THE IRISH SEA PILOT

DEVELOPING MARINE NATURE CONSERVATION OBJECTIVES FOR THE IRISH SEA

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Executive summary

The purpose of the Irish Sea Pilot was to help develop a strategy for marine nature conservation that could be applied to all UK waters and, with international collaboration, the adjacent waters of the North-East Atlantic. The work fulfils a commitment made by the UK Government in May 2002, at the launch of *Safeguarding our Seas*, and was funded primarily by Defra with contributions from other partners.

A proposed framework for marine nature conservation, developed as part of Defra's Review of Marine Nature Conservation, envisaged the need to take action at a range of scales. These scales were i) the Wider Sea ii) the Regional Sea iii) Marine Landscapes and iv) Nationally-important habitats and species. The proposed framework anticipated that a range of measures would be needed to conserve marine biodiversity, including protected areas, spatial planning and other measures. The Pilot tested the practicality and potential method of operation of the proposed framework and the additional measures needed to put it into effect.

The aim of the work described in this report was to develop objectives for nature conservation, for each of the levels of the implementation framework, which contribute to delivery of the UK vision and strategic goals for the marine environment.

The report proposes a framework and process for developing objectives for use at the Whole Sea, Regional Sea and other scales. The key elements of this framework and the principles which should be considered in its development are described. These have been applied to identify an illustrative suite of conservation or 'ecological' objectives for the Irish Sea. These objectives include what previously may have been thought of as broader ecological or environmental objectives, for example in relation to water quality. This is because conservation has shifted away from the more 'traditional' focus on rare and threatened interests, to encompass all ecological components of the ecosystem, including more commonly occurring features, and the functional processes that support them. The conclusions of the Pilot emphasise the important and urgent need to manage and deliver this shift in approach.

The spatial scales at which objectives and targets would need to be developed have been considered. The Pilot concludes that many objectives would be most appropriately set at the Whole Sea or Regional Sea scales, economically and effectively capturing the ecological needs of the marine environment, and reducing the number of objectives needed and the potential conflict between them.

The potential contribution and importance of the conservation objectives to meeting the objectives of other sectors has been assessed and the substantial overlap of interests highlighted. The importance of developing and integrating conservation objectives with social, economic and other environmental interests within a single framework of objectives is highlighted, as is the need for transparent and inclusive processes to achieve this.

The development of objectives for nature conservation is used to illustrate how a more strategic, integrated and sustainable approach to objective-setting and decision-making could be developed, for planning and managing activities in the marine environment. In doing so, the report considers and makes recommendations on how the objectives framework could shape and strengthen links between the various elements of the UK Government's Marine Stewardship process. These include the UK marine monitoring strategy and programme and proposals to improve marine spatial planning.

Contents

Tables

Annexes

1. Background

The Irish Sea Pilot was undertaken to help develop a framework for marine nature conservation within a wider strategy for sustainable development in the marine environment. Such a framework would need to operate at a range of scales, from global to local, including at the scale of the biogeographic ecosystem (the 'Regional Sea'). Regional Seas in the North-East Atlantic area normally include waters within the jurisdiction of several countries. For this reason, it is hoped that the Irish Sea Pilot will be of interest and value to other countries. The policy context and background to the Pilot are summarised below.

On 1 May 2002, the Secretary of State for the Environment, Food & Rural Affairs launched the United Kingdom Government's Report *Safeguarding our Seas: A strategy for the conservation and sustainable development of our marine environment* (Defra 2002). The Report aimed to address the United Kingdom's international and European Union commitments to the conservation and sustainable development of the marine environment based on an ecosystem approach.

One of the important components of the developing strategy initiated through the publication of *Safeguarding our Seas* was the need to develop a framework for marine nature conservation set in the context of sustainable development. Such a framework would incorporate international obligations for nature conservation, particularly those arising from the UK's membership of the European Union, and contribute to delivery of the EU's marine thematic strategy.

During 2000, a draft framework for marine nature conservation was proposed by English Nature, and supported by the UK statutory nature conservation agencies and the Joint Nature Conservation Committee (Laffoley *et al* 2000). The geographical scope of the draft framework extended from high water mark out to the limits of UK jurisdiction. For the seabed, this is the area designated in accordance with the Continental Shelf Act 1964, and, for the water column, the area included within British fishery limits.

The proposed framework for marine nature conservation was one which could, with any necessary amendment and their agreement, be extended to the marine environment of neighbouring countries.

The aims of the Irish Sea Pilot were to:

- test the framework proposed in the paper on *'An implementation framework for the conservation, protection and management of nationally important marine wildlife in the UK'* (Laffoley *et al* 2000) prepared for the Review of Marine Nature Conservation (RMNC);
- set objectives for nature conservation, for each of the levels of the implementation framework, which aim to fulfil the strategic goals for the continental shelf waters;
- test ways of integrating nature conservation into key sectors in order to make an effective contribution to sustainable development on a regional basis;
- determine the potential of existing regulatory and other systems to deliver effective marine nature conservation, and identify any gaps; and
- recommend measures to fill the gaps identified.

Other work undertaken by or for the Irish Sea Pilot which is particularly relevant to developing conservation objectives includes:

- a marine landscape classification of the Irish Sea;
- the identification of nationally important areas and features;
- the collation of information on the human uses and socio-economic importance of the Irish Sea;
- the mapping of the sensitivity of marine landscapes, habitats species in the Irish Sea to human activities; and
- a review of legislation, governance and enforcement.

Details of this work are available as JNCC reports on www.jncc.gov.uk/marine/irishseapilot and described in the final report of the Irish Sea Pilot (Vincent *et al* 2004).

Reviews of the human uses of the Irish Sea, and the impacts of these activities upon it, have been undertaken by the Irish Sea Study Group (1990) and more recently as part of the OSPAR *Celtic Sea Quality Status Review* (OSPAR 2000). English Nature's *Maritime State of Nature Report – getting onto an even keel* report (Covey & Laffoley 2002) highlighted the decline in marine biodiversity. ICES have reviewed the environmental status of the European Seas (ICES 2003). These reports draw attention to significant adverse impacts of human activities upon marine ecosystems, with resultant degradation, decline or loss of their structure and function and richness and a corresponding reduction in the contribution made to socio-economic prosperity. The UK Government will publish its first State of the Seas report in 2004.

2. Aims of this report

The focus of the Pilot has been on marine nature conservation, its needs and future delivery and the contribution which it could make to sustainable development. This report considers the process by which to develop objectives for marine nature conservation. Government would need to consider equivalent processes for developing social, economic and other environmental objectives for the marine environment, and which are able to reconcile conflicts between objectives. The report uses the development of objectives for nature conservation to illustrate how a more strategic, integrated and sustainable approach to objective-setting and decision-making for the marine environment could be developed. In doing so, the report considers and suggests how the links between the various elements of the UK Government's Marine Stewardship process could be made and strengthened.

The report has the following aims:

- To develop and demonstrate a framework and process which the UK Government could use to translate the vision and strategic goals for the UK marine environment into clear environmental, social and economic objectives which define the protection, conservation and recovery requirements of the marine environment and the services which it provides;
- To illustrate how the framework could be used to help integrate the environmental, social and economic objectives into a single suite of objectives for the marine environment and translate this suite into the management actions necessary to deliver it;
- To show how the international obligations of the UK could be integrated within the framework and delivered through it;
- To illustrate how progress towards meeting these objectives and targets would be assessed, through use of marine indicators and monitoring programmes. In particular, to demonstrate the strategic value of such a framework to guide government in selecting an effective and economic suite of marine indicators for the UK marine environment;
- To show how such a framework would help government and others to evaluate and compare the sustainability of different management strategies and inform decision-making. In the framework developed by the Pilot, to illustrate how the conservation objectives would serve as a benchmark against which to assess the likely harm to the marine ecosystems from human activities and to guide the management of human activity;
- To demonstrate how the objectives and targets might be applied across the main spatial scales considered by the Pilot (the Wider Sea, Regional Sea, marine landscapes and nationally-important areas). In particular, to assess the potential to define the requirements of the marine environment more simply, effectively and economically by fewer objectives and targets, set at greater spatial scales;
- To demonstrate the potential contribution of objectives set for marine nature conservation to the delivery of social and economic objectives and sustainable development;
- To demonstrate how the framework facilitates the application of the ecosystem approach and reduces risks in decision-taking, in particular by ensuring that all components of the ecosystem are considered, not just the obvious or charismatic; and
- To demonstrate the central importance of such a framework to underpinning a new marine spatial planning system.

3. Guiding principles for an objectives framework

An overarching framework of our vision, strategic goals, objectives and targets is needed to help to define how future decisions relating to the management of the UK marine environment are made (Defra 2002). The Pilot has considered some of the guiding principles which may need to be adopted in developing such a framework. Links have been drawn to principles and proposals in the UK Government's Marine Stewardship process. It is suggested that the principles are likely to be transferable to equivalent processes in other national governments. The principles proposed by the Pilot are outlined below:

A single framework should be constructed around the vision and strategic goals for the UK marine environment or other sea area:

For the UK, the vision and the strategic goals have been set out in *Safeguarding our Seas* (Defra 2002) and in the Government's response to its *Seas of Change* consultation (Defra 2004), respectively:

Vision for the UK marine environment:

'Clean, healthy, safe, productive and biologically diverse oceans and seas'. We want to see this both nationally and globally. Within one generation we want to have made a real difference.

Strategic goals for the UK marine environment:

1. To conserve and enhance the overall quality of our seas, their natural processes and their biodiversity;
2. To use marine resources in a sustainable and environmentally sensitive manner in order to conserve ecosystems and achieve optimum environmental, social and economic benefit from the marine environment;
3. To promote and encourage economically and environmentally sustainable use of natural resources to ensure long term economic benefits and sustainable employment;
4. To increase our understanding of the marine environment, its natural processes and our cultural marine heritage and the impacts that human activities have upon them; and
5. To promote public awareness, understanding and appreciation of the value of the marine environment and seek active public participation in the development of new policies.

These strategic goals are bold, aspirational and easy to communicate. Together they form a set of goals for sustainable development in the marine environment.

From this set of strategic goals, more detailed environmental, social and economic objectives for the marine environment should be developed, and integrated, within the framework. The Pilot considered that there should be a clear line of sight between the vision and strategic goals for the marine environment in general, right through to the specific actions needed to deliver them.

The ecosystem approach and sustainable development principles should be applied in developing the framework and objectives:

The ecosystem approach and sustainable development require management that seeks to establish and maintain healthy marine ecosystems alongside resource use patterns that meet social and economic needs. This is something of balancing act. The complexity of this balancing act requires, among other things, that all the different sets of objectives (environmental, social and economic) are clearly expressed, communicated among decision-makers and treated as an integrated package. Nature conservation objectives need to be an

integral part of this process. Transparent and inclusive processes are required to translate the strategic goals into objectives, targets and management action, and to integrate and balance environmental, social and economic requirements. Sectors and stakeholders within a regional sea or other area would need to jointly develop, agree and work within such a framework of common objectives to conserve marine ecosystems and the social and economic benefits that they provide.

These processes should demonstrate the application, and progressive refinement, of the ecosystem approach and sustainable development principles adopted by government. The sustainable development principles set out in *Safeguarding our Seas* (Defra 2002) and ecosystem approach principles (Annex 1) should be used to develop a UK framework.

The framework needs to be capable of delivering international and European obligations for the marine environment:

Progress to deliver the aspirations set out by the UK, and by other Irish Sea governments, needs to deliver a range of international and European objectives and targets. These include:

International and European targets for the marine environment

1. Halt the decline of biodiversity across the European Union by 2010 (EU 6th Environmental Action Programme);
2. Encourage the ecosystem approach in marine management by 2010 (World Summit on Sustainable Development, 2002); ecosystem-based management approach formally endorsed by UK (5th North Sea Conference);
3. Identify and designate by 2010 relevant areas of the UK's seas as areas of marine protection belonging to a network of well managed sites (5th North Sea Conference and OSPAR Convention);
4. Restore depleted fish stocks to maximum sustainable yields by 2015 'where possible' (WSSD);
5. Maintain or restore natural habitats and species of wild fauna and flora to a favourable conservation status (EC Habitats Directive); and
6. Prevent further deterioration in and protect and enhance the status of aquatic ecosystems, including estuarine and coastal waters (EC Water Framework Directive).

The framework should enable, and demonstrate, the incorporation of these objectives and targets into the objectives and targets developed for the UK marine environment.

The framework should contain a single suite of objectives that collectively set out the UK's requirements and aspirations for the protection and sustainable use of the marine environment:

Although the Pilot has focused on nature conservation, the process for developing the framework needs, with appropriate sector and stakeholder participation, to be able to translate all of the strategic goals into an integrated suite of objectives, which define the environmental, social, economic requirements and aspirations for the marine environment.

Conservation objectives should identify what needs to be achieved to ensure that the marine ecosystem as a whole, including all its component parts, is sustained in, or recovered to, a healthy ecological state:

The conservation objectives developed by the Pilot are 'ecological' objectives. Nature conservation objectives explicitly focussing on research or on social and economic aspects eg social well-being, education, have not been considered by the Pilot. As such, the conservation objectives developed here include what previously may have been thought of as broader ecological or environmental objectives, for example in relation to water quality.

This is because conservation has shifted away from the more 'traditional' focus on rare and threatened interests, to encompass all ecological components of the ecosystem, including more commonly occurring features, and the functional processes that support them. The conclusions of the Pilot emphasise the important and urgent need to manage and deliver this shift in approach. It may be helpful to refer to such conservation objectives as ecological objectives in future. Together with social and economic objectives, and other environmental objectives, they would form a set of what are often called 'ecosystem objectives'.

The framework should contain the minimum number of objectives and targets necessary to define and meet our national requirements and aspirations and international commitments:

There is the potential to generate large numbers of objectives and targets and the more that are developed, the greater is the potential for conflict between them. The aim should be to develop the least complex and burdensome framework that is fit for purpose.

The framework should aim to be consistent with strategic goals and objectives being developed as part of the European marine thematic strategy:

It might be anticipated that strategic goals and objectives at a European level will overlap substantially with those at a national (UK) level.

The framework should take account of other relevant frameworks and initiatives:

Work undertaken on UK Biodiversity Action Plans, on the implementation of EC Directives, including Water Framework and Habitats, and by OSPAR and ICES on the development of Ecological Quality Objectives, is of particular relevance. Work being undertaken in Canada and Australia to develop an ecosystem approach to the management of regional scale marine ecosystems is also of relevance.

The framework should enable objectives to be linked explicitly to management decisions which may affect them and the management actions necessary to deliver them:

This should be achieved through the setting of objectives and targets at an appropriate level of detail.

The framework and objectives should provide a structure against which to review and revise the selection of marine indicators, for long term monitoring and for decision making:

This is particularly pertinent to the proposed development of a UK Marine Monitoring Strategy.

4. Key elements of an objectives framework

4.1 Key elements

The Pilot envisages that the framework would consist of the following hierarchical elements:

- Vision
- Strategic goals
- High-level objectives
- Ecosystem components
- Operational-level objectives
- Targets

The elements of the framework, and the processes for developing them, are considered below.

4.2 Vision

The vision for the UK environment is of "*Clean, healthy, safe, productive and biologically diverse oceans and seas. We want to see this both nationally and globally. Within one generation we want to have made a difference"* (Defra 2002).

These broad aspirations are likely to be shared by other Irish Sea governments, and by the international community as a whole.

4.3 Strategic goals

At the highest level of the framework, strategic goals and aims are stated in terms that are understandable to a broad audience, including managers, scientists and stakeholders. Goals and aims can be considered as policy statements by government, for example the strategic goals for the UK marine environment (see previous chapter). However, they are not described in a form that is specifically measurable. They also lack the specificity to be linked directly to management action.

4.4 High-level objectives

The strategic goals and aims need to be translated into objectives and targets which set out what needs to be achieved for the marine environment, at a level of detail at which they can be translated into management action. This first step in this process is to develop a suite of high-level objectives. These identify the key areas of ecosystem structure and function for which ecological objectives need to be considered.

