticides or pathogens from animal faeces (Knights, 2007).

A greater incidence of severe winds and larger mean wave heights in western and northern UK waters are being observed. Models predict fewer Atlantic depressions crossing to UK waters

Table 3.46 Key environmental pressures and impacts associated with leisure and recreation. Based on information from: Lyngs (1994); Evans (1998); UK CEED (2000); Ronconi and St Clair (2002); Zakaia and Chadwick-Furman (2002); Woods-Ballard et al. (2003); Kelly et al. (2004); Barker and Roberts (2004); Tyler-Walters (2005); Pinn and Rodgers (2005); Davenport and Davenport (2006); Defra (2007b); JNCC (2008a); RYA Green Blue website (www.thegreenblue.org.uk).

Pressure	**Marine wildlife disturbance (visual and acoustic)**
Impact	The growth of marine ecotourism and nature watching around the UK has highlighted the issue of marine wildlife disturbance (Kelly et al., 2004). Disturbance caused by an external influence can cause animals to stop feeding, resting or travelling and socialising with possible long-term effects of repeated disturbance including loss of weight, condition and a reduction in reproductive success.
Activities involved	Disturbance and harassment (repeated disturbance) of seals, cetaceans and basking sharks can occur from a large variety of recreational users including sailing boats, jet skis, powerboats, swimmers and SCUBA divers. The severity of disturbance is dependent on the type of craft used and behaviour of the recreational user.
Description of environmental change (intensity, spatial extent, frequency, duration)	Difficult to quantify as limited spatial data exist on this issue due to a low level of official reporting and a high level of heterogeneity in where incidents are recorded. A study by Kelly et al. (2004) found that a total of 106 records of potential incidents in the South West of England were reported from 1992 to 2002. The incidents were generally clustered around three main areas; Torbay, Plymouth and St. Ives with further incidents spread around the coastline from Weymouth (Dorset) to Braunton (north Devon).
Existing management measures	The Countryside and Rights of Way Act 2000 makes it an offence to cause 'reckless or intentional disturbance' to basking sharks, cetaceans and some bird species. Difficult to enforce although a number of codes of conduct have been implemented to help reduce this type of disturbance such as the 'WiSe' scheme, the Pembrokeshire Marine Code and the Scottish Marine Wildlife Watchers Code.

Pressure	**Physical disturbance of seabed substrata and alterations to the local benthic habitat**
Impact	Trampling, clambering, smothering and other physical disturbance of marine benthic habitats.
Activities involved	Coasteering, rockpooling, sea angling, anchoring of dive boats and SCUBA diving, intertidal shellfish collection and bait collection.
Description of environmental change (intensity, spatial extent, frequency, duration)	Comprehensive spatial data on subject are limited. The amount of physical disturbance will be dependent on the popularity of a site by water users (i.e. intensity) and the structure and sensitivity of the habitat. In most cases the extent of the 'footprint' will be relatively localized and the significance of impact minor. Concerns surround more sensitive habitats such as pink sea fans, sea pens, soft corals and areas where intensity is likely to be high. Pinn and Rodgers (2005) investigated the influence of visitors on intertidal biodiversity at Kimmeridge Bay. The research found a reduction in the larger, branching species of algae and an increase in ephemeral and crustose species in the more heavily utilized areas.
Existing management measures	Voluntary codes of conduct are in place at various marine reserves and popular dive areas to try and limit the level of physical disturbance, such as at Wembury, Devon and St Abbs, Berwickshire. Various bait collectors codes exist such as the National Federation of Sea Anglers (NFSA) and the Solent European Marine Site (SEMS) codes.

Pressure	**Sewage discharge**
Impact	Sewage discharge from boats causing health problems and nutrient enrichment of coastal areas.
Activities involved	General coastal tourism, leisure-boating.
Description of environmental change (intensity, spatial extent, frequency, duration)	Mainly around coastal resorts and ports.
Existing management measures	Discharge of sewage from boats to coastal waters is regulated through the International Convention on the Prevention of Pollution by Ships (MARPOL 7 3/78). This does not apply to small craft carrying fewer than 15 passengers. Disposal at sea is therefore a value judgement but accepted convention is that holding tanks should not be emptied less than three miles offshore. Since 2006, the EU Recreational Craft Directive has applied to newly built vessels and requires provision to be made for a holding tank to be fitted.

Pressure	**Erosion and increase in suspended sediments**
Impact	Increase in the erosion of soft sediment features and an increase in suspended sediments caused by scouring from boats' wake/wash.
Activities involved	Leisure-boating.
Description of environmental change (intensity, spatial extent, frequency, duration)	Mainly around coastal resorts and ports.
Existing management measures	A number of management approaches are available for controlling boat wash. Non-statutory approaches through zoning, speed restrictions and no wake zones have been implemented and are common in inland waterways. Navigation, harbour and local authorities have the power to enforce byelaws for zoning and speed restrictions if necessary, for example, the Poole Harbour 'Watch your Wash!' program.

Pressure	**Litter**
Impact	Includes plastic, polystyrene, rubber, metals and glass. Litter can impact on marine species through ingestion, entanglement and smothering.
Activities involved	Urban runoff from coastal developments, waste disposal, leisure boating and general beach tourism.
Description of environmental change (intensity, spatial extent, frequency, duration)	Quantity of litter remains high but no trend.
Existing management measures	Dropping litter is an offence under the Environmental Protection Act 1990. Various litter monitoring, clean-up and education schemes are conducted at national and/or local level, such as the MCS Beachwatch. See the Marine Pollution Monitoring Management Group (2002) review for full details of initiatives.

Pressure	**Introduction of non-native species**
Impact	Introduced via fouling on boat hulls.
Activities involved	See Section 3.7 (Maritime Transport) and Case Study 4.
Description of environmental change (intensity, spatial extent, frequency, duration)	See Section 3.7 (Maritime Transport) and Case Study 4.
Existing management measures	See Section 3.7 (Maritime Transport) and Case Study 4.

Pressure	**Removal of marine fauna and flora**
Impact	Reduction in fishing stocks of species exploited by angling. Entanglement of fish, seals and other species by tackle loss and discard.
Activities involved	Angling.
Description of environmental change (intensity, spatial extent, frequency, duration)	Widespread but difficult to quantify.
Existing management measures	NFSA initiatives include abiding by minimum landing sizes and the use of a points system within competitions. The UK shark-tagging programme is a joint project by anglers and fisheries scientists which promotes sustainable angling through tagging and then releasing the sharks and encourages anglers to record if a tagged shark is recaptured. As part of a programme to protect the threatened shark species tope (*Galeorhinus galeus*), the UK Government has put severe controls on the catching of tope in England. From the 6 April 2008 anglers are only allowed to catch tope on a catch and release basis.

Table 3.47 Environmental pressures on ecosystem services associated with leisure and recreation.

Ecosystem Service	*Significance of impact*	*Confidence in understanding of the relationship = information gaps*
Physical environment	**Moderate**. Physical disturbance can be severe in areas that are popular for marine recreation (e.g. diving), but is generally localized in those areas. Disturbance can also be caused by scouring from boats' wake/wash, which increases erosion on a wider scale, but with a less intense impact at any point.	**High**. Impacts on benthic marine environment well understood.
Biological productivity	**Low**. Recreational angling is unlikely to occur at any level that is threatening to fish stocks. Visual and acoustic disturbance can have a severe impact on marine wildlife, but severity is dependent on craft/ equipment type and how it is used.	**Low**. Neither angling nor disturbances are well reported.
Biodiversity provision	**Moderate**. Although visual and acoustic disturbance, sewage discharge and litter are all dispersed in the marine environment, the cumulative impact starts to become severe on the lifecycles of marine wildlife.	**Moderate**. Difficult to quantify disturbance, but effects are understood.
Water purification and waste treatment	**Low**. Although recreation does affect water quality (e.g. through sewage discharge and increase in suspended sediment), the effect is small in comparison to residential and industrial level discharge.	**Moderate**. Recreational contribution to water quality issues not well quantified, but affects and desired level of water quality understood.

but a greater number of deep depressions (intense storms) and an associated increase in wave height (MCCIP, 2008). These conditions are likely to be of mixed fortune for many UK watersports activities. The possibility of intense storm events are likely to create hazardous conditions for surface watersports activities such as sailing, kayaking and swimming by increasing wave height and altering other hydrodynamic conditions. Although a possible increase in wave height could be expected to improve surfing conditions, strong storms can lead to huge confused seas (i.e. lots of different sized waves on top of each other) reducing the quality of the wave and making conditions dangerous (Knights, 2007). An overall reduction in the frequency of Atlantic depressions could be beneficial for some watersports, bringing calmer surface conditions and more settled underwater conditions (e.g. greater visibility for scuba diving and snorkelling).

Increased sea levels could lead to an increased frequency of flooding and damage to infrastructure and facilities such as club buildings, boat parks and jetties. The implications of climate change and coastal defence are discussed further in Section 3.2 (Coastal Defence).

An increase in temperature is predicted to increase the frequency and amount of harmful algal blooms (HABs). Rising temperatures and reduced mixing of the water column (increased stratification) would favour many HAB-causing species which pose a threat to bathers and other watersports users. An increase in jellyfish is also predicted to occur around certain parts of the UK coast such as the North Sea (Attrill et al., 2007). This could mean that stinging jellyfish which can harm humans, such as the lions mane (*Cyanea capillata*) and the mauve stinger (*Pelagia nocticula*), could become more abundant.

Marine wildlife tourism

Marine wildlife tourism includes viewing a range of marine species such as whales, dolphins, basking sharks, seals and seabirds. These species are all highly mobile and environmental factors caused by climate change can cause distribution shifts in these species. A shift in the distribution of the common dolphin (*Delphinus delphis*) and white-beaked dolphin (*Lagenorhynchus albirostris*) which is thought to be related to climate change has already been recorded around northern Scotland (MacLeod et al., 2005). The impacts of climate change on marine mammals remain poorly understood (MCCIP, 2008). Any climate-induced changes in these species has implications for the marine ecotourism sector and ultimately the economy of small rural communities.

Recreational sea angling

Changes in species distribution and abundance could mean that anglers must shift to targeting different fish species or travel further to catch preferred target species.

Adaptation measures

The most likely form of adaptation will be to redirect utilisation towards those areas which in the future are likely to be better suited for that activity, such as more sheltered locations.

3.6.8.2 Impacts of the leisure and recreation sector on climate change

The largest impact associated with leisure and recreation is through carbon emissions associated with travel. Even seemingly low impact sports such as swimming and surfing usually require a substantial coastal tourist infrastructure to support them. People are also willing to travel large distances to undertake marine leisure and recreation activities around the UK coastline (Davenport and Davenport, 2006). For example, in recent years rising berthing costs and lack of space in popular yachting regions such as the South East of England has meant that in some cases it is more cost efficient for sailors to keep their boats berthed in marinas a considerable distance from their homes (taking advantage of the proliferation of low cost airlines to commute to their boats at weekends). Certain activities such as motor boating and personal watercraft also create emissions while undertaking the activity. Construction of leisure craft and other watersports equipment also uses energy. The development and running of coastal developments associated with these activities are another source of carbon dioxide.

Mitigation measures

Mitigation measures for a range of activities may include: using public transport and/or car share where appropriate, avoiding using flights to travel to tourist destinations instead using ferries/boats etc where applicable, and buying second-hand equipment and new equipment made out of material which has a lower carbon footprint.

3.6.8.3 Summary

Table 3.48 summarises the climate change pressures and impacts discussed in this section and indicates the likely significance of the impacts, the level of confidence in the assessment and measures that might be employed to manage the impacts (see Annex 1 for a discussion of the assessment methodology).

Table 3.48. Summary of climate change implications.

Climate change pressure	*Impacts of climate change on Leisure and Recreation*	*Confidence/ significance*	*Adaptation measures*
Temperature changes	Changes to tourist season and geographical location	Medium confidence / medium significance	Changes to tourist infrastructure
Increase in sea temperatures	Warmer sea conditions and milder air temperatures in the future are likely to increase the extent and level of participation in these activities (particularly through the colder winter months)	Medium confidence / low significance	None
	Changes in the distribution of species which are important to marine wildlife watching and angling	Medium confidence / medium significance	Tourist infrastructure in areas more suited to activity
Increase in severity of storms	Short term dangers to watersports participators.	Low confidence / low significance	Can be avoided with forecasting
	Damage to infrastructure through storm damage	High confidence / medium significance	Improved coastal defences or re-siting of infrastructure
Increase in sea level	Damage to infrastructure through flooding	High confidence / medium significance	Improved coastal defences or re-siting of infrastructure
Increased severity of rain storms	Increased runoff causing lowered water quality.	Medium confidence / high significance	Improved sewage treatment works

Impacts of Leisure and Recreation on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
CO_2 emissions from personal watercraft and transport.	CO_2 emissions	Low confidence / unknown significance	Use of lower carbon transport and development of new engine technology to minimise CO_2 emissions
Construction of watersports equipment	CO_2 emissions	Low confidence / unknown significance	Purchase of second hand equipment, use of recycled materials in construction.

3.6.9 Industry stability and sustainability

3.6.9.1 Objectives, targets and indicators

National policies for tourism, recreation and leisure are contained in a number of policy documents:

- In England: Planning Policy Guidance (PPG) 17: Planning for Open Space, Sport and Recreation; PPG20: Coastal Planning; and PPG21:Tourism
- In Scotland: National Planning Framework for Scotland; National Planning Policy Guidance (NPPG) 13 Coastal Planning; NPPG11: Sport Physical Recreation and Open Space
- In Wales: Wales Spatial Plan; Welsh Coastal Tourism Strategy; Technical Advice Note (TAN) 13: Tourism; TAN14: Coastal; TAN16: Sport & Recreation

- In Northern Ireland: Regional Development Strategy; Planning Policy Statement (PPS) 8: Open Space, Sport and Outdoor Recreation.

All of these policy documents recognise the importance of the coast in providing opportunities for tourism, sport and recreation and seek to promote such activities where they are sustainable. They also seek to protect water frontage for those activities and developments that require it, such as access to deep-water areas for slipways or boatyards.

In Wales, the policy framework is particularly developed as a result of the preparation of the Welsh Coastal Tourism Strategy (WAG, 2007) and *Catching the Wave* (WAG, 2004a), the Welsh Assembly Government's tourism watersports activities and facility development strategy. The Welsh Coastal Tourism Strategy presents a number of aims and outcomes, against which progress is monitored (see Box 3.3). *Catching the Wave* also includes specific targets for developing watersports activity:

- To grow the number of domestic watersports trips and nights by 20% to just over one million trips representing around 5 million bed nights
- To grow the value of domestic watersport tourist spending by 40% to over £200 million
- To grow the numbers of trips taken by the higher spend overseas market by 50% and to increase overseas visitor spend by 40% to £15 million.

3.6.10 Forward look

The leisure and recreation sector has experienced large growth in a number of diverse areas over the past decade (e.g. small personal watercraft and activities such as surfing, wakeboarding, kite-surfing and coasteering). The growth and stability of the marine leisure and recreation market is heavily dependent on the general health of the UK economy. A strong economy means that consumers have more disposable income and are more inclined to spend money on this sector than when the economy is weaker.

The 'sector' is not homogeneous throughout the UK in terms of the distribution of activity or value. Some areas are more dependent on the economic income from leisure and recreation and are therefore vulnerable to downturns in activity. Disparity in berthing fees between England and Scotland means that in recent years, some boat owners in the south have found it more cost-efficient to keep their yacht on the West Coast of Scotland and fly up at weekends to use it. The recent UK economic downturn may lead to a reduction in such activities but in the long-term the sector is expected to continue to grow.

Defra (2004c) suggests there is a stable or increasing demand for sea angling with increasing use of charter and private boats. The report also suggests that growth in the sector in England and Wales may be inhibited by a lack of fish or poor fish quality. As with the commercial sector, many charter skippers believe improved technology masks the full impact of stock declines, as nowadays they are better at targeting the fish that remain. In the relatively short term therefore, participation levels may decrease if successful stock recovery measures are not put in place. The Bass Anglers' Sportfishing Society, for example, believes that an annual value of £150 million, is achievable within five years of the introduction of specific management measures aimed at providing more and bigger bass. Expenditure could exceed £200 million within eight years, if trends elsewhere are repeated.

Box 3.3:
Welsh Coastal Tourism Strategy – Aims and Outcomes (WAG, 2007)

Aim: To encourage economic, social and environmental benefits for coastal communities.

Key outcomes:

- Tourism is making an increasing contribution to the economy of coastal communities
- Welsh coastal waters have the highest standards of water quality in the UK
- The quality of Welsh beaches is recognised by the high number of Blue Flag and Green Coast Awards.

Aim: To improve the quality of the visitor experience.

Key outcomes:

- Visitors to the coast express high levels of satisfaction
- The Welsh coastal tourism offer appeals increasingly to the under 25 age group and 'AB' socio economic groups (defined as the higher to intermediate managerial/professional groups in the National Readership Survey grading system)
- Wales is the leading UK watersports destination for the family and multi-activity holiday maker
- More visitors are coming to the coast to enjoy its biodiversity, heritage and culture
- The coast offers a more diverse tourism accommodation base that is meeting visitor needs
- Provision of marina berths is adequate to meet market demands without detrimental environmental or community impacts.

Aim: To achieve an integrated approach to the development and management of coastal tourism.

Key outcomes:

- Local communities are actively involved in the management of the rural coast
- Coastal resorts are managed and developed with the needs of visitors in mind
- Local communities are involved in developing tourism in their area
- Increasing numbers of visitors travel to and along the Welsh coast by sustainable means
- There is a balance on the coast between tranquil areas and areas supporting a large number of people and a range of activity.

Aim: Coastal tourism is a year round industry.

Key outcomes:

- There is a significant increase in the percentage spent by visitors staying at seaside locations outside the main season
- Tourism supports more full time jobs on the coast.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the leisure and recreation sector will need to manage further its activities. For example, GES descriptor 10 states that *...Properties and quantities of marine litter do not cause harm to the coastal and marine environment*. However, it is likely that research to further describe the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.7 Maritime Transport

3.7.1 Key points

- In 2007, the turnover of UK shipping was £9.5 billion with a direct contribution to Gross Value Added (GVA) of £4.7 billion
- In total there are more than 650 ports in the UK for which statutory harbour authorities have been granted, of which 120 are commercially active
- In 2007, UK ports handled 582 million tonnes of freight traffic and contributed around £7.7 billion GVA
- A further £3 billion in tax receipts was provided to the Exchequer
- Employment taxes provide £1.4 billion of this and corporation taxes a further £1 billion
- In 2007, there were 24.8 million international sea passengers; of these, 23.7 million were short-sea ferry passengers mostly travelling to France and the Republic of Ireland and 1.1 million were cruise and other long-sea journeys
- In 2007, there were 24.2 million domestic waterborne passengers
- In 2008, the Maritime Coastguard Agency (MCA) and the Royal National Lifeboats Institution (RNLI) had a combined income of £171.87 million

i. Introduction

Maritime transport is primarily concerned with the transport of freight and passengers by sea. This sector is supported by a diverse range of ancillary activities including shipbuilding, the construction of ports and marinas and activities associated with navigation including dredging and the production of charts.

ii. How has the assessment been undertaken?

A major source of economic information is the Department for Transport's (DfT) annual report on transport statistics for Great Britain (DfT, 2008a). The reports on shipping produced for the Chamber of Shipping (Oxford Economics, 2007) and the report commissioned by the British Ports Association (BPA) on the value of the UK maritime transport industry (Oxford Economics, 2009) provide useful interpretations of economic data. Additional information was obtained from the Scottish and Welsh Transport Statistics (Scottish and Welsh Assembly Government). The Transport Statistics publication compiled by the Northern Ireland Government (DRDNI, 2009) only contains statistics on domestic seaport passengers and coastguard effort, so less information was available for that country. The latest year for which published Department of Transport maritime transport statistics were available was 2007: the report for 2008 was not published until September 2009.

iii. Current status of the maritime transport sector and past trends

In 2007, the turnover of UK shipping (freight, passenger and charter services) was £9.5 billion with a direct contribution to the Gross Domestic Product (GDP) of £4.7 billion GVA. UK ports handled 582 million tonnes of freight traffic although the number of freight passages is unknown due to the commercial sensitivity of shipping data. In 2007, there were 24.8 million passengers making international sea journeys and 42.4 million passengers making domestic trips from UK ports (DfT, 2008a). A total GVA of £7.8 billion was calculated for those

ancillary activities where such information was available (such as port activities, shipbuilding and navigation activities). However, the value to the economy from other service activities is less certain, so this is likely to be an underestimate.

In total, there are more than 650 ports in the UK for which statutory harbour authorities have been established, of which 120 are commercially active (DfT, 2005). Values to the economy were assigned to CP2 reporting regions based on the proportion of freight tonnage handled by major coastal ports in each region. The majority of value to the economy (>£1 billion each) is located in Region 2 (the Southern North Sea which includes major ports in the Thames connecting with London), Region 1 (the Northern North Sea linking with the northern European mainland), Region 5 (the Irish Sea linking Scotland, the Republic of Ireland, Northern Ireland, England and Wales) and Region 3 (the Eastern Channel with key routes to Europe and North Africa). This pattern is also likely to be a fair reflection on the distribution of pressures from shipping among the CP2 Regions.

Key pressures relate to pollution (e.g. oil spills, loss of cargo, leaching of antifoulants), introduction and spread of non-native species (through ship hulls and ballast water), noise impacts and habitat damage (such as from port development, maintenance dredging and disposal of dredge material – see Section 3.16: Waste Disposal). While shipping is generally a very carbon efficient form of transport, continued growth in the sector will increase global emissions which currently account for around 3.3% of global carbon dioxide (CO_2) emissions. Most of the shipping impacts are managed through the International Maritime Organization (IMO). Impacts from local development are managed through local planning policies and conservation objectives where they apply.

iv. What is driving change?

Drivers for changes vary among the different sub-sections of maritime transport.

v. What are the uncertainties?

The sector is extremely diverse with a number of ancillary activities that make a full assessment of the economic value difficult. While records are kept of vessel movements and shipping densities, this information is currently not easily and freely accessible, which hampers an assessment of pressures. Information collated should include aspects such as the size of ships and temporal data such as when and how often they sail.

vi. Forward look

The long-term trend is for sustained growth of 3% to 4% on average per year in the container and Ro-Ro sectors. The Ports Policy review in 2007 proposed no substantive change to the regulatory framework although the recommendation for Master Plans by major ports may help to refine the operating framework for ports.

3.7.2 Introduction

This sector is primarily concerned with the transport of freight and passengers by sea. Maritime transport is supported by a diverse range of ancillary activities including shipbuilding, the construction of ports and marinas and activities associated with navigation including dredging and the production of charts. The principal and ancillary activities associated with this sector are shown in Table 3.49.

Table 3.49 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Maritime transport: of passengers (50.10) and of freight (SIC 50.20)	Full list in Table 3.52, examples include: Shipbuilding (SIC 30.11); Construction of ports and marinas (SIC 42.91); Navigation, pilotage & berthing (SIC 52.22), Capital and maintenance dredging of harbours and navigation channels (SIC 52.22); Storage of freight (SIC 52.10/1)		Manufacture of parts of boats and ships, e.g. sails, anchors, engines, navigation equipment; Shipbroking; Dry bulk chartering; Second-hand tonnage

Around 95% of international goods to and from the UK go by sea, so ports play a vital role in the UK economy (DfT, 2005). In total there are more than 650 ports in the UK for which statutory harbour authorities have been granted, of which 120 are commercially active (DfT, 2005). The major cargo types are shown in Figure 3.25. The sector is diverse ranging from major ports such as London and Liverpool, which carry out a number of functions, to specialised ports such as Dover which is a ferry port, specialised container ports such as Felixstowe and smaller ports catering for local traffic or for particular sectors such as fishing (e.g. Peterhead) and leisure (e.g. Cowes). Economic activity from shipping operations has been assessed by Pugh (2008) and shipping impacts are described in the *OSPAR Quality Status Report 2010* (OSPAR, 2010). This sector is supported by ancillary activities such as shipbuilding, construction of ports and marinas, the dredging activities that keep these operational and storage of freight. Excluded from this sector are the manufacture of boats and parts such as sails and engines.

Freight statistics generally include four categories of traffic (foreign, coastwise, one-port traffic, inland waterway traffic; DfT, 2008a). Foreign traffic is defined as traffic between ports in the UK and foreign countries (countries outside England, Scotland, Wales, Northern Ireland). Coastwise traffic covers goods loaded or unloaded at ports in the UK, and transported to or from another port in the UK. One-port traffic covers cargoes that are not transported from port-to-port and includes dredged materials landed at a port, traffic to and from offshore installations such as oilrigs and material shipped for dumping at sea. Inland waterways are defined as all water areas available for navigation that lie inland of a boundary defined as the most seaward point of an estuary which might be reasonably bridged or tunnelled (DfT, 2008a).

Shipping is an international industry and therefore there is a need for international standards to regulate the industry. This is provided by the IMO, a specialised agency of the United Nations with 168 Member States and three Associate Members. IMO's main task has been to develop and maintain a comprehensive regulatory framework for shipping including, safety, environmental concerns, legal matters and maritime security. The most important convention regulating and preventing marine

Figure 3.25 UK major port traffic by cargo type in 2007. Source: Justine Saunders, Oxford Economics (2009).

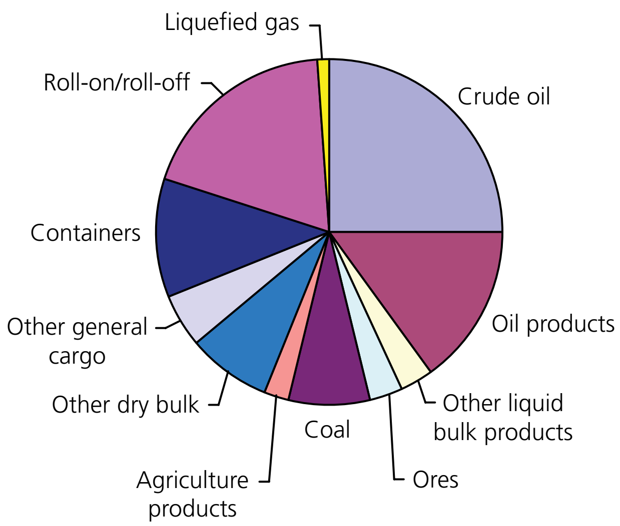
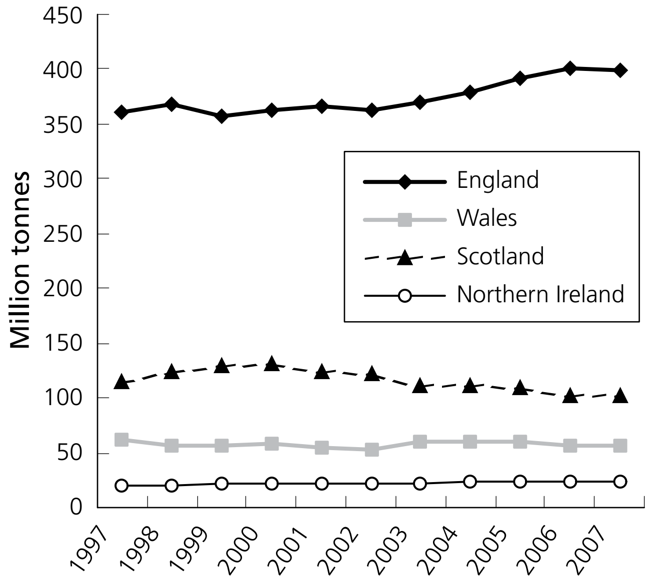


Figure 3.26 Foreign and domestic traffic (million tonnes) through ports by country, 1997-2007.



pollution by ships is the IMO International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL). The convention covers operational and accidental oil pollution as well as pollution by chemicals, sewage, garbage and air pollution.

The maritime transport sector also relies on various ecosystem services that support its productivity, including: the physical environment and chemical cycling/ water purification.

3.7.3 Direct use value

3.7.3.1 Principal activities

The recent report by Oxford Economics (2009), estimates that from a turnover of £9.5 billion the shipping industry[15] contributes around £4.7 billion GVA to GDP (0.5% of the total output of the UK economy). This contribution to GDP was used to estimate the regional value of the CP2 Regions (Table 3.50).

15 This encompasses freight, passenger and charter services but excludes port services that are considered under ancillary activities.

Maritime transport of freight

The latest year that information on freight traffic was available for was 2007. In that year UK ports handled 582 million tonnes of freight traffic (DfT, 2008a). This comprises: 273 million tonnes of foreign imports, 164.5 million tonnes of foreign exports, 57.6 million tonnes of inwards coastwise traffic, 57.2 million tonnes of outwards coastwise traffic, 26.9 million tonnes of inwards one-port traffic and 2.0 million tonnes of outward one-port traffic. The revenue from freight in 2008 was £4023 million (DfT, 2008a) and the type of freight transported is shown in Figure 3.25 (for trends see Section 3.7.5 and Figure 3.26).

Ship arrivals at UK ports totalled 140 000 in 2007, 15% lower than in 2006. These included 77 000 Ro-Ro (Roll on, Roll off), 32 000 general cargo, 21 000 tankers and 10 000 container vessels (DfT, 2008a).

Table 3.50 Allocation of freight to UK coastal ports and estimated value according to CP2 Regions.

CP2 Region	*Amount of UK freight[a], million tonnes*	*Estimated value[b], £ million*
1	106.6	887
2	187.1	1555
3	78.3	651
4	68.1	566
5	89.2	741
6	9.1	75
7	27.2	226
8	0	0
Total	**565.6**	**4700**

[a] Excluding freight from river ports (DfT, 2008a);
[b] based on total GVA allocated to coastal ports (Oxford Economics, 2009).

Maritime transport of passengers

In 2007, 24.8 million international sea passengers went through UK ports (DfT, 2008a). Of these 23.7 million were short-sea ferry passages, with the majority of passengers travelling to France and the Republic of Ireland (ROI), while 1.1 million passengers undertook cruises and other long-sea journeys (DfT, 2008a). The ROI is a major destination of passenger ferries from Welsh ports although numbers of movements to and from the ROI have been declining since 1998 (Statistics for Wales, 2009).

In addition to this, in 2007, 24.2 million domestic sea passengers travelled between ports in the UK[16] (Oxford Economics, 2009). Domestic passengers include those on: (1) sea crossings between mainland Britain, Northern Ireland, Isle of Man, Orkney and Shetland and Channel Islands plus miscellaneous day cruises and crossings, (2) inter-island services including those to and within the isle of Wight, and (3) river crossings, for example, on the Mersey, Thames and other harbours. The total (24.2 million) also includes 18.7 million inter-island crossings, of which 10.7 million passenger trips were made between Hampshire and the Isle of Wight and 8.0 million between the Scottish Islands (DfT, 2008a; Scottish Government, 2008d). There were also 2.35 million passenger crossings between Northern Ireland and Great Britain.

Based on Chamber of Shipping enquiries the revenue raised from passengers is estimated as £430 million (DfT, 2008a).

3.7.3.2 Ancillary activities

This area of economic activity is extremely diverse covering service industries such as port services, shipbuilding and maintenance, and activities of the legislative authorities as listed in Table 3.49 with their relevant SIC numbers. These three groups of economic activity are assessed in the following sections and are summarised in Table 3.51.

Service activities incidental to sea transportation

This section includes, for example, the operation of ports, piers & waterway locks, navigation, pilotage & berthing, lighthouse activities, capital and maintenance dredging of harbours and navigation channels. These are described in detail in the following sections.

Operation of ports, piers and waterways

A report prepared by Oxford Economics (2009) for ABP and the UK Major Ports Group suggested that ports contributed £7.7 billion GVA in 2007. This figure was calculated through employment figures in each industry within the ports sector multiplied by the average

16 This total excludes river crossings of approximately 18 million passengers in 2007.

Table 3.51 Estimated commercial value of some ancillary activities.

Activity	*Turnover, £ million*	*Value-added, £ million*	*Year*
Ports (including shipbuilding)	14 500 (1 950)	7 700 (912)	2007 (2004)
Lighthouse activities	70	27	2007
Navigation	94	46	2007/08
MCA	14	46	2008
RNLI	158	-	2008
Total	**14 836**	**7819**	

productivity of employees working in that sector. In 2006, GVA was £5.2 billion based on a turnover of £9.8 billion (Oxford Economics, 2007). This provides a value-added factor of 0.53. If this factor is applied to the 2007 figure (£7.7 billion) it is possible to estimate a turnover of £14.5 billion. The industries included in this analysis are shown in Table 3.52. A further £3 billion in tax receipts was provided to the Exchequer. Employment taxes provide £1.4 billion of this and corporation taxes a further £1.0 billion.

The number of people directly employed by ports in 2007 was 132 000 (Oxford Economics, 2009). Ports enable a range of industries to function, including the UK marine aggregate dredging fleet, and the offshore oil and gas industry which is supplied through ports. In 2007 there were 6670 fishing vessels working out of UK ports. Some recreation facilities are also provided by ports for watersports and in addition nearly 3000 people were employed in museums in ports in 2007 (Oxford Economics, 2009). Large numbers of these are employed in Liverpool and Portsmouth, which have a number of museums and historical ships. Other employees include an estimated 2175 staff of the UK Border Agency, employed in border control and migration.

Navigation

Admiralty charts and tide tables are prepared and published by the UK Hydrography Office (UKHO). The office employs on average 1111 staff FTE (full-time equivalent) at a cost of approximately £46 million. Total turnover for the year 2007/08 was approximately £94 million (UKHO, 2008). Databases maintained by the UKHO include the national register of wrecks. The principal purpose of this is to alert shipping to hazardous wrecks (the distribution of protected wrecks is shown in Figure 3.27; data on the distribution of wrecks are not freely available).

Responsibility for the provision and management of lighthouses, buoys and beacons on the coasts and seas around the British Isles is vested in the three General Lighthouse Authorities (GLAs); Trinity House, Commissioners of Northern Lighthouses and the Commissioners of Irish Lights. The income to the General Lighthouse Fund comes mainly from the light dues that are charged on commercial shipping, the rate per tonne in 2006 was 35p. In 2008, projected employment was 685 people (DfT, 2008b). In 2007, the income (turnover) from light dues was £70 million, staff costs (value added) were £27 million (DfT, 2008b). Headquarters are in London, Edinburgh and Dublin while operations are distributed around the coast (see Figure 3.27).

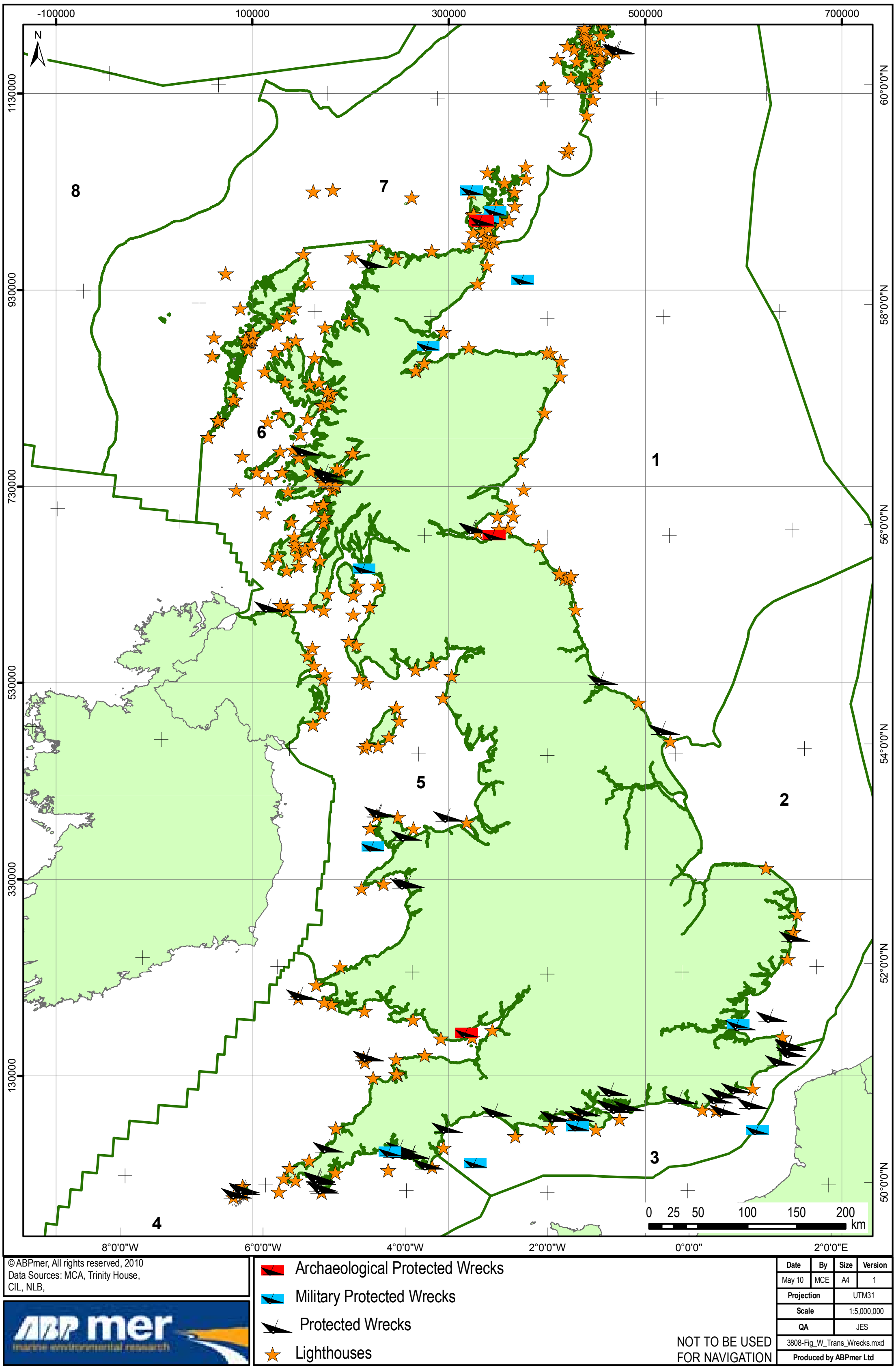
Capital and maintenance dredging of harbours and navigation channels

Disposal of dredging material is dealt with in Section 3.16 (Waste Disposal). Many port and harbour authorities operate under Local Acts

Table 3.52 Industries included in the valuation of the ports sector. Source: Oxford Economics (2009).

SIC Code (2006)	*Example of activities included*
35.11	**Building and repairing of ships**. Building and repair of ships for work purposes (e.g. hovercraft, passenger and freight ferries, fishing boats, etc); Now SIC code 30.11 and 33.15.
35.12	**Building and repairing of pleasure and sporting boats**. Building and repair of boats for pleasure (e.g. sailboats, yachts, power boats, etc)
45.21	**General construction of buildings and civil engineering works**. Construction and laying of offshore pipelines.
45.24	**Construction of water projects**. Dredging; Harbour, marina, dry dock or lock construction.
60.10	**Transport via railways**. Freight transport by inter-urban railways.
60.24	**Freight transport by road**. Road haulage of freight (including in tankers or refrigerated containers).
60.30	**Transport via pipelines**. Gas, liquid or oil transport via pipelines.
61.10	**Sea and coastal water transport**. Excursion, cruise or sightseeing boat operations; Hovercraft, passenger or freight ferries.
61.20	**Inland water transport**. Passenger or freight ferry (on river or estuary).
63.11	**Cargo handling**. Cargo, container and passenger bag handling; Stevedoring
63.12	**Storage and warehousing**. Frozen and refrigerated goods storage services; Bulk liquid and gases storage services; Grain silos and warehouse operation.
63.21	**Other supporting land transport activities**. Goods handling station operation.
63.22	**Other supporting water transport activities**. Cargo and passenger terminal services; Dock and harbour authorities; Harbour operation; Navigation activities; Pilotage activities.
63.40	**Activities of other transport agencies**. Customs clearance agents activities; Packer and shipper; Shipping agent or broker; Transport documents issue and procurement.
66.03	**Non-life insurance**. Marine insurance.
71.22	**Renting of water transport equipment**. Boat, ship or water transport hire for passengers or freight
74.30	**Technical testing and analysis**. Cargo, ship or marine insurance surveyors; Ships certification; Pipeline and ancillary equipment testing activities.
75.11	**General (overall) public service activities**. Customs administration; Duty and tax collection.
75.13	**Regulation of and contribution to more efficient operation of business**. Fishing and transport services administration and regulation
75.22	**Defence activities**. Royal Marines; Royal Navy establishments
75.24	**Public security, law and order activities**. Border and Coast guards

Figure 3.27 Distribution of protected wrecks.



which empower them to undertake dredging works within the limits of their jurisdiction. This means that centralised statistics that reflect the extent of dredging in the UK are not available.

Information collated for the Sector assessment of waste disposal (Section 3.16) indicates that the disposal of 43 million tonnes of dredged material (wet weight) was licensed in 2007. The majority of this relates to maintenance dredging (source: Cefas, FRS).

Shipbuilding and repair and maintenance of ships

The UK ship building industry is dominated by a few large yards mostly engaged in building ships for the Royal Navy. These are mostly based in Scotland (on the River Clyde), in the northwest of England (on the River Mersey) in the northeast (on the River Tyne) and in East Anglia, the southeast and southwest of England (Portsmouth and Plymouth). Ship repair and ship conversion is a larger industry, located in the these areas as well as in Belfast and Pembroke.

In 2004, Pugh (2008) identified that the shipbuilding industry employed 25 000 people with a turnover of £1.95 billion (excluding Value Added Tax, VAT) with GVA standing at £912 million. Strong competition from Eastern Europe and the Far East has made commercial shipbuilding a challenging market but a large naval shipbuilding programme is beginning in the UK. The contribution of shipbuilding to the economy is included in the £7.7 billion GVA figure estimated for the operation of ports.

Activities of the Maritime and Coastguard Agency (MCA) and the Royal National Lifeboat Institution (RNLI)

The Maritime and Coastguard Agency (MCA) promotes maritime safety, assesses emergencies, co-ordinates search and rescue efforts, carries out ship safety inspections and works to prevent and minimise pollution. The MCA employs approximately 1160 staff (as at March 2008) with staff costs of £45.89 million and a total income of £13.87 million (MCA, 2008a). HM Coastguard co-ordinates search and rescue effort through a network of 19 Maritime Rescue Co-ordination Centres (MRCC). In 2007, the MCA invested £0.25 million into research which included studies into environmental protection, vessel safety and accident prevention (MCA, 2008a).

The Royal National Lifeboat Institution (RNLI) is a charity providing a 24-hour search and rescue service around the UK and the ROI coasts. The RNLI operates over 230 lifeboat stations and more than 100 lifeguard units on beaches. The RNLI is independent from the coastguard and governments and depends on voluntary donations and legacies. In 2008, the RNLI crews launched 8182 times and rescued 7535 people. The RNLI has an income of £158 million, most of which is raised through legacies (60%) and raised voluntary income (30%). The locations of coastal and rescue stations are shown by CP2 Region in Figure 3.28.

Summary

Table 3.51 provides a summary of the estimated commercial value of the ancillary activities that were captured in this assessment illustrating the significant additional income provided by port services in supporting maritime transport.

Figure 3.28 Location of coastal and rescue stations.

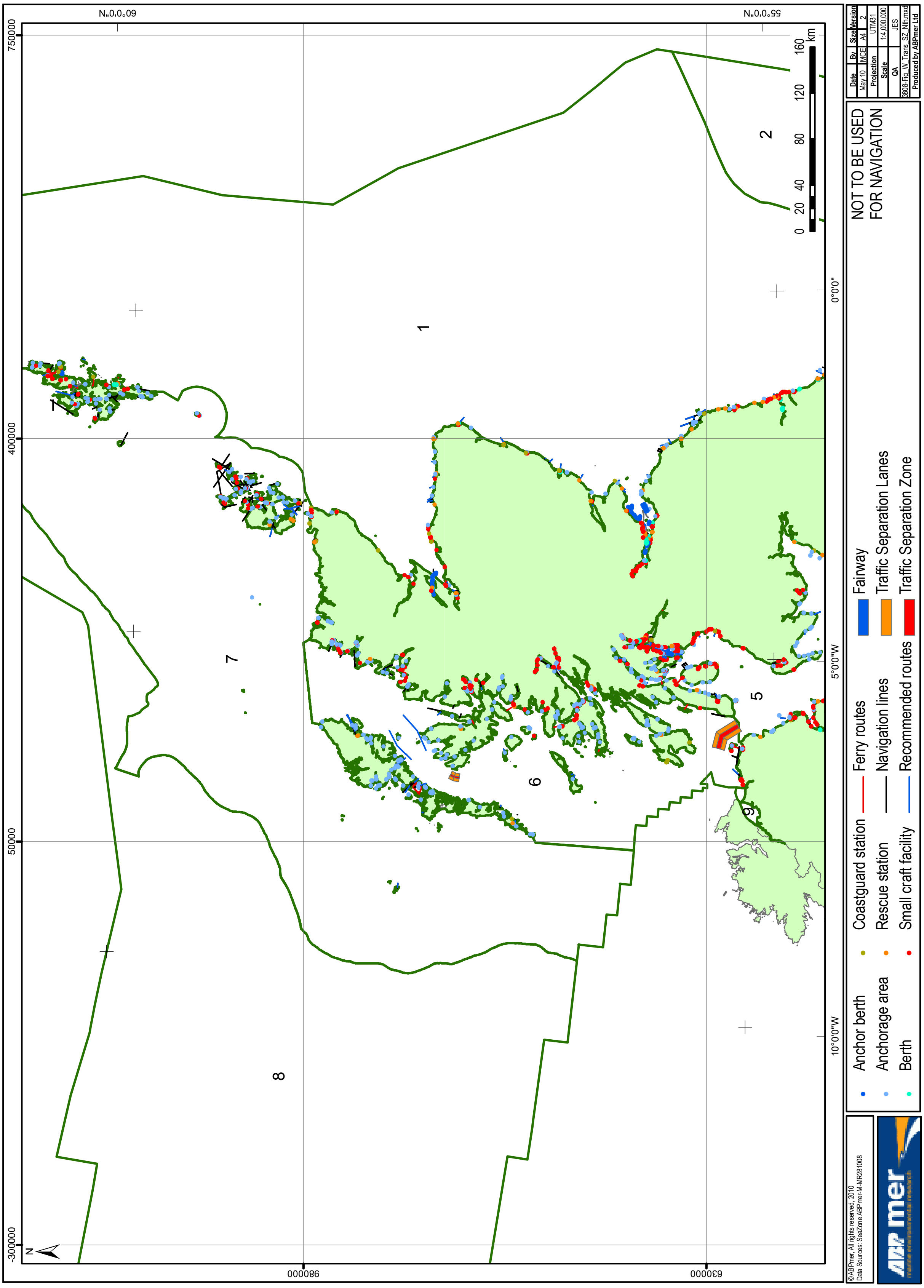
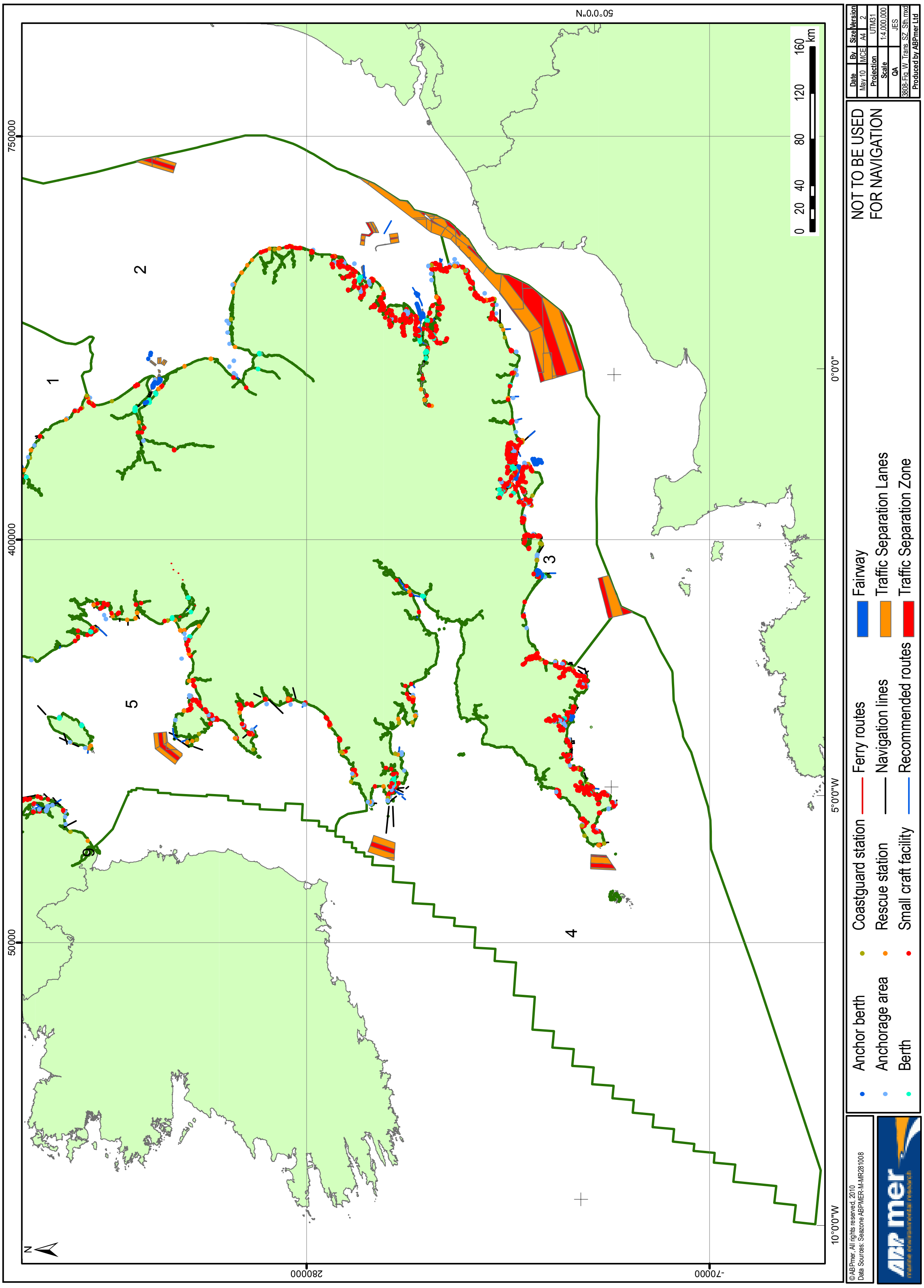


Figure 3.28 continued



3.7.4 Regional distribution of value

3.7.4.1 Ports

The regional distribution of ports and other maritime transport features is given in Table 3.50 and Figures 3.28 and 3.29.

In 2007, 97% of all UK port traffic was handled by 52 major ports (ports handling at least one million tonnes in 2000). Leading ports by tonnage in 2007 are: Grimsby and Immingham (66.3 million tonnes), London (52.7 million tonnes), Tees and Hartlepool (49.8 million tonnes), Southampton (43.8 million tonnes) and Forth (36.7 million tonnes).

The major passenger port in the UK is Dover in CP2 Region 3 (Figure 3.29) and in 2007 handled 14.3 million ferry passengers; this represents 60% of all UK international ferry passengers. In 2007, Dover was also the leading Ro-Ro port and handled 2.4 million road goods vehicles and unaccompanied trailer units.

Table 3.50 shows the regional value based on coastal ports and is estimated from the 2007 throughput in tonnes (DfT, 2008a). Of the total 2007 freight (581.5 million tonnes), 97% (565.6 million tonnes) is handled by coastal ports. Regional value was estimated based on the proportion of tonnage handled by the major ports in each region. This was used to allocate 97% of the estimated total GVA (£7.7 billion) of the ports sector (Oxford Economics, 2009) to each CP2 Region (i.e. £7.5 billion).

The distribution of commercial ports in the UK (and hence value) reflects the historical importance of certain areas for trade, which would have been based on prosperity, population and the presence of inland trade networks supporting demand. The high value that was estimated for Region 2 is probably driven by London which has been an important trading city for centuries. Current trade opportunities and the proximity of Europe mean that Region 3 benefits from the presence of major shipping routes. Hence these areas have high regional values. In turn, Region 1 is also close to Scandinavian shipping routes and as part of the previous industrial heartland of the UK has significant port activity, which has been sustained to date. Region 5 (Figure 3.29) benefits from freight traffic between Scotland, England and Ireland and historically was also a major route for traffic to and from the Americas. The lowest values were assigned to Regions 4, 6 and 7, these areas have smaller populations and are outside major trade networks (although it should be noted that during the industrial revolution Cornwall in Region 4 would have been a major exporter of metals).

Within each region there are non-commercial ports which may also contribute significantly to the local economy. Of the non-commercial ports, Devonport (also in Region 3) is the largest Naval Base in Western Europe. It covers over 650 acres and has 15 dry docks, four miles of waterfront, 25 tidal berths and 5 basins.

3.7.5 Trends

Total port traffic in the UK totalled 582 million tonnes in 2007, 2 million tonnes lower than in 2006 (Figure 3.30). Over the longer term, imports have grown by 24% since 2000 while exports have fallen by 15% (DfT, 2008a). Research suggests that the tonnage tax, an optional regime for shipping companies that was introduced into the UK tax system as part of Finance Act 2000, has been important for the growth of the UK Shipping Industry. Tonnage tax is an alternative method of calculating corporation tax profits by reference to the net tonnage of the ship operated, its introduction

Figure 3.29 Regional distribution of ports and other maritime transport features.

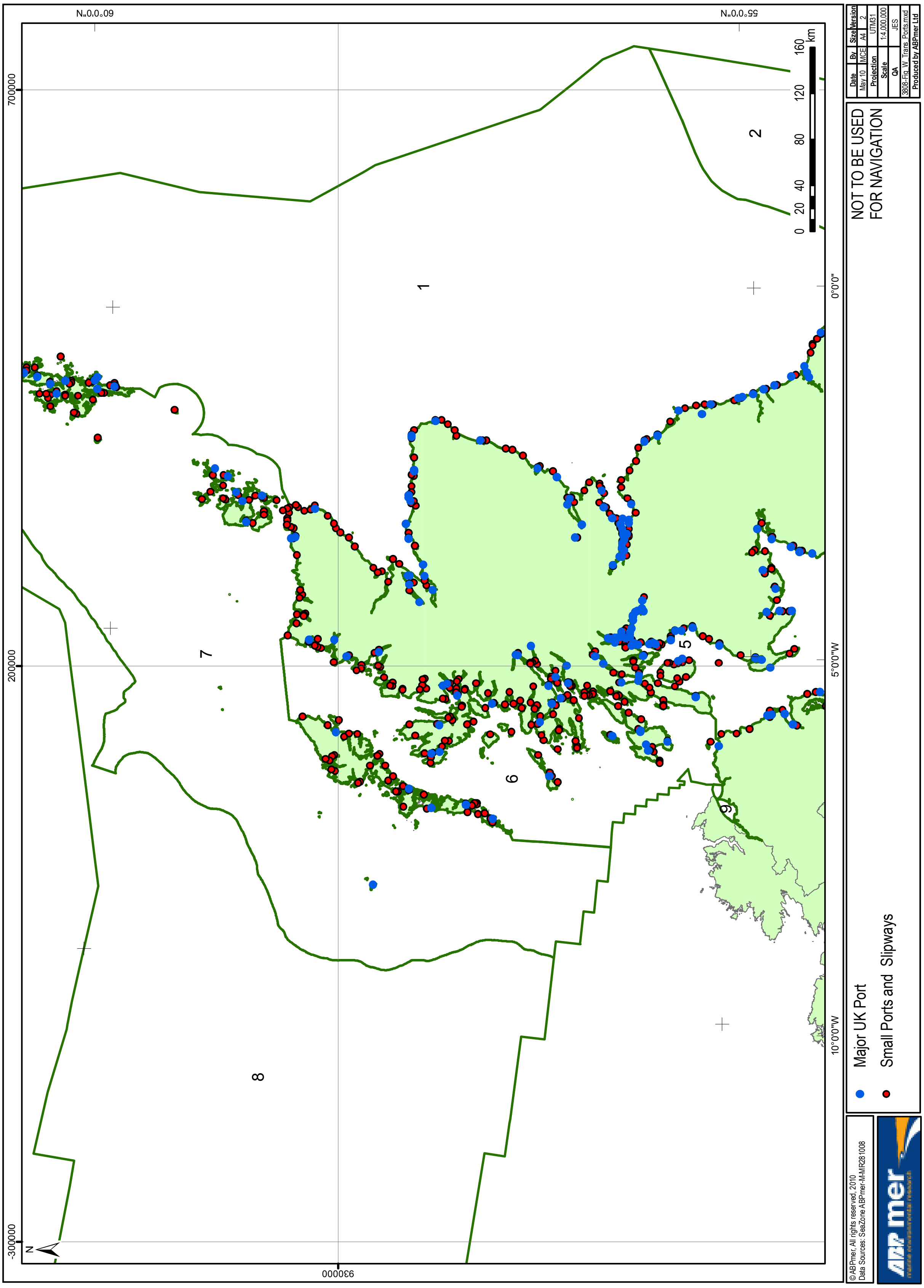


Figure 3.29 continued

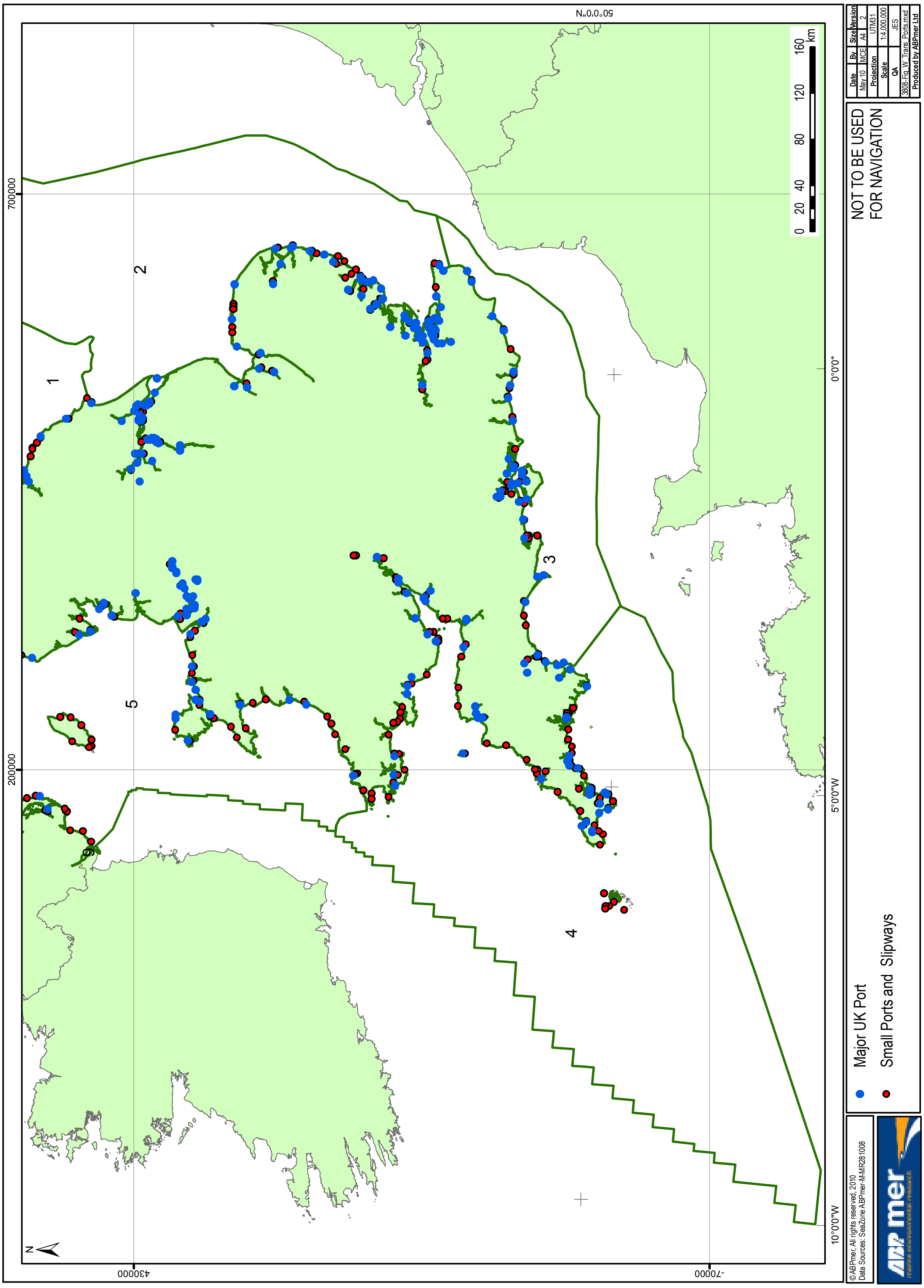
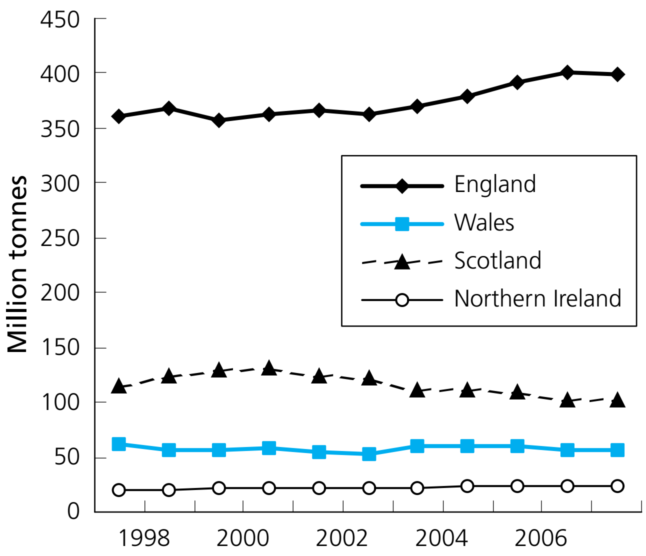
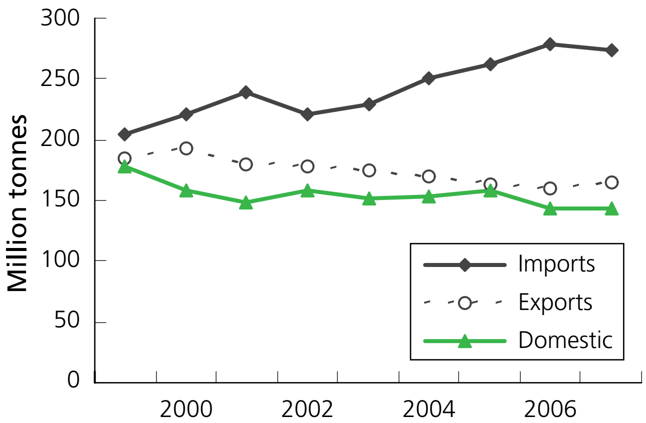


Figure 3.30 Foreign and domestic traffic (million tonnes) through UK ports 1999-2007. Source: DfT (2008a).





created greater certainty for companies and owners. In the short term the shipping industry is likely to be affected by the recession which will lead to a retrenchment in world trade (Oxford Economics, 2009).

Industry figures indicate that Ro-Ro goods vehicle movements have generally increased by 240% since 1985. The fastest period of growth was between 1985 and 2000, particularly in the South East of England and in the Irish Sea. Growth in other UK regions has been slight. Passenger traffic is in some ways a subset of the Ro-Ro market as most passengers travel with vehicles and use the same ferries as lorries. Sea passenger levels reduced in the 1990s due to the Channel Tunnel and low-cost airlines however the sector has stabilised and is again growing (www.britishports.org.uk/public/uk_ports_industry/market_overview).

Numbers of visits by sea travel by overseas visitors declined between 1997 and 2006. However, international sea journeys to and from the UK increased by 263 000 in 2007. In 2007, the number of ferry passengers handled by Dover increased by 3% to 14.3 million. Passenger traffic increased on Thames and Kent (3%) and West Coast (2%) routes. There was a large decrease in passenger traffic on East Coast routes (12%) and a smaller decrease on South Coast routes (<1%) (DfT, 2008a).

Domestic sea crossings increased by 5% in 2007 compared to 2006, to 4.0 million (DfT 2008a). Passenger journeys increased on services to Northern Ireland (4%), the Isle of Man (11%) and the Channel Islands (4%). Passenger numbers on Orkney and Shetland services remained virtually unchanged (DfT, 2008a).

3.7.6 Socio-economic pressures and impacts (positive and negative)

In 2007, the ports industry directly employed 132 000 workers (Oxford Economics, 2009) about half of these jobs were in transport or transport related activities with another 11 000 employed in cargo handling and storage. In total the UK ports sector was estimated, in 2007, to have supported 363 000 jobs which is 1.3% of all employment in the UK. Those indirectly employed were 150 000 people in ports' supply chains and 80 000 jobs owed to the consumer

spending of ports staff and those directly employed in its supply chain (Oxford Economics, 2009).

The shipping industry also provides skilled ex-seafarers, which are in demand for shore-based jobs. In 2003 (Gardner et al., 2003) around 15 700 jobs were identified that employers would prefer to fill with ex-seafarers (for an estimated 42% to 67% of these a shipping background was essential), with a mean annual demand for 700 employees. Jobs which require shipping experience include port terminal operators, consultants and surveyors, shipowners and offshore companies and ship/crew management (Gardner et al., 2003).

In 2007, the UK registered trading fleet consisted of 646 ships, including 134 tankers, 133 Ro-Ro vessels, 165 container vessels and 38 passenger vessels (DfT, 2008a). These all provide employment for associated ancillary industries such as ship repair and shipbuilding. According to Government statistics the UK shipbuilding industry employed 25 000 people in 2004 (source: Department for Business Enterprise and Regulatory Reform, BERR).

This sector supports and is supported by the maritime services cluster in London (see Section 3.18: General Management and Regulation).

Shipping has wider, societal benefits by enabling travel, enhancing communication and providing a leisure service.

3.7.7 Environmental pressures and impacts (positive and negative)

Table 3.53 provides an overview of the environmental pressures and impacts associated with maritime transport and refers to more detailed reports where relevant. The ecosystem services that these pressures impact and the relative significance of these impacts are identified in Table 3.54.

Discharges and littering from ships are difficult environmental issues to manage. Incidents can range from discharges of oil, galley waste and other domestic waste to major incidents where ships lose cargo. The MCA exercises statutory responsibility for taking action when oil or hazardous and noxious substances emanating from any at-sea activity threaten the UK or its surrounding waters. As part of its commitment to provide cleaner seas around the UK, the MCA publishes, via the Advisory Committee on Protection of the Sea (ACOPS), an annual survey of reported discharges attributed to vessels operating in the UK Pollution Control Zone (UKPCZ - roughly equivalent to the entire CP2 reporting area).

Shipping can have harmful impacts on the marine environment. Operational discharges are often small in scale. Accidental spills or losses of cargo, resulting from maritime incidents, can be significantly larger – although they are infrequent. Recent major incidents include the loss of the MSC *Napoli* in 2007, which led to the pollution of Branscombe beach where washed up containers were broken open by salvagers. During the course of towing, beaching and subsequent salvage efforts an estimated total of 302 tonnes of cargo were lost affecting at least 1000 seabirds (ACOPS, 2008). In the English Channel in 2008 the *Ice Prince* lost 2000 tonnes of timber, which subsequently washed up all along the south coast. ACOPS reported that during 2007 there were 20 reported pollution incidents on the UK Continental Shelf (UKCS) from vessels (ACOPS, 2007).

Table 3.53. Key environmental pressures and impacts of maritime transport and existing management measures. Sources: Carlton and Geller (1993); Ambrose (1996); Anbar (1996); Clarke (1998); Environment Agency (2000); ABP Research and Consultancy (2001); Worlund (2003); Streftaris et al. (2005); CSIP (2007); IECS (2008); Bonn Agreement (2009).

Pressure	**Habitat damage**
Impact	Infrastructure associated with shipping activity such as ports replaces natural coastline with man-made structures. Capital and maintenance dredging associated with shipping can damage marine benthic habitats (see also Section 3.8: Mineral Extraction). Boat wash can damage habitats.
Description of environmental change (intensity, spatial extent, frequency, duration)	The spatial extent of these changes can be gauged using data on the distribution of ports around the UK.
Existing management measures	The loss of habitat can be permanent or may require active restoration to recover some ecological value. Structures such as breakwaters, bunds or mounds can be used to protect inter-tidal habitats from ship wash.

Pressure	**Noise impacts**
Impact	Noise can arise from construction, ship movements and other operations.
Description of environmental change (intensity, spatial extent, frequency, duration)	Shipping noise has the potential to disturb cetaceans and noise-sensitive fish. Source noise levels for large commercial vessels average between 160 and 190 dB 1uPa@1m with frequencies in the range 50 to 900 Hz. In estuaries, these noises are likely to be detectable to marine mammals at distances of up to around 700 m and for noise-sensitive fish up to around 900 m. In the open ocean, noise can travel further and therefore shipping noises are likely to be detected by marine mammals at distances of up to 100 km and even greater distances by noise-sensitive fish. The source noise levels are not sufficient to cause permanent hearing damage but have the potential to cause disturbance. In estuaries, marine mammals are likely to show significant avoidance up to 70 m from the source of noise and sensitive fish species are likely to be disturbed within around 300m. In the open ocean, the disturbance effects are more varied with marine mammals only being disturbed within a few metres of the source and sensitive fish likely to show signs of avoidance within 300 m. On occasions, vessels may also attract marine mammals, such as species of dolphin. There is little scientific understanding concerning how cumulative effects of underwater noise from shipping and other human activities may affect marine mammals and fish at the population level. Construction noise also has the potential to disturb marine mammals and fish. The location of most major UK ports within estuaries means that risks to marine mammals are generally low because relatively few marine mammals penetrate significant distances up estuaries. However construction noise (especially intensive noise sources such as percussive piling) has the potential to disrupt the passage of migratory fish in estuaries. Seabirds may also be disturbed by shipping and construction activities. There is limited information on the significance of disturbance by shipping. Various studies of seabirds at the coast have documented the distances over which birds are disturbed by construction and related activities (e.g. Environment Agency 2000; ABP Research and Consultancy, 2001; IECS, 2008).

Existing management measures	There are currently no standards or controls in relation to underwater noise from shipping. At the 58th session of the IMO's Marine Environment Protection Committee (MEPC), the committee agreed to the development of a new work programme agenda on minimising the introduction of incidental noise from commercial shipping operations in the marine environment to reduce the potential adverse impacts on marine life. Risks associated with construction noise are routinely controlled by avoiding noisy construction activities during sensitive times of year for migratory fish or modification of the piling techniques (e.g. use of vibropiling; shrouding pile head). There are currently no controls on shipping in relation to bird disturbance. Risk to seabirds associated with construction activities are routinely controlled by avoiding noisy construction activities during sensitive times (e.g. avoiding overwinter feeding periods or breeding seasons).

Pressure	**Death or injury by collision**
Impact	Collisions with vessels may kill or injure individuals.
Description of environmental change (intensity, spatial extent, frequency, duration)	In 2007, 554 cetacean strandings were recorded and of these only 2 animals died of physical trauma (of unidentified cause) (CSIP, 2007) suggesting that either collisions are a relatively rare event, that injured animals recover or that carcasses are not recovered.
Existing management measures	There are currently no controls on commercial shipping to reduce collision risk. At the 58th Session of the IMO MEPC in 2008 (IMO, 2008b), the Committee agreed to the development of a guidance document for minimising the risk of ship strikes with cetaceans.

Pressure	**Introduction or spread of non-native species**
Impact	Non-native species may be translocated or spread through the UK in ballast water and as fouling organisms on ships' hulls.
Description of environmental change (intensity, spatial extent, frequency, duration)	Species invasions are related to the volume of ballast water discharged, the frequency of ship visits and the environmental 'match' between the donor and recipient region of the ballast water. A number of non-native species are thought to have been introduced to the UK through ballast water or fouling of ships hulls, including common species such as the slipper limpet (*Crepidula fornicate*), the barnacle *Elminius modestus* and the polychaete worm *Marenzellaria wireni*. See also Case Study 4.
Existing management measures	The IMO developed the International Convention for the Control and Management of Ships' Ballast Water and Sediments (adopted in 2004). This establishes technical and operational requirements for the management of ballast water to minimise the risk of species translocations. The Convention is still pending entry into force. Contracting Parties of the OSPAR and Helsinki Conventions have developed voluntary guidelines for the management of ballast water, based on those of the IMO, for use until the IMO Convention enters into force.

Pressure	**Release of antifouling substances**
Impact	Release of chemicals may result in contamination of water and sediments and biological impacts on biota.
Description of environmental change (intensity, spatial extent, frequency, duration)	The impacts of tributyltin (TBT) antifouling substances are extensively documented. Following the partial (1987) and total (2003) ban on the use of TBT as an antifouling substance, significant reductions in the concentrations of TBT in the water column and sediments have been observed, together with marked reductions in biological impacts (imposex in dogwhelks, shell hardening in bivalve molluscs). Alternative antifoulants are now being used, primarily with copper as the active ingredient. The increased use of copper based antifoulants may also have significant impacts on the marine environment, but there are few studies exploring this.

Existing management measures	The IMO Convention on the Control of Harmful Antifouling Systems on Ships entered into force in 2008 and prohibits the use of harmful organotins in antifouling systems. EU Regulation No.782/2003 banned the use of TBT antifouling on ships since 2003 and from 2008 TBT coatings on all ships visiting EU harbours is forbidden.

Pressure	**Waste discharges (litter, sewage) from ships, release of oil, noxious substances and cargoes; discharges from port facilities and shipbuilding/ship repair yards**
Impact	Introduction of litter into the marine environment poses a risk of harm/death to marine wildlife through ingestion of, or entanglement in, marine litter. Release of sewage introduces pathogens and nutrients into the water, affecting water quality and potentially passing on diseases to humans through contact with contaminated water or consumption of contaminated shellfish. Release of oil and other hazardous substances, which arise from the accidental and incidental discharge of these substances, carried as cargo or fuel, may result in contamination of water and sediments and ecological impacts on wildlife, mariculture and tourism.
Description of environmental change (intensity, spatial extent, frequency, duration)	Globally, shipping is responsible for accidental and deliberate discharge of wastes into the sea including galley and domestic wastes, plastics (Clark, 1998) and containers (Worlund, 2003). There are no accurate figures for discharge of ship generated litter at sea for the UKCS, due in part to the difficulties in establishing the source of wastes. However, between 2003 and 2007, the Marine Conservation Society estimated that shipping-related litter comprised about 2% of all litter washed up on UK beaches. See the CSSEG Feeder Report, Section 3.6 for a detailed assessment on litter. ACOPS assesses the known and reported accidental discharges from vessels operating in the UKPCZ. A total of 192 incidents were reported in 2007 in relation to accidental discharges from ships. This is an increase of 29% compared to 2006. The largest oil spill was accrued over 2007 during the MSC *Napoli* incident. See the CSSEG Feeder Report, Section 3.5 for the distribution of reported oil discharges from vessels in 2007 (ACOPS, 2008) and for a full description of incidents from 2002 to 2008. The regional distribution of incidents is addressed in Section 3.7.7. The 2009 report from The Bonn Agreement Annual Reports on Aerial Surveillance of the North Sea states that for about 80% of the oil slicks observed/ confirmed the source of the polluter has not been confirmed. As such it is not possible to quantify how many of these slicks are as a result of accidental or incidental spills from ships but it is recognised that shipping is a possible source of pollution. Discharges from port estates may include surface water, sewage and industrial process discharges. While discharges from port estates are generally fairly minor, they contribute to overall loadings of contaminants to estuaries and coastal waters and elevated concentrations of heavy metals in water, sediment and biota occur in some current and historically industrialised estuaries. See the CSSEG Feeder Report, Section 3.1 on Hazardous Substances for a detailed assessment including the biological effects of contaminants. In the past, discharges from shipyards have caused significant pollution of estuarine and coastal sediments, in particular with heavy metals (cadmium, copper, lead and zinc) and TBT. This has left a legacy of contamination that can restrict dredging and disposal of heavily contaminated sediments. More recently, releases from such sources have been brought under greater control (for example, containment of antifoulant paint removal activities).

Existing management measures	The key regulatory framework for pollution rules for shipping is the MARPOL 73/78 Convention, which includes: • The prohibition of disposal of plastics anywhere into the sea. • Special Areas where more stringent restrictions for discharges of garbage apply • Regulations prohibiting the discharge of sewage within a specified distance of the nearest land unless they have in operation an approved sewage treatment plant. • Particularly Sensitive Sea Areas (PSSAs) are areas of the marine environment which the IMO has designated on the grounds of significance and of risk from international shipping. A PSSA must have an associated protective measure (or measures) which will address the identified threat or vulnerability • SOx Emission Control Areas (SECAs) where more stringent emission and fuel quality requirements apply Directive 2000/59/EC obliges EU Member States to provide adequate port waste reception facilities for ships to deliver ship-generated waste into port. The Bonn Agreement for co-operation in dealing with pollution of the North Sea by oil and other harmful substances. Members include the States bordering the North Sea and the English Channel, Ireland and the European Union. Regulations to control ship to ship transfers of oil carried as cargo are in development internationally (in the IMO) and in the UK. The UK has identified 32 areas (representing around 9% of the UK coastline) which have high environmental sensitivity and are also at risk from shipping activity. These areas are called Marine Environmental High Risk Areas (MEHRAs) and ships are advised to take note of them and exercise an even higher degree of care than usual when passing through them. The UK has a fully developed national contingency plan for responding to marine pollution from both shipping and offshore installations. The MCA maintains an expert pollution response team. It also has specialist Emergency Towing Vessels strategically located in the UK to tow or escort ships in difficulties. Within 1 nm in England, Wales and Northern Ireland (3 nm in Scotland) the WFD sets Environmental Quality Standards (EQS) for specific pollutants and priority hazardous substances, which should not be exceeded to meet good ecological and chemical status. Discharges from port estates and shipyards are controlled under the Water Resources Act 1991 (England and Wales). In Scotland the regulatory framework for managing water discharges is through the Water Environment (Controlled Activities) (Scotland) Regulations. In Northern Ireland NIEA manages discharges. Controls on licensed discharges seek to ensure that relevant water quality objectives can be met. (Water Order 1996, Consent to Discharge).

Table 3.54 Key environmental pressures on ecosystem services associated with maritime transport.

Ecosystem service	*Significance of impact*	*Confidence in understanding of the relationship = information gaps*
Erosion-deposition cycles (of sediment)	**Minimal – Moderate**. Extent of dredging activity and impacts of structure range from small to moderate proportion of estuary systems. Can be significant and necessitate compensatory habitat measures.	**Low**. Can be difficult to distinguish from other impacts on sedimentation processes on coast (e.g. defences of settlements from coastal erosion).
Biological productivity	**Minimal – Moderate**. Pressures on biological productivity services possible from habitat disruption and channel dredging, but usually minor. Impacts of pollution from vessels and invasive species introduced/ spread by international vessel movements potentially widespread and difficult to counteract.	**Low**. Impacts on biological systems through escaped invasive species not well understood.
Biodiversity provision	**Low – Moderate**. Pressures on biodiversity provision services possible from invasive species, noise, channel dredging, port development and/or vessel pollution, can necessitate compensatory habitat measures.	**Low – Moderate**. Biodiversity compensation in intertidal systems now an established practice. Cumulative impacts of noise and collisions less well understood.

The incidents are reported for individual UKPCZ areas. Table 3.55 reports the distribution of vessel-related incidents and type of spill in relation to the relevant CP2 reporting regions for 2007. While it is not possible to give exact figures it is apparent that Region 1 has the highest number of incidents and Regions 7 and 8 the lowest. Eastern Scotland had the highest reported number of large water surface pollution incidents (> 1.6 km). The majority of discharges (66%) occurred within ports and harbours or tidal rivers and estuaries (126 of a total 192). The remainder occurred within bays, beaches, nearshore waters or the open sea. Furthermore, of the vessel incidents occurring within ports (a total of 109) 60 were within England, 32 within Scotland, 15 within Wales and 2 within Northern Ireland.

Introduction of non-native species via ship ballast water and hulls is also a major concern for shipping. Case Study 4 explores the vectors and management measures in more detail, while the distributions of non-natives species and ecological implications are discussed throughout those sections of the HBDSEG Feeder Report concerned with marine habitats and plankton.

However, transport by sea is part of the UK transport infrastructure and produces less CO_2 than other forms of freight transport so this can be seen as an environmental benefit.

In addition, capital and maintenance dredging associated with shipping channels can provide material for beach replenishment schemes, mitigating the effects of flooding and coastal erosion. There is an increasing trend towards 'beneficial use' of this material, although sediment contamination may constrain disposal options.

Shoreline infrastructure presents new structures/ surfaces for colonisation. These artificial structures may increase habitat diversity within an area, which could be viewed as beneficial,

Table 3.55 Distribution of vessel-related incidents and type of spill in 2007 in relation to CP2 Regions. Source: ACOPS (2008).

Area	*CP2 Region*	*Mineral oil*	*Other*	*Total*
NE England	1, 2	15		15
E England	2	15		15
Essex & Kent	2	3		3
S England	3	24		24
SW England	4	23	1	24
Bristol Channel, S Wales	4	17		17
Irish Sea	5	19		19
W Scotland[a]	6, 7, 8	22		22
Orkney & Shetland Islands	1, 7	3		3
E Scotland	1	29	1	30
Offshore UKCS	1	20		20
Total		**190**	**2**	**192**

[a] Excludes the outer NW Approaches of CP2 Region 8.

alternatively a negative impact may result where these structures facilitate the colonisation and spread of non-native species.

3.7.8 Climate change

3.7.8.1 Shipping operations

Impacts of climate change on shipping

It has been recognised that a reduction in Arctic sea-ice cover will have a positive impact on shipping through the reduction in time taken to transport cargo between Asia and Europe and thereby opening up new trade routes (Anisimov et al., 2007). It is also possible that changes in weather patterns could result in changes to other shipping routes due to the potential for increased storm activity; however there is no known work that analyses these changes.

Adaptation measures

None known or proposed.

Impacts of shipping on climate change

Emissions from shipping and port operation contribute to anthropogenic sources of greenhouse gases. While shipping is generally a very carbon efficient form of transport, the Committee on Climate Change (CCC) predicts that continued growth in the sector will significantly increase global emissions (CCC, 2008). Shipping currently accounts for around 3.3% of global CO_2 emissions. Projected increases suggest that emissions from shipping in 2050 will account for 15% to 30% of all UK CO_2 emissions permitted under the CCC's preferred global emissions reduction scenarios (CCC, 2008).

Shipping contributes to greenhouse gas emissions in two different ways. First, emissions are created while a ship is at berth or at anchor when the auxiliary engines are run to generate electricity. Typically, auxiliary engines provide around 15% to 20% of the power of main engines and are run on marine gas oil. Second, emissions are produced when the main engines are propelling the ship through the water. Main engines typically provide around 80% more power than auxiliary engines and run on marine fuel oil.

Emissions from UK shipping have been estimated using refuelling figures from UK fuel bunkers (whether the ships are from the UK or not) this suggests that fuel emissions have remained around the same since 1990 at about 6 to 7 million tonnes of CO_2 per year (Defra, 2008c). However, this assumes that all UK ships refuel in the UK. Phase 1 of the study to update IMO (2000) noted that global estimates of CO_2 emissions from global international shipping

amounted to some 843 million tonnes in 2007 or 2.7% of global CO_2 emissions (IMO, 2008a). Emissions from global domestic shipping totalled 176 million tonnes (IMO, 2008a).

The manufacture of ships also contributes to greenhouse gas emissions, these emissions could not be found in the available literature.

Mitigation measures

Currently, shipping is mainly fossil fuel based. Owing to the long lifespan of ships there is a technical lock in to the use of a specific fuel and therefore changes to new and cleaner technologies are not feasible in the short to medium term (Barker, 2008). Optimised hull and propeller shape can be expected to improve fuel efficiency by between 5% and 20%, and 5% and 10 %, respectively (IMO, 2000).

In addition, innovative vessel designs can combine wind energy along with solar panels and conventional diesel engines. A limited number of these innovations have been deployed by such companies as Solar Sailor, SkySails and Wallenius Marine (ICCT, 2007). Improved efficiencies can also be achieved through good maintenance; biofouling of the hull increases roughness and thereby reduces efficiency (ICCT, 2007). There is also the potential increase in efficiency by optimising the choice of speed and adjusting routes to take into account weather systems (IMO, 2000).

An Energy Efficiency Design Index (EEDI) is under development by the IMO. This aims to stimulate innovation and technical development relating to the energy efficiency of a ship, thereby encouraging the design and manufacture of more energy efficient ships in the future (IMO, 2009). An Energy Efficiency Operational Index (EEOI) is also under consideration by the IMO, which enables operators to gauge the fuel efficiency of a ship and thereby assess effectiveness of measures implemented to reduce energy consumption. The EEOI has been has been used on a trial basis since 2005 and provides a figure in CO_2 per tonne mile for a specific ship (IMO, 2009).

In addition to the EEDI and the EEOI, a Ship Energy Management Plan (SEMP) is under consideration by the IMO. The SEMP will provide guidance on best practices in shipping operations, such as improved voyage planning, speed and power optimisation, optimised ship handling, improved fleet management and cargo handling, as well as energy management for individual ships (IMO, 2009).

While in port, use of an auxiliary engine can be avoided by obtaining energy from the port (cold ironing). If this energy can be obtained from renewable sources (see Section 3.7.8.2) then this represents a greenhouse gas free source of power. Cold ironing is already common in military vessels (ICCT, 2007). However, its potential within the current ship fleets is limited as it is difficult and expensive to retrofit ships with this technology. Existing grid connections to ports may also be inadequate to deal with peak loads if cold ironing was introduced on a significant scale. It is unlikely that the potential benefits of cold ironing can be realised over the short term.

Mitigation can also be achieved through legislative means. Methods of limiting and controlling greenhouse gas emissions from shipping were discussed in July 2009 by the IMO's Marine Environmental Protection Committee (MEPC). The results of this meeting are to be reported to the UNFCCC Climate Change Conference in December 2009. This meeting will be informed by an update of the findings by the IMO's (2000) initial review.

Case Study 4: Non-native species

Introduction

Marine non-native species are organisms that are introduced and become established in the waters around the UK by natural and/or human vectors. Invasive non-native species are the second greatest threat to global biodiversity (after habitat destruction) and can have a range of negative impacts. These include:

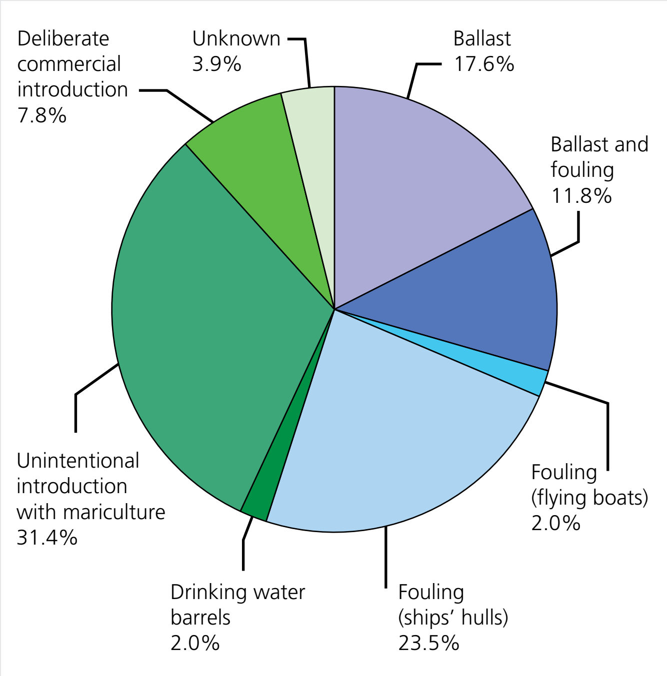
- Transmission of disease to native species
- Competition with native species
- Hybridisation with native species
- Predation on native species
- Increased flooding risk (e.g. by damage to river banks through burrowing)
- Damage to equipment (e.g. clogging of fishing nets or fish cages)
- Human health risks (e.g. by the introduction of toxic phytoplankton).

It is estimated that there could be up to around 87 non-native species present in UK waters (Eno et al., 1997; DAISIE, 2009). However, it is difficult to know for sure how many are present owing to a number of factors such as a lack of long-term monitoring and a need for improved recording of non-native species. There is also a need to ensure that the identification of species is accurate and this is not always straightforward and may rely on a limited number of specialist taxonomists. It is important to ensure that information regarding non-native species is up to date as this information is required for a wide variety of purposes, such as risk assessment and for assessing water quality and good ecological / environmental status (GES) in the Water Framework and the Marine Strategy Framework Directives, respectively.

Main vectors

Although this case study is presented in the section on Maritime Transport, there is a wide range of vectors that can transport non-native species into the UK and for marine species the most important vectors are shipping and aquaculture (see figure).

Vectors associated with the introduction of marine non-native species into UK waters. Source: Eno et al. (1997).



Shipping can transport species either in ballast water and sediments or as biofouling i.e. attached to the hull, anchor chains or other niches around the vessel's hull. Aquaculture activities can introduce non- native species either intentionally (for commercial cultivation) or as an associated unintentional introduction when transporting the species intended for cultivation.

International responses

- International Convention for the Control and Management of Ships' Ballast Water and Sediments (IMO, 2005). Once this has entered

into force internationally, this will require all vessels to manage or treat their ballast water to a specific discharge standard

- A regional Ballast Water Management Strategy for the North East Atlantic has been developed through the Committee of North Sea Senior Officials (CONSSO) – Issue Group on Sustainable Shipping (IGSS) and the Biodiversity Committee of the OSPAR Commission. This strategy aimed to provide guidance to shipping on voluntary ballast water exchange guidelines for shipping entering the North East Atlantic and to identify high risk voyages through a risk assessment based management approach (MCA, 2008b)
- Ongoing development of international measures to reduce the risk of introducing non-native species via biofouling on the vessel
- The International Council for the Exploration of the Sea (ICES) Code of Practice for the Introduction and Transfer of Marine Organisms (ICES, 2005), which aims to reduce the risk of introducing non-native species via aquaculture.

