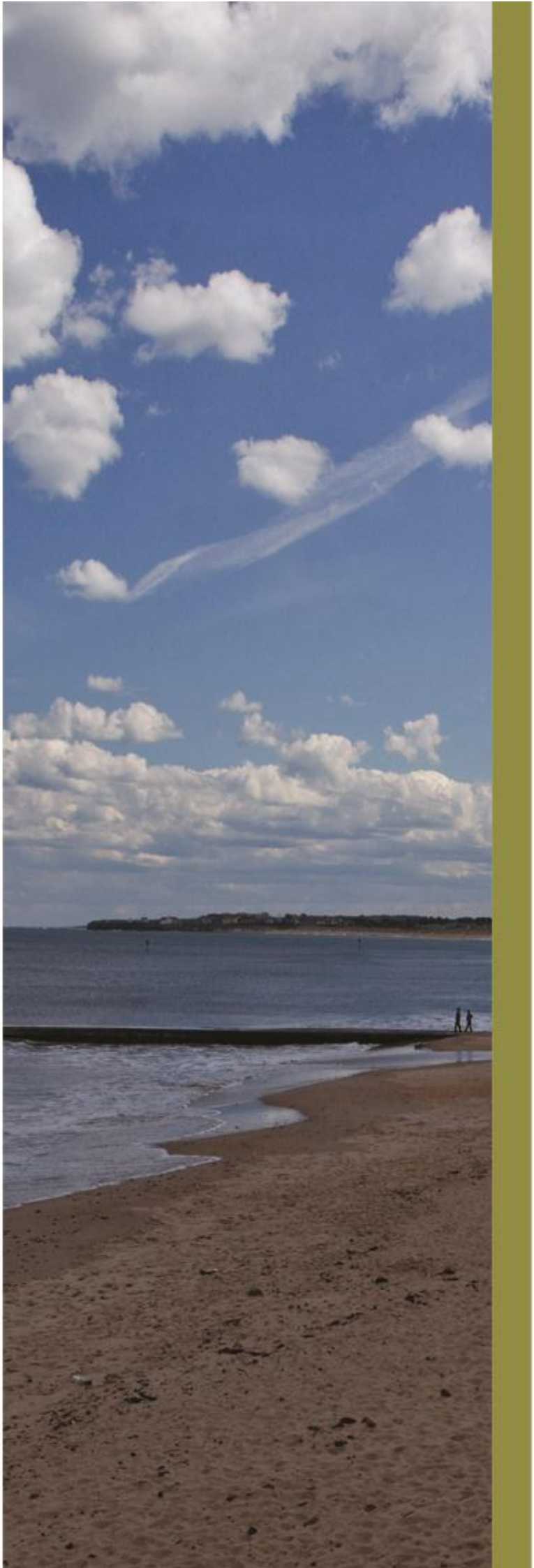
Marine Management Organisation

A Strategic Framework for Scoping Cumulative Effects

December 2014



A Strategic Framework for Scoping Cumulative Effects

MMO Project No: 1055

Marine Management Organisation

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List of Acronyms

AA	Appropriate Assessment
BMAPA	British Marine Aggregate Producers Association
BODC	British Oceanographic Data Centre
BTO	British Trust for Ornithology
CA	Competent Authority
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CFP	Common Fisheries Policy
DECC	Department for Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DPSIR	Driver, Pressure, State, Impact, Response
EEA	European Environment Agency
EIA	Environmental Impact Assessment
ES	Environmental Statement
GES	Good Environmental Status
HRA	Habitats Regulations Assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
IEMA	Institute of Environmental Management and Assessment
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
MarLIN	Marine Life Information Network
MCAA	Marine and Coastal Access Act
MCZ	Marine Conservation Zones
MEDIN	Marine Environmental Data and Information Network
MESH	Mapping European Seabed Habitats
MMO	Marine Management Organisation
MPA	Marine Protected Areas
MPS	Marine Policy Statement
MSFD	Marine Strategy Framework Directive
ODEMM	Options for Delivering Ecosystem-based Marine Management
SAC	Special Area of Conservation
SCANS II	Small Cetaceans in the European Atlantic and North Sea II
SCOS	Special Committee on Seals
SEA	Strategic Environmental Assessment
SPA	Special Protection Area

Executive Summary

The Marine Management Organisation (MMO) must ensure that cumulative effects are identified and assessed appropriately, alongside other evidence in its decision making. NIRAS Consulting Ltd, supported by AMEC, was commissioned by MMO to develop a consistent approach to the identification and consideration of cumulative effects that can be applied at the strategic level across all relevant MMO functions. The work includes a review of current evidence, the creation of a framework to identify and scope cumulative effects at a high level and the production of a series of options to facilitate appropriate and proportionate management of cumulative effects and mitigation measures. The project aims to look at cumulative effects of marine activities across the strategic, regional and individual project level.

In accordance with the principles of sustainable development, there is a need to consider the environmental, social and economic effects of marine activities at both the project and plan level. Cumulative effects should ideally be considered within a strategic planning framework and mitigated by minimising the negative environmental, social and economic impacts of specific activities. Currently, many of the legislative drivers for cumulative effects assessment (CEA) have a strong focus on the consideration of environmental cumulative effects. Therefore, for this project, environmental factors have taken priority, with social and economic considerations of cumulative effects explored to a lesser extent.

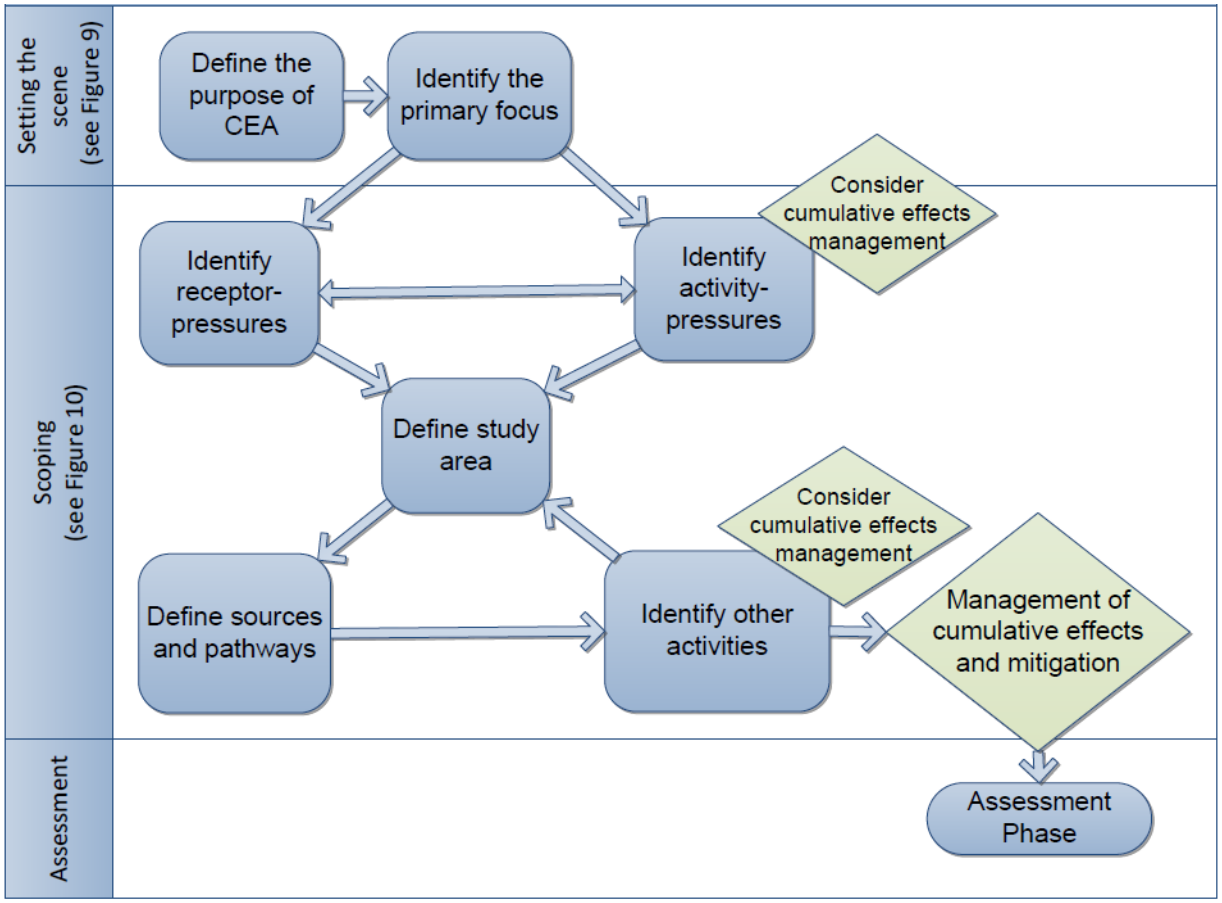
CEA can be defined as “a systematic procedure for identifying and evaluating the significance of effects from multiple pressures and/or activities. The analysis of the causes, pathways and consequences of these effects is an essential part of the process” (MMO, 2013a; adapted from Cooper, 2004). This definition is followed for the current work. A crucial element of MMO’s role is considering how activities might contribute to and mitigate potential cumulative effects. Management approaches should consider the burdens on marine users and aim to minimise those burdens following the principles of sustainable development. Following this, MMO should ensure that licensing decisions and marine plan policies consider long term effects by requiring marine users to contribute to the assessment and mitigation of cumulative effects, and consider how to apportion the mitigation costs fairly and appropriately.

A high level framework to enable scoping of the potential for cumulative effects at a strategic level, has been developed in consultation with MMO staff and external stakeholders. A toolkit of potential management approaches has also been developed. These approaches can be applied at a number of stages of the overarching CEA framework and use of these different approaches would be determined by the level of information available at the time of assessment. The scoping framework was explored further using test cases to demonstrate the process: a number of offshore wind developments in the Greater Wash; and the consideration of CEA from the perspective of large scale activity versus small scale activity in a hypothetical area. This approach could be applied across the work of all relevant MMO functions.

The overall framework is presented in Figure 1 and highlights the stages of the proposed process; including where MMO might need to consider management approaches. The framework considers the scoping stage only; in order to move forward into the assessment phase of the CEA process, further investigation and consultation with key advisors and stakeholders will be required. The report describes each framework step in detail and the framework is tested on a number of case studies.

The framework is underpinned by an evidence database constructed during this work which identifies activities taking place in the marine environment, the pressures that they exert, and the receptors which may potentially be sensitive to those pressures. It provides summary matrices, highlighting where there may be potential for cumulative effects between activities based on overlapping pressures with potential to affect a common receptor, to support an initial assessment. This evidence database considers the most appropriate evidence currently available whilst remaining open for future updates as and when new information becomes available.