4.5 Ecosystem components

Ecosystem components, sometimes referred to as Valued Ecosystem Components or Quality Elements, are the elements of the marine ecosystem which we need to consider in seeking to achieve the aims and high level objectives. Ecological components would include, for example, water quality, seabed habitats and trophic status. Social and economic components might include, for example, water quality also, commercially-exploited fish stocks and marine aggregates. There is likely to be considerable overlap between components identified as being of environmental, social and economic importance. Identification of these components, and overlaps between them, would be a critical area of stakeholder engagement.

4.6 Operational-level objectives

Operational-level objectives translate the high-level objectives into action statements for management. They specify the action that needs to be taken in respect of specific measurable ecosystem components or indicators and the target to be achieved. An example of an ecological operational objective would be *'to maintain spawning stock biomass of a (specified) commercial fish stock above its defined precautionary limit'*. Objectives could equally relate to a social or economic service which the marine ecosystem provides.

Management strategies and actions would be evaluated against their potential to deliver these objectives. Consequently, the objectives and the targets attached to them need to be practical – can they be implemented, and are we able to determine whether they are being met or not? The operational objectives and targets need to be 'SMART' (Specific, Measurable, Achievable, Result-oriented, Time-bound) (see Annex 2). These five criteria largely incorporate all the criteria for effective objective-setting defined by JNCC (1998), Delbaere (2002) and ICES advice to OSPAR.

In defining the operational objectives and the targets linked to them (and particularly when assessing progress towards meeting them) account needs to be taken of the natural variability of marine ecosystems. Some elements of marine ecosystems are highly dynamic whilst others are more stable. The operational objectives aim to safeguard the natural variability through protecting the marine environment from significant change due to human activity, thereby avoiding or minimising disturbance to natural variability and natural processes.

4.7 Targets

A target is a particular value of an operational objective, or indicator associated with the objective. Often they are referred to as Reference Points. Targets identify what we want or what we don't want. Identifying the target is a critical task for management purposes. It is the deviance of the objective or indicator from the target that informs decision-making and management action. Targets may take the form of limits, levels or trends.

Limits:

Some targets will be well quantified limits. Limits provide a mechanism for defining operational objectives that seek to protect the ecosystems and their components from harm. In the case of contaminants, for example, operational objectives might be to ensure that limits for contaminants set to protect human or ecosystem health are not exceeded. Similarly, objectives might require that fish stock spawning biomass is not allowed to fall below a precautionary lower limit, because to do so may result in serious impairment of productivity of the stock and slow or uncertain recovery. Because limits are associated with serious or irreversible harm to the marine ecosystem, the services provided by the ecosystem or to human health, they need to be avoided with a high probability.

Levels:

Some targets will aim to capture the values of the objectives or indicators which correspond to the state of the ecosystem or the services which it provides which society seeks to achieve, taking account of environmental, social and economic requirements. These are 'aspirational' targets. Some targets may relate to a historic state of the objectives or indicator, prior to significant human perturbation. Targets set to achieve good ecological status under the Water Framework Directive will be related to such Reference Conditions. Similar targets may need to be set to achieve favourable condition under the EC Habitats Directive. Some targets may depart substantially from the pristine state, for example where they relate to

sustainable exploitation, for example in seeking to optimise the sustainable yield from a fishery. It may be appropriate to include short and medium term interim targets as milestones, where longer term targets are set or need to met. Where there is insufficient information to set a quantitative target, a trend may be used to provide a directional steer relative to a baseline or limit. This still provides a clear policy steer and measure. The England Biodiversity Strategy adopts this approach.

Collectively, the targets should aim to define our key environmental, social and economic requirements for the sustainable use of the marine environment. Targets are the key stage for taking account of international obligations.

In contrast to the operational objectives themselves, targets (and the management actions being taken to implement them) would be likely to require amendment in the future. Targets would be based upon what specialists and experts consider appropriate and achievable at the time. As our understanding of marine ecosystems and the impacts of human activities on them improves, these targets may need to be reviewed and revised in an iterative process. This is likely to be the case for those ecosystem components for which we lack good baseline data at present. Similarly, future reviews of performance in achieving targets will improve our understanding of what we can achieve through management of human activities and may identify a need to make targets more or less stringent.

5. Developing an objectives framework

5.1 Introduction

The Pilot has developed and applied a framework comprising the key elements described in the previous chapter. It has used this to illustrate a process for translating the vision and strategic goals for the UK into objectives that define, collectively, the ecological needs of the marine environment of the Irish Sea. Although this process is illustrated with ecological examples, the Pilot considers that it could be applied equally to develop socio-economic objectives.

The framework of ecological aims and objectives developed is shown in Table 1. The process of developing the objectives is described below.

5.2 Strategic goals

The UK Government's strategic goals for the marine environment are set out in Chapter 3 above.

The objectives which the Pilot has developed within the framework are intended to address the first of these strategic goals, namely *'to conserve and enhance the overall quality of our seas, their natural processes and their biodiversity'* and to make a substantial contribution to the second goal '*to use marine resources in a sustainable and environmentally sensitive manner in order to conserve ecosystems and achieve optimum environmental, social and economic benefit from the marine environment'*. They would, however, make significant contributions also to the other three strategic goals. Equally, objectives developed under the strategic goal *'to increase our understanding of the marine ecosystem…'* would underpin objectives developed under all of the other strategic goals.

The Irish Sea regional sea (or UK marine environment as a whole) can be considered to consist broadly of three ecological structure and function components: the physical and chemical properties of the Regional Sea, its productivity and its biodiversity. The Pilot proposes that an aim should be set for each of these components as follows:

- to maintain the physical and chemical properties naturally characteristic of the ecosystem;
- to maintain each component of the ecosystem so that it can make its expected contribution to the food web;
- to prevent further loss of marine biodiversity, and promote its recovery where practicable, so as to maintain the natural richness and resilience of the ecosystem.

5.3 High-level objectives

For each of the aims, a series of high level conservation objectives has been developed. For example, under the first aim '*to maintain the physical and chemical properties naturally characteristic of the ecosystem* ' four high-level conservation objectives are proposed:

- to protect seabed features so that they can support the processes, habitats and species characteristic of the marine landscapes;
- to protect water column features so that they can support the processes, habitats and species characteristic of the water column;

- to protect the water quality of the component water column features so that they can support the processes, habitats and species characteristic of the water column and associated seabed habitats;
- to maintain biota quality.

The strategic goals, aims and high level objectives are generic and could be applied to the UK marine environment, the Irish Sea or other regional seas. At this level, once refined and agreed, it is envisaged that the framework would be unlikely to change significantly over time.

5.4 Ecosystem components

For each of these high-level objectives, an illustrative list of the main ecological components or characteristics of the marine ecosystem which need to be considered have been identified. For example, under the first high-level objective '*to protect seabed features so that they can support the processes, habitats and species characteristic of the marine landscapes*' the following ecosystem components or characteristics have been identified:

- Coastal morphology
    - coastal processes
- Seabed habitats
    - substratum type
    - particle size composition
    - topography
    - substratum structure
    - siltation
    - physical processes
    - chemical processes
- Biogenic structures
    - saltmarshes
    - eelgrass beds
    - *Sabellaria* spp reefs
    - *Modiolus* reefs

Again, at this level, the framework would be largely generic. There will be some biogeographic variation in components, for example the types of biogenic structures present. The framework could be applied across a range of marine ecosystems and spatial scales, to generate operational objectives which are appropriate to that ecosystem or scale. An important benefit of the framework is that it should provide a systematic approach to help identify an inventory or 'checklist' of key ecosystem components or characteristics, which can be used when setting operational objectives and targets for a Regional Sea or other area.

5.5 Operational-level objectives

The high-level objectives then need to be refined down to operational-level objectives, which address the conservation requirements of these ecosystem components. For example, for 'biogenic structures', the next level of objective applying to biogenic structures might be to: *'protect biogenic structures from ecologically-significant change due to human activity, and reverse such change where practical'*. At this level the objective cannot be associated directly with a management action. The objective could be refined further to develop an objective for *Modiolus* reefs to: '*recover the extent, distribution and quality of Modiolus reefs to* (*agreed) targets by (specified target date)'*. This objective could be linked with a

management action. Similarly, an objective '*to ensure that (specified) environmental standards are not exceeded*' could be linked to management action.

In the framework developed by the Pilot, this process has not been undertaken to the level of operational objectives but left at a level above this. This unpacking requires significant expert and technical advice, to ensure the ecological requirements of the marine ecosystem are captured in, and linked by, the objectives to the management of human activities, in the most effective and economic manner. It is also important that the operational objectives and targets for marine nature conservation should be developed in conjunction with social and economic objectives.

Again, many of these objectives are likely to be generic at a regional sea scale.

5.6 Targets

Targets have not been developed for the framework. Some targets are likely to be applicable at the Whole Sea scale, for example, environmental standards or limits set for contaminants. However, it is anticipated that the majority of targets would be specific to the particular environmental, social and economic needs of the individual Regional Sea. Targets specific to a Regional Sea, for example, might relate to particular marine landscape features or reflect the uses that are made of them, or define precautionary limits for a particular commercial fish stock. Targets may also be specific at a local scale, for example within a nationally important area.

5.7 Developing the framework at the UK level

To develop this framework at the UK level, the Pilot considers that the following actions would need to be taken:

- integrate the three high-level 'ecological' aims set out in the framework with the five strategic goals for the UK marine environment, by incorporating these aims into the framework, together with other high level environmental, social and economic aims or objectives, at the level below the strategic goals in the framework;
- identify the contributions to this framework which are made, or which would need to be made, through the EC Water Framework Directive, OSPAR work on Ecological Quality Objectives and other programmes, EC wildlife directives and the UK Biodiversity Action Plan; and
- put in place transparent and participative processes for developing, prioritising, balancing and agreeing the objectives and targets for the marine environment at UK and regional sea scales. Such processes would be fundamental to, and at the centre of, a strengthened strategic planning framework for the marine environment. Stakeholder participation in the process and ownership of the outcomes would be essential. The application of the principles of the ecosystem approach and sustainable development would be particularly important in this process.

Table 1 An objectives framework illustrated for ecological components of the marine ecosystem

Aim 1: To maintain the physical and chemical properties naturally characteristic of the ecosystem[1]		
High level objectives	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**
1. Protect seabed features so that they can support the processes, habitats and species characteristic of the marine landscapes.	Coastal morphology • coastal processes	1.1 Protect coastal processes from ecologically-significant change due to human activity, and reverse such change where practicable.
	Seabed habitats • substratum type • particle size composition • topography • substratum structure • siltation • physical processes • chemical processes	1.2 Protect seabed habitats from ecologically-significant change due to human activity, and reverse such change where practicable.
	Biogenic structures • saltmarshes • eelgrass beds • *Sabellaria* spp reefs • *Modiolus* reefs	1.3 Protect biogenic structures from ecologically-significant change due to human activity, and reverse such change where practicable.
2. To protect water column features so that they can support the processes, habitats and species characteristic of the waterbodies.	Water column features • Tides, waves, fetch, currents • Fronts • Stratification • Temporal changes • Freshwater inputs • Salinity • Suspended solids • Turbidity	2.1 Protect the water column features from ecologically-significant change due to human activity, and reverse such change where practicable.
3. Protect the water quality of the component water column features so they can support the processes, habitats and species characteristic of the water column and associated seabed habitats.	Water quality • Physico-chemical eg DO, temp • Nutrients • Dissolved gases	3.1 Maintain or recover water quality to within defined standards which aim to prevent 'undesirable disturbance' caused by eutrophication.
	Chemical pollutants • Non-synthetic pollutants eg trace metals • Synthetic pollutants • Radioactive elements	3.2 Ensure that environmental standards are not exceeded.
	Oil • Chronic • Acute	3.3 Ensure that environmental standards are not exceeded. 3.4 Reduce the input of oil from accidents, as far as practicable.
	Noise and vibration	3.5 Maintain noise and vibration levels below precautionary standards aimed at protecting vulnerable marine species from disturbance.
	Marine litter	3.6 Reduce input of litter to the marine environment to below levels aimed at protecting vulnerable marine habitats and species.
4. Maintain biota quality	Contaminants • Contaminant loads • Bioaccumulations • Health of animals	4.1 Ensure standards for contaminants in biota are not exceeded.

[1] 'Protect' or 'safeguard' may capture the requirements more appropriately than 'maintain'.

Table 1 (continued)

Aim 2: To maintain each component of the ecosystem so that it can make its expected contribution to the foodweb		
High level objective	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**
1. Maintain primary production within bounds of natural variability	Trophic status • nutrient concentrations, • water clarity, • chlorophyll a concentration	1.1 Ensure compliance with precautionary standards which aim to avoid 'undesirable disturbance' of trophic status.
2. Maintain trophic structure so that individual species and stages can sustain their characteristic roles in the foodweb	Trophic complexity • number of trophic levels • biomass at each trophic level	2.1 Ensure harvest of all species at a specified trophic level is below precautionary limits.
	Habitat availability: • pelagic habitats • benthic habitats • nursery areas • spawning areas • migration pathways	2.2 To protect the extent and function of habitats, areas and pathways from significant decline due to human activities.
	Predator-prey relationships • predator-induced mortality rates on prey populations • biomass of key dependent predators: o commercially exploited fish/shellfish o non-target fish species o benthic animals o birds o marine mammals	2.3 Reduce direct and indirect impacts upon prey populations to below levels at which their populations may be affected. 2.4 Reduce direct and indirect impacts upon key dependent predators to below levels at which their populations may be significantly affected.
3. Maintain mean generation times of populations within bounds of natural variability	Longevity • survivorship curves • mortality rate	3.1 Protect populations from changes in longevity which may have a significant impact upon the marine ecosystem, due to human activity.
	Life history strategy • changes in reproductive parameters (age of maturity, time of breeding) • lifetime reproductive success rates	3.2 Protect populations from changes in life history strategy which may have a significant impact upon the marine ecosystem, due to human activity.
	Reproductive potential • fecundity • spawning stock biomass	3.3 Maintain or recover the spawning stock biomass of commercially-exploited fish/shellfish above agreed precautionary biological limits. 3.4 In the longer term to maintain or recover spawning stock biomass above agreed precautionary ecological limits.
	Fishing mortality	3.5 Reduce fishing mortality of commercially-exploited fish/shellfish stocks to below agreed precautionary biological limits. 3.6 In the longer term to reduce fishing mortality further, to below precautionary agreed ecological limits.

Table 1 (continued)

Aim 3: To prevent further loss of marine biodiversity, and promote its recovery where practicable[2], so as to maintain the natural richness and resilience of the ecosystem		
High level objective	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**
1. Maintain habitats/ communities within bounds of natural variability	Trophic level balance • effective number of species within each trophic level • abundance of keystone species	1.1 Protect the trophic level balance from significant changes due to human activity.
	Habitat complexity • overall number of habitats/communities	1.2 Prevent a significant decline in the habitat complexity of marine ecosystems due to human activity.
	Areas identified as being the 'best representative examples' of the range of marine landscapes, water body features, habitats and species	1.3 Maintain the 'best representative examples' in, or recover them to, as close to their natural state as practicable.
	Rare and sensitive habitats	1.4 Protect rare and sensitive habitats from decline due to human activity.
	Habitats which are threatened by decline or have declined	1.5 Protect threatened habitats from decline due to human activity. 1.6 Enable habitats which have declined to recover to a non-threatened state, where practicable.
	Non-native species	1.7 Prevent the introduction of non-native species that may adversely impact the marine environment. 1.8 Reduce impacts of existing non-native species to below levels which risk affecting the marine ecosystem, where practicable.
2. Maintain species within bounds of natural variability	Overall diversity of species	2.1 Prevent significant changes in the overall species diversity of marine landscapes and water bodies due to human activity.
	• Important areas for highly mobile and migratory species • spawning/breeding • nursery • calving • feeding • nesting • migration bottlenecks	2.2 Protect the important areas for aggregations of mobile species (e.g. spawning/breeding, nursery, calving, feeding or nesting areas, and migration bottlenecks.
	Species which are threatened by decline or have declined	2.3 Safeguard species which are threatened by decline due to human activity. 2.4 Promote the recovery of species which have declined, to a non-threatened state, where practicable.
3. Maintain populations within bounds of natural variability	Structure among populations • metapopulation structure • distribution • habitat availability	3.1 Protect the structure among populations from significant change due to human activity.
	Structure within populations • population size • distribution • habitat availability • age structure	3.2 Protect the structure within populations from significant change due to human activity.
	Populations at risk	3.3 Protect populations defined to be at risk and recover them to non-at risk state, where practicable.
	Genetic diversity among populations	3.4 Protect the genetic diversity among populations from significant change due to human activity.
	Genetic diversity within populations	3.5 Protect the genetic diversity within populations from significant change due to human activity.