National responses

- The Great Britain (GB) Programme Board on Non-Native Species established in March 2005 to deliver strategic consideration of the threat of invasive non-native species across Great Britain
- A GB Strategy on Invasive Non-Native Species was launched on 28 May 2008 and provides a framework for a more co-ordinated and structured approach to dealing with non-native species in Great Britain.

A report by the Committee on Climate Change (CCC, 2008) set out to recommend the UK's carbon budget as a result of implementing the Climate Change Bill, as part of this they reviewed the need to include shipping as part of the carbon budget. The conclusion was that international shipping should not be included in the UK national budget but instead should be covered by other policy levers and monitored by the Committee. This decision is based on the difficulties of attributing the UK's shipping emissions and how these emissions would be measured. Although it would be possible to measure CO_2 emissions based on the amount of refuelling in the UK, it is apparent that many ships refuel in other countries and therefore would not be represented in the budget. The Committee recognised that an international agreement, rather than unilateral action, is the best way to achieve effective reductions.

In terms of sulphur, the maximum sulphur content of any marine fuel is regulated by MARPOL Annex VI and emission control areas which encompass the Baltic Sea and North Sea have been established (MCCIP, 2008). The IMO recently revised and updated MARPOL Annex VI (MEPC, 2008) with the global sulphur cap reduced to 3.5% (from the current 4.5%) from January 2012 and then progressively to 0.5% from 1 January 2020. The North Sea sulphur oxide (SOx) Emission Control Area (SECA) requires that ships within that area use fuel that has a sulphur content no greater than 1.5% per mass or that the ships use an exhaust gas cleaning system or other equivalent technology (MCCIP, 2008). The limits applicable in SECAs will be reduced to 1% from 1 July 2010 (from the current 1.5%) being further reduced to 0.1% from 1 January 2015. Reductions in nitrogen oxide are also planned. The updates to Annex VI will come into force on 1 July 2010.

MARPOL Annex VI has so far been ratified by 53 countries, representing approximately 81.88% of the gross tonnage of the world shipping fleet.

At the World Ports Climate Conference (2008 Rotterdam), a Climate Declaration was developed as a guide for action. One of the agreed actions was to develop an Environmental Shipping Index (ESI) for ocean going shipping based on levels of air pollutants and greenhouse gasses. The aim of the ESI was to act as a base for incentives such as reduced shipping dues for less polluting vessels.

3.7.8.2 Ports

Impacts of climate change on port operations

To date little work has been done to assess the impacts of climate change on ports although a scoping report by ABPmer (2007c) on behalf of Associated British Ports identified a number of potential impacts. Using a risk matrix which took into account both scientific certainties, the probability of the impact and the economic severity of the impact the following main impacts were identified:

- Delays, closure of ports and prevention of port activities arising from flooding and severe weather
- Damage to infrastructure and cargo from flooding and severe weather
- Changes to sedimentation and tidal patterns leading to increases in the costs of maintaining navigation channels.

Adaptation measures

At the present time there is no evidence of any impacts on ports from climate change (ABPmer, 2007c) and so no adaptation measures are currently proposed. In the future measures are likely to include:

- Climate proofing of port assets
- Increases in the height of seawalls, lock gates and docks
- Increases or decreases in the frequency of dredging and surveying of navigation channels depending on the impact.

No economic assessment of these adaptation measures is known.

Impacts of port operations on climate change

Port operations emit currently unquantified amounts of greenhouse gases, which contribute to climate change. One important contributor is ships' running generators while in port (see information on 'cold ironing' in Section 3.7.8.1).

Mitigation measures

If renewable energy can be generated within port areas there is potential for this energy to be used onboard ships while they are docked (see information on 'cold ironing' in Section 3.7.8.1) although this would require expenditure on infrastructure and no examples of greenhouse gas free 'cold ironing' are known at present. Some UK ports have developed wind power schemes (see Table 3.56).

3.7.8.3 Summary

Table 3.57 summarises the climate change pressures and impacts discussed in this section and indicates the likely significance

Table 3.56 Summary of wind power schemes in the ports sector.

Location	*Status*	*Description*
Blyth Harbour	Operational	9 turbines with a total generating capacity of 2.7 MW constructed on the east pier in Blyth Harbour, the electricity is exported to the local grid
Bristol (Avonmouth Docks)	Construction complete	3 turbines situated on 8.5 hectares of reclaimed land with a generating capacity of 15 MW will supply Avonmouth docks with 75% of its energy demand
Shoreham Harbour	Proposal	Up to 5 turbines
Holyhead	Proposal	Unknown, proposed as part of breakwater repairs
Liverpool – Merseyside	Operational	5 turbines with a total generating capacity of 15 MW
Liverpool – Royal Seaforth Dock	Operational	6 turbines with a total generating capacity of 3.6 MW
Rotterdam	Operational	No information available
Newport	Proposal	7 turbines
Grimsby	Proposal	1 turbine
Cardiff	Proposal	5 turbines
Barry	Proposal	3 turbines
Swansea	Proposal	7 turbines
Port Talbot	Proposal	7 turbines

of the impacts, the level of confidence in the assessment and measures that might be employed to manage the impacts (see Annex 1 for a discussion of assessment methodology).

3.7.9 Industry stability and sustainability

3.7.9.1 Objectives, targets and indicators

The UK's policy aim is to maintain international shipping markets that are open and competitive subject to proper safety and environmental regulation and to retain a strong UK presence in shipping and, where possible, a strong UK fleet (Dft, 1998). Five key objectives have been set:

- To facilitate shipping as environmentally friendly transport
- To foster an efficient UK shipping industry
- To maintain the skills base by promoting employment and training
- To encourage UK ship registration
- To encourage short sea shipping.

In relation to vessel safety, the MCA has two further objectives:

- To reduce the rate of accidents and deaths involving UK registered merchant ships and fishing vessels
- To reduce the incidence and effect of pollution from shipping activities in the UK pollution control zone.

The UK Ports Policy (Dft, 2000) also sets objectives in relation to ports:

- To make regulation add value rather than unnecessary cost, ensuring that different regulators co-ordinate their overall demands

Table 3.57 Summary of climate change implications.

Climate change pressure	*Impacts of climate change on Maritime Transport*	*Confidence/ significance*	*Adaptation measures*
Reduction to Arctic sea-ice cover	Increased shipping trade	High confidence / low significance	None
Increase in severity of storms	Changes to shipping routes	Low confidence / low significance	None
	Increased stresses and strains on water craft	Low confidence / medium significance	Improved water craft design
	Increased stresses and strains or port infrastructure	Low confidence / high significance	Increases in the height of seawalls, lock gates and docks
	Interruptions to port timetables	Low confidence / medium significance	Increases in the height of seawalls, lock gates and docks and improved water craft design
Changes to sediment transport pathways	Navigation channels may move	Low confidence / medium significance	Changes to dredging and surveying schedules and buoyage
Increase in sea level	Increased risk of flooding events	Low confidence / high significance	Increases in the height of seawalls, lock gates and docks

Impacts of Maritime Transport on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
Shipping emissions	CO_2 emissions	Medium confidence / high significance	Improved efficiency of water craft
CO_2 emissions from shipping manufacture	CO_2 emissions	Low confidence / unknown significance	Unknown
CO_2 emissions from ports	CO_2 emissions	Low confidence / unknown significance	Opportunities for mitigating through the use of marine renewables

- To promote agreed national standards and good practice for port management and port operations alike, without detracting from the legal responsibilities of harbour authorities and other port interests
- To promote training and the recognition of skills for those who work in the ports industry at all levels not just those engaged by harbour authorities
- To maintain a balanced policy on development which aims to makes the best use of existing and former operational land, secures high environmental standards, but supports sustainable projects for which there is a clear need.

There are no specific targets associated with these broad objectives, although UK trends in activity are monitored by DfT and MCA.

The recent Ports Policy Review Interim Report outlined the Government's responsibility to create the conditions in which investment is encouraged, and yet sustainability is ensured

(DfT, 2007). The report outlines a framework to deliver this vision and the broad objectives outlined in the UK Ports Policy 2000 by:

- Commissioning demand forecasts every five years to aid assessment of national need
- Recommending the use of Master Plans by major ports to improve planning
- Setting out broad guidelines on the safeguarding of port land
- Charting the planned course in pursuit of further trust port modernisation
- Setting out plans to enhance the port safety regime.

The report also highlights the Government's commitment:

- To clarify the role of the Marine Management Organisation (MMO) and Infrastructure Planning Commission (IPC) in respect to port development, and consult on plans for a ports National Policy Statement
- To update the Project Appraisal Framework for Ports, to clarify in particular the interpretation of the Habitats Directive
- To stress the need at EU level for transparency in public funding for ports and inland infrastructure.

The Government is also committed to developing a National Policy Statement for ports under the Planning Act 2008, and a draft was published for consultation on 9 November 2009 covering ports in England and Wales (DfT, 2009). The report provides guidance for future decisions on proposals for new port development to be taken by the IPC to deal with nationally significant infrastructure proposals; it may also be a relevant consideration for the MMO, which will in future decide other port development proposals. The Scottish Executive has devolved responsibilities for ports, and has developed its own ports policy under the Scottish National Transport Strategy. Ports policy in Northern Ireland is also devolved.

3.7.10 Forward look

The recent ports policy review interim report (DfT, 2007) predicted that *...demand for port capacity will grow. In the container and Ro-Ro sectors, an average annual growth rate of around 3% to 4% is expected. In time, this growth will require a significant increase in capacity, beyond that which has already been approved in the last two years*. In Scotland the National Planning Framework 2 and the Strategic Transport Project Review both recognised the need for improved access to ports and increased container capacity. Although container traffic has slowed in the current economic climate, the market anticipates longer-term growth. In line with its core purpose the Scottish Government is engaged in dialogue with the ports and renewable energy sectors to identify areas for development. Against the background of strong industry growth at the global level, the Government expects that the market will be ready to fund further expansion, especially as no substantive change to the regulatory and operating framework for ports is proposed (DfT, 2007).

International shipping companies, including the Ro-Ro and container lines, are continually seeking to achieve economies of scale in the transportation of goods. As the proportions of large vessels increase, however, access to Ports, which are dependent on suitable tidal conditions, has become increasingly constrained. An increase in the number of deep-draughted, wider vessels, has impacted on the availability of water with sufficient depth or width to enable vessels to navigate to, from and within

these tidally-constricted Ports, without causing delays to commercial traffic and impacting upon efficient berth utilisation and congestion. This is a key driver for the need for commercial ports to deepen and/or widen navigation channels.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the shipping industry will need to further manage its activities. For example, GES 2 states that *...non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

International Conventions developed by the IMO and the EU ship concept include a number of initiatives to reduce pollution impacts relating to shipping. These include agreements to limit the discharge of oil, to prohibit the disposal of litter by ships and to manage the transport of hazardous substances. Although not currently in force, the Convention relating to ballast water controls to prevent the transport of non-native species and to phase-out harmful antifoulants is also being progressed, all of which will contribute to cleaner, less harmful maritime transport in the future.

3.8 Mineral Extraction

3.8.1 Key points

- This sector includes the extraction of marine aggregates (sands and gravels) from the seabed and the extraction of salt
- The level of information within the marine aggregate dredging industry is good due to a well coordinated industry body (the British Marine Aggregate Producers Association and well funded research through the Aggregate Levy Sustainability Fund
- The marine aggregate sector landed 19.3 million tonnes of primary aggregate in 2008 representing a landed value of £116 million and £54 million Gross Value Added (GVA)
- Secondary values identified were £80 million from processing and £303 million from sales of concrete products in 2005
- Marine aggregates are mainly sourced off the eastern and southern coasts of England (Regions 2 and 3) with smaller amounts off Wales (Regions 4 and 5). There is currently no marine extraction in Scotland and Northern Ireland
- Pressures from marine aggregate dredging are managed through licence-specific environmental impact assessments and coastal impact studies
- Demand for marine aggregate materials could significantly increase over the next five to ten years to support large scale infrastructure projects and coastal defence programmes. Consequently, associated pressures could be expected to increase as well
- Known aggregate deposits will be sufficient for at least 50 years production at current rates of extraction
- The sea salt extraction industry had an estimated turnover of £4 million in 2008

i. Introduction

The mineral extraction sector includes the extraction of marine aggregates (sands and gravels) from the seabed and the extraction of salt. These are both considered separately in this assessment as they are quite different in terms of activity and impact.

ii. How has the assessment been undertaken?

Information on marine aggregate dredging was provided by the British Marine Aggregate Producers Association (BMAPA), The Crown Estate (TCE) and regulatory bodies in Scotland and Northern Ireland. Information on sea salt extraction was provided by two companies involved in its production. Other information was sourced via the internet.

iii. Current status of the mineral extraction sector and past trends

There are eleven companies generally involved in the production of marine aggregates in the UK. In 2008, these companies landed 19.3 million tonnes of primary aggregate for construction in the UK and abroad representing an estimated landed value (turnover) of £116 million and a GVA of £54 million. A further 2 million tonnes were extracted for beach replenishment. Secondary market values for the marine aggregate dredging industry included £80 million GVA from processing and £303 million GVA from sales of concrete

products in 2005. Ancillary market values from exploration and transport were more difficult to define in total but indicators include a dredging fleet replacement value of £1 billion. The sea salt extraction industry was estimated to have a turnover of £4 million in 2008.

Marine aggregates mainly come from the eastern and southern coasts of England (Regions 2 and 3) with smaller amounts off Wales and north-west England (Regions 4 and 5). Since *Charting Progress* (Defra, 2005a), the amount dredged from Regions 2, 4 and 5 has remained fairly stable reflecting the current market demand while production from new dredging permissions in Region 3 has increased. There is currently no dredging within Northern Ireland and Scottish waters due to an adequate land supply of aggregate and lack of suitable and easily accessible resources on the seabed. The maximum depth that dredgers can practically operate in is around 50 m and is limited by available technology and vessel size.

The marine aggregate dredging industry employs about 640 staff, 500 of which are ship crew and the rest provide shore support and administration. A further 600 staff are employed on the wharves that receive UK marine aggregates and an estimated 500 related to the primary delivery of sand/gravel (i.e. from wharves to the point of initial use).

Pressures from marine aggregate dredging include removal of sand and gravel, damage or disturbance of benthic habitats and smothering from extraction operations and sorting of sediments. However, the proportion of seabed directly impacted by removal is 0.007% of the UK continental shelf (UKCS). Impacts are managed through licence-specific environmental impacts assessments (EIAs).

iv. What is driving change?

Activity within the sector is driven by the demand for construction material and the availability of land-won aggregates in comparison with marine aggregates. Demand for construction material is in turn driven by large-scale infrastructure projects such as nuclear new builds, renewable energy developments and coastal defence programmes. In 2005, marine sand and gravel accounted for 19% of total sand and gravel sales in England and 46% in Wales. Estimates of reserves suggest that there is still a large amount of marine resource available. Extraction of sea salt is driven by markets at home and abroad.

v. What are the uncertainties?

There are few uncertainties for the marine aggregate dredging industry with distribution of activity and value being well documented. A well supported research fund (the Aggregate Levy Sustainability Fund) (ALSF), well developed onboard monitoring systems and regional environmental assessments (REAs), means that there is a good understanding of the environmental impacts from marine aggregate extraction and the characterisation of regional aggregate resources and palaeolandscapes. However, there is a lack of information on the sea salt extraction industry due to the small size of the sector.

vi Forward look

Demand for marine aggregate materials could significantly increase over the next five to ten years to support large-scale infrastructure projects and coastal defence programmes. Consequently, associated pressures could also be expected to increase. The marine aggregate industry believes that existing identified deposits will be sufficient for at least 50 years production

at current rates of extraction. Climate change may increase the demand for protection against coastal flooding, which in turn may call for more soft engineered defences. Internationally, demand for exports may grow as continental land supplies become exhausted.

3.8.2 Marine aggregate extraction

3.8.2.1 Introduction

Description of economic activities

The range of economic activities related to marine aggregate extraction is presented in Table 3.58 and includes a range of ancillary and secondary activities. The extraction of resources such as potash and coal occurring beneath the seabed is currently excluded from this assessment as resources within the UK are extracted via underground access mines from land, hence the activity does not involve or impact on the sea. However, it should be noted that potash extraction may require the designation of exclusion zones that could restrict other extraction and construction industries on the seabed. Furthermore, the activity may require forms of seismic survey in areas of the seabed above or near sub-seabed mining areas.

Description of relevant ecosystem services

The mining and quarrying sector relies on various ecosystem services that support its productivity, including: (1) physical environment; and (2) erosion-deposition cycles (of sediment) – although most aggregate resources are relict so fall outside of contemporary erosion/deposition cycles.

Management

Extraction of marine aggregates requires a licence (both for prospecting and commercial extraction) from the seabed owner (in most cases TCE) and an environmental permission from the relevant regulator (the Marine and Fisheries Agency in England, the Welsh Assembly Government in Wales, the Scottish Government in Scotland, and the Northern Ireland Environment Agency in Northern Ireland). Specific policy was recently introduced in England (DCLG, 2006) and Wales (WAG, 2004b). These and specific licensing issues are discussed in more detail in the following sections. The industry in England, Wales and Scotland is represented by BMAPA which represents the industry on issues such as trade, regulation, sustainability and marine policy issues.

3.8.2.2 Direct use value

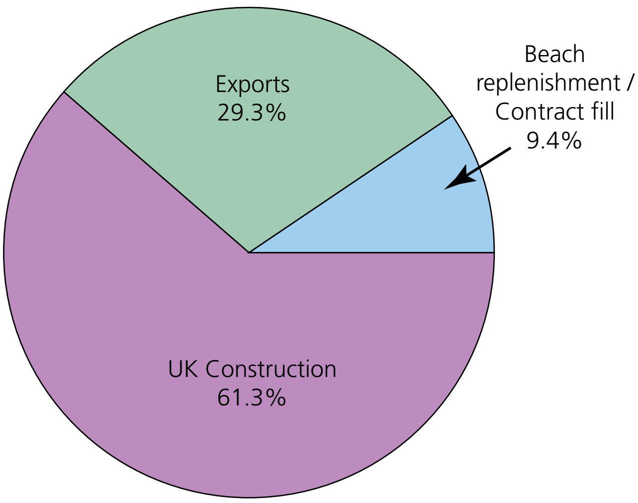
Principal activity

In summary, a total of 21.54 million tonnes of sand and gravel were dredged from Crown Estate licences in England and Wales during 2008 (The Crown Estate, 2008b). This includes material dredged for beach replenishment, contract fill and sources from rivers and miscellaneous tonnages. Of the total marine aggregates dredged, 29% is exported to Europe, 9% is used for beach replenishment and contract fill and the remainder is destined for UK construction markets (Figure 3.31). The amount exported is largely due to the European interests of some of the marine aggregate companies (and/or parent companies) coupled with an ongoing requirement for coarse sand and gravel for construction purposes in the absence of locally sourced alternatives.

Table 3.58. Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Mineral extraction (SIC 08.12);	Support activities – e.g. exploration services (SIC 09.90); Ship building/repair (see also Water Transport)	Processing of aggregate at wharf (SIC 08.12); Manufacture of products, e.g. concrete (SIC 23); Agents involved in the sale of aggregates (SIC 46.12)	None identified

Figure 3.31 Landings of marine aggregates by market (2007). Source: BGS (2007).



BMAPA has provided an indicative value for an 'average' price for landed sand and gravel of £6 per tonne before processing. Prices in continental Europe are about 30% lower than in the UK, i.e. £4.2 per tonne (Pugh, 2008). The value of beach recharge may be significantly lower but is assumed here to be the same. The breakdown of value is given in Table 3.59. This results in a total unprocessed value of £116 million. GVA can be roughly estimated using the combined use matrix in the UK Input-Output Tables for 2004 (ONS, 2004), for the whole sector, at 0.47 of turnover. Hence, GVA is estimated as £54 million.

Ancillary activities

Support activities include exploration services and ship building. Ship-building is assessed as an ancillary activity supporting Maritime Transport (see Section 3.7). However, the ships utilised for marine aggregate dredging are highly specialised and there would be additional machinery that is specific to the industry.

The industry's fleet of 28 specialised aggregate dredgers have a replacement value of around £1 billion. One of the key constraints on the industry's ability to deliver marine aggregates is the capacity of the fleet. The fleet is predominantly British. It is largely an old fleet (between 18 and 25 years old) that is due for some significant capital investment (BGS, 2007). A new vessel can cost between £25 and £40 million to build, implying that an investment of £600 to £900 million will be required in the next ten years. Capacity may be increased in some cases through chartering third party vessels and expanding existing ships.

Secondary activities

Secondary activities include: processing of aggregate at wharf; manufacture of products, such as ready mixed concrete, concrete blocks, etc; the principal activity also contributes to the value of the ultimate end use, for example, construction activities, coastal defence and beach replenishment.

Table 3.59 Value of landed sand and gravel for the construction industry. Regions refer to original source of material, not the wharf where it was landed.

CP2 Region	*Value landed in the UK, £ million*	*Value exported, £ million*[1]	*Beach recharge*	*Total value, £ million*	*Total GVA, £ million*	*Marine sand and gravel wharves*
1	0	0	0	0	0	5
2	36.90	20.24	10.68	67.82	31.88	12
3	29.94	5.88	1.32	37.14	17.46	28
4	8.82	0.00	0.00	8.82	4.15	5
5	2.46	0.00	0.00	2.46	1.16	5
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
Total	**78.12**	**26.12**	**12**	**116.24**	**54.63**	**55**
Tonnage, million tonnes	13.02	6.22	2	21.54		

[1] Prices in continental Europe are about 30% lower than in the UK (Pugh, 2008).

There are 45 marine aggregate wharves located in England and 10 in Wales (see Table 3.59). Most are located in regions where there is a lack of land-won supplies and/or for their proximity to resources and markets. Their strategic location therefore is of great importance to the viability of the industry and there are measures and policies to protect their location, particularly in London and the South East. Once landed, marine aggregates are processed (cleaned) and sorted. Assuming an added value from processing of £6 per tonne of landed aggregate (within the UK only), the additional out of the dock gate value in 2008 would be close to £80 million. Applying the same correction factor as above results in an additional GVA of £38 million for the processed product.

After cleaning and sorting, the aggregates are then manufactured principally into concrete and concrete products for the construction industry. Concrete is a mixture of water, cement and aggregate. Aggregate forms 60% to 80% of concrete by volume thereby influencing its physical properties. Total sales of concrete aggregate were 62.3 million tonnes in 2005 with marine aggregates meeting about 18% of this total demand (DCLG, 2005). The value can be broken down as follows:

- Manufacture of concrete products for construction purposes – total sales (2005) £2618 million, GVA £1130 million
- Manufacture of ready-mixed concrete – total sales (2004) £1663 million, GVA £555 million.

The proportion (at 18%) that can therefore be allocated to marine aggregates is £770 million and £303 million GVA. The key end user of this material is the UK construction industry. In 2005 the construction industry accounted for 6% (£63 billion) of the total UK Gross Domestic Product (GDP).

Contract fill relates to schemes such as civil engineering works including tidal barrage schemes and land reclamation projects. Specific examples of contract fill projects include:

- The 1.1 km long Cardiff Bay Barrage. This required 135 000 m^3 concrete and 2.55 million tonnes of sand (not all from marine sources).
- Concern about road transport to the Sizewell B nuclear power station in Suffolk resulted in 1.46 million tonnes of sand and gravel being delivered by sea.

While these are old projects (late 1980s / early 1990s), the UK Government's future energy strategy is likely to involve further tidal barrage projects and new build nuclear power stations in the next five years for which the marine aggregate sector is likely to play a role in providing the raw materials.

3.8.2.3 Regional distribution of value

The regional distribution of marine aggregate dredging value is given in Table 3.59 and distribution of licence areas in the south of the UKCS is illustrated in Figure 3.32. Marine aggregates are mainly sourced off the eastern and southern coasts of England (Regions 2 and 3) with smaller amounts off Wales (Regions 4 and 5). There is currently no dredging within Northern Ireland and Scottish waters. However, the relative importance of dredging areas changes over time as resources are depleted and new reserves are discovered and explored (BGS, 2007). For example, production began in 2005 in the East English Channel after new reserves were identified and this area is now of growing importance in terms of supply.

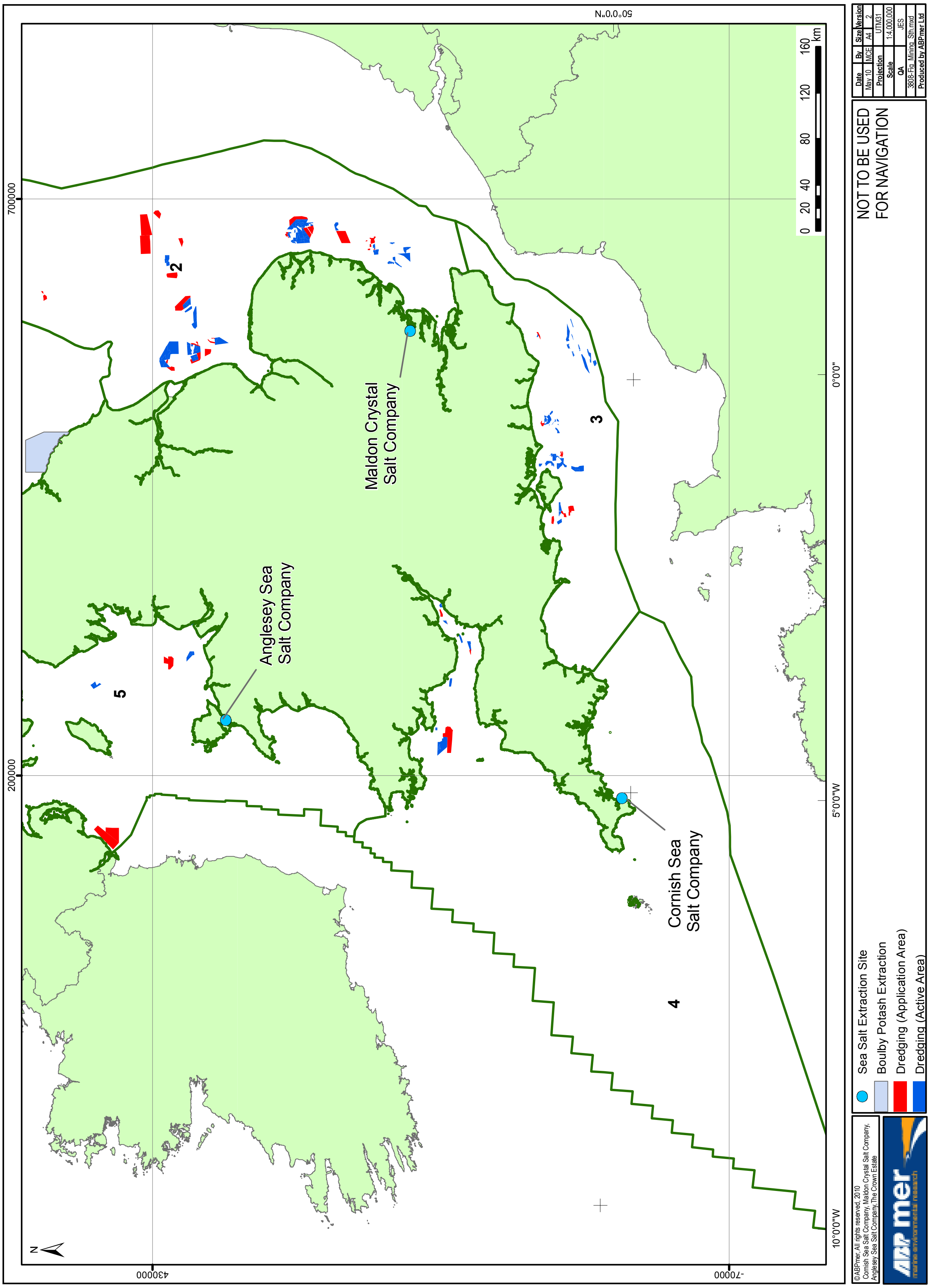
In Scotland the industry is still very small due to an adequate land supply of aggregate and lack of suitable and easily accessible resources on the seabed (Baxter et al., 2008). The Firth of Tay licence has been surrendered and the remaining licensed production areas for the Firth of Forth are subject to a renewal. The latest extraction was in 2005 when 129 387 tonnes (86 260 m^3) were removed from the Firth of Forth to supply infill material for the Leith Western Dock Reclamation Project. These firths are both located in Region 1.

The location of permitted reserves plays a key role in the ability to deliver the right quantity and quality of aggregate to the right landing wharf, thereby, in turn providing stability to the neighbouring construction industries. Generally, resources dredged and landed within the UK have not travelled far from their original source (i.e. are either landed within the Region of source or the neighbouring regions on either side). Some regions are particularly dependent on local resources. Excluding imports, deposits from the Humber (Region 2) are the sole source of marine aggregates for Region 1 (BGS, 2007). South Wales is particularly dependent on marine-dredged sand due to shortages in local land-won sources (in 2005, 80% of sand and gravel sources were marine) and there are currently no realistic alternatives (BGS, 2007).

The maximum depth that dredgers can practically operate in is around 50 m and is limited by available technology and vessel size. Of the 1344 km^2 of seabed licensed 923 km^2 is within the inshore region (0 to 12 nm) and 421 km^2 is from the offshore region (12 to 200 nm).

Material for beach replenishment is often sourced locally in order to maintain the sediment characteristics of the beach and to reduce transportation cost. This market is highly dependent on marine sources and is likely to increase in the future with rising concern about coastal erosion. Schemes for beach replenishment have taken place on the

Figure 3.32 Distribution of license areas for marine aggregate dredging in the south of the UKCS.



Lincolnshire and north Norfolk coasts, in Suffolk and Essex and in various locations along the south coast.

It is difficult to allocate out of dock gate values (i.e. the added value from processing at the wharf) to regional areas as the amounts landed at each wharf vary widely ranging from 20 000 tonnes to 1.7 million tonnes.

3.8.2.4 Trends

The supply of marine dredged sand and gravel for UK construction has been stable since the early 1970s. Figures 3.33 and 3.34 illustrate the trends in marine aggregate extraction between 1998 and 2008 from which the following conclusions can be made:

- The amount dredged has varied by less than 4 million tonnes over the past ten years
- The area of seabed licensed for marine aggregate extraction has decreased in real terms by 387 km², with 750 km² of existing licence area surrendered and 362 km² of new licence area permitted
- The total area of seabed actually dredged between 1998 and 2007 was 462 km², during which time the area of seabed in any one year has decreased from a maximum of 222 km² in 1998 to 135 km² in 2007.

In addition, over the past four years, the average area of new seabed dredged in each year has amounted to 15.7 km², during which time a number of significant new dredging areas have been permitted. The change in dredge area relates to two factors: (1) operators improving the management of their resource, and (2) requirements of the Marine Minerals Guidance Note 1 (DCLG, 2002) to minimise the area of seabed dredged at any one time, and to work areas to economic exhaustion before moving to new areas. The requirements were applied

Figure 3.33 Trend in the quantity of marine sand and gravel dredged between 1998 and 2007. Source: BMAPA (2008).

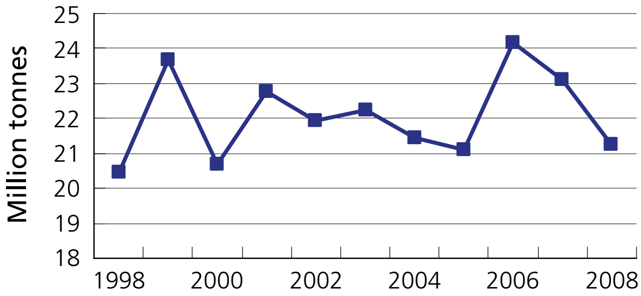
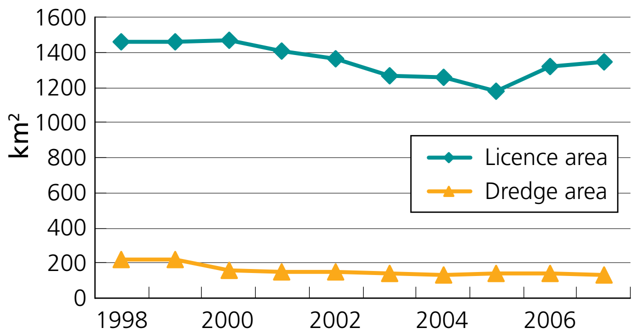


Figure 3.34 Trends in the area licensed for marine aggregate extraction and the actual area dredged between 1998 and 2007. Source: BMAPA (2008).



to permissions issued after 2002, but many operators also reflected these requirements voluntarily across existing licence areas. This commitment formed the basis of the 'area involved' initiative, in which BMAPA and TCE voluntarily began to report changes in licence and dredged area on an annual basis – this is now in its eleventh year.

BMAPA and TCE are currently preparing a ten year review, to examine the trends and changes in the area of seabed licensed and dredged for marine aggregates in UK waters. This will

include consideration of the cumulative dredged footprint over the period, and also the extent of new area dredged each year.

3.8.2.5 Socio-economic pressures and impacts (positive and negative)

Positive

The UK's marine aggregate industry is one of the largest in the world making it a leader in the formation of best practice guidance (technical and environmental), development strategies and supporting policies. This maturity in management has been driven not just by environmental regulation and policy developments but also by voluntary actions within the industry. There are eleven companies currently involved in the production of marine aggregates in the UK, that is, that have a production licence area. Nine are members of BMAPA and who collectively extract over 90% of marine aggregates.

The industry employs about 640 staff, 500 of which are ship crew and the rest provide shore support and administration (BGS, 2007). A further 600 staff are employed on the wharves that receive UK marine aggregates and an estimated 500 related to the primary delivery of sand/gravel (i.e. from wharves to point of initial use). Further down the line of secondary activities, the industry also supports employment for the manufacture of ready-mixed concrete and concrete products and the distribution of these products to the construction industry. In terms of ancillary activities, the industry supports jobs related to the representation of the industry (e.g. BMAPA), ship building and maintenance, manufacture of specialised surveying and dredging equipment, and environmental monitoring and assessment.

The industry also contributes to the Marine Aggregate Levy Sustainability Fund (MALSF) which funds, for example, studies on marine archaeology (see Case Study 5) and the environmental effects of marine aggregate dredging (see Section 3.8.2.8). The MALSF is supported through a levy imposed on sales of primary aggregate which increased to £1.95 per tonne in April 2008[17]. There are also economic benefits through the royalties and VAT (Value Added Tax) that operators pay for every tonne dredged, much of which is passed by TCE to HM Treasury. In 2008, the benefits were as follows:

- Royalties from marine sand and gravel (based on a total marine production of 21.5 million tonnes for the calendar year) = £16.5 million
- UK marine landings for construction aggregate subject to aggregates levy (13.02 million tonnes × £1.95 per tonne) = £25.4 million
- VAT on all UK sales (construction aggregates and beach nourishment: 15.32 million tonnes @ £6 per tonne = £91.9 million. 15% VAT on top) = £13.8 million.

This gave a total tax revenue of £55.7 million in 2008. As illustrated in these calculations, revenue per tonne varies depending on whether it is marine aggregates for UK construction (subject to royalties, aggregates levy and VAT), marine aggregates for UK beach nourishment (subject to royalties and VAT) or exports (royalty only) being considered. However, pro-rata across all production the revenue per tonnes equates to £2.60. Total terrestrial primary aggregate sales in Great Britain in 2008 were 214 million tonnes resulting in a total contribution of £417 million to the MALSF.

17 Marine aggregate supplied to the UK construction industry is subject to the Aggregates Levy but material for export, beach nourishment and contract fill is not.

Marine aggregates are essential for their contribution to creating and maintaining the 'structural framework of the built environment' (BGS, 2007). In 2005, marine sand and gravel accounted for 19% of total sand and gravel sales in England and 46% in Wales. Therefore, marine sources of aggregates have a role in underpinning the security of supply for the construction industry. Land-based sources of aggregate are unevenly distributed, increasingly constrained by environmental designations and requirements for transportation (largely towards London and the South East) which reduce efficiency. There are also regional differences in the significance of wider socio-economic benefits of the industry. Marine aggregates make a 'crucial' contribution to London and the South East (part of Regions 2 and 3), which together account for over one third of construction and economic activity in the UK (BGS, 2007).

Marine aggregates are generally rounded in shape due to natural erosion processes and this characteristic reduces the amount of cement required compared to crushed rock from terrestrial reserves in order to produce concrete (BGS, 2007). Cement is very energy intensive to produce and, as a consequence, is the most expensive component of concrete, both economically and environmentally. Therefore, marine sources of aggregate can indirectly result in economic and environmental benefits.

It should also be acknowledged that marine aggregate dredging infers wider contributions and benefits to society. For example, the data generated from seabed mapping, prospecting, EIAs, industry funded research and monitoring have provided many scientific insights into the dynamics of sedimentary and ecological systems (see Case Study 5).

Negative

Marine aggregate dredging interacts with the seabed both directly through the dredge and indirectly through plume effects. These pressures may affect fisheries in the short-term by deterring fish and in the long-term by affecting recruitment processes. Direct impacts from the passing of the drag head tend to be short-term and localised while plume effects are more widespread (environmental impacts are discussed in more detail in Section 3.8.2.6).

As an example of an approach to resolving stakeholder conflicts, the Overfalls is an area of sand and gravel ridge features off the South Coast of England to the east of the Isle of Wight that were subject to an application for extraction in 1999. Due to strong objection from recreational and commercial fishing interests the application was put on hold. The Overfalls Project was carried out by the University of Portsmouth's Centre for the Economics and Management of Aquatic Resources (http://www.port.ac.uk/special/theoverfalls) to investigate and manage issues in the area through stakeholder-led site and conflict management initiatives. Possible management approaches that were identified (in order of preference across all users) included legally designated conservation status, voluntary codes of conduct, and consensual agreements between different categories of users.

3.8.2.6 Environmental pressures and impacts (positive and negative)

This section describes the processes or activities involved in marine aggregate dredging and assesses the understanding of the spatial and temporal distribution of associated pressures.

In the UK, the main process of dredging is the trailer suction method although static suction dredging is also employed where the industry targets thick, localised deposits. The former involves trailing a draghead across the seabed at slow speed (1.5 knots) and results in a series of grooves 2 to 3 m wide and typically 0.25 to 0.5 m deep. Over time, repeated passes can result in a depth of 6 m of sediment being removed. A typical production lane may be 2 to 3 km long and 50 to 250 m wide. Static suction dredging, where the vessel is fixed in position (through anchoring or dynamic positioning), is typically used for more localised and thicker deposits down to 10 m depth.

Where the sediment composition of the in situ seabed resources matches the requirement of the end user, dredgers will retain all the sediment dredged as an 'as dredged' cargo. Where this is not the case, specialist marine aggregate dredgers have the ability (depending on the individual conditions of their extraction licence) to process the dredged sediment while loading using a technique termed 'screening' in order to alter the ratio of sand to gravel retained onboard. When seeking cargoes with a higher gravel content, dredged material passes over a mesh screen before entering the cargo hopper. A proportion of the water and finer sediment falls through the screens and is returned to the sea, while the coarser sediment is retained. This process can also be reversed to load sand-only cargoes. While the environmental implications must be carefully considered, screening allows more marginal resources to be worked efficiently, which in turn extends their lifetime, thereby reducing the need for new dredging sites. Screening also enables the industry to deliver cargoes to the specification required by the construction industry. Screening is not allowed in all aggregate areas, particularly where deposition of fine material may settle over environmentally sensitive habitats such as herring spawning areas.

The EU EIA Directive and subsequent amendments have now been fully transposed into UK legislation for the extraction of marine aggregates. The new Regulations also transpose into UK law some of the provisions of the EU Habitats Directive with respect to marine mineral extraction.

In order to provide a more robust and consistent assessment of cumulative and in-combination effects, the marine aggregate industry has made a voluntary commitment to undertake Regional Environmental Assessments (REAs) for a number of strategic areas of extraction. These also help to ensure regional sustainability of aggregate extraction and to improve the evidence base for individual licence applications. The first REA was commissioned by the East Channel Association for the East Channel Region. Following the completion of the REA (Royal Haskoning, 2003), a regional environmental monitoring programme was developed by the East Channel Association to test the predictions of the REA. In 2007, REAs were also commissioned for the Outer Thames Estuary and the Humber Area.

The key environmental issues considered in the consenting process include potential effects of dredging on: the coast and coastal processes, sediment transport, ecosystems, fisheries, water quality, navigation, marine conservation areas, archaeological sites, and the contribution to in-combination and cumulative environmental effects.

Dredging permissions include conditions for mitigation and monitoring of potential environmental impacts. This includes the requirement for all dredgers to have an Electronic Monitoring System (EMS) that records

Case Study 5: Improved understanding of marine archaeology from sharing of information by industry: North Sea Palaeolandscapes Project.

The British continental shelf contains one of the most detailed and comprehensive records of the Late Quaternary and Holocene landscapes in Europe. Knowledge of the development of this landscape is critical to our understanding of the archaeology of the larger region, the impact of climate change on palaeobathymetry and shoreline sequences. Despite its importance, until recently this remarkable landscape had not been adequately mapped, and was poorly understood. The North Sea Palaeolandscapes Project was funded by an English Heritage MALSF grant to make use of extensive 3D seismic data sets to generate mapping and landscape models of the inundated Mesolithic land surfaces of the southern North Sea.

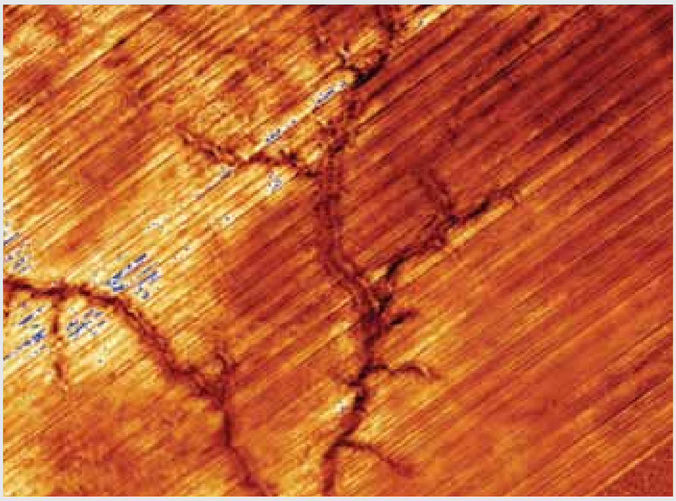
The project used a variety of geophysical data sources, in conjunction with more traditional map data to provide the 'missing' Mesolithic landscape information for the UK sector of the southern North Sea region. The primary geophysical data set consisted of the 3D seismic 'Mega-Survey' as compiled by Petroleum Geo-Services and provided to Birmingham University to assist this research. In addition to this geophysical dataset a suite of high resolution 2D seismic lines acquired using boomer and airgun sources were used for data verification purposes. Bathymetric data, along with a variety of geological mapping information for the area were also used to assist in understanding the archaeological resource.

North Sea Palaeolandscapes Project Study area

In total an area of 23 000 km² was mapped during the 18 month project, representing almost 40% of the *Charting Progress 2* region. The results of the mapping exercise show that inundated landscapes can be reconstructed accurately and extensively. Features observed included palaeolithic coastlines, marine areas, lakes and wetlands, salt marshes, estuaries, and fluvial streams (see the example output in the top left of the facing page).

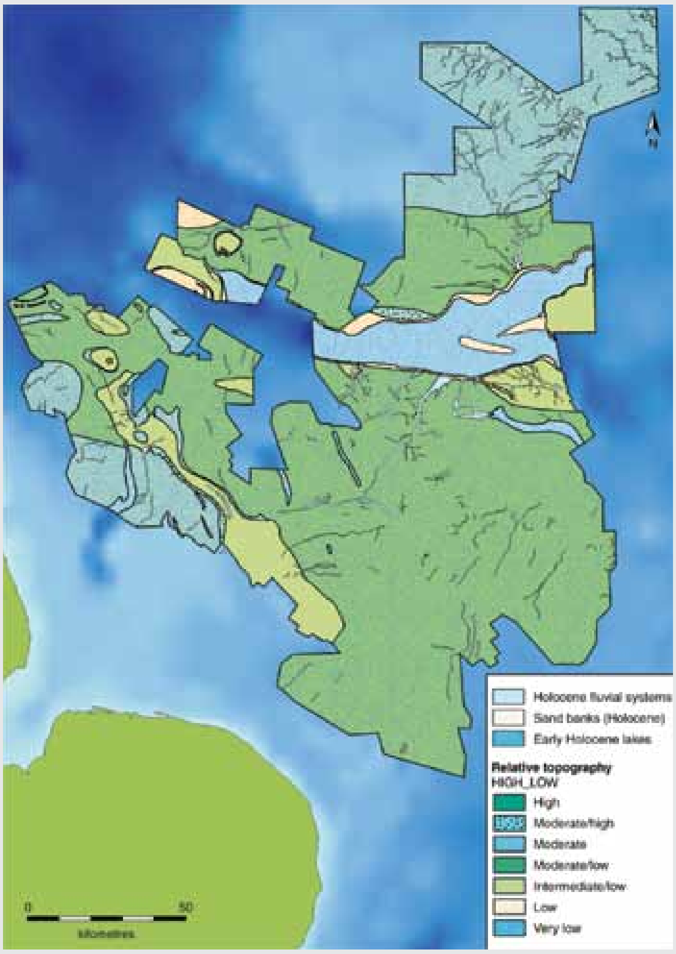
The basic map has major implications for the interpretation of the archaeology of north-west Europe more generally. In the past the region was, perhaps, relatively ignored because of the difficulties of dealing with a resource that was largely invisible and generally inaccessible. This is no longer the case thanks to collaboration with exploration companies and support by industry funding. How such data are used will be a challenge for archaeologists and cultural resource managers for every country around the North Sea.

A Holocene palaeochannel visualised within the 3D Seismic data



The project has been profiled internationally through presentation of results at conferences and publication of research online. Output from the research includes the results of a data audit of relevant marine resources and a number of resource management maps relating to risk and uncertainty of feature detection across the whole of the mapped area. Such information is of value to academic research and heritage management activities, as well as informing planning tools for extractive industries including aggregates, oil and gas and fisheries. In addition to these more technical outputs, virtual reality technologies have also been used to produce visualisations of the landscape which are more accessible for the interested public than traditional paper mapping.

General map of all recorded Holocene landscape features, including general topographic interpretation



Based on Gaffney (2007, 2009) and Fitch et al. (2007).

the ship position and dredging status using a Global Positioning System (GPS). Summary data on the extent and intensity of marine aggregate dredging activities in British waters have been published on an annual basis since 1998 by TCE and BMAPA as part of their area involved initiative (e.g. BMAPA and TCE, 2007). Consequently, through a well-developed and supported monitoring and research system (see MALSF in Section 3.8.2.8), there is a fairly good understanding of the level of exposure (extent, magnitude, intensity) and potential environmental impacts from marine aggregate dredging.

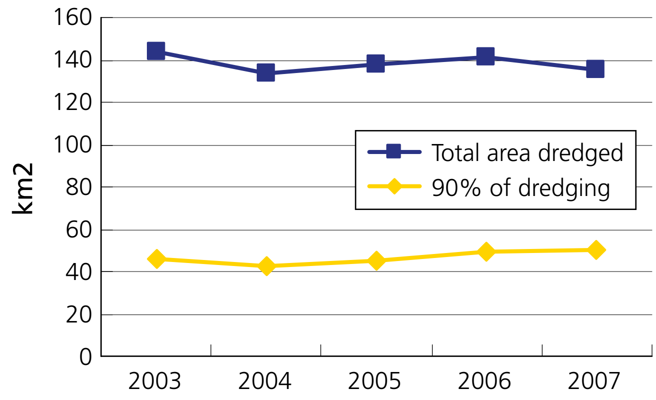
Key environmental pressures and impacts associated with aggregate extraction can be seen in Table 3.60. The ecosystem services that these pressures impact and the relative significance of these impacts are identified in Table 3.61 followed by further detail on the spatial extent and intensity of dredging. The spatial extent and intensity of marine aggregate dredging activities is assessed in Table 3.62 and temporal trends are illustrated in Figure 3.35. The data indicate that although a large area may be licensed for extraction only 10% of this area is utilised on average. Furthermore, of the area actually dredged, 90% of the dredging effort may be focussed on just over a third of that area. This pattern has remained consistent over the past five years.

3.8.2.7 Climate change

Impacts of climate change on marine aggregate dredging

The report by BGS (2007) highlights that the increasing need to protect existing coastal assets will create a continuing demand for marine sand and gravel for construction and material for beach replenishment. However, there are few published studies that discuss in detail the physical impacts of climate change on dredging

Figure 3.35 Area of dredging focus compared to actual area dredged 2003-2007. Source: BMAPA (2008).



activities. Possibility for increased storm and wave activity could reduce the calm weather windows available for dredging aggregates.

Impacts of marine aggregate dredging on climate change

Marine aggregate dredging contributes to emissions of greenhouse gases through shipping and indirectly through downstream production activities. The BMAPA Sustainability Report (BMAPA, 2008) highlights the industry's commitment to and progress towards reducing such emissions (see Box 3.4). In 2007, the amount of marine gas oil used to transport and produce marine aggregate was 2.39 kg per tonne of landed aggregate a slight increase in efficiency compared to 2.44 kg per tonne in 2006 (BMAPA, 2008). Total carbon dioxide (CO_2) emissions in 2007 were 7.614 kg per tonne of landed aggregate (a total of 157 000 tonnes) compared to 7.796 kg per tonne in 2006 (a total of 158 000 tonnes).

However, there are other potential indirect impacts. Changes to sediment pathways could also result in aggregate extraction having an impact on designated sites such as banks

Table 3.60. Key pressures and impacts associated with mineral aggregate extraction. Sources: Kenny et al. (1998); Posford Duvivier and Hill (2001); Boyd and Cooper (2002); Newell et al. (2004); Birklund and Wijsman (2005); Cooper et al. (2005); Marine Ecological Surveys (2007); HR Wallingford et al. (2007).

Pressure	**Abrasion from the pass of the dredge head**
Impact	This can result in habitat change and damage.
Description of environmental change (intensity, spatial extent, frequency, duration)	Total area dredged in 2007 was 135 km2: Some of this consists of multiple passes. 90% of dredging actually occurred within 50 km2 0.007% of the UKCS (out to 200 nm).
Existing management measures	Policy requirements to minimise the area of seabed dredged at any one time.

Pressure	**Removal of substratum**
Impact	Selective extraction may result in changes to the sediment characteristics of the habitat, changes in sea bed topography and associated loss of habitats and species. The significance of the impact depends on the nature of the habitat (sensitivity and recovery rates) and the magnitude of the impact.
Description of environmental change (intensity, spatial extent, frequency, duration)	Although the licence blocks presented in Figure 3.32 are large the actual area dredged within this is very small (see Table 3.62). Furthermore, dredge companies tend to focus on different parts of their licence block each year, allowing the extracted areas to recover. Key issues include the extent of change in sediment composition as a result of removal. The significance of the impact is considered to be relatively moderate due to the small extent of impact and potential for recovery.
Existing management measures	Conditions (of licences) and/or operators' resource management measures restrict the spatial extent of dredging. Monitoring of the impacts of aggregates dredging is required as a condition of the permission (licence).

Pressure	**Disturbance of the seabed**
Impact	Disturbance of the seabed can result in reduced sediment and water quality and changes to benthic fauna.
Description of environmental change (intensity, spatial extent, frequency, duration)	As above, the extent of the impact in both spatial and temporal terms is quite restricted. One study reported a recovery of benthic fauna 12 months after dredging had ceased (Marine Ecological Surveys, 2007) although this may be longer in more stable habitats. Given the restricted extent of change and rapid recovery rates, the significance of the impact is considered to be relatively low.
Existing management measures	

Pressure	**Smothering – introduction of sediment from the screening process**
Impact	This has the potential to smother organisms resulting in habitat change and loss. The sediment plume may also result in reduced water and sediment quality.
Description of environmental change (intensity, spatial extent, frequency, duration)	Direct studies on the behaviour of plumes from marine aggregate dredgers during normal loading operations suggest that the majority of the material is deposited on the sea bed within 2 km from the site of discharge (Hitchcock and Drucker, 1996; Newell et al, 1998; Marine Ecological Surveys, 2002). However, depending on net tidal flow, impacts on benthic biomass may extend up to 4 km 'downstream' of screening disposal (Marine Ecological Surveys, 2002).
Existing management measures	Where required, screening controls may be included in licence conditions.

Pressure	**Noise from exploration activities and operational noise**
Impact	Potential impacts on noise sensitive species such as cetaceans and some fish species.
Description of environmental change (intensity, spatial extent, frequency, duration)	Some preliminary work has been carried out by Cefas (2003). The results were inconclusive but identified species of concern for further study. Work is being carried out under the Marine Aggregate Levy Sustainability Fund to better understand impact of noise.
Existing management measures	No measures as yet.

Table 3.61 Environmental pressures on ecosystem services associated with marine aggregate extraction.

Ecosystem service	*Significance of impact*	*Confidence in understanding of the relationship = information gaps*
Erosion–deposition cycles (of sediment)	**Low**. Extent of impact relates to a small proportion of seabed sediment. The majority of deposits being extracted are relict – i.e. detached from modern processes. Returned sediment (overspill/plume) adds to natural bedload – sensitivity of this depends on natural background levels.	**Low**. Long-term impacts on dynamic seabed habitats are complex and difficult to distinguish from any preceding bottom-trawling activities.
Biological productivity (supporting service)	**Minimal–Low**. Disruption of surface habitat and increase in turbidity from plumes may impact on productivity of biological system, but relates to a minimal proportion of seabed sediment.	**Low**. Long-term impacts on dynamic seabed habitats are complex.
Biodiversity provision	**Low**. Disruption of surface habitat and increase in turbidity from plumes may impact on particular species, but relates to a small proportion of relevant habitat.	**Low**. Long-term impacts on dynamic seabed habitats are complex.

Table 3.62 Distribution of dredging activity in 2007 within each CP2 Region (km^2).

CP2 Region	*2*	*3*	*4*	*5*	*Total*
Total area licensed	854.73	293.04	141.11	54.95	1343.83
Total active dredge area[1]	367.6	113.02	55.45	19.96	556.03
Total area actually dredged	86.54	33.86	13.46	0.81	134.67
Area dredged as percentage of the licensed area	**10.1%**	**11.6%**	**9.5%**	**1.5%**	**10.0%**
Area from which 90% of regional dredging effort was focused	34.19	11.91	4.04	0.39	50.53
As a percentage of the area dredged	**39.51%**	**35.17%**	**30.01%**	**48.15%**	**37.52%**

[1] The area within which dredging may actually take place, as constrained by licence conditions or by voluntary zoning initiatives.

or coastal features. Any changes that may occur as a result of climate change are poorly understood. However, all permissions for extraction must be assessed through a coastal impact study, and the renewal process for permissions means that such assessments will be renewed every 10 to 15 years.

It should be noted that marine aggregate dredging also provides positive benefits to reducing the level of greenhouse gas emissions. Marine aggregates can be supplied close to where they are needed (generally at the coast) lessening the need for land-based transport, thereby reducing related greenhouse gas emissions and impacts on land-based infrastructure. In 2007, the industry delivered 20 000 tonnes of marine aggregate every day to London, the equivalent of 1000 lorry loads (BMAPA, 2008).

Summary

Table 3.63 provides a summary of the climate change pressures and impacts associated with mineral aggregate extraction, the level of confidence in the impact assessment, the significance of the impact and the measures that might be employed to manage the impacts (see Annex 1 for a discussion of the assessment methodology).

3.8.2.8 Industry stability and sustainability

Marine aggregate reserves

Most of the locations of commercially viable sand and gravel deposits are fairly well-known and studied (see BGS, 2007: fig. 12). The industry believes that these deposits will be sufficient for at least 50 years production at current rates of extraction, subject to the necessary permissions being awarded (BGS, 2007). Table 3.64 provides the latest estimates of permitted reserves of primary aggregate and sand. Primary aggregate is defined as a 50/50 blend on production suitable for use as concreting aggregates and typically contains >20% gravel in-situ on the seabed. It should be noted that the most significant reserves of aggregate are in the Eastern English Channel and South Coast areas which have proportionally higher in situ gravel contents. Sand is defined as a product suitable for use as concreting aggregates or concreting/building sand, typically composed of 0% to 40% gravel on production and containing 0% to 20% gravel in-situ on the seabed. National primary marine sand reserves are extensive but are strategically important to the South West and North West where alternatives are not readily available. In addition to the data published in Table 3.64 there are reserves under application that would enable the

Box 3.4: Objectives and indicators for the marine aggregate industry. Source: BMAPA (2008)

Creating sustainable communities

Objective 1
Improving the occupational health and safety of the marine sector's employees.

Indicator:
- *Working days lost through work-related injury.*

Objective 2
Improving employee development through vocational training.

Indicators:
- *Employment – direct/indirect.*
- *Training days per employee*

Objective 3
Increasing the transparency of activities. Maintaining and developing further liaison with other marine stakeholders.

Climate change and energy

Objective 1
Reduce the impact of atmospheric emissions released through the production and transport process.

Indicators:
- *Marine gas oil per tonne landed*
- *CO_2 emissions per tonne landed*

Objective 2
Maximise the efficient use of the dredging fleet.

Indicator:
- *Total landed per kilometre travelled*

Sustainable production

Objective 1
Maintain and improve profitability in order to provide for continuing investment and employment.

Indicators:
- *Annual marine production*
- *National/regional marine contribution to supply*

Objective 2
Maintaining and increasing investment in dredgers and dredging technology in order to improve efficiency and environmental performance.

Indicators:
- *Profile of age/capability of dredging fleet*
- *Investment in vessels/technology over previous five years.*

Objective 3
Make the most efficient use of available licensed resources.

Indicator:
- *Dredging areas and area dredged*

Objective 4
Minimise the screening activity in the production process.

Indicator:
- *Tonnes landed per hour dredged.*

Objective 5
Develop and promote best practice for resource management.

Natural resources and environmental protection

Objective 1
Minimise the spatial footprint of dredging operations through responsible and effective management.

Indicators:
- *Area of seabed licensed for dredging*
- *Extent of active dredge area*
- *Area of seabed actually dredged*
- *Area of seabed where 90% of dredging occurs*
- *Area of seabed dredged for more than 1.25 hours.*

Objective 2
Maintain and develop industry contribution towards the understanding of the marine sand and gravel habitats.

Objective 3
Maintain and develop industry contribution towards the understanding of Britain's marine historic environment.

Objective 4
Minimise effective controls to minimise the potential for pollution to the marine environment.

Indicator:
- *Number of recorded incidents*

Table 3.63 Summary of climate change implications.

Climate change pressure	*Impacts of climate change on Mineral Aggregate Extraction*	*Confidence/ significance*	*Adaptation measures*
Increase in severity of storms	Shortening of suitable calm weather periods during which dredging can be undertaken	Low confidence / medium significance	Changes to design of dredging methods and changes to ship design
Changes to sediment transport pathways	Impoverishment of sediment sources and habitats	Low confidence / low significance	Other resources may become available

Impacts of Mineral Aggregate Extraction on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
Aggregate dredging has an impact on climate change through shipping emissions during the dredging and transportation of sediments	CO_2 emissions	High confidence / unknown significance	Improved ship design

Table 3.64 Permitted reserves of aggregate and sand. Source: The Crown Estate (2008b).

Primary aggregate reserve (million tonnes)		*Annual production*	*Years remaining*
Humber	15.70	4.09	3.84
East Coast	19.09	6.27	3.04
Thames Estuary	15.56	2.09	7.44
E. English Channel	27.40	2.59	10.58
South Coast	42.33	4.23	10.01
National Primary Aggregate Reserve (50:50 sand and gravel)	120.08		
Primary sand reserve (million tonnes)			
South West	9.67	1.56	6.20
North West	12.38	0.43	28.79
National Primary Sand Reserve (<20% gravel)	22.05[1]		

[1] 61.24 million tonnes of sand is also present in the permitted primary aggregate reserves above

marine aggregate industry to maintain its current contribution to national construction aggregate demand for around 25 years, subject to the consenting of new licences. The first application for dredging in Northern Ireland waters was proposed in 2007 but has yet to be determined. Despite the development of new reserves and increases in the number of dredging permissions awarded, there are regional weaknesses. For example, the area surrounding the Bristol Channel is particularly dependent on marine-dredged sand due to a shortage of land-won resources.

Land-based reserves of sand and gravel are declining in south-east England due to a lack of planning applications and an increasing number of planning refusals. Consequently, the role of

marine aggregate supplies in supporting regional requirements for construction aggregates is likely to become more strategically important.

It is difficult to assess the immediate economic future and stability of the marine aggregate sector in light of recent economic events. Unofficial statistics indicate a rapid drop in the demand for marine aggregates due to decreases in land-based construction (pers comm., M. Russell, BMAPA). Large infrastructure projects, on the scale of the Channel tunnel and the proposed Severn Barrage, driven by central Government policies, will continue to play a role in maintaining the industry. However, there are already large consequences of the current economic downturn for small companies further down the supply chain (i.e. secondary activities and values).

Sustainability and objectives

Minerals Policy Statement 1 (DCLG, 2006) sets out the Government's objectives for minerals planning in England (including marine minerals) and the requirement for them to contribute to the achievement of sustainable development:

- Conserve and safeguard mineral resources as far as possible
- Protect nationally and internationally designated areas of landscape and sites of nature conservation value from minerals development, other than in exceptional circumstances where it has been demonstrated that the proposed development is in the public interest
- Secure supplies of the material needed by society and the economy from environmentally acceptable sources
- Ensure, so far as practicable, that outcomes for the minerals industry are consistent with the Government's aims for productivity growth and strong economic performance
- Secure sound working practices so that the environmental impacts of extraction and the transportation of minerals are kept to a minimum, unless there are exceptional overriding reasons to the contrary
- Minimise production of mineral waste
- Promote efficient use and recycling of suitable materials, thereby minimising the net requirement for new primary extraction
- Protect and, where possible, to enhance the overall quality of the environment once extraction has ceased through high standards of restoration and to safeguard the long term potential of land for a wide range of after uses.

In relation to marine minerals, there is a specific objective to encourage the supply of marine-dredged sand and gravel to the extent that environmentally acceptable sources can be identified and exploited, within the principles of sustainable development. To achieve this, the dredging industry requires sufficient access to suitable long-term resources to meet its varied and fluctuating markets and to provide it with sufficient confidence to invest in new ships and wharves. At the same time, it is important that dredging activities do not significantly harm the environment or fisheries or unacceptably affect other legitimate uses of the sea.

To support this intent, Marine Mineral Guidance Note 1 (prepared by DCLG (2002) when they had responsibility for marine minerals regulation in English waters) establishes the following policy objectives:

- Minimise the total area licensed/permitted for dredging

- The careful location of new dredging areas
- Consider all new applications in relation to the findings of an EIA where such an assessment is required
- Adopt dredging practices that minimise the impact of dredging
- Require operators to monitor, as appropriate, the environmental impacts of their activities during, and on completion of, dredging
- Control dredging operations through the use of conditions attached to the dredging licence or dredging permission.

The Welsh Assembly Government has published an Interim Marine Aggregate Dredging Policy (WAG, 2004b) for South Wales. The policy includes the following specific objectives:

- Identify areas where dredging for marine aggregates is likely to be acceptable
- Protect the marine and coastal environment – landscape, habitats, ecology and heritage
- Control the impacts of marine dredging to acceptable levels
- Encourage efficient and appropriate use of dredged aggregates
- Safeguard resources from sterilisation
- Protect the interests of other users of the area.

There are no specific targets associated with these objectives, but the Marine and Fisheries Agency (the current regulator in English waters), the Welsh Assembly Government, TCE and the aggregates industry collect various information to inform management decisions.

BMAPA has taken a lead in reporting on its activities with the publication of a sustainable development strategy in 2006 (BMAPA, 2006) that outlines objectives, indicators and targets. Progress against these indicators is reported annually (BMAPA, 2007, 2008). The 2008 report updated the indicators across four new broad themes (creating sustainable communities, climate change and energy, sustainable production, natural resources and environmental protection – see Box 3.4).

Research needs

Research and information needs in order to support the industry are addressed by the MALSF. The fund was introduced in April 2002, in England, Scotland and Wales, initially as a two-year pilot scheme, to provide funds to tackle a wide range of problems in areas affected by the extraction of aggregates. The aggregate levy generated around £28.2 million from marine landings in 2007. Total terrestrial primary aggregate sales in Great Britain during the same period were 214 million tonnes resulting in a further contribution of £417 million from the levy. A proportion of the total revenue raised by the revenue (typically 5% to 10% of the total) is used to support research through the wider MALSF programme. The surplus is retained by HM Treasury. The third round of the MALSF is currently operating within the period 1 April 2008 to 31 March 2011 on funding at £4.5 million per annum. However, these figures underestimate the value of the MALSF where, after almost eight years of research investment, there have been substantial advances in the understanding of impacts associated with marine aggregate activities.

Key information gaps that have been addressed since the fund began include:

- Distribution of marine aggregate resources and comparisons with land-based resources
- Baseline sediment mobility information and physical impacts of marine aggregate dredging on the seabed

- Baseline ecological distribution and abundance and biological traits information
- Ecological sensitivity to and recovery from marine aggregate dredging activities including effects of plume dispersion from screening processes
- Characterisation of marine archaeology and impacts from marine aggregate dredging
- Data management of research information in a GIS database.

In 2007/08 two Regional Environmental Characterisation studies were awarded for the Thames and the South Coast of England, with two more commissioned for the Humber and the East coast in 2008/09. Research studies being addressed in the current round of the MALSF continue the themes above but also investigate: seabed mapping; localised community impacts; monitoring, mitigation and management techniques; and the socio-economic issues associated with marine aggregate dredging activities.

The industry also commissions Regional Environmental Assessments to address cumulative and in-combination issues at a regional scale through a consistent approach, the outputs from which feed into the site specific EIAs required to support applications for dredging permissions.

3.8.2.9 Forward look

Home market demands could increase in the future, supporting major infrastructure development (e.g. Crossrail, Thames Gateway, nuclear programmes, tidal range projects and the London Olympics 2012). However, there are likely to be indirect impacts from the recent economic recession affecting investment in construction projects: 2008 statistics released by TCE report a 7% reduction in landings to the UK construction market (from 14.45 million tonnes in 2007 to 13.12 million tonnes in 2008).

Demand for beach nourishment material varies from year to year depending on what projects are currently being undertaken. However, climate change may increase the demand for protection against coastal flooding, which in turn may call for more soft engineered defences. Internationally, demand for exports may grow as continental land supplies become exhausted.

If extraction increases in order to meet demand for construction material, coastal defence schemes and beach replenishment, the environmental pressures associated with the activities are also likely to increase.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the marine aggregates industry will need to manage further its activities. For example, GES Descriptor 6 states that *...Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.8.3 Sea salt extraction

3.8.3.1 Introduction

Salt (sodium chloride, NaCl), occurs naturally in the marine environment in solution. The extraction of sea salt from the surrounding marine waters occurs at two sites in England and one site in Wales. Salt extraction is therefore dependent on the following ecosystem services: Provision of water quality, and Tidal cycles (to supply salt pans – assuming this is the method of salt extraction).

The product is destined solely for the food industry rather than the large chemical industries that many land-derived salts support. Other than this, very little specific information exists regarding salt extraction from the marine environment and the information provided here was obtained through individual consultation with the three sea salt production companies in the UK. The range of economic activities is indicated in Table 3.65.

3.8.3.2 Direct use value

The total turnover for all three companies is roughly £4 million (estimated as at 2008). No information exists for GVA. Exports are estimated at 5% to 20% covering 22 different countries.

3.8.3.3 Regional distribution of value

Sea salt is extracted at only three sites: Porthkerris, Cornwall (Cornish Sea Salt Co.); Maldon, Essex (Maldon Crystal Salt Company) and Anglesey, Wales (Anglesey Sea Salt Company). These sites are indicated in Figure 3.32. Regional values cannot be presented as this would directly relate to individual companies who wished for details to remain confidential for commercial reasons.

3.8.3.4 Socio-economic pressures and impacts (positive and negative)

Two of the companies employ 8-9 people each in extraction and production. Water quality is vital to the industry. The main risks to water quality are oil spills and discharges. Concern has also been expressed about bulk ship-to-ship transfer of crude oils.

3.8.3.5 Environmental pressures and impacts (positive and negative)

The pressures on the marine environment related to sea salt extraction are considered to be similar to those for coastal defence (Section 3.2), waste disposal of seawater (Section 3.16) and water abstraction (Section 3.17). However, the impacts on the marine environment from these pressures are relatively benign, such that EIAs are sometimes not required. Where EIAs have been required there have been no objections to the plans. Some disturbance to marine habitats occurs as a result of new structures on the sea bed (e.g. pipelines, coastal defences). However, water is released with only a very slight decrease in salt concentration of 0.5%. At one of the sites, the outgoing seawater is returned to the sea through a rock fault line, ensuring that it is at ambient temperature. Salt water extraction is operational all year round.

3.8.3.6 Trends

Health concerns regarding salt intake are encouraging consumers to trade up to a quality sea salt from table salt. Mintel says that some 30% of households in Britain use sea salt and that sales into the retail sector are growing at about 8% per annum. Future growth is only limited by the size of the premium market.

Table 3.65. Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Mining & Quarrying: Sea salt extraction (SIC 08.93)	Support activities – e.g. construction	Manufacture of salt products	Agents involved in the sale of salt

3.8.3.7 Industry stability and forward look

Sea salt is extracted from natural seawater implying a high level of sustainability but this will be affected by local water quality and other abstractions in the area.

A licence is required from TCE to have a pipeline over the foreshore. Consents are generally not required for abstraction although they are required for the discharges (defined as trade effluent).

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the sea salt extraction industry will need to manage further its activities. For example, GES Descriptor 7 states that *...Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.9 Oil and Gas

3.9.1 Key points

- UK production of oil and gas, principally from the UK continental shelf (UKCS), was equal to nearly two thirds of UK primary energy demand in 2008 (94% of oil demand and 74% of gas demand)
- Indigenous oil and gas production is a major contributor in terms of Gross Value Added (GVA) accounting for £37 billion in 2008, up from £29 billion in 2007
- In 2008 the upstream oil and gas industry invested £4.8 billion in developments and £1.4 billion in exploration, and spent £6.8 billion on operations
- The extraction of oil and gas is supported by highly specialised 'supply chain' activities and also supports a large downstream manufacturing sector
- The value of oil and gas is driven by the sale price of oil and gas and the level of production. For example price per barrel of oil is strongly influenced by volatile energy markets due to a complicated range of supply and demand factors
- There are a number of additional socio-economic benefits from the sector including employment, taxes paid to the Exchequer, export business and energy security
- The majority of UK offshore oil and gas fields are located in the North Sea and Scotland is the largest region of related employment
- There are a number of environmental issues associated with oil and gas extraction, the most notable being the risk of oil spill, noise from exploration and production, historical oil based cutting piles, and inputs of production chemicals
- The extraction, processing and burning of oil and gas to provide energy is very energy intensive resulting in high levels of associated carbon dioxide (CO_2) emissions and concern over climate change impacts
- Decommissioning of offshore installations will be a significant activity over the next three decades

i. Introduction

Oil and gas remain the UK's principal sources of fuel and power, meeting more than 75% of demand in 2008. Production from the UKCS was equal to nearly two thirds of UK primary energy demand in 2008 (94% of oil demand and 74% of gas demand) and is projected to satisfy about half of the UK's oil and gas demand in 2020.

ii. How has the assessment been undertaken?

Information on the economic contributions from the industry is published by the Department of Energy and Climate change (DECC), with further interpretation by the Office for National Statistics (ONS) and by the main trade body, Oil & Gas UK. Information on the spatial distribution of pressures and licensing requirements was provided by DECC. Information on environmental impacts is mostly summarised in reports produced for Strategic Environmental Assessments (SEA) and the OSPAR Commission.

iii. Current status of the oil and gas sector and past trends

Indigenous oil and gas production is a major contributor in terms of GVA accounting for £37 billion in 2008, up from £29 billion in 2007. In 2008, the upstream oil and gas industry invested £4.8 billion in developments and £1.4 billion in exploration and appraisal, and spent £6.8 billion on operations. In 2008, nearly one billion barrels of oil equivalent were extracted from the UKCS, comprising: 72 million tonnes of oil and natural gas liquids (NGLs) and 68 billion cubic metres of gas.

The extraction of oil and gas is supported by highly specialised 'supply chain' activities and also supports a large downstream manufacturing sector (oil refining: net trade surplus £1 billion; petrochemicals: turnover £50 billion; trade surplus £5 billion) although these use a mix of UK and imported production. In 2008, there were 107 oil platforms, 181 gas platforms and 14 000 km of pipelines offshore, plus 9 crude oil refineries and 3 specialist refineries onshore.

There are a number of additional socio-economic benefits from the sector including employment, taxes paid to the Exchequer, export business and energy security. The majority of oil and gas fields on the UKCS are located in the North Sea (Regions 1 and 2) and as a consequence Scotland is the largest region of related employment in the UK. Relevant employment numbers include an estimated 34 000 in the extraction industry itself, 230 000 in supply chain activities and 214 00 in secondary petrochemical industries.

There are a number of environmental issues associated with oil and gas extraction, the most notable being the risk of oil spill, noise from exploration and production, historical oil-based cuttings piles, and inputs of production chemicals. Oil discharges in produced water have fallen and most oil spills are less than 1 tonne. The extraction, processing and burning of oil and gas to provide energy is very energy intensive resulting in high levels of associated CO_2 emissions and concern over climate change impacts.

iv. What is driving change?

The value of oil and gas is driven by the sale price of oil and gas and the level of production. For example, price per barrel of oil is strongly influenced by volatile energy markets owing to a complicated range of supply and demand factors. Total UK oil and gas production peaked in 1999 and has since been declining due to decreasing reserves.

v. What are the uncertainties?

There are some uncertainties relating to the value of ancillary and secondary activities within the industry although the activities themselves are well documented. The distribution of resources is fairly well understood although exploration activities continue in all areas with suitable geology.

vi. Forward look

The recovery of the UK's remaining oil and gas reserves will require additional investment, both in money and expertise. As the North Sea reserves mature, the UK will become increasingly dependent on imported energy, meeting about half of the UK's total annual gas demand by 2020. Around 500 individual structures (including platforms and tie backs) will be decommissioned over the next three decades.

3.9.2 Introduction

This section deals with the extraction of oil and gas in the sub-sea environment. This is a substantial marine sector that makes an important contribution to the UK economy. This section does not deal with the import/export of oil and gas although this is partly considered in Section 3.10 (Pipelines).

Oil and gas remain the UK's principal sources of fuel and power, meeting more than 75% of UK primary energy demand. Production from the UKCS satisfied about two thirds of primary energy demand in 2008 (94% of oil demand and 74% of gas demand; DECC, 2009e: Appendix 10) and is projected to satisfy about half of the UK's oil and gas demand in 2020 (HM Government, 2009b).

3.9.2.1 Description of economic activities

The extraction of oil and gas is supported by a number of highly specialised ancillary activities and also supports a large downstream manufacturing sector. Economic contributions from the industry are generally analysed and published by the Office of National Statistics according to the sectors indicated in Table 3.66. There is some production onshore but the great majority of indigenous oil and gas is extracted from the UKCS (over 98% of crude oil[18] and over 99% of gas[19] in 2008) and therefore sales figures of extracted oil and gas will largely relate to activities carried out in the marine environment. However, some of the ancillary and secondary activities relate to import and export activities and are not directly relevant to indigenous extraction. For example, some pipelines activities will relate to gas import facilities. This is presented separately in Section 3.10. The manufacturing processes to create usable products are secondary activities not directly related to the marine environment and their contribution to the UK economy is considered in Section 3.9.6.

3.9.2.2 Description of relevant ecosystem services

As well as economic services, the oil and gas sector also relies on various ecosystem services that support its productivity. Oil and gas resources are considered relict features, however the sector is dependent on the following: physical environment (provision of a stable physical environment in which to operate), and chemical cycling/water purification (to assimilate wastes).

3.9.2.3 Management

Regulation of UK oil and gas activities is carried out by the Energy Markets and Infrastructure Directorate within DECC, which was split from the then Department for Business, Enterprise and Regulatory Reform (BERR) in 2008. Prior to the establishment of BERR in 2007, oil and gas issues were dealt with by the Department for Trade and Industry.

The Petroleum Act 1998 vests all rights to the nation's petroleum resources in the Crown. However, the Secretary of State can grant licences that confer exclusive rights to … *search and bore for and get* … petroleum. Each of these licences confers such rights over a limited area and for a limited period. The licensing system is summarised on DECC's oil and gas website (www.og.decc.gov.uk/upstream/licensing/overview.htm) and covers oil and gas within Great Britain, its territorial sea and on the

18 Data on oil production from: https://www.og.decc.gov.uk/information/bb_updates/appendices/Appendix9.htm

19 Data on gross gas production from: https://www.og.decc.gov.uk/information/bb_updates/appendices/Appendix10.xls

Table 3.66 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Oil and Gas: Extraction of crude petroleum (SIC 06.10) and natural gas (SIC 06.20)	Support activities – e.g. exploration services and dismantling (SIC 09.10); Utility and pipeline construction (SIC 42.21) and operation (SIC 49.50)	Manufacture of refined petroleum products (SIC 19.20); and industrial gases (SIC 20.11)	Sale of oil and gas (SIC 46.12, 46.71)

UKCS. Northern Ireland's offshore waters are subject to the same licensing system as the rest of the UKCS.

Each licence carries an annual charge, called a rental. Rentals are charged at an escalating rate on each square kilometre that the licence covers at that date. Seaward Production Licences for the offshore region are valid for a sequence of periods, called Terms. There are three Terms designed to follow the typical lifecycle of a field: exploration, appraisal, production. In the 25th Seaward Licensing Round in November 2008, 171 Seaward Production Licences were offered.

A number of licence-related activities require individual approval, often (but not always) from DECC with advice from other government departments such as the Department for Environment, Food and Rural Affairs (Defra) and statutory nature conservation agencies such as the Joint Nature Conservation Committee (JNCC). See Section 3.9.7 for more details on environmental legislation applicable to the oil and gas industry.

The upstream or E&P aspects of the oil and gas industry in the UK is represented by the industry association Oil & Gas UK (previously known as the UK Offshore Operators Association – UKOOA). The association is a well-connected working group representing a wide range of business sizes and experiences.

3.9.3 Direct use value

3.9.3.1 Principal activities

In 2008, oil and gas resources met, respectively, 36% and 40% of the UK's primary energy demand[20], and 84% of this oil and gas came from UK fields, almost all of which (in terms of extraction) are offshore. One billion barrels of oil equivalent (boe) of oil and gas were recovered from the UKCS in 2008 which brings the total amount produced during the past 40 years to 38 billion boe. This comprised 72 million tonnes of oil and NGLs and 68 billion cubic metres of gas.[21] In 2008, the UK ranked globally as follows: 18th in oil production, 11th in oil production, and 14th overall for oil and gas production combined.

Over 160 companies are currently licensed to explore for and/or produce oil and gas from the UKCS. Of these, around 70 companies have production interests with the remaining companies concentrating on exploration (Oil & Gas UK, 2009). At the end of 2008 there were

20 Total demand for electricity heating, fuel etc. Other sources of power include coal, nuclear and renewables.

21 These figures are net of the producers' own energy use.

383 producing fields offshore, including 17 new fields which started production in 2008 (Oil & Gas UK, 2009).

In 2008, the total income was £39 733 million, which included oil sales at £25 102 million, gas sales at £10 612 million, NGL sales at £2204 and other income including revenues from pipelines and terminals of £1816 million (DECC, 2009f[22]). The Annual Business Inquiry (ABI - ONS, 2009b) gives a GVA of £36 814 million for 2008, a significant increase from £29 billion GVA reported for 2007 (ONS, 2009a).

The value of oil and gas is driven by the sale price of oil and gas and the level of production. For example, price per barrel of oil is strongly influenced by volatile energy markets owing to a complicated range of supply and demand factors.

In 2008, the upstream oil and gas industry invested £4.8 billion in developments and £1.4 billion in exploration and appraisal and spent £6.8 billion in operations, making a total expenditure for the year of £13 billion.

3.9.3.2 Ancillary activities

There is significant activity and value within the supply chain.

Developments

The infrastructure in operation in 2008 (Oil & Gas UK, 2009) to recover and deliver oil and gas from the UKCS involved: 107 oil platforms (18 of which are Floating Production Storage and Offloading platforms; FPSOs); 181 gas platforms (some 'oil' platforms are also significant producers of gas); and a total pipeline network of nearly 14 000 km.

Exploration

Of the 160 companies currently licensed to explore for and/or produce oil and gas from the UKCS, 90 are focussed on exploration.

Supply chain

In addition to exploration and production, there are thousands of companies which constitute the supply chain and provide the industry with goods and services which are essential for its operations (Oil & Gas UK, 2009). Activities relevant to the supply chain have been described by Oil & Gas UK (2008) and include:

- seismic data acquisition, evaluation and management of reservoirs
- drilling and completion of wells
- design, procurement, construction, operation, maintenance and decommissioning of facilities – both onshore and offshore
- marine/subsea engineering, pipeline construction and operations, diving and marine logistics
- Support and services for E&P business including asset management, corporate finance and banking, legal and insurance services.

Supply chain exports (e.g. of technical capability and services) are increasing rapidly and at £4 to 5 billion per year now represent about a quarter of total exports of goods and services by the UK's energy industries sector. However, although the supply chain industry in the UK is a global leader in offshore and subsea engineering, it is still highly reliant on domestic business to provide the foundations for its international success.

22 https://www.og.decc.gov.uk/information/bb_updates/appendices/UKCS_I_and_E_Annual.pdf

Owing to the extensiveness and complexity of the supply chain, it is difficult to quantify the total number of active companies. First Point Assessment (FPAL) has more than 2400 companies registered on its UK database, most of which directly contract with E&P companies and their leading contractors. It is certain that this only represents a modest proportion of the total number of businesses within the overall supply chain which is estimated to extend to 5000 to 10 000 companies (Oil & Gas UK, 2008).

UK Trade & Investment (UK-TI) recognises the value of the global supply chain market and the importance to the UK's economy of winning a significant share of this. A marketing strategy was therefore developed for the UK's energy businesses and released in December 2007 (UK Trade and Investment, 2007).

3.9.3.3 Secondary activities

According to information sourced from the UK Petroleum Industry Association (UKPIA), the UK downstream oil sector comprises over 200 companies involved in the refining, distribution and marketing of petroleum products. The key refining companies include BP Oil UK, Chevron, ConocoPhillips, Esso Petroleum, Ineos Refining, Murco Petroleum, Petroplus, Shell UK and Total UK.

The type of crude oil processed influences the type of products that a refinery can produce. Oils refined in the UK are predominately from the North Sea, mainly Norway (about 70% of the total). This local source results in the production of high quality, low sulphur road fuels that modern vehicles require in order to deliver low exhaust emissions. Typically, a barrel of North Sea crude oil will yield approximately 3% LPG (liquefied petroleum gas), 37% petrol, 25% diesel, 20% kerosene (jet fuel/heating oil) and 12% fuel oil (heavy residue for power generation).

The oil refining industry has a net trade surplus of around £1 billion per year on the import and export of oil products. The UK petrochemicals industry has a turnover of £50 billion, employs 214 000 people and has a trade surplus of £5 billion.

3.9.4 Regional distribution of value

Figure 3.36 illustrates the distribution of offshore hydrocarbon fields according to whether they are in development, producing or have ceased production. The figure also illustrates the location of the UK's oil refineries. Figure 3.37 illustrates the surface and sub-surface installations that support the extraction of oil and gas such as well heads and oil rigs. Table 3.67 reports the spatial extent of producing offshore hydrocarbon fields and indicates that economic value is highest in Regions 1 and 2.

According to Experian Business Strategies, the regional distribution of employment within the oil and gas sector reveals distinct clusters (see Section 3.9.6). The largest area of employment is in Scotland where four parliamentary constituencies in Aberdeenshire are estimated to account for 39% of total employment supported by the oil and gas industry. Other regions with sizable employment are Eastern England (5%), North-West England (6%), and London and the South-East (21%).

The oil industry operates nine crude oil refineries and three specialist refineries within the UK. Most are historically located close to offshore oil reserves and/or ports to minimise transport and logistical costs.

Figure 3.36 Distribution of oil refineries and offshore hydrocarbon fields.

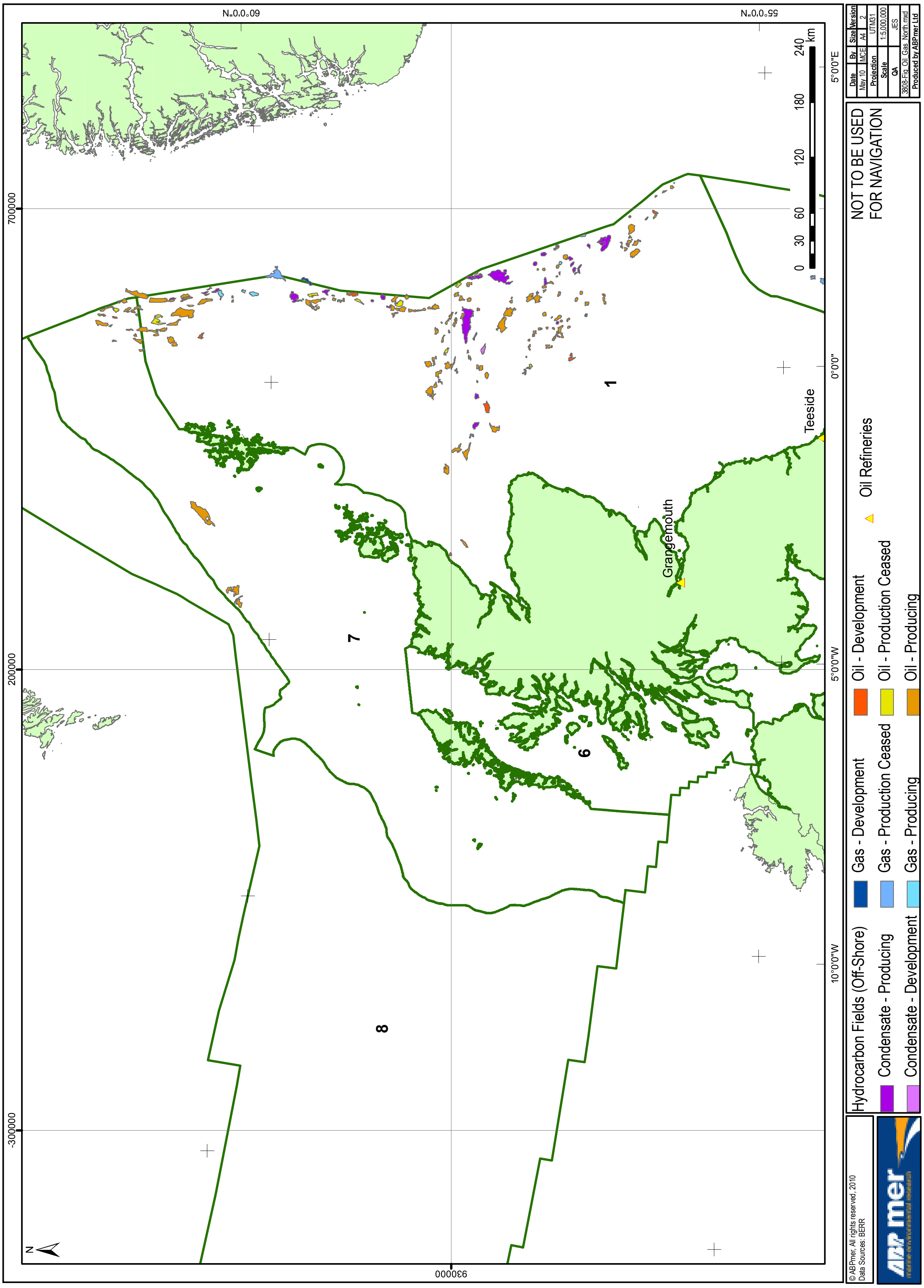


Figure 3.36 continued

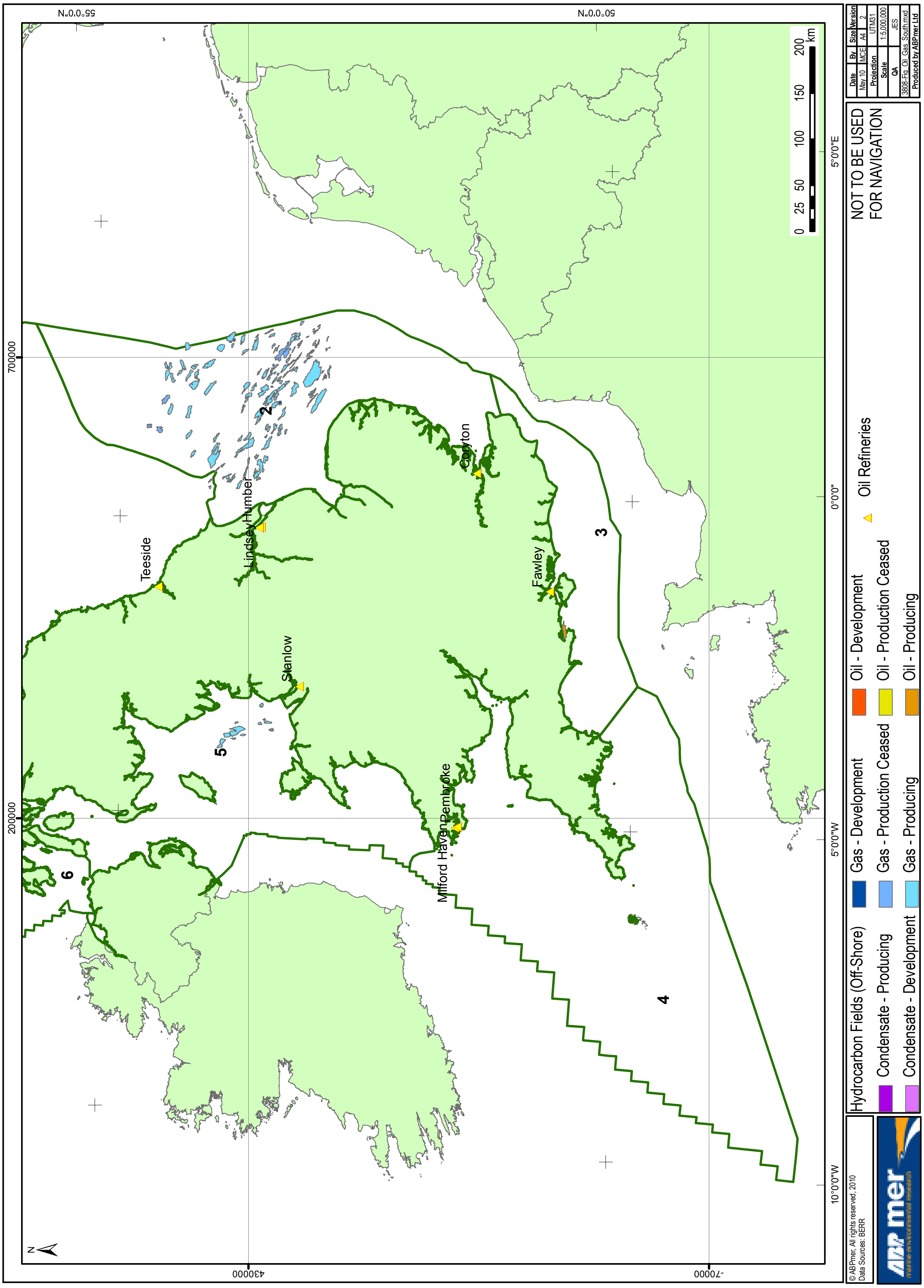


Figure 3.37 Distribution of surface and sub-surface installations that support the extraction of oil and gas.