Figure 1: Strategic framework for scoping cumulative effects and management of responsibility for cumulative effects and mitigation.



There is potential to update and refine the framework and database in future, in accordance with new evidence and any relevant guidance produced externally to MMO. The development of a framework to make it possible to identify and scope cumulative effects in the marine environment is inherently dependent on the current understanding of individual effects within this complex system of environmental, social and economic interactions. Whilst some effects are reasonably well understood, there is a large degree of scientific uncertainty surrounding others. To further support the development of the framework and to ensure the evidence database remains up to date and fit for purpose, a number of recommendations have been provided. Full detailed recommendations are provided within the report, in brief:

Recommendations for evidence requirements:

1. In the short term, there is a need to review the remaining activity-pressure links within the Evidence database against additional evidence, which is required to provide a level of confidence in the link.

2. In the longer term, the evidence database might be expanded to incorporate information on the likely spatio-temporal scale of activity-pressures and pressures-receptor. This will enable more accurate and consistent approach to defining the study area during the scoping exercise.

3. Receptor categories within the evidence database are currently very high level and as more evidence becomes available it is recommended that the groups are refined and the links to pressures re-established as more evidence becomes available.

4. Recommendations 2 and 3 are highly dependent on available evidence, and it is therefore vital that MMO maintain an awareness of on-going projects of relevance. Gaps in evidence relating to this work are highlighted within this report.

5. It is recommended the framework and database are reviewed on a regular basis in order to ensure that the most up to date information is being utilised and continues to be appropriate for MMO's needs. Updates should be made as new evidence becomes available, in particular relating to activity-pressure-receptor interactions, to ensure the framework is underpinned by best-available evidence.

6. Further consideration should be given to the social and economic (cumulative and individual) effects and how these could be incorporated into the evidence database in the most appropriate way. Progress should be based on final outputs of the MMO report "Social impacts and interactions between marine sectors" (MMO, 2014a) as well as previous reports such as MMO (2013b, 2013c, 2014b). This may require collection of additional evidence to support integration.

Recommendations for framework requirements:

7. In the short term, it is recommended that MMO reviews and considers implementation of the framework to support work of MMO functions.

8. In the longer term, consideration could be given to the update of the evidence database and framework to incorporate the differences between types of cumulative effects, such as indirect effects and interactions between effects.

9. It is recommended that further testing of the use of the different approaches to considering management of cumulative effects and mitigation be carried out in consultation with stakeholders as appropriate. Collation and evaluation of case studies where these approaches have been used previously would also help to strengthen the methodologies and develop best practice.

1. Introduction

The Marine Management Organisation (MMO) is an executive non-departmental public body, established and given powers under the Marine and Coastal Access Act (MCAA, 2009)[1]. This brings together, for the first time, key marine decision-making powers and delivery mechanisms. MMO has a number of functions, including: marine planning; marine licensing; marine conservation and enforcement; and fisheries management. In order to support decision making within these functions, MMO developed the Strategic Evidence Plan 2011-2015[2] to set the focus and direction for their evidence and research programme. 'Cumulative Effects' is designated as a priority research area within the Strategic Evidence Plan.

Under the UK Marine Policy Statement (MPS) (Defra, 2011), MMO has an obligation to ensure potential cumulative effects are taken into account in decision making. The identification and evaluation of potential environmental, social, and economic effects of marine activities allows for effective management measures to be established to minimise or remove negative effects. Such measures may potentially be put in place through, for example, licensing conditions or marine plan policies. The assessment of cumulative effects and any mitigation measures applied must be proportionate and achievable on a practical level. A compatible approach to the consideration of cumulative effects across all MMO functions is essential to support effective plan-led management and informed decision-making.

The main output of this project is to develop an overarching framework to provide MMO staff with a methodology for scoping cumulative effects at the strategic level as part of their day-to-day operations. The framework will focus specifically on a step-by-step approach to the identification of potential cumulative effects. It is expected that this project will focus on the first steps in the cumulative effects assessment (CEA) process for MMO and, as such, does not discuss the methodology by which MMO might assess the cumulative effects once they have been identified as potential effects. The project also explores alternative approaches to management of cumulative effects mitigation that can be considered during the initial assessment process.

The framework proposed in this report guides the identification and scoping of cumulative effects. It can be applied at a range of scales whether at the level of the production of marine plans and their supporting policies, or when considering project specific material in support of marine licence application. It also aims to align with current MMO processes following legislative and policy drivers. Detailed and comprehensive scoping of cumulative effects will still be required on a case-by-case basis.

1.1 Objectives

The specific objectives of this project are:

[1] http://www.legislation.gov.uk/ukpga/2009/23/contents [Accessed 28/03/2014]
[2] https://www.gov.uk/government/publications/strategic-evidence-plan

1. Collate current evidence relating to potential high level drivers, pressures and pathways/effects on receptors arising from marine activities.

2. Produce guidelines that define potential options for the management of CEA and mitigation where responsibility cannot be determined from current legislation.

3. Create a series of summary tables based on the outputs of Objective 1, which provide a high level summary of pressures for each marine activity and receptor and highlight where there is potential for cumulative effects between marine activities through the identification of pressures.

4. Detail a framework applicable across MMO functions to identify and scope cumulative effects at the strategic level using summary tables from Objective 3. This includes a process for updating both the framework and the underlying evidence database as new evidence becomes available.

Currently, secondary legislation driving cumulative effects assessment has a strong focus towards environmental cumulative effects and thus the project outputs will reflect this focus. However, following higher level policy drivers, the project will also consider potential social and economic cumulative effects in sufficient depth to ensure compatibility of the project outputs with an ecosystem-based approach to marine management. This will facilitate future balanced integrated assessment of environmental, social and economic cumulative effects under the umbrella of sustainable development.

A number of additional MMO projects have been used to inform this work. MMO project ‘Social impacts and interactions between marine sectors’ (MMO, 2014a) ran parallel to this project, with the aim of providing a body of evidence on social impacts and an assessment of interactions within and between marine sectors; to assist marine plan development and implementation. This evidence was used to suggest an approach towards social effects analysis for the cumulative effects framework and the supporting evidence database.

A practical framework for outlining the integration of the ecosystem approach into marine planning in England has also been developed (MMO, 2014c). The project aimed to demonstrate how MMO could improve the integration of an ecosystem based approach into marine planning. The study reviewed the ecosystem approach and proposed a set of 10 principles for application in marine planning. As the ecosystem approach should underpin MMO work, it is important that the CEA framework also sits within the ecosystem approach and the way in which MMO implements this.

1.2 Overview of cumulative effects assessment

1.2.1 Terminology

A contributing factor to difficulties with CEA, as noted in MMO (2013a), is inconsistency in terminology among regulators, applicants and advisers. Terms used within this project, ensuring a consistent approach, are defined below.

Cumulative Effects Assessment
This report refers to CEA defined by MMO (2013a) (adapted from Cooper, 2004) as "a systematic procedure for identifying and evaluating the significance of effects from multiple pressures and/or activities. The analysis of the causes, pathways and consequences of these effects is an essential part of the process."

Cumulative effects have been defined as "net effect of cumulative pressures", which would include the consideration of both direct and indirect effects resulting from cumulative pressures caused by different activities (HELCOM *et al.*, 2012). For the purposes of this project, the definitions for the types of cumulative effects and interactions between effects have been adapted from the European guidelines (Hyder, 1999):

- **Cumulative effects** – Effects that result from incremental changes caused by other past, present or reasonably foreseeable actions together with the project.
- **Indirect effects** – Effects, which are not a direct result of the project, often produced away from or as a result of a complex pathway.
- **Effect interactions** - The reactions between effects, whether between the effects of just one project, or between the effects of other projects in the area.

Due to the high level nature of this project, only 'cumulative effects', as effects that result from incremental changes cause by other past, present or reasonably foreseeable actions, are considered. There is the potential for other types of cumulative effects (indirect effects and effect interactions) to be included in future.

Cumulative and in-combination effects
The terms 'in-combination effects' and 'cumulative effects' have similar meanings; it is the legislative context which differs and consequently affects how they are described and how CEA is approached. Article 6(3) of EC Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora indicates the need to appropriately assess 'in-combination' effects that a plan or project may have with other plans or projects. Article 4(3) of the European Environmental Impact Assessment (EIA) Directive (85/337/EEC) (as amended), referring to the screening stage, states 'the characteristics of the project must be considered having regard, in particular, to … the cumulation with other projects'. In relation to the content of an Environmental Statement, Article 5(1) of the EIA Directive requires 'assessment of the direct effects and any indirect, secondary, cumulative, short, medium and long-term, permanent or temporary, positive and negative effects of the project'.

The framework proposed here constitutes a common approach to both in-combination and cumulative effects assessment. However, when implemented in practice it is important that the appropriate terminology is used in the relevant context.

Plans, projects and activities
Human activities taking place within the marine environment can be categorised as plans (e.g. The Crown Estate Round 3 offshore wind plan), projects (e.g. individual wind farms) or activities (e.g. commercial fishing). These will interact with the marine

environment through: pre-construction, construction, operation and decommissioning works associated with projects; activities being carried out; and plan policies being implemented.

Pressures and effects

There is a high degree of inconsistency in the use of the terms 'pressure' and 'effect', both in theory and practice. These concepts are often used interchangeably with each other and also with the term 'impact'. In addition, legislation at different levels does not provide clarification on scope or methodology for CEA, which creates uncertainty in regulation for industry and practitioners (Masden *et al.,* 2009). For example, the European EIA Directive (85/337/EEC) (as amended) and European Directive 2001/42/EC (Strategic Environmental Assessment Directive) refer to the assessment of 'significant effects' and 'significant impacts' respectively whereas the Marine Strategy Framework Directive (MSFD) groups together 'pressures' and 'impacts' without differentiating their meaning (MSFD, Annex III).

Following the framework adopted by the European Environment Agency (EEA) for describing the interaction between human development and the environment (the Driver, Pressure, State, Impact, Response (DPSIR) model; Section 3.1.1) there are socio-economic drivers which exert a pressure on the environment depending on the nature of the activity undertaken in response to the driver. This leads to a change in the state of the ecosystem, e.g. through a change in the physical, chemical or biological components, these changes are often negative but sometimes positive – i.e. an effect. These effects on the ecosystem can then have impacts which are categorised in the DPSIR framework in terms of economic and societal well-being; for example sales and purchases in the market and people's way of life. Adapting this framework to the needs of this project, the following terms are therefore defined:

- **Pressures** are "the mechanism through which an activity has an effect on any part of the ecosystem" (Robinson *et al*., 2008). Pressures can be physical, chemical or biological, and can be created by different activities or drivers
- **Effects** occur only when a pressure is present within an environment that is sensitive to it. A cumulative effect is the combined effect of pressures present to which a specific receptor is sensitive.