[2] At this aspirational level of objective, 'where practicable' may be an unnecessary caveat. It would be a critical requirement at the operational objectives level.

6. Spatial scales, objectives and targets

6.1 Spatial scales for setting objectives

The framework of conservation objectives as presented in Table 1 is largely generic and could, in principle, be applied to the Irish Sea or other regional sea, the UK marine environment or wider area.

The Pilot has considered the spatial scale or scales at which the ecological objectives and targets could be defined most effectively and economically to meet the needs of each of the ecosystem components identified in Table 1. For example, requirements to protect, conserve and recover seabed habitats may best be considered at the seabed marine landscape scale (across which there may be a greater similarity of seabed habitat types, human uses and conservation requirements across substantial areas of seabed) and at the nationally important areas scale (where there may be requirements for a higher level of protection for specific habitats). It follows that the operational objectives and targets developed for these ecosystem components may also need to be set at the same spatial scales.

An illustrative assessment of the most relevant scale or scales at which to define the operational objectives for ecosystem components is presented in Table 2. It suggests that the setting of operational objectives would need to consider all spatial scales. Importantly, however, it suggests that a large number of the conservation requirements of marine ecosystems might be defined by operational objectives and targets set at the whole sea and regional sea scales. It also identifies an important role for operational objectives set at the marine landscape scale (see Golding *et al* 2004) particularly for the protection of water quality and for protection and recovery of more widely dispersed habitats and species and for maintaining habitat and species diversity. Operational objectives would need to be set at the nationally important marine areas scale for certain habitats and species, where areas critical for their protection or recovery require a higher level of protection. This illustrates the shift in conservation strategy highlighted in 4.2.

For the list of marine ecosystem components identified in Table 2 it is possible to provide an indication of the proportion of these components for which the ecological requirements of the marine ecosystem might be captured at each of the four spatial scales under consideration. The approximate proportions are:

Whole Sea	20%
Regional Sea	70%
Marine Landscape	50%
Nationally important area	30%

Note that the sum is greater than 100% because some ecosystem components may need operational objectives set at more than one spatial scale.

6.2 Spatial referencing of objectives and targets

Operational objectives and targets would be referenced to maps showing the distribution of the ecosystem component to which they apply. This can already be done for existing European marine sites where, for example, operational objectives relating to salt marshes can be linked to maps showing their distribution and the targets associated with them. Other examples include objectives and targets for protecting spawning areas, areas for the protection or recovery of specific marine habitats eg *Modiolus* bed, or for the recovery of a particular fish stock or areas important for the exploitation of a particular resource.

The objectives and targets of other sectors could be mapped in a similar manner. This would be an important step in the process of integrating environmental, including the conservation objectives considered here, and socio-economic objectives across the range of sectors involved. In particular, it would help to analyse where objectives within or between sectors might complement or be in conflict with each other. It is likely that similar economy of scale could be applied to socio-economic objectives, through development of objectives at the whole sea, regional sea and marine landscape scales, where this is appropriate.

The ability to map the areas of the marine environment to which agreed and integrated environmental, social and economic operational objectives and targets apply is likely to be a fundamental requirement of an improved marine spatial planning system.

6.3 Nesting of objectives and targets

Objectives and targets must be nested, or integrate vertically, across the spatial scales from whole sea to local scale. In some cases, the targets would apply to the Whole Sea. In other cases, the targets would apply to specific areas such as a marine landscape or to critical areas for a particular habitats or species. Collectively, targets set at lower spatial scales must be consistent with, and make appropriate contributions to, targets set at higher spatial scales. Targets would need to be developed and reviewed in an iterative process, recognising that contributions to objectives would change with time across and between spatial scales.

Within an improved marine spatial planning framework (Tyldesley 2004; Vincent *et al* 2004), it should be possible to identify those parts of UK waters or the regional seas which would contribute to specific targets being achieved, and the contribution which they would need to make. Spatial referencing of the agreed targets for the sustainable development of the marine environment, including those for nature conservation, and of the actions necessary to deliver them, would be a key benefit of marine spatial planning. A similar nesting would need to be achieved in governance structures.

Table 2 Appropriate spatial scales for developing objectives

Aim 1: To maintain the physical and chemical properties naturally characteristic of the ecosystem			
High level objectives	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**	**Spatial scales which may be most appropriate for developing objectives**
1. Protect seabed features so that they can support the processes, habitats and species characteristic of the marine landscapes.	Coastal morphology • coastal processes	1.1 Protect coastal processes from ecologically-significant change due to human activity, and reverse such change where practicable.	Marine landscape
	Seabed habitats • substratum type • particle size composition • topography • substratum structure • siltation • physical processes • chemical processes	1.2 Protect seabed habitats from ecologically-significant change due to human activity, and reverse such change where practicable.	Marine landscape Nationally important area (habitat)
	Biogenic structures • saltmarshes • eelgrass beds • *Sabellaria* spp reefs • *Modiolus* reefs	1.3 Protect biogenic structures from ecologically-significant change due to human activity, and reverse such change where practicable.	Marine landscape Nationally important area (habitat)
2. To protect water column features so that they can support the processes, habitats and species characteristic of the waterbodies.	Water column features • Tides, waves, fetch, currents • Fronts • Stratification • Temporal changes • Freshwater inputs • Salinity • Suspended solids • Turbidity	2.1 Protect the water column features from ecologically-significant change due to human activity, and reverse such change where practicable.	Regional sea Marine landscape (water column)
3. Protect the water quality of the component water column features so they can support the processes, habitats and species characteristic of the water column and associated seabed habitats.	Water quality • Physico-chemical eg DO, temp • Nutrients • Dissolved gases	3.1 Maintain or recover water quality to within defined standards which aim to prevent 'undesirable disturbance' caused by eutrophication.	Regional sea Marine landscape (water column)
	Chemical pollutants • Non-synthetic pollutants eg trace metals • Synthetic pollutants • Radioactive elements	3.2 Ensure that environmental standards are not exceeded.	Whole sea Regional sea

Table 2 (continued)

Aim 1: To maintain the physical and chemical properties naturally characteristic of the ecosystem			
High level objectives	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**	**Spatial scales which may be most appropriate for developing objectives**
	Oil • Chronic • Acute	3.3 Ensure that environmental standards are not exceeded. 3.4 Reduce the input of oil from accidents, as far as practicable.	Whole sea Regional sea
	Noise and vibration	3.5 Maintain noise and vibration levels below precautionary standards aimed at protecting vulnerable marine species from disturbance.	Whole sea Nationally important area (species)
	Marine litter	3.6 Reduce input of litter to the marine environment to below levels aimed at protecting vulnerable marine habitats and species.	Whole sea
4. Maintain biota quality	Contaminants • Contaminant loads • Bioaccumulations • Health of animals	4.1 Ensure standards for contaminants in biota are not exceeded.	Whole sea Regional sea

Table 2 (continued)

Aim 2: To maintain each component of the ecosystem so that it can make its expected contribution to the foodweb			
High level objective	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**	**Spatial scales which may be most appropriate for developing objectives**
1. Maintain primary production within bounds of natural variability	Trophic status • nutrient concentrations, • water clarity, • chlorophyll a concentration	1.1 Ensure compliance with precautionary standards which aim to avoid 'undesirable disturbance' of trophic status.	Regional sea Marine landscape (water column)
2. Maintain trophic structure so that individual species and stages can sustain their characteristic roles in the foodweb	Trophic complexity • number of trophic levels • biomass at each trophic level • energy flows between trophic levels	2.1 Ensure harvest of all species at a specified trophic level is below precautionary limits.	Regional sea
	Habitat availability: • pelagic habitats • benthic habitats • nursery areas • spawning areas • migration pathways	2.2 To protect the extent and function of habitats, areas and pathways from significant decline due to human activities.	Regional sea Marine landscape Nationally important areas
	Predator-prey relationships • predator-induced mortality rates on prey populations • biomass of key dependent predators: o commercially exploited fish/shellfish o non-target fish species o benthic animals o birds o marine mammals	2.3 Reduce direct and indirect impacts upon prey populations to below levels at which their populations may be affected. 2.4 Reduce direct and indirect impacts upon key dependent predators to below levels at which their populations may be significantly affected.	Regional sea
3. Maintain mean generation times of populations within bounds of natural variability	Longevity • survivorship curves • mortality rate	3.1 Protect populations from changes in longevity which may have a significant impact upon the marine ecosystem, due to human activity.	Regional sea
	Life history strategy • changes in reproductive parameters (age of maturity, time of breeding) • lifetime reproductive success rates	3.2 Protect populations from changes in life history strategy which may have a significant impact upon the marine ecosystem, due to human activity.	Regional sea

Table 2(continued)

Aim 2: To maintain each component of the ecosystem so that it can make its expected contribution to the foodweb			
High level objective	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**	**Spatial scales which may be most appropriate for developing objectives**
	Reproductive potential • fecundity • spawning stock biomass	3.3 Maintain or recover the spawning stock biomass of commercially-exploited fish/shellfish above agreed precautionary biological limits. 3.4 In the longer term to maintain or recover spawning stock biomass above agreed precautionary ecological limits.	Regional sea
	Fishing mortality	3.5 Reduce fishing mortality of commercially-exploited fish/shellfish stocks to below agreed precautionary biological limits. 3.6 In the longer term to reduce fishing mortality further, to below precautionary agreed ecological limits.	Regional sea

Table 2(continued)

Aim 3: To prevent further loss of marine biodiversity, and promote its recovery where practicable, so as to maintain the natural richness and resilience of the ecosystem			
High level objective	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**	**Spatial scales which may be most appropriate for developing objectives**
1. Maintain habitats/ communities within bounds of natural variability	Trophic level balance • effective number of species within each trophic level • abundance of keystone species	1.1 Protect the trophic level balance from significant changes due to human activity.	Regional sea Marine landscape
	Habitat complexity • overall number of habitats/communities	1.2 Prevent a significant decline in the habitat complexity of marine ecosystems due to human activity.	Regional sea Marine landscape
	Areas identified as being the 'best representative examples' of the range of marine landscapes, water body features, habitats and species	1.3 Maintain the 'best representative examples' in, or recover them to, as close to their natural state as practicable.	Identified at regional sea & marine landscape scales Additional conservation needs addressed through objectives set at the nationally important area level
	Rare and sensitive habitats	1.4 Protect rare and sensitive habitats from decline due to human activity.	Marine landscape Nationally important areas
	Habitats which are threatened by decline or have declined	1.5 Protect threatened habitats from decline due to human activity. 1.6 Enable habitats which have declined to recover to a non-threatened state, where practicable.	Marine landscape Nationally important areas
	Non-native species	1.7 Prevent the introduction of non-native species that may adversely impact the marine environment. 1.8 Reduce impacts of existing non-native species to below levels which risk affecting the marine ecosystem, where practicable.	Whole sea
2. Maintain species within bounds of natural variability	Overall diversity of species	2.1 Prevent significant changes in the overall species diversity of marine landscapes and water bodies due to human activity.	Regional sea Marine landscape
	Important areas for highly mobile and migratory species • spawning/breeding • nursery • calving • feeding • nesting • migration bottlenecks	2.2 Protect the important areas for aggregations of mobile species (e.g. spawning/breeding, nursery, calving, feeding or nesting areas, and migration bottlenecks.	Regional sea Marine landscape Nationally important areas

Table 2(continued)

Aim 3: To prevent further loss of marine biodiversity, and promote its recovery where practicable, so as to maintain the natural richness and resilience of the ecosystem			
High level objective	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**	**Spatial scales which may be most appropriate for developing objectives**
	Species which are threatened by decline or have declined	2.3 Safeguard species which are threatened by decline due to human activity. 2.4 Promote the recovery of species which have declined, to a non-threatened state, where practicable.	Whole sea Regional sea Marine landscape Nationally important areas
3. Maintain populations within bounds of natural variability	Structure among populations • metapopulation structure • distribution • habitat availability	3.1 Protect the structure among populations from significant change due to human activity.	Regional sea
	Structure within populations • population size • distribution • habitat availability • age structure	3.2 Protect the structure within populations from significant change due to human activity.	Regional sea
	Populations at risk	3.3 Protect populations defined to be at risk and recover them to non-at risk state, where practicable.	Regional sea
	Genetic diversity among populations	3.4 Protect the genetic diversity among populations from significant change due to human activity.	Regional sea
	Genetic diversity within populations	3.5 Protect the genetic diversity within populations from significant change due to human activity.	Regional sea

7. Indicators

7.1 Role of indicators

Progress towards achieving strategic goals and the objectives for the marine environment is monitored through the use of indicators of ecosystem status and health or activity-specific ecosystem properties to link monitoring results to conclusions about the correspondence of the current state to the desired state.

There is a need to distinguish between indicators for long-term monitoring and indicators for informing a specific decision. The former provides information on changes in status of the ecosystem and progress towards achieving objectives. The latter enable the implications of decisions upon particular objectives to be evaluated and compared. From a decision perspective, an indicator needs to reliably report the direction of change, be sensitive to any key thresholds crossed and be sufficiently accurate to distinguish the relevant ranking of, and preference for, different policy options. Such indicators or indices might be designed to compare the biodiversity implications of management policies or actions, to aid decision-making.

There may be an opportunity to use higher level indicators and targets to cover a suite of operational objectives (for example, a marine equivalent to the 'farmland bird indicator). Summary metrics will inevitably mask some important attributes of biodiversity and regional discrepancies but if constructed carefully and interpreted cautiously they can lead to better decisions than by using more accurate but cumbersome alternatives, by the delivery of concise and compelling messages. Headline indicators for the marine environment might include the percentage of Marine Protected Areas in unfavourable recovering through to favourable condition. The proportion of coastal waters considered to be in good ecological status under the Water Framework Directive might also be a useful headline indicator. It is likely that a balance of high and low level indicators would be needed.

Laffoley *et al* (2002) provides examples of some indicators that may be relevant to the Irish Sea (Annex 3). The following chapter outlines work under the EC Water Framework Directive, the European Environmental Agency, OSPAR and other auspices, which needs to be taken into account in developing the objectives framework and an appropriate suite of indicators with which to monitor its implementation and achievement.

7.2 Benefits of the objectives framework

There is a need to ensure that the marine indicators used by the UK, Europe and international community provide the most effective and economic coverage of the marine environment as a whole, and avoid focusing on parts of it in isolation.

The development of marine indicators in the UK and Europe has, in general, focused on parts of the marine environment in isolation. The indicators currently in use reflect to a large extent the existence of particular monitoring programmes, and hence available data, and the requirements of specific European Directives eg Habitats Directive, Bathing Waters Directive, or international agreements. The implications of this are that:

- there are components of the marine environment for which we may have inadequate or no indicators by which to assess their state of health;
- the indicators that have been inherited may not be the most effective and economic for monitoring the state of the ecosystem, or to aid decision-making; and

- there is limited guidance on how to select the minimum number of indicators or indices needed to monitor progress and avoid being overwhelmed by detail.