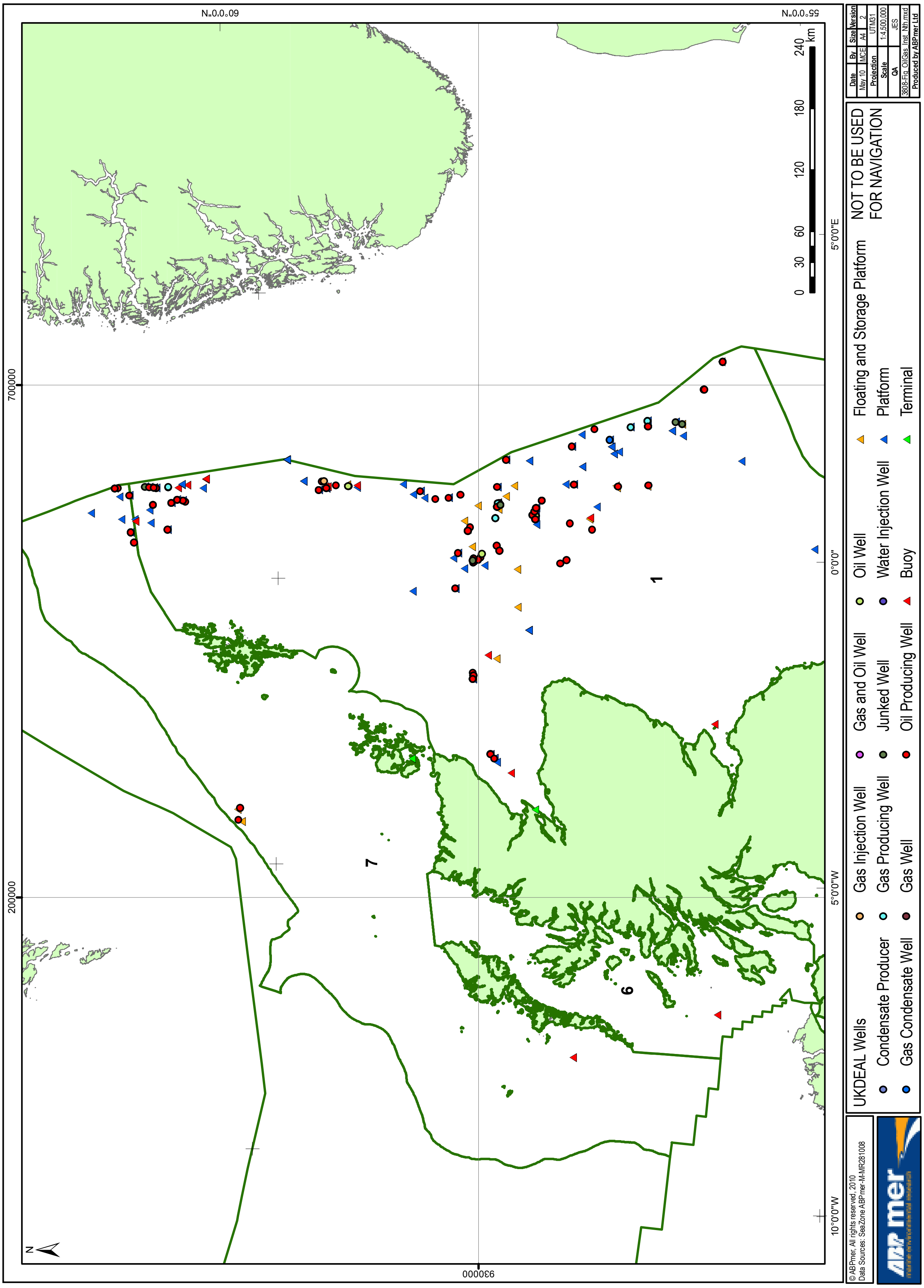


Figure 3.37 continued

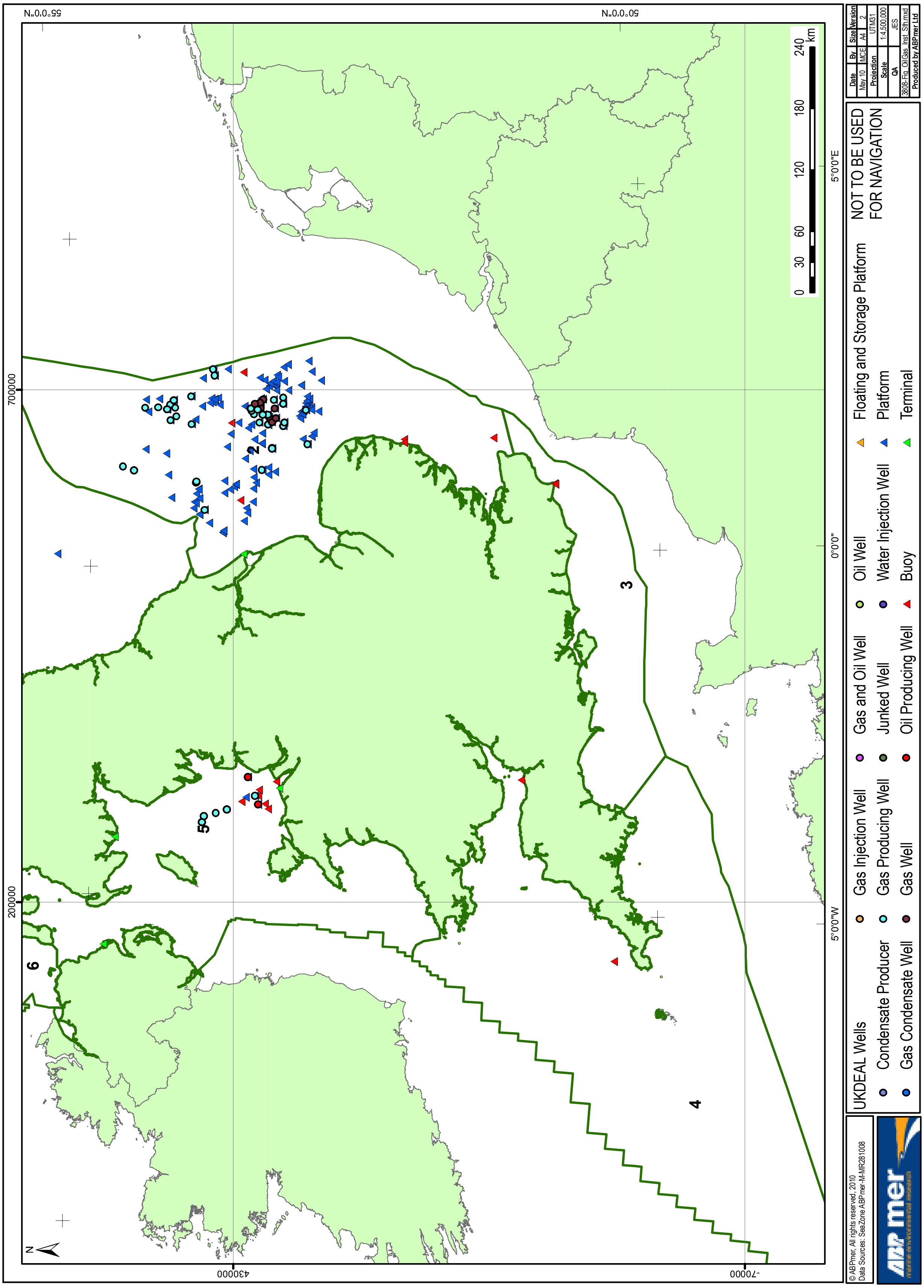


Table 3.67 The spatial extent and value of producing offshore hydrocarbon fields among the CP2 Regions.

CP2 Region	*Condensate, km^2*	*%*	*Gas, km^2*	*%*	*Oil, km^2*	*%*	*Value £ millions*
1	1047	100	118	4	2214	80.6	19000
2	0	0	2626	89	0	0	14200
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	214	7	4	0.1	1100
6	0	0	0	0	0	0	0
7	0	0	0	0	530	19.3	2700
8	0	0	0	0	0	0	0
Total	**1047**	**100**	**2957**	**100**	**2748**	**100**	**37000**

3.9.5 Trends

Production of oil and gas from the UKCS increased steadily from the 1970s to June 1980 when Britain became a net exporter of oil (compare imports and exports in Figure 3.38). Production peaked in the mid-1980s and then experienced a dramatic decline following the *Piper Alpha* disaster in 1988. In the 1990s crude oil recovered, peaking again in 1999. Gas production has steadily increased since the 1980s peaking in 2000 due to increasing demand for gas for power generation (Figure 3.39). Production of crude oil and gas has since declined due to decreasing levels of reserves. Around 2004, the UK again became a net importer of oil and gas (Figures 3.38 and 3.39).

Trends in expenditure on oil and gas activity illustrate the early investments in the 1970s and 1990s that led to peaks in production in the mid-1980s and late 1990s (Figure 3.40). Investment has increased again since 2004 due to increased operating costs and developments of new fields. This includes expenditure of more than £1 billion per year to extend the life of many of the existing offshore assets. This investment is necessary to keep assets operating for decades longer than originally envisaged to realise the full potential of oil and gas reserves (Oil & Gas UK, 2008).

Despite decreasing reserves as a result of extraction, the value of reserves has generally risen since 1994, with increases in the price of oil being particularly significant (see Section 3.9.9.2 for more information on the valuation of reserves). Since 2002, there has also been an increase in average gas prices (ONS, 2009a).

3.9.6 Socio-economic pressures and impacts (positive and negative)

3.9.6.1 Positive

Oil & Gas UK (2009) noted the following direct and indirect social and economic benefits from the industry: employment of 264 000; taxes of £12.9 billion in the 2008-09 fiscal year; supply chain benefits (see Section 3.9.2) – the expertise of the UK's supply chain is well established internationally; improved UK energy security from the use of indigenous resources; and improved balance of trade to the value of £40 billion.

Figure 3.38 Trends in the indigenous production, imports and exports of Crude oil 1970-2008 (Source: DECC, 2009b).

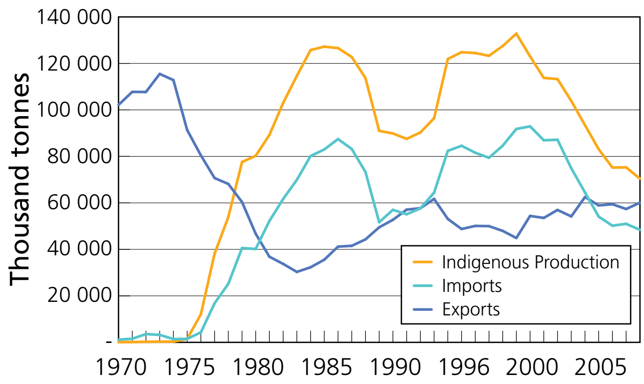
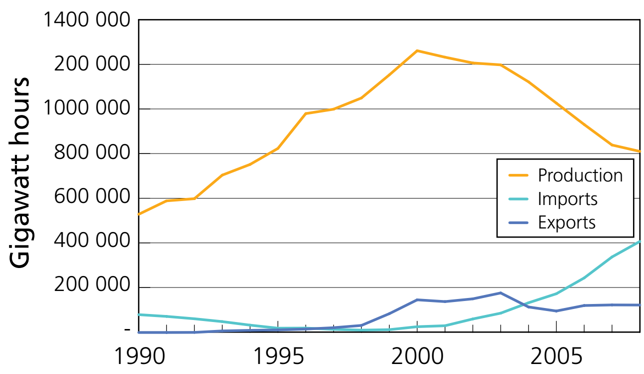


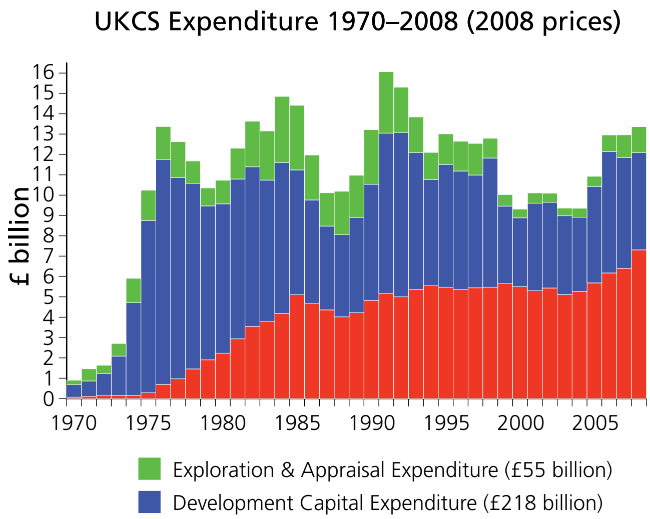
Figure 3.39 Trends in the production, imports and exports of Gas 1970-2008 (Source: DECC, 2009b).



Employment

In 2007, it was estimated that the industry provided 34 000 jobs, employed directly by oil and gas companies and their major contractors, and 230 000 jobs within the wider supply chain. In addition, it is estimated that 100 000 people are employed in export activities by supply chain companies but these may not be directly related to domestic production. It is uncertain how many of these jobs are full or part time. There is a wide diversity of jobs across the industry as a whole including administration,

Figure 3.40 Trends in UKCS expenditure on oil and gas activity 1970-2008 at 2008 prices. (Source: DECC, 2009b).



financial and legal services, design, engineering, environmental and geo-sciences, health and safety, IT, management, operations, sales and marketing (www.oilcareers.com/worldwide/).

Taxes

The Exchequer benefited by £12.9 billion in oil and gas taxes for the 2008-09 fiscal year; an increase from £7.8 billion in the 2007-08 fiscal year. These amounts include corporation tax, the supplementary charge and petroleum revenue tax. Projections vary depending on future oil prices in which case potential revenues will also change. For 2009-10 (as at April 2009 forecast) the projection is for £6.9 billion from oil and gas production across the entire UKCS[23]. This is an expected decrease given the current economic climate. The high level of taxes for 2008/09 was due to the high oil prices in that year. Oil price forecast for the next four years is expected to average about £6 billion.

23 https://www.og.decc.gov.uk/information/bb_updates/appendices/Appendix8.htm

Exporting

Export business is being won in a variety of areas, such as: subsea engineering where the UK is recognised as a world leader; high pressure, high temperature (HPHT) field developments; oil and gas process machinery, equipment and technology; deep water oil and gas developments; design, project management and delivery of new field developments; integrated services for the operation and maintenance of fields; late life operation of mature fields; light weight, slim line structures; economic and technology led consultancy services; legal, financial and insurance services; and health, safety and environmental expertise.

Balance of trade

Use of indigenous resources benefits the balance of trade in goods and services (i.e. the difference between exports and imports). The UK was in overall deficit by £44 billion in 2008. If the UK had had to import oil and gas in 2008 instead of exploiting local reserves, Oil & Gas UK (2009) estimated that this figure would have increased to around £84 billion.

Research

Exploration and survey activities by the oil and gas industry have contributed to the understanding of the marine environment. For example, project surveys provide opportunities to obtain new or improved archaeological data. In addition, industry has historically funded the majority of offshore seabird surveys in UK waters and much of what is known about the distribution of seabirds and marine mammals was obtained through industry funding. Some of the offshore sites currently being considered as Special Areas of Conservation (SACs) were originally located and mapped by the oil and gas industry (e.g. Saturn Reef and Darwin Mounds) and through DECC's extensive programme of Strategic Environmental Assessment (SEA) work. Nature conservation agencies have been able to make use of data obtained by the industry and DECC in order to describe qualifying features for SACs. In particular, surveys under the Atlantic Frontier Environmental Network (AFEN) covered an area of 30 000 km^2 and contributed a huge amount of new information both geological and biological on the Atlantic Margin.

3.9.6.2 Negative

There may be some impacts from the presence of sub-sea structures on other marine activities, including the development of other marine infrastructure and fisheries. Oil and gas activities also have the potential to impact on the seabed and its associated features, in particular through the trenching of cables and pipelines into the seabed and through rig and other vessel anchoring. However, some of these potential impacts are addressed through the licensing system. The licences require the appointment of a Fisheries Liaison Officer and the removal of debris resulting from activities carried out under the licence. The need to safeguard navigation requires an assessment of potential impacts on important shipping routes and consultation with the Maritime and Coastguard Agency (MCA). There may also be block-specific concerns in relation to Ministry of Defence (MOD) activities that may influence the approval and conditions of a licence. In addition, a legal and policy framework for protection of maritime archaeology is in place and is addressed in the Environmental Statement.

3.9.7 Environmental pressures and impacts (positive and negative)

The main stages of oil and gas activity (including natural gas storage) are:

- Exploration, including seismic survey and exploration drilling
- Development, including production facility installation, generally with construction of an export pipeline, and the drilling of producer and injector wells
- Production/operation, with routine supply, return of wastes to shore, power generation, chemical use, produced water, and re-injection of reservoirs
- Monitoring
- Maintenance
- Decommissioning, including cleaning and removal of facilities.

The activities within each stage and potential effects have been described and illustrated by DTI (2001). All stages of the exploration, development, production and decommissioning life cycle are subject to Environmental Impact Assessments (EIAs) and all discharges and emissions are subject to permit. Legislation includes:

- Strategic Environmental Assessment (The Environmental Assessment of Plans and Programmes Regulations 2004 SI 2004/1633). DECC has engaged in SEA work since 1999, preceding the implementation of the SEA Directive. Extensive seabed surveys have been carried out and much information collected. Details can be seen at the offshore SEA website (www.offshore-sea.org.uk).
- SEAs are carried out in advance of licence rounds.
- Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (as amended) (SI 1999/360) – application of the EU Environmental Assessment Directive to certain categories of offshore oil and gas activities. The Regulations require DECC to make an assessment of environmental impact before deciding whether to authorise various offshore activities, including the drilling of wells, the installation of pipelines and most categories of field development. If a significant environmental impact is likely a full EIA must be carried out, including the submission of an Environmental Statement. For certain developments (where production is more than 500 tonnes of oil per day or more than 500 000 m^3 of gas per day or for pipelines greater than 40 km in length and with a diameter greater than 800 mm) an EIA is mandatory.
- Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (SI 2001/1754) and amendments (2007) – application of the EU Habitats and Birds Directives to all oil and gas activities on the UKCS. Under the Regulations, DECC is required to take account of the potential impact of offshore oil and gas activities on listed habitats and species, which may be protected by 'relevant sites' or given more general protection in UKCS waters. As a result, some survey consents, well consents, and pipeline and development consents, must be supported by an environmental case (a stand-alone environmental narrative or a section in a formal Environmental Statement) to demonstrate that the proposed operations are unlikely to have a significant adverse effect on important habitats or species, or the conservation objectives of any potential or existing 'relevant site'.

- Under the Offshore Chemicals Regulations (OCR) 2002 (SI 2002/1355) all use and discharge of offshore chemicals (including drilling fluids) require a permit. This covers activities such as oil and gas production operations, drilling of wells, discharges from pipelines and discharges during decommissioning activities.
- The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (OPPC) prohibits the discharge of oil to sea other than in accordance with the terms and conditions of a permit. Operators of offshore installations must identify all planned oil discharges to relevant waters and apply for the appropriate OPPC permits.
- The Offshore Combustion Installations (Prevention and Control of Pollution) Regulations 2001 – Where power generation equipment on offshore facilities exceeds 50 MW(th) operators must justify that it is operated in accordance with the principles of BAT (best available techniques).
- Food and Environment Protection Act 1985, Part II Deposits in the Sea (as amended) – Deposits of materials on or under the sea bed must be licensed.
- Coast Protection Act 1949 – Offshore oil and gas installations may be located only with prior written consent.
- The Merchant Shipping (Oil Pollution, Preparedness, Response and Co-operation Convention) Regulations 1998 (SI 1998/1056). All spillages of oil to sea must be reported via a PON1. All installations, including pipelines, must have an Oil Pollution Emergency Plan (OPEP) detailing the procedures to be followed in the event of a spill.
- The Offshore Installations (Emergency Pollution Control) Regulations 2002 put in place the powers of intervention conferred on the Secretary of States Representative for Maritime Salvage and Intervention (SOSREP) in the event of an accident with the potential for significant pollution.
- The Greenhouse Gas Emissions Trading Scheme Regulations 2005 – These are relevant to all offshore platforms where the power generation equipment exceeds 20 MW(th).

A full list of permits and current applications is available at: www.og.decc.gov.uk/environment/environ_leg_index.htm

A series of Petroleum Operations Notices (PON) detail requirements and standards for particular activities under the regulations cited above. For example, for all project consents covered by the Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999, a new formal document (– the Application for Consent (Petroleum Operations Notice 16)) is required, regardless of whether an Environmental Statement is required. In granting licences and establishing licence conditions, DECC may engage in consultation with any relevant authority including: Cefas (the Centre for Environment, Fisheries and Aquaculture Science – an agency of Defra), for operations to be carried out in English or Welsh waters; Marine Scotland Science, for operations to be carried out in Scottish waters; the Northern Ireland Environment Agency, for operations in Northern Irish waters; JNCC, or coastal conservation bodies such as Natural England, Countryside Council for Wales and Scottish Natural Heritage; any organisation which the fisheries liaison officer consults in accordance with Clause F1 to the Licence; and

those local authorities with responsibility for the coastline adjacent to the location of the proposed activity.

The UK is also a signatory to the Bonn Agreement for the prevention and remedy of maritime pollution in the North Sea, the English Channel, the waters around Ireland and parts of the Western Approaches.

The potential impacts arising from oil and gas activities have been reviewed by DECC (2009d) and OSPAR (2004a). A summary of the potential impacts arising from oil and gas activities is given in Table 3.68. The ecosystem services that the pressures impact upon and the relative significance of these impacts are identified in Table 3.69.

3.9.8 Climate change

3.9.8.1 Impacts of climate change on the oil and gas industry

The offshore oil and gas industry could be vulnerable to both changes in sea level and increases in waves and winds, leading to greater stresses on oil and gas structures in the marine environment (Rees, 2008). Changes to currents could result in changes to scour around the legs and supports of offshore installations (Rees, 2008). Changes in storminess could also affect air and sea access to offshore installations and pose operational issues in terms of health and safety. There is no published evidence that discusses the effect on operations that could be expected with climate change.

Adaptation measures

There is no published evidence to suggest that the offshore industries currently have to adapt to climate change. The design and operation of offshore structures in the UK is based on comprehensive records of metocean data used to calculate extreme wave, wind and water level events. Although the use of historic data provides an indication of the statistical probability of a past event reoccurring, it will become important to take into account projected future changes to water level, winds and waves as these will impact on the future design of offshore installations. In the future it may become necessary to make offshore structures more robust to deal with likely climate change impacts.

The expected life span of an offshore structure is 20 years (Rees, 2008) but many of the platforms on the UKCS are older than this. Life expectancy of developments is also dependent on the exploitable reserves of fossil fuels in UK waters.

3.9.8.2 Impacts of the oil and gas industry on climate change

Large amounts of energy are required to extract oil and gas, and to process, transform and transport the products to the final user. Oil refining is the most energy intensive process in the supply of fuel from source to consumer. As the refining process is not directly relevant to the marine oil and gas industry the energy uses are confined to the extraction and operational process and include the following (IPIECA, 2007):

- Driving pumps to extract hydrocarbons and to re-inject water
- Heating the output stream to allow separation of the oil, gas and water
- Producing steam and re-injecting gas for enhanced oil recovery
- Powering compressors and pumps for transporting oil and gas through pipelines

Table 3.68 Key pressures and impacts associated with oil and gas extraction – construction, operation and decommissioning. Main sources: Gerrard et al. (1999); Grant and Briggs (2002); UKOOA (2002); Simmonds et al. (2003); OSPAR (2004a); Eastwood et al. (2007); Nowacek et al. (2007); Weilgart (2007); Southall et al. (2007); SMRU (2007); JNCC (2008a); DECC (2009d).

Pressure	**Noise from seismic exploration activities**
Impact	Potential impacts on noise sensitive species such as cetaceans and some fish species.
Description of environmental change (intensity, spatial extent, frequency, duration)	Mostly pre-construction stage although some activities, such as vertical seismic profiling, take place post construction. Noise sources are described as impulsive and the seismic exploration activity is transient (days to weeks) (Simmonds et al., 2003). Characterisation of noise sources from seismic surveys and their impacts on noise sensitive species has been reviewed recently (Nowacek et al, 2007; Weilgart, 2007; Southall et al., 2007; SMRU, 2007) but conclusions remain complicated due the large number of factors involved and the difficulties in measuring behavioural criteria. The spatial extent of the environmental change is largely a reflection of levels of acoustic propagation and transmission loss. Injury to cetaceans may occur within 5.6 to 10 m of the seismic activity (depending on water depth) (DECC, 2009d: table 5.1). Behavioural responses (e.g. avoidance) may occur within 11.2 to 25.1 m of the seismic activity. Frequency of impact may be estimated from the number of exploration activities planned. There were just under 50 2D and 3D surveys in 2006 consisting of about 1000 and 10 000 individual shots respectively (DECC, 2009d). Similar levels of activity are expected in the future (subject to market uncertainties).
Existing management measures	In support of the legislation listed in Section 3.9.7, JNCC (2004) has produced guidelines for minimising acoustic disturbance to marine mammals from seismic surveys. JNCC also reviews PON14s: applications for consent and notification of intention to carry out oil and gas surveys and shallow drilling. Guidance notes for the PON 14 documents are currently being amended. Scottish Natural Heritage intends to produce separate guidance on cetaceans as European Protected Species for Scottish territorial waters. The guidelines require visual monitoring of the area by a dedicated Marine Mammal Observer (MMO) prior to seismic testing to determine if cetaceans are in the vicinity, and slow-start procedures to enable animals to move away from the source. Passive Acoustic Monitoring (PAM) may also be required. In the UK, surveying is not normally permitted at times when certain fish (particularly herring) are spawning. The National Oceanic and Atmospheric Administration also published noise threshold values based on military sonar activities (NOAA, 2006).

Pressure	**Noise (semi-continuous or continuous) from turbines, drilling rigs, production facilities or vessels**
Impact	Potential impacts on noise sensitive species such as cetaceans and some fish species (construction, operation and decommissioning).
Description of environmental change (intensity, spatial extent, frequency, duration)	Noise is generated during all phases of oil and gas production. The sources may be continuous or impulsive and can be described as being transient (weeks) for construction and decommissioning activities (e.g. drilling) or permanent (over years) for operational activities. Although there are few published data, operational noise is likely to comprise low frequency tonal noise from rotating machinery (<1 kHz), qualitatively similar to that from ships. The compression required for gas export may be a significant source of noise, but propagation into the water column will be limited. Non-explosive cutting technology produces relatively little noise production (JNCC, 2008a). For activities that make use of explosions for a relatively short period of time, it is considered that there would be a low likelihood of disturbance occurring that would constitute an offence if suitable mitigation was in place.
Existing management measures	There are no good practice guidelines in the UK for drilling activities since these are thought to be of low concern in terms of disturbance to cetaceans (JNCC, 2008a). However, JNCC has produced draft guidelines for minimising acoustic disturbance to marine mammals from explosive use. Non-explosive cutting technology produces relatively little noise production (JNCC, 2008a). Measures for the use of explosives may be similar to those employed for seismic activities, for example, MMOs, soft start and PAM.

Pressure	**Oil contamination from accidental spills**
Impact	Oil spills may contaminate sediments, water and marine fauna potentially resulting in significant effects and indirect impacts on food chains (DECC, 2009d).
Description of environmental change (intensity, spatial extent, frequency, duration)	The risks of large oil spills resulting from E&P are associated with potentially major incidents on production platforms, export (pipeline and tanker loading sources), with the additional potential for loss of well control and subsequent oil blowout. The historical frequency of such events in the UK and Norwegian continental shelves has been very low (DECC, 2009d). The MCA publishes, via the Advisory Committee on Protection of the Sea (ACOPS), an annual survey of reported discharges attributed to offshore oil and gas installations operating in the United Kingdom Pollution Control Zone (UKPCZ – roughly equivalent to the entire CP2 reporting area). The latest survey reported that during 2007 there were 280 reported mineral oil pollution incidents from offshore oil and gas installations (ACOPS, 2008). The 2007 annual total was the same number as the mean annual total recorded between 2000 and 2006. Most spills are less than 1 tonne. The majority of both oil and chemical spills in 2007 (from a total of 462) were in Regions 1 and 2, with five incidents in the Irish Sea (Region 5) and 29 in northern Scotland (Region 7).
Existing management measures	An approved OPEP is required for all installations. This sets out what to do in case of an accidental release of oil. OPPC & OCR legislation make provisions for preventing pollution occurring. Effective Environmental Management Systems required by all operators reduce the risk of an accidental release. Under the Bonn Agreement, and funded by DECC and MCA, aerial surveillance is undertaken across UK waters. All reported oil pollution incidents are reviewed by DECC and inspections and investigations of installations are carried out. Powers are available to take enforcement action where required.

Pressure	**Introduction of non-synthetic substances and compounds**
Impact	Pollution and other chemical changes.
Description of environmental change (intensity, spatial extent, frequency, duration)	After 30 years of discharges, the spatial extent of cuttings piles appears to be reducing (OSPAR, 2010). The total area of the North Sea seabed resulting in biological disturbance due to cuttings piles has been estimated at 1605 km^2 or 0.23% of the total area (UKOOA, 2002). A report produced for the OSPAR Commission on the extent of potentially damaging cutting piles i.e. those contaminated with oil-based mud (OBM), on the UKCS identified a total of 175 potentially contaminated fields where more than one well had been drilled using OBM. It was estimated that there was a total area of 1.2 km^2 of contaminated seabed in the UKCS. Cuttings piles have not accumulated around installations in the southern North Sea, where the stronger ocean currents and wave action have rapidly dispersed them, in addition to enhancing the natural breakdown of any trace hydrocarbons (UKOOA, 2002). Therefore, 0.4% is likely to be a large overestimate for England and Wales. For platforms that historically used oil-based drilling muds, the area adversely affected could extend up to 5 km from the central platform although the majority of areas impacted are much smaller. By contrast, studies at platforms using more recent water-based drilling muds have found no adverse effects. More specifically, research on the Dutch Continental Shelf estimated the area within which biological effects occur to be 1.5 to 11 km^2. Strong effects occurred within an area of 0.1 to 1 km^2. The area within which biological impacts occur has decreased by 90% to 95% since the discharges of OBM contaminated cuttings was banned. The cumulative impact for all North Sea cuttings piles is small compared with other inputs to the North Sea, e.g., annual input of hydrocarbons from all piles at 330 Te (differential emission measure) to the water column in the North Sea equates to 0.5% of that from other sources at around 65 000 Te.

Existing management measures	Drill cuttings are separated from the drilling mud (which is reused) and either discharged to the seabed, re-injected into a well or taken ashore for treatment and disposal. Regulations effectively banned the release of untreated OBM in 1996, supported by further OSPAR Regulations in 2000 for oil-based cuttings. The focus now is managing the historic/legacy piles. Acting on an OSPAR Recommendation (2006/5) oil companies have been required to assess the rate of leakage of oil from each pile to ensure it is not significant (i.e. >10 Te/yr). The assessments also checked the long-term persistence of piles. No piles have been found to exceed the OSPAR thresholds and decisions on their management (e.g. covering, retrieval, natural degradation) and monitoring will be made when the associated installation is decommissioned.

Pressure	**Introduction of non-synthetic substances and compounds**
Impact	Increase in naturally occurring radioactive material (NORM).
Description of environmental change (intensity, spatial extent, frequency, duration)	NORM scale must be periodically removed from certain equipment. Most scale arising offshore is discharged to sea. Land-based operations are undertaken in Aberdeen but SEPA has ruled that the operation of discharging scale to sea from this site must cease by October 2011.
Existing management measures	A NORM Management Plan has been produced by the International Association of Oil and Gas Producers (OGP, 2008) which seeks to establish long term sustainable disposal routes and stop the release of NORM into the nearshore marine environment.

Pressure	**Chemical contamination from accidental spills**
Impact	Pollution and other chemical changes.
Description of environmental change (intensity, spatial extent, frequency, duration)	Accidental discharges are reported through ACOPS. The total number of non-mineral oil discharge incidents reported for 2007 was 182. The largest loss of chemical reported in 2007 was 157 tonnes of sodium bicarbonate. There has been a marked increase in the total number of non-mineral oil spills attributed to offshore oil and gas installations since 2003 but may be related to a change in the reporting requirements for discharges of this nature.
Existing management measures	All reported chemical pollution incidents are reviewed by DECC and inspections and investigations of installations are carried out. Powers are available to take enforcement action where required.

Pressure	**Chemical contamination (routine) from exploration and production operations**
Impact	Pollution and other chemical changes
Description of environmental change (intensity, spatial extent, frequency, duration)	Routine discharges have been listed by DECC (2009a) and may include discharges of chemicals used throughout the exploration and production process. In addition to these mainly platform-derived discharges, a range of discharges are associated with operation of subsea infrastructure (hydraulic fluids), pipeline testing and commissioning (treated seawater). Biocides and corrosion inhibitors are widely used in the industry to maintain and protect pipelines and structures. However, their effectiveness and therefore their potential impact on the environment is reduced once they have been used. As installations near the end of their lifetime they will produce more water which may be re-injected or discharged.
Existing management measures	Under the Offshore Chemicals Regulations all operational chemicals must be certified, assessed and approved before use and/or discharge offshore. A permit application is made before any chemical can be used and/or discharged and an assessment is made to ensure any discharge will not give rise to any significant effect on the environment.

Pressure	**Oil contamination (routine) from exploration and production operations**
Impact	Pollution with oil.
Description of environmental change (intensity, spatial extent, frequency, duration)	Routine planned exploration and production operations and activities may give rise to discharges that are contaminated with oil, for example oil in produced water. However, concentrations of produced water are highly regulated, low (ca. 20 mg/l) and continue to decline. Operational waste streams are treated to ensure that discharge of oil to sea is minimised.
Existing management measures	Under the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 no planned operational discharge of oil can take place unless it is in accordance with the terms and conditions of an approved permit. A permit application is made before any oil can be discharged and an assessment is made to ensure any discharge will not give rise to any significant effect on the environment. From 1 January 2006 oil in produced water must not exceed a concentration of 30 mg/l as a monthly flow-weighted average. Discharges of oil in produced water have reduced by about 40% from 4968 tonnes in 2005 to 2960 in 2007 and the average industry oil concentration has reduced from 21.1 to 14.6 mg/l over the same period[1]. These levels are half that required under international requirements and domestic environmental legislation and reflect improvements in produced water management.

[1] https://www.og.decc.gov.uk/information/bb_updates/chapters/Table3_2.htm

Pressure	**Smothering**
Impact	Physical loss from construction and decommissioning activities.
Description of environmental change (intensity, spatial extent, frequency, duration)	Pile and drill cuttings have accumulated beneath drilling installations in the central and northern areas of the North Sea, in the UK and Norwegian sectors due to the deep water and weak currents; there are none in the southern North Sea, where there are stronger ocean currents and wave action. Cuttings contaminated with OBM that were historically discharged have in places accumulated into piles with top layers that prevent oxygen and other seawater constituents from penetrating them. This does not occur now with water-based mud discharges. Field studies have shown that, for the majority of North Sea installations, biological communities are largely unaffected beyond a 500-m radius and that the area impacted by contaminated cuttings is reducing (Kingston et al., 1987).
Existing management measures	See management measures for drill cuttings.

Pressure	**Siltation rate changes**
Impact	Physical damage from construction and decommissioning activities.
Description of environmental change (intensity, spatial extent, frequency, duration)	Activities contributing to these pressures from both siltation rate changes and abrasion include piling of jacket foundations; placement of gravity base foundations (including works to level the seabed); anchoring of semi-submersible rigs; placement of jack-up rigs; wellhead placement and recovery and pipeline installation and trenching. Physical disturbance associated with these activities will be negligible in scale relative to natural disturbance and the effects of demersal fishing. The potential for significant environmental effects is considered to be low.
Existing management measures	For biodiversity, the EU Birds and Habitats Directives and associated UK Regulations are the primary mechanism for managing physical damage and loss in Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). The Strategic Environmental Assessment (SEA) and EIA Regulations cover the wider impacts arising from construction, operation and decommissioning oil and gas operations.

Pressure	**Abrasion**
Impact	Physical damage from construction and decommissioning activities.
Description of environmental change (intensity, spatial extent, frequency, duration)	Activities contributing to these pressures from both siltation rate changes and abrasion include piling of jacket foundations; placement of gravity base foundations (including works to level the seabed); anchoring of semi-submersible rigs; placement of jack-up rigs; wellhead placement and recovery and pipeline installation and trenching. Physical disturbance associated with these activities will be negligible in scale relative to natural disturbance and the effects of demersal fishing. The potential for significant environmental effects is considered to be low.
Existing management measures	For biodiversity, the EU Birds and Habitats Directives and associated UK Regulations are the primary mechanism for managing physical damage and loss in Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). The Strategic Environmental Assessment (SEA) and EIA Regulations cover the wider impacts arising from construction, operation and decommissioning oil and gas operations.

Pressure	**Physical presence of structures**
Impact	Loss of species and habitat within the footprint of the structure.
Description of environmental change (intensity, spatial extent, frequency, duration)	The total area of impact for the waters around England and Wales from fixed oil and gas infrastructure is estimated to be 5.4 km^2, equating to less than 0.1% of the total area (Eastwood et al., 2007).
Existing management measures	For biodiversity, the EU Birds and Habitats Directives and associated UK Regulations are the primary mechanism for managing physical damage and loss in Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). The Strategic Environmental Assessment (SEA) and EIA Regulations cover the wider impacts arising from construction, operation and decommissioning oil and gas operations.

Pressure	**Physical presence of structures within the marine environment**
Impact	Colonisation of structures by organisms.
Description of environmental change (intensity, spatial extent, frequency, duration)	Fouling growth can result in a number of subtle ecological impacts (e.g. enrichment) in the immediate vicinity of the structure but these are not regarded as significant effects. Over a wider scale, observed changes over a one-year timescale were related to the absence of fishing in a 500 m exclusion zone around the FINO I research platform, German Bight (Schröder et al., 2006) – increased densities of sedentary filter and deposit feeders; reduced abundance of mobile predators and scavengers compared to fished areas. The cold water coral *Lophelia pertusa* has been found on several offshore installations (M. Borwell of Oil & Gas UK, pers. comm., 2009).
Existing management measures	No management measures identified to encourage fouling.

Pressure	**Physical presence of structures within the marine environment**
Impact	Behavioural changes, death or injury of birds through interactions / collisions with surface structures.
Description of environmental change (intensity, spatial extent, frequency, duration)	The majority of such responses resulting from interactions with offshore oil and gas infrastructure (whether positive or negative) are considered to be insignificant; in part because the total number of surface facilities is relatively small (of the order of a few hundred).

Pressure	**Electromagnetic fields**
Impact	Behavioural changes – attraction and repulsion.
Description of environmental change (intensity, spatial extent, frequency, duration)	Controlled Source Electromagnetic Imaging (CSEM) is a sounding technique, increasingly used by the oil and gas industry. It uses a horizontal electric dipole (HED) which emits a low frequency continuous electromagnetic signal with a frequency range of 0.1 to 1 Hz. Not much is known about the potential effects of this technique on cetaceans. The electric and magnetic fields produced by the transmitter are of concern to animals that are sensitive to these signals (such as sharks and rays). These surveys are typically of short-duration and the area affected is likely to be highly localised around the source, at 30 m above the seabed (JNCC, 2008a). Industry also has a small number of high voltage electricity cables that supply power to oil and gas platforms. They are less powerful than those used for offshore wind farms (32 kV, 50 Hz AC cables) (DECC, 2009d) from which there is no evidence of any environmental impact.
Existing management measures	No guidelines exist on good practice during the use of this technique.

Table 3.69 Environmental pressures on ecosystem services associated with oil and gas extraction.

Ecosystem service	*Significance of impact*	*Confidence in understanding of the relationship = information gaps*
Biodiversity provision	**Low – Moderate**. Low for collision risks, but moderate for noise/ seismic effects for cetaceans and other large marine species sensitive to vibrations. Also oil pollution risk	**Low**. Knowledge improving but long-term effects on biology of species poorly understood
Biological productivity (supporting service)	**Low – Moderate**. Impacts from chemical releases from extraction activities and disturbance to seabed by footprint of installations, abrasion and deposition of waste, may be significant, but only to a relatively small area of seabed and mainly of a temporary nature with recovery of the seabed often within months of cessation of any discharges Risk of major oil pollution incident in UK: damage could be severe, but careful management means probability of occurrence is low	**Moderate – High**. Some aspects of pollution well studied, and extent of sector footprint known in detail Risk difficult to predict, but history of incidents means likely to recur over coming decades
Physical environment	**Low – Moderate**. Impacts can range from consistent, but low level (e.g. pipelines) to rare, but high impact (drilling). Overall, scale, duration and probability of impacts are low, and with low potential for large, 'system overloading' impacts (e.g. oil spills)	**Moderate**. Footprint of impacts and extraction well understood, experience with surface spills allows some understanding

- Driving turbines to generate electricity and heat needed for onsite operations and living quarters
- Transportation of fuel, food and drink to the drilling rig or oil platform (rigs run on diesel and platforms generally run on gas taken from the reservoir unless they are gas deficient. In this case they can import gas or run on diesel)
- Flaring and venting of gas during the extraction process.

The UK oil and gas industry has a total CO_2 emissions allocation of 37.7 Mt/y under the UK National Allocation Plan of the EU Emissions Trading Scheme (ETS) for Phase 2 (2008-2012). This represents about 18% of the 212 Mt/y total from all UK industrial emissions covered by the EU ETS. Offshore oil and gas is allocated 18.1 Mt/y while the rest is allocated to outputs from refineries (19.6 Mt/y). These allocations were based on outputs between 2000 and 2004. Actual emissions have declined since then and are predicted to decline further.

Statistics from Oil & Gas UK estimate that during 2001 some 70% of energy use was associated with compressing and pumping with the remainder mostly accounted for by power generation for other facilities. It is unlikely that the energy consumption of a platform could be met by renewable energy alternatives. Another indirect impact from the oil and gas industry on climate change is the transportation of gas and oil by sea-going oil tankers. The effect of shipping on climate change is further discussed in Section 3.7 (Maritime Transport).

Mitigation measures

Control of flaring

When crude oil is brought to the surface, gas sometimes comes to the surface as well. Where facilities do not exist to use this gas it is (very rarely) vented or (almost always) ignited (flared). The UK is one of the top 20 gas flaring nations in the world. To control gas flaring and venting worldwide, the Global Gas Flaring Reduction Partnership was launched at the 2002 World Summit on sustainable development.

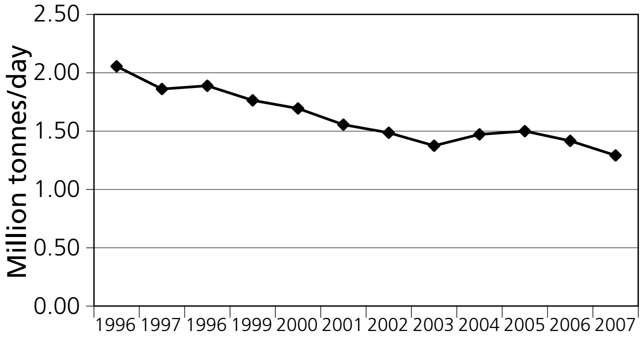
Flaring regulation in the UK is controlled by legislation originally setup to conserve supplies of gas. Figure 3.41 shows change in the amount of gas flaring over time; a gradual decrease of more than 30% over the past ten years. A voluntary Flare Transfer Pilot Trading Scheme was launched in 2001 but has been superseded by the EU ETS from 2008 onwards. This aims to reduce emissions and gas wastage further.

Carbon sequestration

Opportunities also exist for the storage of CO_2 in depleted oil and gas fields. This is discussed in detail in Section 3.14 (Storage of Gases). A summary is provided here however for context.

On the UKCS the suitable areas for geological carbon sequestration tend to coincide with the locations of offshore oil and gas extraction (Bentham et al., 2005). This is because the reservoirs that hold oil and gas are impermeable and are therefore suitable for the long-term storage of CO_2. The total potential for CO_2 storage in/under the seabed of the UKCS was estimated by Holloway et al. (2006a) at more than 31 Gt.

Figure 3.41 Reduction in flaring. Source: World Bank Group (2004) and www.oilandgasuk.co.uk.



Although there are no existing examples of carbon sequestration in UK waters, a case study of relevance is the *Sleipner West* gas field in the Norwegian North Sea. Natural gas extracted from the *Sleipner West* field has a CO_2 concentration ranging between 4% and 9.5%, processing of the gas reduces the CO_2 quantity (normally through venting) to 2.5% or less (Bentham et al., 2005). This separation process results in the production of 1 million tonnes of CO_2 annually which is stored in a reservoir between 800 and 1000 m below the surface. Storage began in August 1996 and is scheduled to continue for the life of the field (estimated at 20 years). Additional costs are estimated at \$15 per tonne of CO_2 avoided (Bentham et al., 2005).

The estimated gross costs for carbon sequestration in the UK (CO_2 capture, transport and storage) range from £4 to £10/teCO_2 for enhanced oil recovery (incorporating financial returns from the additional oil produced) and £22 to £27/teCO_2 for storage in depleted gas reservoirs (DTI, 2003a).

3.9.8.3 Summary

Table 3.70 provides a summary of the climate change pressures and impacts and indicates the likely significance of the impacts, the level of confidence in the assessment and measures that might be employed to manage the impacts (see Annex 1 for a discussion of the assessment methodology).

3.9.9 Industry stability and sustainability

3.9.9.1 Objectives

The Energy White Paper (DTI, 2007a) sets out the UK Government's international and domestic energy strategy to respond to the key long-term challenges of tackling climate change and in ensuring a secure supply of clean and affordable energy. The strategy has four key goals: (1) to put ourselves on a path to cutting CO_2 emissions by some 60% by about 2050, with real progress by 2020; (2) to maintain the reliability of energy supplies; (3) to promote competitive markets in the UK and beyond; and (4) to ensure that every home is adequately and affordably heated.

In relation to fossil fuel production, the strategy seeks to support and maximise economic production of fossil fuels in the UK, by:

- continuing to work with the industry to maximise economic recovery of the UK's oil and gas reserves, including assessment of the potential for establishing infrastructure west of Shetland and by maintaining an appropriate fiscal regime to attract investment; and
- increasing gas storage and import infrastructure by facilitating the construction of gas supply infrastructure both onshore and offshore, through reforms to the planning and licensing regime.

Table 3.70 Summary of climate change implications.

Climate change pressure	*Impacts of climate change on the Oil and Gas industry*	*Confidence/ significance*	*Adaptation measures*
Potential for increased storminess	Increased loads on offshore marine structures and increased scour around foundations	Medium confidence / medium significance	Increased engineering to improve resilience, scour protection
	Reduction in operation and access due to health and safety issues	Low confidence / unknown significance	New health and safety measures, efficient forecasting of extreme events

Impacts of Oil and Gas industry on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures (subject to other regulations)*
Energy used during the extraction of oil and gas	CO_2 emissions	Medium confidence / high significance	Carbon sequestration methods such as at *Sleipner West* gas field in the Norwegian North Sea
Energy used during the transportation of supplies to offshore installations	CO_2 emissions	Medium confidence / unknown significance	More efficient ship design
Energy used during the transportation of oil and gas by sea-going tankers	CO_2 emissions	Low confidence / unknown significance	More efficient ship design
Energy used during day to day running of offshore installations (excluding extraction)	CO_2 emissions	Medium confidence / low significance	Energy from renewable sources can and is being used for smaller installations. Carbon sequestration methods such as at *Sleipner West* gas field in the Norwegian North Sea
CO_2 emissions given off during the flaring of gas	CO_2 emissions	High confidence / medium significance	Legislation controls flaring in the UK (and worldwide), flaring has successfully been reduced with this legislation. In the future flaring will be included within carbon trading schemes

3.9.9.2 Sustainability

Most of the UK's oil demand and nearly three quarters of UK gas demand was met by indigenous production in 2008. However, UK oil and gas production is declining as exploited fields reach maturity. There are still large reserves, however, and further exploration for fields is ongoing.

Reserves are classified according to the following categories:

- Reserves – discovered, remaining reserves which are recoverable and commercial. These can be subdivided as follows depending on confidence level:

– proven reserves – known reserves which, on the available evidence, are virtually certain to be technically and commercially producible, i.e. having a better than 90% chance of being produced

– probable reserves – known reserves which are not yet proven but which are estimated to have a better than 50% chance of being technically and commercially producible

– possible reserves – reserves which, at present, cannot be regarded as 'probable', but are estimated to have a significant but less than 50% chance of being technically and commercially producible

- Potential additional resources – discovered reserves that are not currently technically or commercially producible
- Undiscovered resources – those resources as yet undiscovered but potentially recoverable in mapped leads.

The expected level of reserves is calculated by the Office for National Statistics as the sum of proven and probable reserves and the lower bound estimate of the range of undiscovered reserves.

Simulation models using Monte Carlo techniques have been used each year by DECC to assess the likely existence and size of undiscovered oil and gas fields on the UKCS. Estimates of remaining reserves are indicated in Table 3.71.

Just over half of the currently remaining proven and probable oil and gas reserves are located in the central North Sea, followed by 20% in the northern North Sea and 16% to the west of the Shetlands. In 2008, 109 exploration and appraisal wells were drilled with a 30% success rate and 300 to 400 million barrels of oil equivalent were discovered. However, the commercial viability of these discoveries has still to be assessed.

Since 1994, the value of this remaining resource has increased even as the estimated physical size of reserves has decreased. The value of the UK's recoverable oil and gas reserves mainly depends upon the estimated physical amounts remaining, the current rate of extraction and the assumed future price per unit of oil or gas, net of the cost of extraction (ONS, 2009a). At the end of 2007, stocks of UK oil reserves were valued at £177.9 billion while stocks of gas reserves were estimated to be worth £68.3 billion. This contrasts with respective closing stock values of £121 billion and £69 billion at the end of 2006 (ONS, 2009a: table 13.2).

The UK Petroleum Industry Association (UKPIA) reports that as North Sea oil production declines, planned investments in exploration and production abroad should boost oil production from both OPEC (Organization of the Petroleum Exporting Countries) and non-OPEC reserves, providing the UK and Europe with an ongoing diverse source of crude oil. Reliance on imports and an ever decreasing diversity of supply may increase the risk of potential disruption in the supply of imported crude oil with potential impacts on downstream industries. However, under EU rules, the UK as a current oil producer has to carry 67.5 days of strategic stocks of crude oil and petroleum products thereby minimising the risk of disruption. How long those reserves last though is highly vulnerable to levels of demand and supply of other imports.

3.9.9.3 Regulatory issues

The Energy Group within the then DTI ran a 'Better Regulation Project' in 2007 in consultation with industry to identify ways in which the various aspects of regulation (and

Table 3.71 Estimates of remaining recoverable oil and gas reserves as at 31 December 2008. Source: DECC[1]

	Fields in production or under development	*Other significant discoveries*	*Total*
Oil reserves, million tonnes			
Proven	408	0	408
Probable	265	96	361
Possible	244	116	360
Maximum (total)	**917**	**212**	**1129**
Gas reserves, billion cubic metres			
Proven	293	0	293
Probable	153	157	310
Possible	162	145	307
Maximum (total)	**608**	**302**	**910**

Note: Includes onshore as well as offshore fields. All oil figures include condensate, gas liquids and liquefied products.
[1] https://www.og.decc.gov.uk/information/bb_updates/chapters/reserves_index.htm

supporting legislation) could be streamlined, simplified, consolidated or abolished. Regulatory solutions are needed where possible to increase the stability of the industry.

Many of the issues were addressed in the Energy Act 2008 which delivered the proposals outlined in the 2007 Energy White Paper (DTI, 2007a). The Act aims to strengthen the investment framework for power stations, gas storage facilities and other energy infrastructure in order to help the UK ensure secure supplies of energy and tackle climate change. It also includes improvements to licensing procedures and strengthens statutory provisions for decommissioning of oil and gas installations. An analytical paper was published alongside the White Paper setting out the broad impacts of the individual policies that it contains (DTI, 2007b).

3.9.10 Forward look

3.9.10.1 Overall situation

The Government forecast that oil and gas, whether produced in the UK or not, will account for a declining portion of the UK energy supply – down to around 70% in 2020. In the long term it is forecast that production of oil and NGLs could fall from current levels of 80 million tonnes of oil equivalent (mtoe) in 2008 to just around 33 mtoe by 2025 (DECC analysis in HM Government, 2009b). Gas production is projected to decrease from around 65 mtoe in 2008 to around 25 mtoe by 2025 (DECC analysis in HM Government, 2009b). In particular, the share of UK primary energy demand provided by gas (40% in 2008) is forecast to decline over the next 10 years. Based on current investment plans, oil and gas production overall is expected to decline at an average rate of 5% over the next five years as several larger fields reach the end of their life span.

3.9.10.2 Indigenous reserves

The recovery of these remaining reserves will require additional investment, both in money and expertise. Currently the industry spends around £13 billion a year across all offshore activities. According to Oil & Gas UK (2008), to sustain this rate of expenditure industry, regulators and government alike must ensure that the UK remains globally competitive in the current investment climate.

Figure 3.42 shows actual production levels in recent years and current and previous projections; the colour-coded scales are different for oil and gas while the actual levels of oil and gas production are shown in lighter shades than the projected levels.

3.9.10.3 Decommissioning

Around 500 installations are expected to be decommissioned over the next 30 years. Some 10 000 to 14 000 km of pipelines, 15 onshore terminals and around 5000 wells are also part of the infrastructure planned to be gradually phased out. Five major projects will have been completed by the end of 2009. Before approving decommissioning plans, DECC requires companies to consider re-use of the infrastructure for other purposes, such as development of other oil or gas discoveries, gas storage or carbon capture or storage. These possibilities, the fluctuating oil price and potential for new technologies mean that predictions of decommissioning timescales often change and DECC has now stopped publishing predictions of decommissioning activity. Instead, company predictions of 'cessation of production' are reported, which indicate decommissioning activity peaking between 2016 and 2020.

3.9.10.4 Imports

As the North Sea reserves mature, the UK will become increasingly dependent on imported energy and this will tend to lessen security of supply. Gas imports are already meeting over a third of the UK's total annual gas demand, potentially rising to around 50% by 2020 on the basis of existing policies. This requires the further development of gas importing facilities (see Table 3.73 in Section 10: Pipelines, for a list of recent, current and planned projects). Diversifying supply will help to improve energy security. However, as imports of oil increase to meet consumption needs so will the related shipping traffic and consequent risk of accidental oil spills.

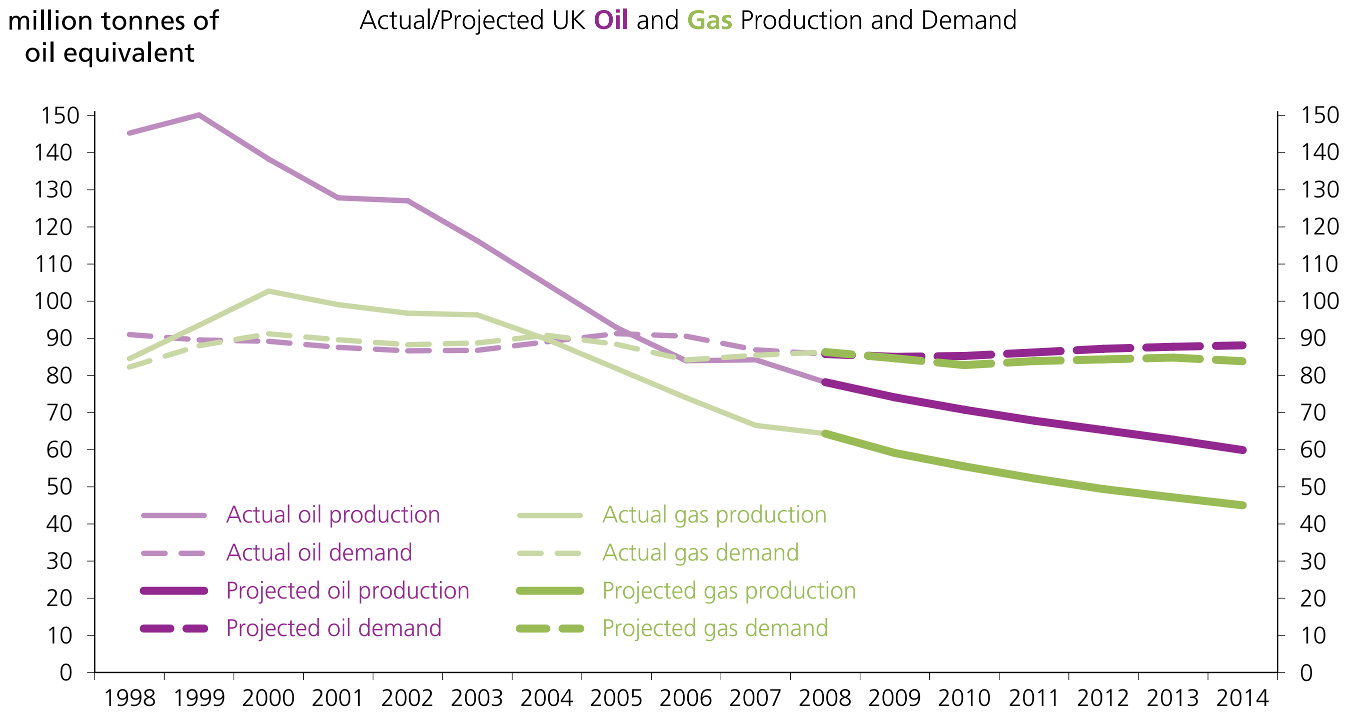
3.9.10.5 Current research and future requirements

Oil & Gas UK estimate that £400 billion has been spent over the past forty years on exploration, development and ongoing investment and operations throughout the UKCS. The recovery of remaining reserves will require additional investment.

A greater degree of research and investment has been targeted towards the supply chain sector given its increasing value in the market. For example, UK Trade and Investment has developed a dedicated international marketing strategy covering the entire energy sector.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the oil and gas industry will need

Figure 3.42 Oil and gas production forecast for UKCS 2008-2014 (Source: DECC as of February 2009).



to manage further its activities. For example, GES Descriptor 8 states that ...*Concentrations of contaminants are at levels not giving rise to pollution effects*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.10 Pipelines

3.10.1 Key points

- There are more than 21 000 km of pipelines on the UK Continental Shelf (UKCS)
- Liquids transported include gas, oil, mixed hydrocarbons and a range of chemicals
- The total length of interconnectors is 900 km, transporting gas to and from other countries
- The existing 21 000 km of pipelines on the UK seabed is estimated to cover approximately 5.5 km^2 representing less than 0.0006% of the UKCS. Impacts from pipeline installation on habitats are spatially minor.
- The amount of oil and gas imported into the UK has increased steadily since 1997, and is likely to increase further, thereby requiring further gas pipeline import projects

i. Introduction

The pipeline sector relates to the transport of materials (predominantly oil and gas) through submarine pipelines into the UK from hydrocarbon extraction fields and to gas storage fields and also within extraction fields.

ii. How has the assessment been undertaken?

This section discusses licensing requirements for all pipelines, provides an assessment of the spatial distribution of all pipelines and highlights past and future trends. The economic value of pipelines from extraction platforms on the UKCS is considered under Section 3.9 (Oil and Gas) as it is difficult to differentiate values for individual supply chain activities. The economic value of interconnector pipelines is not calculated here as the direct use value relates specifically to the use of the seabed which is difficult to quantify. Data on pipelines were sourced from SeaZone.

iii. Current status of pipelines and past trends

There are more than 21 000 km of pipelines on the UKCS. Of these, 900 km are interconnectors, transporting gas to and from other countries (e.g. Republic of Ireland and Europe). Gas is the main commodity transported. Other fluids include oil and mixed hydrocarbons and a range of chemicals such as corrosion inhibitors. It is difficult to define the direct use value of the pipelines sector. Ancillary values include the investments made in installation and this is captured in the value of the supply chain in Section 3.9 (Oil and Gas). The existing 21 000 km of pipelines on the UK seabed is estimated to cover approximately 5.5 km^2 representing less than 0.0006% of the UKCS. Impacts from pipeline installation on habitats are spatially minor with short-term noise and disturbance impacts.

iv. What is driving change?

Trends in the industry are partly related to activities in oil and gas development (see Section 3.9: Oil and Gas) although decreasing production since 1999 has been met by increasing levels of imports. Development in the sub-sea storage of gas reserves and captured carbon dioxide (CO_2) will maintain activity within the industry.

v. What are the uncertainties?

The actual length of pipeline on the seabed depends on how they are defined and so estimates may vary. In particular, within oil and gas fields there may be many small pipelines

transporting chemicals such as corrosion inhibitors, methanol and monoethylene glycol (MEG).

vi. Forward look

The amount of oil and gas imported into the UK has been steadily increasing since 1997 and is likely to increase further in the future, thereby supporting further gas pipeline import projects. Furthermore, pipelines to transport captured CO_2 are likely to start being installed within the next five years.

3.10.2 Introduction

This sector considers the pipeline transport of materials from overseas, between the mainland and islands of the UK (including 'interconnectors' such as the Bacton to Zeebrugge oil and gas interconnector), from hydrocarbon extraction fields to mainland refineries, to gas storage fields and also within hydrocarbon fields.

3.10.2.1 Description of economic activities

Pipeline activities provide support for the oil and gas industry and, as such, it is difficult to separate this value from other support activities such as oil platform construction (Table 3.72). The value of pipeline transport of indigenously produced oil and gas is therefore discussed as an ancillary activity in Section 3.9 (Oil and Gas). However, descriptions of the spatial extent of all pipelines are described here in detail.

Installing pipelines under the sea requires specialised equipment and is expensive, so ships mostly transport products such as oil. The products transported by pipeline are predominately oil and gas but also include condensate, chemicals, mixed hydrocarbons, water and various other products (SeaZone data). Gas is largely imported from Norway, the Netherlands and other parts of mainland Europe.

3.10.2.2 Description of relevant ecosystem services

As well as economic services, the pipelines sector also relies on various ecosystem services that support its activity, including the provision of a stable physical environment in which to operate.

3.10.2.3 Management

The installation and operation of pipelines in the UK is generally governed under The Petroleum Act, 1998 which requires an authorisation (Pipeline Works Authorisation - PWA) from the Department of Energy and Climate Change.

In Scottish internal waters, i.e. those above the low water tide mark or within bay enclosure lines, this is managed under the Pipelines Act 1962, the Gas Act 1986 (as amended by the Gas Act 1995 and extended by the Utilities Act 2000) and the Public Gas Transporter PipeLine Works (Environmental Impact Assessment) Regulations 1999.

In all Northern Ireland waters procedures for the installation or retention of gas pipelines are contained in paragraphs 10–12 of Schedule 3 to the Gas (Northern Ireland) Order 1996. Licences to convey, store or supply natural gas are granted by the Northern Ireland Authority for Utility Regulation (NIAUR - formerly known as the 'Northern Ireland Authority for Energy Regulation'), with the consent of, or in accordance with a general authority given by the Department under Article 8 of the Gas (Northern Ireland) Order 1996.

Table 3.72 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Pipelines: Oil and Gas (SIC 49.50)	Support activities – e.g. exploration services and dismantling (SIC 09.10), Manufacture of pipeline products and machinery Pipeline construction (SIC, 42.21)	None identified	

3.10.3 Direct use value

3.10.3.1 Principal activities

The value of pipeline activities to support indigenously produced oil and gas is discussed in Section 3.9 (Oil and Gas) as an ancillary activity. This section focuses on the value of pipeline transport of materials from overseas, that is, that are not directly related to UK productivity. The direct use value relates to the transport of materials through the pipeline; that is, if the industry could not make use of the seabed to lay pipelines on then it is necessary to rely on other means for importing liquids. It is difficult to assess this value quantitatively, because its calculation is relative to a counterfactual situation that is very difficult to specify.

The Bacton to Zeebrugge pipeline became operational in October 1998 and currently has an import capacity of 25.5 billion cubic metres per year and an export capacity of 20 billion cubic metres per year. It is operated by Interconnector (UK) Limited. Daily flow rates are available online indicating whether net flow is towards the UK or towards Belgium (www.interconnector.com). The net amount of gas flowing each day is dependent on the quantities produced and the quantities nominated by individual shippers. Shippers nominate their requirements to the pipeline operators who manage the process of validation and aggregation which determines the daily quantity of energy to be transported into and out of the system.

The BBL Pipeline (Balgzand to Bacton Line) is the first natural gas pipeline between the Netherlands and the UK and became operational in December 2006. The initial capacity of the pipeline is 16 billion cubic metres, which will be increased to 19.2 billion cubic metres by the end of 2010 by installing a fourth compressor at the compressor station at Anna Paulowna. The overall cost of the project was around €500 million.

Northern Ireland is connected to the national natural gas supply by a pipeline which crosses the Irish Sea from the Rhinns of Galloway to Island Magee.

3.10.3.2 Ancillary activities

The ancillary value relates to the construction of pipelines and importation facilities. Completed and proposed import projects are listed in Table 3.73. There were some delays in 2007 to several substantial projects at home and overseas, mainly because of resource pressures throughout the oil and gas supply chain worldwide. There are also a significant number of new liquefied natural gas (LNG) projects but these are port terminals designed to berth and unload specialist LNG vessels and distribute

Table 3.73 Gas import projects for the UK. Source: Oil & Gas UK (2008).

Name of project	Target date(s)	Capacity, bcm/y
Langeled Pipeline (from the *Ormen Lange* field, Norway)	Complete	20
Bacton Interconnector Expansion	Complete	Increased by 17
Tampen Link (Stajord, Norway to St Fergus, Scotland)	Complete	10
BBL Pipeline (Phase 2 under consideration)	Complete Phase 2 2010 –12	15 3

gas into downstream markets in the UK. Development of port terminals is discussed in Section 3.7 (Maritime Transport).

3.10.4 Regional distribution of value

The total length of the existing pipeline network as at 2008 is estimated to be 21 000 km (from data provided by SeaZone) and illustrated in Figure 3.43. Another study, by Genesis Oil & Gas Consultants Ltd (2008) for the OSPAR Quality Status Report 2010 (OSPAR, 2010), estimated that over 34 159 km of pipelines had been laid on the UKCS. The difference between the two estimates may be due to differences in the methods used to count pipelines. For example, many chemical lines are piggy-backed onto production lines and so may be counted as either one or two pipelines. A small percentage of pipelines are also abandoned or not in use (2%). In addition, a further 1000 km of pipelines are in the pre-commissioning or proposal stage. The total distribution of active pipelines across the UKCS is given in Table 3.74 and the key gas interconnectors are listed in Table 3.75.

3.10.5 Trends

The amount of gas imported has steadily increased since 1997 (see Figure 3.39 in Section 3.9: Oil and Gas). From 1995 to 2004, the UK was self-sufficient, but became a net importer of gas again in 2005. This is likely to have driven the increasing quantity of pipeline installations over the past ten years although the majority of oil and gas is still brought in by ship. Temporal trends in the production rates of oil and gas from the UKCS are described in Section 3.9 (Oil and Gas).

3.10.6 Socio-economic pressures and impacts

Socio-economic pressures and impacts for pipelines can be positive (i.e. employment, research) or negative (i.e. impacts on other sea users such as fisheries, marine aggregates and renewable energy developments). Improved supply of fuel throughout the UK assists in the diversification of fuel sources, provides competition in the energy market and improves industrial competitiveness (Oil & Gas UK, 2009).

Figures for employment are quantified in Section 3.9 (Oil and Gas, see Section 3.9.6.1) as it is difficult to separate supply chain activities for indigenous resources from those for imported material. Details on negative pressures are discussed in Section 3.9.6.2.

3.10.7 Environmental pressures and impacts

The main activities associated with pipelines include pipeline route surveys, installation, operation, monitoring, maintenance and

Table 3.74 Length (km) and distribution of active pipelines across the UKCS. Source: SeaZone.

CP2 Region	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*Total*
Gas	5162	3526	0	0	678	0	611	0	9977
Oil	3369	0	0	0	48	0	525	0	3942
Condensate	514	32	0	0	0	0	0	0	545
Chemical	742	1265	0	0	272	0	52	0	2331
Mixed hydrocarbons	657	94	0	0	32	0	70	0	853
Water	610	0	0	0	0	0	176	0	787
Other fluids	196	117	0	0	0	0	8	0	322
Unknown	1137	949	0	0	187	0	276	0	2548
Total	**12387**	**5982**	**0**	**0**	**1217**	**0**	**1719**	**0**	**21305**

Note: Data from SeaZone have been used to obtain the length of pipelines on the UKCS. These data differ from those presented by Genesis Oil & Gas Consultants Ltd (2008) for the OSPAR Quality Status Report 2010 (OSPAR, 2010) which have been obtained from alternative sources.

Table 3.75 Key existing gas interconnectors in the UK.

Name	*Length, km*	*Origin*	*Destination*
BBL Balgzand to Bacton	232	Bacton	Balgzand, Netherlands
PL1339: Bacton to Zeebrugge	232	Bacton	Zeebruge, Belgium
INTERCONNECTOR 1	204	Moffat, Scotland	Loughshinny, North County Dublin
INTERCONNECTOR 2	192	Beattock, South West Scotland	Gormanstown, County Meath
Scotland to Northern Ireland Gas Pipeline (SNIP)	40	Rhinns of Galloway	Island Magee
Total	**900**		

decommissioning. The legislation governing such activities is the same as for oil and gas (see Section 3.9.7). Key environmental pressures and impacts associated with pipelines are described in Table 3.76. The ecosystem services that these pressures impact and the relative significance of these impacts are described in Table 3.77.

3.10.8 Climate change

3.10.8.1 Impacts of climate change on the pipelines industry

There are no published sources detailing the potential effects of climate change on pipelines, but it could impact on both their installation and maintenance. If there is an increase in storminess at sea then the windows of opportunity to lay the pipelines may be reduced. When the pipelines are installed changes in patterns of erosion and ocean currents could lead to increased scour on the seabed uncovering

Figure 3.43 Pipeline network as at 2008.

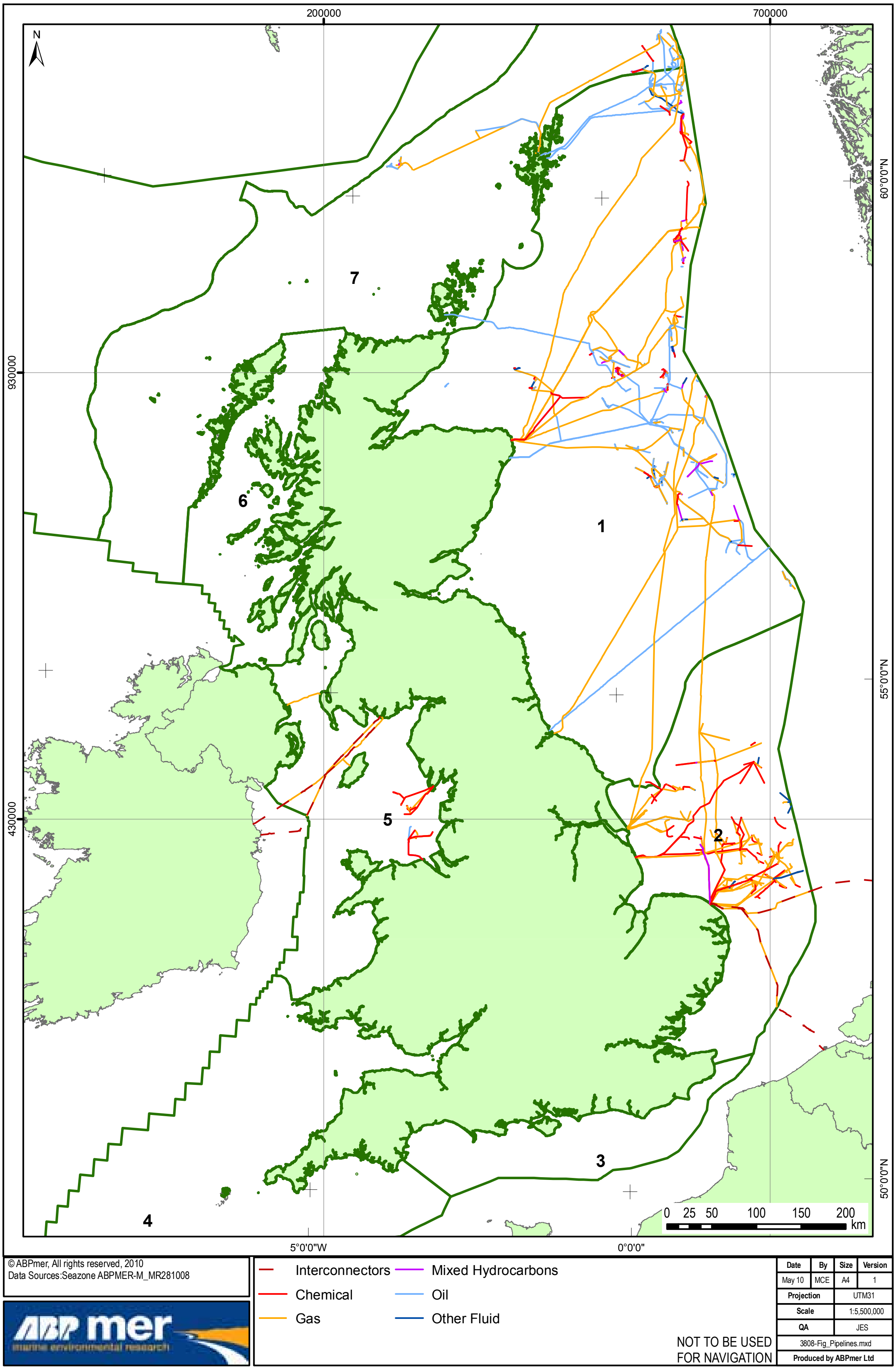


Table 3.76. Key environmental pressures and impacts associated with the installation, removal and presence of pipelines. Based on information from DTI (2001b, 2002); Lewis et al. (2002); Perttilä et al. (2006); ABPmer (2006b, 2007a,b); Eastwood et al. (2007).

Pressure	*Impact*	*Description of environmental change (intensity, spatial extent, frequency, duration)*	*Existing management measures*
Habitat damage	Loss of habitat and species in the 'footprint' of the pipeline. Physical disturbance of seabed substrata causing sediment resuspension and increased turbidity which could result in wider-scale benthic disturbance.	The location of existing pipelines can be seen in Figure 3.43. The study by Genesis Oil & Gas Consultants Ltd (2008) calculated a footprint from pipelines of approximately 5.5 km^2 of the UKCS (of a total area of 892 000 km^2, this equates to 0.0006% of the UKCS). Calculations took into account the numbers of and likely widths of a range of pipelines. Impacts from sediment resuspension are short-term. But, the impacts of pipeline development on the benthic communities will be dependent on the sensitivity of the species that characterise the communities along the pipeline route. Benthos generally begin to colonise a disturbed seabed area quite quickly, but full recovery of the community depends on the scale of the disturbance, the propagation capacities of the species and the status of nearby marine communities.	The *Petroleum Act, 1998* requires an authorisation (Pipeline Works Authorisation - PWA) from DECC for the use of or works for the construction of a submarine pipeline. The application process includes a formal consultation process. The authorisation may include conditions for the design, route, construction and subsequent operation of the pipeline. The PWA process has been streamlined and also includes consenting for the placement of concrete mattresses and rock dumping (DEPCON). The PWA is supported by relevant environmental regulations and associated permits. The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999 require an environmental impact assessment and an Environmental Statement (ES) to be submitted for certain projects including new pipelines with expected production >40 km in length and 800 mm in diameter. Small to medium-sized pipelines may not need an ES to be prepared if a preliminary assessment demonstrates to the satisfaction of the Secretary of State that the project is unlikely to cause a significant adverse environmental impact. The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (SI 2001/1754) and amendments (2007) transposes the EU Habitats and Birds Directives and applies their requirements to all oil and gas activities on the UKCS. See Section 3.9 (Oil and Gas) for more detail.
Habitat change	Change in habitat type. Oil and gas pipelines on the seafloor provide a hard substratum for a variety of sessile epibenthic species to colonise and provide shelter for fish.	The spatial extent of habitat modification, in terms of availability of hard substrate for epifaunal colonisation, is minor or moderate at a regional population level. In soft sediments pipelines are likely to self bury over time. Indirect effects at an ecosystem level are also very unlikely.	
Noise and Vibration	The burial of pipelines has the potential to cause noise and vibration causing avoidance of an area.	Any noise/vibration pressures from pipeline laying will be short term. It is evident from the available data that the noises and vibrations to which most marine species are sensitive and will respond behaviourally by avoidance mechanisms, will not exceed their threshold levels even in the worst-case scenario.	

Table 3.77 Environmental pressures on ecosystem services associated with pipelines.

Ecosystem Service	*Significance of impact*	*Confidence in understanding of the relationship*
Biological productivity	**Low – Moderate.** Spatial extent is limited, but disturbance of physical environment could damage the habitat of specific species during laying and/or operation	**Moderate**. Exact impacts uncertain, but good knowledge of extent of impacts (locations of pipelines)
Biodiversity provision	**Low**. Laying and/or operation of pipelines may disrupt behaviour of some species, but spatial extent is limited and impacts are unlikely to go above threshold disturbance levels	**Moderate**. Exact impacts uncertain, but good knowledge of extent of impacts (locations of pipelines)
Physical environment	**Low – Moderate**. Spatial extent is limited, but impacts are clear	**Moderate**. Impacts known and good knowledge of extent (locations of pipelines)

buried pipelines leading to the risk of breakage. Of the main trunk pipelines which include interconnectors, 66% are trenched and buried (BERR, 2008b).

Adaptation measures

There is no published evidence of any adaptation measures related to climate change. Sediment modelling studies could be necessary to ensure that pipelines do not become exposed above the seabed.

3.10.8.2 Impacts of the pipelines industry on climate change

CO_2 emissions arise from shipping used to install pipelines, but these cannot be quantified based on current information. Mitigation of impacts from shipping is discussed further in Section 3.7 (Maritime Transport).

Mitigation measures

No mitigation methods specifically related to pipeline installation could be identified, for a discussion of those related to shipping see Section 3.7 (Maritime Transport).

3.10.8.3 Summary

Table 3.78 provides a summary of the climate change pressures and impacts and indicates the likely significance of the impacts, the level of confidence in the assessment and measures that might be employed to manage the impacts (see Annex 1 for a discussion of the assessment methodology).

3.10.9 Industry stability and sustainability

3.10.9.1 Objectives, targets and indicators

The Energy White Paper (DTI, 2007a) sets out the UK Government's international and domestic energy strategy to respond to the key long-term challenges of tackling climate change and in ensuring a secure supply of clean and affordable energy. The strategy has four key goals: (1) to put ourselves on a path to cutting CO_2 emissions by some 60% by about 2050, with real progress by 2020; (2) to maintain the reliability of energy supplies; (3) to promote competitive markets in the UK and beyond; and (4) to ensure that every home is adequately and affordably heated.

The White Paper recognises that security of supply requires sufficient, diverse and reliable supplies of energy to meet customers' demand

Table 3.78 Summary of climate change implications.

Climate change pressure	*Impacts of climate change on pipelines*	*Confidence/ significance*	*Adaptation measures*
Increase in severity of storms	Scour around pipelines leading to undermining and breakage	Low confidence / medium significance	Burial of pipelines, increased use of rock or mattresses to cover free spans
	Shortening of suitable calm weather periods during which pipelines can be laid	Low confidence / low significance	Avoidance of periods of bad weather

Impacts of pipelines on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
CO_2 emissions from shipping used to install pipelines	CO_2 emissions	Low confidence / unknown significance	Improved efficiency of shipping

and capacity on the import, transmission and distribution networks to deliver supplies to customers. In turn, this requires reliability of infrastructure such as producing fields, pipelines, import terminals and the rail network to bring primary fuels into the UK market, especially when demand is high.

No specific objectives and targets have been set by the Government in relation to pipelines, but policies are supportive where such projects support economic development or security of supply objectives.

Infrastructure developments are spurred on by hydrocarbon discoveries, changing economics which make previously uneconomical fields profitable, the expected growth in recovery from smaller satellite fields and the small changes, tie-ins etc. which will be installed onto the existing infrastructure that will be needed to allow for this.

3.10.10 Forward look

Currently around 25% of the UK's annual gas demand is satisfied by imports. On current plans this figure is likely to increase to around 40% by 2010. Given the predictions for increasing dependence on imported gas then the number of related supply chain projects is likely to increase. Proposed projects are listed in Table 3.73 and include Phase 2 of the Balgzand to Bacton pipeline.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the pipelines sector will need to manage further its activities. For example, GES Descriptor 6 states that ...*Sea-floor integrity is at a level that ensures that the structure and functions of ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.11 Power Transmission

3.11.1 Key points

- Deployment of marine power cables has been steadily increasing due to increasing demand within the UK and demand for improved security and stability of electricity supply
- Deployment of power cables is likely to increase significantly in relation to offshore renewable power installations
- Impacts from power cable installation on the seabed are short term and spatially minor, estimated to cover approximately 0.16 km^2 or 0.00002% of the UK Continental Shelf (UKCS)
- Pressures from the electromagnetic fields associated with high voltage cables are spatially minor and, if buried to more than 1 m, the consequent impacts on sensitive species is not significant
- The capacity of interconnector cables (among islands) is currently 2540 MW from 212 km of cable

i. Introduction

This sector relates to the transfer of power into and from the UK and between the islands of the UK. It also includes the transmission of power from offshore renewable energy installations.

ii. How has the assessment been undertaken?

Spatial information on the distribution of power cables was sourced from SeaZone. The Energy White Paper provided some forecasts of activities within the industry. Relevant research on environmental impacts was reviewed.

iii. Current status of the power transmission sector and past trends

There is a total of 2368 km of submarine power cables on the UKCS calculated to cover approximately 0.21 km^2 or 0.00002% of the UKCS. Although it is difficult to assess the economic value from power cables the capacity from interconnector cables, which is currently 2540 MW from 212 km of cable, may be used as an indicator of both value and activity. Impacts from power cable installation on habitats are short term and spatially minor. Although there is potential for the electromagnetic fields (EMF) associated with high voltage power cables to impact on animals that are sensitive to such fields, considerable research suggests that the spatial extent is small and, if the cables are buried to more than 1 m, the impact will not be significant.

iv. What is driving change?

The deployment of power cables has been steadily increasing due to increasing demand within the UK and demand for improved security and stability in electricity supply.

v. What are the uncertainties?

There is little information on this sector, particularly in relation to economic value, investments and future forecasts. In addition, geospatial data on submarine powerlines provided by SeaZone does not always include power cables associated with offshore renewable energy installations.

vi. Forward look

Deployment of power cables is likely to increase in relation to offshore renewable energy installations.

3.11.2 Introduction

This sector is concerned with the transmission of power through submarine cables. These include international and national links among the islands of the UK and to Europe (termed here as interconnectors). For example, the England–France interconnector is a 2000 MW high voltage direct current (HVDC) link between French and British transmission systems. Ownership is shared between National Grid and Réseau de Transport d'Electricité (RTE). Within the UK there are links from Scotland to Northern Ireland and among the Scottish Isles and from England to the Isle of Man and the Isles of Scilly.

Offshore renewable energy installations also have associated high voltage power export cables. A typical offshore wind farm can have hundreds of kilometres of associated cable.

3.11.2.1 Description of economic activities

The main economic activities are presented in Table 3.79. Power transmission is supported by a number of activities of which construction and manufacturing are key. Secondary activities include the trade in electricity through the interconnectors and downstream distribution of electricity inland.

3.11.2.2 Description of relevant ecosystem services

The power transmission sector relies on various ecosystem services that support its activity, the most important of which is a stable physical environment in which to operate. As for telecommunication cables (Section 3.15: Telecommunications) physical features of greatest significance include shallow gradients, areas of limited seabed surface change, and soft sediments which allow for the trenching of cable systems. However, the technologies employed to lay cables allow systems to be installed in a variety of conditions and the significance of the physical environment as a hindrance is limited within the UK.

3.11.2.3 Management

In general, the deployment of power cables is managed by DECC and the Devolved Administrations within their respective territories. In England and Wales, an 'interconnector licence' may be obtained under the Electricity (Applications for Licences, Modifications of an Area and Extensions and Restrictions of Licences) Regulations 2008 (No. 2376). In Scotland, applications for power cables are managed under section 37 of the Electricity Act 1989, The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000, the Electricity (Applications for Consent) Regulations 1990 and the Electricity (Applications for Consent) Amendment (Scotland) Regulations 2006. In Northern Ireland, procedures for the installation or operation of submarine power cables are governed by the Electricity (Applications for Licences and Extensions of Licences) (No. 2) Regulations (Northern Ireland) 2007 and the Electricity Consents (Planning) (Northern Ireland) Order 2006. The industry in the UK is represented by the UK Cable Protection Committee (UKCPC – protection of cables in general) and the Energy Networks Association (ENA - energy transmission and distribution).

3.11.3 Direct use value

3.11.3.1 Principal activities

Pugh (2008) was not able to quantify the economics of submarine power cables. The value of the cable relates to the actual use of the seabed across which the cable is laid. This is difficult to assess. If it is assumed that the seabed between islands or mainland

Table 3.79 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Power transmission (SIC 35.12)	Construction of utility projects for electricity (SIC 42.22); Manufacture of electricity distribution and control apparatus (SIC 27.12)	Distribution of electricity (SIC 35.13) Trade of electricity (SIC 35.14)	None identified

Europe could not be used (due to geological instability, political instability or planning or other environmental restrictions), then power would have to be sourced another way. The likely approach would be to increase local supply from oil and gas and renewable resources. Therefore, the value of the power cable could be estimated as the value of alternative options. However, as with pipelines (Section 3.10: Pipelines), it is difficult to assess this value quantitatively, because its calculation is relative to a counterfactual situation that is very difficult to specify. Furthermore, some of the alternative options of sourcing power, such as offshore renewable energy, may require submarine power export cables.

However, as an indicator of the value of interconnector cables the capacity of the cables can be referred to with the counterfactual logic that if the cable could not be laid across the seabed, this energy capacity would need to be sourced elsewhere. It is noted that although power cables have a maximum potential electrical capacity, not all of this may necessarily be available. The amounts are traded on a daily basis and the maximum level that may be traded is governed by various access agreements to the transmission system. This is complex as the amounts available for trade may vary on a seasonal or monthly basis.

For example, the transfer capacity of the Moyle Interconnector for the trading of electricity between the electricity markets of Ireland and Great Britain is 450 MW for east–west trades during the winter and 410 MW during the summer (Moyle Interconnector Ltd, 2008). The trading capacity for west–east trades is 80 MW at present, limited by Moyle's agreements for access to Great Britain's transmission system.

As of 2005, imports of electricity from France have historically accounted for about 5% of electricity available in the UK. Imports through the interconnector have generally been around the highest possible level, given the capacity of the link. In 2006, 97.5% of the energy transfers have been made from France to UK, supplying the equivalent of three million English homes. The link availability is around 98%, which is among the best rates in the world.

For simplicity, Table 3.80 sets out the carrying capacity of the cable, not the transfer capacity but this is considered to be the maximum scenario.

3.11.3.2 Ancillary activities

There is very little known about the ancillary values associated with power transmission cables or investments in construction. As part of an EU Recovery Plan funding package released 28 January 2009, the European Commission proposed €100 million for the development of an interconnector between the Republic of Ireland and Wales. In the UK, the National Grid is a leading developer of HVDC interconnectors.

Table 3.80 Capacity and other details of Interconnector power cables.