Receptors

A receptor is defined as any ecological or other specific feature that is sensitive to or has the potential to be affected by a pressure (IEEM, 2010). Environmental receptors include oceanic and atmospheric processes, water and sediment quality, biological components and habitats. Social and economic receptors include the individuals, social groups, households, businesses and other marine sectors.

Source and pathway

Consideration of the overall process linking pressures exerted by activities to sensitive receptors is critical in understanding both individual and cumulative effects. One way to understand where effects could potentially occur is by identifying the 'source' of a pressure exerted by an activity and the 'pathway' to a receptor which may be sensitive to that pressure. Sources of pressures are specific to different types of activity. Pathways to receptors are highly dependent on the source of a pressure and, as such, can only be defined on a case-by-case basis.

1.2.2 Background

Cumulative effects can be considered as the combined effects of past, present and reasonably foreseeable activities over time, on environmental, economic and social receptors. An individual effect alone may be considered insignificant, but the additive effects of more than one effect, from any number of sources, could result in a significant effect, either positive or negative.

The assessment of cumulative effects is required through a number of legislative drivers (Section 1.2.3). However, cumulative effects are often not fully assessed due to the complexities of the effects, and the lack of available information on both proposed or existing developments and their interactions with the surrounding environment. The marine environment is highly complex with a multitude of environmental, social and economic interactions, therefore understanding and predicting cumulative effects is a challenging exercise. In addition, naturally occurring changes (e.g. due to climate change) must be taken into account as physical drivers when considering further impacts of human activity. By collecting information over long periods of time, data can be obtained on how certain types of activities contribute to a cumulative effect. This is, however, often an unfeasible and resource intensive approach.

CEA has been identified as a key area for improvement across all industry sectors in England (IEMA, 2011), an observation echoed throughout Europe and North America (Duinker and Greig; 2006; Masden *et al.*, 2009). The European Commission provided relatively early and sound guidance on CEA (Hyder, 1999); however this does not provide an explicit framework for the scoping and assessment of cumulative effects (Cooper and Sheate, 2002).

In recent years, a number of initiatives have been taken forward in the UK, particularly driven by the requirement to adequately assess the cumulative impacts of offshore wind development. These include work to develop methodologies for CEA with respect to seabirds (King *et al*., 2009), a general review of cumulative effects for offshore wind farm development (MMO, 2013a), and work to develop guiding principles for offshore wind CEA (RenewableUK/NERC, 2013). Other key studies which have been used to inform the production of this framework include: Options for Delivering Ecosystem-based Marine Management (Robinson and Knights, 2011); and the DPSIR framework utilised by the EEA.

While CEA is seemingly simple to navigate in theory, it is often difficult to implement in practice. MMO must ensure that cumulative effects are identified and assessed appropriately and consistently alongside other evidence in its decision making. Currently, there is no guidance available or system in place to ensure consistency in this process, and so the aim of this project is to develop an initial high level consistent approach to scoping cumulative effects that can be utilised by MMO across all its functions.

The development of a framework for the scoping of cumulative effects is greatly dependent upon current understanding of the potential effects of activities within the marine environment. Whilst some effects are understood to a certain extent, others remain shrouded by a large degree of scientific uncertainty (MMO, 2013a). This lack

of understanding has contributed to the relatively slow pace in developing understanding of and approaches to CEA.

1.2.3 Legislative drivers

The Strategic Environmental Assessment Directive

The Strategic Environmental Assessment (SEA) Directive 2001/42/EC[3] on the assessment of the effects of plans and programmes on the environment seeks to inform decision-making with regards to a particular action (plans, programmes and strategies). For example, MMO undertakes a Sustainability Appraisal (see Section 1.3.1) alongside its plan-making process, to deliver the requirements of the SEA Directive. The Sustainability Appraisal considers the social, economic and environmental effects of marine plans to ensure that these plans meet with sustainable development objectives.

The SEA Directive requires the consideration of "likely significant effects… including synergistic effects on the environment" (Annex I of the SEA Directive). The criteria for determining the likely significance of effects includes the "cumulative nature of the effects" (Annex II of the SEA Directive).

Plans and programmes can lead to projects and activities, with the potential for environmental, social and economic impacts. The SEA process facilitates an early overview of the potential impacts and interactions which could lead to cumulative effects. It also facilitates the analysis of alternatives early in the process, enabling the selection of plans/programmes that are less likely (or unlikely) to contribute to cumulative impacts.

SEA is intended to help identify those sites most suitable for development, and to set the scene for the subsequent project-level EIAs.

The EIA Directive and the Habitats Directive

All proposals for projects that are subject to the European EIA Directive (85/337/EEC[4]) (as amended), must be accompanied by an Environmental Statement (ES) describing the likely potential environmental effects arising from the project. This description should cover the "direct effects and any indirect, secondary, cumulative, short, medium and long-term, permanent and temporary, positive and negative effects of the project". MMO is the appropriate authority responsible for ensuring the requirements of the EIA Directive are met in relation to marine licences and harbour orders. This is implemented through The MCAA 2009[5] and The Marine Works (Environmental Impact Assessment) (Amendment) Regulations 2011[6].

Separately, EC Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora[7] (Habitats Directive) requires that, where a plan or project is likely to have a significant effect on a feature of a Natura 2000 site, either individually

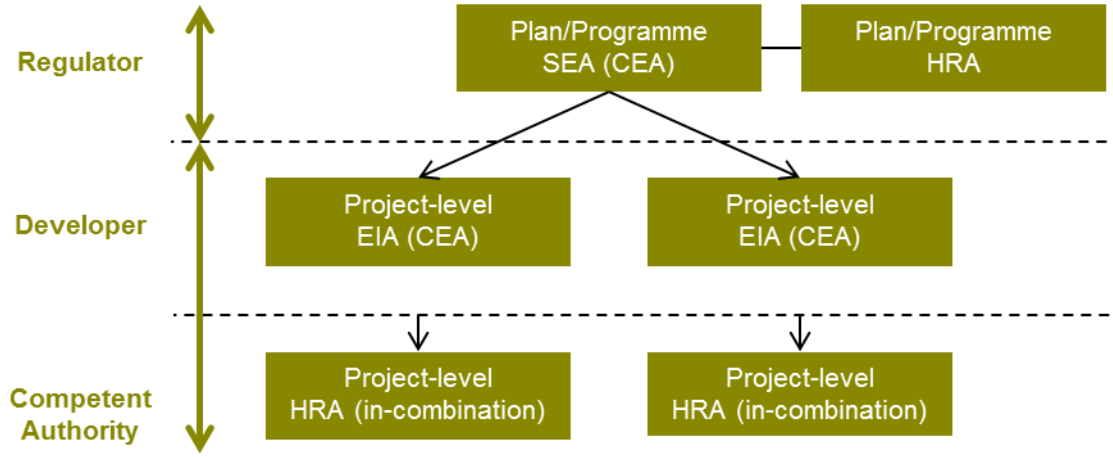
[3] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32001L0042:EN:HTML [Accessed 19/03/2014]
[4] http://ec.europa.eu/environment/eia/eia-legalcontext.htm [Accessed 19/03/2014]
[5] http://www.legislation.gov.uk/ukpga/2009/23/contents [Accessed 08/04/2014]
[6] http://www.legislation.gov.uk/uksi/2011/735/made [Accessed 08/04/2014]
[7] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1992L0043:20070101:EN:HTML [Accessed 19/03/2014]

or in combination with other plans or projects, it will be subject to Appropriate Assessment (AA). The Natura 2000 network comprises Special Areas of Conservation (SACs) and Sites of Community Importance (SCI) that are designated under the Habitats Directive and Special Protection Areas (SPAs) designated under the Birds Directive (Council Directive 71/409/EEC on the conservation of wild birds[8]). Protection is also extended in the UK to Ramsar sites (wetlands of international importance). These Directives are implemented in the UK through the Conservation of Habitats and Species Regulations 2010[9] and the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007[10] (as amended), for projects outside 12 nautical miles (Habitats Regulations).

In accordance with the Habitats Directive, in-combination effects (inter-project cumulative effects) need to be considered for relevant Natura 2000 site features (habitats and species). The process of screening for likely significant effects and, where appropriate, the provision of information to inform an AA is known as a Habitats Regulations Assessment (HRA). MMO is the competent authority for ensuring the requirements of the Habitats Regulations are met in relation to marine licences and harbour orders.

Figure 2 summarises the relationship between SEA, EIA and HRA.

Figure 2: The relationship between SEA, EIA and HRA (Reproduced from RenewableUK, 2013).



UK Marine Policy Statement (MPS)

Within the UK, the MCAA (2009) provides the basis to strategically plan marine activities. The Act divides the UK marine area into marine planning regions with an associated plan authority that is responsible for preparing a marine plan for that region.

[8] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:020:0007:01:EN:HTML [Accessed 19/03/2014]
[9] http://www.legislation.gov.uk/uksi/2010/490/contents/made [Accessed 19/03/2014]
[10] http://www.legislation.gov.uk/uksi/2007/1842/contents/made [Accessed 19/03/2014]

MMO is the plan authority for English marine waters. Subsequently, the MPS (page 15) expects that MMO consider the potential cumulative impact of activities and use best available techniques to assess whether:

- "The cumulative impact of activities, either by themselves over time or in conjunction with others, outweigh the benefits.
- A series of low impact activities would have a significant cumulative impact which outweighs the benefit.
- An activity may preclude the use of the same area/resource for another potentially beneficial activity."

Marine Strategy Framework Directive

Of particular relevance to the implementation of the MCAA is the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC)[11]. Article 1(3) of the MSFD identifies the need for marine strategies to apply "an ecosystem-based approach to the management of human activities, ensuring that the collective pressures of such activities are kept within levels compatible with the achievement of good environmental status and the capacity of marine ecosystems to respond to human-induced changes is not compromised". The overarching aim of the MSFD is for Member States to introduce measures that will lead to the achievement of Good Environmental Status (GES) in their marine waters by 2020. Accordingly, Member States are developing Marine Strategies for their waters, including:

- An initial assessment (characteristics and status of those waters, their economic and social use, and an analysis of predominant pressures and impacts, covering main cumulative and synergetic effects (Article 8))
- Targets and indicators of GES
- The implementation of monitoring, programmes or measures to achieve or maintain GES.

In the UK, the MSFD is being implemented in a coordinated way across the UK Administrations. The Marine Monitoring and Assessment Strategy (UKMMAS) was set up to coordinate monitoring and ensure delivery of the required assessment. Supporting evidence is gathered by four evidence groups that sit under UKMMAS: Healthy and Biologically Diverse Seas (HBDSEG), Clean and Safe Seas (CSSEG), Productive Seas (PSEG), and Ocean Processes (OPEG).