An objectives framework such as that developed by the Pilot, and which integrates environmental, social and economic objectives, would provide a structure and checklist against which marine indicators and monitoring strategies could be evaluated and reviewed. Some indicators will be of greater value than others to inform whether the ecosystem is being used sustainably. Such a framework could be used to help assess what proportion of ecosystem monitoring requirements would be met by investing in a particular indicator or suite of indicators, to help ensure investment in the most appropriate indicators. The Pilot envisages that an objectives framework would be fundamental to the development of the UK Marine Monitoring Strategy and to review the requirements for future State of the Seas Reporting.

8. Integration with other frameworks and initiatives

8.1 Relevant initiatives and frameworks

The framework of strategic goals, objectives and targets being considered in this report needs to take account of other frameworks or initiatives in the Northeast Atlantic and within the EU which are developing objectives, indicators and targets for the marine environment. These include:

- the Water Framework Directive (WFD), particularly the new monitoring and assessment commitments introduced under Annexes II and V, including the characterisation of surface waters in terms of their physical attributes and the definitions of ecological status and development of biological quality elements that will be required;
- the European Environment Agency's DPSIR framework for indicator-based reporting, linking pressures to status, impacts and recommended responses;
- OSPAR and ICES work towards developing the tools (particularly Ecological Quality Objectives) that will be needed to implement the ecosystem approach to management in the North Sea agreed under the Bergen Declaration;
- European wildlife Directives; and
- the UK Biodiversity Action Plan.

These are considered below and in Table 3. Table 3 illustrates how an objectives framework along the lines of that suggested by the Pilot, might be used to achieve greater integration or harmonisation between these various work areas. It uses the conservation examples developed by the Pilot to identify where work being undertaken under these frameworks and initiatives might contribute to developing an appropriate suite of objectives, targets and indicators. Some of the issues which may need to be addressed in seeking greater integration or harmonisation are identified. The table also illustrates the potential value of such a framework to help identify where there may be inadequate coverage of marine ecosystem needs.

8.2 Water Framework Directive

The EC Water Framework Directive establishes a framework for Community action in the field of water policy. Its purpose is to establish a framework for the protection of inland surface waters, transitional waters (estuaries and brackish waters), coastal waters and groundwater that, amongst other things:

- prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems; and
- aims to enhance protection and improvement of the aquatic environment.

The Directive represents a significant new approach in European water legislation. Instead of defining targets as the absence of undesirable elements (e.g. unacceptable levels of named pollutants or eutrophication), this Directive has changed the conceptual approach by defining targets as the presence of desirable outcomes, such as balanced and natural aquatic ecosystems. It therefore incorporates both water quality and conservation objectives within

the overarching concept of achieving 'good ecological status' by the target date of 2016.

The general principle is that sites with existing 'high ecological status' will be used to define reference conditions for a number of 'biological quality elements' against which to assess the ecological status of other, similar, sites. The definitions of 'high status', 'good status' and 'moderate status' are very general. They relate to the simple concept that the target for water management activities should be water bodies containing biota characteristic of natural conditions with no or only very minor anthropogenic impacts (high status), low levels of distortion and only slight deviation from undisturbed conditions (good status), or moderate deviation from undisturbed conditions (moderate status), and so on.

8.3 OSPAR Ecological Quality Objectives

Under OSPAR, work is being undertaken on the use of Ecological Quality Objectives (EcoQOs) as a tool for setting clear operational environmental objectives directed towards specific management and serving as indicators for ecosystem health (Annex 4). This activity should be completed by 2004, and is being coordinated with the development of marine indicators in the EEA and environmental objectives in the EU Water Framework Directive. In the context of this work, Ecological Quality Elements are the individual aspects of overall Ecological Quality (e.g. concentrations of pollutants, biomass of a fish stock or trends in seal populations, while the Ecological Quality Objective is the desired level of that element.

Several initiatives are underway to define environmental quality objectives or environmental quality standards (EcoQO or EQS) for various purposes within Europe, the Northeast Atlantic and internationally, although not all of these targets are necessarily referred to by these titles, nor are all of relevance for the development of nature conservation objectives within the terms of this study.

At the Fifth International Ministerial Conference on the Protection of the North Sea, 2002, Bergen, the Ministerial Declaration recognised the need to manage all human activities that affect the North Sea in a way that conserves biological diversity and ensures sustainable development. The Ministers (including the UK) therefore agreed at their March 2002 meeting in Bergen, Norway, to establish an Ecosystem Approach to Management and laid out a conceptual framework to guide this new approach. This includes 'the use of ecological quality objectives (EcoQOs) as a tool for setting clear operational environmental objectives directed towards specific management and serving as indicators for the ecosystem health' (Annex 5).

The work being undertaken by OSPAR, in cooperation with ICES (Annex 6), is of major relevance to the UK's work on the development of operational objectives. The Biodiversity Committee of OSPAR have sought to develop a description of the conceptual framework for EcoQOs which sets out the way in which the EcoQOs are intended to be applied. A significant difficulty experienced with this is that the development of the pilot project on the EcoQOs for the North Sea has not explicitly considered how the system of EcoQOs should relate to the various other elements of the OSPAR work programmes, to other activities that are in progress at the same time, particularly the EC Water Framework Directive and the implementation of the EC Birds and Habitats Directives (OSPAR 2004), or across the marine ecosystem as a whole.

The current 10 broad features and objectives were identified to enable practical testing of the EcoQO concept and relied upon the existence of suitable monitoring baselines. It does not purport to be comprehensive. It has highlighted a number of difficulties, including:

- the difficulties of establishing such a framework;

- the difficulty of capturing and monitoring ecosystem requirements. The current elements and objectives do not provide a comprehensive enough coverage of the ecosystem as a whole. Whilst eutrophication elements may be captured relatively well, the non-eutrophication elements focus on very narrow elements of ecosystem eg individual species such as harbour porpoise. It is difficult to single out individual species and habitats as ecosystem representatives; and
- the cost implications of implementing a framework if the level of detail and complexity is too great. The existing coverage may not represent the most cost-effective coverage.

The framework suggested by the Pilot could provide a more holistic approach for defining objectives and targets for the marine ecosystem than is offered presently by the OSPAR Ecological Quality Objectives framework. As it stands, the OSPAR framework would contribute to delivering elements of the Pilot framework. There should be a reconciling of the framework suggested by the Pilot and the OSPAR framework.

8.4 European wildlife directives

The EC Habitats Directive requires Member States to protect areas that support certain natural habitats or species of plants or animals of Community interest listed in the Directive. It provides for a range of measures to achieve its objectives, including the selection, designation and protection of sites as Special Areas of Conservation (SACs) (http://www.ukmarinesac.org.uk/).

Under the Conservation (Natural Habitats, &c.) Regulations 1994 that transpose the requirements of the European Habitats and Birds Directives into UK law, the statutory nature conservation agencies have a duty to advise other relevant authorities, as soon as possible after a site becomes a European marine site, as to: '*the conservation objectives for that site'* and '*any operations which may cause deterioration of natural habitats or the habitats of species, or disturbance of species, for which the site has been designated.*' These provisions enable some of the major requirements of the Habitats Directive to be met, namely:

- European marine sites should be managed in order to contribute to the maintenance or restoration at the favourable conservation status of their natural habitats and species.
- In European marine sites steps shall be taken to avoid the deterioration of the habitats, the habitats of the species or the disturbance of species for which the site has been designated.
- A programme of monitoring will be undertaken at each site, to monitor the condition of conservation features of the site and to assess the effectiveness of management measures undertaken.

The UK country conservation agencies have developed guidance for setting conservation objectives for interest features on all sites, describing broad targets which should be met if the feature is to be judged favourable. The attributes that can be used to help define favourable condition may include species population size, structure, habitat requirements and distribution. For habitats, attributes may include area covered, key species, composition and structure and supporting processes. The Joint Nature Conservation Committee has published common standards for monitoring designated sites (JNCC 1998). Examples of conservation objectives, attributes and targets may be found in English Nature (2000) and English Nature and Scottish Natural Heritage (2000).

Conservation objectives are already in place for a range of marine protected areas including:

- marine Natura sites designated under the EC Habitats and Birds Directives (candidate Special Areas of Conservation, Special Protection Areas);
- Marine Nature Reserves, Marine Natural Heritage Areas, Sites of Special Scientific Interest and Areas of Special Scientific Interest; and
- areas protected for other purposes, for example fisheries management, that have objectives which may contribute directly, through protecting fish stocks, or indirectly, through protecting other species or habitats, to marine nature conservation.

These conservation objectives and those set for other marine protected areas or nationally important areas (Lieberknecht *et al* 2004b) should comprise an integral part of a framework of strategic goals and objectives for the UK marine environment. The operational objectives for these areas should identify where a more stringent target than is applied to the marine ecosystem as a whole, needs to be applied to a part or the whole of the area to protect or recover one or more ecosystem components, to achieve the objectives for which the area has been established.

In addition to protecting the features for which they have been designated, existing marine protected areas may make, or have the potential to make, a wider contribution to the protection, conservation and recovery of the marine environment. For example, this might include safeguarding the genetic diversity of some species populations at the regional or whole sea scales. Objectives, management schemes and actions for these marine protected areas may need to be reviewed against the requirements of the objectives framework, and revised where it is found that areas need to make a greater contribution to conservation of the marine environment.

Operational objectives for a marine protected area might aim, for example:

- to protect ecosystem components from a damaging activity;
- to promote the recovery of ecosystem components where they have declined or been damaged as a consequence of human activity; and/or
- to maintain specific areas in, or restore them to, as close to reference conditions (undisturbed by human activities) as possible, for research or conservation purposes.

8.5 UK Biodiversity Action Plan

Biodiversity Action Plans (BAPs) were produced by the UK Biodiversity Group for a large number of maritime species and habitats as part of the Government's response to the Biodiversity Convention. Features covered by BAPs include several of the Irish Sea habitats and species which might require the development of nature conservation objectives under this study. Each published BAP specifies 'Action plan objectives and proposed targets'.

The development of objectives framework for the Irish Sea, or UK marine environment, should take account of the objectives and targets identified under the UK Biodiversity Action Plan process. The UK BAP has made less progress with setting objectives and targets for broad marine habitat types. This reflects in part the relative lack of information on the distribution and conservation needs of these habitat types. The regional sea and marine landscape scales within the marine nature conservation framework being trialled by the Pilot should help address this gap. For example, the marine landscape classification and mapping developed by the Pilot (Golding *et al* 2004) provides a spatial framework within which the human uses and conservation needs can be considered for large areas of the marine ecosystem and objectives and management actions agreed to achieve their sustainable use.

8.6 UK work on marine indicators and monitoring

UK monitoring of the marine environment in relation to European and international obligations (for example under the Water Framework Directive and OSPAR) is coordinated by the Marine Pollution Monitoring Management Group (MPMMG). This group provides the scientific coordination necessary to provide a common approach between government departments and agencies to monitoring marine environmental quality under these obligations and undertaking the related research that supports this monitoring.

The National Marine Monitoring Programme (NMMP) was established in 1993 to monitor long-term trends in ecosystem and biological diversity, trophic status and environmental pollution. The NPMMG reported on the Quality of UK Coastal Waters in 1998, the first of a proposed series, and established inter-agency task teams to coordinate classification and typology for coastal and transitional waters under the Water Framework Directive. The NMMP has been sampling a network of estuarine and coastal sites annually since 1999 using internationally-recognised quality control schemes for field sampling and analysis. The NMMP may need to be revised to ensure that it includes coverage of the indicators necessary to monitor progress towards achieving objectives and targets agreed for sustainable development of the marine environment.

Several UK marine monitoring workshops have contributed not only towards improving national monitoring, but also to the international development of robust indicators of marine environmental quality (e.g. Jones 2002), using the DPSIR approach. These have largely been funded by DEFRA but were organised by various other government marine laboratories or agencies. The outputs from these workshops will contribute to the development of a UK Marine Monitoring Strategy. The strategic goals and objectives framework suggested by the Pilot should inform the development of this monitoring strategy.

Other Defra and associated agency monitoring initiatives include the Centre for Environment, Fisheries and Aquaculture Science's (CEFAS) ongoing work on fisheries, aggregate extraction and other marine activities, and the preparation of a Defra Quality Status Report for the Irish Sea.

Close integration between the objectives framework and marine monitoring strategy and programmes would be essential. The development of an objectives framework for the UK marine environment should help guide the development of the UK marine monitoring strategy. The National Marine Monitoring Programme should then be reviewed and revised to meet the needs of the framework and strategy.

8.7 European Environment Agency's DPSIR framework

The mandate of the European Environment Agency (EEA) includes the development of an indicator-based reporting strategy using a DPSIR framework (Driving force, Pressure, State, Impact and Response, e.g. Elliott (2002)) in order to provide regular information on environmental trends at the European level. In order to do so, it seeks to develop a defined core set of indicators, organised by theme, that enable links to be identified between pressures on the environment and their impact or changes on the ecosystem. By establishing the links between indicators of the pressures on the marine environment, its state and the response measures taken, the DPSIR approach can provide more informed feedback on the effectiveness of management measures. The DPSIR methodology provides a structured approach to identifying indicators within the proposed conservation framework. Experience from workshops on indicators for the marine environments suggests that Pressure, State and Response indicators may be simpler to develop and the most useful.

Some of these indicators are being developed under the EEA work programme, but in most cases the data being used for monitoring come from other organisations (ICES is the EEA's main source of marine data). The assessment may also come from another source, and it is necessary for the EEA to use indicators from these external sources as well as those developed by its own European Topic Centres.

The former European Topic Centre for marine and coastal environment developed and tested a number of state and pressure indicators for eutrophication and hazardous substances. The Topic Centre for Water is tasked with the development of a core set of indicators covering all water types, freshwater, groundwater, transitional and coastal. About 30 indicators relate to estuarine, brackish and coastal waters. These will be developed further as additional datasets become available and the Water Framework Directive is implemented.

The Topic Centre on Nature Protection and Biodiversity is in charge of providing the core set of Biodiversity Indicators. The Centre has reviewed all international initiatives underway at various geographical levels that aim at developing operational indicators for specific fields of interest such as sustainable development, agriculture, landscapes and biodiversity (Delbaere 2002). The following criteria for biodiversity indicators were considered most important, although not all were applied to the indicators listed in the report (because few indicators can fulfil all the criteria). Biodiversity indicators should:

- be easy to understand and policy-relevant;
- provide factual, quantitative information;
- be normative (possibility to compare to a baseline situation)
- be scientifically sound and statistically valid;
- be responsive to change in time/space;
- be technically feasible and cost-efficient to use within acceptable limits (in terms of data collection);
- be useable for scenarios for future projections;
- allow comparison between member states;
- allow aggregation at national and multinational level;
- take into account country-specific biodiversity;
- be user-driven.

Indicators were considered to provide useful tools for monitoring the main objectives of the following biodiversity related global and European policy instruments, many of which are of relevance to the Irish Sea pilot study:

- Ramsar Convention (1971);
- Bern Convention (1979);
- Bonn Convention (1979);
- EC Birds Directive (1979);
- EC Habitats Directive (1992);
- Convention on Biological Diversity (1992);
- Pan-European Biological and Landscape Diversity Strategy (1995);

- EC Water Framework Directive (2000);
- EC Biodiversity Strategy (1998) and Biodiversity Action Plans (2001);
- EU Sustainable Development Strategy (2001);
- Sixth Environment Action Programme (2001).

Delbaere (2002) highlights a problem that in many cases the objectives or targets specified by the above instruments are not quantifiable or SMART but are rather generic in their terms and scope. A framework similar to that suggested by the Pilot would be helpful in considering linkages between these broader objectives and targets and the specific objectives, targets, indicators and management actions through which they should be delivered and monitored.

Annex 7 provides an example of how the DPSIR methodology might be applied to help define and monitor illustrative operational objectives for a biogenic reef habitat (*Sabellaria spinulosa* reef).