Interconnector	*Links*	*Capacity, MW*	*Voltage, kV*	*Length, km*
England–France	Folkestone to Sangatte, France	2000	270	45
Scotland–Northern Ireland	Islandmagee, County Antrim to Auchencrosh in Ayrshire	500		63
England–Isle of Man	Bispham, Blackpool to Douglas Head, Isle of Man	40	90	104
Total		**2540**		**212**

For example, the project to install the proposed BritNed interconnector is valued at €600 million (see Section 3.11.2).

3.11.4 Regional distribution of value

Although value has been difficult to identify, the spatial distribution of activity can be estimated. The distribution of power cables is shown in Figure 3.44 and described in Table 3.80. Much of the present distribution is related to connections between the UK and surrounding islands and mainland Europe. The main focus is on submarine power lines (a total of 1605 km) with key interconnectors (346 km) identified separately. However, the figure also includes national grid lines located coastally (within 0 km of the coast) on the assumption that these interact with coastal marine features where they cross estuaries, for example. These amount to 417 km providing a total of 2368 km of power cable.

3.11.5 Trends

There is little information on trends in the establishment of power cables in recent times but it is likely to have increased gradually with increasing demand for reliable sources of electricity at competitive rates.

3.11.6 Socio-economic pressures and impacts

3.11.6.1 Positive

Stable and reliable supply of power can have a large impact on the national economy. For example, the commissioning of the Moyle Interconnector in early 2002 ended the isolation of Northern Ireland from the much larger electricity systems and markets of Great Britain and the European mainland, improving the energy security of electricity throughout Ireland. It also reduced operating costs and helped to introduce a competitive electricity market. These were key factors in helping to drive electricity prices down in Northern Ireland, which has had a history of high energy costs (Northern Ireland Energy holdings, 2009).

The connection to the Isle of Man in 2000 ended the island's dependence on locally-powered diesel generation.

There are also benefits in being able to export UK experience in developing and constructing interconnectors abroad. The National Grid has been involved in projects in the United States, and recently constructed the 360 km Basslink interconnector between mainland Australia and Tasmania (commissioned in 2006).

Figure 3.44 Distribution of power cables.

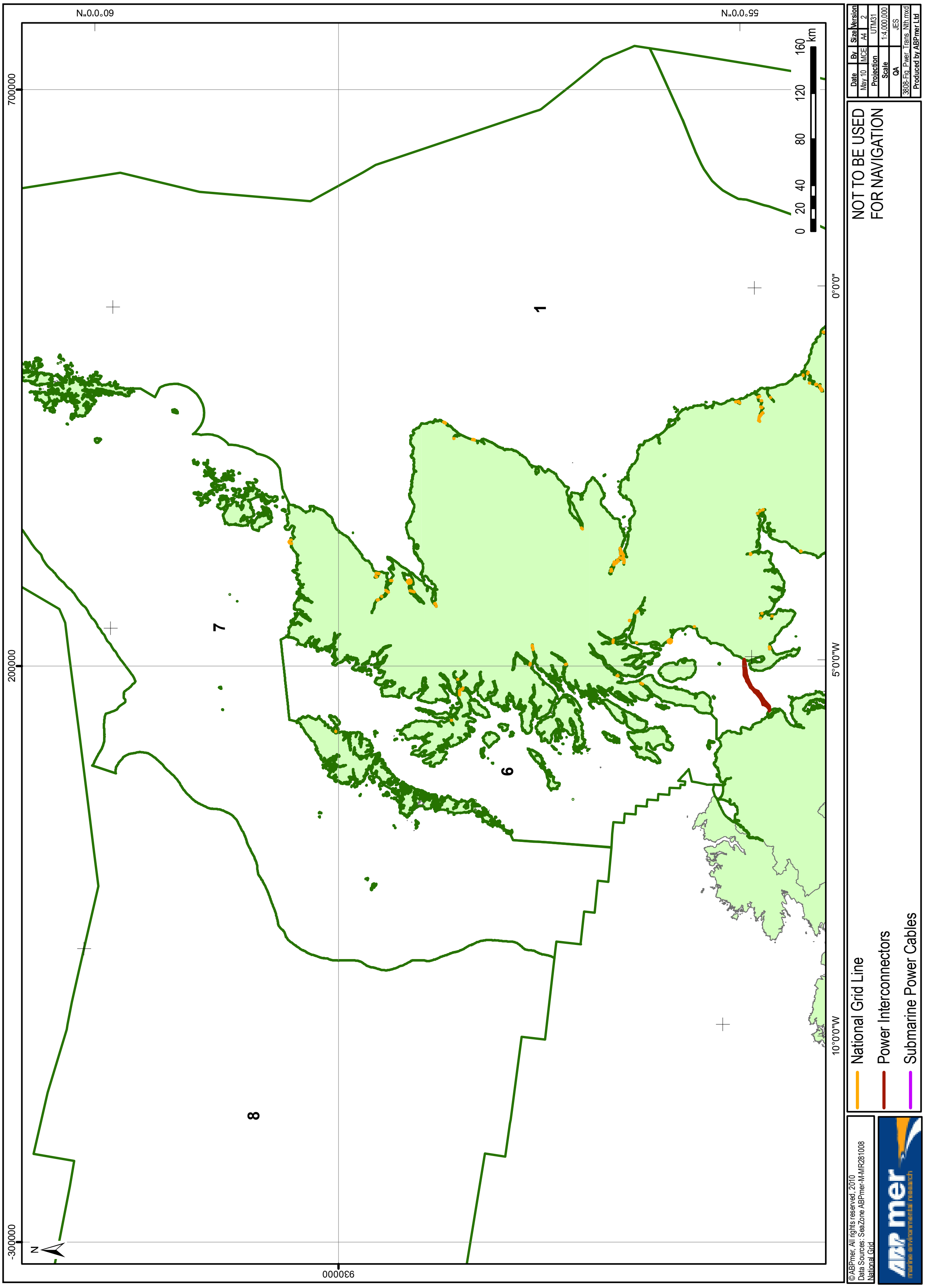
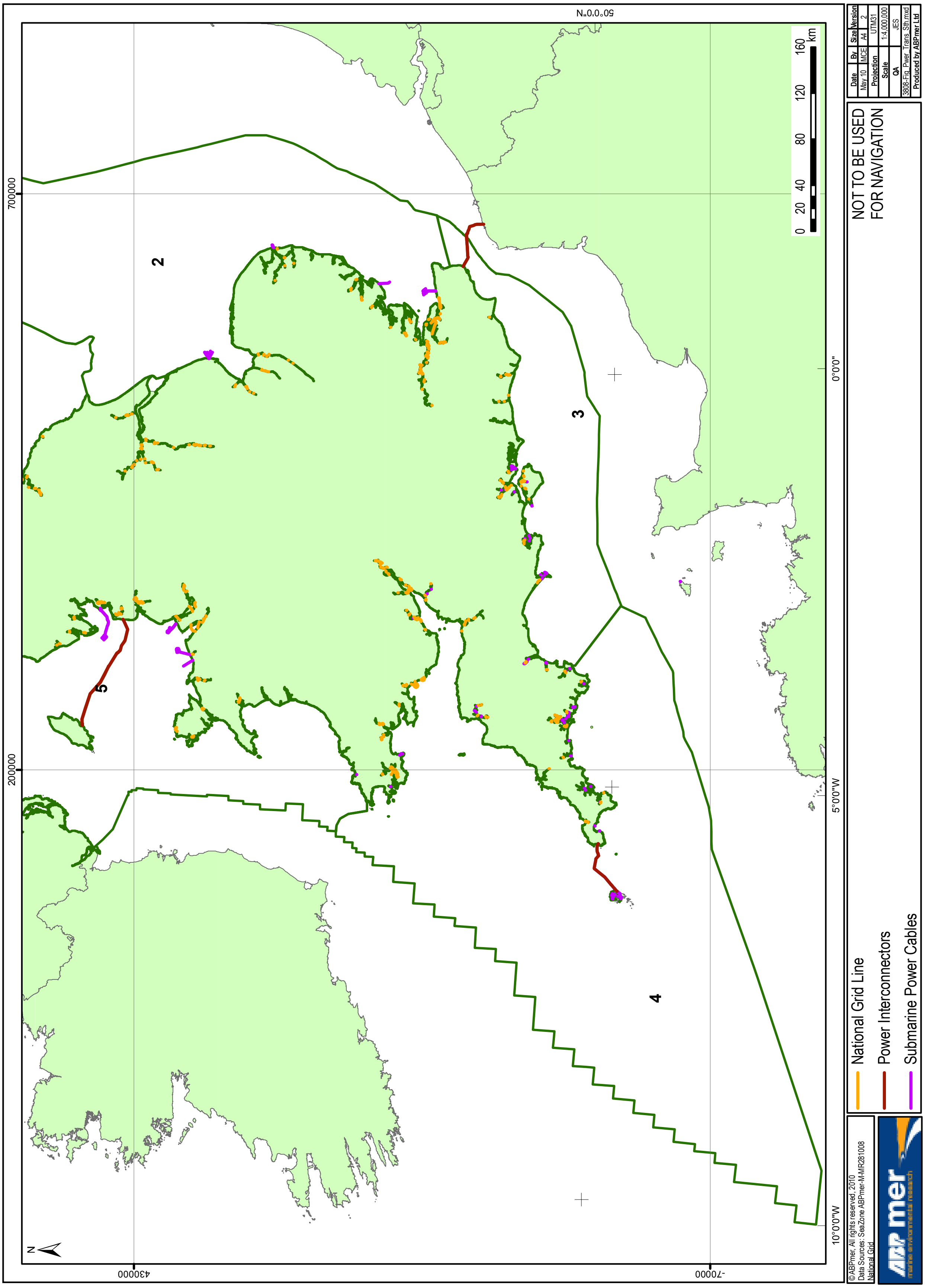


Figure 3.44 continued



3.11.6.2 Negative

The installation and presence of submarine cables on the seabed may interfere with the activities of other socio-economic activities, notably marine aggregate dredging and fisheries. In addition, the dredging activities of these industries present a risk of snagging and damaging expensive cabling materials and also endangering the dredging vessel itself. A Cable Industry / Fishing Industry Liaison group (CIFIG) was set up to assist in resolving issues between the two activities. Furthermore, two Acts of Parliament apply to cable operations: The Submarine Telegraph Act (STA) 1885 and the Telecommunications Act (TA) 1984. Under these regulations:

- It is a punishable offence to break or injure any submarine cable; wilfully or by culpable negligence (STA 1885). Section 8 of the Continental Shelf Act 1964 extended the provisions of the Act to cover all submarine cables and pipelines including high voltage electrical cables.
- Owners of vessels that can prove that they have sacrificed equipment (such as fishing gear) in order to avoid injuring a submarine cable shall receive compensation from the cable owner (STA 1885). This means that the compensation regime will therefore cover all cables and pipelines in the territorial sea and UKCS.
- The Secretary of State shall not approve any plan unless he is satisfied that any person affected by those works has been adequately compensated (TA 1984).

3.11.7 Environmental pressures and impacts

The spatial distribution of power cables in UK waters can be seen in Figure 3.44. Assuming a nominal cable diameter of 0.09 m (see Eastwood et al., 2007) and applying this to the current dataset for power cables for the whole of the UKCS the extent of existing cables (or footprint) is estimated to cover an area of 0.21 km^2 or 0.00002% of the entire UKCS. During cable-laying, a larger area of benthic habitat may be disturbed. Key environmental pressures and impacts associated with power transmission can be seen in Table 3.81. The ecosystem services that these pressures impact and the relative significance of these impacts are identified in Table 3.82.

3.11.8 Climate change

3.11.8.1 Impacts of climate change on power cables

There are no published data regarding the effects of climate change on power transmission. Climate change is likely to impact on both the installation and maintenance of transmission cables. During the installation of transmission cables increases in the frequency and severity of storms could lead to smaller weather windows. Transmission cables can either be buried under the seabed or laid on top. Increased scour due to changes in the current regime could result in cables becoming uncovered or being suspended unsupported above the seabed leading to possible breakages.

Adaptation measures

There is no published evidence of any adaptation measures related to climate change. It could be necessary to restrict cable laying to certain times of the year to allow safe installation of cables.

Table 3.81 Key environmental pressures and impacts associated with power transmission. Based on information from: Centre for Marine and Coastal Studies (2003); CEFAS (2004); Gill et al. (2005); ABPmer (2007a); Eastwood et al. (2007); Scottish Executive (2007c), BERR (2008a).

Pressure	**Electro-magnetic changes**
Impact	Electromagnetic fields (EMF) causing behavioural changes to electro-sensitive and magneto-sensitive species, for example interfering with their migration patterns and prey detection systems. Electro-sensitive species include elasmobranch fishes such as sharks and rays. Magneto-sensitive species include turtles.
Description of environmental change (intensity, spatial extent, frequency, duration)	Power cables for transmitting electricity produce electric and magnetic fields as a result of the current passing along the conductor and the voltage differential between the conductor and earth ground, which is nominally at zero volts. The nature and strength of the fields produced, depend on the system voltage and current (alternating current (AC) or direct current (DC)) passing through. The effects on the surrounding environment will also depend on cable construction, configuration and orientation in space. Burial of the cables will offer a protective barrier to electro-/magneto-sensitive species from the strongest magnetic and induced electric fields generated next to the cable. Electrical and magnetic fields generated by the operation of wave and tidal devices are likely to be small and within the variation range of naturally occurring fields in the North Sea, but will be detectable to electro-/magneto-sensitive species (Scottish Executive, 2007c). The potential impacts of electric fields from wind farm electric power cables were recently discussed by the OSPAR Biodiversity Committee (OSPAR, 2003). The following conclusions were made, on the basis that cables were buried to a sediment depth of at least 1 m: • medium and high voltage power cables with alternating current have no negative effect on the marine environment during operation; • high voltage power cables with direct current develop significant electromagnetic fields that may be six times greater than background field strength; and • high voltage bipolar direct current cables have a magnetic field strength that is minimal and typically substantially less than background readings.
Existing management measures	Specifically, for cabling activities associated with the offshore wind farm industry, a FEPA (Food and Environmental Protection Act) and CPA (Coast Protection Act) licence is required for: • installation of cables; and • deposition of material for cable/scour protection purposes such as rock armouring and grout bags. Under FEPA, the decision as to whether a licence will be granted will depend on the assessment by the Licensing Authority of potential hydrological effects, risk to fish, mammals and other marine life from contaminants, noise and vibration, effects from potential increases in turbidity, smothering and burial of marine life, any adverse implications to designated marine conservation areas or interference to other marine and coastal users. Under CPA, the Secretary of State must determine whether marine works will be detrimental to the safety of navigation in relation to the cabling installation/ removal activities.

Pressure	**Habitat damage/ change**
Impact	The installation of power cables has the potential to cause physical disturbance of seabed substrata causing sediment redistribution and increased turbidity which could result in alterations to the local habitat and shifts in benthic faunal community structure.
Description of environmental change (intensity, spatial extent, frequency, duration)	The impacts of cables on benthic communities will depend on the sensitivity and conservation status of the species that characterise the communities along the cable route. In general, installation impacts will be localised and temporary. The area of seabed impacted is impossible to quantify at the strategic level, as it is dependent on many project specific factors.
Existing management measures	Potential measures , particularly for intertidal areas include directional drilling

Pressure	**Smothering**
Impact	Smothering can occur within the immediate vicinity of cables, as the coarser fraction of the sediment disturbed is likely to be re-deposited on the seabed close to the works.
Description of environmental change (intensity, spatial extent, frequency, duration)	This impact is only expected to be temporary, as material deposited will be re-suspended and distributed by natural hydrodynamic processes, and will only affect those species/habitats that are sensitive to smothering (Scottish Executive, 2007c)
Existing management measures	See above

Pressure	**Noise and vibration**
Impact	Burial of power cables has the potential to cause noise and vibration causing avoidance of an area, disruption of migratory routes and damage to hearing mechanisms.
Description of environmental change (intensity, spatial extent, frequency, duration)	In the context of offshore wind farm construction, much of the work relating to the impact of noise upon species has focused on the effect of pile driving, as this is by far the 'worst case scenario' in terms of the production of high intensity impulsive sound. Sound levels associated with cable installation have received considerably less attention and very few monitoring data are available. Further information is required on the noise levels associated with other forms of cable installation before any clear guidance on the expected levels of associated disturbance to fish and/or marine mammals can be made. However, the early indications are that there is no significant impact from cable burial noise on fish and marine mammal species. In addition, no harmful events have been reported from the subsea telecommunications industry.
Existing management measures	See above

Table 3.82 Environmental pressures on ecosystem services associated with aquaculture.

Ecosystem service	*Significance of impact*	*Confidence in understanding of the relationship = information gaps*
Biological productivity	**Minimal.** Spatial extent is limited, but disturbance of physical environment could damage the habitat of specific species during laying and/or operation.	**Low.** Exact impacts uncertain, but good knowledge of extent of impacts (locations of power cables)
Biodiversity provision	**Low – Moderate.** Laying and/or operation of power cables may disrupt behaviour of some species through noise, electromagnetic fields and physical disturbance. But spatial extent is limited and impacts are unlikely to go above threshold disturbance levels. Electromagnetic disturbance could also alter the composition of species in the immediate vicinity of cables.	**Moderate.** Exact impacts of, for example, electromagnetic fields is uncertain, but there is a good knowledge of the extent of impacts (locations of power cables)
Physical environment	**Low.** Spatial extent is limited, but impacts are clear via smothering, habitat damage, and vibration.	**Low.** Exact impacts uncertain, but good knowledge of extent of impacts (locations of power cables)

Sediment modelling studies could be necessary to ensure that cables do not become exposed on the seabed. If large amounts of stress are exerted it may be necessary to increase the resilience of the cables.

3.11.8.2 Impacts of power cables on climate change

Emissions arise from shipping used to install the cables, although this cannot be quantified specifically for cable installation (see Section 3.7: Maritime Transport).

Mitigation measures

It has not been possible to identify mitigation measures specifically related to the installation of power transmission cables (for general details related to shipping see Section 3.7: Maritime Transport).

3.11.8.3 Summary

Table 3.83 provides a summary of climate change pressures and impacts and indicates the likely significance of the impacts, the level of confidence in the assessment and measures that might be employed to manage the impacts (see Annex 1 for a discussion of the assessment methodology).

3.11.9 Industry stability and sustainability

3.11.9.1 Objectives, targets and indicators

The earlier Energy White Paper (DTI, 2003b) included the following goals:

- To put ourselves on a path to cut the UK's carbon dioxide (CO_2) emissions by some 60% by about 2050, achieved through reducing energy use and development of renewable energy generation schemes.
- To maintain the reliability of energy supplies so that people and businesses can rely on secure supplies of energy.
- To raise the sustainable rate of economic growth and our industrial and business competitiveness through competitive energy markets that are reliable and affordable.
- To achieve our social objectives and ensure that every home is adequately and affordably heated.

Table 3.83 Summary of climate change implications.

Climate change pressure	*Impacts of climate change on Power Transmission*	*Confidence / significance*	*Adaptation measures*
Increase in severity of storms	Scour around cables leading to undermining and breakage. Uncovering of buried cables.	Low confidence / medium significance	Burial of cables, avoidance of areas with high scour potential.
	Increases in horizontal currents lead to breakage of cables.	Low confidence / medium significance	Burial of cables, avoidance of areas with high scour potential, use of stronger materials during construction.
	Shortening of suitable calm weather periods during which cables can be laid	Low confidence / low significance	Avoidance of periods of bad weather.

Impacts of Power Transmission on climate change	*Climate change pressure*	*Confidence / significance*	*Mitigation measures*
CO_2 emissions from shipping used to install cables	CO_2 emissions	Low confidence / unknown significance	Improved efficiency of shipping

The UK Energy Sector Indicators were developed at the same time in order to monitor annual progress towards these goals. These have been reported on since 2004. While there are no direct indicators relating to power cables, the role of power cable interconnectors in meeting these objectives has been described in Section 3.11.6. The White Paper recognises that a significant investment will need to be made in the transmission network over the coming years, in particular to connect renewable energy projects, including marine developments. Over the period 2007-12 the Office of the Gas and Electricity Markets (Ofgem) has provided for capital investment of up to £4.3 billion in the electricity transmission network, an increase of 160% over the previous 5-year price control period, with much of this investment planned for Scotland. The EU is seeking to build more interconnectors to create a single integrated electricity market and to increase cross-border electricity exchange.

3.11.10 Forward look

3.11.10.1 National

The largest growth in this sector is likely to result from the installation of offshore renewable energy arrays. For example, the South West of England Regional Development Agency is currently tendering for the design and supply of a submarine cable for a proposed testing facility for wave devices, Wave Hub, off from Hayle in Cornwall. The contract for the materials alone is advertised to be worth £8 to £13 million.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the

power transmission sector will need to further manage its activities. For example, GES 6 states that sea floor integrity is at a level that ensures that the structure and functions of ecosystems are safeguarded and benthic ecosystems in particular are not adversely affected. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.11.2 International

In 2001, National Grid and Eirgrid (the Republic of Ireland's grid operator) completed a feasibility study into the construction of a 130 km, 500 MW interconnector between Ireland and Wales. National Grid remains interested in this project, which has recently been endorsed by the Irish government. The feasibility study was partly funded by the European Commission's Trans European Networks – Energy (TEN-E) programme.

In 2003, National Grid and Statnett (the Norwegian grid operator) obtained environmental permits for a 1200 MW interconnector between Easington, County Durham, and Suldal in Rogaland County. At the time, however, it was not possible to find a commercial structure that satisfied the requirements of National Grid, Statnett and the Norwegian Government. National Grid and Statnett are continuing to study alternative structures that would make the construction of this project possible. The development and environmental permitting of this project was partly funded by the European Commission's TEN-E programme.

In May 2007, National Grid announced that it would be proceeding with the BritNed interconnector between the UK and the Netherlands. This is a joint venture with Dutch TSO TenneT and is expected to be completed by late 2010. The project represents an investment of €600 million. The cable will be 260 km long with a capacity of 1000 MW. The link will run beneath the North Sea between the Isle of Grain in Kent to Maasvlakte, near Rotterdam.

Furthermore, a consultation was launched on 8 September 2008 by the operators of the existing England–France link to assess opportunities for a second 1300 MW capacity interconnector (Geode, 2008).

It is likely that investment in the activities described in this section will be affected by the downturn in the economy in the short term, but long-term drivers for competitive electricity markets are likely to maintain the impetus towards increasing the level of interconnector capacity.

3.12 Renewable Energy

3.12.1 Key points

- The UK has among the highest levels of exploitable renewable energy resources in the world, potentially making it a global leader in this area
- The resources include wind, wave, tidal stream and tidal range
- There are ten offshore wind farms with an installed capacity of 0.7 GW of electricity
- The estimated turnover of the resultant output is £165 million with £50 million Gross Value Added (GVA)
- There are targets to increase the total installed capacity to 33 GW by 2020
- The UK target is to achieve at least 15% of its total energy needs from renewable energy sources by 2020
- Twelve offshore wind farm projects are either in the process of being constructed or have been consented. A further 17 wind farm projects are in the planning process. If all projects are realised, the total installed capacity will increase to over 14 GW
- Round 3 wind farms may add more than 30 GW of additional generating capacity
- The extraction of energy from renewable sources lessens UK dependence on fossil fuel energy that has much higher associated carbon emissions and improves energy security by increasing the diversity of supply
- Ongoing financial incentives such as the Renewables Obligation Certificates (ROCs), the Scottish Government's Saltire Prize and the Marine Renewables Deployment and Proving Funds will continue to provide support for the industry

i. Introduction

The UK has among the highest density of exploitable renewable energy resources in the world, and has the potential to become a global leader in both engineering development and energy production. The resources include wind (on both coasts); wave (mostly on the west coast); tidal stream (focussed inshore around headlands and in sounds such as Pentland Firth) and tidal range (particularly in the Severn and Mersey estuaries).

ii. How has the assessment been undertaken?

Information on the spatial distribution of existing and proposed wind farms was provided by The Crown Estate (TCE). Distribution of wave and tidal resources was provided by the UK Renewables Atlas (see Section 3.12.4).

iii. Current status of the renewable energy sector

As at 2 December 2009, there were ten offshore wind farms operating 228 turbines with a total installed capacity of 0.7 GW of electricity (two are small demonstrator projects). A further 1.7 GW of capacity was under construction; 2.9 GW had been consented, and around 9.9 GW was in planning and pre-planning processes across the UK. The estimated direct turnover for the industry from current generating capacity is £165 million and GVA is £50 million with additional indirect turnover

from manufacturing and installation (see Section 3.12.3). Although the location of wind, wave and tidal resources is well understood, the location of economically viable renewable energy projects is constrained by a number of other technical factors, such as the capacity of national grid networks, sea conditions and other existing sea users like fisheries and shipping (see Section 3.12.4). The majority of current economic value is related to wind energy developments and is therefore mainly located in Region 2 (southern North Sea) and Region 5 (Irish Sea). Development of wave and tidal power schemes is supported by testing facilities such as the European Marine Energy Centre in Orkney and the New and Renewable Energy Centre in north east England.

iv. What is driving change?

The rapid growth of this sector has been aided by governmental support for energy generation from renewables, involving financial investment and planning and policy initiatives that help to encourage much-needed private investment (see Section 3.12.9). The main driver is the EU 2008 integrated energy and climate change policy under which the UK target is to achieve 15% of its total energy needs from renewable energy sources by 2020. Targets are much higher than this in some parts of the UK with Scotland aiming for 20% by 2020 and Northern Ireland 40% by 2025. The extraction of energy from renewable sources lessens UK dependence on fossil fuel energy that has much higher associated carbon emissions and improves energy security by increasing the diversity of supply.

v. What are the uncertainties?

The industry is currently developing very quickly, in terms of installation, policy and regulation, with the consequence that information may become quickly out of date. Wave and tidal power in particular are fledgling industries with enormous potential and strong government support, aimed at helping prove these technologies and overcoming uncertainty around limited long-term investments in the current economic climate. There is also some uncertainty around environmental pressures such as hydrodynamic changes, construction noise, and collisions by birds or marine mammals with devices that tend to be device and site specific. However, these are being addressed by detailed monitoring programmes and coordinated research initiatives.

vi. Forward look

Twelve offshore wind farm projects are either in the process of being constructed or have been consented and another 17 are in the planning process. The total capacity from all these wind farms will be over 14 GW. This does not include Round 3 wind farms which may add an additional 30 GW generating capacity. There are strong targets to increase total capacity to 33 GW or more by 2020. Ongoing financial incentives such as the Renewables Obligation Certificates (ROCs), the Scottish Government's Saltire Prize and the Marine Renewables Deployment and Proving Funds will continue to provide support for the industry over this period.

3.12.2 Introduction

The Energy Act 2004 defines 'renewable energy installation' as ...*an offshore installation used for purposes connected with the production of energy from water or winds*. The main end uses include fuel (for heat and transport) and electricity. The rapid growth of this sector has been aided by governmental support for energy generation from renewables to meet the EU 2008 integrated energy and climate change

policy under which the UK target is to achieve 15% of its total energy needs from renewable energy sources by 2020.

An array of wind energy devices is usually referred to as an offshore wind farm (OWF). The term offshore (as defined in the Energy Act 2004) is simply used to differentiate between onshore and offshore wind devices.

In the future it is also possible that marine algae (seaweeds and phytoplankton) might be harvested as a form of biomass energy. Forms of marine thermal energy are not likely to be exploited around the UK as this requires a minimum temperature difference of 20 °C between the sea surface and deep water.

3.12.2.1 Description of economic activities

The principal economic activity is the extraction of energy from the sea and its environs for electricity. Ancillary supporting activities include the construction and decommissioning of fixed structures such as platforms to support wind turbines and installation of associated shore cables. Secondary activities include the transmission of electricity to the distribution system. The range of activities is listed in Table 3.84.

3.12.2.2 Description of relevant ecosystem services

As well as economic services, the renewable energy sector also relies on various ecosystem services that support its productivity, including:

- Physical environment (provision of a stable physical environment in which to operate)
- Geomorphological processes (to provide shallow-water locations for OWFs)
- Climate regulation

3.12.2.3 Management

Energy policy, including renewable energy is now dealt with by the Department of Energy and Climate Change (DECC) which took over the energy portfolio from the Department for Business Enterprise and Regulatory Reform (BERR) in 2008. Prior to the establishment of BERR in 2007, energy issues were dealt with by the Department of Trade and Industry (DTI). Although the names of the departments changed it was essentially the same team of people involved, providing important continuity in the management process. The Scottish Executive takes decisions on developments in Scottish waters (out to 200 nm) through the Marine Energy Spatial Planning Group (MESPG). Energy policy in Northern Ireland is a devolved matter and the Department of Enterprise, Trade and Investment (DETI) has responsibility for energy policy and legislation.

Under The Crown Estate Act 1961, TCE is landowner of the UK seabed and areas of foreshore. The placement of renewable energy structures and associated power cables on the seabed therefore requires its permission as landlord in the form of a site option Agreement and Lease (the latter is finally granted when all necessary statutory consents are obtained by the developer).

Energy installations in the marine environment typically require a number of consents:

- A consent under Part II of the Food and Environment Protection Act (FEPA) 1985 for the placement and construction of structures in the sea or in the seabed.
- A consent under section 36 of the Electricity Act 1989 for the construction and operation of an offshore power station with a nominal capacity in excess of 1 MW (in future, by order under the Planning Act 2008 for projects with

Table 3.84 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Renewable Energy Production of electricity from wind, wave and tidal energy (SIC 35.11)	Construction of marine energy installations. Decommissioning of structures	Transmission of electricity to distribution system (SIC 35.12 – see Power transmission)	Sales activities and agents

a capacity of more than 100 MW or under the Marine and Coastal Access Act 2009) or under the Transport and Works Act.

- In some cases planning permission for associated onshore works under sections 57 or 90(2) of the Town and Country Planning Act 1990. It is also possible to obtain deemed planning permission under section 90 of the Town and Country Planning Act 1990 if a section 36 consent is granted.

An amendment by virtue of the Energy Act 2004 negates the need for a consent under section 34 of the Coast Protection Act (CPA) 1949.

The key consents typically have strict environmental mitigation and monitoring requirements and conditions attached to them (see Section 3.12.7).

The Energy Act 2004 provided for the designation of Renewable Energy Zones from 12 nm out to 200 nm in which rights, under Part V of the UN Convention on the Law of the Sea (UNCLOS), may be exercised to exploit water or wind energy. To manage such development of the seabed, TCE announced a round of competitive processes for OWF lease options (the first being in 2001, which covered projects in territorial waters only). Round 1 full term leases are for 22 years including decommissioning. Round 2 leases are for 40 or 50 years depending on the size of project (projects of 500 MW and above have 50 year leases, the smaller projects have 40 year leases). For Round 3, TCE proposes that development could be undertaken within exclusive Zones with the aspiration of providing an additional 25 GW of energy generating capacity (combined total from Rounds 1, 2 & 3 is likely to require in excess of 3000 turbines)[24]. A separate round was also announced in February 2009 for Scottish Territorial Waters (The Crown Estate, 2009) involving agreements for ten sites that may generate 6 GW in total. These rounds did not, however, include Northern Ireland waters.

In English and Welsh waters, DECC is responsible for consenting under the Electricity Act 1989, through its Offshore Renewables Consents Energy Development Unit, which acts as a central point for all OWF consent applications. DECC works closely with the Marine and Fisheries Agency (MFA), which licenses a number of activities in the marine environment on behalf of the Secretary of State for Environment, Food and Rural Affairs, and the Welsh Assembly Government, which undertakes similar licensing in Welsh waters under the Food and Environment Protection Act 1985. On 10 December 2007, BERR launched a Strategic Environmental Assessment (SEA) of UK waters to explore the potential deployment of 25 GW of new offshore wind energy, in addition to existing plans for 8 GW. This process has now concluded and on 24 June 2009 the Government announced their decision to proceed with the plan/programme, accepting the SEA's conclusion that this level of development would

24 Comments provided by Cefas

be permissible without causing unacceptable impacts. In addition, DECC published a policy document which sets out the Government's response to the recommendations contained in the SEA Environmental Report and draws together the key ongoing and planned work to enable large-scale deployment of offshore wind power generation systems (DECC, 2009a). DECC also regulates the decommissioning of renewable developments.

In Scottish territorial waters Scottish Ministers are responsible for Electricity Act 1989 consent decisions and Marine Scotland for FEPA licence decisions. The Offshore Energy SEA by DECC covers wind farms in the Scottish Renewable Energy Zone. An additional SEA is also being undertaken for offshore wind energy in Scottish Territorial waters.

DETI in Northern Ireland is also undertaking an SEA for offshore wind power and marine renewables which will lead to the development with TCE of a competitive call for project proposals in January 2010.

The renewable energy industry in the UK is represented by a number of associations; the most notable being the British Wind Energy Association (BWEA), the Renewable Energy Association (REA) and Scottish Renewables.

Understanding of the potential environmental impacts of offshore wind farms has been assisted by funding provided by the Collaborative Offshore Wind Research into the Environment (COWRIE). COWRIE is an independent charity governed by a Board of Directors drawn from TCE, DECC and the BWEA (see Section 3.12.7 for more details).

3.12.3 Direct use value

Table 3.85 shows that 228 offshore wind turbines were operational by December 2009, providing an installed capacity of 0.674 GW over a total maximum area of 70 km^2 (updated from OSPAR, 2008c). A further 1.7 GW of renewables capacity was under construction; 2.9 GW had been consented, and around 9.9 GW was in planning and pre-planning processes across the UK.

Assuming a 35% output from the installed capacity (Ernst and Young, 2007), this installed capacity is capable of providing roughly 2066 GWh of electricity. This compares with a total of 21 597 GWh which was produced from renewable resources in 2008 (5.5% of the UK electricity supply) including energy from hydroelectricity schemes, landfill gas, photovoltaics and biofuels (DECC, 2009b). In relation to the marine environment the development type that has advanced the furthest in terms of installation and operation is offshore wind farms.

3.12.3.1 Principal activities

Wholesale electricity prices in the UK are difficult to summarise in a single figure because they vary so much. In 2008, wholesale electricity spot prices ranged from £130 per MWh in October 2008 down to £40 per MWh in April 2009 (RWE, 2009). Assuming that the electricity generated (2066 GWh) is sold at an average supply cost of £80 per MWh gives an estimated turnover for the industry of £165 million. The GVA for the electricity generated offshore is £50 million assuming a value-added factor of 0.30 (from the whole electricity-generating sector).

Table 3.85 Generation capacity and size of existing offshore wind farms and current and proposed installation projects (as at December 2009) with the estimated level of investment.

Project	*Capacity, MW*	*Number of turbines*	*Max area, km²*	*Status*	*Investment, £million*
North Hoyle, NW Region	60	30	10	Round 1. Operational 2003	80
Scroby Sands	60	30	10	Round 1. Operational Dec 2004	75.5
Kentish Flats, Thames	90	30	10	Round 1. Operational 2005	105
Blyth Offshore, NE Region	4	2		Demonstrator. Round 1. Operational 2000	7
Barrow, NW Region	90	30	10	Round 1. Operational March 2006	100
Burbo Bank, NW Region	90	25	10	Round 1. Operational 2007	90
Beatrice, Moray Firth	10	2		Demonstrator. Operational	30
Lynn, Greater Wash	90	27	10	Round 1. Operational 2009	300
Inner Dowsing, Greater Wash	90	27	10	Round 1. Operational 2009	
Rhyl Flats, N Wales	90	25	10	Round 1. Operational Dec 2009	190
Total operational	674	228	80		
Robin Rigg, Scotland	180	60	10	Round 1. Partly operational, partly under construction	500
Gunfleet Sands I & II, SE Region	172	48	10	Round 1 & 2. Partly operational, partly under construction, completion due 2010	167[a]
Thanet, Thames	300	100	35	Round 2. Under construction, completion due 2010	450
Greater Gabbard, Thames	504	140	147	Round 2. Under construction, completion due 2012	1300
Sherringham Shoal, Greater Wash	315	88	35	Round 2. Under construction, completion due 2011	1000
Ormonde, NW Region	150	30	10	Co-generation project. Under construction, due 2011	
Teeside/Redcar, NE Region	90	30	10	Round 1. Consented. Under construction	
Total under construction	**1711**				
Walney, NW Region	367	102	73	Round 2. Consented. Construction due in 2010	453[a]
West Duddon, NW Region	500	140	67	Round 2. Consented. Construction in 2010	
London Array	1000	271	245	Round 2. Consented. Construction due in 2010	1500
Gwynt Y Mor, NW Region	750	250	124	Round 2. Consented. Construction planned 2011	
Lincs, Greater Wash	250	41-83	35	Round 2. Consented. Construction planned 2011	
Total consented	**2867**				
Docking Shoal, Greater Wash	500	100	75	Round 2. S36 Consent submitted. Construction planned 2011	

Project	*Capacity, MW*	*Number of turbines*	*Max area, km²*	*Status*	*Investment, £million*
Humber Gateway	300	70	35	Round 2. Consent submitted 2008. Construction due 2011	
Dudgeon, Greater Wash	560	168	35	Round 2. S36 Consent submitted 2009	
Race Bank, Greater Wash	620	88	53	Round 2. S36 Consent submitted, Construction planned 2011	
Triton Knoll, Greater Wash	900–1200	286	207	Round 2. Site awarded. Consent due 2010, Construction planned 2011	
Westermost Rough	180–240	80	35	Round 2. S36 Consent submitted, Construction planned 2012	
Aberdeen (Scottish European testing centre)	<95	<23		Demonstrator. Planning stage	€40 million
Solway Firth, Scotland – E.On	300	100	61	Planning	
Wigtown Bay, Scotland – Dong	280		51	Pre-Planning	
Kintyre, Scotland – Airtricity	378		69	Pre-Planning	
Islay, Scotland – Airtricity	680		95	Pre-Planning	
Argyll Array, Scotland – Scottish Power Renewables	1500		361	Pre-Planning	
Beatrice, Scotland – Airtricity & SeaEnergy Renewables	920		121	Pre-Planning	
Inch Cape, Scotland – NPower & SeaEnergy Renewables	905		150	Pre-Planning	
Bell Rock, Scotland – Airtricity & Fluor Ltd	700		93	Pre-Planning	
Neart na Gaoithe, Scotland – Mainstream Renewable Power	360		105	Pre-Planning	
Forth Array – Fred Olsen Renewables	415		128	Pre-Planning	

[a] Converted from DKK 3800 to GBP equivalent as follows: 1 British pound = 8.386 Danish Krone as at 05/03/09 Bank of England Statistics Database.

3.12.3.2 Ancillary activities

BERR (2007) estimate that around £1 billion was either invested or committed to new UK renewable projects in 2006/07. Offshore wind projects are listed in Table 3.85. Some of the estimated investments are also indicated.

Investments for other renewable energy projects include an estimated £8.5 million for Marine Current Turbines' (MCT) tidal device 'SeaGen' in Strangford Lough (www.power-technology.com/projects/strangford-lough/) and the Wave Dragon demonstrator device off the coast of Pembrokeshire with a capital value of £14 million (PMSS, 2007). In addition, the Scottish Government has issued grants worth around £1.5 million to wave and tidal demonstration projects to date under its Wave and Tidal Energy Support scheme.

Renewable energy projects are highly dependent on access to the National Grid which requires significant investment to provide the capacity necessary to support new projects. As part of an EU Recovery Plan funding package released 28 January 2009, the European Commission proposed €150 million to increase the overall capacity of the North Sea grid and fund the demonstration of a virtual 1 GW power plant.

3.12.4 Regional distribution of value

The location of renewable energy projects is constrained by a number of factors including: the distribution of wind, wave and tidal resources; technical constraints such as grid connection and capacity, connection to ports and supply chain, and seabed characteristics; operational constraints such as metocean characteristics and water depth; socio-economic factors such as navigation routes and protected wrecks; and designated sites and features for marine nature conservation.

3.12.4.1 Wind

Existing wind farms and possible areas for Round 3 development are listed in Table 3.85 and illustrated in Figure 3.45. Most developments have been focused around the coasts of England, where water depths make construction simpler. North Hoyle off the North Wales coast was the first major UK offshore wind farm commissioned in 2003 (Table 3.85). In Scotland, the west coast has the best available wind resources. Northern Ireland's offshore wind resources will be confirmed as part of the current SEA work.

3.12.4.2 Wave and tidal

Given that there are few wave and tidal devices currently in the water, and that they are largely demonstration devices (i.e. small scale deployments of single devices in order to test operation in the marine environment), distribution of potential value is best indicated by the distribution of wave and tidal resources around the UK (Figures 3.46 and 3.47).

A main area for the testing of wave and tidal stream demonstrator devices is the European Marine Energy Centre (EMEC) in Orkney. The centre has two sites, one with wave resources and one with tidal stream resources, where developers can install their devices on the seabed and effectively connect to a sub-sea power cable network (devices tested here include Pelamis Wave Power's 0.75 MW wave energy device and Open Hydro's 0.25 MW Open-Centre Turbine). This links to an inshore testing station that provides monitoring services and connection to the national grid. Another testing facility, the New and Renewable Energy Centre (NaREC) in north east England provides a purpose-built large scale wave flume and offers controlled large-scale testing of tidal stream devices using the Tees Barrage lock

Figure 3.45a Existing wind farms and possible areas for Round 3 development (Regions 1, 6 and 7).

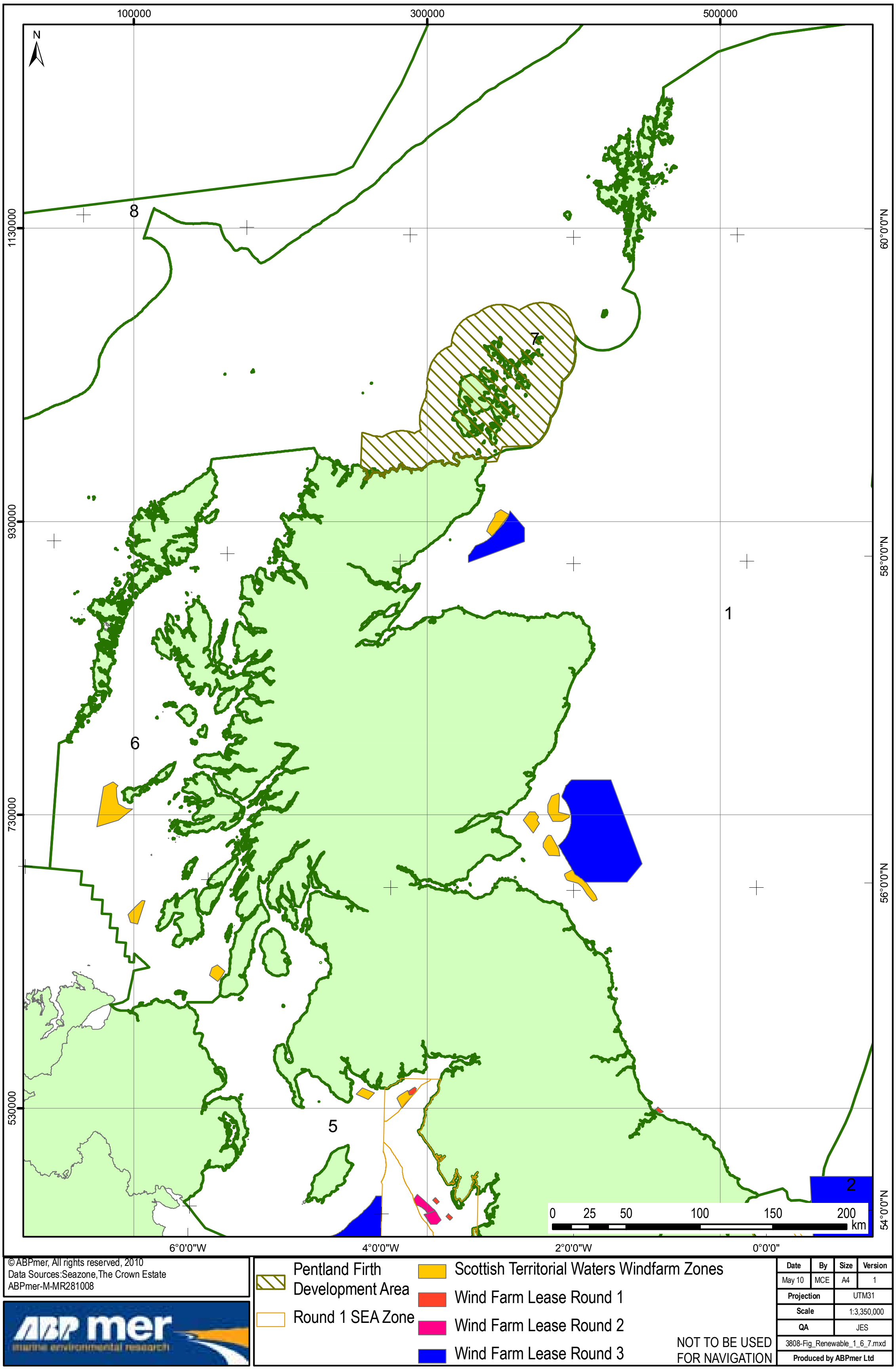


Figure 3.45b Existing wind farms and possible areas for Round 3 development (Regions 2 and 3).

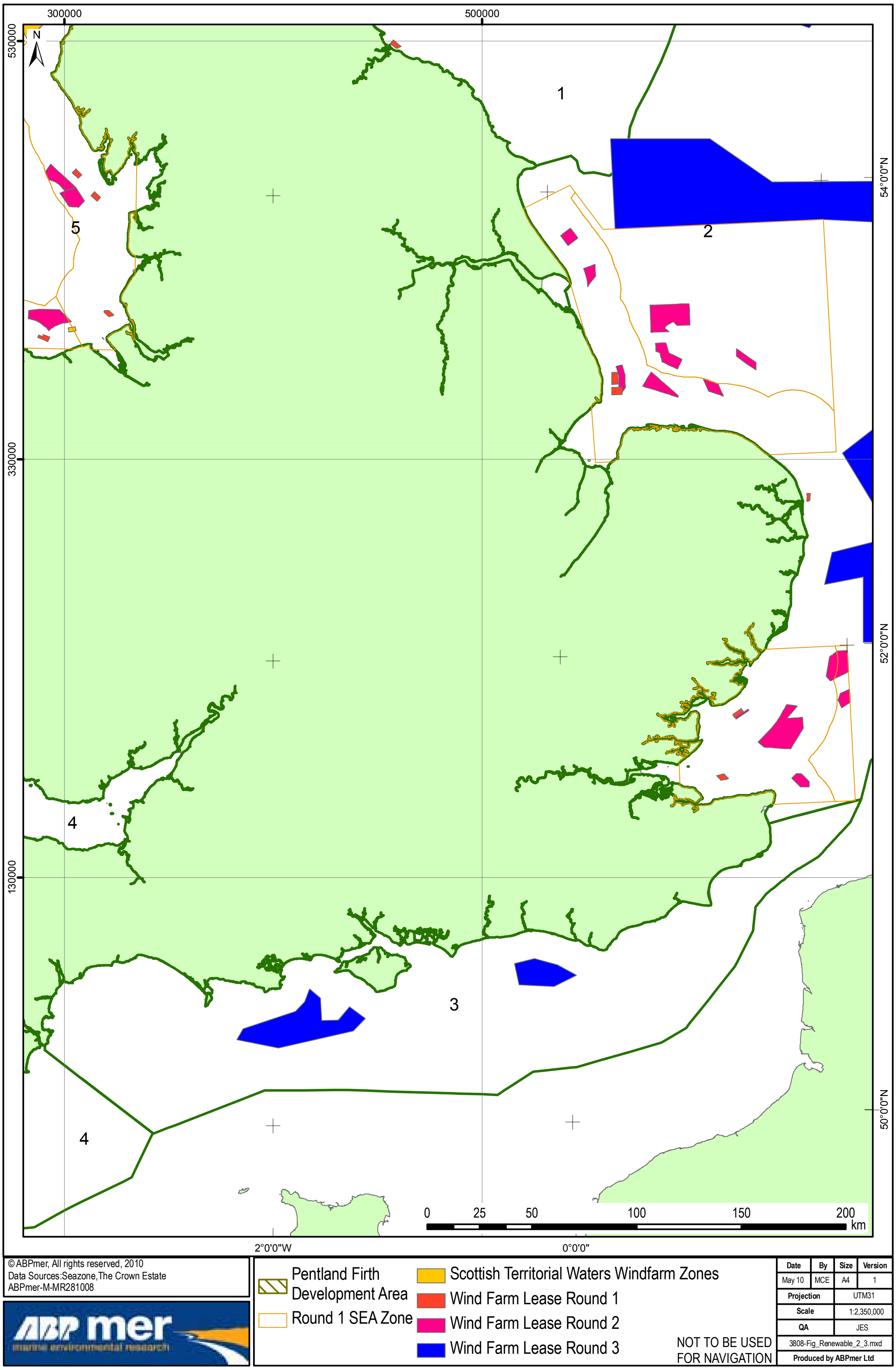


Figure 3.45c Existing wind farms and possible areas for Round 3 development (Regions 4 and 5).

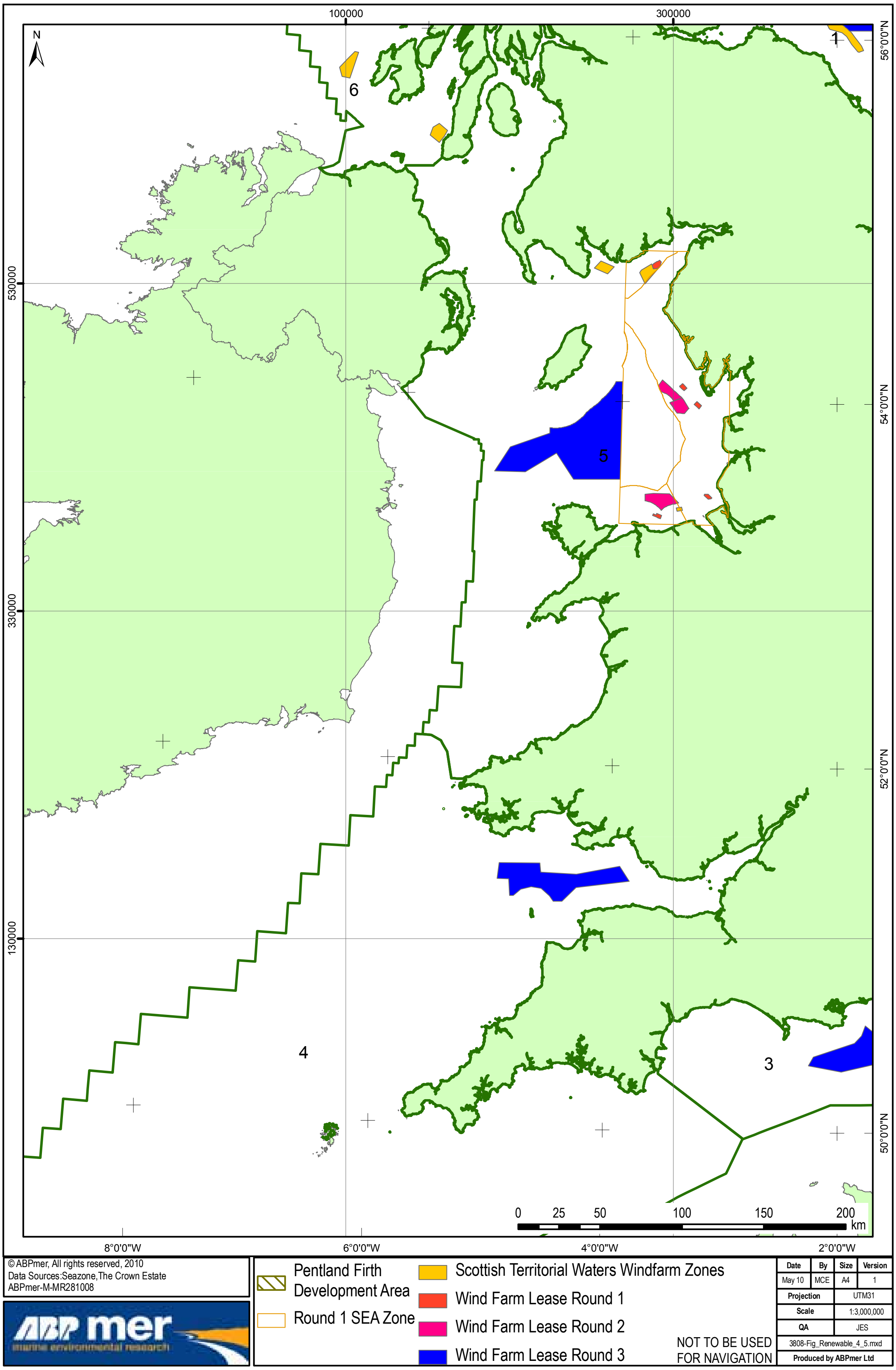


Figure 3.46 Distribution of wave resources around the UK.

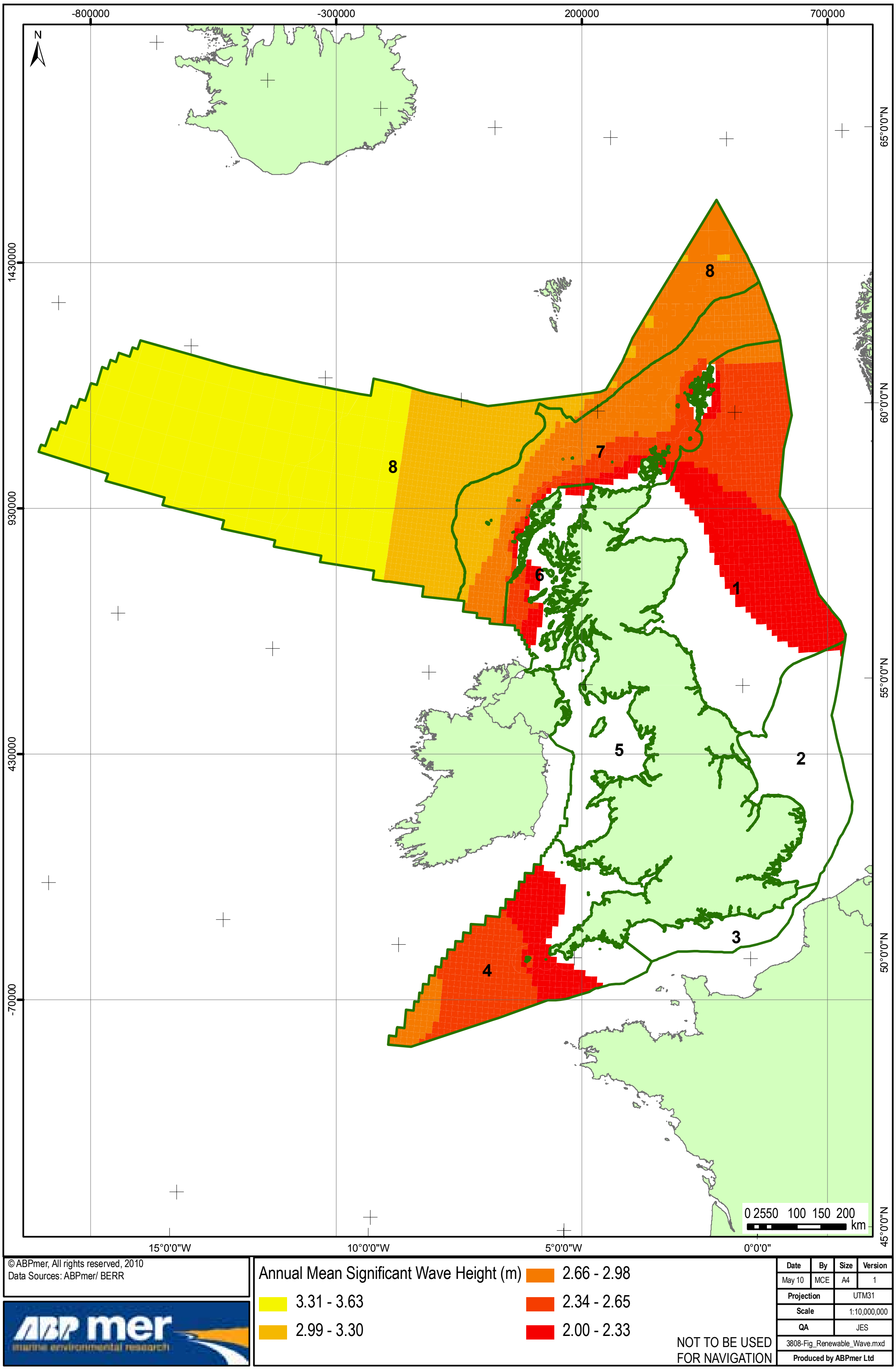
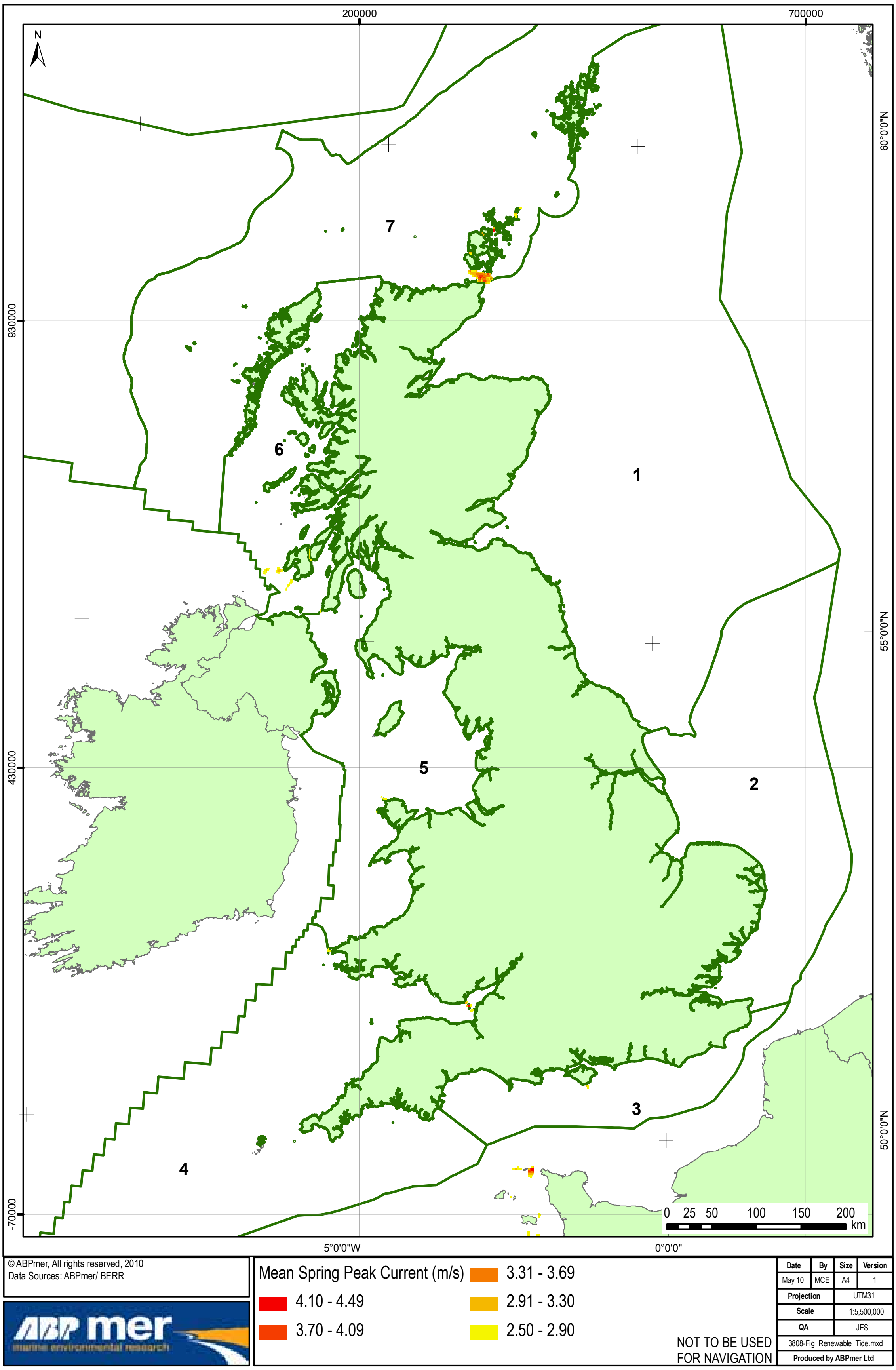


Figure 3.47 Distribution of tidal resources around the UK.



infrastructure. Wave Hub, is under construction off the coast of Cornwall and will provide offshore infrastructure for the testing of wave devices. Such full-scale, at-sea testing facilities are seen as vital to 'de-risk' the technology and attract the necessary private sector investment by demonstrating the commercial viability of devices. In addition to this, demonstrator projects are located in Islay, Scotland (Wavegen's 500 kW 'Limpet' device, operational since 2000, www.wavegen.co.uk/what_we_offer_limpet_islay.htm); Clestrain Sound, Orkney (ongoing testing of ScotRenewables' Tidal Turbine; www.scotrenewables.com/marine.html); Humber Estuary (Pulse Tidal's Pulse Stream 100 kW device – a shallow-water oscillating hydrofoil design) and Strangford Lough, Northern Ireland (www.marineturbines.com/).

The Pentland Firth has some of the strongest tidal streams around the UK (BERR, 2007). TCE announced in November 2008 a round of option leases for tidal stream energy development in the Pentland Firth and received a total of 42 bids. Awards will be notified in 2009.

The tidal range in the Severn Estuary could potentially supply up to 5% of the UK electricity demand. The Severn Tidal Power feasibility study, led by DECC, is investigating a number of tidal power options for the estuary including barrages (generating capacities ranging from 0.6 to 14.8 GW), lagoons (capacities of 0.76 to 1.36 GW) as well as other technologies. The Government Response to an initial public consultation on the options was published in July 2009 (www.decc.gov.uk/severntidalpower) and outlined the following schemes for further consideration in a high-level impact analysis: the Cardiff-Weston barrage (commonly known as 'The Severn Barrage'); two smaller barrages ('Shoots' and 'Beachley'); and two lagoons (one across Bridgwater Bay and one across the Welsh Grounds, roughly between Newport and Caldicot).

The Government is also supporting the further development of two designs for a tidal fence and a low-head barrage and has also provided a feedback loop for excluded schemes, particularly offshore tidal lagoons, to see whether they could become feasible for locations in the Severn Estuary as the evidence base develops.

A recent study by the University of Liverpool (Burrows et al., 2008) has also identified scope to generate electricity from tidal sources in the Irish Sea. The study showed that four estuary barrages – across the Solway Firth, Morcambe Bay, and the Mersey and Dee estuaries – could be capable of meeting half the north west region's needs, and 5% of the UK's energy needs. The Northwest Regional Development Agency has commissioned a £100 000 feasibility study, the Solway Energy Gateway, specifically investigating options on the Solway Firth.

Northern Ireland's offshore marine resources, in particular tidal, will be confirmed as part of the current SEA work.

3.12.4.3 Summary

Table 3.86 provides the spatial distribution of wind farm leases and wave and tidal resources in each CP2 Region. This illustrates that the key wind resources are to the east and west of the country in Regions 2 and 5. There is some installed capacity in these areas already providing 98% of the total capacity of 584 MW. Future developments in Scotland and under Round 3 projects may increase the proportional contribution from Region 1.

Table 3.86 Spatial distribution of activity and resources.

CP2 Region	Existing grid-connected capacity, MW	Turnover (GVA) £million[a]	Round 1 & 2 Wind farm leases, % of total lease area	R3 Wind farm zones, % of total R3 area	Wave resource, % of total UK resource	Tidal resource, % of total UK resource
1	14	3.4 (1.0)	1	15	17	3
2	330	80.9 (24.3)	73	69	0	0
3	0	0	0	4	0	2
4	0	0	1	4	11	9
5	240	80.9 (24.3)	25	8	0	4
6	0	0	0	0	2	26
7	0	0	0	0	18	56
8	0	0	0	0	52	0
Total	**584**	**165.2 (49.6)**	**100**	**100**	**100**	**100**

[a] See Section 3.12.3 for assumptions made in calculating market value and GVA from installed capacity.

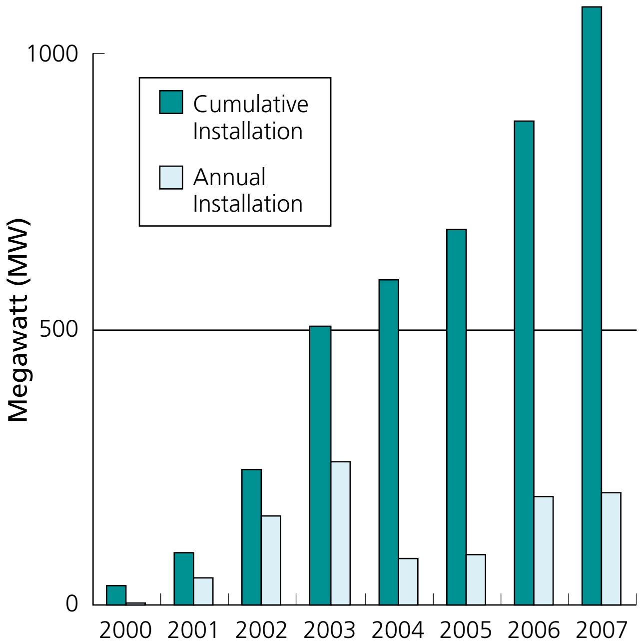
A large amount of wave resource is located offshore in Region 8 (Rockall Bank and NW Approaches), however, with existing technology and installation costs it is unlikely that developments will proceed so far offshore in the immediate future. Prototype testing has been focussed on inshore resources in Region 4 (SW approaches and Celtic Sea where Wave Hub has been proposed) and Region 7 (North Scotland where EMEC has a testing facility). Tidal stream resources tend to be highest around the Western Scottish Isles (Regions 6 and 7) particularly focussed around headlands and narrows such as Pentland Firth. Regional distribution of development is currently restricted due to limitations in the national grid network in receiving and transmitting power from remote areas.

Applying the same assumptions used for the total principal value (see Section 3.12.2), the economic value from the installed and grid-connected capacity within each CP2 Region can be calculated (see Table 3.86). The majority of value is related to existing wind developments in Regions 2 and 5.

3.12.5 Trends

In 2006, electricity supplied from sources eligible under the Renewables Obligation (RO) stood at around 4% of the UK's total, up from 1.8% in 2002 (BERR, 2007). The rate of installation of renewable energy installations has also increased; the first GW of wind energy took around 14 years to become operational and the second only 20 months (BERR, 2007). Between 1996 and 2003 the overall use of renewable sources of energy increased at 14.5% per year. This rate increased to 22% per year between 2003 and 2005 (Pugh, 2008). Figure 3.48 presents European Wind Energy Association (EWEA) data showing increased development through the 2000s.

Figure 3.48 Installed offshore wind capacity in Europe, 2000-2007. Source: OSPAR (2008a).



3.12.6 Socio-economic pressures and impacts (positive and negative)

A number of constraints (see Section 3.12.4) can influence the location of arrays and associated cable landfall. This can have knock-on socio-economic (and environmental) consequences. Positive pressures include the following:

- *Employment*: Provided through manufacturing of wind turbines, construction, operation, maintenance and removal of turbines, research and monitoring. Pugh (2008) gave a value of £2.56 million for staff costs based on an estimated 8% of total turnover. As a more specific example, Wave Hub is estimated to provide an additional 24 jobs per £1 million of expenditure although this would only last for the duration of construction, i.e. 2 years (Halcrow, 2006).
- *Local business*: Wave Hub, a testing facility proposed off the coast of Cornwall, is forecast to provide an additional £5 million GVA in the local region in supporting project construction (Halcrow, 2006).
- *Diversity of supply*: Inputs from renewable energy sources contribute to the overall diversity of supply. In 2006, 36% was generated by gas-fired power stations, 37% from coal, 18% from nuclear, and 4% from renewables (BERR, 2007). Diversity of generation lessens the risks associated with heavy dependency on a single fuel or technology type, helping to maintain secure supplies of electricity. Diversity also provides the system with the flexibility to respond to variations in demand at different times of the day (i.e. at peak *vs*. non-peak times), or year (i.e. in winter *vs*. summer), and in response to changes in fossil fuel prices. However, some renewable resources, such as wind, are both spatially and temporally variable in magnitude and the security of supply benefits must be weighed against potential disadvantages arising from having a larger proportion of UK electricity generation coming from such changeable sources.
- *Coastal defence*: There is also potential for renewable energy devices (in particular tidal range devices such as barrages and oscillating water column devices such as Limpet – www.wavegen.co.uk/what_we_offer_limpet_islay.htm) to protect the coastline from exposure to increasing storm severity and frequency that may result from climate change (see Case Study 6 and Section 3.12.8). There will be a need to assess and balance any wider negative and positive impacts and they will be strongly site specific (see Spalding and de Fontaubert (2007) for options to resolve conflicts).

- *Tourism*: OSPAR (2004b) highlighted the potential to develop tourism associated with boat trips to wind farm sites. The potential associated with wet renewable energy has not been explored, however many devices are underwater and therefore not visible.

As part of the licensing process a developer may choose to apply for a section 36A declaration to extinguish the common law public right of navigation through the areas where individual turbines and ancillary development are located. Where there is an overlap with other economic activities there is the potential for negative impacts on these economic activities as well as marine aggregate dredging and the laying of telecom and power cables and pipelines.

However, at the start of the Round 1 lease options, the BWEA initiated a 'stakeholder dialogue' with more than 200 interested parties including fishermen and other marine users. This resulted in Best Practice Guidelines (BWEA, 2002) that outline a process for addressing the concerns of other sea users who might be affected by offshore wind energy developments. In particular, liaison groups called FLOWW (Fishing Liaison with Offshore Wind and Wet Renewables) and NOREL (Nautical and Offshore Renewables Energy Liaison) were set up by Government to discuss and resolve issues pertaining to fisheries, and to commercial and recreational shipping and ports industries respectively. Such issues may further be addressed through proposed marine planning initiatives under the UK and Devolved Administration Bills.

3.12.7 Environmental pressures and impacts (positive and negative)

The main activities associated with offshore renewable energy development that place pressures on the marine environment include:

- Characterisation of the energy source (installation of met masts etc.)
- Site characterisation (describing the marine environment)
- Side-scan sonar and other geophysical and biological surveys
- Construction equipment including vessels, construction platforms and cabling
- Construction activities such as drilling, pile driving, seabed levelling and trenching of cables
- Operation including the power export cable
- Maintenance and monitoring activities
- Decommissioning

There are a vast range of renewable energy devices from wind turbines to intertidal barrages and underwater structures. Different devices require different construction and mooring methods and occupy differing levels of sea space (both 2D in terms of the seabed but also 3D in terms of seawater and air). They therefore result in a wide range of impacts, varying in degree of significance for the marine environment. The impacts from some activities such as anchored wave devices with no moving parts are considered to be relatively benign. Those with moving parts, above and/or below water, have implications for mobile fauna and their movement patterns. Devices that occupy vast areas of seabed (i.e. have a large footprint) are of concern for benthic habitats and the species that rely on the functioning of those habitats, for example, for food.

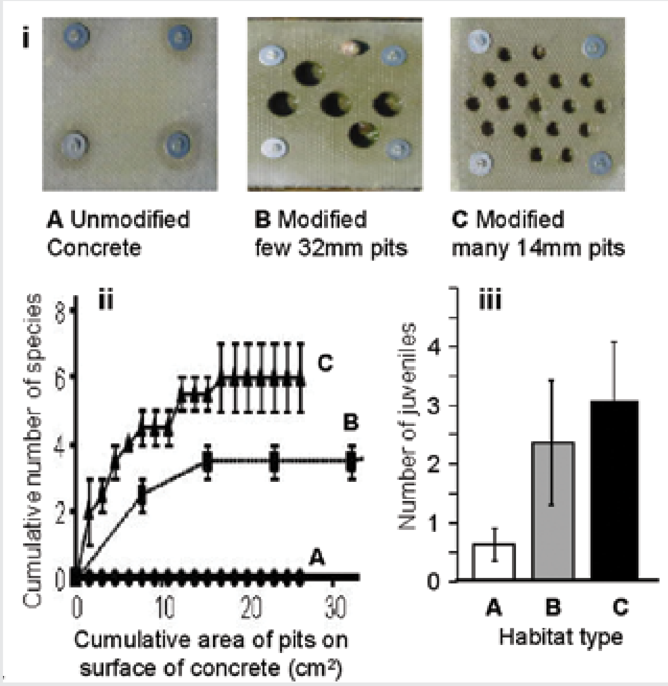
Case Study 6: Making green energy greener

Habitat enhancement of offshore renewable energy devices

Construction of offshore renewable energy developments will result in large quantities of artificial substrate being placed in the marine environment. Maximising the benefits for marine biodiversity while not compromising engineering integrity is seen as an important goal for sustainable use of the marine environment (Airoldi et al., 2005). It is, however, unlikely that habitat enhancement would be effective or desirable in all offshore engineering schemes, therefore a thorough assessment of suitability would have to be made on a site by site basis at the planning stage of any scheme through the environmental impact assessment (Linley et al., 2007).

Where EIA has shown it to be appropriate at a particular site, biological enhancement of marine engineering schemes is likely to have positive impacts on biodiversity and the environment with potential commercial benefits for the fishing and leisure industries. As an example, the scour protection around the monopiles for the *Horns Rev* wind farm was enhanced through the addition of boulders of a maximum diameter of 0.5 m. The area covered by the scour protection was approximately 12 m in diameter. After 2 years a mature biofouling community had developed and was continuing to evolve.

The addition of habitat enhancement to structures could also create seed stock or nursery site for commercial species resulting in spill over effects and benefits for local fisheries. Enhancements can be quite simple involving small pits or holes on the surface of the concrete structure. For example, the photos illustrate modifications made to the surface of experimental concrete plates. The results shown



in the two graphs indicate that the plates with greatest complexity had more species diversity and abundance of juveniles.

Other specific opportunities include:

- New habitat for lobsters and crabs – evidence indicates that lobsters in particular are habitat limited and may benefit from biological enhancement within offshore renewable energy devices
- Ranching or fisheries augmentation – interest in seeding areas with hatchery reared juveniles such as lobsters
- Marine protected areas with potential spill over effects outside the area
- Mariculture – rope fisheries of bivalves or seaweed

A number of important issues, however, still need to be addressed at the policy and licensing level to allow the incorporation of habitat enhancement within marine engineering schemes. For example, FEPA

licensing requirements state that all material deposited on the seabed must be removed in the decommissioning process. This is based on IMO (International Maritime Organization) and UNCLOS requirements and OSPAR guidance and has been transposed into DECC's policy on decommissioning (DTI, 2006). In addition, research needs to be undertaken to provide guidelines to engineers and device developers on incorporating habitat enhancement within marine engineering schemes in the most cost-efficient manner (Inger et al., 2009).

Combining wave energy devices and coastal defences

On 22 January 2009, the Scottish Government granted consent for the Siadar Wave Energy Project (SWEP) on the Isle of Lewis in the Outer Hebrides. The SWEP, which is a joint project between npower renewables and Wavegen, involves an 'active breakwater' which would harness power from the Atlantic waves in Siadar Bay to generate up to 4 MW of electricity. The concept is based upon a modification of Wavegen's demonstrator device, Limpet. The breakwater will consist of nine to ten concrete caissons placed together on the seabed, each of around 25 m in length and each housing a number of Wells turbines to generate electricity. The breakwater will be located around 350 m from the shore.

The energy produced each year could supply the average annual electricity needs of around 1500 homes, equal to a fifth of all homes on Lewis and Harris. In addition, the shelter provided by the breakwater will help facilitate sea users entering the sea at Siadar Bay for fishing and recreation.

The likely pressures that these activities present to the marine environment are summarised in Table 3.87. However, it is important to note that many impacts are device-specific and do not apply to renewable energy as a whole. The specificity of impacts is noted where relevant. The ecosystem services that the pressures above impact upon and the relative significance of these impacts are identified in Table 3.88.

The EIA Directive (85/337/EEC as amended by 97/11/EC) has been transposed into UK law through a number of regulations, the key ones being: the Electricity Works (Environmental Impact Assessment) (England and Wales) Regulations 2000 relating to a Section 36 consent; the Harbour Works (Environmental Impact Assessment) Regulations 1999 in relation to the CPA; and the Marine Works (Environmental Impact Assessment) Regulations 2007.

The regulations require developers of offshore wind farms to undertake an EIA to consider both the positive and negative environmental impact of a development from the construction stage through to decommissioning. Most of the impacts listed in Table 3.87 are therefore considered through the EIA process. The management measures listed in Table 3.87 refer to explicit solutions aimed at avoiding, minimising, mitigating or monitoring impacts.

Some of the environmental impacts of offshore wind farms have been addressed through studies supported by the COWRIE research programme. Environmental impacts have also been extensively reviewed through OSPAR (2006a,b, 2008a,b), ABPmer (2006a, 2009) and SEA (e.g. Faber Maunsell and Metoc, 2007).

There are a number of information gaps that are limiting understanding of the pressures and the potential impacts arising from renewable energy

Table 3.87 Key pressures and impacts associated with marine renewable energy – construction, operation and decommissioning. Main Sources: ABPmer (2006a, 2009); OSPAR (2006a,b, 2008a,b); Faber Maunsell and Metoc (2007).

Pressure	**Noise from exploration activities**
Impact	Potential impacts on noise sensitive species such as cetaceans and some fish species
Description of environmental change (intensity, spatial extent, frequency, duration)	Pre-construction stage only. All devices. Side scan sonar is used to assess the underlying geomorphology for construction purposes. Impact is of short-term duration and considered to be of low significance.
Existing management measures	There are no good practice guidelines specifically relating to side-scan sonar activities in the UK since these are thought to be of low concern in terms of disturbance to cetaceans. Issues are addressed through the environmental impact assessment (EIA) process.

Pressure	**Noise (semi-continuous) from construction and decommissioning activities (drilling and pile driving) or vessels.**
Impact	Potential impacts on noise sensitive species such as cetaceans and some fish species, particularly from pile driving and the use of explosives. Noise impacts from pile driving may result in permanent or temporary threshold shifts for cod, herring, dab and salmon in close proximity to the activity (Thomsen, et al. 2006). In shallow waters piling work may generate a noise field that could act as a barrier to movement for some species (IECS, 2007).
Description of environmental change (intensity, spatial extent, frequency, duration)	Noise is generated during all phases of construction and may be semi-continuous or impulsive and the temporal aspect is described as being transient (weeks). The main concern for pile driving relates to monopiles for offshore wind turbines which are generally of greater diameter than those for tidal devices and may therefore be associated with higher source noise levels. Data from the monitoring of SeaGen indicated a short term decrease in porpoise activity during device installation. Non-explosive cutting technology produces relatively little noise production (JNCC, 2008a). For activities that make use of explosions for a relatively short period of time, it is considered that there would be a low likelihood of disturbance occurring that would constitute an offence *if* suitable mitigation was in place.
Existing management measures	There are no good practice guidelines in the UK for drilling activities since these are thought to be of low concern in terms of disturbance to cetaceans (JNCC, 2008a). However, there are draft guidelines for minimising acoustic disturbance to marine mammals from explosive use (JNCC, 2008b). Suggested measures for the use of explosives are similar to those employed for seismic activities, e.g. marine mammal observers, soft start and passive acoustic monitoring (PAM) (see Section 3.9: Oil and Gas). Issues are addressed through the EIA process.

Pressure	**Noise (semi-continuous or continuous) from sub-sea turbines**
Impact	Potential impacts on noise sensitive species such as cetaceans and some fish species resulting in avoidance behaviour.
Description of environmental change (intensity, spatial extent, frequency, duration)	Although there are few published data, operational noise is likely to be similar to that from oil rigs: low frequency tonal noise from rotating machinery (<1 kHz), qualitatively similar to that from ships.
Existing management measures	Understanding will improve as monitoring data from device developments are published. There are no existing management measures for operational noise. Issues are addressed through the EIA process.

Pressure	**Habitat damage from construction activities**
Impact	Changes to the marine environment (e.g. increased suspended sediments and turbidity, smothering, disturbance of contaminated sediments and direct disturbance)
Description of environmental change (intensity, spatial extent, frequency, duration)	In general, most of the construction activities of concern, such as the use of jack-up legs, piling and activities involved in cable installation, are likely to result in short-term, localised changes to the marine environment from which benthic communities are likely to recover quickly (e.g. PMSS, 2007; IECS, 2007).
Existing management measures	Issues are addressed through the EIA process. Careful site selection and cable route planning can help to ensure that impacts on vulnerable habitats are avoided or minimised. If necessary pre-lay surveys can be undertaken to ensure that highly sensitive areas are avoided.

Pressure	**Habitat loss**
Impact	Loss of habitat from the presence of devices
Description of environmental change (intensity, spatial extent, frequency, duration)	Habitat loss is generally small in relation to the wider array area, for example, Wave Dragon (PMSS, 2007). However, some devices installed in coastal habitats that are restricted in extent (e.g. shorelines, narrow straits, tidal rapids), may result in more significant loss of that particular habitat (Faber Maunsell and Metoc, 2007). It also depends on the nature of the foundation: the amount of habitat directly lost from the presence of a pile (12 m^2) is generally less than that for a mooring block or gravity base (40 m^2).
Existing management measures	Careful site selection and cable route planning can help to ensure that impacts on vulnerable habitats are avoided or minimised. Consideration of array design may also help to manage the impacts.

Pressure	**Biological disturbance**
Impact	The presence and operation of devices may disturb seabed communities, for example, scour around the structure.
Description of environmental change (intensity, spatial extent, frequency, duration)	Scour is largely a concern for piled devices and the potential for impact (substratum loss) is dependent on the particular abiotic environment (tidal flow, seabed sediments) of a development site. Areas suitable for wave and tidal device deployment generally tend to have low amounts of fine sediments due to the high energy of the environment, thereby reducing the potential for scour. Mooring blocks and gravity-weighted devices will tend to bury themselves in the sediment reducing potential for scour. However, in slack-moored systems, the mooring chain (and associated scour on the seabed) can increase the area of habitat lost and/or disturbed.
Existing management measures	Micro-siting of devices and re-use of arisings from drillings as scour protection can reduce the likelihood of any impacts.

Pressure	**Biological disturbance**
Impact	Potential barrier effects of the placement of turbines, piling and scour protection on marine migratory pathways. Behavioural changes, especially in mobile species from the presence and operation of devices
Description of environmental change (intensity, spatial extent, frequency, duration)	Biological disturbance is mainly of concern for devices employed in narrow tidal straits such as loughs and estuaries. During the installation of SeaGen no change in transit behaviour of seals within the Strangford Narrows was detected.
Existing management measures	Monitoring is being carried out in Strangford Lough to investigate the impacts of SeaGen on mobile species through: effort limited visual surveys; passive acoustic monitoring; aerial surveys, and tracking surveys. Impacts are managed through MMO and the development of shut down procedures.

Pressure	**Death and injury by collision with the moving parts of structures and vessels**
Impact	The moving blades of turbines (wind and tidal) may strike mobile animals (birds, fish and marine mammals), injuring or killing them.
Description of environmental change (intensity, spatial extent, frequency, duration)	The spatial extent of the pressure is restricted to the immediate vicinity of the devices (and associated pressure fields). Risk of bird strike and marine mammal collisions will be correlated with periods of migration or activity. However, evidence so far from offshore wind farms indicates that birds have a very high avoidance rate and low risk of collision. The potential for an impact on marine fish and mammals is poorly understood at present due to a lack of empirical evidence regarding the response of marine fish to tidal turbine blades – rotational or oscillating. Turbine tip velocities of 12.5 m/s (Fraenkel, 2006) and velocities greater than 8 m/s for half the radius of a turbine will result in any collisions being fatal (Wilson et al., 2006).
Existing management measures	Monitoring is being carried out in Strangford Lough to investigate the impacts of SeaGen on mobile species through: effort limited visual surveys; passive acoustic monitoring; aerial surveys, and tracking surveys. Impacts are managed through MMO and the development of shut down procedures.

Pressure	**Habitat introduction**
Impact	Alteration in substrate type, habitats, hydrodynamics and sediment dynamics. Introduction of hard substrate.
Description of environmental change (intensity, spatial extent, frequency, duration)	Introduction of new habitat has been described as a benefit of wind farm structures, particularly as fish refuges but is generally considered to be of negligible significance for wave and tidal devices. This is partly because the environmental attributes suitable for wave and tidal devices tend to minimise the potential for natural colonisation. The likelihood of attracting alien species however is unquantified as a negative impact.

Pressure	**Hydrographic changes due to extraction of energy and movement of parts**
Impact	Changes in hydrographic patterns may alter levels of exposure to energy with positive or negative impacts for species that are strongly correlated with or dependent on particular wave or tidal energy environments; for example the species characteristic of the BAP (Biodiversity Action Plan) habitat: tide-swept channels.
Description of environmental change (intensity, spatial extent, frequency, duration)	Tidal devices tend to result in a re-distribution of tidal flow locally and reductions in energy immediately upstream and downstream of the device (Couch and Bryden, 2004; ABPmer, 2006a; IECS, 2007). Impacts from over-topping wave devices such as Wave Dragon appear to be restricted to the immediate vicinity of the device (PMSS, 2007) although modelling studies need to be backed up by monitoring data. Other devices such as floating wave energy conversion buoys (e.g. AquaBuOY on the surface and Archimedes Wave Swing at subsurface level) are likely to result in lower impacts on the wave energy climate (Federal Energy Regulatory Commission, 2006).

Pressure	**Changes to electromagnetic fields (EMF)**
Impact	Avoidance or attraction responses in EMF sensitive species resulting in behavioural changes
Description of environmental change (intensity, spatial extent, frequency, duration)	Existing research suggests that some species of elasmobranch can probably detect the levels of induced electric field generated by an operational cable (CMACS, 2003; Gill et al, 2005). A more recent study indicates that elasmobranchs respond positively to the source and it is theorised that this might be due to a prey response although the basis of this is unclear (Gill et al, 2008). Any impacts appear to be confined to the immediate vicinity of the cable. Salmon, eels and sea trout may also be sensitive to the magnetic fields associated with operational cables, but based on evidence from existing cables, navigation and migration are unlikely to be affected (CMACS, 2003; Gill et al, 2005; Faber Maunsell and Metoc, 2007).

Pressure	**Spillage of fuel oil and construction materials (e.g. cement, antifoulants etc.)**
Impact	Adverse effects on sediment or water quality potentially impacting on benthic communities
Description of environmental change (intensity, spatial extent, frequency, duration)	There is a low risk of accidental discharges from machinery associated with the installation process. The characteristically high-energy environments in which the devices will be located will assist in the dispersion of any localised contamination, thus minimising any impacts unless contamination reaches the shoreline. The exposure to environmental change from spillage is low and the significance of any change is low.

Table 3.88 Environmental pressures on ecosystem services associated with renewable energy.

Ecosystem service	*Significance of impact*	*Confidence in understanding of the relationship = information gaps*
Biological productivity	**Low – Moderate**. Spatial extent is limited, but disturbance of physical environment by structures could alter the habitat of specific species. **High**. For major tidal barrage – may be positives and negatives.	**Moderate**. Exact impacts uncertain, but good knowledge of extent of impacts (locations of structures)
Biodiversity provision	**Low**. Renewables activities and structures may result in collision risk or disrupt the behaviour of some species, but spatial extent is limited. **High**. For major tidal barrage – may be positives and negatives.	**Moderate**. Exact impacts uncertain, especially from collisions, but good knowledge of extent of impacts (locations of structures)
Physical environment	**Low – Moderate**. Spatial extent of structures is limited, but impacts are clear. **Low**. Spillage of fuel and materials used during construction and maintenance is possible, but of low probability and low impact.	**Moderate**. Exact impacts are site specific, but good knowledge of extent of impacts (locations of structures) **High**. Intrinsic requirement of renewables to be placed in high energy locations allows confidence in rapid dispersion of localised spills

devices. These have been assessed in several studies (Faber Maunsell and Metoc, 2007; FRS, 2008c; OSPAR, 2008a; ABPmer, 2009) and BERR's Research Advisory Group (RAG, 2008a,b).

Currently, some of these information requirements are being delivered through a number of initiatives including targeted research through consortia and research organisations, for example, SUPERGEN, MREDS (Marine Renewable Energy Development in Scotland) consortium project (Work Package 5), COWRIE, DECC's successor to the BERR Research Advisory Group and activities at field trial sites, such as EMEC and individual site-specific EIAs.

The EIA process provides for the development of management measures in order to deal with impacts that may have a significant effect on marine nature conservation features. Measures to avoid or reduce pressures, and ultimately potential impacts, should provide inputs into the technological design of devices, project design and site location and project implementation (e.g. methods of construction and operation). The key opportunities for reducing environmental impacts include:

- *Site selection*: the SEA process can be of considerable value in steering development away from areas that present unacceptable environmental risk. At a project level the

detailed site selection process provides an important opportunity to avoid or further reduce such risks.

- *Device selection*: the selection of a particular device is typically made based on a number of technical and physical constraints (Halcrow, 2008). Environmental constraints could be added to the planning process to help guide developers in identifying the best devices for the best sites. An integral part of the EIA process is to use environmental considerations to design projects to eliminate or minimise adverse environmental effects.
- *Mitigation measures*: to avoid and reduce pressures and potential impacts, for example, timing of construction activities to avoid key activity times for sensitive marine species such as breeding or feeding times for birds.
- *Monitoring and adaptive management*: centralised monitoring strategies are vital as they maximise the value of data and allow for adaptive management of schemes that can benefit industry and regulators as a whole.

The liaison group OREEF (Offshore Renewables Energy Environmental Forum) meets three times a year and provides an opportunity for Government, industry and non-governmental organisations to discuss environmental issues relevant to the UK's offshore renewable energy sector. It informs policy-making and facilitates contribution to sustainable development.