Both the initial assessment and establishment of targets and GES indicators have already been finalised in the UK, providing a framework which will be used in the future management of UK seas (Defra, 2012). It is the responsibility of MMO to have due regard to these targets and GES indications, in its decision making and development of operational policies. Therefore, the objectives of this CEA project are of relevance in the context of the MSFD.

[11] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008L0056:EN:HTML [Accessed 19/03/2014]

1.3 MMO requirements in CEA

On 11th and 12th December 2013, a series of preliminary discussions were held with each MMO function at their offices in Newcastle. The aim of these discussions was to gain a more thorough understanding of the requirements of each function in the assessment of cumulative effects, and how the framework might therefore be applied. A summary of the outcome of each discussion session is outlined in the following sections.

1.3.1 Planning

Marine planning is one of the major functions of MMO, the aim of which is to create a marine planning system designed to bring together the environmental, social and economic needs of the UK seas. This will help ensure a sustainable future for coastal and offshore waters through the management of the many activities, resources and assets within the marine environment.

The MPS, developed by the Department for Environment, Food and Rural Affairs (Defra) in co-operation with other government departments and UK administrations, provides the framework for all marine plans and guides general decision-making in the marine area. The marine plans developed for England are intended to guide developers as to where different activities may be permitted, and may indicate any conditions or restrictions that may be enforced. All operators and regulators in an area will be expected to work to the same plan, providing transparency and consistency in decision-making.

The MMO planning team currently looks at CEA within three processes: the Sustainability Appraisal and HRA of marine plans and general planning policy development. The Sustainability Appraisal process for the East marine plans was limited as a result of the typically non-spatial nature of the current policies (Defra, 2014a).

During general policy development for marine plans, MMO are required to outline how others are expected to assess CEA in terms of spatial impact. There are currently 14 spatially explicit policies (i.e. the policy only applies to certain areas) within the East marine plans (Defra, 2014a). Five of these have extents defined by MMO and the remainder are tied to third party spatial considerations such as The Crown Estate lease areas. In consultation, the MMO planning team has expressed that stakeholders are keen to see more spatial policies developed in future plans and plan revision.

A matrix of sensitivity of habitat types to pressures (Tillin *et al.*, 2010) was applied to habitat maps and used by the planning team in the East Plans Evidence and Issues Report (MMO, 2012) to illustrate habitat vulnerability and the potential for cumulative effects at a sector level (e.g. offshore wind and aggregate extraction). However, confidence in the methods and data was not sufficient at the time for the results to contribute to policy development.

There is currently no consensus or national policy/legislative direction on the detailed approach to cumulative effects in marine planning. The Sustainability Appraisal process is required to make some judgement as to the extent of cumulative effects

that could occur as a result of marine plans (i.e. policy implementation). In the East plans (Defra, 2014a), policy ECO1 emphasises the need for consideration of cumulative effects; however, there was insufficient evidence at the time to provide more detailed policy guidance or preferences.

1.3.2 Licensing

MMO is responsible for most marine licensing in English inshore and offshore waters and for Welsh and Northern Irish offshore waters, managing the environmental, social, and economic impacts of construction, deposits and removals in the marine area. Activities are consented through the marine licensing system, under the MCAA 2009, which came into force on 6 April 2011. A marine licence is only required for activities involving a deposit or removal of a substance or object in the UK marine area, as defined in Section 42 of the Act.

All licensing decisions will be made in accordance with marine plans once published, unless relevant considerations indicate otherwise. Broadly, the 'marine area' is the area below the mean high water springs mark and in any tidal river it is the area to the extent of the tidal influence. In some cases a marine licence will be required for activities outside UK waters. For example, where the activity takes place from a British vessel or where the vessel was loaded in UK waters. Section 66 of the Act lists the types of activity that are licensable.

Regarding the duties of the MMO licencing team, cumulative effects are generally considered through EIA and in the information prepared by the applicant/developer to support HRA. MMO considers the information provided within the EIA/HRA and will return to the applicant/developer for more information if necessary.

MMO is required to highlight projects for inclusion in CEA, and any specific issues of concern for each proposal, if they are known. There is no specific assessment process for smaller projects which do not require EIA and it is the areas with multiple, smaller projects which potentially pose the greatest challenge in terms of assessing cumulative effects. Generally the team would consult with the relevant stakeholders if issues are raised.

1.3.3 Marine conservation and enforcement

All public authorities, including MMO, have a duty to carry out their functions in a way which has regard to the conservation objectives set for Marine Protected Areas (MPAs). These include national designations, for example Marine Conservation Zones (MCZs) and European designations, such as SACs and SPAs designated under the Habitats and Wild Birds Directives respectively. MMO has powers under the MCAA 2009 to make byelaws for the protection of features of MPAs (and potential MPAs). They may also issue permits to allow certain levels of activity which a byelaw would normally prohibit.

With respect to the MPAs, when considering potential management measures, MMO currently look at cumulative effects with respect to how activities could affect the designated site. This is a receptor driven process. There is currently no fixed process or method in place to do this, although some guidance is provided by Statutory Nature Conservation Bodies (SNCBs). Whilst it is relatively simple to review the

effects of single activities on particular sites, the challenge is the identification of smaller impacts which might together constitute a cumulative impact.

1.3.4 Fisheries management

MMO are currently working on streamlining the management and regulation of fisheries in England. The Common Fisheries Policy (CFP) is the EU instrument for the management of fisheries and aquaculture, and it is the responsibility of EU member states to make sure that the rules agreed under the CFP are respected. This is the primary role of the MMO fisheries team.

Fisheries management by MMO is driven by stock quotas informed by a scientific approach to monitoring and management at EU level, setting limits for UK quotas and fishing effort. Given this, where fisheries are a stressor exerting a negative impact on stocks, management measures are likely to lead to a reduction in fish quotas or effort limits within licences. This monitoring/management can take account of other potential stressors in the area and takes a more precautionary approach to stock quotas and effort limits where appropriate. This does not, however, explicitly include CEA.

Under current policy and legislation, fisheries are not classed as ‘plans or projects’ and thus are not assessed as such under the legislation requiring CEA (see Section 1.2.3). The fisheries sector should, however, be considered under other MMO functions and should be assessed as a ‘baseline’ impact and receptor within CEA and in-combination assessments for marine licence applications under the EIA and Habitats directives. They should also be considered as potential receptors in terms of social and economic impacts.

2. Cumulative effects evidence database

Collation of current evidence to support the high level CEA framework produced under this project was achieved through the construction of an evidence database. Microsoft Office Access was considered the most appropriate tool to construct the database as such a database can be relatively easy to update as new evidence becomes available. This also provides for an organised collection of data, which can be viewed and manipulated in a flexible manner. Data is organised by means of related tables, which can be linked using common fields (key words or codes). The structure of the database is defined by the requirements of the CEA framework described under Section 5. The following sections describe the development and structure of the database.

The database was designed to allow incorporation of evidence relating to potential high level drivers, pressures and pathways on environmental, social and economic receptors, resulting from marine activity. It categorises the activities, pressures and receptors and provides tables and summary matrices demonstrating links between activities, pressures and receptors.

As a first step, linkage tables produced by the ODEMM project[12] were used to establish the links between activities and pressures. This was followed by a review of available, peer-reviewed evidence to further inform these links and to describe the sources of each pressure that each activity exerts. This is a key component of the database. Sources are provided in general terms in order to help understanding of activity-pressure interactions; however they must be adapted to the project or plan specific information.

Reports reviewing literature on impacts of marine activities and sectorial guidance documents were prioritised over project-specific literature, as the former provide an overview of potential pressures at a high level, which is in line with the purpose of the database. A full list of references used for the review can be found in Annex 1.

2.1 Activity, pressure and receptor description tables

The first set of summary tables within the database provides descriptions of each of the main categories –activities, pressures and receptors. Cumulative effect assessment must consider social and economic factors as well as environmental factors in order to ensure sustainable development in the marine environment (Defra, 2011). Environmental issues have been separated from economic and social issues in the following sections to reflect the different levels of information available for the topics and thus information available for this project. However, it is anticipated that all three pillars of sustainability will be more fully integrated in future work.

Marine activities have benefits and costs that can be economic, social and environmental. Environmental costs and benefits are related to pressures exerted from marine activities on an environmental resource. Following the DPSIR

[12] http://www.liv.ac.uk/odemm/

framework, social and economic drivers exert pressure on the environment. This leads to a change in the state of the environment and subsequent effects on environmental receptors which can lead to societal and economic impacts that feed back into the drivers.

MMO (2014a) examined social impacts on communities, documenting how activities interactions give rise to social effects, with the aim of informing social impact scoping exercises. Accordingly, these outputs have been used to identify an approach towards their inclusion in the proposed strategic CEA scoping framework.

2.1.1 Activities list

Environmental, social and economic

The list of activities used for this project and for which evidence is available in the database is presented in Annex 2. To ensure consistency with work being undertaken in parallel with this project, the list of activities aligns with those defined by JNCC for the UK Marine Monitoring and Assessment Strategy (UKMMAS) evidence groups and presented in October 2013 to the Healthy and Biologically Diverse Seas Evidence Group (HBDSEG) (JNCC, 2013). At the time of writing this report, the list is undergoing review by JNCC. A further table links these activities to those as presented in the MPS (Annex 2), to ensure that this meets the requirements of MMO.

The activities used for the scoping of social and economic cumulative effects are the same as those used for environmental cumulative effects. The JNCC activities list is in line with the MPS activities, as per MMO (2014a). It was therefore deemed appropriate for use in this context.

Some activities were combined as available evidence does not support detailed analysis of pressures at this time (e.g. activity-pressure links for fishing refer to mobile and static gear use instead of specific fishing techniques). Whilst other activities were subdivided into their development phases where available evidence supported this (e.g. renewable energy – wind was sub-divided into construction, operation and decommissioning phases).

2.1.2 Environmental pressure list

The categories utilised to describe environmental pressures were adapted from the OSPAR pressure list (OSPAR, 2011) presented by the Intersessional Correspondence Group on Cumulative Effects (last amended 25 March 2011). It groups pressures by pressure themes and provides a short description for each pressure, which can be found in Annex 2.

It should be noted that the environmental pressures list used for this project lacked consideration of ‘positive pressures’ or benefits that marine activities can also bring and therefore might be considered incomplete.

2.1.3 Receptor list

Environmental receptors

Categories for environmental receptors are based on those defined by the MSFD and utilised in the ODEMM project. However, they have been broadened in keeping

with the high level nature of the requirements for a strategic approach to CEA. A description of environmental receptor categories can be found in Annex 2.