Table 3 Integration with other frameworks and initiatives

Aim 1: To maintain the physical and chemical properties naturally characteristic of the ecosystem			
High level objectives	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**	**Examples of frameworks and initiatives which need to be taken into account**
1. Protect seabed features so that they can support the processes, habitats and species characteristic of the marine landscapes.	Coastal morphology • coastal processes	1.1 Protect coastal processes from ecologically-significant change due to human activity, and reverse such change where practicable.	Shoreline Management Plans, Coastal Habitat Management Plans and Coastal Strategies – need to incorporate appropriate objectives, targets, indicators and actions.
	Seabed habitats • substratum type • particle size composition • topography • substratum structure • siltation • physical processes • chemical processes	1.2 Protect seabed habitats from ecologically-significant change due to human activity, and reverse such change where practicable.	Shoreline Management Plans – need to incorporate BAP and/or other coastal habitat targets; Defra High Level Target flood and coastal defence reporting – changes in BAP habitats arising from schemes; Water Framework Directive – hydromorphological quality element of good ecological status; Defra/CEFAS work on seabed disturbance indicators; COST-IMPACT research on seabed disturbance and sediment/water nutrient fluxes.
	Biogenic structures • saltmarshes • eelgrass beds • *Sabellaria* spp reefs • *Modiolus* reefs	1.3 Protect biogenic structures from ecologically-significant change due to human activity, and reverse such change where practicable.	BAP Habitat Action Plans - contain objectives, indicators and targets which may need to be reviewed.
2. To protect water column features so that they can support the processes, habitats and species characteristic of the waterbodies.	Water column features • Tides, waves, fetch, currents • Fronts • Stratification • Temporal changes • Freshwater inputs • Salinity • Suspended solids • Turbidity	2.1 Protect the water column features from ecologically-significant change due to human activity, and reverse such change where practicable.	Water Basin Management Plans – links to freshwater inputs, salinity and suspended solids.

Table 3(continued)

Aim 1: To maintain the physical and chemical properties naturally characteristic of the ecosystem			
High level objectives	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**	**Examples of frameworks and initiatives which need to be taken into account**
3. Protect the water quality of the component water column features so they can support the processes, habitats and species characteristic of the water column and associated seabed habitats.	Water quality • Physico-chemical (eg DO, temp) • Nutrients • Dissolved gases	3.1 Maintain or recover water quality to within defined standards which aim to prevent 'undesirable disturbance' caused by eutrophication.	OSPAR EcoQOs; Water Framework Directive - classification scheme development and objectives for 'good ecological status for estuarine and coastal waters;. Defra – NE Irish Sea work to identify indicators of undesirable disturbance caused by eutrophication; Bathing Water Directive (essentially microbiological, related to human health); Urban Wastewater Treatment Directive – standards and indicators.
	Chemical pollutants • Non-synthetic pollutants (eg trace metals) • Synthetic pollutants • Radioactive elements	3.2 Ensure that environmental standards are not exceeded.	Environment Agency
	Oil • Chronic • Acute	3.3 Ensure that environmental standards are not exceeded. 3.4 Reduce the input of oil from accidents, as far as practicable.	Environment Agency – discharge standards; MARPOL – discharge standards; OSPAR EcoQOs.
	Noise and vibration	3.5 Maintain noise and vibration levels below precautionary standards aimed at protecting vulnerable marine species from disturbance.	JNCC Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys.
	Marine litter	3.6 Reduce input of litter to the marine environment to below levels aimed at protecting vulnerable marine habitats and species.	MARPOL.
4. Maintain biota quality	Contaminants • Contaminant loads • Bioaccumulations • Health of animals	4.1 Ensure standards for contaminants in biota are not exceeded.	Water Framework Directive – considering standards for endocrine disruption, sub-lethal effects, bioaccumulation OSPAR EcoQOs – seabirds.

Table 3(continued)

Aim 2: To maintain each component of the ecosystem so that it can make its expected contribution to the foodweb			
High level objective	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**	**Examples of frameworks and initiatives which need to be taken into account**
1. Maintain primary production within bounds of natural variability	Trophic status • nutrient concentrations, • water clarity, • chlorophyll a concentration	1.1 Ensure compliance with precautionary standards which aim to avoid 'undesirable disturbance' of trophic status.	Water Framework Directive - classification scheme development and objectives for 'good ecological status for estuarine and coastal waters. Defra – NE Irish Sea work to identify indicators of undesirable disturbance caused by eutrophication for offshore?
2. Maintain trophic structure so that individual species and stages can sustain their characteristic roles in the foodweb	Trophic complexity • number of trophic levels • biomass at each trophic level • energy flows between trophic levels	2.1 Ensure harvest of all species at a specified trophic level is below precautionary limits.	ICES – stock assessments, TACs and reference points OSPAR EcoQOs
	Habitat availability: • pelagic habitats • benthic habitats • nursery areas • spawning areas • migration pathways	2.2 To protect the extent and function of habitats, areas and pathways from significant decline due to human activities.	EC/Fisheries departments/Sea Fisheries Committees – fisheries protected areas and recovery plans
	Predator-prey relationships • predator-induced mortality rates on prey populations • biomass of key dependent predators: o commercially exploited fish/shellfish o non-target fish species o benthic animals o birds o marine mammals	2.3 Reduce direct and indirect impacts upon prey populations to below levels at which their populations may be affected. 2.4 Reduce direct and indirect impacts upon key dependent predators to below levels at which their populations may be significantly affected.	Defra – cetacean by-catch strategy Biodiversity Action Plans EC/Fisheries departments/Sea Fisheries Committees – fisheries management, legislation, technical measures. Water Framework Directive – some coastal benthic communities, whole fish communities? OSPAR EcoQOs – sea mammals, seabirds

Table 3(continued)

Aim 2: To maintain each component of the ecosystem so that it can make its expected contribution to the foodweb			
High level objective	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**	**Examples of frameworks and initiatives which need to be taken into account**
3. Maintain mean generation times of populations within bounds of natural variability	Longevity • survivorship curves • mortality rate	3.1 Protect populations from changes in longevity which may have a significant impact upon the marine ecosystem, due to human activity.	ICES EC/Fisheries departments/Sea Fisheries Committees – fisheries management, legislation, technical measures.
	Life history strategy • changes in reproductive parameters (age of maturity, time of breeding) • lifetime reproductive success rates	3.2 Protect populations from changes in life history strategy which may have a significant impact upon the marine ecosystem, due to human activity.	EC/Fisheries departments/Sea Fisheries Committees – fisheries management, legislation, technical measures.
	Reproductive potential • fecundity • spawning stock biomass	3.3 Maintain or recover the spawning stock biomass of commercially-exploited fish/shellfish above agreed precautionary biological limits. 3.4 In the longer term to maintain or recover spawning stock biomass above agreed precautionary ecological limits.	ICES – stock assessments, TACs and reference points OSPAR EcoQOs spawning stock biomass Biodiversity Species Action Plans – commercial stocks including skates and rays
	Fishing mortality	3.5 Reduce fishing mortality of commercially-exploited fish/shellfish stocks to below agreed precautionary biological limits. 3.6 In the longer term to reduce fishing mortality further, to below precautionary agreed ecological limits.	ICES – stock assessments, TACs and reference points OSPAR EcoQOs Biodiversity Species Action Plans – commercial stocks including skates and rays

Table 3(continued)

Aim 3: To prevent further loss of marine biodiversity, and promote its recovery where practicable, so as to maintain the natural richness and resilience of the ecosystem			
High level objective	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**	**Examples of frameworks and initiatives which need to be taken into account**
1. Maintain habitats/ communities within bounds of natural variability	Trophic level balance • effective number of species within each trophic level • abundance of keystone species	1.1 Protect the trophic level balance from significant changes due to human activity.	Water Framework Directive - classification scheme development and objectives for 'good ecological status for estuarine and coastal waters – some benthic communities in estuaries and coastal waters?
	Habitat complexity • overall number of habitats/communities	1.2 Prevent a significant decline in the habitat complexity of marine ecosystems due to human activity.	
	Areas identified as being the 'best representative examples' of the range of marine landscapes, water body features, habitats and species	1.3 Maintain the 'best representative examples' in, or recover them to, as close to their natural state as practicable.	European wildlife directives OSPAR Marine Protected Areas Other Marine Protected Area legislation
	Rare and sensitive habitats	1.4 Protect rare and sensitive habitats from decline due to human activity.	Biodiversity Habitat Action Plans – take account of in developing operational objectives
	Habitats which are threatened by decline or have declined	1.5 Protect threatened habitats from decline due to human activity. 1.6 Enable habitats which have declined to recover to a non-threatened state, where practicable.	Biodiversity Habitat Action Plans – take account of in developing operational objectives
	Non-native species	1.7 Prevent the introduction of non-native species that may adversely impact the marine environment. 1.8 Reduce impacts of existing non-native species to below levels which risk affecting the marine ecosystem, where practicable.	International Maritime Organisation

Table 3(continued)

Aim 3: To prevent further loss of marine biodiversity, and promote its recovery where practicable, so as to maintain the natural richness and resilience of the ecosystem			
High level objective	**Ecosystem components (illustrative)**	**Requirements of the 'operational' objectives**	**Examples of frameworks and initiatives which need to be taken into account**
2. Maintain species within bounds of natural variability	Overall diversity of species	2.1 Prevent significant changes in the overall species diversity of marine landscapes and water bodies due to human activity.	
	Important areas for highly mobile and migratory species • spawning/breeding • nursery • calving • feeding • nesting • migration bottlenecks	2.2 Protect the important areas for aggregations of mobile species (e.g. spawning/breeding, nursery, calving, feeding or nesting areas, and migration bottlenecks.	
	Species which are threatened by decline or have declined	2.3 Safeguard species which are threatened by decline due to human activity. 2.4 Promote the recovery of species which have declined, to a non-threatened state, where practicable.	BAP Species Action Plan targets –review. Species subject to BAP Species Action Plans (see also EcoQOs) – review species covered. Focus on species whose needs are not met through wider measures.
3. Maintain populations within bounds of natural variability	Structure among populations • metapopulation structure • distribution • habitat availability	3.1 Protect the structure among populations from significant change due to human activity.	
	Structure within populations • population size • distribution • habitat availability • age structure	3.2 Protect the structure within populations from significant change due to human activity.	
	Populations at risk	3.3 Protect populations defined to be at risk and recover them to non-at risk state, where practicable.	
	Genetic diversity among populations	3.4 Protect the genetic diversity among populations from significant change due to human activity.	
	Genetic diversity within populations	3.5 Protect the genetic diversity within populations from significant change due to human activity.	

9. Integration with socio-economic objectives

9.1 Contribution of conservation objectives to sustainable development

An objective of the Pilot was to assess how the framework for marine nature conservation could contribute to sustainable development in the marine environment. In particular, there was a need to consider how nature conservation objectives and other sectoral objectives could be aligned.

The Pilot has explored an approach to translating the strategic goals proposed for the UK marine environment into detailed objectives and targets, linked to specific managements actions necessary for their delivery and to indicators to monitor their achievement. The Pilot has illustrated this approach by considering how a set of ecological objectives might be defined for the UK marine environment.

In developing this approach, the Pilot recognised that:

- the application of the ecosystem approach and sustainable development principles at all stages would be essential;
- to contribute to sustainable development the approach needed to be capable of being used to define social, economic and other environmental objectives for the UK marine environment;
- there would need to be a high level of engagement of stakeholders to agree appropriate objectives and targets for the marine environment and to support appropriate management action for their delivery; and
- A critical part of the process would be an assessment of the compatibility between objectives and targets, both within and across environmental, social and economic domains.

The nature of the Pilot and the resources available to it, and to other partners, precluded the large scale and longer term engagement of stakeholders which would be required to progress the development of environmental, social and economic objectives and targets for the Irish Sea or wider UK marine environment. Instead, the Pilot focused on trying to identify the potential contribution that achieving the conservation objectives and targets that would be needed to protect, conserve and recover the marine environment might make to achieving social and economic objectives and sustainable development.

During the summer of 2003, the Pilot undertook a wide-ranging consultation on its initial ideas on conservation objectives and invited comments on the approach taken and on how the conservation objectives proposed related to the objectives of the various other marine sectors. This consultation identified a range of important issues which were common to nature conservation and various other sectors, and this information was used to help in the further development of the conservation objectives.

In addition to the consultation on conservation objectives, the Pilot undertook similar consultations with respect to the issues of legislation, enforcement and governance during the summer and autumn of 2003. These consultations were followed up by a number of meetings to consider issues of particular relevance to individual sectors.

From the consultations and discussions held with the range of marine sectors, it has been possible to:

- collate a set of broad objectives for the various marine sectors which relate to the environment;
- identify the dependency of these sector objectives upon the services provided by the marine ecosystem; and
- consider the relationship between these sector objectives and the conservation objectives.

For most sectors, there appears to be no single set of agreed objectives. Consequently, the sector objectives used in the assessment have been accessed from a variety of sources. The presumption has been made that these sources represent the objectives of the sectors sufficiently well for the purpose of this assessment.

The results of the assessment are presented in Table 4 which also references the sources from which the information has been obtained. Table 4 does not include a catalogue of the socio-economic objectives for each sector, so it is not comprehensive.

Table 4 Contribution of conservation objectives to sustainable development of marine sectors

Sector objectives for the environment relevant to the proposed conservation objectives	Dependency of these sector objectives upon services provided by the marine ecosystem	Interaction of these sector objectives with the proposed conservation objectives
Tourism and recreation[1]		
Recreational leisure boating and the development needed to support it should be carried out in harmony with the environment and allow its qualities to be enjoyed by future generations. To support appropriate designations and resist those which would unnecessarily limit or prohibit recreational use of the coast	Recreational leisure boating requires a clean and healthy marine environment to prosper and be sustainable. Conservation designations aimed at protecting marine ecology and wildlife habitats can play an important role in this. More effective consultation is required with users to ensure that this is achieved.	There should be a high level of common interest in integrating sector objectives for the environment with the proposed conservation objectives. The Pilot has trialled the identification of nationally-important marine areas. Where a need is identified to afford such areas an increased level of protection, this should involve participation of affected stakeholders.
To support government initiatives to improve water quality	People engaging in water contact sports need protection from the risk of illness caused by viruses and other pathogens released into coastal waters and inland waters. Other elements of water quality also need to be addressed.	The Pilot recognises the application of the Water Framework Directive to the seawards limits agreed, and recommends the application of appropriate principles and measures derived from the Water Framework Directive out to territorial limits.
To ensure boating activities are environmentally sound	Encourage boat users to make sure that their activities do not harm vulnerable habitats or other marine environmental interests.	There should be a high level of common interest in integrating sector objectives for the environment with the proposed conservation objectives.
To minimise the adverse impacts or tourism through effective visitor management and the promotion of environmental good practice by tour operators[2]	The coastline and adjoining sea areas have a particularly high conservation value whilst also providing an economic resource for fishing and tourism and leisure activity.	There should be a high level of common interest in integrating sector objectives for the environment with the proposed conservation objectives.
Oil & gas[3]		
To achieve continual improvement in the industry's offshore environmental performance and to develop continually our knowledge of the environmental impact of our operations.	The industry requires access to hydrocarbon and gas fields for prospecting, exploration and production. The industry also needs to construct infrastructure including pipelines. Access to fields and to install infrastructure is dependent upon the ability of the industry to demonstrate that it achieves high levels of environmental performance and minimises the impacts of its operations on the environment.	There should be a high level of common interest in integrating sector objectives for the environment with the proposed conservation objectives. The industry is subject to strong environmental protection measures and has a high level of compliance.

[1] Objectives from Draft Royal Yachting Association Planning and Environmental Strategy; British Marine Federation (personal communication, Justine Cooper)

[2] Objectives from Wales Tourist Board and Wales Local Government Association Joint Response to the European Commission consultation: Basic orientations for the sustainability of European tourism 31 July 2003

[3] From: The UK Offshore Oil and Gas Industry: Strategy for its Contribution to Sustainable Development 2001.