3.12.8 Climate change

Overall, the extraction of energy from renewable sources has been encouraged in order to lessen the dependence on fossil fuel energy that has much higher associated carbon emissions. According to BERR (2007), for every 1 GW of fossil fuel fired electricity generation capacity displaced by an equivalent amount of renewable electricity, carbon emissions would be around 0.7 to 1.5 million tonnes lower.

3.12.8.1 Impacts of climate change on the renewable energy industry

The specific impacts of climate change will vary according to the type of power generation.

Climate change and the potential for increased storminess may have a negative impact on the structural stability of offshore wind and wave farms (Rees, 2008). Changes to currents could result in changes to scour around the legs and supports of offshore installations and array and export cables (Rees, 2008). Increases in the occurrence of bad weather could also result in operation and maintenance issues.

Tidal barrages which will be situated closer to the coast in estuaries and embayments may be prone to projected increased storminess and sea level rise. Increased storminess will put additional stresses on barrage structures and sea level rise could lead to the overtopping and flooding of the structures.

In terms of resource, the predicted changes to waves, wind and tides could provide an increased source of energy for the renewables industry resulting in an increased potential for electrical generation from both waves and wind. The potential for increased electrical generation will vary from region to region. The south and east areas off the coast of the UK have been projected to experience the largest increases in the 2-year return period daily average wind speed by 2080 (Hulme et al., 2002) with an increase of between 2% and 8% depending on the scenario. In the summer, wind speeds have been projected to decrease around much of the UK with the west coast experiencing a reduction of 10% (Hulme et al., 2002). However,

changes to the future wind climate are hard to predict and therefore the United Kingdom Climate Impacts Programme (UKCIP) attributes a low level of confidence in these projections. Spatial changes in the wave climate are hard to predict, making it unclear where increased wave resources could be available.

Adaptation measures

The renewables sector is mainly concerned with time scales of up to 20 years into the future (Rees, 2008) although projects such as the Severn Barrage will be looking at longer timescales. To plan ahead good metocean data will be required along with a sound understanding of probable future climate change. Scour protection could be required for foundations and cable arrays to compensate for possible increases in current stress on the seabed. Any reduction in the windows for construction and maintenance will require increased reliability and automation of offshore installations. Reductions in the windows may result in increased pressure on access to available equipment to enable construction, leading to delays in renewable development. Tidal barrages should be designed to account for probable rises in sea level to avoid the overtopping and flooding of these structures later in their lifetimes.

3.12.8.2 Impacts of the renewable energy industry on climate change

Although marine renewables do not emit carbon dioxide (CO_2) during power generation, some CO_2 will be emitted during the construction, maintenance and decommissioning of renewable energy projects (POST, 2006). Carbon emissions have been calculated for a number of low carbon electrical generation technologies (POST, 2006). During the lifecycle of a wind farm 98% of the CO_2 emissions arise from the construction and manufacturing stage. Maintenance of offshore wind turbines will be undertaken using a boats and helicopters which emit additional CO_2. In total, offshore wind electricity generation emits 5.25 gCO_2eq/kWh (POST, 2006). Different designs are likely to have different carbon footprints, for example, current designs for gravity base foundations utilise 2700 tonnes of concrete per turbine, however it is not clear whether these calculations for the different foundation types have been published.

Wave energy converters are at an early developmental stage and so no formal lifecycle analysis has been carried out (POST, 2006). However, it has been estimated that typical lifecycle emissions for this type of technology range between 25 and 50 gCO_2eq/kWh, most CO_2 is emitted during the construction phase of the lifecycle (POST, 2006).

No study has been undertaken to assess the carbon footprint of the lifecycle of a tidal power scheme. An assessment of the potential embodied carbon in the raw materials used to build the proposed Severn barrage is 2.42 gCO_2/kWh, and is 1.58 gCO_2/kWh for the Cardiff-Weston and the Shoots scheme (SDC, 2007). As this assessment excludes emissions from the transport of materials to the site and emissions from operations and decommissioning it is not a full lifecycle analysis although if construction emissions are as significant as for other renewables (wind and wave) it is likely that this figure represents a significant proportion of lifecycle emissions. A full lifecycle carbon footprint is to be formulated as part of the Severn Tidal Power SEA.

Mitigation measures

No current mitigation measures are known. However, the carbon emissions during the lifecycle of all marine renewables could be reduced if the manufacturing and other stages of their lifecycles were fuelled by low carbon energy sources (POST, 2006).

3.12.8.3 Summary

Table 3.89 provides a summary of the projected climate change pressures and impacts and indicates the likely significance of the impacts and the level of confidence in the assessment and measures that might be employed to manage the impacts (see Annex 1 for a discussion of the assessment methodology).

3.12.9 Industry stability and sustainability

3.12.9.1 Objectives

The Energy White Paper (BERR, 2007) sets out the UK Government's international and domestic energy strategy to respond to the key long-term challenges of tackling climate change and in ensuring a secure supply of clean and affordable energy. The strategy has four key goals:

- To put ourselves on a path to cutting CO_2 emissions by some 60%[25] by about 2050, with real progress by 2020
- To maintain the reliability of energy supplies
- To promote competitive markets in the UK and beyond
- To ensure that every home is adequately and affordably heated

To support the development of renewable energy, the Government has put in place a number of measures to encourage renewable energy development. In particular, the Renewables Obligation (RO) requires electricity suppliers to obtain a specified and increasing proportion of their electricity from renewable sources or pay a buy-out price. The RO has been successful in increasing the level of RO-eligible renewable generation in the UK from less than 2% in 2001 to around 4.4% in 2006 and 10% by 2010 (BERR, 2008c). Specifically in relation to marine renewables, the Government has been developing a plan for the installation of a total of 33 GW of offshore wind energy – nearly a third of existing electricity generating capacity – and provides financial support for the development of wave and tidal power technologies.

The EU has established a binding target that 20% of the EU's energy consumption (transport, heat and power) must come from renewable sources by 2020 as part of the Renewable Energy Directive that became European law on 5 June 2009. The European Commission has proposed that the UK's contribution to this should be to increase the share of renewables in its energy mix from around 1.5% in 2006 to 15% by 2020. The Government published its Renewable Energy Strategy in 2009 – essentially an action plan which sets out the range of measures that the UK will undertake in order to achieve the 15% target. While no specific targets have been set for the contributions of individual sectors or technologies to this 2020 target, an illustrative breakdown suggests that about 30% of the UK's electricity might come from renewables. Analysis suggested that the contribution of marine renewables to this might be in the order of: offshore wind – 19%; and wave and tidal – 2

The analysis did not include the possible contribution from a tidal power scheme in the Severn Estuary, as this will be the subject of a feasibility study reporting in 2010.

25 This target has subsequently been increased to 80% in the Climate Change Act.

Table 3.89 Summary of climate change implications.

Climate change pressure	*Impacts of climate change on Renewable Energy*	*Confidence/ significance*	*Adaptation measures*
Increase in severity of storms	Increased loads on marine structures	Medium confidence / medium significance	Dependent on form of renewable energy, will need extra engineering and design changes to withstand conditions
	Increased wind and wave resource	Medium confidence / high significance	None
	Shortening of suitable calm weather periods during which construction and maintenance can be undertaken	Low confidence / low significance	Undertake construction / maintenance during periods of calm weather although this may have indirect effects on industry.
Increase in sea level	Overtopping and flooding of tidal barrage structures, potential flooding of other devices	Low confidence / low significance	Ensure that devices are built to cope with increased sea levels. Lifecycle of most devices less than 50-year horizon over which changes to sea level may not be so extreme

Impacts of Renewable Energy on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
CO_2 emissions released during the manufacture, installation, maintenance and decommissioning	CO_2 emissions	Medium confidence / low significance (wind) to medium significance (wave and tide)	Source material from low carbon sources, use renewable energy during manufacture and construction

In the longer-term it is estimated that wave and tidal power technologies could contribute up to 30 GW by 2050 (BWEA, 2005; UKERC, 2008). Tidal range technologies could provide at least a further 5% of UK electricity supply, the resource for which is primarily focused in a limited number of locations, including the Severn Estuary, Liverpool and Morecambe Bays, the Solway Firth, the Wash, the Duddon, the Wyre and the Conway (SDC, 2007).

The Renewable Energy Strategy also committed to retaining and extending the Marine Renewables Deployment Fund to 2011-14 with an additional £60 million directed towards particular projects (e.g. £9.5 million for Wave Hub). In addition, the Marine Renewables Proving Fund (MRPF) was announced on 22 Sept 2009 and provides £22 million of grant funding for the testing and demonstration of pre-commercial wave and tidal stream devices.

In addition to actions at UK level, the Devolved Administrations have also developed a number of national policies and targets.

Working with the Forum for Renewable Developments in Scotland (FREDS), Scottish Ministers are developing a comprehensive approach to promote renewable energy as part of their overall aim in the Strategy for Economic Development to promote sustainable economic

growth in Scotland. FREDS produced a road map for wave and tidal energy development on 1 July 2009, which will form part of a wider Renewables Action Plan for Scotland (Scottish Government, 2009d). Key indicators designed to support renewable development include commitments to reduce emissions, such as working towards a reduction of emissions by 80% by 2050 and to meet 50% of Scottish electricity demand from renewable sources by 2020, with 31% by 2011 (BERR, 2008c). The Scottish Government has introduced enhanced ROCs for marine renewables (5 ROCs for wave projects and 3 ROCs for tidal projects) under the Renewables Obligation (Scotland).

In Wales, the Renewable Energy Route Map for Wales (WAG, 2008) sets out how Wales could maximise the use of its natural resources to generate renewable energy and explores the associated potential environmental, planning, grid and community benefits issues alongside how best to overcome barriers to each type of renewables development. It will be followed by more detailed action plans covering potential marine and biomass developments in Wales.

The current renewable energy target in Northern Ireland relates to electricity and aims to have 12% of electricity generated from indigenous renewable resource by 2012. In addition, the Northern Ireland Sustainable Development Strategy (OFMDFM, 2006) contains challenging targets for energy, ensuring that beyond 2025, where technologically and economically feasible, 40% of all electricity consumed in Northern Ireland will be obtained from indigenous renewable energy sources, with at least 25% of this being generated by non-wind technologies. DETI will publish a revised Strategic Energy Framework document in summer 2009 which will contain proposals for new renewable electricity targets to 2020.

3.12.9.2 Stability

Costs of development

Pugh (2008) notes that ...*wide uptake of offshore renewable energies must depend on production costs being competitive*... alongside conventional sources. A key area is the cost of offshore energy installations. Current generation costs (Ernst and Young, 2007) are as follows:

- Offshore wind energy: £73 – £88 per MW hour
- Offshore wave energy: £120 – £280 per MW hour
- Tidal stream energy: £120 – £240 per MW hour

These are much higher than conventional costs and are rapidly rising due to global supply and demand issues with components such as turbines. A study by Offshore Design Engineering Limited (ODE, 2007) identified areas where funding could be focussed in order to achieve benefits for the industry. In particular, site location is paramount to the level of efficiency and output from turbines; a 15% change in load factor could lead to a 60% change in output. ODE's cost model (2007) suggested that development costs would rise initially from roughly £1.6 million per installed MW to about £1.75 million in 2011 before reducing to about 80% of the original cost by 2020. However, this scenario was dependent on the benefits of Research and Development (R&D) and learning which need both investment and positive steps by Government and industry in order to be realised.

TCE announced in February 2009 that it would match-fund the option fees for the Pentland Firth in order to facilitate research and development and reduce the level of risk in tidal stream energy investment.

3.12.9.3 Management issues

Key issues related to offshore renewables have been identified in the Energy White Paper (BERR, 2007) as follows:

1. Technologies like offshore wind are proving more expensive than anticipated. As a result, in its current form, the RO will not deliver sufficient financial support to deploy these at the levels needed to keep on track towards the 20% aspiration.
2. Securing planning consent for renewables can be a difficult process, with developers facing uncertainty and significant risk of delays. For example, according to industry statistics, it takes an average period of 21 months for wind farms to secure planning consent under the Electricity Act regime (BWEA, 2006). However, in some cases improvements to the applications submitted to the regulators (i.e. better project descriptions, including: fewer options on project design, layout, construction methodology, material) could greatly reduce the time required to make determinations on consents. There is currently more than 1.4 GW of renewables capacity awaiting consent under the planning system after applications were placed early 2009 but this excludes upcoming Round 3 projects. Conversely, there are also over 4.1 GW of consented projects still not constructed (BWEA, 2009), implying that consenting issues while important are not a major limiting factor.
3. There are significant challenges and delays in connecting renewables generation projects to the transmission and distribution network, affecting both onshore and offshore renewables. At present there are no major connections in the Pentland Firth, and National Grid's earliest offer of a connection is 2018 although capacity may be gradually progressed from 2013 if planning and site selection starts immediately (i.e. March 2009) (New Energy Focus, 2009a).

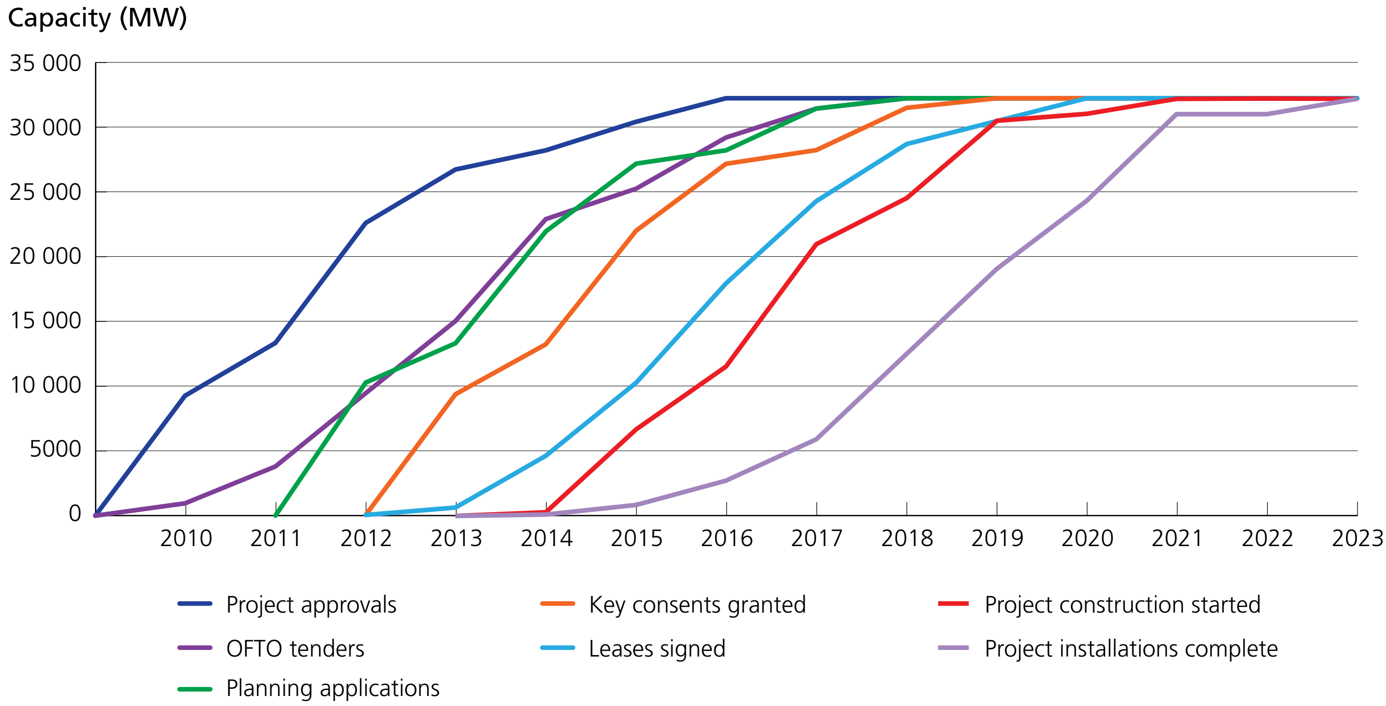
3.12.10 Forward look

Internationally, the UK is forecast to be the biggest market in renewables for three main reasons: (1) the excellent wind, wave and tidal resources that exist around the coastline; (2) the market mechanisms and funding in place, which are comparatively strong and give more investor confidence than in other countries; and (3) the UK is home to a large number of wave and tidal device developers, including some of the early market leaders (Douglas-Westwood, 2008).

The political aspirations noted above may support the continued growth and development of this sector. Major progress will include the construction and commissioning of Round 2 and Round 3 offshore wind farms. A total of 40 zone bids from 18 different companies or consortia were received in the competitive tender for Round 3 OWF. These included international companies from at least nine different countries (New Energy Focus, 2009b). Realisation of the potential for more than 30 GW of new capacity by 2020 under Round 3 (Figure 3.49) will be dependent on solutions to a number of issues, including grid connection, consenting processes, supply chain development and economic support for the projects. On 29 July 2009, TCE announced that it is offering wind farm operators and developers the opportunity to apply for area extensions for existing Round 1 and 2 wind farms.

In February 2009, TCE granted nine companies exclusivity agreements for the development of offshore wind across ten sites in Scotland with the potential to generate more than 6 GW of wind power (see Table 3.85). Pentland Firth

Figure 3.49 Projected delivery dates and capacity from Round 3 wind farm projects. Source: R3 Developer Programmes, as of December 2009 – The Crown Estate.



is expected to be a major area of progress for tidal power technology over the next few years. Consultation on the Severn Estuary tidal range options is planned for 2010 after which consenting and development is expected to proceed quickly.

Monitoring information of actual pile driving noise levels in a range of different conditions and well-controlled studies of behavioural and physiological responses is required to assess adequately impacts on fish. Monitoring of operational noise levels has also been identified as a key requirement for improved understanding of the impact from wave and tidal devices. An agreed monitoring methodology for measuring noise needs to be developed to ensure consistency in the assessment approach among different studies. Furthermore, cumulative impacts of devices are not well understood, particularly in relation to birds and marine mammals. Understanding will improve as monitoring data from device developments are published.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the renewable energy sector will need to manage further its activities. For example, GES Descriptor 11 states that *...Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.13 Research and Development

3.13.1 Key points

- The cognitive value of the marine environment was estimated at £453 million for 2006
- The Research Councils spent £67 million on marine science in 2006/07
- Ancillary value was estimated to be £76 million Gross Value Added (GVA) from the incomes of a number of key research institutes
- There are no centrally collected statistics on where marine research is carried out.

i. Introduction

This sector refers to the use of the marine environment in order to 'increase the stock of knowledge'. This sector incorporates three main categories, the industry sector, university (higher education institutes; HEI) sector and public sector.

ii. How has the assessment been undertaken?

The principal value of this activity is the value of the knowledge obtained from the marine environment which is very difficult to quantify in traditional market value terms. Funding levels may also provide an indicator of the value placed on knowledge. The ancillary value related to the activities of the main research and development institutions is easier to estimate from the annual reports of research institutes.

iii. Current status of the research and development sector and past trends

Cognitive values of the marine environment are suggested of £453 million. Funding levels may provide an indicator of the ancillary value of R&D and associated knowledge. The Research Councils spending on marine science in 2006/07 was £67 million. All of the research institutes combined (HEI and other research bodies) had an average annual income (GVA) of £76 million (various figures from 2006 to 2008). No secondary values were calculated although the downstream value to be gained from research and development information is likely to be significant. The majority of value is located in Regions 1, 3 and 4.

iv. What is driving change?

As with education (Section 3.4: Education), change in research and development is driven by high level policy developments and changes in economic activities that support cognitive development in the marine environment and in turn drive funding.

v. What are the uncertainties?

This area is difficult to value due to the range of institutions involved, the wide distribution of activities and the lack of centrally available statistics that are specifically marine in focus.

vi. Forward look

While industry investment in research and development may decrease in the short term due to the current economic situation, public sector funding may increase in order to stimulate economic activities. Recent examples of this include commitments from governments to marine science strategies for the UK.

3.13.2 Introduction

Research and development (R&D) and related concepts follow internationally agreed standards defined by the Organisation for Economic Co-operation and Development (OECD): ...*creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications*.

This sector incorporates three main categories (Pugh 2008), the industry sector, university (HEI) and the public sector. This area is difficult to value, particularly the industry sector, due to the range of institutions involved, the wide distribution of activities and the lack of centrally available statistics. Information on industry sector research, for example, may be integrated into company accounts, while research bodies such as the Natural Environment Research Council (NERC) fund research across a range of sectors and are not specifically marine focussed. Research undertaken by industry is included as an ancillary activity within the appropriate sector, so that Section 3.13 deals solely with higher education and the public sector.

The main sources of funding for public sector marine research in the UK are the Research Councils, primarily NERC, but also to a lesser extent the Biotechnology and Biological Sciences Research Council (BBSRC), the Engineering and Physical Sciences Research Council (EPSRC) and the Economic and Social Research Council (ESRC). Government departments and non-departmental public bodies and other private sources also contribute to public sector research including the Department for Environment, Food and Rural Affairs (Defra), the Department for Innovation, Universities and Skills (DIUS), the Scottish Government Marine Directorate (SGMD), the Ministry of Defence (MOD), the Environment Agency, the Department for Business, Enterprise and Regulatory Reform (BERR) and the Department of Agriculture and Rural Development (DARD) Northern Ireland. The Government proposed that the principal public investors in marine science tackled strategic, cross-Departmental issues through a committee, the Marine Science Co-ordination Committee (MSCC). This replaces the Inter-agency Committee on Marine Science and Technology (IACMST). As these committees are in a transition phase this may partly account for the lack of current information on funding for marine science.

3.13.2.1 Description of economic activities

The main economic activities are highlighted in Table 3.90. The principal value relates to the knowledge gained from R&D activities. Ancillary activities include those of the research institutes that acquire the information. Secondary activities may include use of the information gained for further understanding. R&D related to specific industries is addressed where possible in the relevant sectoral assessments (see the various sub-sections of Section 3).

3.13.2.2 Description of relevant ecosystem services

The research and development sector (as with education) is generally dependent on clean and safe seas to operate in and, for some activities, biologically healthy and diverse marine populations to study. As such its productivity is reliant on the following ecosystem services: the physical environment, biological productivity, water purification and waste treatment, and biodiversity.

Table 3.90 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Research and Development (SIC 72.1)	Activities of Research Institutes	Use of information for further understanding	Industry related R&D (see relevant sections)

3.13.3 Direct use value

3.13.3.1 Principal activities

Using market data, Beaumont et al. (2006) estimated that the cognitive value of the marine environment in 2004 was £317 million (undiscounted monetary value per annum). Moran et al. (2008) modified this to £453.3 million on 2006 data (based on different assessments of the original market data). Cognitive values include that related to both education and research (Beaumont et al., 2006) therefore there is some overlap between the present section and Section 3.4 (Education).

More specifically, in this sector, research funding was used as an indicator of the principal value of the R&D activity with the assumption that valuable information would receive more funding. This is not strictly true as some information may be of lower knowledge 'value' but is more costly to retrieve or assess. However, applied across the entire range of funding, such a methodology should be robust.

Funding was assessed based on the research councils marine spend only, to avoid double counting (Table 3.91). For many bodies it was not possible to separate the marine component from the annual research spend. The heritage sector (English Heritage, Cadw, Historic Scotland, Environment and Heritage Service) undertake some marine related research to meet their objectives. English Heritage, for example, spent approximately £2.11 million on maritime ALSF (Aggregate Levy Sustainability Fund) projects

Table 3.91 Research council marine science spend. Source: House of Commons (2007).

Research council	*Year*	*Marine science related funding, £ million*
NERC	2006/2007	60.1
BBSRC[a]	2006/2007	3.11
EPSRC	2006/2007	3.14
ESRC[b]		0.17
Total	–	**66.52**

a Forecast spend
b annual figure, estimated from five years total expenditure.

between 2005 and 2007. In 2007/08 major marine projects funded by Historic Scotland included ScapaMAP2; Enhancing the protection of Underwater Cultural Heritage with a grant offered to the Scapa Flow Submerged Landscape projects, an Aird Calanais coastal erosion publication and Coastal Zone Survey Assessment projects.

Defra's science programme covers both research and monitoring at an annual cost of around £26 million (House of Commons report, 2007). Of all the research councils NERC is the major funder of marine science (Table 3.91) and funds the British Antarctic Survey (BAS) in Cambridge which conducts marine-related research in the Southern Ocean, the Proudman Oceanographic Laboratory (POL) which is a world leader in modelling and forecasting patterns in the coastal and open sea water environment, and the

Centre for Ecology and Hydrology and the British Geological Survey (BGS) which both conduct some marine related research.

In June 2007, the Government created DIUS. The aim of this Department is to enhance science, research and innovation in Britain. DIUS is responsible for the allocation of the Science Budget into research via the seven Research Councils.

Scottish Government Marine Directorate – Marine Scotland

The Scottish Government has responsibility for protecting and enhancing the environment as well as aiding the economic performance of Scotland's agriculture, aquaculture and food industries. It provides advice on management and sustainable development of the environment and commissions a range of agricultural, biological and environmental science covering basic and strategic research as well as development (science-led) work. From 1 April 2009 a new marine management Directorate, Marine Scotland, has been created. This will combine the current functions of the Scottish Fisheries Protection Agency (SFPA), the SGMD and Fisheries Research Services (FRS). Currently, there is no information available on the research strategy and level of funding for research from Marine Scotland body.

The Scottish Government has previously relied on evidence from existing science providers and undertakes research to fill evidence gaps to support policy development within the Scottish Government. Projects are conducted in partnership with FRS, Scottish Natural Heritage (SNH), and the Scottish Environment Protection Agency (SEPA).

3.13.3.2 Ancillary activities

Leading UK marine research institutes

Identifying funding sources for research institutions is complex as they typically derive funding from a range of sources. This is illustrated in the breakdown of funding to POL and the British Oceanographic Data Centre (BODC) (Table 3.92). Although POL is a NERC-owned research centre it has also received research money from a range of other institutions, including those that are commissioning research.

The Centre for Environment, Fisheries and Aquaculture Science (CEFAS) provides scientific advice to the UK government and other agencies. Most income is received from the government (£40.909 million) from Defra (£34.392 million), Defra agencies (£993 000) and other government departments (£5.534 million). Other income (£6.648 million) is received from the UK public sector (£669 000), the UK private sector (£3.347 million) the European Union (£1.195 million) and other sources (£817 000).

The FRS is an agency of the Scottish Government Marine Directorate and provides scientific and technical advice to the Scottish Government as its main function. Research and development is undertaken to support these regulatory and statutory objectives. In 2008, total income for the FRS was £2.52 million and staff costs were £11.43 million. On 1 April 2009 the FRS was merged with the SFPA and the SGMD to form Marine Scotland.

The National Oceanography Centre, Southampton (NOCS) is a Collaborative Centre owned by NERC and the University of Southampton. It employs approximately 520 staff (2007/08 Annual Review) including research

scientists, lecturing support and seagoing staff and provides training for approximately 790 students (estimated as 100 PhD students, 50 Masters students, 600 undergraduates). Total funding in 2007/08 was approximately £41 million resourced from NERC, the University School of Ocean and Earth Science, the National Marine Facilities Division and the Corporate Services Division.

Plymouth Marine Laboratory (PML) is an independent research charity and NERC Collaborative Centre. In 2006/07 total income was £8.119 million and was resourced from NERC (£4.289 million), commissioned research (£2.656 million), commercial trading operations (£0.138 million) and others. Commissioned research came from the Research Councils (52.4%), international bodies (24.1%), the UK Public Sector (16.4%) and others (7.1%). PML will receive £23 million over five years as part of Oceans 2025, funded by NERC.

POL is a research centre, housed at Liverpool, which is wholly owned by NERC. Main research areas are sea level and allied science, the physics of shelf and slope seas, marine observation and modelling systems and data management in POL-hosted data centres.

The Scottish Association of Marine Science (SAMS) is one of the oldest oceanographic organisations in the world. It is a NERC collaborative centre and is also an academic partner in the University of the Highlands and Islands. Total income in 2006/07 was £7.413 million.

The Sir Alister Hardy Foundation for Ocean Science (SAHFOS) is a charity set up to maintain the Continuous Plankton Recorder (CPR) Survey. In 2007, total income was £1.121 million mostly from grants and contracts (£1.044 million).

Table 3.92 Funding sources for the Proudman Oceanographic Laboratory and the British Oceanographic Data Centre. Source: BODC (2007).

Funding source	*Amount, £ thousand*
NERC core strategic	2418
NERC Infrastructure	2012
NERC other	178
External	2371
Environment Agency	754
Defra	192
EU	209
Private Sector	162
Overseas (non EU)	42
Met Office	72
Total	**8410**

Employees consist of operations staff, plankton analysts, researchers and staff responsible for the CPR database, education and administration.

Table 3.93 provides a summary of the estimated income and GVA for the leading public sector research bodies. Although some funding also comes through EU programmes, Pugh (2008) noted that this only forms a small part of the UK component. An EU project, the INTERREG IVA programme awarded nearly £5 million to research into marine biofuels, divided between SAMS, Queens University Belfast and the University of Ulster in Northern Ireland (with other portions going to institutions in the Republic of Ireland).

Higher education sector

The ancillary value of this sector also includes the supporting activities of universities. Pugh (2008) estimated the GVA of the marine related HEI research as £31 million. This estimate used scaling factors that were developed in a

Table 3.93 Annual income, gross value added (GVA) and employment for leading research institutes. Source: CEFAS (2007); FRS (2007); NOCS (2007); PML (2007), POL (2007); SAHFOS (2007); SAMS (2007).

	Year	*Income, £ million*	*GVA[a], £ million*	*Employment*
CEFAS	2007/08	47.56	19.68	523
FRS	2007/08	2.52	11.43	399
NOCS	2007/08	41.00	-	483
PML	2006/07	8.12	5.35	127
POL	2006/07	8.41	4.63	120 (POL) 45 (BODC)
SAHFOS	2006/07	1.12	0.69	29
SAMS	2006/07	7.41	2.80	150
Total[b]		**116.14**	**44.58**	**1876**

[a] GVA estimated as staff costs
[b] 2006/07 and 2007/08 data were used to produce the total annual estimate.

previous report (Pugh 2008) and were based on a detailed analysis of employment in the higher education sector undertaken by Pugh and Skinner (2002).

Summary

Principal value has been estimated from the Research Council spend to be £66.2 million. But this is only a small proportion of the funding going into research and development. Other sources include European funding sources for pure science. Ancillary value from the activities of research institutes was estimated to be £44.6 million GVA and of the HEIs was estimated by Pugh (2008) to be £31 million, providing a total of £75.6 million GVA.

3.13.4 Regional distribution of value

Figure 3.50 shows the location of institutions with marine research vessels (some of these are shown inland, although associated research takes place at sea). These maps also show members of the International Association of Maritime Institutions (IAMI).

Given that the principal value of R&D in the marine environment has been so difficult to define, the assessment has concentrated on assigning the ancillary value to identify, at least, where the main economic value of research and development is located. It should be highlighted that this is not where the actual marine research is carried out. These results are summarised in Tables 3.94 and 3.95.

The major UK universities engaged in marine science (based on the number of researchers) are Southampton, Bangor, Stirling, Plymouth, Aberdeen and St Andrews. Centres of excellence in marine engineering are located where shipbuilding is, or was, prominent (the University of Strathclyde, the University of Edinburgh, Southampton University, the University of Newcastle and Imperial College London).

For an analysis of regional distribution of value, the methodology used by Pugh (2008, as described above) was employed to give the GVA attributed to employment at major marine research institutions (Table 3.94) and hence derive a regional analysis of the distribution of value. The GVA was calculated from the numbers employed as academics, postdoctoral researchers, technicians and PhD students, using the salary multipliers described by Pugh (2008) (i.e. academic staff multiplied by £50 000, technicians £40 000, postdoctoral researchers, £25 000 and postgraduates £12 000). Although it was not possible within the scope of this study to create a detailed analysis of marine related HEI staff it was possible to obtain approximate figures for the leading UK HEI institutions undertaking marine related research from departmental websites (accessed January

Figure 3.50 Higher education marine research institutes, institutions with marine research vessels, and members of the International Association of Maritime Institutions.

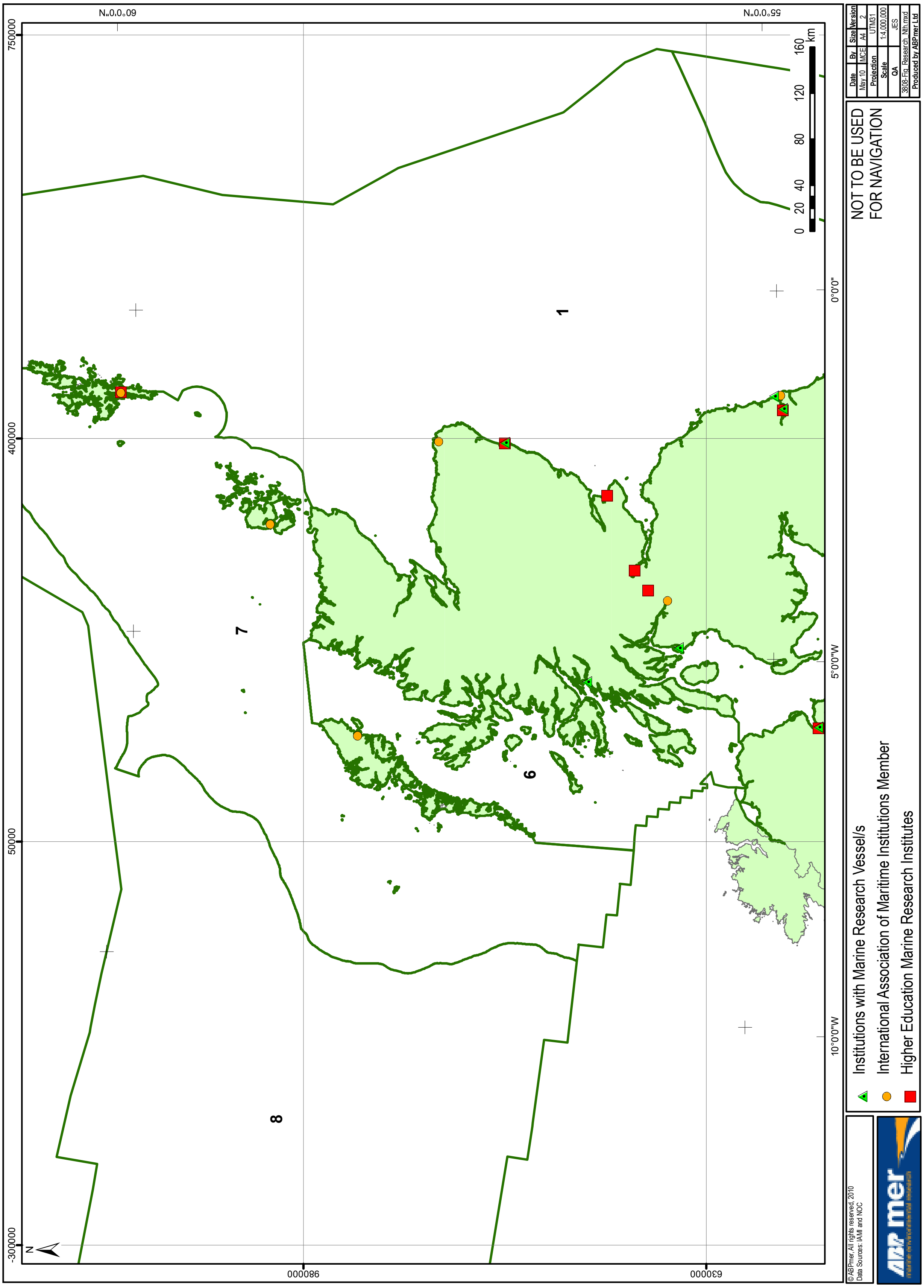


Figure 3.50 continued

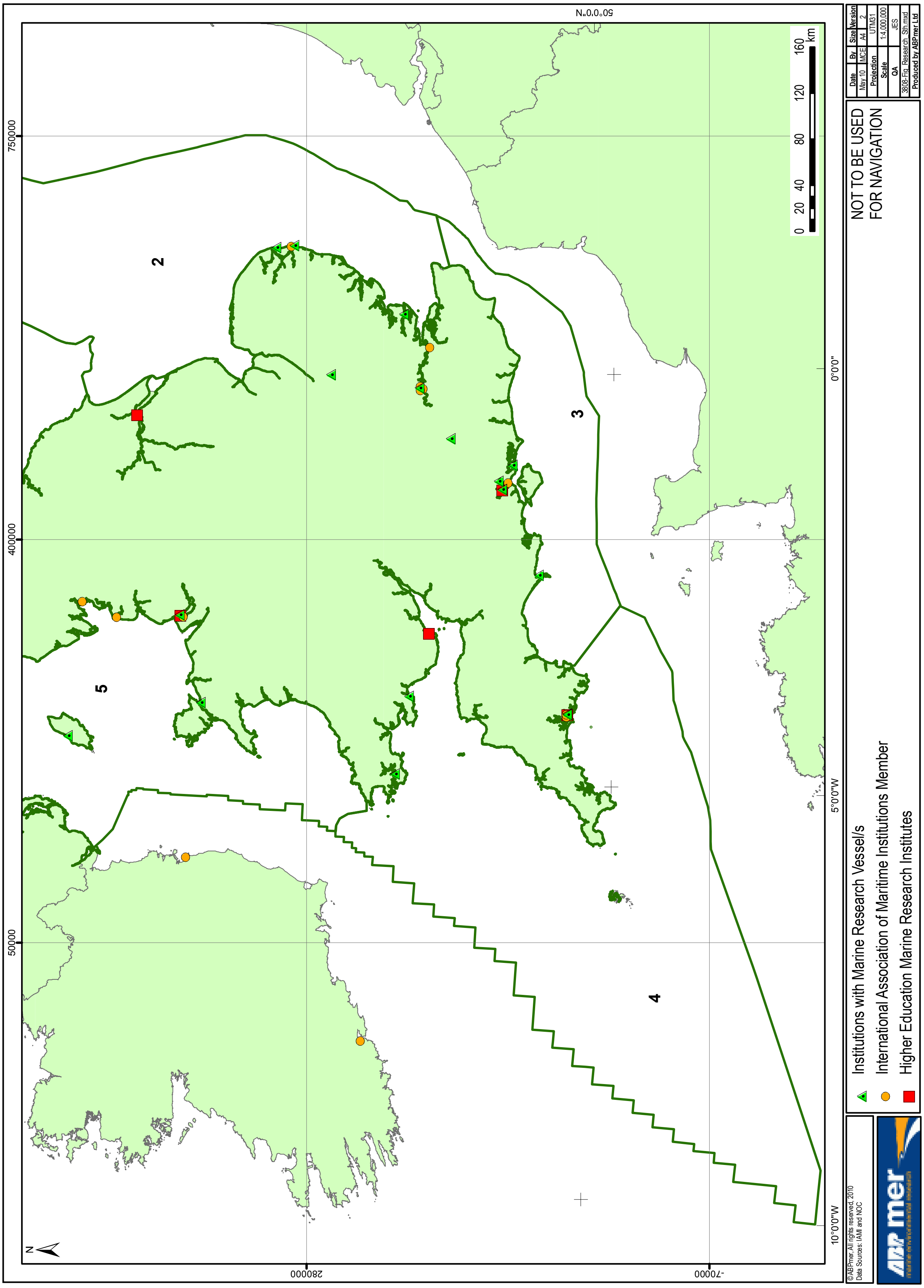


Table 3.94 Estimated GVA of leading UK HEI engaged in marine research.

Institution	*School, centre or department*	*CP2 Region*	*Employment numbers*	*Estimated GVA, £ million*
University of Southampton	School of Ocean & Earth science	3	235	6.54
University of Stirling	Institute of Aquaculture	1	94	3.28
University of Plymouth	Marine Biology and Ecology Centre/School of Earth & Ocean Science	4	91	2.99
University of Newcastle	School of Marine Science & Technology	1	73	2.65
University of Wales	School of Ocean Science	5	85	2.76
University of Strathclyde	Naval Architecture and Marine Engineering	5	65	2.19
University of St Andrews	Gatty Marine , Sea Mammal Research Unit	1	44	1.61
University of Aberdeen	Oceanlab	1	26	0.80
University of Hull	Centre for Environmental & Marine Sciences	2	20	0.65
University of Liverpool	School of Biological Sciences	5	19	0.56
University of Highlands and Islands	NAFC marine centre (Shetland)	7	7	0.33
Queen's University Belfast		5	8	0.38
Total				**24.74**

Table 3.95 Summary table of regional distribution of values.

CP2 Region	*HEI, GVA £ million*	*Research bodies, GVA £ million*
1	10.53	11.43
2	0.65	19.68
3	6.54	0
4	5.75	8.84
5	0.94	4.63
6	0	0
7	0.33	0
8	0	0
Total	**24.74**	**44.58**

2009 – these data are approximate as university websites may not be regularly updated and also do not differentiate between full and part-time employment). This method provides a total of £24.74 million which captures 80% of the GVA attributed to the HEI sector by Pugh (£31 million, 2008). Table 3.95 summarises the GVA of research institutes and HEIs for each CP2 Region.

3.13.5 Trends

The Government has substantially increased spending on science; between 1997 and 2007 the science budget has more than doubled rising to £3.4 billion (DTI, 2005). Spending on civil research from all sources has increased although spending on defence has declined (Figure 3.51).

NERC funding of marine science has increased by around £15 million between 2001/02 and 2006/07 (Figure 3.52). NERC has funded a major £25 million research programme to deliver key strategic goals in marine science (Oceans 2025) over five years. This programme is implemented through seven of the NERC collaborative UK marine centres. (NOCS, PML, The Marine

Figure 3.51 Total annual expenditure on research all sectors. Source: National Statistics (2008).

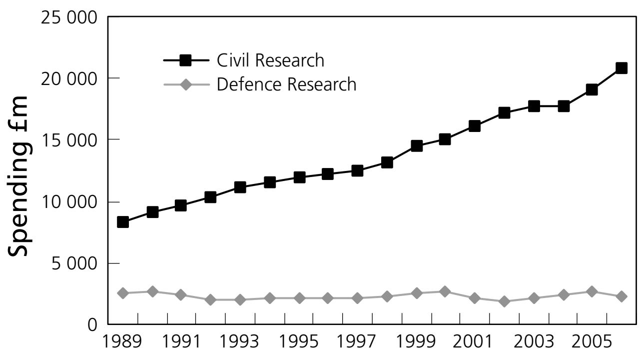
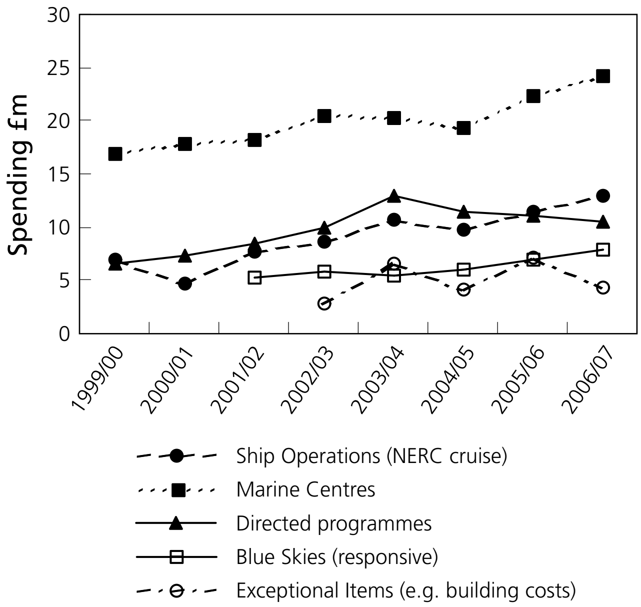


Figure 3.52 NERC Marine science expenditure 1999 to 2007. Source: House of Commons (2007).



Biological Association (MBA), POL, SAMS, the Sea Mammal Research Unit (SMRU) and SAHFOS).

3.13.6 Socio-economic pressures and impacts (positive and negative)

A number of socio-economic benefits arise from research and the existence of bodies that conduct research. Marine research benefits the economy through new and improved industrial and engineering products. The development of wave and tidal energy devices is an example of how marine technology can be used to develop new products, in this case to meet energy needs and mitigate environmental impacts. Other established industrial sectors such as oil and gas exploitation and ship building also have research needs to improve existing technology and efficiency.

Sustainable management of the marine environment is underpinned by research on ecosystem processes, the effects of human impacts, the distribution of habitats and the natural history of species. Research in these areas will aid the implementation of policies, such as the designation of Marine Protected Areas to meet international obligations.

Society also benefits indirectly from research. Universities provide teaching that produces a skilled workforce. Graduates can be a source of wider innovation and economic growth (Blundell et al., 1999).

3.13.7 Environmental pressures and impacts (positive and negative)

The HBDSEG Feeder Report identifies bioprospecting as an environmental pressure relating to research activity. A number of other potential pressures were identified relating to access and sampling, such as the use of research vessels and the deployment of investigative gear such as grab samples. Pressures and impacts associated with research and development are described in Table 3.96 which is based on information presented in Section 3.4 (Education). Table 3.97 summarises the impacts of pressures on ecosystem services.

Table 3.96 Key impacts and pressures associated with research and development activities.

Pressure	**Marine wildlife disturbance (visual and acoustic)**
Impact	Disturbance caused by an external influence can cause animals to stop feeding, resting or travelling and socialising with possible long term effects of repeated disturbance including loss of weight, condition and a reduction in reproductive success.
Description of environmental change (intensity, spatial extent, frequency, duration)	Difficult to quantify as few spatial data exist on this issue due to a low level of official reporting and a high level of heterogeneity in where incidents are recorded. Intensity is likely to be small compared to disturbance associated with leisure and tourism. Likely to be highest around sailing schools and marine training centres (see Figure 3.6 in Section 4: Education).
Existing management measures	The Countryside and Rights of Way Act 2000 makes it an offence to cause 'reckless or intentional disturbance' to basking sharks, cetaceans and some bird species. Difficult to enforce although a number of codes of conducts have been implemented to help reduce this type of disturbance such as the 'WiSe' scheme, the Pembrokeshire Marine Code and the Scottish Marine Wildlife Watchers Code.

Pressure	**Physical disturbance of seabed substrata and alterations to the local benthic habitat**
Impact	Sampling, trampling, smothering and other physical disturbance of marine benthic habitats.
Description of environmental change (intensity, spatial extent, frequency, duration)	Comprehensive spatial data on subject is limited. Highest impacts will be around research locations. The amount of physical disturbance will be dependent on the intensity of research and the structure of the habitat. In most cases the extent of the 'footprint' will be relatively localized and small.
Existing management measures	Voluntary codes of conduct are in place at various marine reserves and popular dive areas to try and limit the level of physical disturbance such as at Wembury, Devon and St Abbs, Berwickshire.

Pressure	**Litter**
Impact	Includes plastic, polystyrene, rubber, metals and glass. Litter can impact on marine species through ingestion, entanglement and smothering.
Description of environmental change (intensity, spatial extent, frequency, duration)	Mainly around research sites but difficult to quantify (although likely to be very small).
Existing management measures	Dropping litter is an offence under the Environmental Protection Act 1990. Education through various leaflets and codes such as the Marine Conservation Society 'seashore code'

3.13.8 Climate change

The risks and uncertainties posed by climate change are likely to provide research and development opportunities throughout all sectors. Quantification is not available.

3.13.9 Industry stability and forward look

The UK is second only to the United States in global scientific excellence as measured by citations and leads the G7 nations in the productivity of its research base (HMSO, 2006).

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The

Table 3.97 Select environmental pressures on ecosystem services associated with research and development.

Ecosystem service	*Significance of impact*	*Confidence in assessment*
Physical environment	**Low**. Physical disturbance can be severe in areas that are popular research areas, but is generally localized in those areas and researchers usually attempt to reduce their impact. Disturbance can also be caused by scouring from a boat's wake/wash, which increases erosion on a wider scale, but with a less intense impact at any point.	**High**. Impacts on benthic marine environment well understood.
Biological productivity	**Low**. Extraction for research purposes is unlikely to occur at any level that is threatening to fish stocks. Visual and acoustic disturbance can have an impact on marine wildlife, but severity is dependent on craft/ equipment type and how it is used.	**Low**. Neither extraction nor disturbance is well reported.
Biodiversity provision	**Minimal – Low**. Impacts on biodiversity are likely to result from visual and acoustic disturbance, sewage discharge and litter. However, these pressures from research are likely to be minimal to low.	**Moderate**. Difficult to quantify disturbance, but effects are understood.
Water purification and waste treatment	**Minimal**. Although research activities may affect water quality, the effect is likely small and localised.	**Moderate**. Education and training contribution to water quality issues not well studied, but effects and desired level of water quality understood.

indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the research and development sector will need to manage further its activities. For example, GES Descriptor 11 states that ...*Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.13.9.1 Objectives, targets and indicators

Investment in research by business is supported in a number of ways, for example R&D tax credits, the Technology Programme and other R&D Support Products such as Collaborative R&D and Knowledge Transfer Networks. In addition the Technology Strategy Board promotes innovation in key technology areas.

Defra's research priorities are guided by its Evidence and Innovation Strategy (e.g. Defra, 2006c) and building on its ten year forward look (Defra, 2004d). The Scottish Government is also committed to developing a Scottish Marine Science Strategy. Furthermore, the primary responsibility of the Scottish Marine Science Strategy is to develop and implement a marine science strategy for the UK.

3.14 Storage (of Gases)

3.14.1 Key points

- The use of geological structures in the sub-sea environment for the storage of gases has been in existence in the UK and Europe for over 30 years and is a growing industry
- More recently there have been proposals to store carbon dioxide (CO_2), released from power generation and industrial processes, in geological structures; a process known as Carbon Capture and Storage (CCS)
- Structures can include depleted oil and gas fields, or deep salt caverns and saline aquifers
- There is only one offshore gas storage facility currently in operation in the UK: the *Rough 47/8 Alpha* facility
- There will be increasing economic activity in both areas over the next decade because of increasing levels of gas imports and drivers to reduce CO_2 emissions as part of an overall strategy to mitigate climate change, while maintaining security of supply
- In 2007, the Department of Trade and Industry (now the Department of Energy and Climate Change) estimated that £10 billion of investment in new gas storage and input facilities was in place or planned over the next few years
- Subsea gas storage capacity is estimated to be between 31 000 and 22 000 million tonnes

i. Introduction

The use of geological structures in the sub-sea marine environment for the storage of gases is a growing industry. Structures can include depleted oil and gas fields or deep salt caverns and saline aquifers and they have been used to store natural gas in Europe and the UK for over 30 years. More recently there have also been proposals to store CO_2, released from power generation and industrial processes, a process known as Carbon Capture and Storage (CCS).

ii. How has the assessment been undertaken?

Information on the proposed development of gas storage has been sourced from the Department for Energy and Climate Change (DECC) and relevant reports.

iii. Current and likely future status of gas storage

It is difficult to estimate the principal value of this activity due to the intangible benefits derived from such storage, i.e. improved energy security and mitigation of climate impact. However, information on investment may provide a useful indicator for ancillary activities. In 2007, the Department of Trade and Industry (now DECC) estimated that £10 billion of investment in new gas storage and import facilities was in place or planned over the next few years. Subsea gas storage capacity is estimated to be between 31 000 and 22 000 million tonnes depending on the assumptions made. There is only one offshore gas storage facility currently in operation in the UK: the *Rough 47/8 Alpha* facility. Likely environmental impacts have been predicted from existing gas production. Use of existing storage features and infrastructure is likely to have negligible additional environmental impacts although the production of salt caverns may have some localised effects.

iv. What is driving change?

Long-term trends for increasing economic activity in this sector are likely to be driven by targets for secure energy supplies and reductions in carbon emissions.

v. What are the uncertainties?

Given that it is a fledgling industry, there is considerable uncertainty surrounding future rates of development, regulation, specific location of developments, investment, cost-efficiency of construction, financial incentives and final economic contribution.

vi. Forward look

There will be increasing economic activity within both of these areas over the next decade because of increasing levels of gas imports and drivers to reduce CO_2 emissions as part of an overall strategy to mitigate climate change, while ensuring energy security.

3.14.2 Introduction

This sector refers to the use of the sub-sea marine environment for storage of gas reserves and CO_2 produced from power generation and industrial processes. Recent developments in technology mean that it is possible to store gas (natural gas or 'captured' CO_2) under the sea in man-made salt caverns and other geological structures (e.g. saline aquifers), as well as in depleted oil or gas fields (such as the existing *Rough* storage facility in the North Sea).

The storage of natural gas refers to storage of reserves for future use. Currently the UK has the lowest natural gas storage rate in Europe although this is set to increase.

Carbon dioxide, particularly that from power generation and industrial processes, may be captured and stored to reduce atmospheric concentrations of CO_2 in a process known as carbon capture and storage.

More recently there have been proposals to use storage facilities to store energy from wind power as compressed air enabling a more steady supply of electricity from variable wind resources (Energy Saving Trust, 2009).

3.14.2.1 Description of economic activities

Economic activities related to storage are listed in Table 3.98. Due to the developing nature of the industry, storage of natural gas and CO_2 currently has no appropriate SIC number. The process is supported by a number of specialised ancillary activities, such as surveying and prospecting and pipeline construction. Secondary activities are not considered here as no currently commercially viable end use for stored CO_2 has been identified.

There is only one offshore gas storage facility currently in operation in the UK: the *Rough 47/8 Alpha* facility (hereafter referred to as *Rough*) which lies approximately 26 miles off the Humber Estuary. The *Rough* field was originally purchased by the then British Gas Corporation in 1980 and converted into a gas storage facility. It became operational in 1985. It is now owned and operated by Centrica Storage Ltd. *Rough* has a total storage capacity equivalent to 30 TWh at pressures of over 200 bar and gas can be injected into the reservoir at an average of 160 GWh a day, depending on the reservoir pressure (DECC, 2009d). A description of the *Rough* facility is provided by Centrica Storage Ltd and gives some understanding of the activity associated with natural gas storage:

Table 3.98 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Storage: Natural Gas Storage Carbon Capture and Storage (Part SIC 06.10 and 06.20)	Support activities – e.g. surveying and prospecting (SIC 09.10), engineering design (SIC 71.12/1), utility and pipeline construction (SIC 42.21) and operation (SIC 49.50)	None identified	None identified

Gas is injected and extracted via 30 wells which have been drilled into the reservoir. Gas is extracted as a vapour and undergoes several separation processes offshore before being sent via a 91cm (36inch) subsea pipeline to the Easington terminal. Gas from Rough is a mixture of condensate (a light oil similar to paraffin) and gas. Separation dries out the gas before the liquid condensate is treated. Gas is introduced to the National Transmission System through an entry point adjacent to the Easington terminal. The liquid condensate is stabilised and sent by underground pipeline to the neighbouring BP Dimlington terminal. It is then piped to either BP's Saltend facility near Hull or another site where it is shipped for use in the petrochemical industry. Extracts from Centrica Storage (2010).

CO_2 capture technologies are based on three types of technologies: pre-combustion, post-combustion and oxyfuel combustion and can be applied to coal- or gas-fired power generation as well as industrial facilities such as steel, cement and chemicals. All three techniques use energy, potentially decreasing the efficiency of the power plant. There are also difficulties in scaling up and integrating all parts of the system, from source to sink, into one project. CCS therefore represents a major technological challenge, and there are also cost uncertainties and regulatory issues that still need to be resolved.

As yet, no commercial-scale CCS power station has been developed with storage in UK waters. However, the UK Government has committed that any new coal power stations being developed will need to demonstrate CCS (initially for about 25% of their capacity – or 400MW) in order to win planning approval. The UK has also introduced a carbon capture ready policy on all new thermal generating stations (i.e. gas as well), and there is now a commitment to building 4 CCS projects by 2020.

An existing case study highlighting the process is the *Sleipner West* gas field in the Norwegian North Sea. Natural gas extracted from the *Sleipner West* field has a CO_2 concentration ranging between 4% and 9.5%, processing of the gas reduces the CO_2 quantity (normally through venting) to 2.5% or less (Bentham et al., 2005). This separation process results in the production of 1 million tonnes of CO_2 annually which is stored in a reservoir between 800 and 1000 m below the surface, storage began in August 1996 and is scheduled to continue for the life of the field (estimated at 20 years). Additional costs are estimated to be US$15 per tonne of CO_2 avoided (Bentham et al., 2005).

3.14.2.2 Description of relevant ecosystem services

As well as economic services, the gas storage sector would also rely on various ecosystem services that support its productivity, including the provision of a stable physical environment in which to operate.

3.14.2.3 Management

DECC is the competent authority for the regulation of natural gas and CO_2 storage. It is working towards developing the regulatory framework for CCS.

Internationally, two global marine environment conventions have been amended to facilitate CCS: the 1996 Protocol to the London Convention was amended in November 2006 and the OSPAR Convention for the protection of the North-East Atlantic ocean was amended in July 2007 although this has not yet been ratified by the convening countries. On 23 January 2008, the European Commission put forward an integrated package of policies on climate and energy which included a legislative proposal establishing the regulatory framework for CCS and recognition of CCS in the EU Emissions Trading Scheme. An EU Directive on the geological storage of carbon dioxide was formally adopted on 6 April 2009 as part of the climate-energy legislative package (2009/31/EC).

Concurrently, the UK Government outlined plans for new and simpler legislation of CCS in the Energy White paper (DTI, 2007a). This now involves two determining authorities – The Crown Estate, which will issue geographically bound leases for the use of the seabed or water column, and DECC, which will issue a Gas Storage Licence for offshore gas storage as well as a CO_2 storage licence. Gas storage in partially depleted oil and gas fields will still require a Petroleum Production Licence.

The new Energy Act 2008 makes provision for the designation of Gas Importation and Storage Zones (GISZ) out to 200 nautical miles and creates a licensing framework for the underground storage of combustible gas offshore and CO_2.

An industry body called the Gas Storage Operators Group represents gas storage companies in the UK on relevant issues including licensing, planning, safety and environmental issues. It has a membership of 15 companies operating both on and offshore. The Carbon Capture & Storage Association (CCSA) was launched in March 2006 to represent its members in the fledgling economic industry and now has a membership of 80 companies and organisations. Furthermore, a UK-wide group of technical scientists, called the UK Carbon Capture and Storage Consortium are working together under the umbrella of the UK Energy Research Council to investigate a number of issues related to CCS.

3.14.3 Direct use value

3.14.3.1 Principal activities

The values associated with storing natural gas and CO_2 in or under the seabed are largely related to indirect socio-economic and environmental benefits; i.e. indirect use values such as energy security from storage of gas reserves and climate change benefits from reductions in atmospheric CO_2. These are discussed further in Section 3.14.6.

3.14.3.2 Ancillary activities

Ancillary activities include survey and construction. Captured CO_2 may need to be transported to storage sites and this, in the UK, is most likely to occur by pipeline. Hubs have been proposed where emitters of CO_2 will be connected to a central pipeline, or pipelines, that will transport the CO_2 to offshore storage sites. For example, a scoping study released by E.ON has proposed a pipeline system to transport captured CO_2 from new and existing power stations and refineries around the Thames area to the *Hewett* gas field in the southern North Sea. The hub or cluster would be capable of transporting a total of 28 million tonnes of CO_2 annually (E.ON, 2009). Similarly, the provision of a transport system for the Yorkshire and Humber region has been proposed that includes the re-use of suitable existing gas infrastructure, such as pumps and pipelines (Yorkshire Forward, 2008). By 2030, CO_2 capture and storage using this network could provide about £1.2 billion per year of economic activity to the Yorkshire and Humber region through EU-ETS credits alone.

There are significant values associated with the ancillary activities (and industries) that support the principal activity. This value can be estimated from the costs of, or investments in, CCS.

It is likely that CCS would not be commercially viable unless costs fell substantially relative to the cost of other cheaper forms of energy generation, or unless the carbon price rose sufficiently to provide a larger financial incentive (DTI, 2007a).

The overall costs of CCS have been estimated to range from £28 to £35 per tonne of CO_2 abated ($teCO_2$) for enhanced oil recovery and £22 to £27 per tonne for storage in depleted gas reservoirs. Storage involving enhanced oil recovery is more expensive to implement than injection into depleted gas reservoirs because it requires extra investment in injection and production wells and modifications to production platforms (DTI, 2003a). Enhanced oil recovery gives some financial return from the additional oil produced which reduces the overall cost to £4 to 10/$teCO_2$ (DTI, 2003a). However, a European study suggests that early demonstration projects will typically have a significantly higher cost of €60 to €90 per tonne of CO_2 abated, approx £54 to £81 per tonne[26] (McKinsey, 2008). It is expected that costs will come down to around €30 to €45 per tonne of CO_2 in 2030.

Investments to date include £35 million of capital grants in the Carbon Abatement Technology (CAT) programme, launched in June 2005 for the pilot demonstration of key CCS components. As part of an EU Recovery Plan funding package released 28 January 2009, the European Commission proposed €250 million for the development of CCS at four coal-fired plants in Britain: Kingsnorth in Kent, Longannet in Fife, Tilbury in Essex and Hatfield in Yorkshire. This commitment was detailed in the UK budget released 22 April 2009 along with an additional £90 million to pay for more research into the technology.

3.14.4 Regional distribution of value

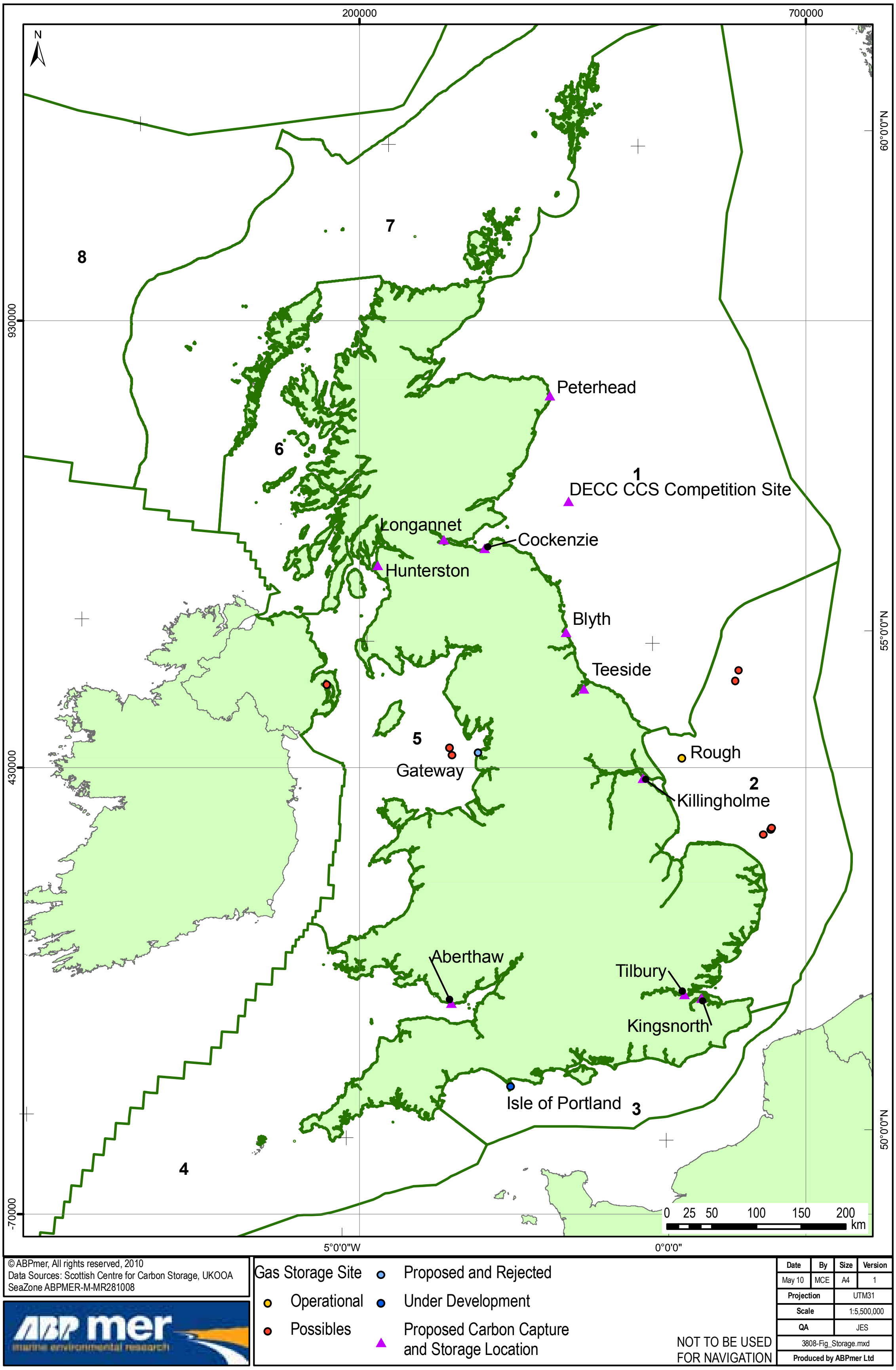
Distribution of gas storage and CCS sites are illustrated in Figure 3.53. These sites are discussed further below.

3.14.4.1 Natural gas storage

As noted in Section 3.14.2 the *Rough* facility is the only offshore gas storage site currently in operation (see Figure 3.53). There are currently a small number of potential new offshore

26 Using a conversion rate of 1€ to £0.897.

Figure 3.53 Distribution of gas storage and proposed CCS sites.



gas storage developments although some of these have also been proposed for CCS (see Table 3.99). They include the Gateway gas storage project, an offshore underground salt cavern in the East Irish Sea, northwest England.

It should be noted that a large number of existing proposals are located coastally, accessing geological strata under terrestrial land rather than specifically under the seabed. However, they may interact with the marine environment through coastal infrastructure such as supporting pipelines. For example, a development site in the South is a land-based project making use of old salt layers nearly 2500 m underneath Portland Bill to create impermeable storage caverns. As such, the associated £450 million investment is not included in analyses here although the project will involve pipelines crossing Weymouth Bay to link with the national gas transmission system on land.

3.14.4.2 Carbon capture and storage

Within UK territorial waters the suitable areas for CCS tend to coincide with the locations of offshore oil and gas extraction (Bentham et al., 2005). This is because the reservoirs that hold oil and gas tend to be impermeable and are therefore suitable for the long-term storage of CO_2. Saline aquifers are also suitable for storage, however more research is required. CO_2 can either be sourced from large point sources of CO_2 (such as power stations or industrial facilities) or from the offshore installation itself (in the case of Enhanced Oil Recovery). The total potential for CO_2 storage in/under the seabed of UK territorial waters is estimated to be more than 31 000 million tonnes (Holloway et al., 2006a) with the greatest potential in Regions 1 and 2 (Table 3.99). It is worth noting that Holloway et al. (2006b) also provided more conservation estimates for the Department for

Table 3.99 Estimated UK CO2 storage capacities (Holloway et al., 2006a).

Location	*Estimated storage capacity, Gt*
Gas fields of the Southern North Sea Basin	3.88
Oil fields of the Northern and Central North Sea Basin	6.50
Gas fields of the East Irish Sea Basin	1.05
Bunter Sandstone saline aquifer (S. North Sea Basin)	14.25
Bunter Sandstone saline aquifer (E. Irish Sea Basin)	0.63
Leman Sandstone saline aquifer (S. North Sea Basin)	3.13
Palaeocene Sandstone saline aquifer (Northern and Central North Sea Basin)	≥ 2
Total	**≥ 31 Gt**

Business, Enterprise and Regulatory Reform (BERR) of a total of 22 000 million tonnes, which did not include the more theoretical storage reserves.

3.14.5 Trends

As these are developing industries there are currently few economic trends available to report on. Activity at the *Rough* storage facility is dependent on patterns of supply and demand which tend to be seasonal. Gas is withdrawn from the National Transmission System at Easington during periods of low gas demand (largely in warmer weather) and re-injected into the *Rough* field for storage (Centrica Storage, 2010).

3.14.6 Socio-economic pressures and impacts

Having reliable gas reserves has benefits for energy security and supply and, as a consequence, gas prices. As an example, a fire at the *Rough* facility in February 2006, combined with a cold winter spell that increased demand, resulted in an increase in gas prices. Shippers were forced to rely on more expensive (and less abundant mid-range and Liquefied Natural Gas storage) rather than *Rough* withdrawals to meet demand (MJM Energy, 2006).

The technical, economic, environmental and social aspects of CCS are currently attracting worldwide interest, with over 20 countries pursuing activities and programmes. There is large potential for the UK to become a world leader in this technology making important contributions to a number of international fora and collaborations and exporting knowledge and strategies.

The main environmental benefit of CCS is in mitigating the levels of CO_2 and therefore plays an important role within the portfolio of approaches required to make significant reductions in the level of CO_2 emissions. CCS will be a key technology supporting the continuation of important industries while helping to ensure that the required reductions in CO_2 emissions are met. Three industries account for over half of global emissions, namely Power Generation (46%), Iron & Steel (13%) and Cement (8%) (L.E.K. Consulting, 2009). These three industries represent the most significant potential for CCS commercial deployment and where the greatest benefit might be achieved. Other industrial processes already carry out CO_2 separation and provide early opportunities for CCS deployment including gas extraction and processing, industries associated with ammonia, refineries and oil sands, and other gasification-based processes.

CCS can also help enhance oil recovery from some reservoirs with a significant positive and permanent effect on the recovery efficiency of available UK reserves (Entec, 2009).

3.14.7 Environmental pressures and impacts

For CCS, potential storage methods include injection into underground geological formations, injection into the deep ocean, or industrial fixation in inorganic carbonates. Key environmental pressures and impacts associated with storage can be seen in Table 3.100. The ecosystem services that these pressures impact and the relative significance of these impacts are identified in Table 3.101.

Three treaties designed to protect the marine environment are relevant to offshore UK CCS in geological structures: the 1972 London Convention, its 1996 Protocol and the 1992 OSPAR Convention. These treaties refer to waste disposal into the water column or underlying 'subsoil' and did not consider the possibility of offshore CCS when they were drafted. An OSPAR review concluded that CCS is consistent with the Convention if carried out by pipeline from land. Further reviews of CCS in the context of both the London Convention and the OSPAR Convention (the latter on environmental aspects) are underway. Enhanced oil recovery is allowed under all three treaties as 'placement of matter for a purpose other than mere disposal'.

Gas storage projects need an environmental impact assessment (EIA) under the requirements of the EU EIA Directive. However, the basis for applying EIA to such projects is currently unclear in UK legislation, and early resolution is

Table 3.100 Key environmental pressures and impacts associated with storage of gases. Based on information from: Johnston and Santillo (2003); Parliamentary Office of Science and Technology (2005); Benson and Cook, (2005); Fabry et al. (2008); Entec (2009).

Pressure	**CO_2 leakage**
Impact	Leakage could cause local acidification with a permanent effect on marine habitats if allowed to persist Leakage into the sea would result in a change in pH and changed gas balance in the water which could have significant effects on marine ecology including sub-surface microbial systems and plankton dynamics
Description of environmental change (intensity, spatial extent, frequency, duration)	Leakage of CO2 may originate from pipelines and sub-seabed geological formations The potential for such leakage will depend upon caprock integrity and the security of well capping methods in the longer term, together with the degree to which the CO2 is eventually 'trapped' through solubility in, for example, residual oil, formation waters or by reaction with formation minerals to form carbonates
Existing management measures	The risk of leakage or escapes from pipelines can be mitigated through the monitoring regime and regulatory compliance with COMAH and HSE

Pressure	**Salinity increase**
Impact	The creation of salt caverns involves the injection of water through a well down into the cavern. The water dissolves the salt, creating brine which flows back up the well. This hypersaline water may be highly toxic to marine organisms. Furthermore, it forms a dense layer across the seabed
Description of environmental change (intensity, spatial extent, frequency, duration)	The potential for impact on marine communities at a local scale is significant although the magnitude is relatively unknown
Existing management measures	The risk of leakage or escapes from pipelines can be mitigated through the monitoring regime and regulatory compliance with COMAH and HSE

Pressure	**Introduction of non-synthetic substances and compounds**
Impact	Pollution and other chemical changes: due to the use of solvents in carbon capture, any discharged waters are likely to carry contaminants

Pressure	**Smothering**
Impact	Physical loss from construction and decommissioning activities
Description of environmental change (intensity, spatial extent, frequency, duration)	Activities contributing to these pressures include construction of supporting infrastructure and pipeline installation. Given that the aim is to re-use existing infrastructure where possible, additional physical disturbance associated with CCS will be negligible in scale relative to natural disturbance and the effects of demersal fishing
Existing management measures	For biodiversity, the EU Birds and Habitats Directives and associated UK Regulations are the primary mechanism for managing physical damage and loss in Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). The Strategic Environmental Assessment (SEA) and EIA Regulations cover the wider impacts arising from construction, operation and decommissioning oil and gas operations. Measures include careful site selection and routing of pipelines, use of best practice construction techniques such as horizontal drilling and post construction restoration

Pressure	**Siltation rate changes**
Impact	Physical damage from construction and decommissioning activities, reduction in water quality. Dredging, e.g. for pipelines, may also resuspend sediments and release contaminants
Description of environmental change (intensity, spatial extent, frequency, duration)	Activities contributing to these pressures include construction of supporting infrastructure and pipeline installation. Given that the aim is to re-use existing infrastructure where possible, additional physical disturbance associated with CCS will be negligible in scale relative to natural disturbance and the effects of demersal fishing
Existing management measures	For biodiversity, the EU Birds and Habitats Directives and associated UK Regulations are the primary mechanism for managing physical damage and loss in Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). The Strategic Environmental Assessment (SEA) and EIA Regulations cover the wider impacts arising from construction, operation and decommissioning oil and gas operations. Measures include careful site selection and routing of pipelines, use of best practice construction techniques such as horizontal drilling and post construction restoration

Pressure	**Physical presence of structures**
Impact	Loss of species and habitat within the footprint of the structure
Description of environmental change (intensity, spatial extent, frequency, duration)	Activities contributing to these pressures include construction of supporting infrastructure and pipeline installation. Given that the aim is to re-use existing infrastructure where possible, additional physical disturbance associated with CCS will be negligible in scale relative to natural disturbance and the effects of demersal fishing
Existing management measures	For biodiversity, the EU Birds and Habitats Directives and associated UK Regulations are the primary mechanism for managing physical damage and loss in Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). The Strategic Environmental Assessment (SEA) and EIA Regulations cover the wider impacts arising from construction, operation and decommissioning oil and gas operations. Measures include careful site selection and routing of pipelines, use of best practice construction techniques such as horizontal drilling and post construction restoration

Pressure	**Reduction in CO_2 emissions**
Impact	Reduced climate change impact
Description of environmental change (intensity, spatial extent, frequency, duration)	Likely to be overall benefits for ecology (Entec, 2009) although these are unquantified at present
Existing management measures	For biodiversity, the EU Birds and Habitats Directives and associated UK Regulations are the primary mechanism for managing physical damage and loss in Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). The Strategic Environmental Assessment (SEA) and EIA Regulations cover the wider impacts arising from construction, operation and decommissioning oil and gas operations. Measures include careful site selection and routing of pipelines, use of best practice construction techniques such as horizontal drilling and post construction restoration

Table 3.101 Environmental pressures on ecosystem services associated with storage of gases.

Ecosystem service	*Significance of impact*	*Confidence in the assessment*
Biodiversity provision	**Low – Moderate.** Low for collision risks, but moderate for noise/seismic effects for cetaceans and other large marine species sensitive to vibrations.	**Low. K**nowledge improving but long-term effects on biology of species poorly understood
Biological productivity (supporting service)	**Low**. Disturbance to seabed by footprint of installations, abrasion and deposition of waste, may be significant, but usually only to a relatively small area of seabed.	**Moderate – High. S**ome aspects of pollution well studied, and sector footprint known in detail.

desirable in light of the drivers for increased UK gas storage capacity. An SEA has more recently been carried out investigating a framework for the development of clean coal (Entec, 2009) that includes the development of carbon capture technologies. The SEA included objectives to consider the impacts of the framework on ecology, water quality, flood risk and coastal erosion. Impacts of noise were excluded until further data are available, but for an overview see Section 3.9 (Oil and Gas).

Gas storage developments are predicted to be very similar, in terms of noise, to existing gas production. Furthermore, the potential list of marine discharges from gas storage activities will be similar to that for oil and gas exploration (see Section 3.9), although produced water and scale volumes will be minor. The effects of the majority of these are judged to be negligible although they would still be considered in detail in EIAs and chemical risk assessments under existing permitting procedures. However, the production of salt caverns may have significant environmental effects within the vicinity (E.ON, 2010).

The physical presence of anthropogenic structures in the marine environment is not expected to increase significantly following gas storage licensing (DECC, 2009d).

3.14.8 Climate change

3.14.8.1 Impacts of climate change on carbon capture and storage

The sequestration of CO_2 involves the capture at source and the subsequent storage of CO_2 in a geological formation under the seabed. As the CO_2 storage is under the seabed in an offshore location it is likely that the impacts of climate change will be similar to those that could be experienced by the oil and gas industry. These could include vulnerabilities to both changes in sea level and increases in waves and winds, leading to greater stresses on structures in the marine environment. Changes to currents could result in changes to scour around the legs and supports of offshore installations and pipelines (Rees, 2008).

Adaptation measures

There is no evidence to suggest that the offshore industries are currently having to adapt to climate change. The design and operation of offshore structures in the UK is based on comprehensive records of metocean data used to calculate extreme wave, wind and water level events. Although the use of historic data provides an indication of the statistical probability of a past event reoccurring, it will be become important to take into account projected future changes in water level, winds

and waves as these will impact on the future design of offshore installations. It may become necessary to make offshore structures more robust to deal with future climate change.

3.14.8.2 Impacts of carbon capture and storage on climate change

For the purposes of this report, carbon storage is taken to be geological carbon sequestration whereby CO_2 is captured at source (for example during combustion at a power station) and is compressed and transported to a suitable geological site (in this case under the seabed).

The main impact of geological carbon sequestration is likely to be related to the energy required to fuel the process. As a result not all of the CO_2 captured and placed in storage in CCS schemes can be counted as CO_2 emissions abated. This is because the efficiency of a power plant with CO_2 capture is less than that for a non-capture plant, therefore more fuel is burnt to generate the same amount of electricity, and because energy is used by compressors and injection facilities used to transport and store CO_2, which creates additional CO_2 emissions (DTI, 2003a).

Atmospheric emissions are also associated with gas storage, which includes the power requirement from compression. Atmospheric emissions emanate from a variety of sources at *Rough* and the Easington Terminal, including the consumption of gas, fuel and diesel, flaring and venting and fugitive and other emissions, with the greatest amount of gas released being CO_2. In 2002, total emissions of CO_2 from *Rough* amounted to 106 172 tonnes (equating to 0.6% of the total CO_2 emissions from offshore facilities). CO_2 emissions from Easington Terminal in 2002 amounted 94 786 tonnes (equating to just over 2% of the total CO_2 emissions from onshore facilities) (DECC, 2009d).

Mitigation measures

Carbon dioxide emissions could be reduced if the compressors and injection processes were powered by renewable energy sources or if the CO_2 created was also stored. There is also potential for negative emissions through the combination of CCS with biomass energy plants.

3.14.8.3 Summary

Table 3.102 provides a summary of the climate change pressures and impacts associated with storage of gases and indicates the likely significance of the impacts and the level of confidence in the assessment.

3.14.9 Industry stability and sustainability

3.14.9.1 Gas storage

With around £10 billion of investment in new gas storage and import facilities in place or planned over the next few years, storage capacity available in the UK is set to increase substantially (DTI, 2007a). More than 5.6 billion cubic metres of new gas storage capacity is either under construction, planned or proposed, potentially doubling UK storage capacity by the middle of the next decade (based on 2005/2006 levels). In particular, the Gateway gas storage project and associated infrastructure is expected to be completed by 2011/12.

3.14.9.2 Carbon capture and storage

The individual processes (capture, transport, and storage) involved in CCS are not new but have yet to be demonstrated together at a commercial scale on large CO_2 point sources (e.g. power generation and industrial processes). A lack of demonstration projects has been identified as a barrier to full-scale commercial CCS deployment. Following drivers in the

Table 3.102 Summary of climate change implications.

Climate change Pressure	*Impacts of climate change on Storage of Gases*	*Confidence/ significance*	*Adaptation measures*
Increase in severity of storms	Increased loads on marine structures	Medium confidence / medium significance	Offshore structures will need extra engineering to withstand conditions
	Shortening of suitable calm weather periods during which maintenance can be undertaken	Low confidence / low significance	Restrict maintenance to periods of calm weather

Impacts of Storage of Gases on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
Energy required in the processing, transport and storage of CO_2	CO_2 emissions	Low confidence / low significance	Source the extra energy from renewable sources or capture carbon produced

2007 Budget, the Government launched a competition in November 2007 to develop the UK's first full-scale demonstration of carbon capture and storage. Key objectives of the demonstration competition in the UK are: (1) to deliver a successful demonstration of the full chain of CCS technologies on a power plant at a commercial scale; and (2) to demonstrate technology that is relevant and transferable to key global markets – particularly in emerging economies. Successful bidders were announced in June 2008.

The UK and Norway have been collaborating on how the transportation and storage of CO_2 in the North Sea should be managed, establishing the North Sea Basin Task Force in December 2005. The Task Force submitted a report to the UK energy ministers in 2007 (Element Energy Ltd, 2007). This helped to support the development of a regulatory framework in the UK to enable CCS to develop effectively, safely and in line with the Government's environmental principles.

3.14.10 Forward look

The Energy White Paper (DTI, 2007a) sets out the UK Government's international and domestic energy strategy to respond to the key long-term challenges of tackling climate change and in ensuring a secure supply of clean and affordable energy. The strategy has four key goals:

- To put ourselves on a path to cutting CO_2 emissions by some 60% by about 2050, with real progress by 2020
- To maintain the reliability of energy supplies
- To promote competitive markets in the UK and beyond
- To ensure that every home is adequately and affordably heated

More recently, through the Climate Change Act 2008, the UK is committed to an 80% reduction in CO_2 by 2050, as well as meeting interim carbon budgets (such as 34% by 2020).

The UK Government is committed to increasing gas storage and import infrastructure by facilitating the construction of gas supply infrastructure both onshore and offshore,

through reforms to the planning and licensing regime (DTI, 2007a). No specific targets have been established for storage capacity, as the Government considers that the key to security of supply lies with a regulatory framework that provides incentives for commercial storage and with liberalisation of the gas market in Europe[27].

The Government believes that the development and wide-scale deployment of CCS is important for the UK's climate change and security of supply objectives. It is taking forward the development of the CCS concept through the promotion of a demonstration project and addressing current regulatory barriers. Depending on the outcome of the demonstration project, this may lead to more widespread use of CCS.

DTI (2007a) noted that storage capacity available in the UK is set to increase substantially. If all the planned storage projects go ahead the proportion of peak day demand that could be met by storage operating at its maximum level would increase from 24% in 2006/07 to between 40% and 60% by 2015/16.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the gas storage sector will need to manage further its activities. For example, GES Descriptor 6 states that *...Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

27 In the Energy Review Report (DTI, 2003a), the Government rejected the case for domestic strategic gas storage. Analyses indicated that strategic storage would dull the incentives for commercial investment into storage, thus reducing the volume available commercially, and possibly reducing the overall level of security of supply.

3.15 Telecommunications

3.15.1 Key points

- It is difficult to define the direct use value of the telecommunication sector in the marine environment
- An indicative gross value added (GVA) of £2.7 billion was estimated based on the number of international phone calls. However this figure does not include the value of internet and data capacity which are now the primary commodity and which are increasing
- The true value of telecommunications cables should incorporate both the value of the traffic which is carried and the significance of the UK as a key strategic location for international systems. These are difficult to capture in market value terms but are significant
- Impacts from cable installation on the seabed are short term and spatially minor. The existing 18 000 km of cable is estimated to cover approximately 1.6 km^2 or 0.0002% of the UK Continental Shelf (UKCS)
- The sector went through a period of correction (2002-2006) following the growth and downturn associated with the Dotcom bubble but major domestic and international systems are now being installed
- Future developments in this sector are focused on extending the global reach of the submarine networks, investing in higher capacity circuits and increasing resilience by diversity

i. Introduction

The overwhelming majority of international communication transmissions are through fibre optic submarine cables. These carry telephony, internet and data transmissions which service many other industries such as finance, commerce and media. As with pipelines, the principal marine activity is not providing the resource that is being transported (in this case information and communications) but is the use of a stable seabed to lay cables across.

ii. How has the assessment been undertaken?

The assessment was facilitated by advice from the UK Cable Protection Committee. Information on the distribution of cables across the UKCS was provided by the Kingfisher Information Service – Cable Awareness programme (KISCA).

iii. Current status of the telecommunications sector and past trends

It is difficult to define the direct use value of the telecommunication sector in the marine environment. For example, an indicative value of £2.7 billion has been estimated based on the number of international phone calls. However, this figure is conservative as it does not include the value of internet and data capacity which are now the primary commodity and which are increasing. The true value of telecommunication cables should incorporate both the value of the traffic which is carried and the significance held by the UK as a key strategic location for international systems looking to reach markets in America, Europe, Africa and Asia. This is difficult to capture in market value terms but is significant.

There are some 18 000 km of telecommunication cable (active and non-active) on the UKCS covering approximately 1.6 km^2 or 0.0002% of the UKCS. The majority of international telecommunications cables (43%) are located and come ashore in Region 4 (south west approaches and Celtic Sea). Impacts from cable installation on the seabed are short term and spatially minor.

iv. What is driving change?

The UK telecommunications sector went through a period of correction, mostly in the early 2000s following the growth and downturn associated with the Dotcom bubble. Since *Charting Progress* (Defra, 2005a) major domestic and international systems are now being installed.

v. What are the uncertainties?

The economic value is difficult to capture. Market information is not freely available. However, there is a high level of confidence in the information on the spatial distribution of cables and their environmental impacts.

vi. Forward look

Future developments in this sector are focused on extending the global reach of the submarine networks, investing in higher capacity circuits and increasing resilience by operating networks over a number of different cables.

3.15.2 Introduction

This section deals with telecommunications, a sector which has seen massive growth over the past decade. The overwhelming majority of international communication transmissions are through fibre optic submarine cables. These carry telephony, internet and data transmissions which service many other industries such as finance, commerce and media. The economic activities are noted in Table 3.103.

3.15.2.1 Description of economic activities

As with pipelines, the principal activity is not providing the resource that is being transported (in this case information and communications) but use of a stable seabed to lay cables across. Key telecom cable operators include BT, Cable & Wireless, Apollo, TATA Hibernia Atlantic, Reliance Globacom, Level3 Communications and Virgin Media. Installation contractors include Global Marine Systems Ltd, Alcatel-Lucent, Tyco Telecommunications and CTC Marine Projects. These are supported by other equipment manufacturers and operators such as Soil Machine Dynamics Ltd.

3.15.2.2 Description of relevant ecosystem services

As well as economic services, the cables sector also relies on various ecosystem services that support its activity, including a stable physical environment in which to operate.

Physical features of greatest significance include shallow gradients, areas of limited seabed surface change, and soft sediments which allow for the trenching of systems. However, the technologies employed to lay cables allow systems to be installed in a variety of conditions and the significance of the physical environment as a hindrance is limited within the UK.

3.15.2.3 Management

Proposals to install cables at sea (within Territorial Seas of England and Wales and UK offshore waters) require consent(s) via application to the MFA (Marine & Fisheries

Table 3.103 Economic activities.

Principal	Ancillary	Secondary	Excluded
Telecommunications Operation of submarine telecommunications facilities (SIC 61.10)	Construction of utility projects (part SIC 42.22); Operation of communication facilities	None identified	None identified

Agency). Scotland and Northern Ireland have devolved responsibility to manage such activities within their territorial waters.

The UK Government and Devolved Administrations are also signatories to the UN Convention on the Law of the Sea (UNCLOS) which governs UK waters beyond 12 nm. The agreement sets out national jurisdictions and establishes the legal regime for the High Seas. It provides the legal basis for the protection and sustainable development of the marine environment and addresses environmental control, scientific research, economic activities and the settlement of disputes over seabed rights.

The industry in the UK is represented by the UK Cable Protection Committee (UKCPC). About 10% to 15% of the operators come within the medium-sized enterprise category (50 to 249 employees; turnover £10 to 50 million) with the rest defined as large enterprises.

3.15.3 Direct use value

3.15.3.1 Principal activities

As with pipelines (see Section 3.10: Pipelines), the principal value is not of the resource that is being transported (in this case information and communications) but of the use of the seabed to provide a substrate for the cable. The value could be estimated from alternative means of transmitting this information if the industry could not make physical use of the seabed, for example comparing it with the implications of using air and space as media via the use of more satellites, if this was realistic and economically viable. However, it is difficult to assess this value quantitatively, because its calculation is relative to a counterfactual situation that is very difficult to specify.

The further difficulty in identifying the contribution made by submarine telecom cables to the UK is the way in which such systems are observed from a regional perspective and their role in providing a subsequent service. Cable systems are commissioned on both a national and international basis and observed from that perspective, this limits the extent to which a system can be divided and any quantifiable evidence provided on the contribution made on any given sub-section. Secondly, the value of a given system is not an entity in its own right but for the services it enables.

The value of international phone calls was used by Pugh (2008) to estimate the value of the sector[28], i.e. the market value of being able to use the cable for communications. In 2005, the total telecoms revenue was £46.6 billion for the UK. It was reported by the Office of Communications (Ofcom) that 10.7% of the calls revenue was from international calls. If this percentage is used as a proxy for telecommunication cable related value,

28 The number of minutes of international calls made by businesses and residential service users is included in the Monthly Digest of Statistics published by the Office for National Statistics (www.statistics.gov.uk/downloads/theme_compendia/MD-Oct-2008/MD-Oct-2008.pdf).

a value of £4.9 billion is estimated (Pugh, 2008). Pugh (2008) referenced the Office for National Statistics (ONS) combined used matrix for 2004 which gives a value added factor of 0.54 resulting in an estimated GVA due to telecommunication cables of £2.7 billion.