Social and economic receptors and impacts

MMO project "Social impacts and interactions of marine sectors" (MMO, 2014a) ran concurrent to this work. Categorisation of social receptors and impacts can be drawn directly from that project. It is recognised that categorisation of social impacts is more challenging than in the case of environmental impacts as social impacts cannot be as readily grouped (MMO, 2014a).

Interaction tables were developed in MMO (2014a) in order to begin to identify the social impacts that interactions between marine activities can have. The identification of consequences, defined as 'non-social consequences that may occur due to the interaction' could be used to link environmental pressures identified within the framework, to the final social impacts resulting from cumulative effects of various activities, plans or projects.

MMO (2014a) adapted a social impact typology from the social impact list developed by the International Association for Impact Assessment (IAIA) (2003). The modification ensured that it is fit for MMO purposes (see Table 1). IAIA (2003) identifies social impacts as changes to a series of elements which relate to individuals, communities and societies (i.e. receptors).

It is clear that the social and economic receptors and impacts evidence base needs further development and thus work will need to continue on the alignment of both lines of research in order to enable inclusion in the evidence database and CEA framework. A potential approach to integrating social and economic factors into CEA is discussed in Annex 3.

Table 1: Social impact categories (MMO, 2014a).

Impact type	Description
People's way of life	How people live, work (including employment and income), play and interact with one another on a day-to-day basis.
Culture	People's shared beliefs, customs, values and language or dialect.
Community	The cohesion, stability, character, sense of place, services and facilities.
Political systems	The extent to which people are able to participate in decisions that affect their lives, the level of democratisation that is taking place, and the resources provided for this purpose.
Environment	The quality of landscapes and seascapes, the quality of the air and water people use; the availability and quality of the food they eat; the level of hazard or risk, dust and noise they are exposed to; the adequacy of sanitation, their physical safety, and their access to and control over resources.

Impact type	Description
Health	A state of complete physical, mental, social and spiritual wellbeing and not merely the absence of disease or infirmity.
Personal and property rights and equity	Particularly whether people are economically affected or personally disadvantaged, which may include a violation of their civil liberties; equality and effects on minority group or other relevant or disadvantages groups.
Fears and aspirations	People's perceptions about their safety, their fears about the future of their community, and their aspirations for their future and the future of their children

2.1.4 Limitations in the use of social and economic information

The activities used for the scoping of social and economic impacts in CEA are the same as those used for environmental cumulative effects, in line with the MPS, as per the MMO's 'social impacts and interactions between marine sectors' report (2014a). The impacts and receptors have also been initially identified through the MMO (2014a) report, although some further work is required.

This means that the database cannot at this time be used to support the framework in the scoping of potential social and economic impacts in CEA. The scope of this project called for a focus on potential environmental cumulative effects, however with some modification in line with the final published MMO (2014a) report the approach might be applied for social and economic impacts in the future. Based on the outputs available from MMO (2014a) at the time of writing this report, activities, receptors and effects for potential social and economic impacts in CEA have begun to be mapped under the activity and receptor list categories. The categorisation of social and economic impacts and receptors is also often not as straightforward as that of environmental considerations.

A mechanism to integrate consideration of social and economic effects in CEA is described at a high level in Annex 3.

2.3 Environmental activity-pressure tables

Activity-pressure tables present the mechanisms through which an activity may affect receptors. The database aims to align with existing UK activity-pressure interaction assessments. Linkage tables which summarise activity-pressure interactions produced under the ODEMM project were utilised as a starting point for the identification of activity-environmental pressure interactions. The Charting Progress 2 Productive Seas Feeder Report (UKMMAS, 2010) was also used for the initial identification of environmental pressures associated with specific activities. These high level activity-environmental pressure tables can be viewed in the evidence database as a matrix and excerpts of these tables are given in Section 5.

For each of the initial activity-pressure interactions highlighted, further supporting evidence was gathered from reports including peer reviewed academic literature,

'grey' literature and technical reports (see Annex 1 for full reference list). This permitted the identification of potential sources of pressures which could be exerted by each activity. These sources are part of a more detailed table within the database, which means that the user is not only able to identify where there is potential for pressures from activities to overlap, but also to understand how these pressures are produced for each of the activities individually.

The original reports can also be accessed if further information is required. Each report used within the database has been subject to a Quality Assurance (QA) assessment following MMO evidence QA procedures, which gives an overall assessment of the confidence as a percentage score.

Each of the activity-pressure links is also accompanied by a more subjective level of confidence, which measures the level of certainty that exists around that interaction (i.e. the potential presence of knowledge gaps, robustness of data and the confidence in the judgement exercised). Three levels of confidence were used, in line with the assessment methodology utilised by UKMMAS (2010):

- **Low level of confidence:** Activity-pressure interaction has been inferred from broad-scale data with limited or no supporting references.
- **Moderate level of confidence:** Interaction has been identified in the literature but has not been quantified.
- **High level of confidence:** Interaction is well understood, and has been quantified through detailed modelling or analysis of specific data.

Confidence assessments on interactions ultimately reflect the confidence within the pressures and provide a gap analysis. Accordingly, a summary table which highlights where there is a low level of confidence can also be produced in the database to indicate potential evidence gaps.

2.4 Environmental pressure-receptor table/matrix

Pressure-receptor tables were also produced and indicate the pressures to which each environmental receptor group may be sensitive. These, as with the activity-pressure tables, can be viewed in the evidence database as a matrix and excerpts of these tables are given in Section 5.

The linkage tables produced by ODEMM have been used to inform development of the environmental pressure-receptor tables, and equivalency tables produced by JNCC as part of an activity-pressures matrices review, have been utilised to ensure alignment with the pressure descriptions. A level of confidence in the receptor-pressure link is also provided, using the following criteria:

- **Low level of confidence:** Receptor-pressure interaction has been inferred from broad-scale data with limited or no supporting references.
- **Moderate level of confidence:** Interaction has been extrapolated to the JNCC pressures through links to other similar pressures using equivalency tables and expert judgement
- **High-moderate level of confidence**: Interaction has been inferred using equivalency tables with similar pressure descriptions

- **High level of confidence:** Interaction has been extrapolated directly from ODEMM linkage tables with the same/very similar pressure descriptions

Within this table, pressures are considered to affect each receptor in the same way, regardless of the activity or magnitude of pressure. The link to activities will be considered during application of the framework by identification of pathways through which receptors are affected by each pressure exerted by a specific activity. This is supported by further tables within the database and is discussed in more depth in Section 5.

2.5 Summary matrices

The database was designed to provide summary tables, enabling the user to gain an 'at a glance' view of the potential for cumulative effects between activities on each receptor group. By selecting the required activity from a drop-down list within the summary table for a specific receptor group, the user will be able to view a matrix that shows the other activities with the potential to exert similar pressures on that receptor (Figure 3).

2.6 Reference tables

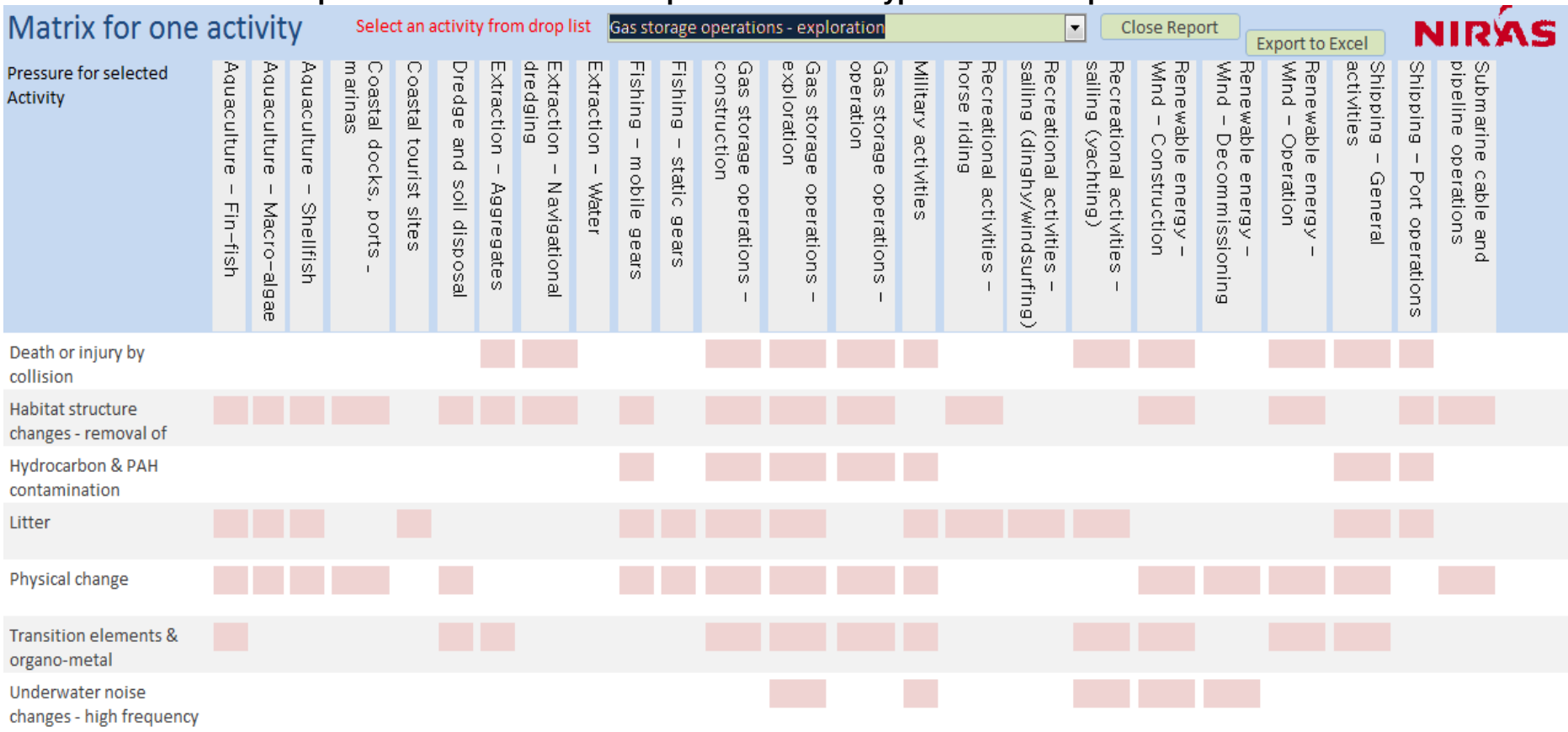
Users can access the original evidence reports utilised to populate the database via a reference table, which includes the full citation of the publication and an overall quality assessment. The full list of references is provided in Annex 1 of this report. The quality assessment appears as a percentage score, obtained through the MMO QA checklist process, which takes into account quality standards, methodology, timeliness and appropriateness of the evidence used.