Table 4 (continued)

Ports & shipping[4]		
To achieve cleaner seas through MARPOL provision which is compatible with the operational needs of ports and ships	Shipping requires appropriate access to ports, safe navigation channels and routes, and the sea. Shipping has the potential to significantly impact on environmental services utilised by others. It has a particularly important responsibility to avoid the transfer of non-indigenous organisms by ballast water and sediments, which is one of the greatest threats to biodiversity. Shipping operations also have a need to minimise the risks of chronic or acute pollution from oil and of air pollution. Marine litter, including that originating from vessels, presents a threat to the marine environment and to its recreational and tourism use.	Effective and timely implementation of this sector objective is crucial to delivery of the conservation objectives for the physical and chemical properties, for non– native species and for protection of biodiversity.
To promote dredging and disposal methods which are sympathetic to local coastal and estuarial conditions	There is increasing emphasis on working with rather than against natural coastal processes. The industry is required to consider potential beneficial uses of dredge spoil in applications for disposal licences. Good practice guidance has been developed for dredging and disposal operations.	The sector objective is particularly relevant to the objectives set for physical and chemical properties and biodiversity, as well as objectives set to protect habitat availability.
Renewable energy[5]		
To use strategic environmental assessment to guide the pattern and scale of development	Development of offshore wind resources is fundamentally constrained by environmental factors, e.g. access to areas of seabed within suitable water depths. The industry requires access to sufficient suitable areas of seabed and water column to make an appropriate contribution to meeting the UK's target.	Potential benefits for conservation might occur if the location of windfarms provided effective protection for surrounding areas of seabed which require a high level of protection for conservation (including fisheries) purposes. It is unclear whether this will be an incidental result of the current site selection process; it does not appear to be a material site selection feature, or strategic consideration, currently.
To ensure proper evaluation of impacts through strategic planning and consenting processes, and; to provide for monitoring, mitigation and control of individual and cumulative impacts	The offshore wind industry is a new industry and potential impacts of it upon the marine ecosystem, and the services which the ecosystem provides, are understood with different levels of confidence. Development of wind farms sites is likely to depend upon the industry being able to demonstrate that environmental impacts are within acceptable limits.	In view of the potential extent of development of the offshore wind farm industry, it would be particularly important to ensure that there is a close integration of industry objectives and the objectives proposed by the Pilot. It is also necessary to ensure that interactions between the wind farm industry and other sectors do not constrain the ability to achieve the conservation objective, for example by displacement of activities onto more environmentally sensitive areas.

[4] From: British Ports Association's Aims and Policies

[5] Objectives from UK government renewable energy target; DTI (2002) Future Offshore.

Table 4 (continued)

Defence[6]		
MOD aspires to maintain, protect and enhance the nature conservation value of the Defence Estate.	In the marine environment the main requirement of the MOD is for dockyard and berthing facilities, naval exercise areas, low flying areas and for firing and bombing ranges.	The set of conservation objectives proposed by the Pilot provide guidance on what needs to be achieved on marine Defence Estate.
Ensure that integrated management plans, supported as necessary by environmental steering groups, are used to implement our specific objectives.	Uses are site dependent.	The integrated management plans would provide an appropriate mechanism for the integration of conservation objectives into spatial planning and management at the local scale.
Use of private and public land will seek to avoid disruption to nature conservation, cultural heritage, the landscape and will take account of the potential competing interests of other non-military users.	The main uses of the marine environment by the MOD require access to specific areas (open or restricted to the public) permanently or temporarily.	The conservation objectives will inform this sector objective.
Mariculture[7]		
To identify the species and methods best suited to particular areas To identify what scope exists for the expansion of shellfish cultivation	Mariculture is the sector with one of the highest dependencies upon a naturally functioning, productive and high quality marine environment. It relies strongly upon sustaining the physical and chemical properties and avoiding significant disturbance to the food web and biodiversity. Significant disturbance to any of these has potential for detrimental impact upon the mariculture operations. Site selection is important.	There should be a high level of common interest in integrating sector objectives for the environment with the proposed conservation objectives. The conservation objectives should inform consideration of potential areas for mariculture, by identifying their conservation requirements.
To identify potential ecosystem effects from increasing the biomass of shellfish in certain areas To find out if specific sites have a finite carrying capacity in terms of the ability of an areas natural productivity to support growth	Increasing the scale of mariculture operations increases the risk of significant disturbance to the ecosystem and impact upon the mariculture operations.	The Pilot proposes conservation objectives which aim to maintain or, where necessary, recover ecosystem components which may be affected by activities such as mariculture. These include objectives for trophic status, trophic level balance, water bodies and biodiversity. There should be a high level of common interest in minimising ecosystem effects.
Marine aggregates[8]		
The Government wishes to see the continued use of marine dredged sand and gravel to the extent that this remains consistent with 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.	The industry requires long-term environmentally sustainable access to commercially viable areas of marine aggregates.	The conservation objectives should inform assessments of the environmental sustainability of exploitation of particular aggregate deposits. There will be a need to ensure that individually, and cumulatively with other sectors, the marine aggregate extraction does not prevent the achievement of the conservation objectives.
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.	Measures put in place by the industry and regulators aim to reduce the footprint and impact of aggregate extraction on the environment and other users. Aggregate extraction has the potential to affect services provided to other sectors e.g. fisheries.	There should be a high level of common interest in integrating this sector objective for the environment with the proposed conservation objectives.

[6] Objectives from MOD 2000. The Strategy for the Defence Estate

[7] Objectives from DARDNI 2001. The Shellfish Aquaculture Management Plan for Northern Ireland

[8] Objectives from Office of the Deputy Prime Minister (2002) Marine Mineral Guidance 1: extraction by dredging from the English seabed

Table 4 (continued)

Fisheries[9]		
Protect and conserve marine resources Rational exploitation on a sustainable basis	Fisheries are highly dependent upon access to the marine environment and to stocks of fish to harvest. Currently many stocks are heavily fished or overfished. Many stocks are outside, or almost outside, of safe biological limits. Key cod stocks are on the verge of collapse	There is a common interest in ensuring that exploitation of fish stocks is managed to optimise long-term environmentally-sustainable yields. Integration of fisheries and nature conservation objectives is crucial to the achievement of both. The conservation objectives include objectives for the protection and recovery of foodwebs, including the stocks of commercially-exploited fish.
Take account of implications for marine ecosystems Integrate environmental protection requirements	Fisheries are also responsible for some of the most significant of human impacts upon the marine ecosystem, not just on target fish stocks.	There is an urgent need to integrate environmental protection requirements into fisheries. Fisheries collectively have the potential for a negative impact upon most of the proposed conservation objectives. Certain fisheries conservation measures, particularly those controlling the use of mobile bottom gear in areas, have the potential for wider benefits to nature conservation. The conservation objectives provide a framework which could guide this integration.
Shellfisheries[10]		
Achieve 'A' classification status for all shellfish waters; reduce other forms of pollution	The shellfish industry requires high water quality coastal waters to improve shellfish hygiene, to permit harvesting of shellfish (mussels, cockles etc) from unclassified or Class 'C' beds and to avoid or minimised purification requirements for harvested shellfish. (This objective is relevant also to mariculture).	This sectoral objective is consistent with the achievement of the proposed water quality objectives.
Sustainable commercial shellfisheries within 0-12nm and beyond 12nm	The sector requires access to sustainably exploited stocks of shellfish.	The industry needs to protect stocks of shellfish at, or where necessary recover them to, levels at which they can be sustainably and optimally exploited. There should be a high level of common interest in integrating sectoral objectives for the environment with the proposed conservation objectives

[9]Objectives from UK Fisheries Industry - Current Situation Analysis. Number 10 Strategy Unit: Evaluation of the CFP, Source EC.

[10] Objectives from Shellfish Association of Great Britain response to Number 10 Strategy Unit consultation on the UK Fisheries Industry

9.2 Assessment of the relative importance of the conservation objectives to sectors

In the light of the foregoing, the Pilot has made a preliminary assessment of the likely relative importance, now and in the future, of each of the operational conservation objectives for the sustainable development of each of the key marine human use sectors.

This assessment has been done by taking each operational conservation objective and subjectively scoring, against each of the major sectors, the potential importance which achieving the conservation objective might make to helping to achieve the sustainable development of that sector. Three broad categories of relationship are identified, which are not mutually exclusive:

- where the sector has generally low negative impacts upon the marine ecosystem but depends upon a high quality environment, e.g. recreation;
- where the sector has potential for substantial negative impact on the marine ecosystem but achievement of the conservation objectives has potential substantial social and economic benefits for the sector, e.g. recovery and sustainable exploitation of fish stocks is of high mutual interest to fisheries and nature conservation sectors;
- where the compliance with the conservation objectives (high environmental standards) may be required to achieve regulatory approval e.g. in the oil and gas sector.

The following categories of assessment are used:

	High: the implementation of, or compliance with, an operational objective similar to this may be of major importance to the sustainable development of the sector
	Moderate: the implementation of, or compliance with, an operational objective similar to this may significantly enhance the sustainable development of the sector
	Low: an operational objective similar to this is unlikely to make a significant contribution to the sustainable development of the sector

The results of the preliminary assessment are presented in Table 5. Note, this analysis is offered as a contribution forwards the process needed to consider the interface between environmental (including conservation), economic and social objectives which will need to be undertaken as part of a much wider debate, including in relation to marine spatial planning.

Table 5 Importance of conservation objectives for sustainable development of marine sectors

Objective number	Operational conservation objective	Aggregates	Coast development	Dredging & disposal	Energy	Fisheries (mobile gear)	Fisheries (static gear)	Mariculture	Military	Recreation	Shipping
Aim 1: Physical & chemical											
1.1	Protect coastal processes										
1.2	Protect seabed habitats										
1.3	Protect biogenic structures										
2.1	Protect water bodies										
3.1	Protect water quality										
3.2	Chemical pollutants										
3.3	Oil										
3.4	Oil spills										
3.5	Noise & vibration										
3.6	Marine litter										
4.1	Contaminants										
Aim 2: Productivity											
1.1	Trophic status										
2.1	Harvest										
2.2	Protect habitats										
2.3	Protect prey populations										
2.4	Protect predator populations										
3.1	Protect population longevity										
3.2	Protect population life history										
3.3	Recover spawning stock										
3.4	Ecologically sustainable fishery										
3.5	Reduce fishing mortality										
3.6	Ecologically sustainable fishery										
Aim 3: Biodiversity											
1,1	Trophic level balance										
1.2	Protect habitat complexity										
1.3	Maintain best areas										
1.4	Protect rare habitats										
1.5	Protect threatened habitats										
1.6	Recover declined habitats										
1.7	Protect against non-native species										
1.8	Reduce impacts of non-native species										
2.1	Protect species diversity										
2.2	Protect important areas										
2.3	Safeguard species										
2.4	Recover declined species										
3.1	Protect population structure										
3.2	Protect population structure										
3.3	Protect populations at risk										
3.4	Protect genetic diversity										
3.5	Protect genetic diversity										

10. Translating the framework into management action

Following consideration of the relationship between the 'ecological' objectives and the environmental objectives of the various marine sectors, the Pilot considered the need to regulate human activity in relation to the Irish Sea within the sustainable development context. The Pilot has addressed this issue in terms of:

- strategic planning and the sustainable use of the Irish Sea;
- action needed to conserve nationally-important areas; and
- action needed to conserve certain mobile nationally-important species.

This is described in Vincent *et al* (2004).

The Pilot also considered the cross-cutting and sectoral action needed to achieve the conservation objectives and in support of the foregoing.

The objectives framework developed by the Pilot (Table 1) identifies the ecological requirements for the Irish Sea, and for the UK marine environment as a whole, at a strategic level. At this strategic level, the Pilot has set out the key management measures needed to deliver the proposed objectives, and the national and international targets for marine nature conservation and sustainable development, in Table 6 below. This table identifies which of the ecological objectives each of the proposed management measures would contribute to the delivery of. This list of actions is not comprehensive, and some of the actions specified are already ongoing.

The development of operational objectives within the framework would enable a similar assessment to be made of more specific management requirements, decisions and actions.

Table 6 Management mechanisms and measures needed to deliver the conservation objectives for the Irish Sea

Key mechanisms and measures		Relevant Operational Objectives	Comments
Strategic planning and sustainable use			
1.1	**An integrated and effective marine spatial planning and management system in place, incorporating zoning of marine uses, over the UK territorial waters and adjacent regional seas**	All objectives	• More integrated and effective marine spatial planning is critical to deliver improved regulation, management and protection of the marine environment that addresses the multiple, cumulative and potentially conflicting uses of the sea. Likely to be based upon new legislation, duties and powers.
1.2	**All developments, proposed changes and activities brought within the scope of a marine spatial planning system. Fisheries are a critical area for inclusion.**	All objectives	• It is inappropriate that some activities, most notably fisheries, fall largely outside of current spatial planning and regulatory systems when their environmental impacts may approach or exceed those within the systems. • This is recognised on land now, with agriculture and forestry increasingly being brought within land use planning.
1.3	**Conservation objectives integrated with other objectives for sustainable development and delivered through an improved marine spatial planning system**	All objectives	• Within the UK, the Marine Stewardship process needs to ensure the integration and delivery of conservation and sustainable development objectives, in pursuit of the vision and strategic goals for the environment. Ecosystem approach principles should guide this integration. These objectives will in turn drive marine spatial planning and plans.
1.4	**Planners and regulators with appropriate responsibilities, powers and tools to enable them to promote, ensure and enable the conservation and sustainable development of the marine ecosystem.**	All objectives	• As part of the improvement of the marine spatial planning system it would be appropriate and necessary to review the responsibilities, powers and tools placed upon or available to planners and regulators.
1.5	**Strategic Environmental Assessment (and Sustainability Assessment) undertaken for all marine sectors. Include coastal and marine fisheries**	All objectives	• This relates to the requirements outlined in the European SEA Directive (2001/42/EC) and being transposed into national legislation. Sectoral SEAs are being undertaken by DTI for offshore energy. SEA would feed into an improved marine spatial planning framework. • SEA should be undertaken for the fisheries sector.
1.6	**Developments and activities which have the potential for a significant impact upon the marine ecosystem be subjected to Environmental Assessment.**	All objectives	• Most sectors and significant developments in the marine environment are already subject to environmental assessment e.g. coastal development, oil and gas development, capital dredging. • The fisheries sector, which is responsible for some of the most significant impacts upon the marine ecosystem, is generally not subject to environmental assessment. • Ongoing and proposed changes in fisheries activities could be regulated and practiced through fisheries
1.7	**Water quality objectives for transitional and coastal water bodies taken forward primarily through the Water Framework Directive and appropriate measures taken for waters to seawards**	Water quality objectives -2.2.1, 2.3.1-2.3.6 & 2.4.1	• This is currently being implemented by European states • Adoption of equivalent measures in Crown Territories may be necessary • The Water Framework Directive includes some principles and approaches which it may be appropriate to consider applying to the marine water bodies (and indeed the marine environment as a whole). • These objectives need to inform consideration of the ecological carrying capacities of enclosed or semi-enclosed water bodies (e.g. sea lochs, rias, estuaries, saline lagoons) for mariculture and similar operations

Table 6 (continued)