This is a very conservative figure based only on UK international calls revenue, and takes no account of the economic value of internet and data transactions which use the majority of 'lit' or current capacity. Additionally, the value the UK provides is not limited to uses employed by the UK but the significance held by the UK as a key strategic location for international systems looking to reach markets in America, Europe, Africa and Asia. Substantial international capacity directly services and transits the UK due to the UK's strategic location as an international hub. These values are difficult to capture in market value terms but are significant.

3.15.4 Regional distribution of value

The spatial distribution of telecommunication cables in UK waters can be seen in Figure 3.54 and totals some 18 000 km. Just over 11 000 km of these are active. The total area of the UKCS that is occupied by cables is estimated to be 1.6 km² representing 0.0002% of the UKCS (based on a nominal cable diameter of 0.09 m including rock armour or double armour; Eastwood et al., 2007). The total distribution across the UKCS is given in Table 3.104. This indicates that the majority of telecommunications cables (43%) are located in Region 4 and Figure 3.54 suggests that many of these are international connectors.

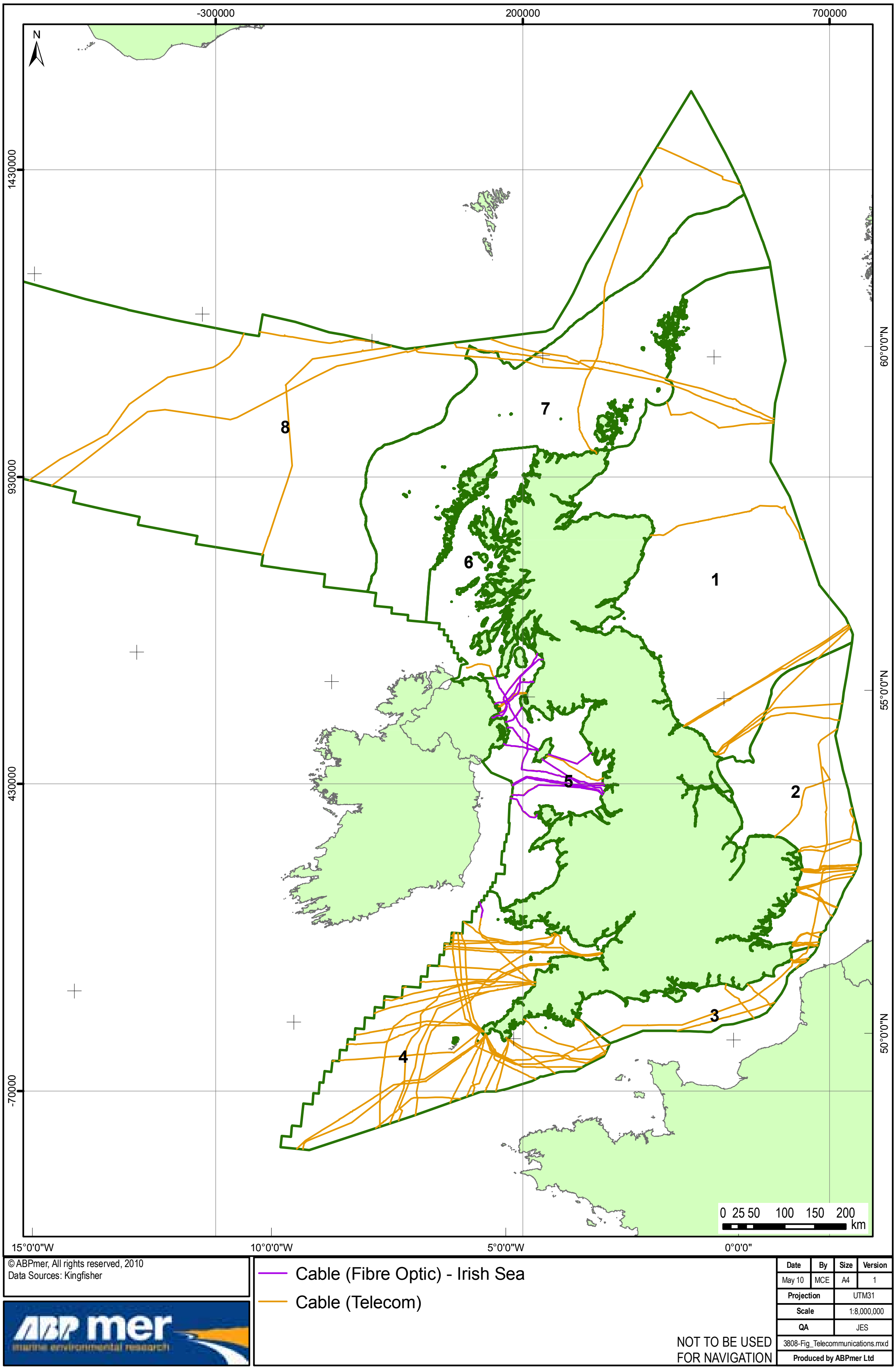
Table 3.104 Distribution of all telecom cables across CP2 Regions.

CP2 Region	*Length*	*Percentage of total length*
1	1876	10.45
2	2288	12.75
3	784	4.37
4	7786	43.37
5	1764	9.82
6	61	0.34
7	904	5.03
8	2491	13.87
Total	17 954	100.00

3.15.5 Trends

The bursting of the 'dotcom' bubble in 2001 caused a downturn in the telecommunications market for installation companies. However, use of the internet and continued development of e-commerce has led to an increasing demand for communication cable capacity. Cordah (2001) stated that in the previous three years (i.e. 1998 to 2001) traffic on a global scale had grown by over 500%. This rapid development lead to an increase in the number of new subsea telecommunication cables traversing the North Sea to link the UK with mainland Europe and traversing the Atlantic to link the UK with North America (Cordah, 2001; Hartley Anderson Ltd, 2004). The downturn and changes in technology also made many systems laid in UK waters during the early 1990s redundant. A mini boom in installation activity was seen in 2008 (www.smd.co.uk/news/smd_winter_08.pdf), which has continued into 2009 with the development of the Europe India Gateway (EIG), a new system linking the UK with India via the Mediterranean/Red Sea route.

Figure 3.54 Distribution of telecommunication cables in UK waters.



3.15.6 Socio-economic pressures and impacts

Socio-economic pressures and impacts for telecom cables can be positive (e.g. the internet, employment, research) or negative (e.g. impacts on other sea users such as fisheries, marine aggregates and renewable energy developments). Telecom cables directly support the economy through facilitating improved communications and data transference. Pugh (2008) estimates that about 26 000 jobs in the telecommunications sector are marine related.

New technologies for burying cables deeper are constantly being developed and employed. For example, Soil Machine Dynamic's plough, MD3, set a new benchmark for cable protection by making it possible to trench a fibre optic telecoms cable to a maximum depth of 3 m in soft sediments, matching the depth of protection to the likely threat seen in South East Asia where aggressive fishing techniques require greater protection. In the UK, achieving 3 m burial is highly unlikely due to the physical nature of the seabed preventing such depths being reached. Additionally, where deep burial tools are developed there must also be new technology to retrieve deeply buried cables in the event of fault/ repair.

3.15.7 Environmental pressures and impacts

The main activities from telecom cables include survey, installation, operation, monitoring, maintenance and decommissioning. These activities are all regulated by government legislation and industry standards. Key environmental pressures and impacts associated with telecommunications cables can be seen in Table 3.105. The ecosystem services that these pressures impact and the relative significance of these impacts are identified in Table 3.106.

3.15.8 Climate change

3.15.8.1 Impacts of climate change on the telecom cabling industry

There is no published work that describes climate change impacts on the telecommunications industry. Telecommunication cables are either buried within the seabed or laid on its surface. Cables laid in water shallower than 1500 m tend to be buried which gives them some degree of protection from climate change and activities such as anchoring and trawling which could break the cables (ICPC, 2009). Cables deeper than 1500 m tend to be laid on the surface of the seabed as there is less risk of breakage (ICPC, 2009). Cables in shallow water are around 50 mm in diameter as they have a protective outer layer, cables in deeper water are not protected and so are only 17 to 20 mm in diameter (ICPC, 2009). This means that cables laid in shallow water will not be prone to scour at the seabed but could be prone to becoming unburied in areas of high sediment mobility, leading to possible breakage as a result of the cable becoming exposed to external aggression (anchors, trawling). Increases in the current regime could increase the frequency of this occurrence. There is no evidence to suggest an increased frequency in cable breakage due to scour at this time. A cable is more flexible and also narrower than a submarine pipeline so impacts on cables could be less.

There have been reported incidents of submarine cable failures in deeper water being attributed to submarine earthquakes and sediment flows. The submarine cable industry is addressing this issue by diversity (operating networks with a number of physically diverse routes) and avoiding areas prone to major submarine events.

Table 3.105 Key environmental pressures and impacts associated with the installation, removal and presence of telecommunications cables. Based on: Bochert and Zettler (2004); ABPmer (2007a); Eastwood et al. (2007); Scottish Executive (2007c); BERR (2008a); International Cable Protection Committee (www.iscpc.org); Marine Consents and Environment Unit (www.mceu.gov.uk - now part of the MFA).

Pressure	**Electromagnetic changes**
Impact	Electromagnetic fields (EMF) causing behavioural changes to electrosensitive and magnetosensitive species.
Description of environmental change (intensity, spatial extent, frequency, duration)	Telecommunication cables produce very small electric and magnetic fields. Burial of the cables will offer a protective barrier to electro- / magnetosensitive species from the strongest magnetic and induced electric fields generated next to the cable. Minimal impact is likely to marine species as detection levels of electric or magnetic fields above those of the earth's natural levels will be within a few inches of the cable.
Existing management measures	Consent is required from the Secretary of State for Environment, Food and Rural Affairs for any proposal to install telecommunications cables at sea and in other tidal waters below the level of Mean High Water Springs (MHWS). The type of consent required depends upon whether the applicant is a telecommunications 'code operator' to whom the Electronic Communications Code (set out at Schedule 2 of the Telecommunications Act 1884 - as amended by Schedule 3 of the Communications Act 2003), has been applied by Ofcom by a direction under section 106 of the Communications Act 2003. If the applicant is such a 'code operator' then an application should be made under Paragraph 11 of the Electronic Communications Code. If not, section 34 of the Coast Protection Act 1949 (CPA) applies. Under the Telecommunications Act 1984, the Secretary of State's powers will normally only apply out to the 12 mile limit of United Kingdom territorial waters[a]. Where the proposed cable route extends beyond territorial waters and passes within 500 metres of an offshore installation, section 107 of the Act applies in respect of the installation, extending those powers to the UKCS. Where an application is made under the CPA, the Secretary of State's powers extend to the entire length of the cable across the UKCS by virtue of the CPA's jurisdiction being extended by the Continental Shelf Act 1964, section 4(1). Cable protection activities, such as rock dumping or the deposit of concrete mattresses, are likely to require a FEPA licence unless specifically consented by a Works Authorisation under the Petroleum Act 1998.

Pressure	**Noise and vibration**
Impact	The burial of telecommunication cables has the potential to cause noise and vibration causing avoidance of an area
Description of environmental change (intensity, spatial extent, frequency, duration)	BERR (2008a) reported that no harmful events related to noise and vibration during burial of telecommunication cables have been reported. Noise and vibration is minimal with only short term/ temporary effects likely to cause avoidance during operations
Existing management measures	[As for Electromagnetic changes – first box in this table]

Pressure	**Abrasion**
Impact	The deployment and burial of telecommunication cables has the potential to abrade some kinds of sea bed communities
Description of environmental change (intensity, spatial extent, frequency, duration)	Cables that are surface laid may abrade the seabed, but generally cables are only installed like this in deep water, or where the sediment is too hard for burial. Abrasion is infrequent, occurring only in very limited areas, and of a very short duration.
Existing management measures	[As for Electromagnetic changes – first box in this table]

Pressure	**Habitat loss**
Impact	Loss of habitat and species in the 'footprint' of the cable.
Description of environmental change (intensity, spatial extent, frequency, duration)	Assuming a nominal cable diameter of 0.09 m (see Eastwood et al., 2007) the spatial footprint of existing telecom cables is estimated to be 0.00007 km^2. Use of mattressing / rock placement to protect cables in some environments may increase the scale of disturbance but this would again be a small area of a few square metres. The presence of the cable and/or mattressing/rock berms has been shown to increase habitat
Existing management measures	[As for Electromagnetic changes – first box in this table]

Pressure	**Habitat damage**
Impact	Physical disturbance of seabed substrata during installation causing sediment resuspension and increased turbidity which could result in wider-scale benthic disturbance.
Description of environmental change (intensity, spatial extent, frequency, duration)	The impacts of cable deployment on the benthic communities will be dependent on the sensitivity and conservation status of the species that characterise the communities along the cable route. Physical disturbance of the seabed and associated sediment re-suspension is short term/ temporary. Assuming a disturbance of 5 m either side of the cable the extent of disturbance is estimated to be 0.91 km^2 or 0.0001% of the UKCS. This is minimal in magnitude when compared with that caused by natural elements such as tides and storms.
Existing management measures	[As for Electromagnetic changes – first box in this table]

[a] www.mceu.gov.uk/MCEU_LOCAL/FEPA/CPA-TA-JURISDICTION-MAP.HTM

Table 3.106 Select environmental pressures on ecosystem services associated with telecommunications cables.

Ecosystem Service	*Significance of impact*	*Confidence in understanding of the relationship*
Biological productivity	**Minimal.** Spatial extent is limited and short term / temporary, but disturbance of physical environment could damage the habitat of specific species during laying and/or operation.	**Low.** Exact impacts uncertain, but good knowledge of extent of impacts (locations of cables)
Biodiversity provision	**Minimal.** Laying and/or operation of cables may disrupt behaviour of some species through noise and physical disturbance. But spatial extent is limited, of short term / temporary duration and impacts are unlikely to go above threshold disturbance levels. Electromagnetic disturbance could also alter the composition of species in the immediate vicinity of cables.	**Low.** Exact impacts uncertain, but good knowledge of extent of impacts (locations of cables)
Physical environment	**Low.** Spatial extent is limited, but impacts are clear via smothering, habitat damage, and vibration.	**Low.** Exact impacts uncertain, but good knowledge of extent of impacts (locations of cables)

The cost of repairing a submarine cable is variable and will depend on the distance offshore, depth of water, burial status, tide, current and the prevailing weather conditions. If storms become more severe there will be a smaller window of opportunity in which to undertake cable operations, as per current practice, to ensure the safety of the crew and vessel and to avoid further damage to the cable.

Adaptation measures

There is no evidence to suggest impacts from climate change at this time or any literature detailing proposed adaptation measures. Route selection, armouring and burial requirements of cables will be assessed, as per current practice, during the route engineering process. This will ensure that the most suitable route is chosen, and that the cable design and installation method selected suit the surveyed environmental conditions.

3.15.8.2 Impacts of the telecom cabling industry on climate change

As telecommunication cables are laid by ships, the impacts on climate change and potential mitigation measures are covered in Section 3.7 (Maritime Transport).

3.15.8.3 Summary

Table 3.107 provides a summary of the climate change pressures and impacts and indicates the likely significance of the impacts and the level of confidence in the assessment.

3.15.9 Industry stability and sustainability

The Communications White Paper (DCMS, 2001) sets out the Government's aim of making the UK home to the most dynamic and competitive communications and media market in the world. It also aims to ensure that environmental issues are properly reflected in the regulatory framework, while at the same time ensuring that there are no unnecessary barriers to the construction of the communications infrastructure the UK needs.

Furthermore, the recent government report Digital Britain (DCMS, 2009) outlines the importance of the communications sector, its crucial contribution to the economy and its role in building Britain's industrial future. The report includes more than 20 recommendations on Next Generation Networks, universal access to Broadband and enhancing the digital delivery of public services, all of which rely heavily on the submarine telecommunications networks within the waters surrounding the UK.

3.15.10 Forward look

The UK telecommunications sector went through a period of correction in the early 2000s following the growth, and downturn, associated with the Dotcom bubble. Changes in bandwidth and the development of high speed internet as well as continued growth in the sector are using up the spare capacity. Further development of more resilient networks by diversity requires a greater reliance on a number of submarine cable routes rather than a few. Major domestic and international systems are now being installed.

Market demand generally determines activity and companies have developed their own future plans. For example, additional systems have been identified to feed market demand in alternative locations such as India and Africa where the location of the UK as a stepping stone is greatly beneficial. A forthcoming example of this is the Europe India Gateway while existing examples include the two SEA-ME-WE systems (South East Asia–Middle East–Western Europe) 3 and 4.

Table 3.107 Summary of climate change implications.

Climate change pressure	*Impacts of climate change on Telecommunications cables*	*Confidence/ significance*	*Adaptation measures*
Increase in severity, frequency and duration of storms	Scour around cables (in shallow water <100 m) leading to undermining and breakage and potential exposure to external aggression. Uncovering of buried cables	High confidence / low impact	Deeper burial of cables if geophysical nature of seabed allows, pro-active route selection (as per current practice) to avoid areas with high scour potential
	Increases in horizontal currents lead to breakage of cables and uncovering of buried cables. Potential for exposure to external aggression	High confidence / low impact	Burial of cables if depth of water and geophysical nature of seabed allows, pro-active cable design (as per current practice) to armour cables according to expected conditions
Increase in severity, frequency and duration of storms	Shortening of suitable calm weather periods during which cable operations can be performed	Low confidence / low impact	Avoidance of periods of bad weather

Impacts of Telecommunications cables on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
There are no known impacts of telecommunication cables on climate change	There are no known impacts of telecommunication cables on climate change	Unknown	Not relevant

More locally, Northern Ireland has approved Project Kelvin: a cross border project bringing a direct link to the transatlantic submarine communications network into the north west of Ireland. This is co-financed under the European INTERREG IVA programme 2007-2013, and in partnership with the Department of Communication, Energy and Natural Resources in the Republic of Ireland. Project Kelvin will involve connecting a new submarine cable to the Hibernia North Transatlantic cable located 22 nm off the north coast and bringing it ashore in the Portrush area. Work on the project by Hibernia Atlantic is underway with new infrastructure to be in place and commissioned by March 2010.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the telecommunications industry will need to manage further its activities. For example, GES 6 states that ...*Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.16 Waste Disposal

3.16.1 Key points

- Disposal of waste material into the marine environment includes the regulated discharge of wastewater and the disposal of hazardous and non-hazardous waste
- Environmental pressures from both activities are well documented and monitored by the relevant agencies and can include organic enrichment and the introduction of contaminants and smothering from waste disposal
- Although there are around 215 marine disposal sites for dredged material in the UK, only about 100 are in use at any one time
- Waste disposal is dependent on the sea's ability to assimilate wastes and provides positive economic benefits to communities where it allows industries to function
- As an indicator of value, income from licensing within the UK includes about £0.3 million for waste disposal (2007 data) and £9.1 million for water discharges (2007/08 data)
- Employment in the licensing of water discharges provided an estimated £6.0 million gross value added (GVA) in the UK in 2007/08

i. Introduction

Disposal of waste material into the marine environment includes the regulated discharge of wastewater and the disposal of hazardous and non-hazardous waste. Solid wastes include disposal of dredged material from capital and maintenance dredging.

ii. How has the assessment been undertaken?

Economic and spatial information has been provided by the respective regulatory agencies responsible for managing waste disposal throughout the UK.

iii. Current and likely future status of the waste disposal sector

The environment agencies throughout the UK impose strict regulations and controls on discharges to the sea. Although there are around 215 marine disposal sites for dredged material in the UK, only about 100 of these are in use at any one time. The amount of material disposed of (as wet weight tonnages) has remained relatively constant in each country over time (see Section 3.16.5). Environmental pressures from both activities are well-documented and monitored by the relevant agencies and can include organic enrichment and introduction of contaminants and smothering from waste disposal.

Waste disposal is dependent on the sea's ability to assimilate wastes and has a positive economic benefit to communities where it allows industries to function. The maritime transport sector, for example, is reliant on shipping access to the coastline and without dredging of navigational channels (supported by disposal) this sector would either be limited or face costly alternative means of disposal. As an indicator of investment, income from licensing includes about £0.3 million for waste disposal (2007 data) and £9.1 million for water discharges (2007/08 data). Employment in the licensing of water discharges provided an estimated £6.0 million Gross Value Added (GVA) in the UK reflecting additional social benefits from the activity.

iv. What is driving change?

Demand for waste disposal and dredging activities will continue, however there is increasing pressure from the various environment agencies to minimise disposal into the marine environment. An Environment Agency Technical Advisory Group is attempting to produce a protocol to allow beneficial uses of dredged material, such as use in contract fill and for constructing soft and hard flood defences, rather than classifying all material as waste.

v. What are the uncertainties?

The principal value of waste disposal is defined as the value of being able to use the sea and its ecosystem service of assimilating wastes. The value therefore could be estimated from the cost of alternatives means of disposing of waste if the industry could not make use of the sea, for example, land disposal if this was realistic and economically and environmentally viable. However, it is difficult to quantitatively assess this value, because its calculation is relative to a counterfactual situation that is very difficult to specify. Instead the income generated through licensing of discharges and disposal was used to estimate and spatially allocate market value.

vi. Forward look

It is unlikely that demand for disposal will decrease; a number of future construction projects have been proposed which will require the disposal of large amounts of dredged material.

3.16.2 Introduction

This section considers the disposal of waste material into the marine environment. This includes the discharge of wastewater and the disposal of solid wastes, such as dredged material. Disposal of wastes at sea is regulated for environmental protection purposes. Since the 1980s disposal at sea of radioactive wastes, industrial wastes, colliery minestone and sewage sludge have progressively been prohibited, the only significant exceptions being for material dredged from ports and harbours. This is only allowed where the material cannot be used beneficially following an assessment of options (for example to replenish beaches). Other types of waste that may be considered for disposal include biologically inert materials of natural origin. As well as the disposal of solid wastes, effluents are also discharged to the marine environment. Again there has been increasing control with time over these discharges for the protection of the environment.

3.16.2.1 Description of economic activities

The principal and ancillary activities related to waste disposal in the marine environment are outlined in Table 3.108.

3.16.2.2 Description of relevant ecosystem services

As well as economic services, the waste disposal sector also relies on various ecosystem services that support its productivity, including: the physical environment (provision of a stable physical environment in which to operate); and chemical cycling/ water purification (to assimilate wastes).

3.16.2.3 Management

Waste disposal

The disposal of wastes to the marine environment is strictly controlled. Licensing of deposits (both waste disposal and coastal construction) is controlled by the Food and Environment Protection Act (FEPA) (1985).

Table 3.108 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Waste disposal Discharges of wastewater (Standard Industrial Classification, SIC, 37 – urban and industrial wastewater, stormwater); disposal of non-hazardous waste (SIC 38.21) and hazardous waste (SIC 38.22 – including dredged material)	Construction of sewer systems and disposal plants and pumping stations (SIC 42.21) Remediation activities – cleanup of sites and oil spills (SIC 39)	None identified	None identified

The Marine and Fisheries Agency (MFA) is the Executive Agency that oversees the licensing of marine disposal for England. The Welsh Assembly Government (WAG) is responsible for FEPA licensing in Wales. Marine Scotland licenses deposits applied for in Scottish Waters. Waste disposal around the coast of Northern Ireland is the responsibility of the Northern Ireland Environment Agency (NIEA). The seabed / landowner (usually The Crown Estate) also has a role in the deposition consent process.

Although there are around 215 marine waste disposal sites UK-wide (see Figure 3.55), only about 100 of these are in use at any one time. The type of material that can be deposited and the quantity and rate of this depends on the prevailing environmental conditions. Disposal licences are categorised according to the type of material. Biological wastes arising from fish processing may be considered suitable for marine disposal however the majority of material disposed of arises from dredging activities. Capital dredgings are material arising from the excavation of the seabed, generally for construction or navigational purposes in an area or down to a level (relative to Ordnance datum) not previously dredged during the preceding ten years. Maintenance dredgings are defined as material arising from an area where the level of dredging proposed is not lower than it has been at any time during the preceding ten years or from an area for which there is evidence that dredging has previously been undertaken to that level (or lower) during that period. The Centre for Environment, Fisheries and Aquaculture Science (Cefas) and Fisheries Research Services (FRS) reported that on average, between 1985 and 2005, 78% of the total amount of dredged material disposed to sea was related to maintenance dredging.

Water discharges

Discharges to waters are controlled by the Environment Agency (EA) in England and Wales through the Environmental Permitting (England and Wales) Regulations 2007. The Scottish Environment Protection Agency (SEPA) in Scotland regulates discharges through the Water Environment (Controlled Activities) (Scotland) Regulations 2005. Activities for which wastewater discharge consents are issued are shown in Table 3.109. In Northern Ireland the NIEA manages discharges. As discussed in Section 3.17 (Water Abstraction), coastal power stations abstract large volumes of water for cooling purposes. This represents a non-consumptive use because the water is returned to the environment, however its properties (heat and chemical composition) are changed, so these returned waters are discussed in this section as wastewater discharges.

Figure 3.55a Distribution of marine waste disposal sites around the UK (Regions 1, 6 and 7).

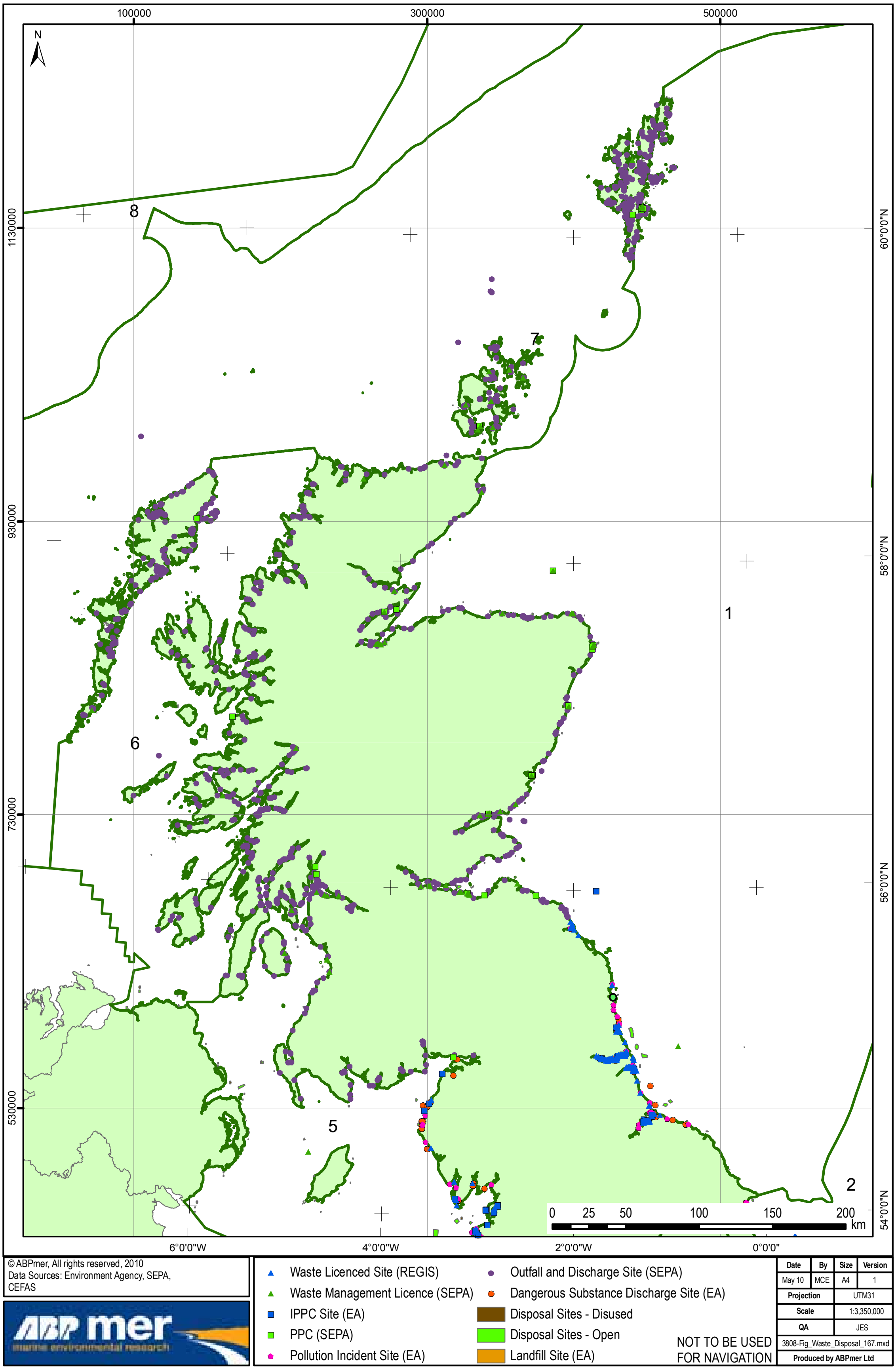


Figure 3.55b Distribution of marine waste disposal sites around the UK (Regions 2 and 5).

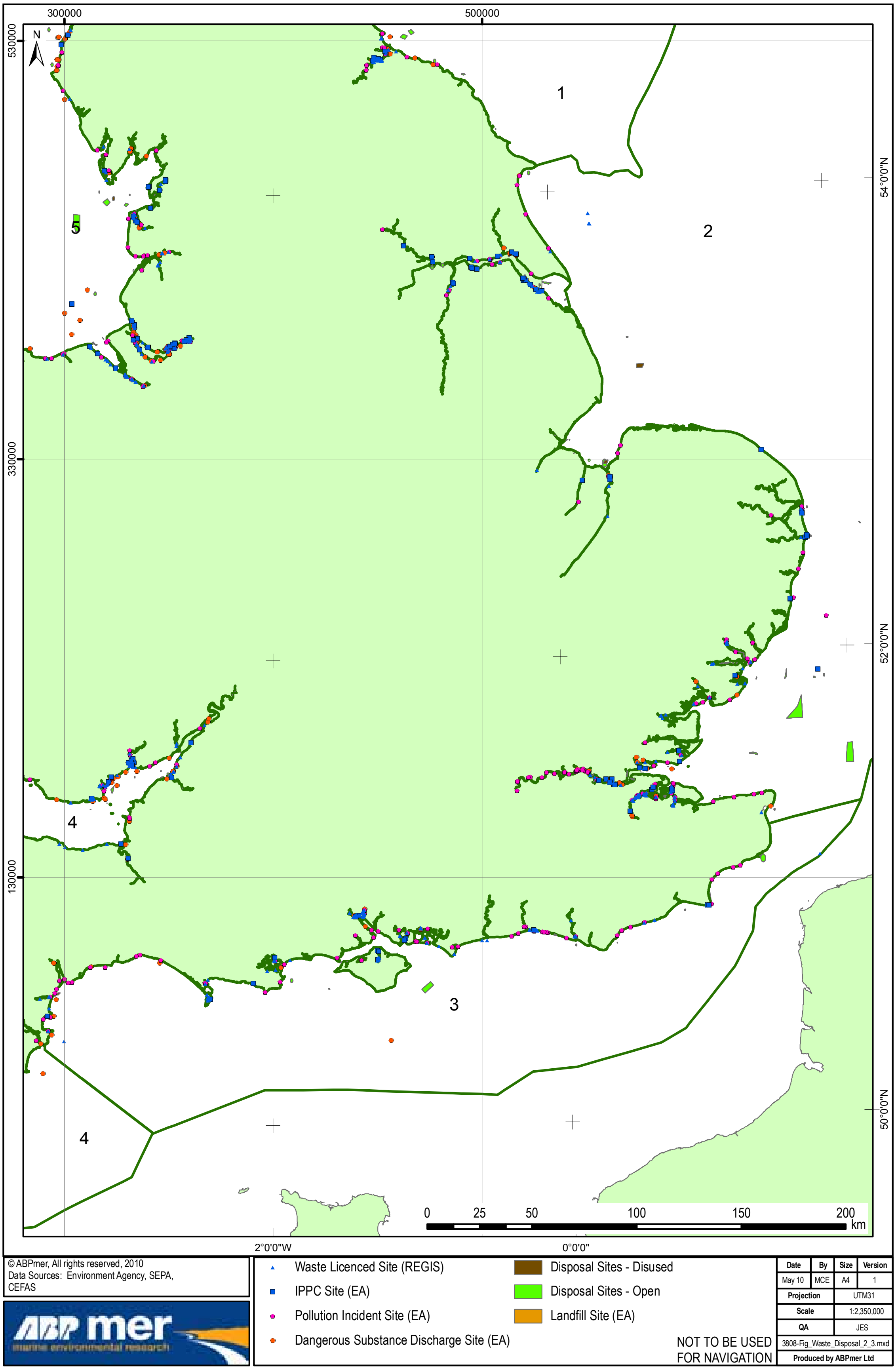


Figure 3.55c Distribution of marine waste disposal sites around the UK (Regions 3 and 4).

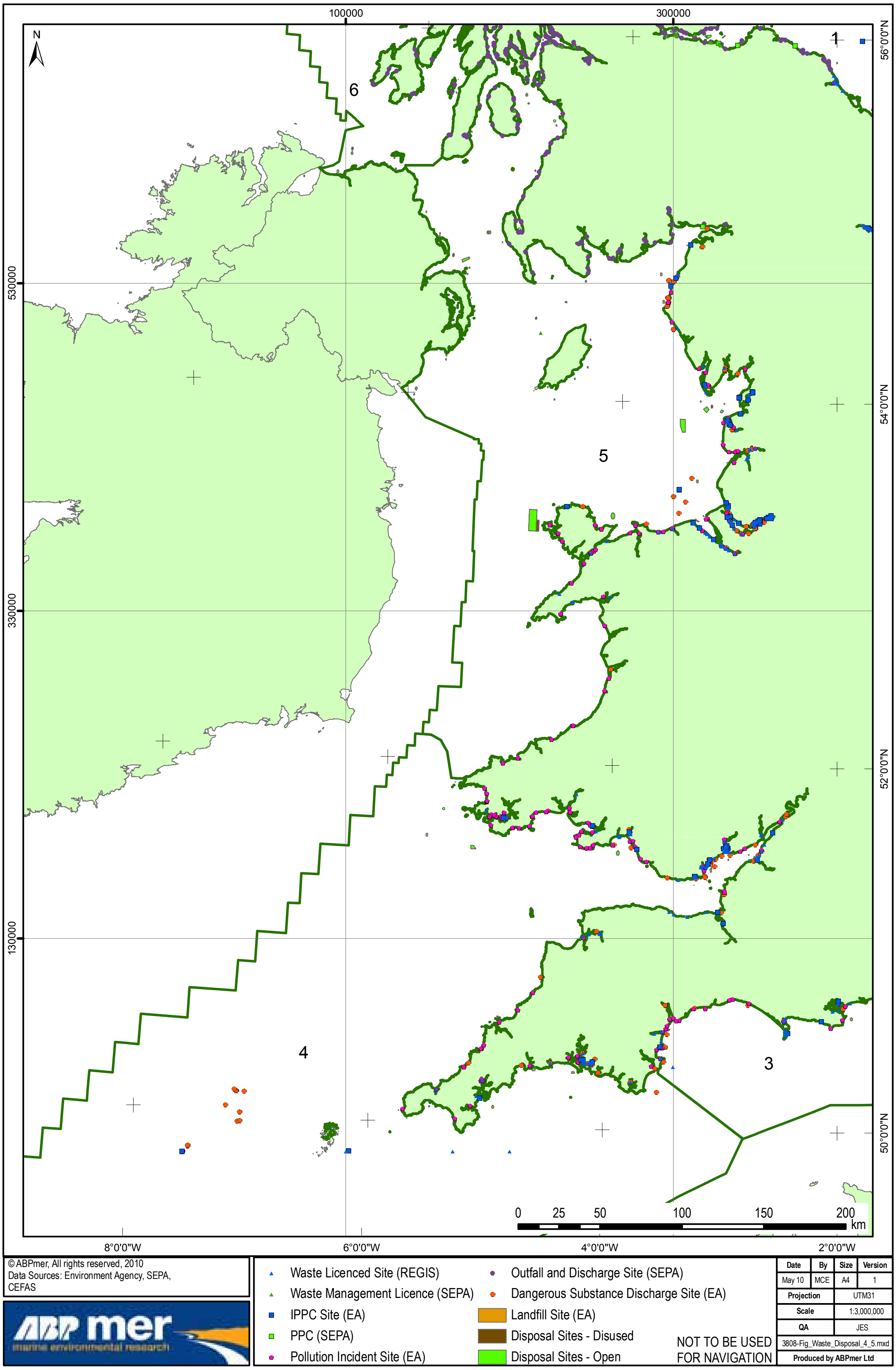


Table 3.109 SEPA wastewater discharge consents types.

Wastewater – consented discharge types	*No. of consents*
Fish farms	378
Other effluent	47
Cooling water	7
Distilling effluent	10
Food processing effluent	16
Landfill leachate	3
Sewage	883
Commercial, industrial and other	30
Total	**1374**

3.16.3 Direct use value

The principal value of waste disposal is defined as the value of being able to use the sea and its ecosystem service of assimilating wastes. The value therefore could be estimated from the cost of alternatives means of disposing of waste if the industry could not make use of the sea, for example, land disposal if this was realistic and economically and environmentally viable. However, it is difficult to assess this value quantitatively, because its calculation is relative to a counterfactual situation that is very difficult to specify. However, the income from licensing fees may be used as an indicator of the value of the service, i.e. what fees are charged in order to use the ecosystem service. Much of the licensing income covers the cost of monitoring (fish farms are mostly self-monitoring) such that the value actually reflects the cost of maintaining the ecosystem service. The income from licensing of both waste disposal and water discharges is detailed in the following sections.

3.16.3.1 Waste disposal

In 2007, the functions of the Marine and Consents Environment Unit (MCEU) transferred from the Department for Environment, Food and Rural Affairs (Defra) to the Marine and Fisheries Agency. Among other responsibilities the new Marine Environment Team at MFA undertakes the administration of FEPA licensing.

In England and Wales, 228 licences were issued for dredged material disposal between 2005 and 2007. The annual revenue from dredge disposal licensing in 2007 was estimated at £218 956, based on the 76 licences issued that year and the average annual revenue of £2881 per licence in 2004/05 (Defra, 2007d).

In Scotland, between 2005 and 2007, 66 FEPA licences were issued for the disposal of dredged material disposal. For 2005/06 the average revenue from each licence was £912 (Defra, 2007d); therefore the estimated income for 2007 for 22 licences was estimated at £20 064.

In 2007/08 the NIEA issued 7 FEPA disposal licences and the revenue raised from fees was estimated to be £16 219.

The income from licensing fees for 2007 therefore provides an estimated value of £255 239 for the UK. The majority of this income is raised by licensing for dredged material disposal in England and Wales (£218 956). Revenue from Northern Ireland and Scotland £20 064, contributes 0.06% and 0.08% respectively.

These figures may underestimate the value of maintaining the ecosystem service as they are based on the average FEPA licence charge in 2004/05 (England and Wales) and 2005/06 (Scotland). In addition, the average charge is calculated across all licences including many

small construction proposals that will incur lower fees than dredge disposal. Furthermore, the method above does not pick up on fees from longer term two- to three-year licences that tend to be larger operations falling within the larger fee band. It is likely that the value of maintaining the ecosystem service may be in the order of millions of pounds (MFA, pers comm.).

3.16.3.2 Water discharges

The EA and SEPA are funded by Grant in Aid by Defra and the Scottish Government. Costs that relate to licensing activities are recovered through charges, 'the polluter pays' principle, so that licensing income should be equivalent to expenditure. In England and Wales income is raised via 'Charging for Discharges' (CfD) which recovers the costs of issuing discharge consents and monitoring discharges and their impacts on receiving waters (Environment Agency, 2008b). CfD raised £65.2 million in 2007/08 and expenditure on licences was £65.7 million (Environment Agency, 2008a). The EA estimates that 70% of environment protection costs (which include CfD), relate to staff providing a GVA factor of 0.7. Based on the distribution of active Integrated Pollution Prevention and Control (IPPC) consents (now Environmental Permitting consents) issued by the EA (see Figure 3.55), 5% of discharges in England and Wales are to coastal waters. Licensing these discharges provides an estimated CfD income for 2007/08 of £3.26 million with a GVA of £2.34 million (the value of these with regard to CP2 Regions is shown in Table 3.110).

Table 3.110 Regional distribution of waste disposal sites and estimated value.

CP2 Region	*Percentage of total sites*	*Estimated value, £ thousand*
1	20.47	46
2	25.58	57
3	10.23	23
4	13.02	29
5	21.40	48
6	5.12	11
7	4.19	9
8	0	0
Total		**223**

In Scotland approximately 1220 out of 4000 discharge licences (31%) are coastal (see SEPA discharge and outfall sites Figure 3.55). As virtually all major discharges are to coastal waters, the majority of water discharge volume (about 80%) is to coastal and estuarine waters (SEPA and EA, 2007). Scottish power stations, for example, abstract 20 million cubic metres of water daily, which are returned to adjacent water bodies. In 2007/08 the income from the Water Environment and Water Services (Scotland) Act 2003, which licenses water discharges, was £18.8 million, while the agency expended £18.5 million on licensing activities. Of this expenditure, staff costs were £11.9 million providing a GVA factor of 0.63 (SEPA, 2008a). Using these figures it can be estimated that proportionally (based on licence numbers) £5.83 million of income can be related to disposal in coastal waters with a GVA of £3.67 million. The value of these with regard to CP2 Regions is shown in Table 3.111. These costs have been lower than anticipated due to a shortfall in complicated licence applications with a corresponding increase in simpler licence applications (source: SEPA).

In Northern Ireland there are currently 93 consented discharges of industrial and private sewage effluents to estuarine/ coastal waters and these represent approximately 3% of discharges. In 2008, income raised from all

Table 3.111. Regional distribution of water discharge sites and estimated revenue.

CP2 Region	*Estimated value IPPC sites, £ million*[a]	*Estimated value SEPA outfalls, £ million*[b]	*Total, £ million*
1	0.37	1.84	2.21
2	1.06	–	1.06
3	0.32	–	0.32
4	0.63	–	0.63
5	0.88	1.04	1.92
6	–	1.58	1.58
7	–	1.38	1.38
8	–	–	–
Total	**3.26**	**5.84**	**9.1**

a Based on EA data on distribution of IPPC sites
b Based on SEPA outfalls and discharges

consented discharges was £487 605. It is therefore estimated that, proportionally, the income that could be assigned to coastal discharges is £14 628 (source: DOENI). Assuming a GVA factor similar to Scotland of 0.63 the GVA is estimated to be £9216.

The total revenue raised by licensing of water discharges in 2007/08 is therefore estimated to be £9.1 million for the UK with a GVA of £6.02 million.

3.16.4 Regional distribution of value

The regional distribution of waste disposal sites is shown in Table 3.110 and illustrated in Figure 3.55. Regions 1, 2 & 5 contain a high proportion of disposal sites (based on data supplied by Cefas and Marine Scotland Science). The Northwest Scottish mainland and Islands (Regions 6 & 7) where population and industrial activities are lower contain the lowest proportion of disposal sites. Waste disposal activities in these regions are predominantly from outfalls (Figure 3.55).

The economic value allocated to each CP2 Region was estimated from the annual value of £223 000, derived in Section 3.16.3 based on the issue of FEPA licences and the percentage of disposal sites within that region.

The total income raised through charging schemes was £9.1 million (see Section 3.16.3). The regional value of discharges was calculated using information on IPPC licences (England and Wales) and outfalls and discharges.

3.16.5 Trends

Between 2001 and 2007 the number of dredged material disposal licences issued for Northern Ireland and Scotland remained relatively constant, while the number of licences declined from 123 to 76 in England and Wales (Figure 3.56). This is due to the introduction of longer-term licences, as the amount of material disposed of (as wet weight tonnages) has remained relatively constant in each country over time (subject to annual fluctuations). Disposal of capital dredge material can vary annually although disposal of maintenance dredge material is more constant (Figure 3.57).

Maintenance dredging disposal has tended to reduce over the past 20 years as operators have sought to reduce costs of dredging where possible. In the future there may be some increases in maintenance dredging associated with port expansion projects.

Figure 3.56. Number of licences for dredged material disposal issued by home country between 2001 and 2007.

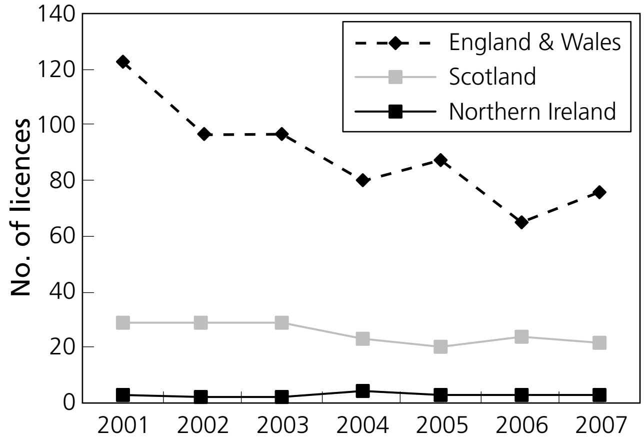
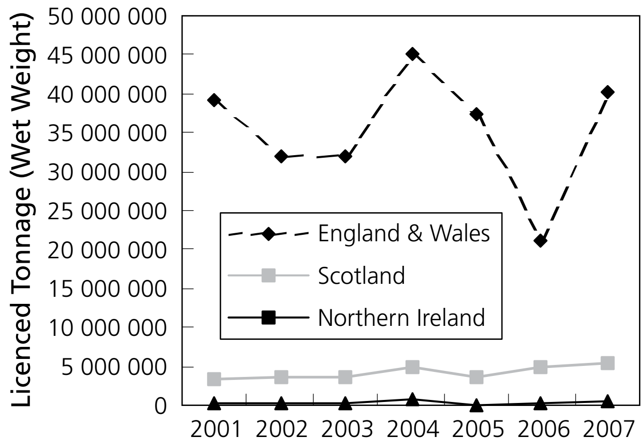


Figure 3.57 Tonnage (wet weight) of dredged material licensed for disposal from 2001 to 2007.



3.16.6 Socio-economic pressures and impacts (positive and negative)

Waste disposal to the marine environment has a positive economic benefit where it allows industries to function. The maritime transport sector, for example, is reliant on shipping access to the coastline and without dredging (supported by disposal) operations would be limited. Additional benefits also accrue where navigationally dredged material (supporting maritime transport, see Section 3.7) can be re-used beneficially. Dredged material has been used as contract fill and to provide and enhance flood defences (Section 3.16.7), reducing the requirement for aggregate extraction in the marine environment for this purpose.

The Scottish water authority, Scottish Water, and private industry depend heavily on the marine environment for the disposal of effluents. Most coastal towns and many large commercial plants discharge their wastewater directly to the sea via outfalls. The major use of water abstracted from coasts and estuaries is to cool power station plant, this water is returned with some changes and this represents a major source of discharged water (Section 3.17: Water Abstraction). Waste disposal therefore benefits the economy and supports jobs in ancillary sectors such as power generation.

As identified in Section 3.16.3, employment in the licensing of water discharges provided an estimated £6.02 million GVA in the UK in 2007/08 reflecting additional social benefits from the activity.

The socio-economic value of waste disposal to communities will vary regionally. Scotland has a greater ratio of coastline to land compared with England and Wales, and has a significant island-based population, so that a greater proportion of discharges to controlled waters are coastal in Scotland (SEPA and EA, 2007).

Bathing waters are routinely tested and in 2008 the EA measured the water quality at 495 bathing waters in England and Wales. Almost all (97%) met the minimum quality standards. Since 1998 water quality has improved reflecting improvements in treatment and the prohibition on the disposal of sewage sludge at sea from specialist vessels. In Scotland, in 2008, SEPA measured the bathing quality of 80 waters

and 91% of these achieved the EU mandatory standard (SEPA, 2008b). In 2008, 23 out of the 24 Northern Ireland bathing waters achieved the mandatory EU standard.

Monitoring and compliance with standards is important to achieve consistent good quality in bathing waters, which are important for a range of interests, particularly tourism. Investment by sewage companies has improved water quality but diffuse agricultural sources also pollute waters. The Scottish Government has introduced a Quality and Standards (Q&S) process for setting capital expenditure plans for Scottish Water to enhance drinking water and sewage provision in Scotland. In Scotland, between 2000 and 2005, £1.17 billion was invested in sewerage and waste water treatment, £5.3 billion was invested in the sewerage system of England and Wales during this period. During the 2005/10 period, water and sewerage companies are projected to invest around £20 billion in maintaining and improving water and sewerage services in England and Wales.

Finally, the assumption that all material dredged to develop and maintain navigation channels is waste, is an interpretation of European regulations and is currently being studied by the EA Waste Protocol Technical Advisory Group which is attempting to produce a protocol to allow use of suitable material rather than classify all as waste. Alternative beneficial use may include contract fill as well as beach nourishment. See also positive environmental benefits in the following section.

3.16.7 Environmental pressures and impacts (positive and negative)

The main environmental pressures associated with disposal of dredged material and wastewater discharges are highlighted in Table 3.112. Impacts on ecosystem services are detailed in Table 3.113.

Figure 3.58 shows that levels of contaminants in dredged material have remained relatively constant. However, it should be recognised that action levels are only established for a limited number of determinands and no action levels exist for 'new' contaminants such as brominated flame retardants (OSPAR, 2008d). Contaminants are also present in discharges effluents and Figure 3.55 shows the location of sites in England and Wales where substances listed (List 1) in the Dangerous Substances Directive (76/464/EEC and Daughter Directives) are discharged. The EA authorises these discharges in order to eliminate pollution by List I substances and limit pollution by List II substances, through control conditions (including treatment requirements) in licences. Information on pollution incidents is collected by the EA and coastal incidents are shown in Figure 3.55.

The licensing authority has a statutory duty to consider what practicable alternative disposal options are available before granting a disposal licence under FEPA. Increasingly maintenance dredged fine-grained sediment, providing it meets environmental quality standards, is seen as a valuable resource and is deposited at sites within estuaries, such as the Stour and Orwell and Humber estuaries, to maintain sediment budgets and to conserve features of nature conservation importance. One example of the beneficial use of navigation dredgings is the intertidal recharge scheme undertaken by

Table 3.112 Key environmental pressures and impacts associated with waste disposal. Based on: Capuzzo (1980); SOAEFD (1996); Essink (1999); Bamber and Seaby (2004); Bolam and Rees (2004); Schiel et al. (2004).

Disposal of dredged material

Pressure	**Introduction of waste at disposal point – changes to substratum and habitat type**
Impact	Habitat damage
Description of environmental change (intensity, spatial extent, frequency, duration)	A large proportion of the deposited material descends rapidly to the seabed. At the point of disposal most species will be smothered. Newly deposited material tends to be azoic. The deposition of fine grained sediment on coarser grained natural sediment can lead to a reduced complexity and changes in community structure (OSPAR, 2008d).
Existing management measures	Disposal is only permitted at designated sites after having regard to the type and amount of material to be deposited. Dredging method and timing of disposal are licensed with regard to the environmental conditions of the disposal site to minimise impacts. Negative effects can be minimised by selecting areas for disposal that have impoverished benthic fauna (Essink, 1999).

Pressure	**Introduction of waste at disposal point – changes in siltation rates**
Impact	Disposed material spreads laterally and there will also be some short-term turbidity in the water column leading to changes in siltation rates at adjacent seabed locations.
Description of environmental change (intensity, spatial extent, frequency, duration)	Impacts on the seabed adjacent to the placement point will depend on the habitat type. Habitats with predominantly infaunal communities subject to higher levels of natural impacts may suffer less than epifaunal, filter feeding communities. On the outer fringes of the disposal site benthic communities may be modified but not substantially altered by dispersing material. In some areas dispersing particles may lead to organic enrichment and/or stabilisation and this may increase benthic productivity. In some cases this can lead to communities dominated by opportunistic fauna such as polychaetes and nematodes. Changes in turbidity can reduce foraging for visual predators (birds and fish) (Essink, 1999).
Existing management measures	Disposal only permitted at licensed sites. The type and amount of material, dredging method and timing of disposal are licensed with regard to the environmental conditions of the disposal site to minimise impacts.

Pressure	**Disposed material contaminants**
Impact	Dredged materials may contain a number of contaminants known to have an adverse effect on marine organisms
Description of environmental change (intensity, spatial extent, frequency, duration)	OSPAR suggests that dredged materials are analysed for the presence of heavy metals, organotins (e.g. tributyltin, TBT) and organic compounds (polycyclic aromatic hydrocarbons, PAHs) and polychlorinated biphenyls (PCBs).
Existing management measures	Disposal of sediments at sea regulated so that only uncontaminated or slightly contaminated sediments that meet established environmental quality criteria (action levels) are disposed.

Wastewater discharges

Pressure	**Addition of nutrients – especially nitrates and phosphates and their derivatives**
Impact	Risk of eutrophication, potentially resulting in changes in the species composition of phytoplankton communities, toxic algal blooms, loss of submerged vegetation through shading, development of hypoxic conditions due to decomposition of excess plant biomass, changes in benthic community structure due to hypoxia or toxic algae, fatalities of fauna due to oxygen deficiencies.
Description of environmental change (intensity, spatial extent, frequency, duration)	The impact of a discharge depends on the quality and quantity of the discharge and the characteristics of the receiving waters. The risk is generally low although there are some localised inshore areas of concern in particular estuaries. Many of these also support national sites of nature conservation importance that increases the significance of the risk. See CSSEG Feeder Report, Section 3.3 on Eutrophication for a detailed assessment.
Existing management measures	WFD risk assessment identifies water bodies at risk. WFD also sets guideline standards on nutrient levels (dissolved inorganic nitrogen) to classify the 'status' of water bodies where there is evidence of biological impacts. The EU Nitrates Directive identifies polluted waters based on nitrate concentrations, and designates the land draining into those waters as Nitrate Vulnerable Zones. The discharge of sewage or trade effluent directly into surface water, groundwater or the sea requires a 'discharge consent' from the appropriate regulatory body (EA, SEPA or NIEA). Impact assessments are undertaken of the duration, the area of impact and the presence of other discharges prior to licensing.

Pressure	**Addition of faecal material**
Impact	Pathogens (bacteria, viruses or parasites) arising from faecal material may cause illness / infection if ingested through recreational water use or shellfish consumption.
Description of environmental change (intensity, spatial extent, frequency, duration)	See CSSEG Feeder Report, Section 3.4 on Microbiological Contamination on Microbiology for a detailed assessment.
Existing management measures	The EU Urban Waste Water Treatment Directive (91/271/EEC) sets the treatment levels required for waste water discharges on the basis of the sizes of the sewage discharges and the sensitivity of the waters receiving the discharges. Microbiological monitoring of faecal pollution is required under the Bathing Waters Directive (76/160/EEC and revised 2006/7/EC), the Shellfish Waters Directive (2006/113/EC) and European food hygiene legislation (primarily Regulation (EC) No. 854/2004, as amended). The discharge of sewage or trade effluent directly into surface water, groundwater or the sea requires a 'discharge consent' from the appropriate regulatory body (EA, SEPA or NIEA).

Pressure	**Addition of hazardous substances – organic, metal and radioactive contaminants from industrial discharges.**
Impact	Risk of pollution from hazardous substances, reduced water and sediment quality, reduced survivorship and mortality of organisms
Description of environmental change (intensity, spatial extent, frequency, duration)	Metal concentrations in water around the UK are generally below Environmental Quality Standards, although industrial areas (Thames Estuary, Wash, Dee Estuary) have higher concentrations. Metal concentrations in sediment are elevated in some English and Welsh estuaries. Organic contaminant levels (e.g. PCBs, PAHs, brominated flame retardants) are elevated in industrialised areas: Anglian, Severn, English Channel and Clyde Estuary most affected by elevated PCBs; Tynes/Tees, Anglian, Western English Channel and Severn most affected by elevated PAHs; highest levels of BFRs in the Clyde Estuary and offshore from the Tay Estuary. Elevated levels of metals and organic contaminants in biota (i.e. in fish liver and/ or mussels) generally found in industrialised estuaries: Forth and Clyde Estuaries and Irish Sea most affected by PCBs; Tynes/Tees and Western English Channel most affected by PAHs. See the CSSEG Feeder Report, Section 3.1 on Hazardous Substances for a detailed assessment including the biological effects of contaminants. Contamination by hazardous substances has been identified as having a high potential impact on UK waterbird populations. See the HBDSEG Feeder Report, Section 2 on the Overall Assessment for further detail issues for water birds – high risk. Radionuclides discharges from nuclear and non-nuclear installations persist in the marine environment via uptake to sediments and biota. Discharges from Sellafield and resuspension of historic Sellafield discharge from marine sediments are a key pressure in the Irish Sea (Region 5). Discharges of tritium and carbon-14 (from a radiopharmaceutical plant) near Cardiff (Region 4) have been reduced, but tritium levels remain elevated compared to other coastal areas. Radioactive particles have been found in small areas around Dounreay and Sellafield. See the CSSEG Feeder Report, Section 3.2 on Radioactivity for detailed assessment.
Existing management measures	The EU Dangerous Substances Directive controls discharges of dangerous substances. WFD risk assessment identifies water bodies at risk. WFD also classifies the 'status' of water bodies and sets guideline standards on environmental quality for specific pollutants and priority hazardous substances, which should not be exceeded to meet good ecological and chemical status. The discharge of sewage or trade effluent directly into surface water, groundwater or the sea requires a 'discharge consent' from the appropriate regulatory body (EA, SEPA or NIEA). Ecological Quality Objectives (EcoQOs) developed under OSPAR, include: mercury and organohalogen concentrations in seabird eggs from industrialised estuaries should not significantly exceed concentrations in eggs from similar but not industrial habitats. All radioactive discharges in the UK are regulated under the Radioactive Substances Act 1993. Discharges of radioactive material from nuclear licensed sites are subject to authorisation from the relevant environment agency (EA, SEPA, Environment and Heritage Service). Regular monitoring is undertaken by the EA, SEPA and the Department of Health, to ensure compliance with UK and European limits of exposure.

Pressure	**Addition of chlorine biocides and oxidants from coastal power stations**
Impact	Risk of pollution from hazardous substances, reduced water and sediment quality, reduced survivorship and mortality of organisms
Description of environmental change (intensity, spatial extent, frequency, duration)	Continuous low-levels of oxidants are generally used to prevent the settlement and growth of epifaunal organisms (biofouling) on the inner surfaces of water-cooled power stations. Oxidant is introduced either through the electrolysis of seawater or the injection of sodium hypochlorite solution (Taylor, 2006). Oxidant use results in the likely release of chlorination by-products including organohalogens. Mortality and decreased survivorship of entrained zooplankton have been observed, these effects are also due to temperature changes and mechanical damage (Capuzzo, 1980; Bamber and Seaby, 2004; Taylor, 2006). Overall sensitivity to exposure varies by taxa and life stage (Bamber and Seaby, 2004). Mixing with seawater rapidly negates toxic effects and few have ever been observed beyond outfalls (Taylor, 2006). Continuous low-level introduction via the once through water.

Existing management measures	The EU Dangerous Substances Directive controls discharges of dangerous substances. WFD risk assessment identifies water bodies at risk. WFD also classifies the 'status' of water bodies and sets guideline standards on environmental quality for specific pollutants and priority hazardous substances, which should not be exceeded to meet good ecological and chemical status. The discharge of sewage or trade effluent directly into surface water, groundwater or the sea requires a 'discharge consent' from the appropriate regulatory body (EA, SEPA or NIEA). Discharges are subject to testing to ensure that effluents comply with licensing terms. WFD risk assessment identifies water bodies at risk. See also Hazardous Substances Directive

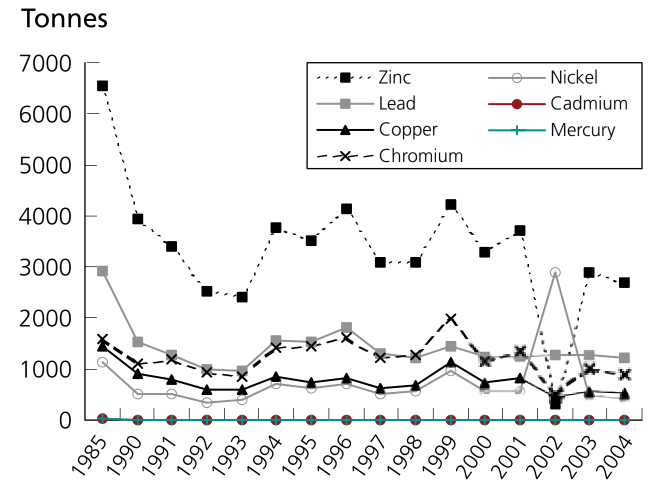
Pressure	**Litter – in wastewater**
Impact	Risk of harm to wildlife through ingestion or entanglement, which may result in infection, starvation and/or mortality
Description of environmental change (intensity, spatial extent, frequency, duration)	Litter (e.g. cotton bud sticks, nappies, sanitary products), may enter the marine environment via the sewage system, either through inadequately treated sewage, illegal connections or combined sewer overflows after heavy rainfall. Region 5 (Irish Sea) has the highest levels of sewage related debris (notably cotton bud sticks) of all UK regions. See the CSSEG Feeder Report, Section 3.6 on Litter for detailed assessment of extent of sewage-related debris.
Existing management measures	Quantities of sewage-derived litter entering the marine environment are significantly reduced through sewage treatment and screening of storm outfalls.

Pressure	**Return of heated waters from coastal power stations**
Impact	Potential thermal pollution
Description of environmental change (intensity, spatial extent, frequency, duration)	Thermal pollution is a rise or fall in the temperature of a natural body of water caused by human activities. When water used as a coolant is returned to the natural environment at a higher temperature it can cause impacts by decreasing oxygen supply and by altering the assemblage composition. These effects are usually fairly limited as power station outfalls are usually located in dispersive areas. Seasonal effects may be possible, with thermal shock most likely in warm days in summer. An American study found that thermal discharges affected rocky shore communities over 2 km of coastline (Schiel et al., 2004). Changes in the timing and length of breeding periods and in growth rates of marine species have been observed (Barnett, 1971). Taylor (2006) found that in Kingsnorth power station amphipods larvae are recruited to the channel but adults were unable to survive the temperatures.
Existing management measures	Discharges are subject to testing to ensure that effluents comply with licensing terms. Standards differ depending on the surrounding environment, e.g. the standard for Baglan Bay power station discharge is that the temperature of the plume does not exceed 1.5 °C above the ambient river water temperature within a zone not to extend more than 50% of the width of the estuary. The EA usually requests 2D and 3D modelling of the near, mid and far-field impacts, incorporating tidal and seasonal factors. Discharges may be restricted to high tidal states by the regulator to maximise diffusion.

Table 3.113 Environmental pressures on ecosystem services associated with marine waste disposal.

Ecosystem service	*Significance of impact*	*Confidence in understanding of the relationship = information gaps*
Physical environment	**Low**. Precludes other uses of physical environment, but small footprint of activities within water column and on seabed.	**Moderate**. Most impacts on habitats understood.
Biodiversity provision	**Low – Moderate**. Impacts on species from smothering by deposited material, increased turbidity, higher temperatures of effluent potentially altering oxygen levels, and from chemical contamination, but effects usually localised.	**Low**. Knowledge improving but long-term effects on biology of species poorly understood.
Biological productivity (supporting service)	**Low – Moderate**. Impacts from chemical releases from disposal activities and disturbance to seabed by deposition of waste material, may be significant, but usually only to a relatively small area of seabed.	**Moderate – High**. Some aspects of pollution well studied, and extent of sector footprint known in detail as licensed.

Figure 3.58 Dredged sediment contamination (tonnes) between 1985 and 2004. Source: Cefas.



Harwich Haven Authority in the lower Orwell estuary.

Other materials can also be beneficially reused. Shell wastes, known as 'cultch', from shellfish processing activities have been reused in the marine environment to provide a substrate for the establishment of shellfish beds. Clean shell is laid on the seabed in the area designated for shellfish growing and recognised as being likely to receive larval settlement. After one to four years the settled oysters are removed and the shell is returned to sea (source: Seafish). This provides a beneficial re-use for materials that would otherwise have to be disposed of on land and, as a low-cost option, benefits producers of waste who would have to find alternative routes of disposal. However this option is only available locally in areas suitable for oyster growing.

3.16.8 Climate change

3.16.8.1 Impacts of climate change on waste disposal

Increases in rainfall would increase the discharge from drains into the coastal environment. In the case of combined sewage treatment plants where drainage and sewage water are both processed at the same location, it is possible that an increased volume of water would result in the untreated sewage along with the drainage water being discharged into the marine environment through a combined sewer overflow (Knights, 2007).

Increased runoff can also result in diffuse pollution: this is caused by runoff from diverse sources such as agricultural land and urban areas. When drainage water is not treated this is deposited into the marine environment (Knights, 2007; MCCIP, 2008).

If the current regime is impacted by climate change, disposal of sewage by longfall pipelines could become ineffective as the discharge could flow in an unexpected direction. Changes in flow regimes in estuaries and rivers could also result in reduced dilution of pollutants with more pollution of the marine environment. The release of contaminants from seabed sediments could be affected by changes in salinity, wave regimes or currents (MCCIP, 2008).

Changes in currents further offshore could lead to disposal grounds for dredged material becoming less benign and therefore unsuitable for this activity. Without site specific modelling it is difficult to comment on how this could impact different areas in the UK. There is no evidence to suggest that any of these impacts are occurring now, or that they might become particularly significant in the future.

Adaptation measures

No published evidence of adaptation within the water industry could be found. The water industry will adapt to climate change through the upgrading of sewage systems, although upgrading is likely to lead to increased energy demand. Changes to flow patterns may result in sewage discharge pipes being re-sited. There is no evidence that this is currently happening. The possible future costs of this cannot be quantified. The disposal of dredged waste uses ships, more details of shipping adaptation can be found in Section 3.7 (Maritime Transport).

3.16.8.2 Impacts of waste disposal on climate change

The water industry is energy intensive and uses 2% to 3% of energy in the UK (Water UK, 2009). This results in around five million tonnes of greenhouse gas emissions every year (Water UK, 2009), although this includes all water treatment and not just that which is related to the marine environment. The energy use associated with increasing treatment quality is likely to contribute further greenhouse gas emissions in the future. The disposal of dredged waste uses ships, more details of shipping emissions can be found in Section 3.7 (Maritime Transport).

Mitigation measures

The water industry as a whole uses renewable energy for about 14% of its energy needs, half of this is generated on site (Water UK, 2009). Further advances in technology could lead to energy savings in the treatment of sewage, however, more stringent water quality standards and a rising population have been increasing the energy requirement of the water sector at the same time. For mitigation methods that apply to shipping see Section 3.7 (Maritime Transport).

3.16.8.3 Summary

Table 3.114 provides a summary of climate change pressures and impacts and indicates the likely significance of the impacts, the level of confidence in the assessment and measures that might be employed to manage the impacts (see Annex 1 for a discussion of the assessment methodology).

Table 3.114 Summary of climate change implications.

Climate change pressure	*Impacts of climate change on Waste Disposal*	*Confidence/ significance*	*Adaptation measures*
Increased severity of rain storms	Increased runoff causing lowered water quality	Medium confidence / high significance	Improved sewage treatment works
Changes to currents and increased storminess	Changes in current flow and wave regime bringing discharged sewage back inland and mobilising contaminants within seabed sediments	Low confidence / medium significance	Improved sewage treatment works
Changes to sediment transport pathways	Sediment disposal areas may become less benign and unsuitable for disposal	Low confidence / low significance	Use of different disposal areas

Impacts of Waste Disposal on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
Energy required in the treatment and disposal of water	CO_2 emissions	Medium confidence / medium significance	Some energy used to treat water and dispose of waste is from renewable sources, there is more scope for this

3.16.9 Industry stability and sustainability

Waste disposal to the marine environment is undertaken by various industries including disposal of dredged material and industrial and wastewater discharges to estuarine and coastal waters.

The dispersive and assimilative capacity of marine waters have long been relied upon as a means of waste disposal. In the past few decades significant progress has been made in ensuring that such disposals do not have significant adverse environmental impacts, although it is recognised that much still needs to be done. For example, assessments for the Water Framework Directive have indicated that 81% of water bodies in England and Wales do not currently meet the requirements for 'Good Status'.

Most of the policies relating to waste disposal are associated with environmental protection requirements, in particular the management of impacts on water quality. The Government's new water strategy for England (Defra, 2008b) includes a number of vision statements in relation to desired improvements in water quality (see Box 3.5).

EU Environmental Directives have been, and will continue to be, key drivers for improvements in water quality. Water company investment in England and Wales to meet these legislative requirements is regulated by the Office of Water Services (OFWAT) through the quinquennial Asset Management Planning (AMP) review process. Similar processes apply in Scotland and Northern Ireland.

Box 3.5. Water quality vision for 2030 (Defra, 2008b)

- Large majority of water bodies in England having good ecological and chemical status
- People maximising sustainable use and amenity benefits gained from safe, healthy and attractive waters and water environments
- Healthy rivers, lakes, estuaries, coasts and groundwaters that provide maximum resilience to climate change and sustain biodiversity
- Major improvements achieved from tackling problems of nutrient pollution, chemical pollution, water resources, litter and microbial contamination
- Land increasingly flexibly managed for flood storage
- Reduced adverse impact of agriculture on the water environment through continued evolution of the EU Common Agricultural Policy to deliver more environmental benefit

3.16.10 Forward look

It is unlikely that demand for disposal will decrease and a number of future schemes have been proposed which will require the disposal of increased amounts of dredged material. These include the construction of the Thames Gateway; a terminal on the Thames which will enlarge UK container port capacity by two thirds. To enable large vessels to navigate the Thames and berths, large amounts of material will be dredged and some of this will be reused beneficially.

Significant reductions in the concentrations of contaminants discharged from point source discharges over the past 30 years are likely to be sustained. Some further reductions are likely to occur through implementation of the EC Water Framework Directive and revised Bathing Waters Directive and in line with ongoing reductions in the UK manufacturing base.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the industries which dispose of waste into the marine environment will need to manage further their activities. For example, GES Descriptor 8 states that ...*Concentrations of contaminants are at levels not giving rise to pollution effects*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.17. Water Abstraction

3.17.1. Key points

- Abstractions from estuarine and coastal waters primarily occur to provide cooling water to power stations
- The various environment agencies throughout the UK license abstractions from inland waters and groundwater. This includes some saline abstractions as inland waters includes estuaries, embayments and arms of the sea
- Abstractions associated with navigation and dredging activities in saline waters are largely exempt from abstraction licensing
- Principal values are difficult to quantify. It is estimated that power companies generate an additional £150 million of electricity annually as a result of the greater energy efficiency associated with once-through cooling water systems which are dependent on a coastal location
- Environmental concerns relate to the impingement of fish, invertebrates and algae through water intake systems

i. Introduction

The majority of water abstractions in the UK are from surface freshwaters and groundwater for use in public water supply, with relatively few from estuarine and coastal waters.

ii. How has the assessment been undertaken?

Information on water abstraction has been provided by the various regulatory agencies throughout the UK.

iii. Current and likely future status of the water abstraction sector

The major saline abstractions provide cooling water for power stations. A large power station may abstract up to 40 m^3/s or more during peak load. Other types of saline abstraction include fish farms and fish processing factories, passive and pumped navigation abstractions (to maintain water levels in impounded docks), ballast water abstractions and abstractions associated with certain dredging activities (e.g. hydraulic dredging).

The various environment agencies throughout the UK license abstractions from inland waters and groundwater. This includes some saline abstractions as 'inland waters' includes estuaries, embayments and arms of the sea. Historically, navigation abstractions and abstractions associated with dredging activities in saline waters have been exempt from licensing. Some modifications to these exemptions are being proposed as part of the implementation of the abstraction provisions of the Water Act 2003 but such activities will remain largely exempt. Environmental concerns relate to the impingement of fish, invertebrates and algae (see Section 3.17.7). Risk assessments made under the Water Framework Directive indicate that no sites are considered to be 'at risk' of failing the Directive although nine sites are 'probably at risk'.

It is difficult to calculate the contribution to the economy associated with saline abstractions, although it is clear that they are fundamental to sustaining several major economic activities. The annual market value of electricity sales from coastal power stations is in the region of £5 to £10 billion. Coastal power stations with 'once through' cooling water systems have an energy efficiency advantage over air cooled power stations, of the order of 2%. On this basis it

could be argued that the specific value to the economy of coastal power generation was of the order of £100 million to £200 million per annum. No indicative values were identified for ancillary or secondary activities.

iv. What is driving change?

Investment in power stations has been driven by a need for increased energy security and supply which has in turn increased the demand for affordable cooling water (see Section 3.17.10).

v. What are the uncertainties?

It is difficult to quantify the true value of water abstraction as this depends on the use value to industry. If waters were unable to be abstracted then considerable investment would be required to build new plants with lower water requirements.

vi. Forward look

The amount of water abstracted for industrial purposes has remained relatively constant over time and it is likely that the requirement for coastal water abstraction will continue at the same levels. While many coastal power stations are due to be decommissioned over the next two decades, it is likely that a series of new coastal nuclear power stations will be developed.

3.17.2 Introduction

The primary use (by volume) of abstracted estuarine and coastal waters is as a source of cooling water for certain types of coastal power station (Table 3.115). Electricity generation accounts for over 50% of all water usage in the industrialised and developing world and for almost 75% of industrial usage (Turnpenny and Coughlan, 2003). This section therefore focuses on the use of water abstraction by power stations. Other coastal industrial uses include the maintenance of water levels in impounded docks, the use of water to suppress dust on port estates and to wash marine aggregates. Water is also abstracted for sea salt production at three sites in the UK (see Section 3.8: Mineral Extraction). More novel uses that were identified in this sector assessment are small-scale abstractions to service a seal sanctuary and to fill the recently restored lido at Tinside, Plymouth.

The construction of projects that abstract water is treated as an ancillary activity of this sector. Secondary activities may include the use of the thermally heated water for aquaculture.

Water abstraction relies on various ecosystem services that support its productivity including water regulation.

Abstractions from inland waters and groundwater are licensed by the Environment Agency (EA) (England and Wales), the Scottish Environment Protection Agency (SEPA) and the Northern Ireland Environment Agency (NIEA). This includes some saline abstractions as ‘inland waters’ includes estuaries, embayments and arms of the sea.

3.17.3 Direct use value

The direct use value of cooling water to the power sector is not easily quantifiable. A large proportion of UK electricity production is reliant on a coastal location for cooling water, including all of the 18% of UK electricity supply from nuclear power stations. If it is assumed that 30% of the UK’s annual electricity consumption of 350 TWh is derived from coastal power stations, these stations would contribute between £5 billion and £10 billion in annual electricity sales (based on an electricity price of 5p to 10p per kWh).

Table 3.115 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
Water abstraction for e.g. cooling water (SIC 36 – Water collection, treatment and supply)	Construction of utility projects (SIC 42.22)	Ancillary uses of water for aquaculture	None identified

The use of 'once through' cooling water results in power output that is a few per cent higher than for air cooled condensers. This is why many power stations are located on the coast with access to adequate supplies of cooling water. Assuming that such systems provide a 2% gain in energy output, this would equate to an additional economic value of between £100 million to £200 million per annum assuming an electricity price of 5p to 10p per kWh. While these figures are illustrative they clearly identify the significant value attached to coastal water abstractions.

This notional value can be allocated to CP2 Regions based on abstraction from tidal waters per region by power stations (see Figure 3.59), for this study the estimate was based on a total value of £150 million (Table 3.116).

Table 3.116 Distribution of power stations abstracting water per CP2 Region and estimated value.

CP2 Region	*Percentage of power stations abstracting water*	*Estimated value, £ million*
1	23.53	35
2	20.59	31
3	5.88	9
4	14.71	22
5	29.41	44
6	5.88	9
7	0	0
8	0	0
Total	**100%**	**£150 million**

3.17.4 Regional distribution of value

The regional distribution of tidal water abstraction sites is shown in Figures 3.59. Abstraction is categorised for three purposes (electricity, industrial, other) based on EA and SEPA licensing information. The location of power stations that abstract water for cooling purpose is also shown and from these locations the value of water abstraction was estimated. Water abstraction occurs in all CP2 Regions for which there is information available, although information for Northern Ireland, beyond abstraction by power stations, was not available (Table 3.117).

In England and Wales for 2006/07, 24 000 megalitres (Ml) were abstracted daily from tidal waters primarily for electricity production (Environment Agency, 2008c). Abstraction from tidal waters per region (megalitres litres daily – Ml/day) is shown for England and Wales for electricity supply (Figure 3.60) and other industrial uses (Figure 3.61). These data were sourced from the Environment Agency and are not, therefore, allocated per CP2 Region. In general the EA North West region which corresponds to Region 5 abstracts the greatest volume of water annually for electricity production. The region contains five power stations, including Heysham. The Welsh region

Figure 3.59 Regional distribution of tidal water abstraction sites.

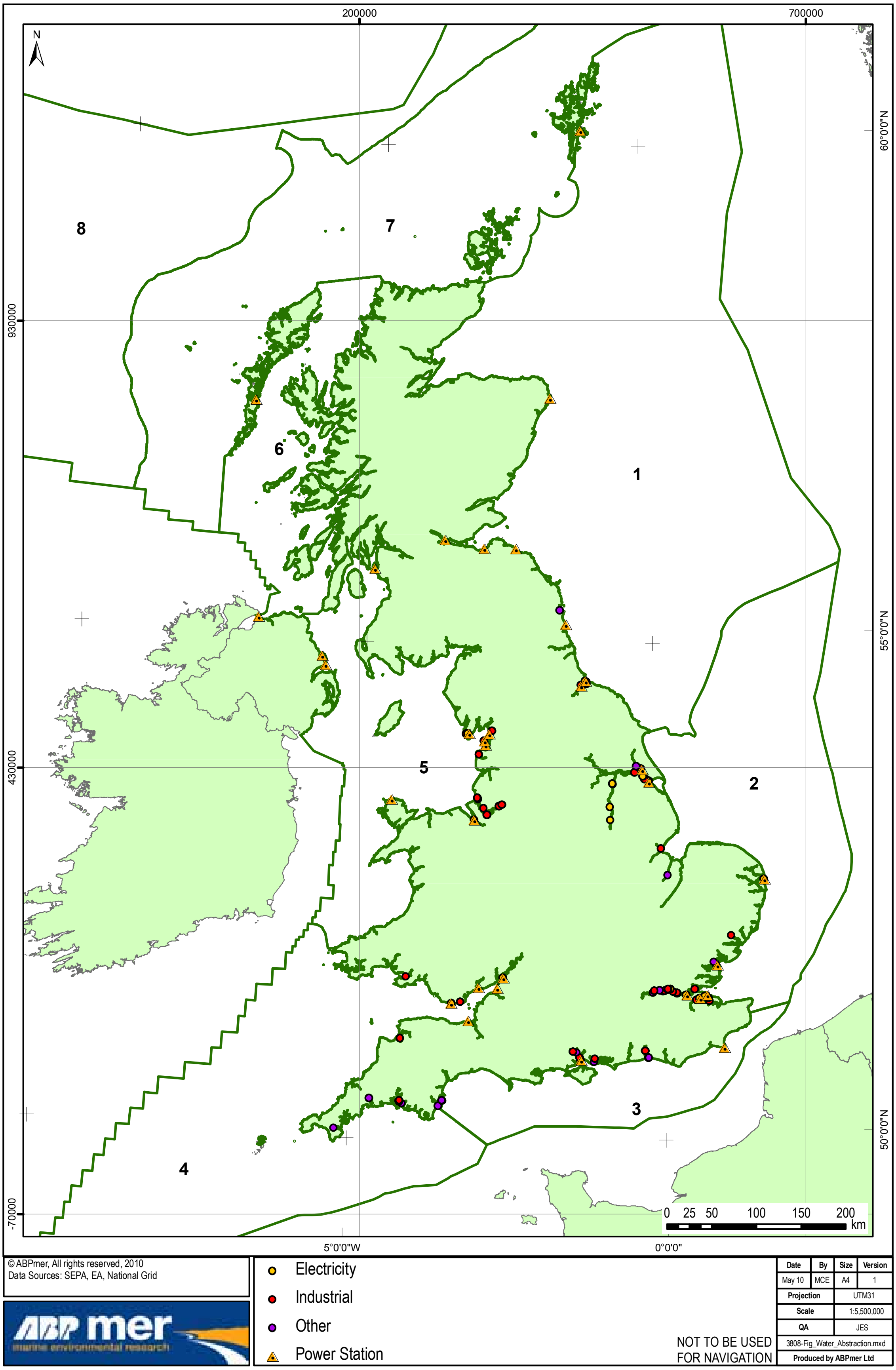


Table 3.117 Rates of abstraction of cooling waters for non-evaporative cooling in UK power stations. Data were not available for England and Wales at this time.

Power station	*Maximum rate of abstraction, Ml/d*
Scotland	
Lerwick	80
Torness	4067
Hunterston B	2570
Peterhead	2436
Longannet	7776
Cockenzie	3215
Kirkwall	53
Loch Carnan Generating Station	1
Northern Ireland	
Ballylumford	393
Coolkeeragh	648
Kilroot	360

has the smallest abstraction demand for electricity production and this is reflected in the low value for Region 4.

As cooling water abstraction by power stations, for electricity generation, is a major use of water, extraction rates are given for Scotland and Northern Ireland (Table 13.117).

Based on the locations of UK power stations that abstract from tidal waters the estimated value of abstraction per CP2 Region is shown in Table 3.116. The total value of electricity was estimated to be £150 million (from an average value of power generation that was estimated to be between £100 million and £200 million). The value of abstraction relates to the number

Figure 3.60 Abstraction from tidal waters for electricity production by EA region between 1995 and 2005. Source: Defra (2008a).

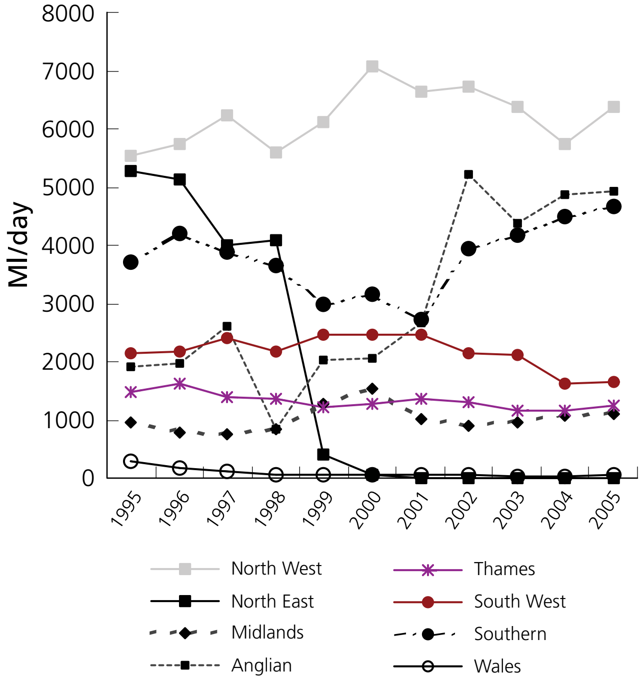
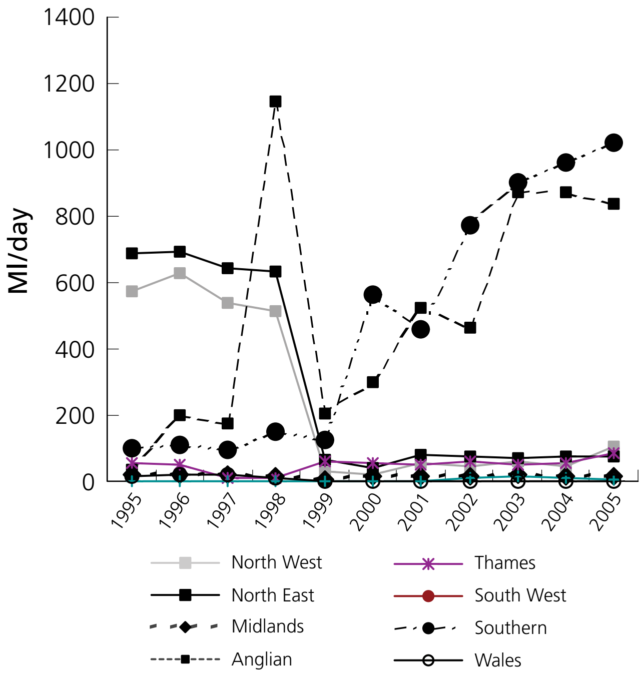


Figure 3.61 Abstraction from tidal waters for other industrial purposes production by EA region between 1995 and 2005. Source: Defra (2008a).



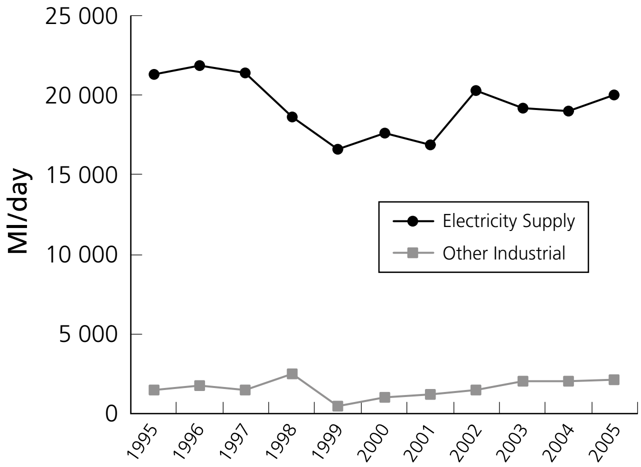
of power stations and this correlates well with published information on the volume of water abstracted.

Estimated value was greatest for Region 5 which corresponds with the North West region where volumes abstracted for electricity production are highest (Figure 3.60). Regions 1 and 2 also have high estimated values for water abstraction (£35 million and £31 million respectively). These regions correspond in general to the EA water regions North East (the English portion of Region 1) and Anglian (Region 2), and both have large urban centres exerting energy demands. It can be seen from Figure 3.60 that abstraction demand grew in the Anglian region between 1995 and 2005 which reflects the opening of new power stations. The EA North East region does not include the Scottish power stations that Region 1 includes, which explains the discrepancy between the volume of water abstracted (Figure 3.60) and the value in Table 3.116. The drop in abstraction demand in this region in 1999 is due to the closure of Blyth power station.

3.17.5 Trends

Information from England and Wales indicates that the volumes abstracted from tidal waters have remained relatively constant between 1995 and 2005 (Figure 3.62). The demand for water by power stations has far outweighed demand for water for other industrial purposes. The fluctuations in abstraction volumes in Figures 3.60 and hence Figure 3.62 indicate how the opening and closure of single power stations can significantly alter demand. The decrease in demand in the North East region from 1999 (Figure 3.60) follows from the closure of Blyth power station. The decrease in abstraction in 2004 in the North West region is due to reduced electricity production by Heysham power station.

Figure 3.62 Licensed abstraction volumes, England and Wales, from tidal water between 1995 and 2005. Source: Defra (2008a).



3.17.6 Socio-economic pressures and impacts (positive and negative)

Some fish farms use cooling waters from power stations, as these are heated they are particularly suitable for sea bass (*Dicentrarchus labrax*) which have lower thermal tolerances. Wild sea bass have been observed to congregate and feed in the plume of discharged waters at power station sites. Studies have shown that the livers of these fish may accumulate chlorinated by-products but harmful effects have not been discovered (Taylor, 2006). The company Seabait in Newcastle uses cooling water discharges from Lynemouth power station to farm worms for bait and as aquaculture feed. This has a positive environmental value as it reduces the need for harmful bait digging in natural habitats.

Fish impingement on cooling water intakes can be significant, for example, at Longannet coal fired power station on the Forth Estuary recent studies found that impingement was approximately 129 tonnes per annum (Greenwood, 2008). This study by Greenwood (2008) found that between 1999 and 2000 the

potential commercial value of adults, lost due to juvenile mortality was around €429 266. Large intakes of fish, jellyfish and macroalgae are detrimental to power station functioning and in extreme cases power stations have to be shut down during periods of maximum entrainment. Fish return systems are utilised at some stations, for example Sizewell B, and behavioural deterrent systems, such as bubble curtains and noises to deter fish have been trialled and are used at other stations to reduce impingement. Compared with commercial landings the 'catch' of power stations has been shown to account for a 'trivial' amount of adult equivalents (Turnpenny, 2006). Therefore this activity is not expected to be detrimental to the livelihoods of commercial fishers.

Estimating specific employment related to this sector is problematic as engineers and users are embedded in different sector assessments (e.g. power station employment).

Abstraction infrastructure (e.g. pipelines) may impact on coastal amenities for leisure and recreation including sailing.

3.17.7 Environmental pressures and impacts (positive and negative)

Key environmental pressures and impacts associated with water abstraction can be seen in Table 3.118. The ecosystem services that these pressures impact and the relative significance of these impacts are identified in Table 3.119.

The large volumes of water abstracted pose environmental risks associated with the impingement of fish, invertebrates and algae (Turnpenny and Bamber, 2006) on cooling water intake drum screens. Concerns have been raised about the impacts on invertebrates and especially fish populations. At certain locations the volumes of animals that are captured can be extremely high and in some cases large influxes have damaged the plant and/or lead to closure. Future changes in legislation, particularly with regard to the EU Water Framework Directive may focus on further reducing fish intake through redesign of intake systems and physical or behavioural barriers, such as lights and noise (Taft, 2000). Cooling water abstraction also causes entrainment of planktonic organisms and subsequent mortality as a result of chlorination and thermal shock.

The marine biological material that is collected on drum screens requires disposal, either to landfill or by using alternative methods of disposal such as composting or return to sea. These disposal methods all have associated environmental impacts, such as increased vehicle traffic, potential for pollution etc.