2.7 Spatial and temporal range of pressures

At present, the database does not provide information on the spatial and temporal range of pressures as insufficient information is available to allow this for all pressures. This could be integrated in future; a table linking each activity with each pressure and its 'worst case' spatial and temporal scale might be provided which would assist in the initial scoping process for potential cumulative effects. GIS may also prove to be a useful tool in the future adaptation of the evidence base if examining cumulative effects at a project level.

Spatial and temporal range will be project specific and may need to be defined differently depending on each activity. A significant amount of further development of the evidence base and consultation/agreement on appropriate spatial and temporal ranges would be required to incorporate this aspect of assessment into the database going forwards.

Figure 3: Extract of database showing summary matrix indicating links between 'Gas storage operations – exploration' and other activities with potential to exert the same pressures on a hypothetical receptor.



3. Development of high level approach to cumulative effects

The high level approach to cumulative effects includes a framework to assist in scoping cumulative effects and options to facilitate management of cumulative effects and mitigation. The framework to allow scoping of cumulative effects at a high level should provide MMO with an overarching methodology for internal use across its functions, at both the planning (regional) and licensing (project/local) level. In this respect, the framework needed to be high level and broad in scope to allow flexibility in its application.

A range of information on CEA and the development of appropriate frameworks is available in published scientific literature, 'grey literature' and professional reports. A literature review has been carried out, including key sources as discussed in Section 3.1 and a range of additional studies considered listed under Annex 4. This review informed the development of the framework.

MMO are guided by various policy and legislative requirements for undertaking CEA (see Section 1.2.3).

- MMO are the competent authority for project applications that have potential to adversely affect Natura 2000 sites; and is required to carry out an in-combination assessment, as part of an AA.
- Applicants are required to complete a CEA as part of the application for a marine licence, which marine licensing is responsible for making a judgement on. The only exception to this is for disposal at sea, where the responsibility for CEA lies with marine licensing. In all scenarios, the onus is on the applicant to provide information to MMO, either as a CEA or to inform an in-combination assessment.
- Marine planning is expected to consider cumulative effects and thus should consider potential contributions of marine users to cumulative effects, assessment and mitigation when creating marine plans and related draft plan policies.

In many cases, the 'responsibility' for mitigation of cumulative effects determined in these examples will be clearly outlined in legislation. However, in some situations this is not the case and guidance on how to address this is currently lacking. The easiest solution to this might be to take a 'first come, first served' approach; however this is not always conducive to enabling sustainable development and may lead to some activities being 'blocked' from areas where e.g. environmental carrying capacities have been reached.

A more flexible, defined management approach when considering contribution to cumulative effects and mitigation could be of benefit, where appropriate under current legislation. It could improve regulatory transparency and could also be of benefit to marine planning, especially in relation to the drafting of plan policies potentially providing:

- Consideration of the effect that the presence of multiple activities could have on each other's obligations for cumulative effects.
- Scenarios to allow assessment of the potential cost to activities in terms of mitigation of effects based on different potential plan options.
- Clarity on practical application of spatial policies and potentially some guidance on expectations to be written into the marine plans if required. For example, if there is an objective to prioritise an activity for an area, but another activity emerges earlier, there may need to be some direction to help prevent exclusion within the plans.

The following sections outline the methodology undertaken in the development of the framework (Objective 4) informed by a review of existing frameworks and guidance for management of cumulative effects (Objective 2). The consultation process is also detailed, alongside descriptions of how the final outputs were influenced at each stage.

3.1 Review of existing frameworks

An extensive array of information exists on both CEA and the development of appropriate frameworks. A targeted literature review has been carried out in order to inform the outputs of this project. A number of studies have been reviewed, including those published in academic, 'grey' and professional literature and the concepts evaluated in terms of their applicability to the aims of this project.

This section presents the key concepts which have been instrumental in the development of the final proposed scoping framework. The other relevant studies considered during framework development are summarised in Annex 4.

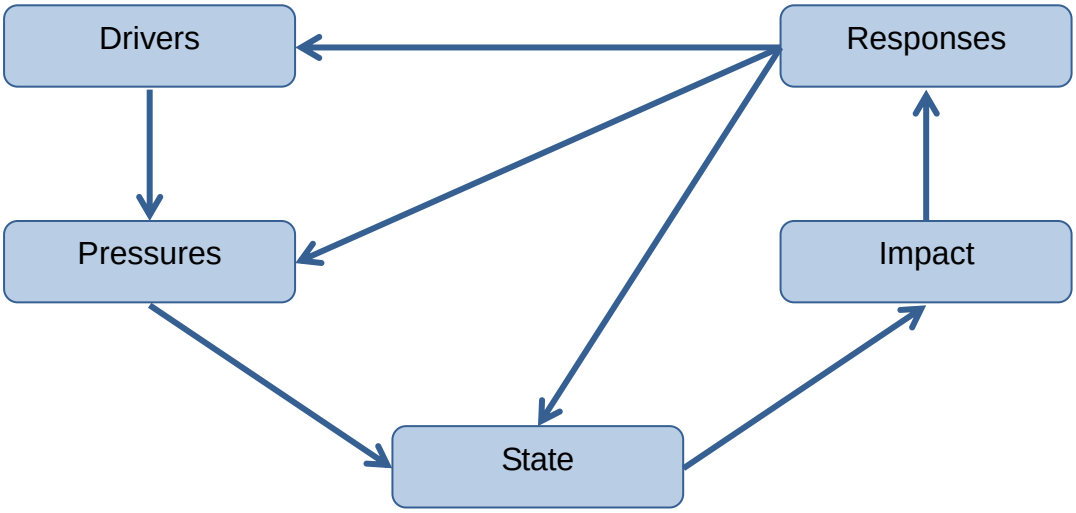
3.1.1 The DPSIR framework

The Netherlands National Institute of Public Health and Environment proposed the use of the DPSIR framework (Figure 4) to the EEA to aid the development of a strategy for integrated environmental assessment. The framework is an extension of the pressure-state-response model developed by the Organisation for Economic Co-operation and Development (OECD). The DPSIR framework further expands this to include driving forces, pressures, states, impacts and responses (Kristensen, 2004). This has been more widely adopted by the EEA, providing an integrated approach to reporting, e.g. in the EEA's State of the Environment Reports (EEA, 1998). The structure of the framework enables policy makers to receive feedback on appropriate indicators of environmental quality that have implications for political choices both presently and in the future.

According to the DPSIR framework there is a chain of causal links running in sequence, which includes:

1. 'Driving forces' (e.g. economic sectors, human activities)
2. 'Pressures' (e.g. emissions, waste)
3. 'States' (e.g. physical, chemical and biological)
4. 'Impacts' (e.g. on ecosystems, human health and functions)
5. Political 'responses' (e.g. prioritisation, target setting, indicators).

Figure 4: The DPSIR framework.



The complete causal chain is complex and so its description tends to be broken down into sub-tasks, for example by considering the pressure-state relationship individually. It has been previously suggested that the DPSIR framework could potentially be adapted to create a suitable tool for CEA for use by MMO (MMO, 2013a). As it stands, the framework could facilitate the targeting of issues to be included within the assessment. Whilst allowing for a simplified framework that could be utilised effectively across all MMO functions, this method also has potential for future-proofing due to its flexibility. However, this flexibility may also mean that more is left open to user interpretation, which in turn could allow for greater potential for inconsistencies or errors in its application.

Cooper (2012) suggests that the 'Impact' step be replaced by 'Welfare' i.e. a change in human welfare attributable to a change in 'State'. This isolates the human aspects of the interaction with ecological systems, enabling a direct comparison as required by cost-benefit analysis. Enabling this change to the model also supports accountability within human systems; in isolating human from environmental effects it is possible to identify which effects and the extent to which they are attributable to those who perform 'Driver' activities (Cooper, 2012).

The DPSIR framework requires a comprehensive understanding of the drivers of change. These drivers create pressures, which have implications for the state of the system and translate into impacts on each component (MMO, 2013a). The final stage of this assessment is to consider the overall response to these changes in the marine system and the repercussions for the environment (Elliott, 2002).

A CEA framework based on the DPSIR approach would therefore be an activity-led approach, focused on the drivers of pressure. This is suited to the way in which MMO marine licensing teams currently operate. However, the consideration required under the framework for this project is at a much higher level, allowing for flexibility in the amount of information required.

3.1.2 Evaluation of the current state of knowledge on potential cumulative effects from offshore wind farms to inform marine planning and marine licensing

The MMO (2013a) report focused on CEA in the offshore wind industry. The rapid expansion of this sector in the past decade is widely recognised and offshore wind now plays a major role in meeting the UK Government renewable energy targets. With such an increase in offshore construction, there is an obvious need to consider the potential cumulative effects arising from marine activities and in particular from large-scale developments.

The MMO report provides a summary of the sensitivity of key environmental receptors arising from the construction and operation of offshore wind farms. A specific assessment of receptors in the East marine plan areas is also undertaken. Based on the DPSIR approach, a conceptual framework is discussed and used to describe the main steps for CEA within the context of marine planning.

The report concludes that no existing approaches to CEA can be applied without modification; however, a bespoke approach might evolve from a hybrid of the available options. In order to fully account for the complexity of cumulative effects arising from offshore wind developments, more novel approaches would also need to be identified and applied.

Although this report was focused on offshore wind farms, the discussions presented have usefully shaped the development of a framework to fit within this scope of work. Examination of the potential modification of the DPSIR approach to inform CEA in particular influenced one of the options for a strategic framework which was taken forward into consultation.