Conservation of important marine areas			
2.1	**Completion of the UK marine Natura series out to 200nm and UKCS where appropriate**	All objectives	• Being undertaken in the UK by Defra/JNCC/Country conservation agencies (within 12 miles) for existing Annex I and II habitats and species. This will consider both the overall extent of the current four 'offshore' Annex I habitats which should be included within Natura 2000 and the specific sites.
2.2	**Completion of an ecologically – coherent national network of marine protected areas within the Irish Sea/UK which includes Natura and additional marine protected areas as necessary and makes an appropriate contribution to the protection, conservation and recovery of the marine ecosystem.**	All objectives	• Draft criteria have been developed and trialled by JNCC through the Irish Sea Pilot. • The contribution which current and proposed Natura 2000 would make to forming this core, and the possible implications for the management of these Natura 2000 sites, needs to be evaluated. The management measures required for these areas needs to be fully assessed. A proportion will already be within protected sites and subject to appropriate management.
2.3	**European marine site conservation objectives, management schemes and outcomes reviewed against national and regional sea conservation and sustainable development objectives and requirements and revised as necessary.**	All objectives	• There would be a need to ensure that European marine sites are making the most appropriate contribution to meeting national and regional sea objectives and targets for their designated interests.
Conservation of certain mobile nationally-important species			
3.	**Strengthened legal measures to protect and to promote the recovery certain vulnerable marine species**	Foodweb – 2. & 3; biodiversity – all.	• Existing species measures fall short of what is required to meet their conservation needs. These include the need to strengthen protection against incidental damage and to take measures to promote the recovery of vulnerable species which have declined.
Sectoral measures			
Sea fisheries			
4.	**Measures available and implemented effectively to reduce the harmful impacts of fisheries.**	Seabed features - 1.1.2 & 1.1.3; water quality 3.3.1; marine foodwebs - all; biodiversity – all.	• The harmful effects of bottom-towed fishing gears on seabed habitats need to be reduced or, where necessary, removed. Bottom-towed fishing gears are responsible for some of the most significant impacts upon parts of the marine ecosystem. Promotion of alternative, sustainable fisheries methods which avoid the use of gear which damages or disturbs the seabed. • Further measures need to be taken to reduce the impacts of fisheries on marine foodwebs and biodiversity, including the recovery of target species stocks and protection of non-target species • There may need to be a significant shift from a focus on improving the catching efficiency of fishing gears to improving their environmental sustainability.
Mariculture			
5.	**Sustainable development strategies developed and implemented for mariculture, which are integrated with other uses of the marine environment and ensure its conservation.**	Physical features - all; marine foodwebs – 2.2.2; biodiversity – all.	• Mariculture requires a high quality environment in which to operate and yet has the potential to cause significant environmental change, for example where operations are undertaken at inappropriately locations or scales. • Mariculture operations can directly and indirectly affect a wide range of uses of the marine environment
Shipping and navigation			
6.	**Effective measures in place to increase shipping safety and reduce the risk of environmental pollution from shipping accidents**	Non-native species - 3.1.7 & 3.1.8	• Transfer of non-indigenous organisms by ballast water and sediments is one of the greatest threats to marine biodiversity

11. Recommendations

The Irish Sea Pilot (Vincent *et al* 2004) makes four recommendations concerning conservation objectives:

1. **The national strategic goals, objectives and targets for the marine environment should form the basis for policy guidance and strategic planning for the marine environment and its sustainable development.**
2. **The conservation objectives should be integrated into a single, unified set of national strategic goals and objectives for the marine environment and its sustainable development.**
3. **A process should be established to identify and set appropriate targets for each operational conservation objective which are consistent with achieving international and national commitments and strategic goals, including implementation of the ecosystem approach.**
4. **The government should identify which of the conservation objectives and targets should be incorporated for use in the national marine monitoring programme.**

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Annex 1 The 12 principles of the ecosystem approach adopted by the Convention on Biological Diversity

The 12 principles of the ecosystem approach adopted by the Convention on Biological Diversity:

Principle 1: The objectives of management of land, water and living resources are a matter of societal choice

Principle 2: Management should be decentralised to the lowest appropriate level

Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems

Principle 4: Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:

a. reduce those market distortions that adversely affect biological diversity;

b. align incentives to promote biodiversity conservation and sustainable use;

c. internalise costs and benefits in the given ecosystem to the extent feasible.

Principle 5: Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach

Principle 6: Ecosystems must be managed within the limits of their functioning

Principle 7: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales

Principle 8: Recognising the varying temporal scales and lag-effects that characterise ecosystem process, objectives for ecosystem management should be set for the long-term.

Principle 9: Management must recognise that change is inevitable

Principle 10: The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity

Principle 11: The ecosystem approach should consider all forms of relevant information including scientific and indigenous and local knowledge, innovations and practices

Principle 12: The ecosystem approach should involve all relevant sectors of society and scientific disciplines

Annex 2 SMART criteria for objective setting

From Fowler (2003)

Specific:	• relate to a particular interest feature [ecosystem component] and define the condition(s) required to satisfy the [conservation] objective.
Measurable:	• …and reportable – enabling monitoring to be undertaken to determine whether the objectives are being met; • easily and accurately measured, with a low error rate; • provide factual, quantitative information; • based on an existing body or time-series of data to allow a realistic setting of objectives; • normative (possible to compare with baseline); • scientifically sound and statistically valid; • allow aggregation at national and multinational level.
Achievable:	• realistic – given a reasonable time-frame and application of resources; • technically feasible and cost-efficient to use within acceptable limits (in terms of data collection); • take into account country-specific biodiversity [regional variation]; • measurable over a large proportion of the area to which the metric is to apply.
Result-oriented:	• consistent in approach – same structure across all sites supporting the same interest feature [ecosystem component], use similar attributes and targets'; 'allow comparison between member states (or sites); • comprehensive –attributes and targets should cover the properties of the interest feature necessary to describe condition as either favourable or unfavourable; • responsive primarily to a human activity, with low responsiveness to other causes of change; • sensitive to manageable human activity; • useable for scenarios for future projections; • policy-relevant; • user-driven.
Time-bound:	• relatively tightly linked in time to that activity; • responsive to change in time/space.

Annex 3 Summary of some possible indicators of the status of marine ecosystems and associated components of marine biodiversity

From Laffoley *et al* 2002

Ecosystem focus	**Indicator/indicator area**	**Progress tracking against goal**
Food webs – Productivity – Trophic structure	Plankton/chlorophyll Average trophic level	• SAHFOS to advise • A halt in the decline in trophic structure of marine ecosystems and subsequent recovery of structure
Species assemblages	Fish assemblages Sediment assemblages Reef assemblages	• Recovery of assemblage • Recovery of assemblage • Recovery of assemblage
Habitats	Quality and extent Diversity	• Maintenance of quality and extent of irreplaceable habitats • Maintenance in quality and extent of fragile and/or sensitive habitats, and increase area and recover quality where impacted • Reduction in levels of contaminants in water, sediment and biota • Maintain current diversity of habitats and recover where impacted
Species	Range Size Cohorts Abundance	• Expand range of slow growing, long-lived and/or low fecundity species • Halt downward trends in populations and increase average size • Expand age classes present in populations • Increase abundance of slow growing and/or low fecundity species
Maintaining the gene pool	Extinctions Range reduction Vitellogenin precursor? Niche disruption including crossbreeding	• Prevent extinctions at local, regional, national and global levels • Prevent anthropogenically determined range reductions • Prevention of levels of endocrine disruption that interfere with reproductive behaviour • Prevention of introduced and/or genetically modified organisms displacing or interbreeding with native flora and fauna

Annex 3 OSPAR work on Ecological Quality Objectives

General description of work

General methodological development of Ecological Quality Objectives (EcoQOs) has been undertaken by the North Sea Task Force and subsequently by the OSPAR Commission since the Third North Sea Conference in 1990. This work has been combined with the development of the ecosystem approach to environment and fisheries management since the 1997 Intermediate Ministerial Meeting of the 5th North Sea Conference on integration of fisheries and environmental issues. The 5th North Sea Ministerial Conference in 2002 (see above) agreed formally that EcoQOs should be developed to serve as indicators for the ecosystem health and to monitor progress towards delivering the ecosystem-based approach to marine management adopted by the Conference. OSPAR was tasked with continuing work on the development and application of these EcoQOs, including piloting the most advanced EcoQOs initially in the North Sea, developing the remaining EcoQOs by 2004, and developing coherent monitoring arrangements to monitor progress in meeting EcoQOs.

The following summary of OSPAR's work in this area is taken from the records of OSPAR Biodiversity Committee and Commission meetings from 2001 onwards, published on the OSPAR Commission website (www.ospar.org). This work has benefited significantly from the scientific advice provided by the International Council of the Exploration of the Sea (ICES), with many of OSPAR's conclusions derived directly from ICES reports.

OSPAR's Biodiversity and Eutrophication Committees (BDC and EUC) have been taking the lead, with advice from ICES on developing proposals for EcoQOs for marine mammals and seabirds in the North Sea (under the ICES 2000 work programme), and work by the Netherlands and Norway. The main focus has been to develop first proposals for EcoQOs for the North Sea, as a test case. Early work is summarised in Skjoldal (1999) and Lanters *et al* (1999). The latter was prepared for an initial Workshop on Ecological Quality Objectives for the North Sea and considered primarily EcoQOs for the North Sea Large Marine Ecosystem, excluding the coastal zone, based on knowledge of existing monitoring activities and data. The EcoQOs recommended by Lanters *et al* (1999) were proposed as the starting point of an iterative process along at least two dimensions:

- to develop a consistent, sufficient and reliable set of objectives where the EcoQOs form an umbrella for more specific, operational objectives. Thus there is a need to ensure that the new EcoQOs are in agreement with specific objectives and whether any adjustments in the existing specific objectives are needed.
- to consider the monitoring and data requirements in relation to the set of objectives."

The 1999 workshop identified ten issues on which specific EcoQOs should be developed, and the work of developing these was subsequently undertaken by the Netherlands, Norway, the OSPAR EUC and ICES. A subsequent workshop in 2001 agreed a number of Ecological Quality Elements (EcoQs) for which it would be possible to set EcoQOs. It identified a subset of the former that were ready for adoption by the 5th North Sea Ministerial Conference, a second set that would be ready for adoption in the near future, and a third set

for which a longer term approach was needed. These results were used to prepare a report from the BDC to the 5th North Sea Conference describing the progress being made towards the development of operational EQOs (Biodiversity Committee 2001). The process was slightly complicated by the need to develop objectives that would together provide an holistic view of the quality of the marine environment, without infringing the strict application of OSPAR's competence, particularly as regards the exclusion of issues of fisheries management, even though fisheries clearly represented one of the most clear and present problems faced by the marine environment in large areas of OSPAR's jurisdiction.

OSPAR's progress was recognised in the Bergen Declaration (March 2002), when the Fifth International Conference for the Protection of the North Sea committed North Sea Ministers to an approach based on ecological quality objectives and formally established a pilot project for the North Sea for the development and application of ecological quality objectives.

Paragraph 4 of the Declaration gives more detail and is therefore provided here in full:

4. *For delivering an ecosystem approach for the North Sea, the Ministers stress the importance of developing a coherent and integrated set of Ecological Quality Objectives. Therefore they welcome the progress that is being made within OSPAR and ICES to develop operational ecological quality objectives. To progress this work, the Ministers agree that:*

   i) *the issues and their related elements listed in Annex 3 Table A are the set for which ecological quality objectives (EcoQOs) will be developed. These EcoQOs will include both the desired level of ecological quality and baselines against which progress can be measured;*

   ii) *the ecological quality baselines will be established for each element, either by utilizing baselines already agreed (e.g. fish stock assessments), or by developing new baselines. EcoQOs must not permit any worsening of existing conditions;*

   iii) *the EcoQOs for each of the elements listed in Annex 3 Table B will be applied as a pilot project for the North Sea. By 2004, EcoQOs for the remaining elements will be developed and applied within the framework of OSPAR in coordination with the development of marine indicators in the EEA and environmental objectives in the EU Water Framework Directive. This work will include agreement on the procedures necessary for the sound application of the EcoQOs;*

   iv) *the pilot project will:*

      a) *assess the information that is, or can be made, available in order to establish whether the EcoQOs are being, or will be, met. Where the EcoQOs are not being met, the information will be used to determine the reason. Costs and practicability should be taken into account in deciding what information can be made available;*

      b) *where an EcoQO is not being met, review any policies and practices which are contributing to that failure; and*

      c) *if need be, reconsider the formulation of such EcoQOs;*

   v) *coherent monitoring arrangements will be established, in order to enable progress towards meeting the EcoQOs to be assessed. These arrangements will be integrated into the OSPAR Joint Assessment and Monitoring Programme;*

vi) *OSPAR 2005 should be invited to review progress, in collaboration with ICES and other relevant bodies, with the aim of adopting a comprehensive and consistent scheme of EcoQOs and to report on this to the North Sea Ministers; and*

vii) *thereafter, the value, use and practicability of the scheme of EcoQOs should be periodically reviewed by OSPAR, in cooperation with ICES and other relevant bodies.*

As part of this pilot project, the ten ecological quality issues and 21 ecological quality elements, with related objectives for ten of them, which had been identified under OSPAR's work programme, were adopted (see Annex 5 in this report). The Bergen Declaration included a commitment that EcoQOs for the remaining elements will be developed by 2004 and applied within the framework of OSPAR, in coordination with the development of marine indicators in the European Environment Agency (EEA) and environmental objectives in the EU Water Framework Directive. This work will include agreement on the procedures necessary for the sound application of the EcoQOs.

The June 2002 meeting of the OSPAR Commission noted the moves towards implementation of the ecosystem approach made by the Ministerial Conference and agreed to include the further development of ecological quality objectives within the future work programme, again under the lead of Norway and the Netherlands.

Definitions

OSPAR's work on EcoQOs, following advice from ICES, has produced the following definitions of the purpose and use of EcoQOs that are of relevance to the Irish Sea Pilot:

Ecological Quality: an overall expression of the structure and function of the marine ecosystem, taking into account the biological community and natural physiographic, geographic and climatic factors as well as physical and chemical conditions including those resulting from human activities. Ecological Quality can be expressed as a number of parameters or variables describing the physical, chemical and biological environment of a marine ecosystem. These are denoted as Ecological Quality Elements.

Ecological Quality Elements (EcoQs): aspects of marine ecosystems where levels can be established which can be measured (preferably quantitatively, but in some cases only qualitatively). In order to measure these, it is necessary to define or chose an appropriate measurement scale:

Ecological Quality Metric: a measurement scale or dimension by which Ecological Quality may be measured quantitatively (or, when appropriate, qualitatively) and in a suitable way to measure the ecological property that the EcoQ is intended to capture. Once a metric is established, it is important to collect and analyse relevant data sets regularly, with quality control applied to ensure that advice derived from such data is defendable. The desired or target level of an EcoQ is its Ecological Quality Objective (EcoQO).

Ecological Quality Objective (EcoQO), the target level of an EcoQ, must fulfil several purposes:

- define the levels of these ecological quality elements (EcoQs) towards which we wish to see progress in the marine ecosystems;
- provide a tool to support the development and application of an ecosystem approach to the management of fisheries and the environment;

- set a bench-mark against which policies and management actions can be judged, by describing the quality of the environment at which policies and management actions are aimed; and
- be part of a suite, or holistic and internally consistent set of objectives that will help to achieve overall management objectives and give guidance to management actions to be taken (inconsistencies or incompatibilities between some desirable EcoQOs may require careful examination of the trade-offs of benefits between them).

As noted by ICES, EcoQOs also need to be,:

- relatively easy to understand by non-scientists and decision-makers;
- sensitive to manageable human activity;
- relatively tightly linked in time to that activity;
- easily and accurately measured, with a low error rate;
- responsive primarily to a human activity, with low responsiveness to other causes of change;
- measurable over a large proportion of the area to which the EcoQ metric is to apply; and
- based on an existing body or time-series of data to allow a realistic setting of objectives.

It is important that the linkages between EcoQOs and relevant human activities can be described, and that there should be a likelihood that monitoring of the marine ecosystems can link the effects of changes in human activities to the observed levels of ecological quality elements on a credible timescale.

Finally, regular evaluation should be planned after a specific number of years, with the possibility of adaptation of the EcoQOs in order to produce a dynamic process which will lead to an holistic instrument for the protection of the environment and its sustainable use.

As the desired level of an ecological quality element (EcoQ), EcoQOs may be set in relation to a specified "Reference Level" (this is not the same as the reference point or reference value used in advice given by ICES in relation to fisheries management).

Reference level: this can be defined as the level of EcoQ where the anthropogenic influence on the ecological system is minimal (or, to allow for natural variation, a range of possible levels). Lack of baseline (pre-disturbance) data may make it difficult or impossible to determine such reference levels. This may require a pragmatic approach to establish proxies for the historic levels of the pristine environment that cannot now be determined. Furthermore, environmental carrying capacity may have changed to such an extent that pristine levels are no longer achievable.