In England and Wales the EA has undertaken work through River Basin Management Plans (RBMPs) to identify transitional and coastal (TraC) waters that are at risk of decline in ecological status, assessed by fish entrainment, from large-scale abstraction for industrial purposes. The resulting maps of TraC water abstraction pressures show that no sites are considered to be 'at risk' of failing the Water Framework Directive (Environment Agency, 2004). Very few sites (approximately nine, covering 15% of England & Wales water bodies) are considered to be 'probably at risk' of failing the Directive. No specific abstraction measures were identified for the power sector in TraC waters in the draft RBMPs. It is currently unclear whether actions to address abstraction pressures in some of the draft RBMPs relate to rivers or TraC waters and this should be clarified in the final RBMPs. Individual RBMPs may contain some actions that could have implications for coastal power stations if they relate to TraC waters, for example an action in the South West RBMP required the

Table 3.118 Key environmental pressures and impacts associated with water abstraction. Source: Taft (2000); Bamber and Seaby (2003); Maes et al. (2004).

Pressure	**Species level pressures**
Impact	Removal of species via cooling water in flows
Description of environmental change (intensity, spatial extent, frequency, duration)	Biological impingement and entrainment occurs at power stations and typically consists of fish, seaweeds, jellyfish, other macroinvertebrates and planktonic species. In some cases intake volumes, particularly of the small fish Sprat (*Sprattus sprattus)* and jellyfish have been great enough to damage plant and cause the station to shutdown. Removal of organic material will be continuous through station operation but the amounts and type of species entrained varies seasonally and by station (Bamber and Seaby, 2003).
Existing management measures	Increasingly deterrent systems are used to scare away fish and invertebrates (Taft, 2000; Maes et al., 2004). Another method to control removal is location and design of the inflow pipes.

Pressure	**Water flow changes (local)**
Impact	Changes in water flow due to water intake pipes
Description of environmental change (intensity, spatial extent, frequency, duration)	No evidence found. Effects are predicted to be very localised and the major impact would be the removal of species. Any effects would occur throughout station operation.
Existing management measures	N/A

Pressure	**Pollution**
Impact	Chlorine biocides and oxidants used to limit biofouling organisms
Description of environmental change (intensity, spatial extent, frequency, duration)	Assessed in Section 3.15 (Waste Disposal)
Existing management measures	Water quality monitored through licensing regulations.

Pressure	**Thermal changes**
Impact	Abstracted water from power stations returned at higher temperatures.
Description of environmental change (intensity, spatial extent, frequency, duration)	Assessed in Section 3.15 (Waste Disposal)
Existing management measures	Water quality monitored through licensing regulations.

Table 3.119 Environmental pressures on ecosystem services associated with water abstraction.

Ecosystem service	*Significance of impact*	*Confidence in understanding of the relationship = information gaps*
Biological productivity	**Low**. Biological impingement of small fish is common, potentially reducing juvenile levels, but spatially limited. Entrainment of planktonic organisms generally not considered significant at a systems scale.	**Moderate**. A known issue within industry, but longer-term effects not well studied.
Biodiversity provision	**Low**. Water previously abstracted for cooling is returned at much higher temperatures, potentially altering oxygen levels and assemblage composition, but effect is localised.	**Moderate–High**. Effects of altering environment fairly well understood.

identification of high risk abstraction leaks and intakes for fish entrainment, and screening be undertaken where feasible.

The proposed standards for the Water Framework Directive are intended to supersede the standards in the Directives on Freshwater Fish and Shellfish Waters when these directives are repealed in 2013. Thermal standards for classification of the ecological status of rivers have been set but the UK Technical Advisory Group suggested that these should not be used for classification for estuaries and coastal waters as there is inadequate information to link the ecology generally to the complex thermal structure created by temperature gradients. Controls would therefore continue to be focussed on the individual thermal discharges and making sure that the extent of the mixing zone allows the ecology to meet the objectives of the Water Framework Directive (UK TAG, 2008).

3.17.8 Climate change

3.17.8.1 Impacts of climate change on water abstraction

Power stations and other industries abstract water from the sea for use as a coolant, if sea temperatures increase it could make these processes less efficient. Quantification of inefficiencies due to temperature change of cooling water could not be sourced. However, as industries are able to extract cooling water in regions of the world with warmer water temperatures than the UK it is unlikely that this will impact on industry significantly. Spatially, the warming of the sea is expected to be more pronounced in the south east UK (0.5 to 1.4 °C by the 2080s) (Hulme et al., 2002) where high concentrations of population are located.

The cooling water that is released from an industrial plant is higher than the surrounding waters, for example during operation, the Bradwell power station discharged 2 million m^3 of water into the Blackwater Estuary per day and raised the surface water temperature by 0.2 to 1.7 °C (Clark, 1999). A further rise in the temperature of the sea could increase the temperature of the water discharged further. The Freshwater Fish Directive sets standards for fresh salmonid waters of a 1.5 °C increase and an overall maximum temperature of 21.5°C for no more than 2% of the time at the edge of the mixing zone. Although the directive is not strictly applicable in saline waters, the same criteria are applied by the Environment Agency as an Environmental Quality Standard (EQS) in the Thames Tideway. An increase in temperature of the water could make this directive difficult to adhere to (see also the WFD standard for TraC waters in Section 3.17.7).

Adaptation measures

There is no published information on adaptation methods within water abstraction. More efficient cooling processes could be developed to avoid warming of water and to reduce energy consumption.

3.17.8.2 Impacts of water abstraction on climate change

An increase in sea surface temperature could reduce the efficiency of cooling within industrial processes and in turn lead to greater energy consumption depending on the industry. Quantification of this is not available.

Mitigation measures

The UK is actively exploring the potential for carbon capture and storage whereby carbon dioxide (CO_2) emissions from coal-fired power stations would be collected and stored in underground strata. This would significantly reduce CO_2 emissions associated with such forms of electricity generation in coming decades.

3.17.8.3 Summary

Table 3.120 provides a summary of climate change pressures and impacts and indicates the likely significance of the impacts, the level of confidence in the assessment and measures that might be employed to manage the impacts (see Annex 1 for a discussion of the assessment methodology).

3.17.9 Industry stability and sustainability

The planning responsibility for electricity generating stations greater than 50 MW lies with the Secretary of State for Energy and Climate Change in England and Wales, decisions on applications in Scotland are devolved to Scottish Ministers and are also devolved in Northern Ireland.

In the White Paper on Nuclear Power the Government set out that it believes it is in the public interest that nuclear power stations play a role in future energy generation in the UK (HM Government, 2008). The Government also confirmed that it would carry out a Strategic Siting Assessment (SSA) to identify and assess the sites which are potentially suitable for deployment of new nuclear power stations by 2025. Eleven sites (all coastal) have been nominated in England and Wales (www.nuclearpowersiting.decc.gov.uk/nominations) and public consultation on these took place in Autumn 2009. The SSA assessment includes consideration of the effects of water abstraction on the environment (DECC, 2009c).

3.17.9.1 Objectives, targets and indicators

Water abstraction from the marine environment is undertaken by various industries for a range of different purposes. There are no overarching policies, objectives or targets promoting water abstraction, but the use of such resources is implicit in Government support for sustainable development of industries that depend upon a supply of water for abstraction.

Most of the policies relating to water abstraction are associated with environmental protection requirements, in particular the management of impacts on water quantity. For example, the Government's new water strategy for England (Defra, 2008b) includes as part of its vision for 2030 that ...*People, businesses and industry [are] using water resources sustainably, with no interruptions to essential supply during drought*. The roll-out of the water abstraction provisions of the Water Act 2003 in England and Wales will also support more sustainable abstraction.

Table 3.120 Summary of climate change implications.

Climate change pressure	*Impacts of climate change on Water Abstraction*	*Confidence/ significance*	*Adaptation measures*
Rising sea temperature	Cooling water processes become less efficient	Low confidence / low significance	More efficient cooling processes could be developed to avoid warming of water and to reduce energy consumption
	Discharged cooling water is warmer and could breach legislation	Low confidence / low significance	None

Impacts of Water Abstraction on climate change	*Climate change pressure*	*Confidence/ significance*	*Mitigation measures*
An increase in sea surface temperatures may reduce the efficiency of cooling water and increase energy consumption.	CO_2 emissions	Low confidence / unknown significance	Improvements in efficiency of cooling processes

Implementation of the Water Framework Directive will also take account of the ecological impacts of water abstraction from estuaries and coastal waters.

3.17.10 Forward look

The amount of water abstracted for industrial purposes has remained relatively constant over time (Figure 3.62) and it is likely that the requirement for coastal water abstraction will continue at the same levels. If changes in abstraction rates do occur it is likely that these will be related to the requirements of coastal power stations. While some power stations are due to be decommissioned, new ones will be commissioned to maintain electricity supply. The Scottish Government has indicated that Scotland is aiming for a non-nuclear future and will have no new nuclear power stations.

Historically, navigation abstractions and abstractions associated with dredging activities in saline waters have been exempt from licensing. Some modifications to these exemptions are being proposed as part of the implementation of the abstraction provisions of the Water Act 2003 but such activities will remain largely exempt.

The EU Marine Strategy Framework Directive adopted in 2008 requires that measures are put in place to achieve Good Environmental Status (GES) in all UK marine waters by 2020. The indicators and targets for the eleven descriptors of GES have not yet been defined and agreed. As a result it is not yet possible to assess whether measures under existing legislation in relation to these descriptors are sufficient to achieve GES and whether the industries that abstract water from the sea will need to manage further their activities. For example, GES Descriptor 11 states that *...Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment*. However, it is likely that research to describe further the spatial and temporal extent of some pressures will be required in order to assist the assessment of GES.

3.18 General Management and Regulation

3.18.1 Key points

- Estimated income for marine management agencies (excluding grant-in-aid from Governments), scaled to the marine sector is £109 million
- London is the leading centre worldwide in the supply of a range of business services to the international business community
- Business services had a combined turnover of £3.06 billion in 2004
- The 2007/08 value of the marine property owned by the Crown Estate is estimated at £370 million
- In 2007/08 the marine estate provided turnover of £42 million, 15.8% of the total Crown Estate turnover
- The Government revenue from UK oil and gas licensing fees was estimated provisionally at £60 million for 2007/08

i. Introduction

This section reviews the ancillary activities that support the principal activities that have been described in the previous sections of this Feeder Report and assesses the value of the public administration bodies such as the statutory conservation agencies, business services such as insurance and chartering and licence and rental of the seabed.

ii. How has the assessment been undertaken?

The activities provide supportive management and regulatory activities that will not directly impact on the marine environment or other activities. Therefore, socio-economic and environmental pressures are not assessed.

iii. Current status of the general management and regulatory sector

As many of the bodies carrying out these activities are centrally based (e.g. London is the centre of business services) regional values have not been assigned for this sector. The turnover values from general management and regulation activities includes income of £109.39 million from public administration, £3.06 billion from business services and £102 million from licence and rental (£42 million from the Crown Estate (TCE) and £60 million from oil and gas licensing).

iv. What is driving change?

The need for management and regulation in the marine environment is driven by policy developments and changes within the industries that use the marine environment (this might be related to a number of factors including market demand, investment, and technological progress).

v. What are the uncertainties?

There are a range of different organisations with responsibilities in both the marine and terrestrial environments. It is not easy to source economic data that distinguishes among these two areas and as a result this assessment relies upon scaling factors.

vi. Forward look

Owing to increasing activity in the marine environment, general management and regulation activities are likely to increase, particularly in relation to initiatives proposed in various Marine Acts in the UK (e.g. marine planning and nature conservation proposals).

3.18.2 Introduction

3.18.2.1 Description of the sector

This section reviews the ancillary activities (Table 3.121) that support the principal activities described in Sections 3.1 to 3.17.

The ancillary activities include the activities of public administration bodies such as the conservation agencies, of England, Wales and Scotland (Natural England, NE; Countryside Council for Wales, CCW; Scottish Natural Heritage, SNH), the Environment Agency (EA), Scottish Environment Protection Agency (SEPA) and Northern Ireland Environment Agency (NIEA). Business services that support marine activities are included, as are insurance, financial, legal activities and the licence and rental of the seabed through the Crown Estate.

These are supportive management and regulatory activities that will not directly impact on the marine environment or other activities. Therefore, socio-economic and environmental pressures are not assessed here. Also, they do not directly rely on any ecosystem services, although as they rely on other sectors, they indirectly rely on the ecosystem services those sectors rely on.

3.18.3 Ancillary value

3.18.3.1 Public administration

Economic information was taken from the annual reports of the following bodies and used to assess the ancillary value of these activities. Non-departmental public bodies such as SNH, CCW and NE are primarily financed by grant–in-aid from Government but also receive income such as EU funding and money for professional services. This section reports the stated income from annual reports (not grant-in-aid), staff costs and total expenditure. The gap between income and expenditure is filled by grant-in-aid. The agencies cover terrestrial activities as well as marine activities, so the scaling factors used by Pugh (2008) were used to assess the proportion of activities that are related to the marine environment (see Table 3.122).

Conservation agencies

The Joint Nature Conservation Committee (JNCC) is the statutory adviser to Government on UK and international nature conservation on behalf of the Council for Nature Conservation and Countryside, CCW, NE, and SNH. The JNCC is funded on a proportionate basis by these bodies. In 2008, the JNCC contributed to the preparation of the draft Marine Bill, was involved in UK negotiations on the EU Marine Strategy Framework Directive and the provision of environmental and fisheries advice. The gross income for the JNCC in 2007/08 was £1.67 million (excluding grant-in-aid), of which £0.464 million was provided by EU funds and £1.203 million was income from activities. Payments made in 2007/08 were £9.6 million and of these £4.59 million relate to staff costs. Pugh (2008) estimated that a quarter of the activities of the JNCC relate to the marine environment, which gives a value for marine

Table 3.121 Economic activities.

Principal	*Ancillary*	*Secondary*	*Excluded*
None identified	Public administration – (SIC 84) including the activities of the statutory conservation agencies – the Joint Nature Conservation Committee (JNCC), NE, CCW, SNH, SEPA, EA, NIEA Non-governmental organisations (NGOs) and trusts – e.g. The National Trust Business Services including: Employment in Ship finance (SIC 64), Insurance underwriting (SIC 65), Legal and accounting activities (SIC 69). Shipbroking. Licence and Rental (SIC 68.2).	None identified	None identified

Table 3.122 Estimated statistics for marine management agencies (scaled to marine sector using factors from Pugh, 2008).

	Year of Annual Report [a]	*Approx. percentage marine, Pugh (2008)*	*Income, £ million*	*Staff costs, £ million*	*Number employed*
JNCC	2007/08	25	0.418	1.150	33
NE	2007/08	20	1.290	18.760	469
CCW	2007/08	20	0.258	3.850	103
SNH	2007/08	20	0.298	5.180	149
SEPA	2007/08	20	7.050	9.300	260
EA	2007/08	20	79.400	97.840	2500
NIEA	2008/09	20	1.250	5.110	149
National Trust	2007/08	5	19.425	6.850	226
Total			**109.390**	**148.040**	**3889**

[a] Data sourced from JNCC (2008c), Natural England (2008), CCW (2007), SNH (2008a), SEPA (2008a), Environment Agency (2008a), NIEA (2009), National Trust (2008).

income of £0.418 million from the total income of £1.67 million. Using the same scaling factor, staff costs were estimated at £1.15 million.

Natural England is a public body established in 2006 as a result of the merger of English Nature, the majority of the Countryside Agency and the Rural Development Service (formerly part of the Department for Food, Environment and Rural Affairs; Defra). In 2007/08 the marine activities of NE included the development of shellfish management policies, advising the Government on coastal access provisions in the draft Marine Bill and work towards the establishment of a network of marine conservation zones (MCZs). NE is financed by annual grant-in-aid from Defra. Gross income for 2007/08 was £6.5 million (excluding grant-in-aid) and expenditure for this period was £247 million of which £93.8 million relates to staff costs. Using the scaling factors from Pugh (2008) it was estimated that the income and staff costs related to marine activities were £1.29 million and £18.76 million, respectively.

The CCW is the Government's statutory advisor on the environment for Wales. CCW is financed by grant-in-aid from the Welsh Assembly Government (£41.4 million in 2007/08). The gross income for 2007/08 was £1.3 million (excluding the £41.4 million received as grant-in-aid) and total expenditure was £43.2 million. Using the scaling factors from Pugh (2008) it was estimated that the income and expenditure (including staff costs) related to marine activities were £0.258 million and £8.64 million respectively.

Scottish Natural Heritage was established in 1992 and is the government body responsible for heritage protection in Scotland. It is funded by grant-in-aid (£63.4 million in 2007/08) and is accountable to Scottish Government Ministers and through them to the Scottish Parliament. The statutory purposes as set out in the Natural Heritage (Scotland) Act 1991 are to secure the conservation and enhancement of Scotland's natural heritage, foster understanding and enjoyment of it and to encourage sustainable use. In 2007/08, income for SNH (excluding grant-in-aid) was £1.49 million. This consisted of external funding (£0.363 million), EU Funding (£0.298 million) and income from activities (£0.83 million). Total expenditure was £67.57 million of which staff costs made up £25.92 million. Using the scaling factors from Pugh (2008) it was estimated that £0.29 million of income and £5.18 million of staff costs related to the marine environment.

Public bodies: Environment protection

The Environment Agency is an executive Non-Departmental Public Body set up under the Environment Act 1995 and is the leading public body for the protection and improvement of the environment in England and Wales. The EA employs around 12 500 members of staff. In 2007/08 total funding was £1025 million most of which was grant-in-aid from Government. The English Government (through Defra) and the Welsh Assembly Government (WAG) provided 61% of funding (£628 million). Other income streams were charging schemes set up by parliament (£347 million (34%) from charging schemes and local flood defence levies), and £50 million (5%) from miscellaneous sources. Expenditure in 2007/08 was £1103 million of which staff costs were £489.2 million. Using the scaling factors from Pugh (2008) the proportion of income (excluding grant-in-aid) and staff costs that could be allocated to the marine environment were estimated at £79.4 million and £97.84 million, respectively.

The NIEA (formerly the Environment Heritage Service; EHS) is an Executive Agency within Northern Ireland's previous Department of the Environment. It includes four Directorates – Natural Heritage, Built Heritage, Environment Protection and Corporate Services. The annual report (2008/09) records that the majority of income £4.6 million (out of £6.25 million) is sourced from environment protection services. The NIEA employs 882 staff in total and staff costs for 2008/09 were £25.56 million. Scaling to the marine sector following Pugh (2008) indicates that income was £1.25 million and staff costs were £5.11 million.

The Scottish Environment Protection Agency is the principal environmental regulator in Scotland. It protects and improves the Scottish environment through regulatory activities, monitoring analysis and reporting and implementing the National Waste Strategy. SEPA employs 1300 staff across 22 offices. In 2007/08 SEPA had an income of £73.85 million; £38.3 million from grant-in-aid, £32.78 million from charging schemes and £2.45 million from other sources. Total expenditure in

2007/08 was £74.76 million, with staff costs of £46.45 million. The proportion of income (excluding grant-in-aid) and staff costs that could be assigned to the marine environment was estimated using the scaling factor from Pugh (2008). Income was estimated at £7.05 million and staff costs at £9.3 million.

Charities

The National Trust is a charity founded in 1895 to promote the permanent preservation for the benefit of the nation of lands and tenements (including buildings) of beauty or historic interest. It is now Europe's biggest conservation organisation. In 2007/08, the total income of the National Trust was £388.5 million, the majority of this was raised through membership (£111.7 million), legacies (£57.8 million) and enterprises (£51.1 million). Total expenditure was £351.4 million. Expenditure on capital projects related to the coast and countryside was £29.7 million, with £3.8 million spent on acquisitions. The National Trust owns and manages 709 miles (1141 km) of coastline. Using the scaling factors from in Pugh (2008) the value of the marine sector was estimated at £19.4 million with staff costs of £6.85 million.

Summary

The income and staff costs from public administration and trusts are summarised in Table 3.22. Scaling factors from Pugh (2008) were used to assess the proportion of activities that are related to the marine environment.

3.18.3.2 Business services

London is the leading centre worldwide in the range of business services supplied to the international maritime community (Table 3.123). London and the UK are a leading source of capital and expertise for marine insurance, ship-

Table 3.123 International market share of UK maritime services. Source: IFSL (2007) and references therein.

Activity	*Percentage share 2006*
Ship finance	18
Insurance- underwriting	23
Insurance P&I Clubs	65
Lloyd's Register	19
Shipbroking (estimates)	
tanker chartering	50
dry bulk chartering	30-40
second hand tonnage	50

chartering, shipping finance, ship classification, legal and accounting skills and dispute resolution.

This sector contributes to the UK economy through overseas earnings, skilled jobs and also enhances the status of London as a global financial centre. Total UK employment in maritime services in 2007 is estimated at 14 300 (IFSL, 2007).

Shipbrokers are the biggest contributor to UK overseas earnings with net exports increasing from £551 million in 2004 to £706 million in 2006, banking also generates overseas earnings of £240 million. Due to the limited response to surveys, overseas earnings from other maritime services are not available for activities such as legal services and insurance brokers (IFSL, 2007). Based on earlier estimates however IFSL (International Financial Services London) estimates in a recent report (IFSL, 2007) that in 2006 the total overseas earnings of UK maritime services are likely to be in the region of £1.5 billion.

Commercial value was estimated using the methodology described by Pugh (2008). An estimate of marine-related turnover can be obtained from the 2006 employment statistics produced by IFSL (Table 3.124) and average city salaries (estimated at £50 945; Pugh, 2008), linked to turnover in the 2004 combined-use matrix from the UK input-output analyses (ONS, 2006). The Office for National Statistics combined-use matrix for 2004 shows that employee compensation in the banking and finance sector was 28.6% of turnover. This gives a turnover of £214 000 per employee, which for 14 300 employees gives a total marine-related turnover of £3.06 billion. Based on employee numbers, salaries and factors from the 2004 combined-use matrix, the value added is estimated at 69.4% of turnover. This gives an estimated Gross Value Added (GVA) of £2.11 billion (Table 3.125).

Table 3.124. UK employment in maritime services 2007. Source: IFSL (2007).

Activity	*Number employed*
Shipbroking	5000
Ship classification	1700
Banking	200
Insurance	2950
Law firms	2050
Other	2400
Total	**14 300**

Table 3.125. Commercial value of business services.

	Turnover, £ million	*GVA, £ million*	*Exports, £ million*	*Number employed*
Business services	3060	2111	1500 [a]	14 300

a Estimated by International Financial Services London (IFSL) for 2006 from previous reports (IFSL, 2007).

3.18.3.3 Licence and rental

The Crown Estate

The Crown Estate owns and manages extensive marine assets including 55% of the foreshore (50% in Scotland), the beds of tidal rivers and estuaries and almost the entire seabed out to the 12 nautical mile territorial limit. The marine estate has the right to explore and utilise the natural resource of the continental shelf with the exception of oil, coal and gas. It covers a diverse portfolio of interests embracing marine aggregates, potash mining, oil and gas pipelines, telecommunications and power cables, aquaculture, renewable energy, moorings, marinas, wildfowling and ports. The 2007/08 value of the marine property is estimated at £370 million. In 2007/08 the marine estate provided a turnover of £41.9 million (Tables 3.126 and 3.127), this is 15.8% of the total Crown Estate turnover. The revenue from these assets is paid directly to HM Treasury.

Oil and gas licensing by the Government

The Petroleum Act 1998 vests all rights to the nation's petroleum resources to the Crown but the Secretary of State (i.e. the Government) can grant licences that confer exclusive rights for exploration and extraction of oil and gas over a limited area and time period. The licensing system is administered by the Department for Business Enterprise and Regulatory Reform (BERR) and covers oil and gas within Great Britain, its territorial sea and the UK Continental Shelf (UKCS).

The Government's revenue from UK oil and gas licensing fees was estimated provisionally at £60 million 2007/08 (Table 3.128). The UK's

Table 3.126. UK marine estate revenues from the Crown Estate 2007/08.

Activity	*Revenue, £ million*
Marine aggregates	17.7
Coastal estate (marinas ports, harbours)	11.3
Renewable energy	1.1
Cables/pipelines	10.0
Fish farms	1.8
Total	**41.9**

Table 13.127. Regional distribution of Crown Estate Revenue 2007/08.

Region	*Turnover, £ million*
Northern Ireland (Marine & Foreshore)	0.672
Scotland (Marine & Foreshore)	3.500
Wales (Marine & Foreshore)	1.200
Total	**5.37**

Mineral revenues are not included in this table as these are not exclusively marine.

Table 3.128 Commercial value of licence and rental of the seabed.

	Turnover, £ million
Crown Estate	41.9
Oil and Gas (2007/08)	60.0
Total	**101.9**

oil and gas sector supports over 450 000 jobs throughout the economy but identifying the proportion which can be allocated to licensing activities, was not possible.

3.18.3.4 Summary

The economic contribution of management and regulatory bodies is summarised in Table 3.129.

3.18.4 Regional distribution of value

Most of the administration of the marine environment is from central office so a regional valuation was not attempted. In particular:

- The Public Bodies are regionally devolved
- The UK Maritime Business Services sector is centred on London
- The Marine Estate of the Crown Estate is managed from two main offices: Scottish estate from the Edinburgh office and the English, Welsh and Northern Ireland interests from London.

3.18.5 Trends

The UK shipping sector has been showing sustained growth with the UK-owned fleet up by 150% from a low-point of 7.2 million tonnes at end-1999 to 17.9 million tonnes at end-2006. The registered fleet has risen by 350% during

Table 3.129 Summary of the general management and regulatory sector.

Activity	*Year*	*Turnover, £ million*	*GVA, £ million*	*Exports, £ million*	*Number employed*
Public administration	2006/07–2007/08	256	143	–	3740
Business services	2006/07	3060	2111	1500[a]	14 300
Licence and rental	2007/08	102	–	–	50
Total	**–**	**3425**		**1500**	**18 090**

[a] Estimated by IFSL for 2006 from previous reports (IFSL 2007).

this period. This is due to inward investment by international shipping companies, partly to take advantage of the beneficial economic and tax environment in the UK.

The UK is estimated to have 20 billion barrels of oil and gas in the North Sea fields, currently more licences to exploit this reserve have been offered (in 2008) than before and this should lead to an increase in licensing revenue, at least over the short term.

3.18.6 Industry stability and sustainability

3.18.6.1 Objectives, targets and indicators

The Government's better regulation agenda aims to eliminate obsolete and inefficient regulation, create user-friendly new guidelines and tackle inconsistencies in the regulatory system. The Better Regulation Executive (BRE) is part of BERR and leads this regulatory reform agenda across Government. Its aims are:

- To work with departments to improve the design of new regulations and how they are communicated
- To work with departments and regulators to simplify and modernise existing regulations
- To work with regulators (including local authorities) and departments to change attitudes and approaches to regulation to become more risk-based

Significant progress has been made across all these areas. The Government's ambitious and wide-ranging regulatory reform agenda is one of the most respected programmes in the world, which has been confirmed by a number of international surveys. BRE's work is underpinned by five key principles of regulation, which are now a cornerstone of the better regulation strategy and implementation. These state that any regulation should be:

- Transparent
- Accountable
- Proportionate
- Consistent
- Targeted – only at cases where action is needed

To support better regulation, Departments with regulatory functions are required to prepare and implement Simplification Plans which set out how they will reduce the burden of regulation. Government has set a target of achieving approximately £3.4 billion of net annual savings for business by 2010.

3.18.7 Forward look

Owing to increasing activity in the marine environment, general management and regulation activities are likely to increase, particularly in relation to initiatives proposed in various Marine Acts in the UK (e.g. marine planning and nature conservation proposals).

SECTION 4
MARINE MANAGEMENT

The marine environment in the UK has a complex system of management that has developed in order to deal with various political and sectoral issues over many years. This Section sets out the policies that currently manage socio-economic activities in the marine environment. It identifies the targets and objectives that have developed within a range of legislation and provides a forward look at forthcoming policy developments.

4.1 Marine policy

There is a wide range of legislation relevant to the exploitation of marine resources and the management of human impacts on the marine environment (see Box 4.1). These main legislative drivers are supported by a raft of national, regional and in some cases local policies. Historically many of these policies have related to sector specific activities. However, the increasing pressure on the marine environment and the application of the ecosystem approach to the management of human activities demand that more integrated approaches to management are adopted. This is exemplified by the EU Maritime Policy and the Marine and Coastal Access Act 2009, the Marine (Scotland) Act 2010 and similar legislation under development in Northern Ireland.

4.2 Marine management

Historically, marine management has taken a sectoral approach, evolving as new socio-economic pressures arose. As a result, there is a myriad of marine management agencies throughout the UK and Devolved Administrations that are responsible for managing and licensing the various socio-economic activities that occur in the marine environment. As a consequence, developers

Box 4.1: Key Drivers

UNCLOS – the UN Convention on the Law of the Sea provides an overarching framework for the marine environment. It sets out national jurisdictions and establishes rights of navigation and the legal regime for the High Seas. It provides the legal basis for the protection and sustainable development of the marine environment and addresses environmental control, scientific research, economic activities and the settlement of disputes.

IMO Conventions – The International Maritime Organization has established a number of conventions to tackle pollution from shipping (International Convention for the Prevention of Pollution from Ships (MARPOL), International Convention on the Control of Harmful Anti-fouling Systems on Ships (Anti-fouling Substances Convention, International Convention for the Control and Management of Ships' Ballast Water and Sediments).

Convention on Biological Diversity – The Convention seeks to conserve biological diversity, and promote the sustainable use of its components and the fair and adequate sharing of benefits from the use of genetic resources. The 2002 World Summit on Sustainable Development (WSSD) sought to encourage the ecosystem approach to marine management to contribute to sustainable development.

OSPAR Convention – The 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic aims to contribute to the control and prevention of marine pollution within the waters of the North East Atlantic and scientific co-operation in assessing the quality of these waters. Annex V requires Contracting Parties to take the necessary measures to protect and conserve marine ecosystems and biodiversity of the North East Atlantic, and to restore, where

practicable, adversely affected areas. Annex V of the OSPAR Convention also provides for the adoption of programmes and measures to assist management of human activities that can have an adverse impact on the marine environment.

EU Maritime Policy – the Integrated European Maritime Policy published in 2007 seeks to develop a thriving maritime economy in an environmentally sustainable manner. The publication of the Policy was accompanied by an Action Plan identifying a set of actions that the European Commission proposes to take as a first step towards the implementation of the policy. A communication on a *Roadmap for Maritime Spatial Planning: Achieving Common Principles in the EU* was adopted in 2008 (EC, 2008).

EU Common Fisheries Policy – the CFP provides for the management of marine fisheries across the waters of Member States. Council Regulation 2371/2002 on the conservation and sustainable exploitation of fisheries resources provides for stricter environmental criteria to be applied to fisheries management decisions.

EU Directives – A number of EU directives are important in setting environmental protection objectives for the marine environment. Principal among the Directives are:

- Marine Strategy Framework Directive (2008/56/EC) (MSFD)
- Water Framework Directive (2000/60/EC) (WFD)
- Habitats Directive (92/43/EC) and Birds Directives (79/409/EEC)

Marine and Coastal Access Act 2009 – the Act provides a framework for the integrated and sustainable management of human activities in the UK marine area, including the creation of a new body for marine management (the Marine Management Organisation), marine planning, streamlined marine licensing, establishment of a network of Marine Protected Areas and improved fisheries management arrangements. In Scotland, the Marine (Scotland) Act 2010 makes comparable provisions for marine planning, streamlined licensing provision and the creation of a power to designate marine protected areas. A marine management organisation (Marine Scotland) was established from April 2009. At a high level, all the UK administrations have agreed to develop a joint marine policy statement for the management of the seas.

and/or regulators often need to consult with many agencies in order to progress with their plans. For example, oil and gas developments are managed by the Energy Markets and Infrastructure Directorate within the Department of Energy and Climate Change (DECC). In granting licences and establishing licence conditions, DECC may need to engage in consultation with the relevant authorities including the following:

- Cefas – Centre for Environment, Fisheries and Aquaculture Science (an agency of the Department for Environment, Food and Rural Affairs – Defra) (for operations to be carried out in English or Welsh waters)
- Marine Scotland (for operations to be carried out in Scottish waters)
- NIEA – Northern Ireland Environment Agency (for operations in Northern Irish waters)
- The Joint Nature Conservation Committee (JNCC), or coastal conservation bodies such as Natural England (NE), Countryside Council for Wales (CCW) and Scottish Natural Heritage (SNH)
- Any organisation which the fisheries liaison officer consults in accordance with Clause F1 to the Licence
- Those local authorities with responsibility for the coastline adjacent to the location of the proposed activity.

The Marine and Coastal Access Act 2009 and Marine (Scotland) Act 2010 seek to resolve this issue by bringing a number of marine management responsibilities under the umbrella of a single organisation, the Marine Management Organisation (MMO) and Marine Scotland respectively. Northern Ireland is also considering as part of the policy development work for a Northern Ireland Marine Bill, how best to deliver functions in the marine area.

However, these new agencies may still need to consult with the relevant coastal Local Authorities and/or Infrastructure Planning Commission (IPC) where appropriate.

4.3 Marine objectives

Effective management of the marine area requires a clear set of objectives against which management actions can be identified, implemented and monitored. In the past, the objectives for many human activities have not been explicit and there has been a lack of integration among economic and social objectives and between those objectives and environmental protection objectives (e.g. MSPP Consortium, 2006; Rogers et al., 2007). To deliver ecosystem-based approaches to management of the marine area greater clarity and better integration of these objectives is required. While the sectoral accounts identify some of the broad policy objectives relevant to each sector, this framework is incomplete and clear targets are generally lacking. While it is neither possible nor necessarily desirable to define quantified objectives and targets for all areas of policy, clarity of objectives and enunciation of targets is likely to be necessary in priority areas if Government goals are to be delivered through the marine planning system.

4.3.1 Overview and existing initiatives

The EU Maritime Policy (termed the 'Blue Book') generally does not contain specific objectives for marine activities but does require that national integrated maritime policies are developed by Member States. However, the EU Marine Strategy Framework Directive (MSFD), the 'environmental pillar' of the Maritime Policy, has a number of objectives, including:

- To take the necessary measures to achieve or maintain Good Environmental Status (GES) in the marine environment by 2020 (see descriptors in Box 4.2) (Article 1(1))
- To protect and preserve the marine environment, prevent its deterioration or, where practicable, restore marine ecosystems in areas where they have been adversely affected (Article 1(2a))
- To prevent and reduce inputs in the marine environment, with a view to phasing out pollution, so as to ensure that there are no significant impacts on or risks to marine biodiversity, marine ecosystems, human health or legitimate uses of the sea (Article 1(2b))
- To apply an ecosystem-based approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of GES (Article 1(3)).

These objectives can be seen as providing the high-level environmental objectives with which human activities in the marine area should comply.

Box 4.2. Annex I Qualitative descriptors for determining GES

1. Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.
2. Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.
3. Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
4. All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
5. Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.
6. Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
7. Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
8. Concentrations of contaminants are at levels not giving rise to pollution effects.
9. Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
10. Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
11. Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

Under the MSFD, an initial assessment of environmental status is required by 2012 including a socio-economic analysis of the use of UK seas and the cost of degradation of the marine environment. The PSEG Feeder Report is expected to provide much of the information necessary for the assessment of socio-economic activities.

As part of the development of policy to support implementation of the Marine and Coastal Access Act the UK Government, Northern Ireland Executive and Welsh Assembly Government consulted (in June 2008) on a number of high level marine objectives which articulate the outcomes they are seeking for the UK marine area as a whole (outcomes in Box 4.3) and which take account of the broad aims of the EU Maritime Policy and MSFD objectives. A parallel consultation was undertaken by the Scottish Government as part of its consultation on the Marine (Scotland) Act 2010. Many of these objectives are directly relevant to productive seas either in terms of resource exploitation or the management of environmental impacts.

Under the Marine and Coastal Access Act 2009, Marine (Scotland) Act 2010 and similar legislation under development in Northern Ireland the high level objectives will inform the development of a joint Marine Policy Statement that will guide marine planning and management in UK waters. The Marine Policy Statement (MPS) will take account of UK Government and Devolved Administrations' priorities and relevant targets and should serve to integrate better some of the sectoral objectives that exist within the sectoral policy documents.

A framework of targets and indicators to underpin the 11 descriptors of GES under the MSFD will be developed over the next two

Box 4.3. UK High-level Marine Objectives (HM Government, 2009a)

Achieving a sustainable marine economy:

- Infrastructure is in place to support and promote safe, profitable and efficient marine businesses.
- The marine environment and its resources are used to maximise sustainable activity, prosperity and opportunities for all, now and in the future.
- Marine businesses are taking long-term strategic decisions and managing risks effectively. They are competitive and operating efficiently.
- Marine businesses are acting in a way which respects environmental limits and is socially responsible. This is rewarded in the marketplace.

Ensuring a strong, healthy and just society:

- People appreciate the diversity of the marine environment, its seascapes, its natural and cultural heritage and its resources and act responsibly.
- The use of the marine environment is benefiting society as a whole, contributing to resilient and cohesive communities that can adapt to coastal erosion and flood risk, as well as contributing to physical and mental wellbeing.
- The coast, seas, oceans and their resources are safe to use.
- The marine environment plays an important role in mitigating climate change.
- There is equitable access for those who want to use and enjoy the coast, seas and their wide range of resources and assets

and recognition that for some island and peripheral communities the sea plays a significant role in their community.

- Use of the marine environment will recognise, and integrate with, defence priorities, including the strengthening of international peace and stability and the defence of the UK and its interests.

Living within environmental limits:

- Biodiversity is protected, conserved and, where appropriate, recovered, and loss has been halted.
- Healthy marine and coastal habitats occur across their natural range and are able to support strong, biodiverse biological communities and the functioning of healthy, resilient and adaptable marine ecosystems.
- Our oceans support viable populations of representative, rare, vulnerable, and valued species.

Promoting good governance:

- All those who have a stake in the marine environment have an input into associated decision-making.
- Marine, land and water management mechanisms are responsive and work effectively together, for example through integrated coastal zone management and river basin management plans.
- Marine management in the UK takes account of different management systems that are in place because of administrative, political or international boundaries.
- Marine businesses are subject to clear, timely, proportionate and, where appropriate, planled regulation.
- The use of the marine environment is spatially planned where appropriate and based on an ecosystems approach which takes account of climate change and recognises the protection and management needs of marine cultural heritage according to its significance.

Using sound science responsibly:

- Our understanding of the marine environment continues to develop through new scientific and socio-economic research and data collection.
- Sound evidence and monitoring underpins effective marine management and policy development.
- The precautionary principle is applied consistently in accordance with the UK Government and Devolved Administrations' sustainable development policy.

years which will assist the UK Government and Devolved Administrations in managing the marine environment. Any significant gaps identified will require the development of additional targets and indicators to tackle those issues not covered by the MSFD. It is intended that these targets and indicators will be a key means of providing information on progress towards the overall vision and the evidence necessary to adapt and refine policies to respond to the changing state of the marine environment.

4.3.2 Assessment of productivity and sustainability of human activities

While the sectoral accounts clearly demonstrate that the sea is productive, it is difficult to make an objective assessment of the sustainability of the marine area or the contribution that human activities in the marine area make to sustainable development. In part, this reflects differing stakeholder interpretations of what constitutes sustainable development. Sustainable Development of the marine environment is referred to in the 2007 Integrated European Maritime Policy, the UK Government 2005 paper *Securing the Future* (HM Government, 2005) and various devolved government strategies. Since these documents, many industries have also developed their own strategies towards achieving sustainable development in their areas of business. Ideally strategies should outline clear systems of objectives, measures and targets. Table 4.1 outlines progress towards embedding the principles of SD into strategies. All of the industries are supported by sustainable development strategies that incorporate economic, environmental and social objectives. However, not all have clearly defined time-bound targets.

In relation to fisheries, a number of fish stocks are acknowledged to be outside safe biological limits and for many exploited species that are within safe biological limits, the current level of productivity is possibly lower than it might be if stocks were able to recover to historic levels. For new activities such as renewable energy generation, exploitation of available resources is low compared to its future potential. Thus while such activities might be seen as making an important contribution to sustainable development they would not yet be seen as fully productive.

There have been a range of different approaches and solutions to improving sustainable development including:

1. New measurements of sustainability – for example, aquaculture and assessments of carrying capacity (Section 3.1.7) and implementation of measures to avoid and mitigate environmental impacts from marine aggregate dredging (Section 3.7.2.7)
2. Reducing capacity – for example, fisheries and decommissioning schemes (Section 3.5.5.3)
3. Adapting activities – for example, carbon capture and storage to reduce impacts of oil and gas extraction (Section 3.14)
4. Win-win opportunities – for example, combining wet renewable energy devices and coastal and flood defence measures (Section 3.11.6)
5. Off-setting impacts – for example, offsetting the impacts associated with port development and construction of coastal defences through the provision of compensatory habitat (Section 3.2.6 – Case Study 1).

Table 4.1 Progress towards developing sustainable development strategies

Industry	*SD Strategy (Y/N)*	*Time bound targets (Y/N)*
Aquaculture	Y – European, UK and DA strategies	Y
Coastal Defence	Y - Various DA strategies and planning policy statements	Y
Defence – Military	Y – MOD SD Strategy 2008	Y
Education	Y – SD principles translated in PSAs	Some
Fisheries	Y - SD principles embedded in CFP	Some
Leisure and Recreation	Y – SD principles translated into various planning policies	Some
Maritime Transport	Y - Modern Ports: A UK Policy, 2000 and the Port Policy Review, 2008	Y
Mineral Extraction	Y – SD strategy and annual reporting	Y
Oil and Gas	Y – Principles embedded in Energy Act 2008	Some
Pipelines		
Power Transmission		
Renewable Energy		
Research and Development	N	
Storage (of Gases)	Y – Principles embedded in Energy Act 2008	Some
Telecommunications	Y - The Communications White Paper	Y
Waste disposal	Y - Future Water 2008	Y
Water Abstraction	Y - Future Water 2008	Y

Overall, many industries are making good progress towards embedding the principles of SD into their business but greater consistency is required in establishing clear time-bound targets.

There are a number of good examples of how industries have sought to improve the sustainability of their activities. For example, in the marine aggregates sector, improved management of finite marine aggregate resources and implementation of measures to avoid and mitigate environmental impacts have increased the sustainability of such activities. In relation to port development and flood and coastal erosion risk management there are also a number of examples whereby impacts associated with construction and operation have been offset through the provision of compensatory habitat.

4.4 Forward look

The many policy developments, in particular, application of new marine management polices and arrangements across the UK and Devolved Administrations and implementation of the MSFD, are expected to advance significantly sustainable development in the marine area. In addition, wider economic development and efforts to mitigate climate change will also lead to changes in human activity in the marine area. These changes are described in the following sections.

4.4.1 Modernising governance

Implementation of the MSFD requires greater co-operation between Member States sharing regional seas. The Directive strengthens the role of the European Commission in governance of European Seas and requires existing co-operation mechanisms, such as the regional conventions (e.g. OSPAR), to be utilised for regional co-operation.

The Marine and Coastal Access Act 2009, the Marine (Scotland) Act 2010 and proposals for similar legislation in Northern Ireland will establish new governance arrangements for the marine area. Separate marine management organisations are being established for English waters and waters offshore of England, Wales, Northern Ireland and Scotland (for reserved matters) and for Scottish territorial waters. Marine management functions in Welsh territorial waters will continue to be undertaken by the Welsh Assembly Government and Northern Ireland will develop management arrangements for its territorial waters through separate marine legislation. The existing Sea Fisheries Committees' responsibilities for English waters will be vested in new Inshore Fisheries and Conservation Agencies (IFCAs).

The marine management organisations will provide a powerful focus for marine management with the following broad responsibilities:

- Marine planning and management
- Licensing for a wide range of marine development activities
- Enforcement of marine nature conservation
- Fisheries enforcement (for England and Wales, beyond IFCA limits).

The implementation of marine planning will also improve co-ordination between marine stakeholders, including those organisations with responsibilities for the management of sectoral activities. Improved co-ordination and integration of human activities is expected to make a substantial contribution to sustainable development in the marine area as well as providing a transparent process for public involvement.

Case Study 7 provides an assessment of the development of marine planning in the UK and the various concepts to be considered.

4.4.2 Streamlining regulation

The UK and Scottish Marine Acts will streamline legislation for the licensing of the majority of marine development activities and contribute to reducing the legislative burden. Legislative reform will be accompanied by improvements to the management of the licensing process, for example better co-ordination of requirements across Government Departments, Devolved Administrations and Agencies as part of the Government's drive to deliver better regulation. Implementation of marine planning is also expected to provide greater certainty for key development activities, thus supporting investment in the marine area.

Separately, for England and Wales, under the Planning Act 2008, decisions on large infrastructure developments (including major marine developments) will be taken by the IPC. Establishment of the IPC is particularly intended to streamline decision-making on these large development projects. In Wales, the Welsh Ministers will however retain their existing FEPA/Marine licensing functions for such projects. In Northern Ireland, streamlining of marine

Case Study 7: Towards a system of marine planning in the UK

Genesis of planning

Proposed systems of Marine Planning in the UK have been built upon a number of discussions and developments including the following:

- Review of Marine Nature Conservation (RMNC) and Irish Sea Pilot (Defra, 2004e; Vincent et al., 2004)
- Making the case for marine spatial planning in Scotland (Tyldesley, 2004a)
- The added value of Marine Spatial Planning (MSP) – an informal discussion paper (Interagency MSP Working Group, 2005)
- The Marine Spatial Planning Pilot (MSPP Consortium, 2006)
- The Marine and Coastal Access Act 2009
- Recommendations of the Advisory Group on Marine and Coastal Strategy (AGMACS) (Scottish Executive, 2007d)
- Workshops by the Sustainable Seas Task Force (SSTF, 2008).

Early developments in 2004 focused on spatial approaches to marine planning (MSP), dependent on zoning mechanisms for the management of marine activities. The Scottish Coastal Forum (SCF) at the time defined the purpose of marine spatial planning as *...two fold: (a) to secure sustainable and integrated development which balances and, where appropriate advances, economic, social and environmental objectives, and considers the implications of the ecosystem approach; and (b) to allocate space in inshore waters in a rational manner which minimises conflicts of interest and maximises synergistic relations* (quoted in Tyldesley, 2004b).

However, more recently there is broad agreement that MSP is just one of many tools that may assist in the management of activities. Marine planning as a minimum should also include sets of objectives and policies (spatial and non-spatial; sectoral and general), as well as potential zoning mechanisms if and where necessary to achieve the aims of the plan (ABPmer, 2008). The Royal Town Planning Institute state in *Sustainable Seas for All* (Scottish Government, 2008e) that ...*a plan is not just a map, it has to be associated with the activity of planning as a management process and must therefore be action orientated and linked to mechanisms, both regulatory and proactive, for ensuring that the intended results are achieved*.

Objectives for marine planning may range from provision for nature conservation to assessments of the distribution of renewable energy resources. Existing examples of marine planning in the UK with various objectives and levels of spatial prescription include the following:

- Designated sites for marine nature conservation, for example existing Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) and proposed Marine Conservation Zones
- Industry planning, for example The Crown Estate's (TCE) Marine Resource System (MaRS); Port Master plans; Marine Aggregate Dredging Regional Environmental Assessments (REAs)
- Strategic Environmental Assessment (SEA), for example for Offshore Energy; Marine Renewable SEA Scotland; Scottish Offshore wind SEA, Renewable energy SEA for Northern Ireland Department of Enterprise, Trade and Investment (DETI); Marine

renewable energy framework for Wales, SEA on the inshore shellfish fisheries for the North Eastern Sea Fisheries Committee

- Multi-sector plans, for example Pentland Firth Marine Spatial Planning; Sustainable Scotland Marine Environment Initiatives (SSMEIs)
- Coastal Fora plans, for example Dorset Coastal Forum plan; Solent Forum Initiative on marine planning.

Benefits

Experiences from the examples above have illustrated a number of common benefits that may be realised from marine planning as follows:

- A streamlined and consistent system of decision-making
- Greater integration between decision-making bodies on land and sea
- Greater transparency of, and stakeholder involvement in, the decision-making process
- Improved ability to consider cumulative effects from activities in the marine environment
- Improved ability to incorporate an ecosystem approach to management through consideration of ecosystem capacity
- Provision of freely available data for all stakeholders.

Policy development

The Marine and Coastal Access Act 2009 proposes a system of 'Marine Planning' which aims *...to clarify our marine objectives and priorities for the future, and direct decision-makers and users towards more efficient, sustainable use and protection of our marine resources*. Marine Planning is to be implemented in two steps:

1. Agreeing on a marine policy statement to create a more integrated approach to marine management and setting short and longer-term objectives for sustainable use of the marine environment.
2. Creating a series of marine plans, which will implement the policy statement in specific areas, using information about spatial uses and needs in those areas.

The Marine (Scotland) Act 2010, likewise outlines a formal system of statutory marine planning to ensure sustainable economic growth in the seas around Scotland. Three tiers are proposed to capture the various international, national (Scottish) and regional aspects of planning. The core system will therefore consist of a national marine plan that outlines policies and priorities for sustainable development and a set of objectives to guide planning at regional levels.

At an international level, in 2007, the European Commission presented an Integrated Maritime Policy for the European Union and an associated action plan that prioritised work on integrated maritime policies and maritime spatial planning. Such policies have provided further drivers for the development of marine planning in the UK.

Challenges

Based on experiences in existing marine planning initiatives and policy developments outlined above, a number of challenges have been highlighted that will need to be overcome in the further development of marine planning. These include:

1. Achieving agreement in the preparation of a joint marine policy statement.
2. The need to rationalise multiple sectoral legislation.

3. International jurisdiction – partly addressed through the proposed declaration of an Exclusive Economic Zone (EEZ).
4. Time frames – predetermining EU Maritime Policy and MSFD – as a result there will be a need later to ensure integration among objectives.
5. Ability of MMO to deliver – funding, institutional capacity.
6. Dependency on good quality spatial data. Decisions should be made to achieve sustainable development, having regard to planning policies prepared using the best available data. This will need ongoing investment in data management and delivery (e.g. Marine Environmental Data Information Network MEDIN).
7. Marine planning will need to integrate with existing plans both on land and in the sea – i.e. Integrated Coastal Zone Management (ICZM). The principles of ICZM are embedded in the Marine and Coastal Access Act 2009. However, uncertainty remains over the impact of the proposed Infrastructure Planning Commission (IPC) and proposed changes to the land planning system and River Basin Management Plans (RBMPs).
8. Managing the transition to marine planning – may result in a hiatus or uncertainty on proposed developments while plans are developed.
9. The need for clear objectives for sustainable development to provide certainty for industry.
10. Developing a flexible mechanism that can adapt to manage changes in pressures (i.e. from sectoral activities) and environmental status while also incorporating a degree of prescription that will provide certainty for stakeholders and economic investments.

licensing, further to that which is provided for in the UK Act, will be considered through separate marine legislation.

4.4.3 Reducing environmental impacts

Implementation of the MSFD and the pursuit of GES are likely to require additional measures to reduce the magnitude and extent of the impact of human activities. Such efforts are likely to be supported by existing measures under EU Directives, particularly the WFD and by further measures under the reformed Common Fisheries Policy (CFP).

The new Marine Acts will strengthen the ecosystem-based approach to the management of human activities through the establishment of objectives, including ecosystem objectives, as part of marine planning. The designation of marine protected areas, having regard to social and economic factors, will also add to the ecosystem based approach. Such an approach will improve the protection and management of the marine area while taking account of social and economic costs.

The increasing application of strategic environmental assessment to marine plans and programmes – and in particular, their intended application to marine plans – also provides a valuable opportunity to avoid or reduce environmental risks at the planning stage.

As scientific knowledge of marine ecosystems improves, this will also provide opportunities to assess better the cumulative impacts of development and human activities in the marine area.

4.4.4 Understanding value

The increasing use of impact assessment as part of policy development across Government is improving the information base on the economic and social values generated by human activity as well as their environmental costs and benefits. The adoption of an ecosystem goods and services approach to valuation provides recognition to the significant value that ecosystem goods and services provide to society (see list in Annex 1, Table A1). Such information is likely to be increasingly influential in informing policy choices and can make a substantial contribution to sustainable development.

4.4.5 Changing nature of activities

Use of the seas continues to change. Oil and gas production is predicted to decline by around two-thirds over the period 2010 to 2030 and will lead to a major programme of decommissioning of oil and gas installations. In contrast, marine renewable energy development is likely to expand significantly with plans for the installation of up to 25 GW of offshore wind by 2020 and scope for up to 30 GW of wave and tidal power by 2050. The use of suitable formations under the seabed for gas storage is likely to increase to improve security of gas supplies and, subject to the success of a proposed demonstration project, it is possible that carbon capture and storage could become a notable activity in the future. A range of existing activities is also forecast to continue to grow, for example, seaborne trade, recreation and leisure and aquaculture.

Against this backdrop of changing use, the implementation of marine planning will be important in managing competing demands for sea space and in seeking to optimise sea use.

4.5 Summary and recommendations

Implementation of the UK and Scottish Marine Acts and similar marine legislation in Northern Ireland, the Water Framework Directive, Marine Strategy Framework Directive and the Common Fisheries Policy reforms provide major opportunities to achieve sustainable development in our seas. However, the scale of the changes in the marine policy framework and management arrangements over the next few years is unprecedented. It is vital that clear arrangements are in place to manage the transition and that implementation of new requirements does not unnecessarily delay new development applications. The management of this change is therefore likely to be a significant challenge in its own right.

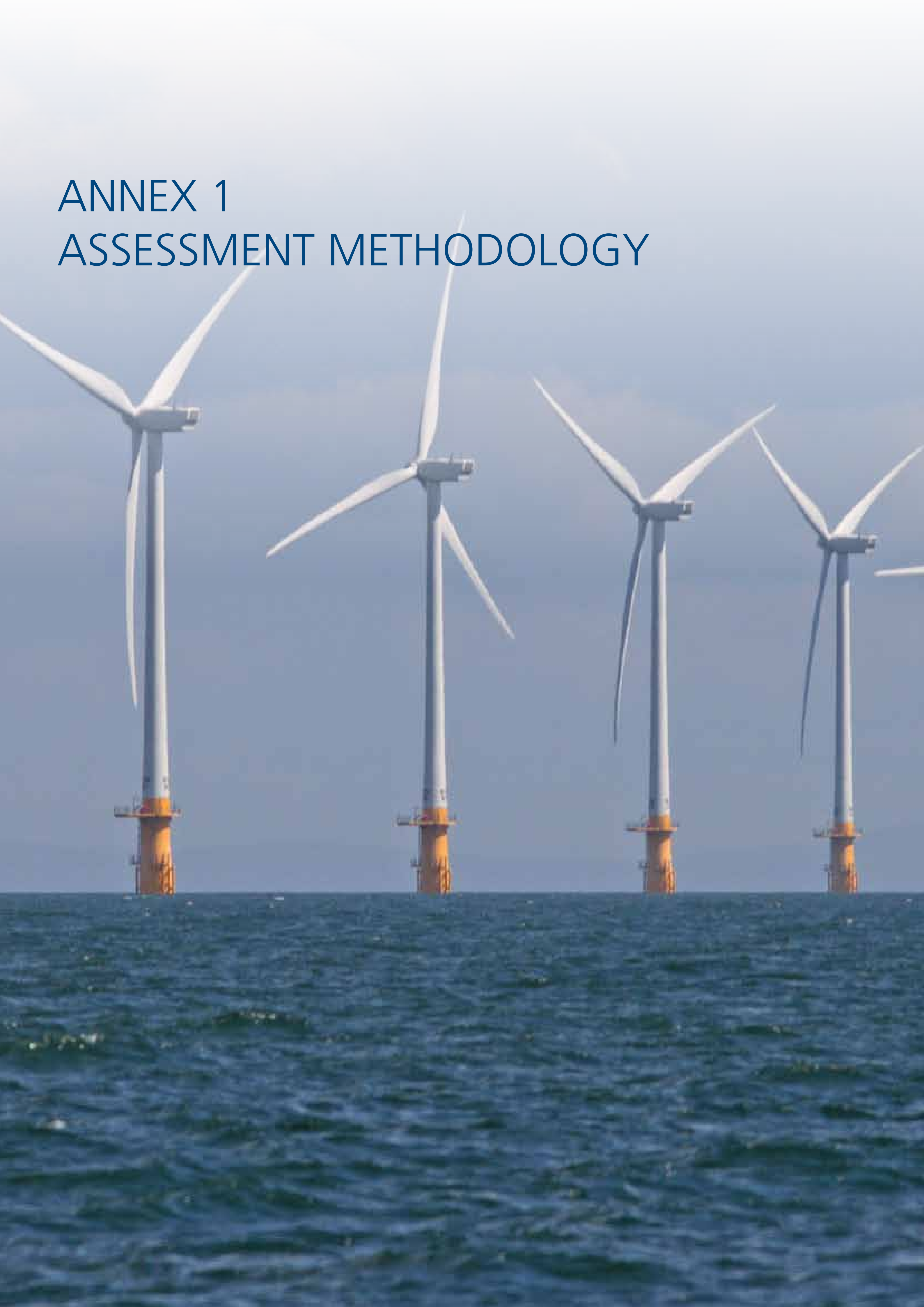
Human use of the marine environment will also continue to change. Over the next decades there is likely to be significant expansion of marine renewable energy generation (wind, waves, tides) and increases in mariculture. In contrast oil and gas activity is expected to decline significantly over this period. Implementation of Common Fisheries Policy reforms may lead to significant changes for some commercial fisheries but has the potential to deliver long-term improvements in catches.

To support sustainable development, clearer objectives and policies will need to be developed by Government to ensure that stakeholders understand what is to be achieved and how success will be measured. This is particularly likely to be needed for new human development activities to ensure that they can access areas of suitable resource. Establishing such a framework for human activities will be challenging, particularly in ensuring that any such framework has sufficient flexibility to respond to market

requirements. In implementing marine planning it will be important that the management bodies provide sufficient steer through the plans while avoiding an overly-bureaucratic process – the plans need to facilitate sustainable development without becoming an end in themselves.

A key measure of the effectiveness of the new policy requirements and management arrangements will be the extent of improvements in the marine environment. The measurement of marine environmental quality presents many challenges and there is likely to be an increasing focus on what is monitored, how it is monitored and how such information is used to assess the state of the marine environment. From a socio-economic perspective there is also likely to be an increasing emphasis on measuring the costs and benefits of human activities linked to their effects on the provision of ecosystem goods and services and concepts of welfare.

ANNEX 1
ASSESSMENT METHODOLOGY



This annex comments on the specific methodology and definitions that were adopted in assessing the productive status of UK seas including:

1. How relevant *ecosystem services* were identified
2. How *economic value* is assessed
3. How this information was broken down into *regional assessments*
4. How *socio-economic* pressures were described
5. How the *marine environmental* pressures of socio-economic activities were assessed
6. How *climate change* impacts were considered
7. How *sustainability* was assessed.

1.1.1 Ecosystem services

In order to understand the relationship between economic activity and the marine environment the study aimed to identify the main ecosystem goods and services that the activity was dependent on. This process also helped to clarify whether an activity was principal, ancillary or secondary.

A common set of ecosystem goods/services was established as a basis for this. This issue was discussed in a study on marine ecosystem structure and function for the Joint Nature Conservation Committee (JNCC, 2007). A list provided by Laffoley et al. (2004) in relation to economic benefit was adapted for this assessment (see Table A1).

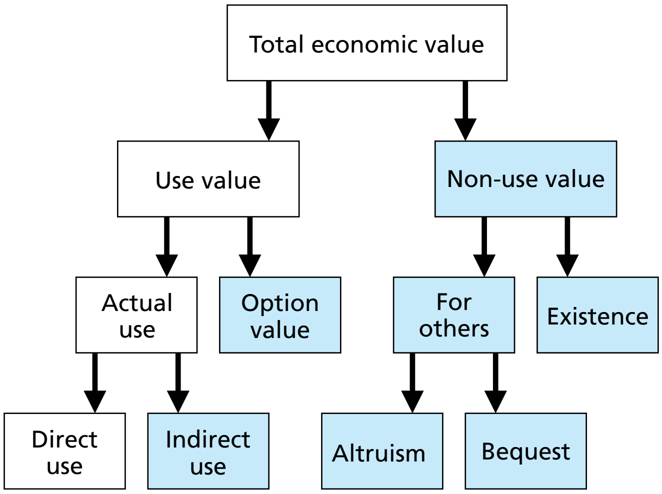
1.1.2 Assessing economic value

The total economic value of marine ecosystem goods and services has many different aspects, as illustrated in Figure A1. The present report relates to marine productivity and so focuses on the 'direct use' values of marine ecosystem resources.

Table A1 Marine ecosystem goods and services. Source: adapted from Laffoley et al. (2004).

Direct	*Indirect*
• Raw materials • Food and employment • Genetic resources • Medical resources • Ornamental resources • Spiritual and cultural values • Education opportunity • Coastal tourism • Recreation • Physical environment	• Flood and storm protection • Nutrient cycling • Climate regulation • Bioremediation of waste • Functional habitats • Geophysical processes • Tidal cycles • Biological productivity
Other final services	
• Chemical cycling, water purification and waste treatment • Erosion-deposition cycles (of sediment) • Provision of water quality • Biodiversity provision	

Figure A1 Direct use values as a component of total economic value. Source: Defra (2007a).



Principal activities

Principal activities, as defined in Section 1 (Introduction; see Table 1.1), make direct use of an ecosystem good or service. These include consumptive uses, i.e. the use of goods extracted from the ecosystem (e.g. fish, aggregates, energy) and non-consumptive uses, i.e. the use of

services without extracting any elements from the ecosystem (e.g. recreation, maritime transport, telecommunication transmissions). Maritime transport and telecoms may also be referred to as ‘occupational uses’ where the activity occupies space (seabed or sea) but does not extract anything from the environment. This helps to differentiate between non-consumptive and non-occupational uses such as wildlife watching.

The economic value of the principal activity is defined as closely as possible to the direct use of the marine good or service. This is important, as it can be argued, for example in the case of telecommunications, that the sea does not provide the telecommunications cable, nor the data that flow through it, merely the ability to transfer these data across the sea, compared to alternative means. Such issues are explored in more detail in the relevant activity assessments.

Ancillary activities

Ancillary activities are identified through their relationship to the primary activities and may include upstream manufacturing, construction and management. However, their economic values may be much more difficult to assess as there may be overlap with other principal activities and data may not exist in a form that is specific to a principal activity. These issues are discussed in detail in Section 3. However, for the overall UK assessment, summaries of ancillary values (and secondary values – see next sub-section) have been avoided due to inconsistencies in how these have been assessed.

Secondary activities

Secondary activities can be more difficult to define as the links from the principal product/service become increasing less distinguishable moving further down the production chain. In addition, the further downstream in the activity chain one proceeds the more interwoven secondary activities become with those from other principal activities, resulting in potential double-counting. As a result, comparisons of secondary values among activities have been avoided.

Different data that can measure economic ‘value’ are available for the different sectors assessed in this report. Economic value is fully described as ‘Total Economic Value’ which has three main components: use values, option values and non-use values. This report is primarily concerned with use values, as reflected in market activity. Market prices are used to measure this activity, but this still gives rise to a number of different measures of economic activity that have been used in this report as follows:

- Turnover is the total market value of goods or services sold – it measures output.
- Investment is the spending on assets that will produce goods or services in the future (e.g. investment in research and development secures the benefits from such information in the future). It is a minimum measure of expected future benefits – because if this benefit was less than the investment, it would not be a rational choice.
- Expenditure is the total market value of goods and services purchased. It is a proxy for turnover, because if it was greater than turnover, an activity would not be economically viable.
- Gross Value Added (GVA) is the added value of outputs of goods and services from an activity compared to inputs[1]. GVA figures are available for some activities, or can be estimated as a proportion of Turnover based

1 For example, the GVA of fish fingers is their sale value, minus the value of the raw fish, labour, machinery etc needed as inputs to their manufacture. It therefore reflects the extra value created from the combination of these inputs into the final product.

on sector-specific, or generic, ratios. Being net of the value of inputs means that GVA can be summed from different sectors without risk of double counting and is used to represent the contribution to Gross Domestic Product (GDP).

Gross value-added (GVA) economic figures are used whenever possible as this reduces the risk of double-counting marine-related revenue as well as clearly laying out the principal, ancillary and secondary revenue streams. Where information on value added is unavailable, substitute criteria such as turnover, investments and expenditure have been used (see Box A1).

All estimates will be gross estimates since the value of the capital assets actually consumed (the 'capital consumption') during the productive process can not be known and so will not be subtracted. Furthermore, all values will be based on 'basic prices' as defined in Box A2.

Information for describing economic activity is often published by the relevant industry body or government statistics. Many economic sectors were also recently reviewed by Pugh (2008) and more locally for Scotland (Baxter et al., 2008).

1.1.3 Regional assessments

The aim of the PSEG Feeder Report is to provide regional assessments of productivity according to the eight CP2 Regions. Information on the spatial distribution of most activities is relatively well known. However, the economic information associated with these activities is not always readily available and for some activities it has been necessary to develop and agree appropriate assumptions concerning how value might be assigned in a spatial context and linked to aspects of production. Particular methodologies and assumptions relating to each principal activity are detailed further in the relevant activity assessments.

Box A1:
Assessing economic value: the input-output approach (ONS, 2007b).

Value added is the basic concept for the determination of the classification of a unit according to economic activities. The gross value added (GVA) is defined as the difference between output and intermediate consumption. Value added is an additive measure of the contribution of each economic unit to the gross domestic product (GDP).

Sometimes it is not possible to obtain the information on value added associated with the different activities carried out, and the determination of the activity classification must be achieved using substitute criteria:

Substitutes based on output:

- Gross output of the unit that is attributable to the goods or services associated with each activity
- Value of sales or turnover of those groups of products falling within each activity

Substitutes based on input:

- Wages and salaries attributable to the different activities (or income of self-employed)
- Number of staff involved in the different economic activities of the unit
- Time worked by staff attributable to the different activities of the unit.

Box A2:
Definition of basic prices

Basic prices are the preferred method of valuing output in national accounts. They reflect the amount received by the producer for a unit of goods or services, minus any taxes payable, and plus any subsidy receivable on that unit as a consequence of production or sale (i.e. the cost of production including subsidies). As a result the only taxes included in the price will be taxes on the output process – for example business rates and vehicle excise duty – which are not specifically levied on the production of a unit of output. Basic prices exclude any transport charges invoiced separately by the producer. When a valuation at basic prices is not feasible then producers' prices may be used.

1.1.4 Socio-economic pressures

This section of the activity assessment explores both the positive and negative socio-economic pressures from a principal activity. Positive pressures included employment, tax revenues, research, exports and balance of trade, and cultural benefits. These are often related to secondary activities and it can be difficult to define the end point in the secondary 'production' chain. Some principal activities have well-organised industry bodies that produce thorough and regular industry reports on secondary activities and values while others do not. There is also a risk of double-counting with other principal activities (e.g. the secondary activities of fish processing, distribution and marketing relate to both aquaculture and sea fisheries). As such it is recommended that direct comparisons of secondary values are not made across the various principal activities and such summaries have been avoided in the presentation of the report. Any economic data quoted here are used as a proxy for social impacts.

Negative pressures generally relate to impacts on other socio-economic activities. There is generally legislation in place to avoid and/or minimise such impacts (particularly in relation to impacts on maritime navigation and safety) and further solutions may arise through marine planning approaches. Such matters are described where relevant.

1.1.5 Marine environmental pressures

1.1.5.1 Development of a framework

Principal activities and some ancillary and secondary activities may place pressures on ecosystem elements (structure and function) of the marine environment. The DPSIR (Driving forces – Pressures – State – Impacts - Responses) Framework provides a process within which the interactions between society and the environment can be described. *Driving forces* are identified here as the economic activities identified in Section 1 (Introduction: Table 1.2). These forces and their related activities place a *pressure* on the *state* of the environment (i.e. marine ecosystem structures and functions) potentially resulting in *impacts* (positive or negative). If no appropriate *response* results (i.e. regulatory action to adequately manage or control the activity) the impacts on the environment may eventually feedback again to the *driving forces* (including other socio-economic activities).

The approach used here maps the pathway from driving forces to pressures and impacts on ecosystem elements.

1.1.5.2 Identifying and describing pressures

For each driving force (i.e. principal activity) the range of pressures relevant was assessed. Pressures were identified for the entire lifecycle of an activity, for example, survey and exploration, construction, operation and decommissioning. A matrix of pressures was developed by the Healthy and Biologically Diverse Seas Evidence Group and this was used as a common point of reference.

Pressures may result in an environmental change on the marine environment. In order to describe this environmental change a number of components were considered including the following (based on an example from the change in noise levels in the marine environment due to seismic surveys):

- The spatial extent of the change – e.g. the area over which particular species will respond or be injured by noise emitted during seismic surveys
- The intensity of the change – e.g. the sound intensity emitted from seismic surveys
- The frequency of the change – e.g. the number of seismic surveys carried out per year
- The duration of the change – e.g. the length of seismic surveys for oil and gas exploration.

These components were described in as much detail as was possible in a matrix format based on the best available evidence. It should be noted that there are interactions among the components and also with the sensitivity characteristics of the marine environment. In the example above, the spatial extent of the change in noise levels will depend upon sensitivity threshold criteria that are set to represent the levels at which noise sensitive species will respond to the change. Responses may be behavioural (e.g. avoidance) or biophysical (e.g. damage to hearing sensors and/or mortality). The spatial extent of this pressure will also be dependent on the intensity of the noise source and the transmission loss over distance. This example highlights the large range of factors that may influence the environmental changes associated with pressures and the large amount of information required to describe the changes adequately.

Information on environmental pressures is often held in scientific review literature. It is also partly being assessed by the other Evidence Groups (the Clean and Safe Seas Evidence Group and the Healthy and Biologically Diverse Seas Evidence Group) in describing the status of the marine environment for *Charting Progress 2*. There is also parallel work ongoing for the OSPAR *Quality Status Report 2010*, particularly in relation to climate change impacts. A detailed analysis of pressures is beyond the scope of this report although references are given to direct the reader, either to other parts of the evidence reports or to external literature, for more detail.

1.1.5.3 Identifying interactions with state

Components of the state of the marine environment with which pressures might interact have been identified with reference to a common list of ecosystem structures and functions (see Table A2). This is broader than the list of goods and services detailed in Table A1 as focusing entirely on a goods and services approach may overlook important ecosystem functions that are not directly used by humans, but that may be important for the overall resilience of the ecosystem (Hiscock et al., 2006). JNCC (2007) provided a detailed discussion of this topic. Structures and functions may involve biological (biotic) and physical (abiotic) attributes. Furthermore, there is a close link between structure and function (see Table A2).

Table A2 List of marine ecosystem structures and functions. Source: Adapted from JNCC (2007).

Ecosystem structure	*Ecosystem function*
Biotic • Habitat types • Habitat preferences • Substrate types • General biology • Range and distribution • Reproduction and longevity • Species diversity • Species richness • Biomass • Amounts of chlorophyll • Functional groups • Community structure	• Biotic habitat provision • Diversity • Growth • Primary production • Plankton • Benthic organisms • Predation • Decomposition • Food supply • Productivity • Spawning conditions • Habitat provision • Adult in-migration and out-migration • Biotic modification of physical processes
Abiotic • Temperature • Grain size (sediment type) • Salinity • Oxygen level • Seabed type • Light regime	• Energy cycling/transfer • Nutrient cycling/ regeneration • Abiotic habitat provision • Tidal flow • Flushing rate/freshwater input • Heat flux • Residence time of a water mass in an estuary • Erosion-deposition cycles (of sediment) • Gas assimilation and climate regulation • Waste assimilation/ degradation

1.1.5.4 Assessing impacts

The main environmental pressures on ecosystem services that each activity generates were identified. The classification of ecosystem services is complex, and there is no comprehensive and established list and descriptions of marine ecosystem services. The ecosystem services relevant to an activity were identified from the list shown in Table A1.

This list was based on classifications of marine ecosystem structure and function (Table A2), but were developed in line with the analytical structure described by Defra (2007a).

Table A1 shows the direct and indirect services identified by Laffoley et al. (2004). However, some these services can be both final services (i.e. delivering goods or services with utility for people), and supporting services (i.e. being an input to other final services). Therefore a number of other final services, which are particularly relevant to the marine activities identified in this report, are also included in Table A1. There is clearly some overlap between these services and the ecosystem functions that support them, but this reflects the fact that different marine activities use different aspects of ecosystem services in different ways. For example, the inclusion of both 'water purification' and 'provision of water quality' may seem duplicitous, but they reflect reliance on different services stemming from the same ecosystem functions. Purification can reflect a reliance of a waste-producing activity to clean up that waste, whereas provision can reflect the need to operate in a high-quality environment.

The significance of the activity's main impacts on ecosystem services were assessed, taking into account the extent of the activity. The qualitative scale used for judging the significance of impact was as follows:

Nil:	Not present/none (and therefore not recorded).
Minimal:	Present at a very low level, unlikely to be large enough to make a noticeable impact.
Low:	Present/detectable, may have a small noticeable impact on ecosystem service, but unlikely to cause a meaningful change.
Moderate:	Present/detectable, noticeable incremental change.
High:	Present/detectable, order of magnitude impact.

Level of Confidence uses a similar scale to measure the certainty in the assessment of the scale of benefits based on the availability and robustness of data and the confidence in the judgement exercised.

The purpose of this assessment is to enable further analysis of the impacts of sectors to be identified. For example, if sector A is placing significant pressure on an ecosystem service that is relied upon by sector B, then this poses a risk to sector B. Combining this analysis with relevant scientific information may help identify more productive and sustainable marine management options.

The ecosystems services information can also help with analysis of climate change impacts. Climate change is expected to alter ecosystem services. The information on the services that sectors rely on can help predict how sectors might be impacted by climate change. Information on the services that sectors impact on can be combined with climate change predictions to highlight the extent of different pressures on ecosystem services.

The analysis of ecosystem services is not intended to be comprehensive or in-depth. It acts as a starting point to consider the productivity of the marine environment from an ecosystem services perspective, and also to link to scientific information about ecosystem services to enable analysis of sustainability.

The ecosystem services identified have similarities and overlaps, for example, biodiversity provision and biological production are both identified. While they do overlap, they also have independent components and therefore are identified separately because the main objective is to describe the main impacts. If these categories were developed into a basis for economic valuation of ecosystem services, they would require careful scrutiny to avoid double-counting.

1.1.5.5 Assessing interactions

It is beyond the scope of this project to make the link between environmental impacts back to the driving forces (i.e. socio-economic activities). This requires discussions on the relationship between ecosystem structure and function and the goods and services that they feed into. Therefore, it is considered to be an issue for scientific analysis, and beyond the scope of this work, to link the conclusions from these two aspects of the analysis. However, this approach provides an improvement in the evidence base and an important framework for helping to inform the assessments of the other evidence groups and set them within context.

1.1.5.6 Summary approach

In summary, for each principal activity, the following will be identified, assessed and/or described in a matrix format:

1. The pressures from the activity
2. Ecosystem functions (see Table A2) with which the pressures interact
3. Potential impacts from the pressures on ecosystem functions

1.1.6 Climate change impacts

The assessment of climate change implications for each principal activity reviews both the pressures of socio-economic activities that contribute to climate change and the effects of climate change on socio-economic activities. The section also reviews the effectiveness of mitigation and adaptation measures in managing impacts.

1.1.6.1 Impacts of climate change on the principal activities

Where possible, the effects of climate change on marine human activities have been quantified in terms of costs and expected timelines of the impact. Examples are given of potential and existing adaptation measures.

There is currently a vast amount of information available relating to the potential effects of climate change on the marine environment. The principal sources of data within the UK are as follows:

- Marine Climate Change Impacts Partnership (MCCIP). The aim of the group is to collate and present the most up to date sources of climate change study across a wide range of sectors. This work is useful in providing an overview of the current state of knowledge.
- United Kingdom Climate Impacts Programme (UKCIP). The UKCIP programme presents scenarios of future climate change for the UK based on current understanding of climate change. Currently the UKCIP09 report is available. The 2009 report featured a large amount of marine related climate change data as well as regional based output whereby climate change data was extracted from above and below the surface of sea areas around the UK.

Data sources such as the MCCIP were useful in defining a level of confidence in the impact assessment as they provide an indication of the present level of understanding within a particular sector of climate change science.

A more global source of data regarding the impacts of climate change is the Intergovernmental Panel on Climate Change (IPCC). The IPCC reviews and collates climate change data from around the world. The most recent review – the Fourth Assessment Report (AR4) – was published in 2008. As well as periodic reviews, the IPCC also publishes various technical reports looking at specific climate change issues.

In addition, much information is published by industry bodies according to principal activities.

1.1.6.2 Impacts of the principal activity on climate change

These sections summarise the pressures that a given principal activity has in contributing to climate change. In most cases, because of the far-reaching and secondary impacts that a given activity could have on climate change, it has been necessary to restrict the analysis to the immediate or direct effects.

Examples are also given of potential and existing mitigation measures. It is understood that mitigation within the context of this work refers to human responses to reduce the sources or enhance the sinks of greenhouse gases. Reduction of carbon emissions is required as part of the Climate Change Act 2008 which put into statute the UK's targets to reduce carbon dioxide emissions through domestic and international action by at least 80% by 2050 and at least 34% by 2020. Broadly speaking, mitigation approaches fall under the following categories: carbon sequestration; use of renewable energy; and improved efficiencies.

The *Assessment of Mitigation of Climate Change* being progressed for the OSPAR Quality Status Report 2010 (OSPAR, 2010) also reviews mitigation measures, their impacts, consequences and effectiveness.

1.1.6.3 Summary

A summary table is provided at the end of each section. The columns in the table have been filled as follows:

Climate issue	This describes the climatic issue that (1) causes an impact on an activity or (2) is caused by the activity
Impact	This summarises the identified impact on (1) the human activity or (2) climate change
Impact confidence	This summarises the level of confidence that can be placed in the identification of the impact. A low level of confidence signifies that the impact has been inferred from broad-scale climate change data with limited or no supporting references. A medium level indicates that the impact has been identified in the literature but not quantified. A high level indicates that the impact has been quantified either through detailed modelling studies or analysis of specific data.
Potential significance	This assigned level is qualitative due to the lack of data in many of the sectors and is based on a combination of the likelihood of the impact, the severity of the impact and the ease with which the impact can be adapted. It is important to be aware that there is a large amount of uncertainty involved in assigning this level due to the inherent uncertainties in climate change predictions and the often unquantifiable costs of the impacts and adaptation.

1.1.7 Sustainability and indicators

While the productivity of the sea can be defined following this methodology, it is more difficult to make an objective assessment of the sustainability of activities in the marine area or the contribution that human activities in the marine area make to sustainable development. In part, this reflects differing stakeholder interpretations of what constitutes sustainable development, but this is compounded by the lack of a comprehensive and agreed system of objectives and targets for each sector. *Securing the Future* was published by the UK Government in 2005 outlining the pathway to delivering sustainable development (HM Government, 2005). The Scottish Government also set out a new marine and coastal strategy for sustainability in *Seas the Opportunity* (Scottish Government, 2005). A number of targets and objectives have also been outlined in relation to legislation such as 'Good Ecological Status' (GES) for the EU Water Framework Directive and 'Good Environmental Status' (GES) for the Marine Strategy Framework Directive.

With significant advances likely in the transposition of sustainable development principles into industry strategies and development of targets and objectives for the Marine Strategy Framework Directive, it was deemed premature (and beyond the scope of this report) to review and rationalise the range of sustainable development indicators. A traffic light system to represent concepts such as sustainability was also parked until further developments allow a consistent and robust approach at appropriate spatial scales.

1.2 Spatial data

Given the strong focus of *Charting Progress 2* on spatial assessments the report was dependent on the use of a Geographic Information System (GIS). The methodology employed in managing, analysing and presenting data is outlined in the following sections.

1.2.1 Data preparation

1.2.1.1 Sourcing data

GIS Data were sourced from a wide range of data suppliers including Government departments and agencies, academic institutions, and private companies. A summary is provided in Table A3. An initial review was

Table A3 Summary of the main spatial data sources.

Data source	*Coverage*
Department of Energy and Climate Change (DECC)	UK
British Marine Federation (BMF)	UK
Carbon Capture and Storage Association (CCSA)	UK
Centre for Environment, Fisheries and Aquaculture Science (Cefas)	England, Wales
Digital Energy Atlas and Library (UK DEAL)	UK
Environment Agency (EA)	England, Wales
Fisheries Research Services (FRS)	Scotland
Health and Safety Executive (HSE)	UK
Kingfisher	UK
National Grid	UK
Northern Ireland Environment Agency (NIEA)	Northern Ireland
Oil and Gas UK	UK
Royal Yachting Association (RYA)	UK
Scottish Environment Protection Agency (SEPA)	Scotland
SeaZone	UK
Shipbuilders and Shiprepairers Association (SSA)	UK
The Crown Estate (TCE)	UK
Trinity House	UK

undertaken on data availability, coverage, accessibility, cost and quality. It was important not to compromise too much on quality, as this was essential in order to compare datasets, assess trends and produce meaningful outputs.

The requirements for data capture and preparation were different for each source. The chosen GIS Software for data capture and analysis was ESRI (Environmental Systems Research Institute) ArcMap V9.3 so all data were sourced wherever possible in ESRI Shapefile (.shp) format. In addition, the chosen geographical projection for data analysis was WGS (World Geodetic System) 1984 UTM (Universal Transverse Mercator) Zone 31N. This was chosen because data coverage extended out to the UK continental shelf (UKCS) boundary and area/distance calculations were required so that it would provide the most accurate and realistic results.

1.2.1.2 Capturing data

It was necessary for a range of marine activities such as Carbon Capture and Storage to go through several steps prior to any further GIS analysis:

1. Capture the required information in a Microsoft (MS) Excel spreadsheet
2. Geo-reference this information to provide a geographical location – input X and Y coordinates from an online source, such as www.streetmap.co.uk
3. Import this table into ArcMap V9.3
4. Create a GIS Shapefile from this imported table.

Furthermore, the spatial location of some activities such as artificial reefs and important dive sites required digitising off screen dumps from internet sites.

1.2.1.3 Preparation of marine activity data

Where data were not already sourced in the required projection (WGS 1984 UTM Zone 31N) it was necessary to define this projection using ArcTools. If sourced data were in the OSGB (Ordinance Survey Great Britain) 1936 / British National Grid projection then it was necessary to 'transform' the data in ArcTools using the 'OSGB_1936_To_WGS_1984_Petroleum' transformation. Table A4 summarises the data corrections required prior to GIS analysis.

Table A4 Data corrections required for Marine Activity Data prior to GIS analysis.

Data Source	*Correction required*
SeaZone	Transformation from WGS 1984 to WGS 1984 UTM31N
The Crown Estate	Transformation from BNG (British National Grid) to WGS 1984 UTM31N

Finally, all GIS datasets had to go through a few more steps in order to prepare the data for subsequent analysis. These steps together with the reason why they were necessary are summarised in Table A5.

1.2.1.4 Preparation of base data

It was necessary to source the GIS data that would be used in the analysis in the same format and projection to the marine activity data layers.

- Data format – ESRI Shapefile (.shp)
- Data Projection – WGS 1984 UTM Zone 31N

A summary of the output categories required for breakdown of the PSEG Feeder report results including data preparation requirements is given in Table A6.

To increase time and resource efficiency for the data analysis it was decided to create a '*Union*' dataset (ArcTools) of all the GIS data categories as shown in Table A3. This would ensure that any derived data from this Union dataset as part of the GIS analysis would have a flag in it highlighting the source and would increase the ease of creating statistical outputs.

1.2.2 Data analysis

The method used to assign data to a CP2 Region varied depending on whether the feature was a point, polyline or polygon. For example, oil and

Table A5 Final preparation steps for Marine Activity Data.

Preparation step	*Reason for step*
Remove data of poor quality	To ensure only good quality data would be used in the analysis
Merge datasets of the same marine activity from different sources (e.g. England, Scotland, Wales)	To provide one UK dataset for subsequent analysis
Dissolve merged datasets by a common field name where applicable	To avoid duplication of areas in final results
'Explode' data to ensure that any multi-feature data are isolated into individual data features	To ensure duplication of features during the analysis steps
Remove unwanted attribute information from the datasets	To speed up GIS analysis
Clip datasets to the UK continental shelf (UKCS) boundary	Only data within the UKCS boundary will be used for reporting

Table A6 Categories of GIS Analysis breakdown of results.

Category	*Number of sub-divisions*	*Data preparation*
CP2 Regions	8	Union of CP2 Regions with 0.5 km coastal layer
Country boundaries	4	Create 12 nm buffer of UK coast, unite with 0.5 km coastal layer, cut to country boundaries to give territorial waters
Inshore (<12 nm), Coastal (-500 m) Offshore (>12 nm)	3	Create 12 nm buffer of UK coastline, unite with UKCS and 0.5 km coastal layer.

gas platforms are presented as points and could be allocated within the GIS framework to each Region to provide the total number of platforms for each Region. Telecommunication cables are represented as polylines in the GIS and the total length of line within each Region could be calculated. Licensed areas for marine aggregate dredging are represented as polygons, enclosing a defined area. These areas could be allocated to each Region providing a total licensed area in each Region. The specific calculations are outlined in each activity assessment. Onshore activities related to the marine environment, such as the location of universities engaged in marine-related research, were allocated to the nearest Region to provide the total number of universities in each Region, for example, universities in London were allocated to CP2 Region 2.

1.2.3 Limitations

It is acknowledged that data used in this analysis have their limitations. These limitations are summarised in Table A7 together with the actions used to minimise these effects.

Table A7 Data limitations and solutions.