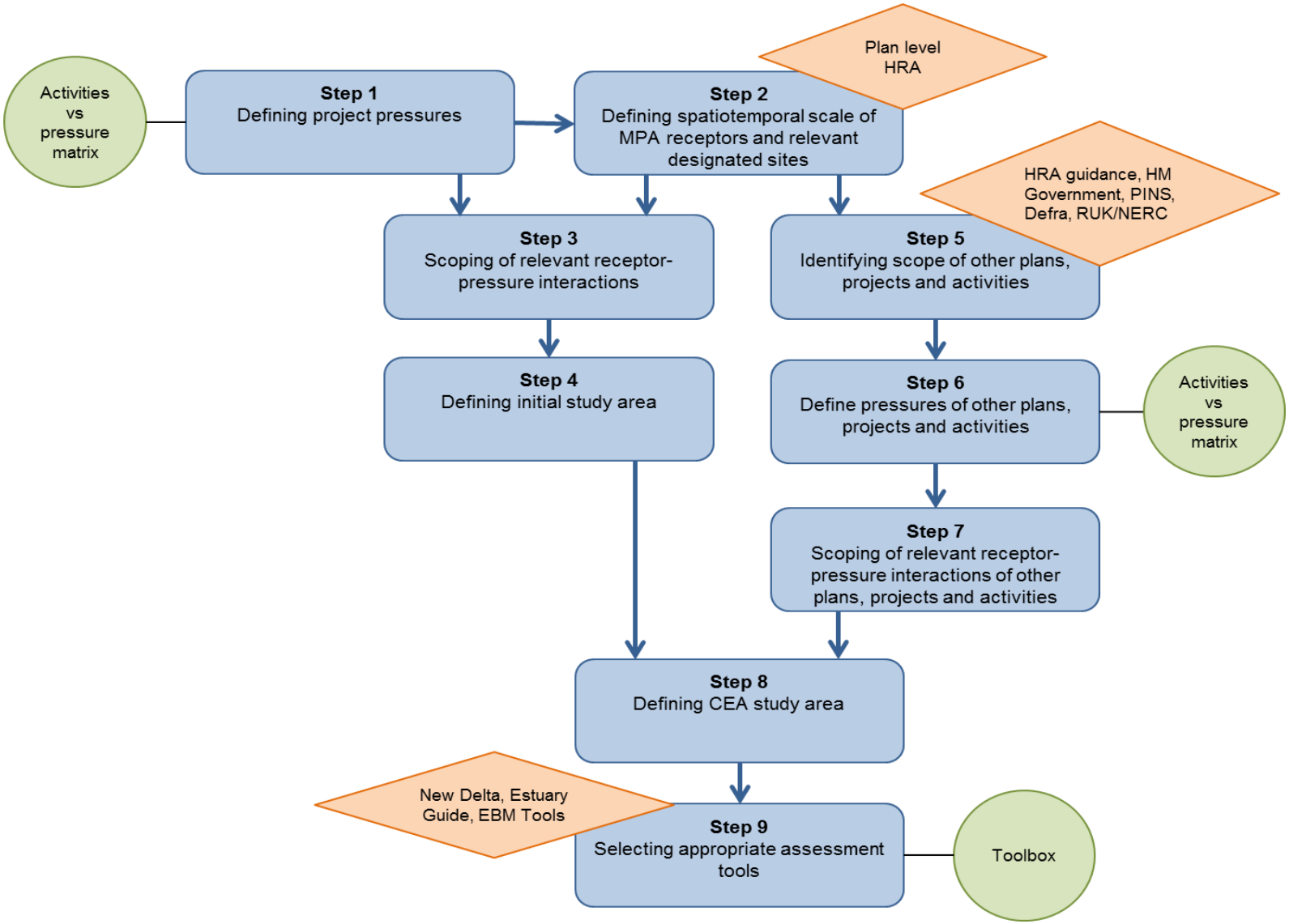
3.1.3 Natural England CEA framework

Natural England sought to develop a generic framework to support Natural England advisors in guiding the CEA of human activities in MPAs (Natural England, 2013). In order to support this, a detailed review and evaluation of methods for conducting CEA both within and beyond the marine environment is presented.

A number of CEAs undertaken (as part of EIAs) are reviewed and case studies selected based on the provision of clear CEA methodologies, enabling their strengths and weaknesses to be evaluated. The selected case studies, alongside a targeted literature review, support the identification of a range of assessment tools which can be used for assessing major cause and effect pathways within environmental assessments.

The generic framework developed for the scoping phase of the Natural England study is shown in Figure 5, and is the most applicable outputs of that work in terms of this project. The key process steps are outlined in blue boxes, a variety of supporting tools are identified in green circles, and relevant guidance and/or information sources are highlighted in orange diamonds

Figure 5: Natural England Framework (Natural England, 2013).



The Natural England tool provides a process which is focused to a particular strand of CEA – namely, CEA of development projects on MPAs which is one aspect of MMO's role in relation to licensing and conservation. MMO has a number of additional functions which require the consideration of CEA and so while this method could not be considered as wholly appropriate, it influenced aspects of the options brought forward for consultation. It should also be noted that, when scoping cumulative effects, it may be appropriate for MMO to consider taking guidance from the Natural England framework in relation to MPAs, particularly, if the purpose of the scoping exercise is a result of an HRA.

3.1.4 Options for Delivering Ecosystem-based Marine Management (ODEMM)

The ODEMM framework aims to assess which management responses might help to reduce impacts on the state of the environment. This EU funded project[13] included case studies across four regional seas and considered environmental, social, economic and governance issues. The ODEMM approach (Figure 6) also builds on the DPSIR model, but incorporates the aspirations of the MSFD.

These aspirations require that:

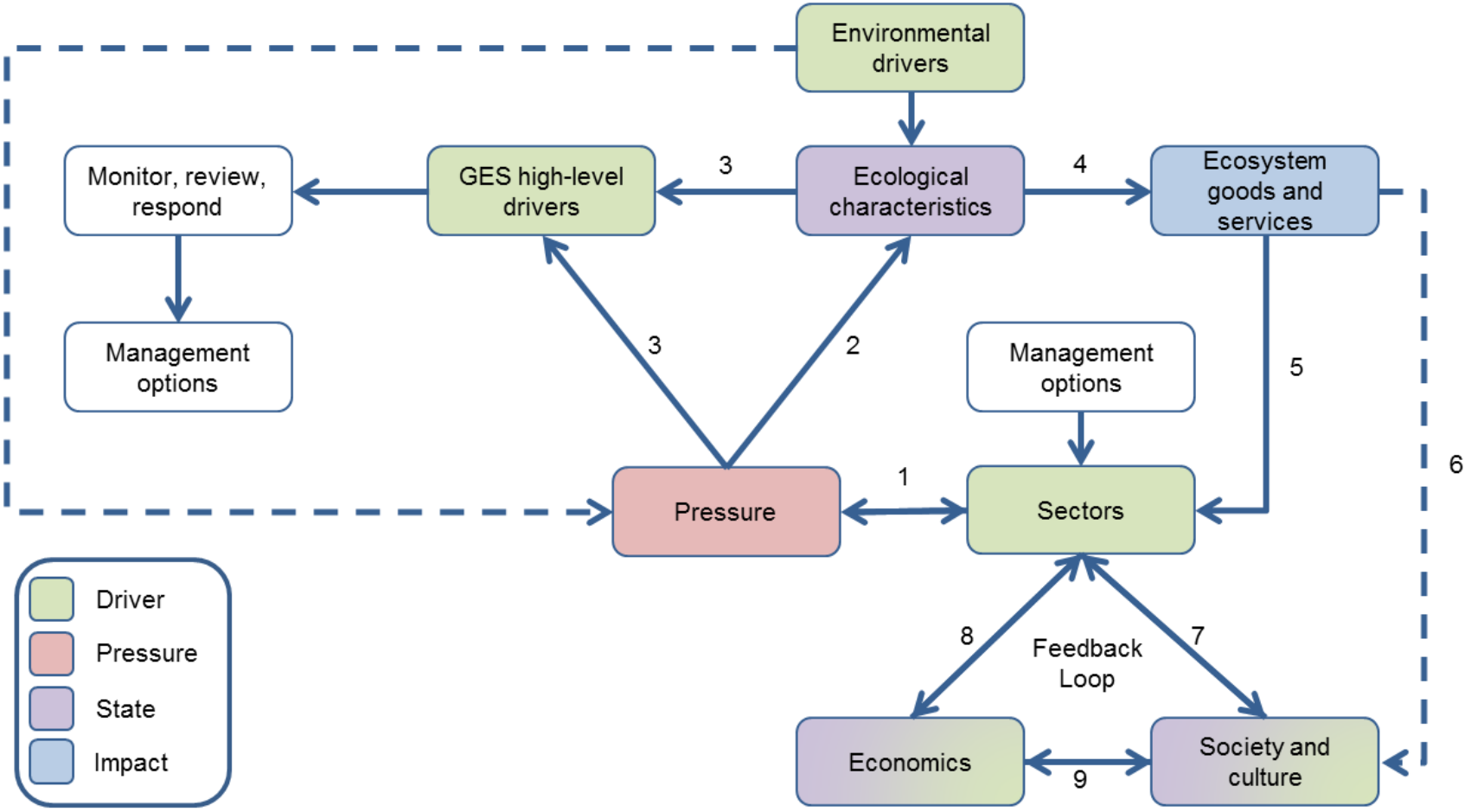
1. "The state of the ecosystem can be interpreted in terms of impacts on the high level objectives (GES as described under 11 Descriptors of the MSFD)
2. The state of the ecosystem can be interpreted in terms of impacts on the provision of Ecosystem Goods and Services (EGSs) (which is essential if managers are to be able to weigh up the costs and benefits of particular management responses; a requirement under the MSFD)
3. The wide range of interactions between ecological, economic and socio-cultural factors can be considered in terms of the likelihood of failing to achieve the MSFD high-level objectives for GES." (Robinson and Knights, 2011).

The ODEMM framework illustrated in Figure 6 shows drivers in green, pressures in red, states in purple and impacts in blue. The interactions between the different components are shown by either one-way arrows where there is either an effect of one component on the other, or two-way arrows where there is potential for both components to affect each other. Numbers have been attributed to each arrow to indicate the order in which each interaction should be considered.

The key aspect of the ODEMM approach which has influenced the strategic framework developed under this project is in relation to the activity-pressure matrices or linkage tables which were produced in support of the ODEMM project. A method for the assessment of pressures is also discussed within the ODEMM project.

[13] http://www.liv.ac.uk/odemm/ [Accessed 8 October 2014]

Figure 6: ODEMM linkage framework for evaluating options for ecosystem-based management.



1 - 9 indicates the sequence in which the framework should be considered.

3.2 Cumulative effects scoping framework development

Initially, three 'options' for the structure of the strategic framework were developed, guided by existing examples (Section 3.1) and tailored to meet the needs of MMO (Section 1.3). In summary, the options were:

1. A 'top down' approach, considering CEA beginning with the individual effects of a plan, project or activity
2. A more flexible method, incorporating feedback loops and following the DPSIR model but similar to Option 1
3. A 'bottom up' approach, starting with a receptor and considering all potential effects from all possible sources.

These initial options were presented during stakeholder consultation (Section 3.4) to identify the most appropriate for final development. These options are described in full detail in Annex 5 including the concept and the applicability to each MMO function.

3.3 Development of approaches to CEA management

Eight initial approaches were developed relating to how cumulative effects and mitigation may be managed depending on the circumstances of each individual case. The development of the initial options for this was guided by discussions with MMO personnel, and experience of working with marine developers and of negotiating and completing CEA, primarily as part of the EIA and consenting processes.