OSPAR also makes the following important points:

- **Policy decisions** are made by the appropriate management authorities to set EcoQOs. Although not scientific decisions, they have to be based on scientific advice.
- **Relevant stakeholder involvement** in the formulation of EcoQOs, setting of levels, policy making, management actions, and observation of progress towards them is important and requires a pro-active approach by the relevant authorities.
- **Monitoring** the development of levels of chosen ecological quality elements needs a

consistent approach across the whole of the marine ecosystem for which EcoQOs have been established.

- **Costs and Benefits**. Decisions on selecting EcoQOs and setting their levels need to take into account the best estimates of costs (including the direct costs of establishment and monitoring, and the indirect costs imposed on human activities) and benefits (including the specific benefits of maintaining resources for sustainable exploitation and the general benefits of a healthy environment).

Future work by OSPAR

Although the ultimate aim is to form a holistic entity to safeguard the North Sea ecosystem, it is recognised as being convenient (for pragmatic and practical reasons) to implement the development of EcoQOs in steps. This process is still a long way from completion. The current work programme involves a substantial input from OSPAR's Biodiversity Committee and from ICES, through its Advisory Committee on Ecosystems. The links between the requirements of the EC Water Framework Directive and the EcoQOs will be made clear so that their consistency can be judged, and account taken of the development of marine indicators by the European Environment Agency

Evaluation by ICES of the ten EcoQOs selected for the pilot project concluded that only two of the EcoQ metrics met all the criteria. Most of those initially selected failed to meet the criterion of a close link to human activities and responsiveness primarily to a human activity. In particular, problems were noted with the integrated nature of the set of five EcoQO elements for eutrophication. Difficulties were also noted with the potential use of threatened and declining species as EcoQOs.

Annex 4 OSPAR Ecological Quality Objectives

Annex 3 to the Bergen Declaration.

Ecological Quality (EcoQ) is defined as *'An overall expression of the structure and function of the marine ecosystem taking into account the biological community and natural physiographic, geographic and climatic factors as well as physical and chemical conditions including those resulting from human activities.'*

Ecological Quality Elements *are the individual aspects of overall Ecological Quality.*

An **Ecological Quality Objective (EcoQO)** *is the desired level of an ecological quality (EcoQ). Such a level may be set in relation to* ***a reference level.***

TABLE A

Issue	**Ecological quality element**
1. Commercial fish species	(a) Spawning stock biomass of commercial fish species
2. Threatened and declining species	(b) Presence and extent of threatened and declining species in the North Sea
3. Sea mammals	(c) Seal population trends in the North Sea (d) Utilization of seal breeding sites in the North Sea (e) By-catch of harbour porpoises
4. Seabirds	(f) Proportion of oiled Common Guillemots among those found dead or dying on beaches (g) Mercury concentrations in seabird eggs and feathers (h) Organochlorine concentrations in seabird eggs (i) Plastic particles in stomachs of seabirds (j) Local sand-eel availability to black-legged Kittiwakes (k) Seabird populations trends as an index of seabird community health
5. Fish communities	(l) Changes in the proportion of large fish and hence the average weight and average maximum length of the fish community
6. Benthic communities	(m) Changes/kills in zoobenthos in relation to eutrophication (n) Imposex in dog whelk (*Nucella lapillus*) (o) Density of sensitive (*e.g.* fragile) species (p) Density of opportunistic species
7. Plankton communities	(q) Phytoplankton chlorophyll *a* (r) Phytoplankton indicator species for eutrophication
8. Habitats	(s) Restore and/or maintain habitat quality
9. Nutrient budgets and production	(t) Winter nutrient (DIN and DIP) concentrations
10. Oxygen consumption	(u) Oxygen

TABLE B

Ecological quality element	Ecological quality objective
(a) Spawning stock biomass of commercial fish species	Above precautionary reference points[1] for commercial fish species where these have been agreed by the competent authority for fisheries management
(c) Seal population trends in the North Sea	No decline in population size or pup production of ≥10% over a period of up to 10 years
(e) By-catch of harbour porpoises	Annual by-catch levels should be reduced to levels below 1.7% of the best population estimate
(f) Proportion of oiled Common Guillemots among those found dead or dying on beaches	The proportion of such birds should be 10% or less of the total found dead or dying, in all areas of the North Sea
(m) Changes/kills in zoobenthos in relation to eutrophication[2]	There should be no kills in benthic animal species as a result of oxygen deficiency and/or toxic phytoplankton species
(n) Imposex in dog whelks (*Nucella lapillus*)	A low (<2) level of imposex in female dog whelks, as measured by the *Vas Deferens* Sequence Index
(q) Phytoplankton chlorophyll *a*[2]	Maximum and mean chlorophyll *a* concentrations during the growing season should remain below elevated levels, defined as concentrations >50% above the spatial (offshore) and/or historical background concentration
(r) Phytoplankton indicator species for eutrophication[2]	Region/area - specific phytoplankton eutrophication indicator species should remain below respective nuisance and/or toxic elevated levels (and increased duration)
(t) Winter nutrient concentrations (dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphate (DIP)[2]	Winter DIN and/or DIP should remain below elevated levels, defined as concentrations >50% above salinity related and/or region specific natural background concentrations
(u) Oxygen[2]	Oxygen concentration, decreased as an indirect effect of nutrient enrichment, should remain above region-specific oxygen deficiency levels, ranging from 4–6 mg oxygen per liter

[1] In this context, 'reference points' are those for the spawning stock biomass, also taking into account fishing mortality, used in advice given by ICES in relation to fisheries management.

[2] The ecological quality objectives for elements (m), (q), (r), (t) and (u) are an integrated set and cannot be considered in isolation. ICES will give its further advice during the implementation phase.

Annex 5 ICES contributions to OSPAR work

International Council for the Exploration of the Sea (ICES)

ICES was established in 1902 to promote and coordinate research into the sea and its living marine resources, and to provide advice on the sea and its resources, within its geographical remit of the North Atlantic Ocean and adjacent seas. Its clients for advice include the EC, OSPAR, and 19 member countries. ICES has undergone considerable changes during the past almost 100 years as its emphasis has moved from a focus almost solely on fisheries exploitation to providing advice on many aspects of biological diversity assessment and management. Its current strategic plan includes the following areas of work:

- Characterising biological diversity, its role and its importance in the functioning of marine ecosystems;
- Developing a classification system and mapping of marine habitats;
- Evaluating the potential impacts of introduced and escaped species on marine ecosystems;
- Establishing the scientific basis for the Precautionary and Ecosystem Approaches and their application in ICES advice;
- Developing tools to assess marine habitat quality;
- Developing improved technical measures for fisheries management.

The ICES Advisory Committee on Ecosystems, in particular, is heavily involved in the provision of advice on biodiversity issues. ICES (2002; and earlier reports) has reviewed evidence for the proposed OSPAR Priority List of Threatened and Declining Species and Habitats and is continuing to do so. Many of the species and habitats identified by OSPAR are also relevant to the work covered by the Pilot, particularly the work on nationally important features (Lieberknecht *et al*, 2004a).

ICES is also advising OSPAR on the development of Ecological Quality Objectives. ICES (2002) contains a useful summary of ICES Advisory Committee and Working Group contributions to this.

ICES has expressed specific concerns regarding the six key qualities of Ecological Quality (EcoQ) metrics, the importance of being able to assess metrics against these practical qualities or criteria, and the importance of using science to define the current and historical levels of each metric. These are important points to consider when developing operational objectives for the marine ecosystem.

Annex 6 Example of possible operational objectives and indicators for a biogenic reef

Case study: *Sabellaria spinulosa* reefs

There are three main sources for the following review of this biogenic habitat: the UK Habitat Action Plan, Holt *et al* (1998), who reviewed its dynamic and sensitivity characteristics, and the draft criteria and assessment process test case for selecting nationally important marine species in the Irish Sea.

Habitat description

These subtidal biogenic structures are produced by a small tube-building worm which is very widely distributed around the UK but which can, under certain circumstances, form massive long-lived structures raised above the seabed to a height of up to 60 cm. They provide a habitat for a wide range of other species and significantly increase the biodiversity of the benthic community. *Sabellaria spinulosa* reefs are of greatest nature conservation importance when they occur on predominantly sediment or mixed sediment areas. They have also been associated with commercially important fisheries for benthic species associated with them; destruction of the habitat during fishing operations is known to have led to the collapse of the associated fishery.

Environmental requirements

In order to become established, *S. spinulosa* reefs require sand grains to be present in suspension in turbid fast moving water (tidal currents or wave action) and initial anchorage points (shell, stone or other substrata) for the attachment of tubes. The latter is no longer necessary once an initial nucleus of tubes has become established; the colony will continue to grow as planktonic larvae settle onto existing tubes. These conditions are apparently widespread in the Irish Sea study area, but appear not to have been quantified in the literature in terms of an apparently acceptable range of turbidity measurements, current speed, seabed sediment size etc.

Environmental constraints

Poor water quality appears not to be a directly limiting factor, although possibly implicated in broader ecosystem changes that have prevented the re-establishment of *S. spinulosa* reefs destroyed by fishing activities in the Wadden Sea. Water temperature is not a constraint for this species in the subtidal; neither, it appears, is variation in salinity (the species appears to have been common in the past in east coast estuaries). Quantities of planktonic larvae are assumed to be more than sufficient to enable the colonisation and expansion of existing reefs, because this species is extremely common; it is the biogenic structures that it forms which are rare and of high nature conservation interest. There is no reason to believe that changes in the availability of suspended food particles are a limiting factor for the establishment and maintenance of this habitat.

The main constraint on the establishment of persistent *S. spinulosa* reefs is physical disturbance, either naturally as a result of, for example, winter storms (reefs do not persist in shallow exposed areas) or due to anthropogenic factors such as benthic fishing activity, aggregate extraction, dumping and navigational dredging.

Threats (Pressures)

Benthic fisheries, particularly dredging and trawling, is presumed to take place over the majority of the study area where suitable environmental conditions for this biogenic habitat occur. This activity can break up *S. spinulosa* reefs badly and is a documented cause of reef loss in other parts of the Northeast Atlantic. In order of importance, the most damaging activity will be scallop dredging, followed by hydraulic dredging (if this occurs in suitable environmental conditions for reef growth), beam trawling and otter trawling. Combined, these are the most significant of the four major threats to this fragile habitat. Netting and potting are less damaging because either unlikely to take place under environmental conditions favoured by this species, or because their physical impact and the total area affected are much less.

Aggregate extraction is likely the next most important impact, because aggregate deposits are likely to be present in particularly suitable environmental conditions for reef establishment. Not only will suitable substrate for reef establishment be removed during extraction, so will existing colonies. The other two impacts (navigation dredging and dumping) take place in relatively small areas, not all of which are suitable *S. spinulosa* reef habitat. Conversely, the suspension of fine sediments during dredging and dumping operations is probably not a threat – it may even aid the growth of colonies in areas adjacent to the extraction site.

The following Pressure Indicators presented in Jones (2002) may be relevant for *S. spinulosa* reefs:

Table 1Benthic fisheries (divided by class: scallop dredge, hydraulic dredge, beam trawl and otter trawl)

Indicator	Unit of measure	Data sources
Fishing effort: area	Square Kilometres or %, fished once, twice or more	Fisheries agencies (SFC, government etc.), fisheries statistics
Fishing effort: time	Hours at sea	
Fishing effort: other measures of intensity	Vessel capacity in tones or kW by time	
Area closed to fishing	Square Kilometres or %	Fisheries, environment & conservation agencies

Table 2 Aggregate extraction

Indicator	Unit of measure	Data sources
Area extracted within licence/yr	Square Kilometres or %	Industry raw data to Crown Estate Commissioners (CEC)
Total hours dredged /yr	Hours	
Total quantity landed /yr	Tonnes or cubic metres	
Mobility of sediment, bed-load sediment transport (nature of bedforms)	None defined. Index could be developed from particle size analysis, nearbed currents etc.	Industry, BGS sidescan sonar data, models
Sediment Grain Size Distribution [will influence biology]	% weight in each standard size fraction from particle size analysis	Monitoring data

Table 3 Disposal at sea

Indicator	Unit of measure	Data sources
Area designated as disposal site	Square Kilometres or %	FEPA licensing authorities
Total quantity disposed per annum	Tonnes or cubic metres	
Load of contaminants	? weight, normalization, ppm/ppb	
Sediment Grain Size Distribution [will influence biology]	% weight in each standard size fraction from particle size analysis	Monitoring data
Area subject to change in particle size distribution	% or square metres	Monitoring data
Community structure in/near disposal sites	NMMP to develop unit of measure	Monitoring data

Occurrence within the study area (Status)

There are very few known examples of this habitat within the Irish Sea study area, despite apparently widespread occurrence of apparently suitable environmental conditions. It may prove to be more widespread in areas not yet properly surveyed. Alternatively, the habitat may be genuinely uncommon because of the widespread physical damage to and removal of the structures described above.

The known and expected distribution of *Sabellaria spinulosa* reefs has been mapped, based on data from the MNCR database

Impacts

The most obvious and most easily measured impacts on this feature are implicit from the above sections:

- the destruction or removal of colonies as a result of physical disturbance;
- death of colonies by sediment smothering; and
- physical disturbance or smothering that prevents colonies from becoming re-established under suitable natural environmental conditions.

A simple Indicator for the above would be the presence or absence of colonies in apparently environmentally suitable areas. Development of this Indicator could be through size and extent of colony, percentage of area covered *etc*.

Response

Addressing disturbance from fisheries is difficult because of the very widespread nature of this pressure and its impacts and the forces (social and economic) that drive them. However, areas where no mobile bottom towed gear was used might, as a minimum, protect seabed areas known to support reefs. They should also incorporate areas of apparently suitable habitat where reefs should be able to develop, if protected from disturbance. Responses are easier for those activities requiring licenses and which affect only clearly specified and restricted areas. For example, aggregate dredging licenses should, in future, exclude areas that support major reefs and some suitable areas for reef development. Navigational dredging tends always to take place in the same area, thus affecting only limited areas of potential reef habitat, and may not require a response. Dumping may, up to a point, encourage reef growth by increasing turbidity (significant smothering by fines of existing reef colonies and coarse or mixed sediments suitable for colony establishment would presumably be damaging).

Responses to all of these pressures, however, require more information on the extent of the feature of interest (current and historical), and its environmental requirements.

Possible operational objectives for *S. spinulosa* reef habitat

- No reduction in the total area (extent) of existing *S. spinulosa* reef habitat in the Irish Sea.
- Recover the quality and long-term viability of existing *S. spinulosa* reef habitat in the Irish Sea to [*agreed target levels*] by 2010.
- Increase in area of occurrence of *S. spinulosa* reef habitat by [*quantitative target*] by 2010.

Metrics/Indicators of status and change

- Area of extent of habitat.
- Temporal persistence of reef structures.
- Index for 'health' of reef structures (volume, height, area, complexity – requires development).
- Index for abundance and diversity of associated reef community (requires development).

Information requirements

- Identification, description, mapping and quantification of existing key areas of *S. spinulosa* reef habitat.
- Identification, mapping and quantification of historical extent (baseline) of *S. spinulosa* reef habitat.
- Identification and description of environmental characteristics of areas currently supporting reefs (e.g. water movement, turbidity/sediment load and quality, natural disturbance regimes, benthic sediment particle size distribution).
- Identification and mapping of similar environmental conditions in other areas.
- Identification and quantification of benthic biodiversity associated with reef structures (preferably through non-invasive, non-destructive survey techniques!).

Potential responses to anthropogenic disturbance

Maintain key existing and potential reef sites free from physical damage or disturbance by:

- establishing mobile gear fishery exclusion zones over key areas for existing and potential *S. spinulosa* reef habitat;
- reviewing dredging and dumping licenses in existing and potential key areas, to minimise impact of these activities.