Limitation	*Action to minimise effects*
Seazone. Duplication of data - Individual Feature Codes show overlap where data have originated from different sources	Merge and then dissolve duplicate data (e.g. by common field name)
Fish farms. Data for the same marine activity have been sourced from different data suppliers	
Data age. Data used in the analysis are of varying age	The most up to date data have been sourced wherever possible
Data quality. Data have been sourced though known and unfamiliar sources and so will be of inconsistent quality	Where possible, data have been sourced through known and familiar sources with known data quality standards
Data aggregation. Data for the same marine activity have been derived by merging data from sub-categories	Attribute detail lost during merging process

Abbreviations

2SL	Second Sea Lord – see Military Defence
ABP	Associated British Ports
AC	alternating current
ACOPS	Advisory Committee on Protection of the Sea
ALSF	Aggregate Levy Sustainability Fund
AMP	Asset Management Planning
ASFB	Association of Salmon Fishery Boards
ASSG	Association of Scottish Shellfish Growers
BAP	Biodiversity Action Plan
BAS	British Antarctic Survey
BBL	Balgzand Bacton Line – see Pipelines
BBSRC	Biotechnology and Biological Sciences Research Council
BCM	billion cubic metres
BERR	Department for Business Enterprise and Regulatory Reform
BGS	British Geological Survey
BMAPA	British Marine Aggregate Producers Association
BMF	British Marine Federation
BNG	British National Grid
BOD	Biochemical Oxygen Demand
BODC	British Oceanographic Data Centre
BOE	Barrels of Oil Equivalent
bpa	Precautionary minimum biomass
BPA	British Ports Association
BRE	Better Regulation Executive
BRNC	Britannia Royal Naval College
BWEA	British Wind Energy Association
CAR	Controlled Activities Regulations – in relation to Marine Aquaculture
CAT	Carbon Abatement Technology – see Storage section
CATS	Central Area Transmission System – in relation to Oil and Gas
CCS	Carbon Capture and Storage
CCSA	Carbon Capture and Storage Association
CCW	Countryside Council for Wales
Cefas	Centre for Environment, Fisheries and Aquatic Science
CfD	Charging for Discharges
CFP	Common Fisheries Policy (EU)
CIFIG	Cable Industry / Fishing Industry (liaison) Group
C-in-C	Commander-in-Chief – see Military Defence
CMACS	Centre for Marine and Coastal Studies
CNCC	Council for Nature Conservation and the Countryside (Northern Ireland)
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CoSA	Conservation of Seals Act
CP2	Charting Progress 2
CPA	Coast Protection Act
CPR	Continuous Plankton Recorder
CSEM	Controlled Source Electromagnetic Imaging

CSIP	Cetacean Strandings Investigation Programme
CWEIY	Capital Works Expensed in Year
DARD	Department of Agriculture and Rural Development (Northern Ireland)
DASA	Defense Analytical Services and Advice
DC	direct current
DCF	Data Collection Framework (EU)
DCLG	Department for Communities and Local Government
DCMS	Department for Culture Media and Sport
DCR	Data Collection Regulation (EU)
DEAL	Digital Energy Atlas and Library
DECC	Department for Energy and Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
DEL	Departmental Expenditure Limits
DETI	Department of Enterprise, Trade and Investment
DfT	Department for Transport
DIUS	Department for Innovation, Universities and Skills
DOENI	Department of Environment Northern Ireland
DPSIR	Driving forces – Pressures – State – Impacts – Responses framework of assessment
DTE	Defence Training Estate
DTI	Department for Trade and Industry
E&P	Exploration and Production
EA	Environment Agency
EC	European Commission
ECA	Eastern Channel Association
ECE	Equilibrium Concentration Enhancement
EEZ	Exclusive Economic Zone
EHS	Environment and Heritage Service
EIA	Environmental Impact Assessment
EMEC	European Marine Energy Centre
EMF	Electromagnetic fields
EMS	European Marine Site
EMS	Electronic Monitoring System
ENA	Energy Networks Association
EOR	Enhanced Oil Recovery
EPSRC	Engineering and Physical Sciences Council
EQS	Environmental Quality Standard
ERF	Environmentally Responsible Fishing
ES	Environmental Statement
ESI	Environmental Shipping Index
ESRC	Economic and Social Research Council
ESRI	Environmental Systems Research Institute
ETS	Emissions Trading Scheme
EU	European Union
EWEA	European Wind Energy Association
F	Fishing mortality
FEPA	Food and Environment Protection Act
FIAC	Flooding Issues Advisory Committee
FLOWW	Fishing Liaison with Offshore Wind and Wet Renewables
FOST	Flag Officer Sea Training
Fpa	Precautionary maximum fishing mortality
FPAL	First Point Assessment
FSPO	Floating Storage Production and Offloading

FRS	Fisheries Research Services
FSAP	Federation of Scottish Aquaculture Producers
FSC	Field Studies Council
FTE	Full-Time Equivalent (in relation to employment)
GB	Great Britain
GDP	Gross Domestic Product
GES	Good Environmental Status (under the MSFD) or Good Ecological Status (under the WFD)
GHG	Greenhouse Gases
GIS	Geographic Information System
GLA	General Lighthouse Authorities
GNP	Gross National Product
Gt	Giga tonnes
GT	gross tonnage
GVA	Gross Value Added
HAB	Harmful Algal Bloom
HBDSEG	Healthy and Biologically Diverse Seas Group
HED	Horizontal Electric Dipole
HEI	Higher Education Institution
HMNB	Her Majesty's Naval Bases
HPHT	High Pressure, High Temperature (in relation to field developments)
HSE	Health and Safety Executive
HVDC	High Voltage Direct Current
IACMST	Inter-agency Committee on Marine Science and Technology
IAMI	International Association of Maritime Institutions
ICES	International Council for the Exploration of the Sea
ICIP	International Cable Protection Committee
ICZM	Integrated Coastal Zone Management
IDB	Internal Drainage Board
IECS	Institute of Estuarine and Coastal Science
IFCAs	Inshore Fisheries and Conservation Authorities
IMO	International Maritime Organisation
IPC	Infrastructure Planning Commission
IPCC	Intergovernmental Panel on Climate Change
ISA	Infectious Salmonid Anaemia
IFSL	International Financial Services London
IT	Information Technology
IUCN	International Union for Conservation of Nature
IUU	Illegal, Unreported and Unregulated fishing
JMC	Joint Maritime Courses
JNCC	Joint Nature Conservation Committee
LA	Local Authority
LNG	Liquefied Natural Gas
LOA	overall length
LPA	Local Planning authority
LSA	Low Specific Activity
MARPOL	International Convention for the Prevention of Pollution from Ships
MaRS	Marine Resource System
MBA	Marine Biological Association
MCA	Maritime and Coastguard Agency
MCCIP	Marine Climate Change Impacts Partnership
MCT	Marine Current Turbines Ltd
MCZ	Marine Conservation Zone
MDP	Ministry of Defence Police
MEDIN	Marine Environmental Data Information Network

MEHRAS	Marine Environmental High Risk Areas
MEPC	Marine Environment Protection Committee (part of the IMO)
MEPF	Marine Environment Protection Fund
MESPG	Marine Energy Spatial Planning Group
MFA	Marine and Fisheries Agency
MHWS	Mean High Water Springs
MMO	Marine Mammal Observer
MOD	Ministry of Defense
MPS	Marine Policy Statement
MRCC	Maritime Rescue Co-ordination Centre
MREDS	Marine Renewable Energy Development in Scotland
MS	Microsoft
MSC	Marine Stewardship Council
MSCC	Marine Science Co-ordination Committee
MSFD	Marine Strategy Framework Directive
MSP	Marine Spatial Planning
MSPP	Marine Spatial Planning Pilot
MSY	Maximum Sustainable Yield
mt	million tonnes
NaCl	Sodium chloride
NASCO	The North Atlantic Salmon Conservation Organization
NATO	North Atlantic Treaty Organization
NE	Natural England
NEAFC	North East Atlantic Fisheries Commission
NERC	Natural Environment Research Council
NFCDD	National Flood and Coastal Defence Database
NFSA	National Federation of Sea Anglers
NHC	Commander-in-Chief's Naval Home Command
NIAUR	Northern Ireland Authority for Utility Regulation
NIEA	Northern Ireland Environment Agency
NGO	Non-governmental organisation
NOAA	The National Oceanic and Atmospheric Adminsitration
NOCS	The National Oceanography Centre
NORM	Naturally occurring radio-active material
NPPG	National Planning Policy Guidance
OBM	Oil Based Mud
OCR	Offshore Chemicals Regulations
ODE	Offshore Design Engineering
ODPM	Office of the Deputy Prime Minister
OECD	Organisation for Economic Co-operation and Development
Ofcom	Office of Communications
Ofgem	Office of the Gas and Electricity Markets
OFMDFM	Office of First Minister and Deputy First Minister
OFWAT	The Office of Water Services
ONS	Office for National Statistics
OPEC	Organisation of the Petroleum Exporting Countries
OPEP	Oil Pollution Emergency Plan
OPPC	Oil Pollution Prevention and Control
OSCP	Oil Spill Contingency Plan
OSGB	Ordinance Survey Great Britain
OSPAR	OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic

OST	Operational Sea Training
OWF	Offshore Wind Farm
PAH	Polyaromatic hydrocarbon
PAM	Passive Acoustic Monitoring
PBR	Potential Biological Removal
PCB	Polychlorinated byphenol
PEXA	Designated Military Practice and Exercise Areas
PML	Plymouth Marine Laboratory
POL	The Proudman Oceanographic Laboratory
PPG	Planning Policy Guidance
PPS	Planning Policy Statement
PRT	Petroleum Revenue Tax
PSA	Public Service Agreement
PSEG	Productive Seas Evidence Group
PWA	Pipeline Works Authorisation
PWC	Pricewaterhouse Coopers LLC
QSR	Quality Status Report
R&D	Research and Development
RAC	Regional Advisory Council
RAG	Research Advisory Group
RBMP	River Basin Management Plan
REA	Regional Environmental Assessment – in relation to marine aggregates
REA	Renewable Energy Association
REC	Regional Environmental Characterisation
RMNC	Review of Marine Nature Conservation
RNLI	Royal National Lifeboats Institution
RO	Renewables Obligation
ROI	Republic of Ireland
Ro-Ro	Roll on, Roll off
RSPB	Royal Society for the Protection of Birds
RTE	Réseau de Transport d'Electricité
RYA	Royal Yachting Association
SAC	Special Area of Conservation
SAHFOS	Sir Alistair Hardy Foundation for Ocean Science
SAMS	Scottish Association of Marine Science
SAR	Search and Rescue
SARF	Scottish Aquaculture Research Forum
SCF	Scottish Coastal Forum
SD	Sustainable Development
SDA	Sea Danger Area
SDC	Sustainable Development Commission
SEA	Strategic Environmental Assessment
SeaFAR	Sea Fisheries Advisory and Reference group
SEA-ME-WE	South East Asia – Middle East – Western Europe line
SECA	Sulphur Emission Control Area
SEERAD	Scottish Executive Environment and Rural Affairs Department
SEMPTA	Sector Skills Council for Science, Engineering and Manufacturing Technologies
SEMS	Solent European Marine Site
SEPA	Scottish Environment Protection Agency
SFC	Sea Fisheries Committee
SFDAD	Scottish Flood Defence Asset Database
SFPA	Scottish Fisheries Protection Agency
SG	Scottish Government
SGMD	Scottish Government Marine Directorate – in past tense only, now Marine Scotland
SIC	Standard Industrial Classification

SMD	Soil Machine Dynamics
SMP	Shoreline Management Plans
SNH	Scottish Natural Heritage
SNIFFER	Scotland & Northern Ireland Forum for Environmental Research
SNIP	Scotland–Northern Ireland (Gas) Pipeline
SOAEFD	Scottish Office Agriculture, Environment and Fisheries Department
SOx	Sulphur Oxides
SPA	Special Protection Areas
SPP	Scottish Planning Policy
SRTT	Scottish Renewables' Tidal Turbine
SSA	Ship builders and Ship Repairers Association
SSB	Spawning Stock Biomass
SSBN	Ballistic Missile Submarines
SSMEI	Sustainable Scotland Marine Environment Initiative
SSPO	Scottish Salmon Producers' Organisation
SSSI	Site of Special Scientific Interest
SSTF	Sustainable Seas Task Force
STA 1885	Submarine Telegraph Act 1885
STECF	Scientific, Technical and Economic Committee for Fisheries
SXA	Royal Navy's Scottish Exercise Areas
t	tonnes
TA 1984	Telecommunications Act 1984
TAC	Total Allowable Catch
TAN	Technical Advice Note
TBT	Tri-butyl tin
TCE	The Crown Estate
Te	differential emission measure
TEN-E	Trans European Networks – Energy
TLB	Top Level Budget
TSO	Transmission System Operator
UCAS	Universities & Colleges Admissions Service
UKCIP	United Kingdom Climate Impacts Programme
UKCPC	United Kingdom Cable Protection Committee
UKCS	UK Continental Shelf
UKERC	UK Energy Research Centre
UKHO	UK Hydrographic Office
UKMMAS	UK Marine Monitoring and Assessment Strategy
UKOOA	UK Offshore Operators Association – past tense only, now 'Oil and Gas UK'
UKPCZ	United Kingdom Pollution Control Zone
UKPIA	UK Petroleum Industry Association
UK-TI	UK Trade & Investment
UNCLOS	United Nations Convention on the Law of the Sea
UTM	Universal Transverse Mercator
UWTC	underwater television camera
VAT	Value Added Tax
VMD	Veterinary Medicines Directorate
VMS	Vessel Monitoring System
WAG	Welsh Assembly Government
WBM	Water-Based drilling Mud
WEWS	Water Environment and Water Services
WFD	Water Framework Directive
WGS	World Geodetic System
WLMP	Water Level Management Plan
VMS	Vessel Monitoring System
WSSD	World Summit on Sustainable Development

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4. Non-native species – Tracy McCollin (FRS)
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References

AB Associates Ltd. 2008. Rural Development Strategy for Shetland.

ABP Research and Consultancy, 2001. ABP Grimsby & Immingham, Immingham Outer Harbour Environmental Statement. ABP Research & Consultancy Ltd, Research Report No. R.903.

ABPmer, 2006a. The Potential Nature Conservation Impacts of Wave and Tidal Energy Extraction by Marine Renewable Developments. ABP Marine Environmental Research Ltd.

ABPmer, 2006b. Uskmouth Power Station Gas Pipeline – Information for Appropriate Assessment. ABP Marine Environmental Research Ltd.

ABPmer, 2007a. Cost Impacts of Marine Biodiversity Policies on Business – The Marine Bill. ABP Marine Environmental Research Ltd.

ABPmer, 2007b. Pipeline Route Corridor Investigation Study: Offshore Pipeline Alternative – Paull to Hatton. ABP Marine Environmental Research Ltd. Report No. R.1314.

ABPmer, 2007c. Climate Change and ABP: Risks and Opportunities. Report No. R1387, December 2007. ABP Marine Environmental Research Ltd.

ABPmer, 2008. Achieving Natural Heritage Objectives in Scotland through a System of Marine Spatial Planning. Report to Scottish Natural Heritage.

ABPmer, 2009. Wet Renewable Energy and Marine Nature Conservation: Developing Strategies for Management. A Report for the Npower Juice Fund. ABP Marine Environmental Research Ltd.

Access Broad Bench Association, 2009. Available at: www.broadbench.co.uk/?q=node/19.

ACOPS, 2007. Annual Survey of Reported Discharges Attributed to Vessels and Offshore Oil & Gas Installations Operating in the United Kingdom Pollution Control Zone 2007. A survey conducted on behalf of the Maritime and Coastguard Agency. Advisory Committee on Protection of the Sea.

ACOPS, 2008. Annual Survey of Reported Discharges Attributed to Vessels and Offshore Operating in the United Kingdom Pollution Control Zone. Report on behalf of the Maritime and Coastguard Agency by the Advisory Committee on Protection of the Sea.

Airoldi, L., Abbiati, M., Beck, M.W., Hawkins, S.J., Jonsson, P.R. and Martin, D., 2005. An ecological perspective on the deployment and design of low-crested and other hard coastal defence structures. Coast. Eng. 52, 1073-1087.

Ambrose, P., 1996. A cleaner Caribbean. Mar. Pollut. Bull. 32, 456.

Anbar, H., 1996. Litter in the Arabian Gulf. Mar. Pollut. Bull. 32, 455-456.

Anderson, J., Curtis, H., Stewart, A-M. and McShane, H., 2008. 2006 Economic Study of the UK Fishing Fleet. SEAFISH, July 2008. 128pp.

Anisimov, O.A., Vaughan, D.G., Callaghan, T.V., Furgal, C., Marchant, H., Prowse, T.D., Vilhjálmsson, H. and Walsh, J.E., 2007. Polar regions (Arctic and Antarctic). In: Climate Change 2007 – Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. and Hanson, C.E. Cambridge University Press. pp. 653-685.

Atkins, 2004. ICZM in the UK: A Stocktake.

Attrill, M.J., Wright, J. and Edwards, M., 2007. Climate-related increases in jellyfish frequency suggest a more gelatinous future for the North Sea. Limnol. Oceanogr. 52, 480-485.

Bamber, R.N. and Seaby, R.M.H., 2004. The effects of power station entrainment passage on three species of marine planktonic crustacean, *Acartia tonsa* (Copepoda), *Crangon crangon,* (Decapoda) and *Homarus gammarus* (Decapoda). Mar. Environ. Res. 57, 281-294.

Barker, T., 2008. Proposal for a global emissions trading scheme (GETS) for international bunkers (aviation and shipping). A Briefing Note supporting the 'Open Letter' from the First International Scientific and Business Congress on Protecting the Climate – A World Joint Strategy. Tyndall Briefing Note No. 26.

Barker, N.H.L. and Roberts, C.M., 2004. Scuba diver behaviour and the management of diving impacts on coral reefs. Biol. Conserv. 120: 481-489.

Barnett, P.R.O., 1971. Some changes in intertidal sand communities due to thermal pollution. P. Roy. Acad. Sci. 177, 363-364.

Barnett, J., 2001. Security and Climate Change. Tyndall Centre for Climate Change Research Working Paper No. 7, October 2001.

BASS, 2004. A Review of the Recreational and Economic Status of Bass (*Dicentrarchus labrax*) in England and Wales and Proposals for Revised Management of the UK Bass Fishery. Report Prepared By the B.A.S.S Restoration Committee for Submission to Defra, The UK Government and the Devolved Administrations.

Baxter, J.M., Boyd, I.L., Cox, M., Cunningham, L., Holmes, P. and Moffat, C.F., 2008. Scotland's Seas: Towards Understanding their State. A Report produced for the Scottish Executive by the Fisheries Research Services, Scottish Environment Protection Agency and Scottish Natural Heritage. 174 pp.

Beare, D., Burns, F., Greig, A., Jones, E.G., Peach, K., Kienzle, M., McKenzie, E. and Reid, D.G., 2004. Long-term increases in prevalence of North Sea fishes having southern biogeographic affinities. Mar. Ecol. Prog. Ser. 284, 269-278.

Beaugrand, G., Brander, K.M., Lindley, J.A., Souissi, S. and Reid, P.C., 2003. Plankton effect on cod recruitment in the North Sea. Nature, 426, 661-664.

Beaumont, N., Townsend, M., Mangi, S. and Austen, M.C., 2006. Marine Biodiversity – An Economic Valuation. Building the Evidence base for the Marine Bill. Prepared for the Department for Environment, Food and Rural Affairs.

Benson, S. and Cook, P., 2005. Underground geological storage. In: Carbon Dioxide Capture and Storage. Edited by Metz, B., Davidson, O., de Coninck, H., Loos, M., and Meyer, L. A Special Report by the Intergovernmental Panel on Climate Change. Available at: www.ipcc.ch/ipccreports/special-reports.htm

Bentham, M., Kirk, K., Holloway, S. and Angel, M., 2005. The concept of geological storage of carbon dioxide. In: An Integrated Assessment of Carbon Dioxide Capture and Storage in the UK. Edited by Gough, C. and Shackley, S. Tyndall Centre for Climate for Climate Change Research. Technical Report 47.

BERR, 2007. Meeting the Energy Challenge. Energy White Paper. Department for Business, Enterprise and Regulatory Reform. Available at: www.berr.gov.uk/files/file39387.pdf

BERR, 2008a. Review of Cabling Techniques and Environmental Effects Applicable to the Offshore Wind Farm Industry – Technical Report. Department for Business, Enterprise and Regulatory Reform.

BERR, 2008b. Review of Oil & Gas Pipelines on the UKCS. June, 2008. Department for Business, Enterprise and Regulatory Reform.

BERR, 2008c. UK Renewable Energy Strategy: Consultation. Department for Business, Enterprise and Regulatory Reform. Available at: www.berr.gov.uk/files/file46799.pdf

BGS, 2007. The Strategic Importance of the Marine Aggregate Industry to the UK. Research Report OR/07/019. British Geological Survey.

Birklund, J. and Wijsman, J.W.M., 2005. Aggregate Extraction: A Review on the Effect on Ecological Functions. Delft Hydraulics.

Black, K.D., Hansen, P.K. and Holmer, M., 2008. Salmon Aquaculture Dialogue: Working Group Report on Benthic Impacts and Farm Siting. Worldwildlife Fund. 54 pp.

Blackadder, A., Clayton, P., Copus, A., Mitchell, M., Petrie, S. and Sutherland, R., 2009. Lot 20: Scotland and Northern Ireland. In: Regional Socio-economic Studies on Employment and the Level of Dependency on Fishing. Final report to DGXIV European Commission (note that the content of this Final Report is the sole responsibility of the publisher and it in no way represents the views of the Commission).

Blundell, R., Dearden, L., Meghir, C. and Sianesi, B., 1999. Human Capital Investment. Fisc. Stud. 20: p14.

BMAPA, 2006. Strength from the Depths: A Sustainable Development Strategy for the British Marine Aggregates Industry. November, 2006. British Marine Aggregate Producers Association.

BMAPA, 2007. Strength from the Depths. First Sustainable Development Report for the British Marine Aggregates Industry. November 2007. British Marine Aggregate Producers Association.

BMAPA, 2008. Strength from the Depths: Second Sustainable Development Report for the Marine Aggregates Industry. November, 2008. British Marine Aggregate Producers Association.

BMAPA and TCE, 2007. Marine Aggregate Dredging. The Area Involved – 10th Annual Report. British Marine Aggregate Producers Association, The Crown Estate.

BMF, 2007a. Economic Benefits of Coastal Marinas (UK and Channel Islands). British Marine Federation.

BMF, 2007b. UK Leisure and Small Commercial Marine Industry Key Performance Indicators 2006/7. British Marine Federation.

BMF, 2008. UK Leisure and Small Commercial Marine Industry Key Performance Indicators 2006/7. British Marine Federation.

BMF, MCA, RNLI, RYA and Sunsail, 2007. Watersports and Leisure Participation Report 2007. British Marine Federation, Maritime and Coastguard Agency, Royal National Lifeboat Institution, RYA and Sunsail.

Bochert, R. and Zettler, M.L., 2004. Long-term exposure of several marine benthic animals to static magnetic fields. Bioelectromagnetics 25, 498-502.

BODC, 2007. Annual Report 2006-2007. British Oceanographic Data Centre.

Bolam, S.G. and Rees, H.L., 2004. Minimizing impacts of maintenance dredged material disposal in the coastal environment: a habitat approach. Environ. Manage. 32, 171-188.

Bonn Agreement, 2009. Annual Report on Aerial Surveillance for 2009. Bonn Agreement Aerial Surveillance Programme.

Bournemouth Borough Council, 2007. Boscombe Spa Village Information Pack.

Boyd, S.E. and Cooper, K.M., 2002. Final Report on the Cumulative Environmental Impacts of Aggregate Extraction (CSG 15). CEFAS Contract Report. 24pp.

Brampton, A.H., Harcourt, J.S., Rogers, J.R. and Bean, N., 2007. Scoping Study: Updating the Beach Management Manual. R& D technical Report SC0600005. Environment Agency.

Brown, J.R., Gowen, J.R. and McCluskey, S.D., 1987. The effects of salmon farming on the benthos of a Scottish sea loch. J. Exp. Mar. Biol. Ecol. 109, 39-51.

Burridge, L., Weis, J., Cabello, F. and Pizarro, J., 2008. Chemical Use in Salmon Aquaculture: A Review of Current Practices and Possible Environmental Effects. Worldwildlife Fund.

Burrows, R., Walkington, I., Yates, N., Hedges, T., Chen, D., Li, M., Zhou, J., Wolf, J., Proctor, R., Holt, J. and Prandle, D., 2008. Tapping the Tidal Power Potential of the Eastern Irish Sea. A report for the Northwest Regional Development Agency and the Joule Centre. December, 2008.

BWEA, 2002. Best Practice Guidelines: Consultation for offshore wind energy developments. British Wind Energy Association.

BWEA, 2005. Path to Power. June, 2005. British Wind Energy Association.

BWEA, 2006. Onshore Wind: Powering Ahead. March 2006. British Wind Energy Association.

BWEA, 2009. Statistics accessed April 2009. British Wind Energy Association. Available at: www.bwea.com/statistics/

Cabinet Office, 2004. Net Benefits. A sustainable and profitable future for UK fishing. Prime Minister's Strategy Unit, March 2004.

Cadrin, S.X. and Pastoors, M.A., 2008. Precautionary harvest policies and the uncertainty paradox. Fish. Res. 94, 367-372.

Capuzzo, J.M., 1980. Impact of power-plant discharges on marine zooplankton: A review of thermal mechanical and biocidal effects. Helgolander Meeresun. 33, 422-433.

Carlton, J.T. and Geller, J.B., 1993. Ecological roulette: the global transport of non-indigenous marine organisms. Science 26, 78-82.

CCW, 2007. Audited Financial Accounts for the Year ended 31 March 2007. Countryside Council for Wales.

CCC, 2008. Building a Low-carbon Economy – The UK's Contribution to Tackling Climate Change. Climate Change Committee. www.theccc.org.uk/reports

CEFAS, 2003. Preliminary investigation of the sensitivity of fish to sound generated by aggregate dredging and marine construction. A report commissioned by DEFRA. Centre for Environment, Fisheries and Aquaculture Science.

CEFAS, 2004. Offshore Wind Farms: Guidance note for Environmental Impact Assessment in respect of FEPA and CPA requirements. Prepared by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) on behalf of the Marine Consents and Environment Unit (MCEU).

CEFAS, 2007. Annual Report and Accounts 2007-08. Available at: www.cefas.co.uk/about-us/annual-report-and-accounts.aspx

CEFAS, 2008. Shellfish News 26, Autumn/Winter 2008. Centre for Environment, Fisheries and Aquaculture Science.

Centre for Marine and Coastal Studies, 2003. A Baseline Assessment of Electromagnetic Fields Generated by Offshore Windfarm Cables. A report commissioned by COWRIE (Collaborative Offshore Wind Research Into the Environment).

Centrica Storage, 2010. Rough Guide. How it works. Accessed online at: www.centrica-sl.co.uk/index.asp?pageid=46

Clark, R.B., 1999. Marine Pollution. Fourth Edition. Oxford University Press.

CMACS, 2003. COWRIE Phase 1 Report. A Baseline Assessment of Electromagnetic Fields Generated by Offshore Wind farm Cables. Centre for Marine and Coastal Studies. COWRIE Report EMF-01-2002 66.

Cooper, N.J., 2003. The use of 'managed retreat' in coastal engineering. Proc. Instit. Civil Engineers – Engineering Sustainability, ES2, 101-110.

Cooper, J.A.G. and McKenna, J., 2008. Working with natural processes. Geogr. J. 174, 315-331.

Cooper, N.J. and Pontee, N.I., 2006. Appraisal and evolution of the littoral 'sediment cell' concept in applied coastal management; experiences from England and Wales. Ocean Coast. Manage. 49, 498-510.

Cooper, K.M., Eggleton, J.D., Vize, S.J., Vanstaen, K., Smith, R., Boyd, S.E., Ware, S. Morris, C.D. Curtis, M., Limpenny, D.S. and Meadows, W.J., 2005. Assessment of the rehabilitation of the seabed following marine aggregate dredging-part II. Sci. Ser. Tech. Rep. Cefas, No. 130. 82pp.

Cordah, 2001. Human Activities in the North Sea Relevant To SEA2. Technical report produced for Strategic Environmental Assessment – SEA2.

Cornwall Enterprise, 2001. Assessment of the Potential Contribution of Marinas & Watersports to Increasing Prosperity in Cornwall.

Couch, S.J. and Bryden, I.G., 2004. TheImpact of Energy Extraction on Tidal Flow Development. A report funded by EPSRC as part of the Supergen Marine Consortium.

Cromey, C., 2008. ECASA Model description template: DEPOMOD. Available at: www.ecasatoolbox.org.uk/the-toolbox/eia-species/models/depomod#AutoDEPOMOD

CSIP, 2007. Annual report for the period 1st January to 31st December 2007. UK Cetacean Strandings Investigation Programme. www.cwtstrandings.org/MSN_Reports/WC0601_7291_ANN.pdf

Curtis, H., Metz, S. and Brodie, C., 2009. 2007 Economic Survey of the UK Fishing Fleet. SEAFISH, November 2009. 76pp. Available online at: www.seafish.org/pdf.pl?file=seafish/Documents/2007FleetEconomicSurveyFinal.pdf

Cushing, D.H., 1984. The gadoid outburst in the North Sea. J. Conseil 41, 159-166.

DAISIE, 2009. Delivering Alien Species Inventories for Europe. www.europe-aliens.org/

DASA, 2008. UK Defence Statistics 2008. Defence Analytical Services and Advice.

Davenport, J. and Davenport, J.D., 2006. The impact of tourism and personal leisure transport on coastal environments: A review. Estuar. Coast. Shelf S. 67, 280-292.

Dawson, A., Smith, D.E. and Dawson, S., 2001. The Potential Impacts of Climate Change on Sea Levels around Scotland. Scottish Natural Heritage Research Survey and Monitoring Report, No. 178. Scottish Natural Heritage. 77 pp.

DCLG, 2002. Marine Mineral Guidance 1: Extraction by dredging from the English seabed. Department of Communities and Local Government.

DCLG, 2005. Collation of the results of the 2005 Aggregate Minerals Survey for England and Wales. Department of Communities and Local Government.

DCLG, 2006. Minerals Policy Statement 1: Planning and Minerals, November 2006. Department of Communities and Local Government.

DCMS, 2001. A New Future for Communications. Communications White Paper. Department for Culture Media and Sport.

DCMS, 2009. Digital Britain: The Interim Report. Department for Culture Media and Sport.

Dean, R.J., Shimmield, T.M and Black, K.D., 2007. Copper, zinc and cadmium in marine cage fish farm sediments: An extensive survey. Environm. Pollut. 145, 84-95.

DECC, 2009a. A Prevailing Wind. Advancing UK Offshore Wind Deployment. Department of Energy and Climate Change. Available at: www.berr.gov.uk/files/file51989.pdf

DECC, 2009b. Digest of UK Energy Statistics (DUKES) 2009. Department of Energy and Climate Change. Available at: www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx

DECC, 2009c. Towards a nuclear national policy statement: Government response to consultations on the Strategic Siting Assessment process and siting criteria for new nuclear power stations in the UK; and to the study on the potential environmental and sustainability effects of applying the criteria. Office for Nuclear Development.

DECC, 2009d. UK Offshore Energy. Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report. Department of Energy and Climate Change.

DECC, 2009e. Digest of United Kingdom energy statistics (DUKES). Department of Energy and Climate Change.

DECC, 2009f. UKCS Oil and Gas Production Projections. Department of Energy and Climate Change. Web update, March 2009.

Defra, 2002. Safeguarding our Seas – A Strategy for the Conservation and Sustainable Development of Our Marine Environment. Department for Environment, Food and Rural Affairs. 80 pp.

Defra, 2004a. Making Space for Water. Developing a New Government Strategy for Flood and Coastal Erosion Risk Management in England. A consultation exercise, July 2004. Department for Environment, Food and Rural Affairs.

Defra, 2004b. National Assessment of Defence Needs and Costs for Flood and Coastal Erosion Management. Summary Report. Flood Management Division, June 2004. Department for Environment, Food and Rural Affairs.

Defra, 2004c. Research into the Economic contribution of Sea Angling. Drew Associates. 71pp. Department for Environment, Food and Rural Affairs.

Defra, 2004d. Evidence and Innovation: Defra's Needs from the Sciences over the Next 10 Years. Department for Environment, Food and Rural Affairs.

Defra, 2004e. Review of Marine Nature Conservation: Working Group report to Government. Department for Environment, Food and Rural Affairs.

Defra, 2005a. Charting Progress. An Integrated Assessment of the State of UK Seas. Department for Environment, Food and Rural Affairs, March 2005.

Defra, 2005b. Charting a New Course. Department for Environment, Food and Rural Affairs Publ. No. PB 11300.

Defra, 2006a. Review of Local Authority Skills and Capacity for Coastal Defence Functions (Project HA1). Report commissioned by Defra and undertaken by Coast and Country projects Ltd. Available at: www.defra.gov.uk/environ/fcd/policy/strategy/ha1laskl.pdf. Department for Environment, Food and Rural Affairs.

Defra, 2006b. Flood and Coastal Defence Appraisal Guidance FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts. October 2006. Department for Environment, Food and Rural Affairs.

Defra, 2006c. Our Approach to Evidence and Innovation. Department for Environment, Food and Rural Affairs.

Defra, 2007a. An introductory guide to valuing ecosystem services. Department for Environment, Food and Rural Affairs.

Defra, 2007b. Consultation on a Recreational Sea Angling Strategy for England Inshore Fisheries Working Group Recreational Sea Angling Subgroup.

Defra, 2007c. Fisheries 2027: A long-term vision for sustainable fisheries. Publ. No. PB 12780.

Defra, 2007d. Explanatory Memorandum to the Marine Works (Environmental Impact Assessment) Regulations 2007. No 1518. Department for Environment, Food and Rural Affairs.

Defra, 2008a. Estimated abstractions from tidal waters by purpose and Environment Agency region: 1995-2005. e-Digest of Environmental Statistics. Department for Environment, Food and Rural Affairs.

Defra, 2008b. Future Water – the Government's Water Strategy for England. Department for Environment, Food and Rural Affairs.

Defra, 2008c. Sustainable Development Indicators in your Pocket 2008. An update of the Government Strategy indicators. Department for Environment, Food and Rural Affairs. www.defra.gov.uk/sustainable/government/progress/data-resources/documents/SDIYP2008_a6.pdf

Defra, 2008d. The United Kingdom operational program for the European Fisheries Fund (2007-2013). Department for Environment, Food and Rural Affairs.

Defra and EA, 2008. Defra and Environment Agency Flood and Coastal Erosion Risk Management Research and Development Programme. Annual Review 2007-08. Department for Environment, Food and Rural Affairs, Environment Agency.

Defra, WAG, Scottish Executive, and DARD, 2005. Securing the Benefits. The joint UK response to the Prime Minister's Strategy Unit Net Benefits report on the future of the fishing industry in the UK. Publ. No. PB 10900.

DfT, 1998. British Shipping: Charting a New Course. Department for Transport.

DfT, 2000. Modern Ports: A UK Policy. Department for Transport.

DfT, 2005. Transport Statistics Bulletin: Port Employment and Accident Rates. Department for Transport.

DfT, 2007. Ports Policy Review Interim Report. 19 July 2007. Department for Transport. www.dft.gov.uk/pgr/shippingports/ports/portspolicyreview/portspolicyreviewinterimreport

DfT, 2008a. Maritime Statistics 2007. Department of Transport.

DfT, 2008b. The General Lighthouse Fund 2006–2007. Department for Transport.

DfT, 2009. Draft National Policy Statement for Ports. 9th November 2009. Department for Transport. www.dft.gov.uk/consultations/open/portsnps/npsports.pdf [Accessed 12th November 2009]

Dinmore, T.A., Duplisea, D.E., Rackham, B.D., Maxwell, D.L. and Jennings, S., 2003. Impact of a large-scale area closure on patterns of fishing disturbance and the consequences for benthic production. ICES J. Mar. Sci. 60, 371-380.

DOENI, 2006. An Integrated Coastal Zone Management Strategy for Northern Ireland 2006-2026. Department of the Environment Northern Ireland.

Douglas-Westwood, 2008. The World Wave and Tidal Market Report 2009-2013.

DRDNI, 2009. Northern Ireland Transport Statistics 2007-08. Department for Regional Development Northern Ireland.

Drinkwater, K.F., 2005. The response of Atlantic cod (*Gadus morhua*) to future climate change. ICES J. Mar. Sci. 62, 1327-1337.

DTI, 2001a. An Overview of Offshore Oil and Gas Exploration and Production Activities. Department for Trade and Industry.

DTI, 2001b. Strategic Environmental Assessment of the Mature Areas of the Offshore North Sea SEA2. Department for Trade and Industry.

DTI, 2002. Strategic Environmental Assessment of Parts of the Central & Southern North Sea SEA3. Department for Trade and Industry.

DTI, 2003a. Review of the Feasibility of Carbon Dioxide Capture and Storage in the UK. Cleaner Fossil Fuels Programme. DTI/Pub URN 03/1261. Department for Trade and Industry.

DTI, 2003b. Our Energy Future – Creating a Low Carbon Economy. Energy White Paper. Department for Trade and Industry.

DTI, 2005. Science Budget Allocations 2005-06 to 2007-08. Department for Trade and Industry. Available at: www.berr.gov.uk/files/file14994.pdf

DTI, 2006. Decommissioning of Offshore Renewable Energy Installations under the Energy Act 2004. Guidance notes for Industry. December 2006.

DTI, 2007a. Meeting the Energy Challenge. A White Paper on Energy. Department for Trade and Industry. May 2007.

DTI, 2007b. Synthesis of the Analysis of the Energy White Paper. May 2007. Department for Trade and Industry. Available at: www.berr.gov.uk/files/file39198.pdf

Dunstone, D., 2008. Development of spatial information layers for commercial fishing and shellfishing in UK waters to support strategic siting of offshore wind farms. Cowrie Ltd., 2008. www.offshorewind.co.uk.

Eastwood, P.D., Mills, C.M., Aldridge, J.N., Houghton, C.A. and Rogers, S.I., 2007. Human activities in UK offshore waters: an assessment of direct, physical pressure on the seabed. ICES J. Mar. Sci. 64, 453-463.

EC, 2008. Roadmap for Maritime Spatial Planning: Achieving Common Principles in the EU. Communication from the Commission. COM(2008) 791 Final.

EC, 2009a. Communication from the Commission to the European Parliament and the Council. Building a sustainable future for aquaculture. A new impetus for the Strategy for the Sustainable Development of European Aquaculture. 8 April 2009. Available at: http://ec.europa.eu/fisheries/cfp/aquaculture_processing/aquaculture/strategy_en.htm

EC, 2009b. Reform of the Common Fisheries Policy. Green Paper. Released 22 April 2009.

Edwards, T. and Cook, G., 2001. Aquaculture. The Scottish Parliament.

eftec, 2008. Costs of Illegal, Unreported and Unregulated (IUU) Fishing in EU Fisheries. Economics for the Environment Consultancy Ltd. Available at: www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Protecting_ocean_life/eftec_Costs_IUU_Fishing.pdf

Ekos Ltd, 2006. Economic impact of salmon farming mergers. Final report for Highlands and Islands Enterprise, Ekos Ltd, Inverness.

Ekos Consulting (UK) Ltd. & Nautilus Consultants, 2003. Socio-Economic Baseline Study of the South West Fishing Industry. Commissioned by PESCA and the South West Regional Development Agency. April 2003.

Element Energy Ltd, 2007. Development of a CO_2 Transport and Storage Network in the North Sea. Report to the North Sea Basin Task Force. In association with Element Energy, Pŷyry and British Geological survey. Available online: www.berr.gov.uk/files/file42476.pdf

Ellis, J.R., Clarke, M.W., Cortés, E., Heessen, H.J.L., Apostolaki, P., Carlson, J.K. and Kulka, D.W., 2008. Management of elasmobranch fisheries in the North Atlantic. In: Advances in Fisheries Science: 50 years on from Beverton and Holt. Edited by Payne, A., Cotter, J. and Potter, E. Blackwell. pp. 184-228.

Energy Saving Trust, 2009. Salt caverns to store energy as compressed air. 03 March 2009. Accessed online: www.energysavingtrust.org.uk/Resources/Daily-news/Renewable-energy2/Salt-caverns-to-store-energy-as-compressed-air

Enever, R., Revill, A. and Grant, A., 2009. Discarding in the North Sea and on the historical efficacy of gear-based technical measures in reducing discards. Fish. Res. 95, 40-46.

Engelhard, G., 2008. One hundred and twenty years of change in fishing power of English North Sea trawlers. In: Advances in Fisheries Science: 50 years on from Beverton and Holt. Edited by Payne, A., Cotter, J. and Potter, E. Blackwell. pp. 1-25.

Eno, N.C., Clark, R.A. and Sanderson, W.G., 1997. Non-native Marine Species in British waters: A Review and Directory. Joint Nature Conservation Committee. 152pp.

Entec, 2009. Strategy Environmental Assessment for a framework of the development of clean coal. Environmental report: Annex A. Report produced for DECC, June 2009.

Environment Agency, 2000. Humber Geomorphological Studies – Stage2: Technical report. Report for the Environment Agency by ABP Research, 2000.

Environment Agency, 2004. River Basin Management Plans. Available at: www.environment-agency.gov.uk/research/planning/33112.aspx.

Environment Agency, 2007. Managed Realignment Electronic Platform. Available at: www.intertidalmanagement.co.uk.

Environment Agency, 2008a. Annual Report and Accounts 2007/08. Available at: http://publications.environment-agency.gov.uk/pdf/GEHO0708BOFC-e-e.pdf?lang=_e

Environment Agency, 2008b. Discharges to Controlled Waters (CfD) Charges for 2008/2009. Factsheet. Available at: http://publications.environment-agency.gov.uk/pdf/GEHO0308BNTU-e-e.pdf

Environment Agency, 2008c. Water Resources in England and Wales – Current State and Future Pressures.

Environment Agency, 2009. Investing for the Future: Flood and Coastal Risk Management in England, A long term investment strategy.

E.ON, 2009. Capturing Carbon, Tackling Climate Change: A vision for a CCS Cluster in the South East. April 2009.

E.ON, 2010. Salt Cavern Gas Storage. Accessed online: www.eon-uk.com/generation/saltcavern.aspx

Ernst and Young, 2005. Review of Current Trends in the Scottish Salmon Farming Industry.

Ernst and Young, 2007. Impact of Banding the Renewables Obligation – Cost of Electricity Production. April 2007. Report to the Department for Trade and Industry.

Essink, K., 1999. Ecological effects of dumping of dredged sediments: options for management. J Coast. Cons. 5, 69-80.

Eurosion, 2004. Living with Coastal Erosion in Europe: Sediment and Space for Sustainability. Major findings and policy recommendations of the EUROsion project. European Commission. Directorate General Environment, Service contract B4-3301/2001/329175/MAR/B3.

Evans, P., 1998. Human disturbance of cetaceans. In: Exploitation of Mammal Populations. Edited by Taylor, V.J. and Dunstone, N. Chapman & Hall, London. pp 376-394.

Faber Maunsell and Metoc, 2007. Scottish Marine Renewables. Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive. March 2007.

Fabry, V.J., Seibel, B.A., Feely, R.A. and Orr, J.C., 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. ICES J. Mar. Sci. 65, 414-432.

FAO, 1995. Code of Conduct for Responsible Fisheries. UN Food and Agriculture Organization. Available at: www.fao.org/DOCREP/005/v9878e/v9878e00.htm.

Federal Energy Regulatory Commission, 2006. Makah Bay Offshore Wave Energy Pilot Project. FERC Docket No. DI02-3-002. October 2006.

Fernand, L. and Brewer, P., 2008. Changes in surface CO_2 and ocean pH in ICES shelf sea ecosystems. ICES Coop. Res. Rep. 290. 35 pp.

Ferreira, J.G., Hawkins, A.J.S., Monteiro, P., Service, M., Moore, H., Gowen, E.R., Lourenco, P., Mellor, A., Nunes, J.P., Pascoe, P.L., Ramos, L., Sequeira, A., Simas, T. and Strong, J., 2007. SMILE – Sustainable Mariculture in northern Irish Lough Ecosystems – Assessment of Carrying Capacity for Environmentally Sustainable Shellfish Culture in Carlingford Lough, Strangford Lough, Belfast Lough, Larne Lough and Lough Foyle. Institute of Marine Research. 100 pp.

Fitch, S., Gaffney, V.L. and Thomson, K., 2007. In Sight of Doggerland: From Speculative Survey to Landscape Exploration. Internet Archaeology 22.

Foresight, 2004. Foresight Future Flooding. Executive Summary. Flood and Coastal Defence Project of the Foresight Programme. Office of Science and Technology.

Fraenkel, P.L., 2006. Tidal current energy technologies. Ibis 148, 145-151.

FRS, 2004. Case Study: Munitions Dumping at Beaufort's Dyke. Fisheries Research Services.

FRS, 2007. Annual Report 2007-2008. Available at: www.marlab.ac.uk/FRS.Web/Uploads/Documents/RAaccount07-08.pdf. Fisheries Research Services.

FRS, 2008a. Scottish Fish Farms Annual Production Survey, 2007. Fisheries Research Services.

FRS, 2008b. Scottish Shellfish Farm Production Survey 2007. Fisheries Research Services.

FRS, 2008c. Strategic Research Assessment for Wet Renewables. Fisheries Research Services Internal Report No 11/08.

FSC, 2002. Teaching biology outside the classroom: Is it heading for extinction? Field Studies Council.

Gaffney, V. Thomson, K. and Fitch, S., 2007. Mapping Doggerland: Mesolithic Landscapes of the Southern North Sea. Archaeopress.

Gaffney, V., Fitch S. and Smith, D., 2009. Europe's Lost World. The Rediscovery of Doggerland. Council for British Archaeology Research Report.

Gardner, B.M., Marlow, P.B., Naim, M.M., Nair, R.V. and Pettit, S.J., 2003. The UK Economy's Requirements for People with Experience of Working at Sea 2003. Report commissioned by the Department for Transport, Chamber of Shipping & Marine Society.

Genesis Oil & Gas Consultants Ltd, 2008. Review of Oil & Gas Pipelines on the UKCS. A report for the Department for Business, Enterprise and Regulatory Reform. June 2008.

Geode, 2008. TSO, RTE, ELIA and national Grid launch consultation to assess opportunities for strengthening Franco-British interconnection. Geode Informs, No. 539. September 2008. [Available online at: www.energynetworks.org/GEODE/539_September2008.pdf]

Geoff Broom Associates, 2005. HMS *Scylla* Initial Economic Impact Study. Report for the South West Regional Development Agency.

Geological Society, 2001. The Earth in Our Hands. No. 7, Coastal Erosion. Available at: www.geolsoc.org.uk/webdav/site/GSL/shared/pdfs/education%20and%20careers/erosion.pdf.

Gerrard, S., Grant, A., London, C. and Marsh, R., 1999. Drill Cuttings Piles in the North Sea: Management Options during Platform Decommissioning .UEA Centre for Environmental Risk, Research Report 31, 224pp. Available at: www.uea.ac.uk/~e130/cuttings.pdf.

Gill, A.B., Gloyne-Phillips, I., Neal, K.J. and Kimber, J.A., 2005. COWRIE Phase 1.5 Report. The Potential Effects of Electromagnetic Fields Generated by Sub-sea Power Cables associated with Offshore Wind Farm developments on Electrically and Magnetically Sensitive Marine Organisms – A Review. A report commissioned by COWRIE (Collaborative Offshore Wind Research Into the Environment).

Gill, A.B., Gloyne-Phillips, I., Huang, Y., Metcalfe, J., Quayle, V., Spencer, J. and Wearmouth, V., 2008. Determination of the response of electromagnetic sensitive fish to electromagnetic fields (EMF) generated by offshore windfarms: experimental project results. Presentation at the International Scientific Meeting on Marine Renewable Energy and the Environment, Royal Institute of Great Britain, London, 16-17 June, 2008.

Gillibrand, P.A., Cromey, C.J., Black, K.D., Inall, M.E. and Gontarek, S.J., 2006. Identifying the Risk of Deoxygenation in Scottish Sea Lochs with Isolated Deep Water. A report to The Scottish Aquaculture Research Forum.

Grafton, R.Q., Arnason, R., Bjorndal, T., Campbell, D., Campbell, H.F., Clark, C.W., Connor, R., Dupont, D.P., Hanneson, R., Hilborn, R., Kirkley, J.E., Kompas, T., Lane, D.E., Munro, G.R., Pascoe, S., Squires, D., Steinshamn, S.I., Turris, B.R. and Weninger, Q., 2006. Incentive-based approaches to sustainable fisheries. Can. J. Fish. Aquat. Sci. 63, 699-710.

Grant, A. and Briggs, A.D., 2002. Toxicity of sediments from around a North Sea oil platform: Are metals or hydrocarbons responsible for ecological impacts? Mar. Environ. Res. 53, 95-116.

Greathead, C., Jackson, J. and Davies, I.M., 2006. Seasonal Variation in the Relative Importance of Aquaculture, Land Run-off and Tidal Exchange as Sources of Nutrients in Scottish Sea Lochs. Fisheries Research Services Internal Report No 05/06.

Greenwood, M.F.D., 2008. Fish mortality by impingement on the cooling-water intake screens of Britain's largest direct cooled power station. Mar. Pollut. Bull. 56, 723-739.

Gubbins, M.J., Gillibrand, P.A., Miller, B.S. and Davies, I.M., 2003. OSPAR Eutrophication Assessment of Aquaculture Hotspots in Scottish Coastal Waters. Addendum Report. Fisheries Research Services Collaborative Report No 12/03.

Halcrow, 2006. Wave Hub Environmental Statement. Produced for the South West of England Regional Development Agency. June 2006.

Halcrow, 2008. Marine Renewable Project Development Draft Guidelines. A report produced for the European Marine Energy Centre, May 2008.

Halcrow Group Ltd, HR Wallingford, and John Chatterton Associates, 2001. National Appraisal of Assets at Risk from Flooding and Coastal Erosion, including the Potential Impact of Climate Change. Department for Environment, Food and Rural Affairs, Flood Management Division.

Hall, J.W., Sayers, P.B., Walkden, J.A.M. and Panzeri, M., 2006. Impacts of climate change on coastal flood risk in England and Wales: 2030-2100. Phil. Trans. R. Soc. A 364, 1027-1049.

Hall-Spencer, J., Allain, V. and Fossa, J.H., 2002. Trawling damage to northeast Atlantic ancient coral reefs. Proc. R. Soc. B 269, 507-511.

Hartley Anderson Ltd, 2004. Existing Users and Management Initiatives Relevant to SEA 5.

Hiscock, K., Marshall, C., Sewell, J. and Hawkins, S.J., 2006. The Structure and Functioning of Marine Ecosystems: An Environmental Protection and Management Perspective. English Nature Research Reports, No 699.

Hitchcock, D.R. and Drucker, B.R., 1996. Investigation of benthic and surface plumes associated with marine aggregates mining in the United Kingdom. In the Global Ocean – Towards Operational Oceanography Vol. 2. Proceedings of the Oceanology International Conference. pp. 221-234.

HM Government, 2005. Securing the Future. The UK Government Sustainable Development Strategy. Publ. No. Cm 6467. March 2005. Available at: www.defra.gov.uk/sustainable/government/publications/uk-strategy/documents/SecFut_complete.pdf.

HM Government, 2008. Meeting the Energy Challenge: A White Paper on Nuclear Power. Department for Business, Enterprise and Regulatory Reform, CM 7296. Available at: www.berr.gov.uk/files/file43006.pdf

HM Government, 2009a. Our Seas – A Shared Resource High Level Marine Objectives. Produced in association with Northern Ireland Executive, The Scottish Government and the Welsh Assembly Government.

HM Government, 2009b. The UK Low Carbon Transition Plan: Analytical Annex. Presented to Parliament 15 July 2009.

HMSO, 2006. Science and Innovation Investment Framework 2004-2014: next steps. Available at: www.berr.gov.uk/files/file29096.pdf

Holloway, S., Vincent, C.J., Bentham, M.S. and Kirk, K.L., 2006a. Reconciling top-down and bottom-up estimates of CO_2 storage capacity in the UK sector of the Southern North Sea Basin. Environ. Geosci. 13, 71-84.

Holloway, S., Vincent, C.J. and Kirk, K.L., 2006b. Industrial Carbon Dioxide Emissions and Carbon Dioxide Storage Potential in the UK. Report No. COAL R308 DTI/Pub URN 06/2027. October 2006.

House of Commons, 2007. House of Commons Science and Technology: Investigating the Oceans. Tenth report of Session 2006-07. Volume 1. Available at: http://www.publications.parliament.uk/pa/cm200607/cmselect/cmsctech/470/470i.pdf

Hoyt, E., 2000. Whale-watching 2000: Worldwide Tourism Numbers, Expenditures, and Expanding Socioeconomic Benefits. Crowborough: International Fund for Animal Welfare.

HR Wallingford, Royal Haskoning & University of Newcastle upon Tyne, 2007. Development of a Risk Assessment Framework: MARA (Marine Aggregates Extraction Risk Assessment) Framework. Produced for the ALSF – MEPF 04/03. Final Technical Report.

Hulme, M., Jenkins, G.J., Lu, X., Turnpenny, J.R., Mitchell, T.D., Jones, R.G., Lowe, J., Murphy, J.M., Hassell, D., Boorman, P., McDonald, R. and Hill, S., 2002. Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report. Tyndall Centre for Climate Change Research. 120pp.

Hutton, T., Mardle, S. and Tidd, A.N., 2008. The decline of the English and Welsh fishing fleet? In: Advances in Fisheries Science: 50 years on from Beverton and Holt. Edited by Payne, A., Cotter, J. and Potter, E. Blackwell. pp. 26-48.

ICCT, 2007. Air Pollution and Greenhouse Gas Emissions from Ocean-going Ships: Impacts Mitigation Options and Opportunities for Managing Growth. The International Council on Clean Transportation. www.theicct.org

ICES, 2005. ICES Code of Practice on the Introductions and Transfers of Marine Organisms. International Council for the Exploration of the Sea. 30pp.

ICES, 2007. Workshop on the use of UWTV surveys for determining abundance in *Nephrops* stocks throughout European waters (WKNEPHTV). ICES CM 2007/ACFM 14.

ICES, 2008a. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak – Combined Spring and Autumn (WGNSSK). ICES CM 2008/ Acom.09.

ICES, 2008b. Report of the Working Group on the Assessment of Northern Shelf Demersal Stocks (WGNSDS). ICES CM 2008/Acom.08.

ICES, 2008c. Report of the Working Group on the Biology and Assessment of Deep-Sea Fishery Resources (WGDEEP). ICES CM 2008/ Acom.14.

ICES, 2008d. Report of the Working Group on Elasmobranch Fishes (WGEF). ICES CM 2008/ Acom.16.

ICES, 2009a. Report of the Study Group on *Nephrops* Surveys. ICES CM 2009/LRC:15.

ICES, 2009b. Report of the Benchmark Workshop on *Nephrops*, with UWTV surveys. ICES CM 2009/ACOM:33.

ICES, 2009c. Report of the ICES Working Group on Demersal Stocks in the North Sea and Skagerrak (WGNSSK). ICES CM 2009/ ACOM:10.

ICES, 2009d. Report of the ICES Working Group on the Celtic Seas Ecoregion (WGCSE). ICES CM 2009/ACOM:9.

ICPC, 2009. About Submarine Telecommunications Cables. Communicating via the ocean. International Cable Protection Committee. International Cable Protection Committee Ltd. Available at: www.iscpc.org/ publications/About_Cables_in_PDF_Format. pdf

IECS, 2007. The River Humber (Upper Burcom tidal stream generator) Order. Environmental Statement. Final Draft. October 2007. A report produced by the Institute of Estuarine and Coastal Studies, University of Hull.

IECS, 2008. Conservation Goals for Waterfowl in Estuaries. Institute of Estuarine and Coastal Studies, University of Hull. Report produced as part of the European Interreg IIIB Harbasins project.

IFSL, 2007. Maritime Services. International Financial Services London. www.ifsl.org.uk

IMO, 2000. Study of Greenhouse Gas Emissions From Ships. International Maritime Organization.

IMO, 2005. Ballast Water Management Convention. International Maritime Organization. 138pp.

IMO, 2008a. Updated Study on Greenhouse Gas Emissions From Ships, Phase 1. Report, 58/4/INF.6. International Maritime Organization.

IMO, 2008b. Major progress on air pollution, ship recycling and ballast water management at IMO environment meeting. Briefing 48, 13 October 2008. International Maritime Organization.

IMO, 2009. March 2009: Second intersessional meeting of IMO's Working Group on Greenhouse Gas Emissions (GHG) from Ships. International Maritime Organization. www.imo.org/Environment/mainfram.asp?topic_id=1737

Inger, R., Attrill, M.J., Bearhop, S., Broderick, A.C., Grecian, W.J., Hodgson, D.J., Mills, C., Sheehan, E., Votier, S.C., Witt, M. and Godley, B.J., 2009. Marine renewable energy: potential benefits to biodiversity? An urgent call for research. J. Appl. Ecol. 46, 1145-1153.

Interagency MSP Working Group, 2005. The added value of Marine Spatial Planning (MSP) – an informal discussion paper.

IPIECA, 2007. The Oil and Gas Industry and Climate Change. International Petroleum Industry Environmental Conservation Association. www.ipieca.org

Jamieson, L., Munro, G. and Perrier, M., 2009. Social Change in Scottish Fishing Communities: A Brief Literature Review and Annotated Bibliograph. Available at: www.scotland.gov.uk/Publications/2009/07/10100136/0.

JNCC, 2004. Guidelines for Minimising Acoustic Disturbance to Marine Mammals from Seismic Surveys. April 2004. Joint Nature Conservation Committee. Available at: http://www.jncc.gov.uk/pdf/seismic_survey_guidelines_200404.pdf

JNCC, 2007. Conservation Challenge No. 2. Discussion document on ecosystem structure and function: How can we use concepts of structure and function to integrate the ecosystem approach into marine monitoring? Report produced for the Joint Nature Conservation Committee.by the Marine Resources Assessment Group (MRAG) & World Conservation Monitoring Centre (UNEP-WCMC). May 2007. 28pp.

JNCC, 2008a. The Deliberate Disturbance of Marine European Protected Species: Interim Guidance for English and Welsh Territorial Waters and the UK Offshore Marine Area. Joint Nature Conservation Committee.

JNCC, 2008b. Guidelines for Minimising Acoustic Disturbance to Marine Mammals whilst using Explosives. March 2008. Joint Nature Conservation Committee.

JNCC, 2008c. Annual Report 2007/2008. Joint Nature Conservation Committee.

Johnston, P. and Santillo, D., 2003. Carbon Capture and Sequestration: Potential Environmental Impacts. Proceedings of IPCC Workshop on Carbon Dioxide Capture and Storage 2002. Regina, Canada 18-21 November 2002. Publ. Energy Research Centre of the Netherlands (ECN): 95-110.

Kaiser, M.J. and de Groot, S.J., 2000. The Effects of Fishing on Non-target Species and Habitats: Biological, Conservation and Socio-economic Issues Blackwell.

Kelly, C., Glegg, G.A. and Speedie, C.D., 2004. Management of marine wildlife disturbance. Ocean Coast. Manage. 47, 1-19.

Kelso, B. and Service, M., 2000. Environmental Effects of Shellfish Cultivation and Harvesting. A report commissioned by the Environment and Heritage Service (EHS).

Kenny, A.J., Rees, H.L., Greening, J. and Campbell, S., 1998. The Effects of Marine Gravel Extraction on the Macrobenthos at an Experimental Dredge Site off North Norfolk, UK (results 3 years post-dredging). ICES CM 1998/V, 14. 14pp.

Kindleysides, D., Lees, G., Tilbrook, C. and Mathieson, S., 2003. Coastal realignment in Scotland: Legislation, Policy and Management Requirements. Unpublished.

Kingston, P.F., Warren, L.M., Hughes, R.G., Earll, R., Parker, J.G. and Gray, J.S., 1987. Field effects of platform discharges on benthic macrofauna. Philos. T. Roy. Soc. B 316, 545-565.

Knights, A., 2007. Climate Change – A Surfers Perspective. A Surfers against Sewage report into the potential impacts of climate change on surfers in the UK. Prepared by SAS for the Crown Estate.

Laffoley, D., Maltby, E., Vincent, M.A., Mee, L., Dunn, E., Gilliland, P., Hamer, J.P., Mortimer, D. and Pound, D., 2004. The Ecosystem Approach: Coherent actions for marine and coastal environments. A report to the UK Government, Peterborough. English Nature. 65pp.

Lantra, 2007. The Sector Skills Agreement for the Aquaculture Industry. Report by Lantra, the Sector Skills Council for the Environmental and Land-based sector. February 2007. 18 pp.

Lee, M., 2001. Coastal defence and the Habitats Directive: predictions of habitat change in England and Wales. Geogr. J. 167, 39-56.

Leggett, D.J., Cooper, N. and Harvey, R., 2004. Coastal and estuarine managed realignment – Design issues. Construction Industry Research And Information Association. 215 pp.

L.E.K Consulting, 2009. An Ideal Portfolio of CCS Projects and Rationale for Supporting Projects. Report produced for the Global CCS Institute, 16 October 2009.

Lewis, L.J., Davenport, J. and Kelly, T.C., 2002. A study of the impact of a pipeline construction on estuarine benthic invertebrate communities. Estuar. Coast. Shelf S. 55, 213-221.

Linley, E.A.S., Wilding, T.A., Black, K., Hawkins, A.J.S. and Mangi, S., 2007. Review of the Reef Effects of Offshore Wind Farm Structures and their Potential for Enhancement and Mitigation. Report from PML Applications Ltd and the Scottish Association for Marine Science to the Department for Business, Enterprise and Regulatory Reform (BERR), Contract No: RFCA/005/0029P.

Lyngs, P., 1994. The effects of disturbance on growth rate and survival of young razorbills *Alca torda*. Seabird 16, 46-49.

MacLeod, C.D., Bannon, S.M., Pierce, G.I., Schweder, C. Learmonth, J.A., Herman, J.S. and. Reid, R.J., 2005. Climate change and the cetacean community of north-west Scotland. Biol. Conserv. 124, 477-483.

Maes, J., Turnpenny, A.W.H., Lambert, D.R., Nedwell, J.R., Parmentier, A. and Ollevier, F., 2004. Field evaluation of a sound system to reduce estuarine fish intake rates at a power plant cooling water inlet. J. Fish Biol. 64, 938-946.

Marine Ecological Surveys, 2002. Impact of Marine Aggregate Dredging and Overboard Screening on Benthic Biological Resources in the Central North Sea. Production licence area 408 Coal Pit. Prepared for the British Marine Aggregate Producers Association.

Marine Ecological Surveys, 2007. Predictive Framework for Assessment of Recoverability of Marine Benthic Communities Following Cessation of Aggregate Dredging. Prepared for the Department for Environment, Food and Rural Affairs.

Marine Pollution Monitoring Management Group, 2002. The Impacts of Marine Litter. Report of the Marine Litter Task Team (MaLiTT). May 2002.

Masselink, G. and Russell, P., 2008. MCCIP Annual Report Card 2007-2008. Scientific Review – Coastal Erosion and Coastal Geomorphology. Marine Climate Change Impacts Partnership.

Masters, D., Nautilus Consultants and Carter, J., 1998. Marine Wildlife Tourism: Developing a Quality Approach in the Highlands and Islands. Submitted to the Tourism and Environment Initiative and Scottish Natural Heritage. May 1998. 39pp.

MCA, 2008a. Annual Report and Accounts 2007-2008. Maritime and Coastguard Agency. www.mcga.gov.uk/c4mca/ara_07-08.pdf

MCA, 2008b. The Control and Management of Ships' Ballast Water and Sediments. Marine Guidance Note 363 (M+F). Maritime and Coastguard Agency.

MCCIP, 2008. Annual Report Card 2007–2008. Marine Climate Change Impacts Partnership.

McEvoy, D., Handley, J.F., Cavan, G., Aylen, J., Lindley, S., McMorrow, J. and Glynn, S., 2006. Climate Change and the Visitor Economy: the Challenges and Opportunities for England's Northwest. Sustainability Northwest (Manchester) and UKCIP (Oxford).

McKinsey, 2008. Carbon Capture & Storage: Assessing the Economics. Report published for the McKinsey Climate Change Initiative, September 22, 2008.

Menn, I., Junghans, C. and Reise, K., 2003. Buried alive: effects of beach nourishment on the infauna of an erosive shore in the North Sea. Sencenbergiana Maritima 32, 125-145.

MEPC, 2008. 176(58) Amendments to the Annex of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (Revised MARPOL Annex VI). Marine Environmental Protection Committee, International Maritime Organization.

META, 2002. Genuinely Sustainable Marine Ecotourism in the EU Atlantic Area: A Blueprint for Responsible Marketing. Marine Ecotourism for the Atlantic area project, Bristol. 36pp.

MFA, 2008. United Kingdom Sea Fisheries Statistics 2007. Marine and Fisheries Agency. www.mfa.gov.uk.

MJM Energy, 2006. MZINE. The Winter Gas Issue. June 2006. www.mjmenergy.com/MZINE/2006/winter_gas.htm.

MOD, 2003. Delivering Security in a Changing World. Defence White Paper. Ministry of Defence.

MOD, 2006a. Investigations by local civilian police forces, the Ministry of Defence police and service police forces. Further memorandum from the Ministry of Defence to the Select Committee on Armed Forces, March 2006.

MOD, 2006b. Beauforts Dyke Background. Ministry of Defence Paper by R. Bowles. Available at: http://www.mod.uk/NR/rdonlyres/52954E9D-A12E-4DB8-85D5-BA5AC8EFB45C/0/bd_backgrd.doc.

MOD, 2006c. The Future of the United Kingdom's Nuclear Deterrent. Cm 6994. December 2006. Ministry of Defence.

MOD, 2007a. EMP04: Environmental Impact Assessment Plan. Release V2.2e. November 2007. Available at: www.mod.uk/NR/rdonlyres/EAF14EEB-3758-4041-8C6B-DDBCA82AF02E/0/EMP04v22final.pdf. Ministry of Defence.

MOD, 2007b. EMP05: Environmental Impact Assessment and Reporting. Release V2.2e . Available at: www.mod.uk/NR/rdonlyres/C9896765-6826-4125-9174-879A4F20FE8E/0/EMP05v22final.pdf. Ministry of Defence.

MOD, 2008. Ministry of Defence Sustainable Development Strategy.

MOD, 2009. Ministry of Defence Climate Change Strategy.

Moody Marine Ltd, 2009. Burry Inlet Cockle Fishery: Public Certification Report. Ref: 82001 v5.

Moran, D., Hussain, S., Fofana, A., Frid, C., Paramour, O. et al. 2008. The Marine Bill – Marine Nature Conservation Proposals – Valuing the benefits. Final Report to Defra. CRO380.

Moreira, J., Chapman, M.G. and Underwood, A.J., 2006. Seawalls do not sustain viable populations of limpets. Mar. Ecol. Prog. Ser. 322, 179-188.

Moschella, P.S., Abbiati, M., Aberg, P., Airoldi, L. and Anderson, J.M., 2005. Low-crested coastal defence structures as artificial habitats for marine life: using ecological criteria in design. Coast. Eng. 52, 1053-1071.

Moyle Interconnector Limited, 2008. Moyle Interconnector Trading from 1 October 2008. A paper prepared by Moyle Interconnector Limited and approved by the Northern Ireland Authority for Utility Regulation. 02 May 2008.

MSPP Consortium, 2006. Marine Spatial Planning Pilot. Final Report. February, 2006.

National Statistics, 2008. MA14 Research and Development in UK Businesses 2006. Information Notice. 13February 2008. www.statistics.gov.uk/downloads/theme_commerce/MA14_2006.pdf

National Trust, 2005. Shifting Shores: Living with a Changing Coastline.

National Trust, 2008. Annual Report 2007/08. Our Future – Join in.

Natural England, 2008. Natural England Annual Report and Accounts 2007/2008. No. 0727 2007-08.

Nautilus Consultants, 2005. The Motivation, Demographics and Views of South West Recreational Sea Anglers and their Socio-economic Impact on the Region. Invest in Fish South West report.

Naylor, R.L., Goldburg, R.J., Primavera, J.H., Kautsky, N., Beveridge, M.C.M., Clay, J., Folke, C., Lubchenco, J., Mooney, H. and Troell, M., 2000. Effect of aquaculture on world fish supplies. Nature 405, 1017-1024.

Nedwell, J.R., Turnpenny, A.W.H., Lovell, J.M., Langworthy, J., Howell, D. and Edwards, B., 2003. The effects of underwater noise from coastal piling on salmon (*Salmo salar*) and brown trout (*Salmo trutta*). Subacoustech Report No. 576R0113.

New Energy Focus, 2009a. Appeal for urgency in Pentland Firth connection bids. Hydro and Marine News, 20 March 2009.

New Energy Focus, 2009b. 40 bids in Round Three offshore wind programme. Wind News, 17 March 2009.

Newell, R.C., Seiderer, L.J. and Hitchcock, D.R., 1998. The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed. Oceanogr. Mar. Biol. 36, 127-178.

Newell, R.C., Seiderer, L.J., Simpson, N.M. and Robinson, J.E., 2004. Impacts of marine aggregate dredging on benthic macrofauna off the south coast of the United Kingdom. J Coastal Res. 20 115-125.

NIEA, 2009. Annual Report and Accounts 2008/09. Northern Ireland Environment Agency.

NOAA, 2006. Small Takes of Marine Mammals Incidental to Specified Activities; Rim of the Pacific (RIMPAC) Antisubmarine Warfare (ASW) Exercise Training Events Within the Hawaiian Islands Operating Area (OpArea). Federal Register 71 (No.78). National Oceanic and Atmospheric Administration.

NOCS, 2007. Review 2007-2008. National Oceanography Centre, Southampton.

Northern Ireland Energy holdings, 2009. The Moyle Interconnector. Available online at: www.nienergyholdings.com/The_Moyle_Interconnector/Index.php

Nowacek, D.P., Thorne, L.H., Johnston, D.W. and Tyack, P.L., 2007. Responses of cetaceans to anthropogenic noise. Mammal Rev. 37, 81-115.

O'Brien, C.M., Fox, C.J., Planque, B. and Casey, J., 2000. Climate variability and North Sea cod. Nature, 404, 142.

ODE, 2007. A Study of the Costs of Offshore Wind Generation. A Report to the Renewables Advisory Board and the Department for Trade and Industry. URN No. 07/779. Offshore Design Engineering Ltd.

OFMDFM, 2006. A Sustainable Development Strategy for Northern Ireland. Office of the First Minister and Deputy First Minister.

OGP, 2008 Guidelines for the Management of Naturally Occurring Radioactive Material (NORM) in the Oil and Gas Industry. Report no. 412. International Association of Oil and Gas Producers. www.ogp.org.uk/pubs/412.pdf

Oil & Gas UK, 2008. 2008 Economic Report.

Oil & Gas UK, 2009. 2009 Economic Report.

ONS, 2004. United Kingdom Input–Output Analyses, 2004. Edn October 2004 (consistent with the 2004 Blue Book). The Stationery Office. Office for National Statistics.

ONS, 2006. United Kingdom Input-Output Analyses. 2006. Office for National Statistics.

ONS, 2007a. United Kingdom National Accounts. The Blue Book 2007. Office for National Statistics.

ONS, 2007b. The UK Standard Industrial Classification of Economic Activities 2007 (SIC 2007). Structure and explanatory notes. Office for National Statistics.

ONS, 2008a. Annual Business Inquiry. Office for National Statistics. Available at: www.statistics.gov.uk/abi.

ONS, 2008b. Annual Survey of Hours and Earnings – First Release. Office for National Statistics.

ONS, 2008c. United Kingdom National Accounts: The Blue Book. Office for National Statistics.

ONS, 2009a. United Kingdom National Accounts: The Blue Book. 2009 Edition 06 August 2009. Office for National Statistics. www.statistics.gov.uk/downloads/theme_economy/BB09.pdf

ONS, 2009b. Annual Business Inquiry. Section B. Mining and Quarrying. Office for National Statistics. www.statistics.gov.uk/abi/2008-data.asp

OSPAR, 2000. Quality Status Report 2000. OSPAR Commission. 108 pp.

OSPAR, 2003. Preliminary outline of the potential problems related to the placement of cables (including high voltage cables), excluding those related to oil and gas activities. OSPAR Commission. Meeting paper: BDC 03/4/6.

OSPAR, 2004a. Environmental Impact of Oil and Gas Activities other than Pollution. OSPAR Commission.

OSPAR, 2004b. Problems and Benefits Associated with the Development of Offshore Wind-Farms. Biological Diversity and Ecosystems Series, OSPAR Commission. Publication No. 212/2004.

OSPAR, 2006a. Review of the Current State of Knowledge on the Environmental Impacts of the Location, Operation and Removal/Disposal of Offshore Wind Farms – Status Report, April 2006. Biological Diversity and Ecosystems Series, OSPAR Commission. Publication No. 278/2006.

OSPAR, 2006b. An Overview of the Environmental Impact of Non-Wind Renewable Energy Systems in the Marine Environment. Biological Diversity and Ecosystems Series, OSPAR Commission. Publication No. 280/2006.

OSPAR, 2008a. Assessment of the Environmental Impact of Offshore Wind Farms. Biological Diversity and Ecosystems Series, OSPAR Commission. Publication No. 385/2008.

OSPAR, 2008b. Guidance on Environmental Considerations for Offshore Wind Farm Development, Agreement 2008-3. OSPAR Commission.

OSPAR, 2008c. Database on Offshore Wind-farms. 2008 Update. Biological Diversity and Ecosystems Series, OSPAR Commission. Publication No. 364/2008.

OSPAR, 2008d. Literature review on the impacts of dredged sediment disposal at sea. Biodiversity Series. OSPAR Commission.

OSPAR, 2010. Quality Status Report 2000. OSPAR Commission.

Oxford Economics, 2007. The Economic Contribution of the UK Shipping Industry in 2007.

Oxford Economics, 2009. The Economic Contribution of Ports to the UK Economy. www.britishports.org.uk/files/Economic%20impact%20of%20ports%209%20March.pdf

Parliamentary Office of Science and Technology, 2005. Carbon Capture and storage (CCS).

Parsons, E.C.M., Warburton, C.A., Woods-Ballard, A., Hughes, A and Johnston, P., 2003. The value of conserving whales: the impacts of cetacean related tourism on the economy of rural West Scotland. Aquat. Conserv 13, 397-415.

Pascoe, S., 2006. Economics, fisheries, and the marine environment. ICES J. Mar. Sci., 63, 1-3.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R. and Torres Jr., F., 1998. Fishing down marine food webs. Science 279, 860-863.

Pawson, M.G., Pickett, G.D. and Walker, P., 2002. The coastal fisheries of England and Wales, Part IV: A review of their status 1999-2001. Sci. Ser. Tech. Rep.. CEFAS, Lowestoft, 116. 83 pp.

Peel, D. and Lloyd, M.G., 2008. Governance and planning policy in the marine environment: regulating aquaculture in Scotland. Geogr. J. 174, 361-373.

Perttilä, M., Kankaanpää, H., Kotilainen, A.L, Lehtoranta, J., Leivuori, M., Myrberg, K. and Stipa, T., 2006. Implementation of the north European gas pipeline project – data inventory and further need for data for environmental impact assessment. Finnish Institute of Marine Research, Report No. 58.

Pilcher, R. and Burston, P., 2002. Seas of Change – The Potential Area for Inter-tidal Habitat Creation around the Coast of Mainland Britain. Royal Society for the Protection of Birds.

Pilkey, O.H. and Dixon, K.L., 1996. The Corps and the Shore. Island Press. [Cited from Cooper & McKenna 2008].

Pinn, E.H. and Rodgers, M., 2005. The influence of visitors on intertidal biodiversity. Mar. Biol. Assoc. UK 85, 263-268.

Pinnegar, J.K., Sims, D.W. and Heath, M. 2008. MCCIP Annual Report Card 2007-2008 Scientific Review – Fish and Fisheries. Marine Climate Change Impacts Partnership. www.mccip.org.uk/arc/2007/PDF/Fish-and-Fisheries.pdf.

PML, 2007. Annual Review 2007. Plymouth Marine Laboratory.

PMSS, 2007. Wave Dragon Pre-Commercial Wave Energy Device. Environmental Statement. Volume 2. Document Number: 26906-2. Project Management Support Services Ltd.

POL, 2007. Annual Report 2006-07. Available at: www.bodc.ac.uk/about/annual_reports/documents/pol_annual_report_2006-2007.pdf. Proudman Oceanographic Laboratory.

Poseidon, 2004. Feeding the Fish: Sustainable Fish Feed and Scottish Aquaculture. A report to the Joint Marine Programme.

Posford Duvivier Environment and Hill, M.I., 2001. Guidelines on the Impact of Aggregate Extraction on European Marine Sites. www.ukmarinesac.org.uk/pdfs/aggregates-report.pdf. 126pp.

POST, 2006. Carbon Footprint of Electricity Generation. Parliamentary Office of Science and Technology Postnote, October 2006, Number 268.

PricewaterhouseCoopers, 2007. The Social and Economic Impact of Recreational Angling in Northern Ireland. A report to the Department of Culture, Arts and Leisure, The Loughs Agency of the Foyle, Carlingford and Irish Lights Commission and the Northern Ireland Tourist Board.

Pugh, D., 2008. Socio-Economic Indicators of Marine-Related Activities in the UK Economy. The Crown Estate. 68 pp.

Pugh, D. and Skinner, L., 2002. A New Analysis of Marine-related Activities in the UK Economy with Supporting Science and Technology. IACMST Information Document No. 10. 48 pp.

Radford, A., Riddington, G. and Gibson, H., 2009. Economic Impact of Recreational Sea Angling in Scotland. Prepared for the Scottish Government. July 2009.

RAG, 2008a. Combined RAG/COWRIE List of Environmental Issues and Research Topics V5-310807. Produced in association with Defra, Department for Transport and The Crown Estate. Research Advisory Group.

RAG, 2008b. Wave and Tidal Stream Energy Monitoring and Research Strategy V6-070906. Produced in association with Defra, Department for Transport and The Crown Estate. Research Advisory Group.

Rees, J., 2008. MCCIP Annual report Card 2007-2008 Review – Built Structures. Marine Climate Change Impacts Partnership.

Revill, A. and Doran, S., 2008. Further North Sea fishing trials with the 'Eliminator' ™ trawl. www.seafish.org/pdf.pl?file=seafish/Documents/Cefas_Pair%20team%20Eliminator%20report%202008%20FINAL.pdf.

Rijnsdorp, A.D, Piet, G.J. and Poos, J.J., 2001. Effort allocation of the Dutch beam trawl fleet in response to a temporary closed area in the North Sea. ICES CM 2001/N:01.

Ritchie, W., 2001. The environmental impact of changing uses on the North Sea littoral of Scotland. In: Denmark and Scotland: The Cultural and Environmental Resources of Small Nations. Edited by Fellows-Jensen, G. The Royal Danish Academy of Sciences and Letters. pp. 103-122.

Rogers, S.I., Tasker, M.L., Earll, R. and Gubbay, S., 2007. Ecosystem objectives to support the UK vision for the marine environment. Mar. Pollut. Bull. 54, 128-144.

Ronconi, R.A. and St Clair, C.C., 2002. Management options to reduce boat disturbance on foraging black guillemots (*Cepphus grille*) in the Bay of Fundy. Biol. Conserv. 108, 265-271.

Royal Commission on Environmental Pollution, 2004. Turning the Tide: Addressing the impact of Fisheries on the Marine Environment.

Royal Haskoning, 2003. Regional Environmental Assessment for Aggregate Extraction in the Eastern English Channel. Report for the Eastern Channel Association.

RWE, 2009. Electricity prices in the UK and in Central Eastern European markets. Report on the First Quarter of 2009. Available at: http://rwecom.online-report.eu/2009/ir/1/reviewofoperations/environment/ukelectricitypricesia.html

SAHFOS, 2007. Annual Report 2007. Available at: www.sahfos.ac.uk/annual_reports/annual%20rep%202007%20and%20Eco%20stat%20rep%202007/sahfos-ann-rep-2007-web.pdf

SAMS, 2007. Annual Report 2006-2007. Scottish Association for Marine Science.

SCF, 2004. A Strategy for Scotland's Coast and Inshore Waters. Scottish Coastal Forum.

Schiel, D.R., Steinbeck, J.R. and Foster, M.S., 2004. Ten years of induced ocean warming causes comprehensive changes in marine benthic communities. Ecology 85, 1833-1839.

Schröder, A., Orejas, C. and Joschko, T., 2006. Benthos in the Vicinity of Piles: FINO 1 (North Sea). In: Offshore Wind Energy Research on Environmental Impacts. Edited by Köller, J., Köppel, J. and Peters, W. Springer Berlin. pp. 185-200.

Scottish Executive, 2007a. Scottish Executive Geographic Information Service: Impact of Flooding in Scotland. In-house GIS analysis using the SEPA Indicative Flood Map.

Scottish Executive, 2007b. Scottish Flood Defence Asset Database: Final Report. JBA Consulting for the Scottish Executive.

Scottish Executive, 2007c. Scottish Marine Renewables: Strategic Environmental Assessment (SEA). Report prepared for the Scottish Executive by Faber Maunsell and Metoc PLC.

Scottish Executive, 2007d. Recommendations of the Advisory Group on Marine and Coastal Strategy. A Follow up to Seas the Opportunity: A Strategy for the Long Term Sustainability of Scotland's Coasts and Seas.

Scottish Executive, 1999. Policy Guidance Note: Locational Guidelines for the Authorisation of Marine Fish Farms in Scottish Waters. Available at: www.scotland.gov.uk/library2/doc06/mff-00.htm.

Scottish Executive Central Research Unit, 2002. Review and Synthesis of the Environmental Impact of Aquaculture.

Scottish Government, 2003. A Strategic Framework for Scottish Aquaculture.

Scottish Government, 2005. Seas the Opportunity: A strategy for the long-term sustainability of Scotland's coasts and seas.

Scottish Government, 2007. Scottish Sea Fisheries Statistics 2007. Available at: www.scotland.gov.uk/Publications/2008/09/04090427/0.

Scottish Government, 2008a. The Future of Flood Risk Management in Scotland: A Consultation Document.

Scottish Government, 2008b. Scottish Aquaculture – A Fresh Start. A consultation on a renewed strategic framework for Scottish Aquaculture.

Scottish Government, 2008c. Scottish Fisheries Council. News Release. 22 January 2008.

Scottish Government, 2008d. Scottish Transport Statistics: No. 27 – 2008 Edition. A National Statistics Publication for Scotland. www.scotland.gov.uk/Publications/2008/12/22091243/0

Scottish Government. 2008e. Sustainable Sea for All: A consultation on Scotland's first marine bill.

Scottish Government, 2009a. Marine Scotland. 2009 Strategy Statement. Available at: www.scotland.gov.uk/Publications/2009/03/31091025/3.

Scottish Government, 2009b. Real Time Closures Details for 2009 and Technical Measures Agreed at December Council. Available at: www.scotland.gov.uk/Resource/Doc/1061/0076199.doc.

Scottish Government, 2009c. Fish Conservation Efforts to Step Up. News Release. 3 February 2009.

Scottish Government, 2009d. Renewables Action Plan. News Release 1 July 2009. Available at: www.scotland.gov.uk/News/Releases/2009/07/01150922

Scottish Government, 2010. Live Closed Areas. Available at: http://www.scotland.gov.uk/Topics/Fisheries/Sea-Fisheries/COMPLIANCE/closures/closed

SDC, 2007. Turning the Tide. Tidal Power in the UK. Sustainable Development Commission.

SeaFAR, 2006. A Sustainable Framework for Scottish Sea Fisheries: Progress Report and Action Plan. Sea Fisheries Advisory and Reference Group. Scottish Executive.

Seafish, 2006. Towards a National Development Strategy for Shellfish in England.

Seafish, 2008. Fisheries Issues Management Report. July 2008. Available at: www.seafish.org/upload/file/fisheries_management/FMIR_July_08.pdf

SEMPTA, 2006. Sector Skills Agreement for the UK Marine Sector. The Sector Skills Council for Science, Engineering and Manufacturing Technologies.

SEPA, 2008a. Annual Report 2007-2008. Scottish Environment Protection Agency.

SEPA, 2008b. Scottish Bathing Waters 2008. Scottish Environment Protection Agency.

SEPA and EA, 2007. Benchmarking Report – A Review of Scottish Environment Protection Agency and Environment Agency Charging Schemes for 2005/2006. Scottish Environment Protection Agency, Environment Agency.

Sharpe, J., Hirons, G., Kew, J., Pilcher, R., Brooks, W. and Lamberth, C., 2002. Regulated tidal exchange: intertidal habitat without the tears. Proc. 37th DEFRA Conference of River and Coastal Engineers, Keele, 03-3-3.

Simmonds, M., Dolman, S. and Weilgart, L., 2003. Oceans of Noise: A Whales and Dolphins Conservation Society Science Report.

SMRU, 2007. Potential impact of Oil and Gas Exploration and Development on SACs for Bottlenose Dolphins and Other Marine Mammals in the Moray Firth and Cardigan Bay/Pembrokeshire. Report to the Department of Trade and Industry. Sea Mammal Research Unit. 13pp.

SNH, 2008a. Annual Report 2007/2008. Scottish Natural Heritage.

SNH, 2008b. Valuing our Environment: The Economic Impact of Scotland's Natural Environment. Scottish Natural Heritage.

SNIFFER, 2008. Coastal Flooding in Scotland: A Scoping Study. Final Report. Project FRM10. Scotland & Northern Ireland Forum for Environmental Research.

SOAEFD, 1996. Monitoring and assessment of the marine benthos at UK dredged materials disposal site. Scottish Fisheries Information Pamphlet No. 21. Scottish Office Agriculture, Environment and Fisheries Department.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene, Jr. C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A. and Tyack, P.L., 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33, 411-522.

Spalding, M.J. and de Fontaubert, C., 2007. Conflict Resolution for Addressing Climate Change With Ocean-Altering Projects. Environmental Law Reporter, News and Analysis 37, 10740-10746.

Speybroek, J., Bonte, D. and Courtens, W., 2006. Beach nourishment: an ecologically sound coastal defence alternative? A review. Aquat. Conserve. 16, 419-435.

SSTF, 2008. Marine Planning and Integrated Coastal Zone Management. Workshop report paper: Edinburgh, 9 April 2008. Sustainable Seas Task Force.

Statistics for Wales, 2009. Welsh Transport Statistics. Welsh Assembly Government.

STECF, 2007. Evaluation of closed area schemes (SGMOS-07-03). Scientific, Technical and Economic Committee for Fisheries. https://stecf.jrc.ec.europa.eu/docs.

STECF, 2008. Report of the SGRST-08-03 Working Group Fishing Effort Regime. Scientific, Technical and Economic Committee for Fisheries.

Streftaris, N., Zenetos, A. and Papathanassiou, E., 2005. Globalisation in marine ecosystems: the story of non-indigenous marine species across European seas. Oceanogr. Mar. Biol. 43, 419-453.

Symes, D., 2006. Fisheries governance: A coming of age for fisheries social science? Fish. Res. 81, 113-117.

Taft, E.P., 2000. Fish protection technologies: a status report. Environ. Sci. Policy 3, 349-359.

Taylor, C.J.L., 2006. The effects of biological fouling control at coastal and estuarine power stations. Mar. Pollut. Bull. 53, 30-48.

The Crown Estate, 2008a. Marine Aggregates. The Crown Estate Licences. Summary of Statistics 2007. Available at: www.thecrownestate.co.uk/aggregates_port_landing_stats_2007.pdf.

The Crown Estate, 2008b. Marine Aggregates. The Crown Estate Licences. Summary of Statistics 2008. Available from: www.thecrownestate.co.uk/aggregates_port_landing_stats_2008.pdf

The Crown Estate, 2009. The Crown Estate Announce Awards for Offshore Windfarms within Scottish Territorial Waters. Press release 16 February 2009. Available at: www.thecrownestate.co.uk/newscontent/92-scottish-offshore-windfarm-awards.htm

Thomsen, F., Ludemann, K., Kafemann, R. and Piper, W., 2006. Effects of offshore wind farm noise on marine mammals and fish. Biola, Hamburg, Germany translated for COWRIE Ltd.

Turnpenny, A.W.H., 2006. Fish impingement at estuarine power stations and its significance to commercial fishing. J. Fish Biol. 33, 103-110.

Turnpenny, A.W.H. and Bamber, R.N., 2006. The critical swimming of the sand smelt (*Atherina presbyter* Cuvier) in relation to capture at a power station cooling water intake. J. Fish Biol. 23, 65-73.

Turnpenny, A.W.H. and Coughlan J., 2003. Using water well? Studies of power stations and the aquatic environment. Innology plc.

Tyldesley, D., 2004a. Making the case for marine spatial planning in Scotland. Report commissioned by RSPB Scotland and RTPI in Scotland.

Tyldesley, D., 2004b. Irish Sea Pilot Project: Coastal and Marine Spatial Planning Framework. Report to the Joint Nature Conservation Committee.

Tyler-Walters, H., 2005. Assessment of the Potential Impacts of Coasteering on Rocky Intertidal Habitats in Wales. Report to Cyngor Cefn Gwlad Cymru / Countryside Council for Wales from the Marine Life Information Network (MarLIN). Marine Biological Association of the UK, Plymouth. CCW Contract no. NWR012.

UK CEED. 2000. A Review of the Effects of Recreational Interactions within UK European Marine Sites. Countryside Council for Wales (UK Marine SACs Project).

UK TAG, 2008. UK Environmental Standards and Conditions Phase 2. UK Technical Advisory Group on the Water Framework Directive.

UK Trade and Investment, 2007. UK Energy Excellence: An International Marketing Strategy for the UK's Energy Business. Available at: www.uktradeinvest.gov.uk/ukti/fileDownload/UKEnergyExcellenceBrochure.pdf?cid=412811

UKERC, 2008. UKERC Marine (Wave and Tidal Current) Renewable Energy Technology Roadmap, Energy Research Centre Marine (Wave and Tidal Current), June. Report by UK Energy Research Centre, Edinburgh.

UKHO, 2008. Annual Report and Accounts 2007/2008. The United Kingdom Hydrographic Office.

UKOOA, 2002. UKOOA Drill Cuttings Initiative Final Report February 2002. www.oilandgas.org.uk/issues/drillcuttings/pdfs/finalreport.pdf

University of Brighton, 2008. Strategic Plan for Water Related Recreation in the East of England.

Vincent, M.A., Atkins, S.M., Lumb, C.M., Golding, N., Lieberknecht, L.M. and Webster, M., 2004. Marine Nature Conservation and Sustainable Development – The Irish Sea Pilot. Report to the Department for Environment, Food and Rural Affairs by the Joint Nature Conservation Committee.

WAG, 2004a. Catching the Wave. Welsh Assembly Government.

WAG, 2004b. Interim Marine Aggregates Dredging Policy. Welsh Assembly Government.

WAG, 2007. Welsh Coastal Tourism Strategy. Draft Final Strategy Document. January 2007. Welsh Assembly Government.

WAG, 2008. Renewable Energy Route Map for Wales consultation on way forward to a leaner, greener and cleaner Wales, February. Welsh Assembly Government.

Walker, A.M., Beveridge, M.C.M., Crozier, W., Maoiléidigh, N.O. and Milner, N., 2006. Monitoring the incidence of escaped farmed Atlantic salmon, *Salmo salar* L., in rivers and fisheries of the United Kingdom and Ireland: current progress and recommendations for future programmes. ICES J. Mar. Sci. 63, 1201-1210.

Walmsley, S.A. and Pawson, M.G., 2008. The coastal fisheries of England and Wales, Part V: A review of their status 2005-6. Sci. Ser. Tech. Rep. CEFAS, Lowestoft, 116. 83 pp.

Walther, G-R., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T.J.C., Fromentin, J-M., Hoegh-Guldberg, O. and Bairlein, F., 2002. Ecological responses to recent climate change. Nature 416, 389-395.

Water UK, 2009. What the water industry is doing to mitigate climate change. Available at: http://www.water.org.uk/home/policy/climate-change/mitigation. Downloaded 22 Jan 2009.

Weilgart, L.S., 2007. The impacts of anthropogenic ocean noise on cetaceans and implications for management. Can. J. Zool. 85, 1091-1116.

Weston, D.P., 1990. Quantitative examination of macrobenthic community changes along an organic enrichment gradient. Mar. Ecol. Prog. Ser. 61, 233-244.

Wilding, T.A., Kelly, M.S. and Black, K.D., 2006. Alternative marine sources of protein and oil for aquaculture feeds: State of the art and recommendations for further research. The Crown Estate, 63pp.

Wilson, B., Batty, R.S., Daunt, F. and Carter, C., 2006. Collision risks between marine renewable energy devices and mammals, fish and diving birds. Report to the Scottish Executive. Scottish Association for Marine Science.

Woods-Ballard, A.J., Parsons, E.C.M., Hughes, A.J., Velander, K.A., Ladle,R.J. and Warburton, C.A., 2003.The sustainability of whale-watching in Scotland. J. Tourism 11, 40-55.

World Bank Group, 2004. Global Gas Flaring Reduction. A Public – Private Partnership. Regulation of Associated Gas Flaring and Venting: A Global Overview and Lessons. Report No. 3. World Bank Group.

Worlund, B., 2003. Reinsurance. Financial Times Information Ltd.

Yeoman, I., 2005. Understanding the Impact of Climate Change on Scottish Tourism. A report by Visit Scotland.

Yorkshire Forward, 2008. A carbon capture and storage network for Yorkshire and Humber: An introduction to understanding the transportation of CO_2 from Yorkshire and Humber emitters into offshore storage sites. June 2008.

Zakaia, D. and Chadwick-Furman, N.E., 2002. Impacts of intensive recreational diving on reef corals at Eilat, northern Red Sea. Biol. Conserv. 105, 179-187.

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