Consultation was undertaken on these options (Section 3.4). Some adjustments to the options and inter-linkages between options were made in response to the consultation; however all approaches were taken forward as potential routes for MMO to consider. Full details on how these approaches could be used and when is included in Section 4. These approaches should be considered in an integrated manner with the high level framework described in Section 5. In brief, the potential approaches were:

1. Equal responsibility: allocating equal responsibility for a given effect to all contributing developers
2. Activity-specific effects: allocating responsibility based on a process of elimination of those projects for which there is no linkage between project specific activity and the effect
3. Apportioning the effect(s): allocating responsibility for the effect on proportion of effect attributable to each development
4. Scale of effect (spatial and/or temporal): allocating responsibility based on the scale of the effect
5. Application timeframe: allocating responsibility based on development's stage in the application process
6. Precedents in previous applications: reviewing the processes used in CEA for previous applications

7. Developer forums hosted by MMO: bringing developers together to discuss specific cumulative effects
8. Consultation with industry bodies: seeking expert guidance and opinion.

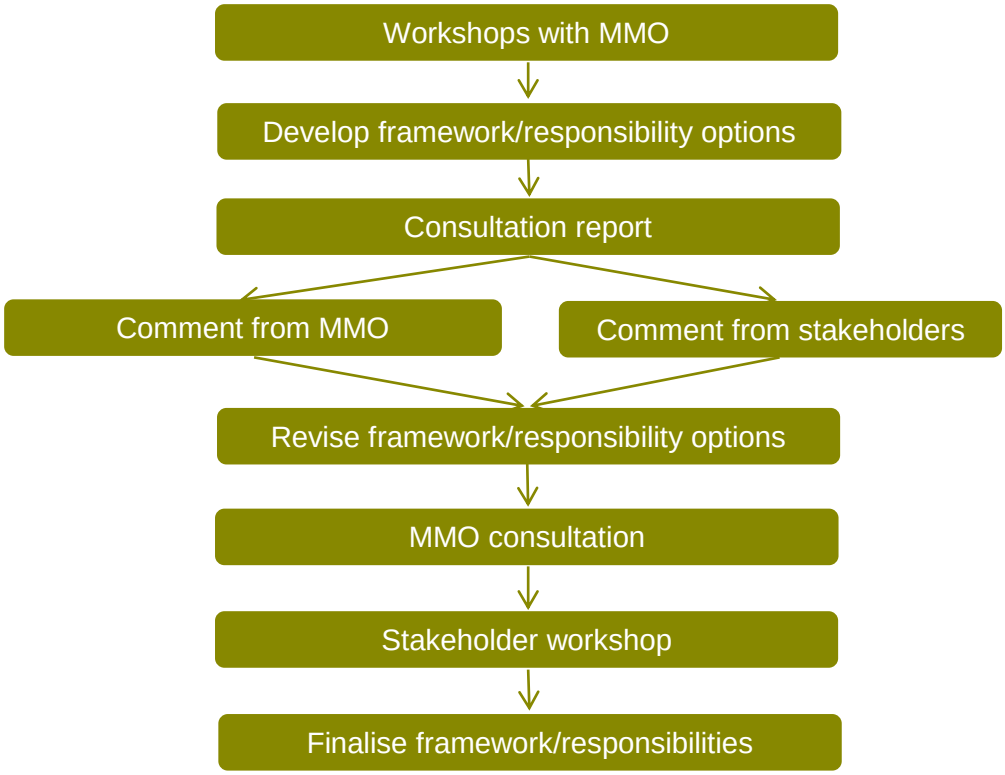
3.4 Consultation process

Consultation has been undertaken throughout the life cycle of this project, primarily through a focus group and a wider stakeholder group. The consultation process engaged throughout this project is illustrated in Figure 7.

The focus group included representatives from The Crown Estate, the Environment Agency, Natural England, the Planning Inspectorate, Defra and Marine Scotland. Wider stakeholders consulted during the work included marine industry/sector representatives, trade bodies, non-governmental organisations, and other statutory nature conservation bodies and marine regulators. The process aimed to obtain input from a full range of sectors representative of all marine activities/interests.

Stakeholder engagement plays a crucial role in ensuring the success of any project. Discussions with the MMO and relevant stakeholders has influenced the development of options for the strategic framework, identification of responsibilities, production of guidance and subsequently refining the approaches produced.

Figure 7: Consultation Process.



The three framework options and eight approaches for managing cumulative effects and mitigation were outlined in a Consultation Report (Annex 5), alongside a detailed description of the aims and objectives of the project and overview of MMO functions.

This report was distributed within MMO and to a focus group set up specifically for this project. The focus group includes a range of regulatory bodies, SNCBs and other advisors. The wider stakeholder group, including industry bodies and developers, were also invited to comment.

Questionnaires were provided with the report, with one set of questions for MMO staff as potential future users of the CEA framework, and another set of questions directed at wider stakeholders. Stakeholders were asked to use the MMO online consultation system (MMO Connect) to log their feedback and, as an alternative, telephone interviews were offered. Nineteen responses were received from the online consultation forms and telephone interviews, encompassing a wide range of stakeholders from varying sectors (see Annex 6).

Following receipt of the initial consultation responses, the options were revised and a single draft framework and set of draft management options produced. This was then offered to MMO for comment, before being presented and tested at a workshop with the focus group and wider stakeholder group in attendance. Feedback from the workshop was reviewed and incorporated into the design of the final framework and management options.

Communication with MMO staff members has been maintained throughout the life cycle of the project, with additional input provided as required.

3.5 Summary of the consultation for framework options

A full analysis of consultation responses is presented in Annex 6.

Upon review of the initial consultation responses, it became apparent that there was no single approach that would be appropriate for all functions.

Option 1 was considered to be the most straightforward and robust, and a good approach for licensing. However, it would prove difficult for the planning team, due to the level of detail required, which is currently unavailable at a regional level. External stakeholders felt that Option 1 was logical and in line with current practice. It was acknowledged that the top-down approach provides robust outputs, although may be more appropriate for licensing work than for planning. It is also largely dependent on the availability of adequate data.

Option 2 was equally well received by both MMO staff and external stakeholders and viewed as the most flexible option. Feedback suggested that it may be workable for all teams; however, as the methodology was broad in scope, there would be compromises with its efficacy. It was generally thought that it may be more suited to the plan level as it does not necessarily require as much detailed information to be fed into the framework. It was suggested that Option 2 would be a good ‘bridge’ between planning and licensing, in terms of the planning team ensuring that any policies developed use an approach which is practical for the licensing team at the project level. However, it was also clear that it would require much more evidence and input from the user to ensure that it was robust than might be available at the regional scale of planning.

Option 3 was considered by stakeholders to be very detailed and therefore technically sound. However, some stakeholders viewed this as a disadvantage, stating that since it would require a lot of information so the option could be too complex to be practical. Option 3 would be the most appropriate for planning, where working from the receptor level seems to provide a more holistic view useful for developing and supporting policy; however, it was recognised that the available evidence base is not currently detailed enough to make this a feasible option. A similar method was considered, but could not be progressed for the development of the East marine plans as the confidence levels associated with the underlying evidence base were too low.

Taking into account the comments received from both MMO staff and the wider stakeholder group, the framework options were reviewed and refined to produce a single framework to take forward. A hybrid was created, combining Options 1 and 3, to create a framework that can be either activity-led or receptor-led. The feedback loops from Option 2 were utilised, providing greater flexibility and making it applicable for use across all MMO functions. With these revisions, the framework retains the straightforward prescriptive steps of Option 1, but provides alternative choices in direction and feedback loops to allow flexibility. This flexibility is important in ensuring that the framework can be applied across all functions within MMO, to suit each individual case.

Following comment on the revised framework from MMO, it was presented at a workshop on March 13th 2014 and received largely positive feedback. The ability to begin the process from either an activity or receptor focus was thought to be useful and sensible given potential gaps on information. It was deemed to be a clear and useful process, providing MMO with a common methodology and thus improving consistency when scoping cumulative effects.

It was raised during the workshop that clear guidance is needed in order to ensure that the tool is used in the same way by any user, providing same results. Concerns were also raised regarding the reliance of the framework on the database and available information. This could potentially be inadequate unless an appropriate and robust process is in place to update the evidence base with the most recent information.

These concerns were addressed in the development of the final framework.

3.6 Summary of the consultation for management options

Full analysis of consultation responses is presented in Annex 6.

Overall, the first four approaches for managing cumulative effects assessment and mitigation, were not considered useful as standalone options, but could be run in sequence with each informing the next. For example, it was felt that assigning equal responsibility could only be feasible if it was used as an interim measure within marine planning to be followed up with another method of apportioning the responsibility. It was recognised that this option alone may trigger mitigation measures across multiple projects that may be unnecessary and ineffective. Where one activity is only contributing to the effect in a minor way compared to another, it

would be more appropriate to require the larger contributor to provide a greater level of mitigation.

Relying on the application timeframe is potentially contentious, as there is often inadequate information available for applications in the earlier stages. It could be a useful approach if applied at a project level but decisions should be made on a case by case basis. This method is similar to the current process utilised by licensing teams, where only consented projects are considered for mitigation contribution.

Looking at precedents in previous applications was strongly supported, but again as part of a process and not an approach in itself. It was also noted that care should be taken not to carry past mistakes through into current assessments and this option should always be applied in conjunction with others and not be considered as a standalone option.

Developer forums were also well received, particularly with respect to situations where a number of sectors are involved, with multiple activities in a small area. This is a potentially useful approach that might feed into the planning process and policy-making, although it was recognised that resources may be a key constraint. Advice from industry bodies was considered appropriate in terms of general advice, rather than as a solution to issues in individual applications.

With the exception of assigning equal responsibility (when considered as a standalone option), all options were generally thought to be useful in different situations and could be part of an overall decision making process. As a result, all initial options consulted on were carried through the latter consultation stages. The discrete options became processes, supported by methods and approaches to aid the consideration of contribution to cumulative effects and mitigation. A decision tree was created in order to guide users towards the appropriate approach depending on circumstances. The final options/processes developed are outlined in detail in Section 4.

4. Management options for cumulative effects and mitigation

A crucial element of MMO's role is considering how activities might contribute to and mitigate potential cumulative effects. Management approaches should consider the burdens on marine users and aim to minimise those burdens following the principles of sustainable development. Following this, MMO should ensure that licensing decisions and marine plan policies consider the long term effects of requiring marine users to contribute to assessment and mitigation of cumulative effects, and how to apportion that fairly and appropriately. This process describes various approaches that could be taken to meet these requirements.

This cumulative effects management process could be applied by MMO either as part of the CEA scoping framework (Section 5) or on a case by case basis where current policy/legislation does not provide clear guidance for specific situations. The relative aspects of cumulative effects considered by this project which may require management can include:

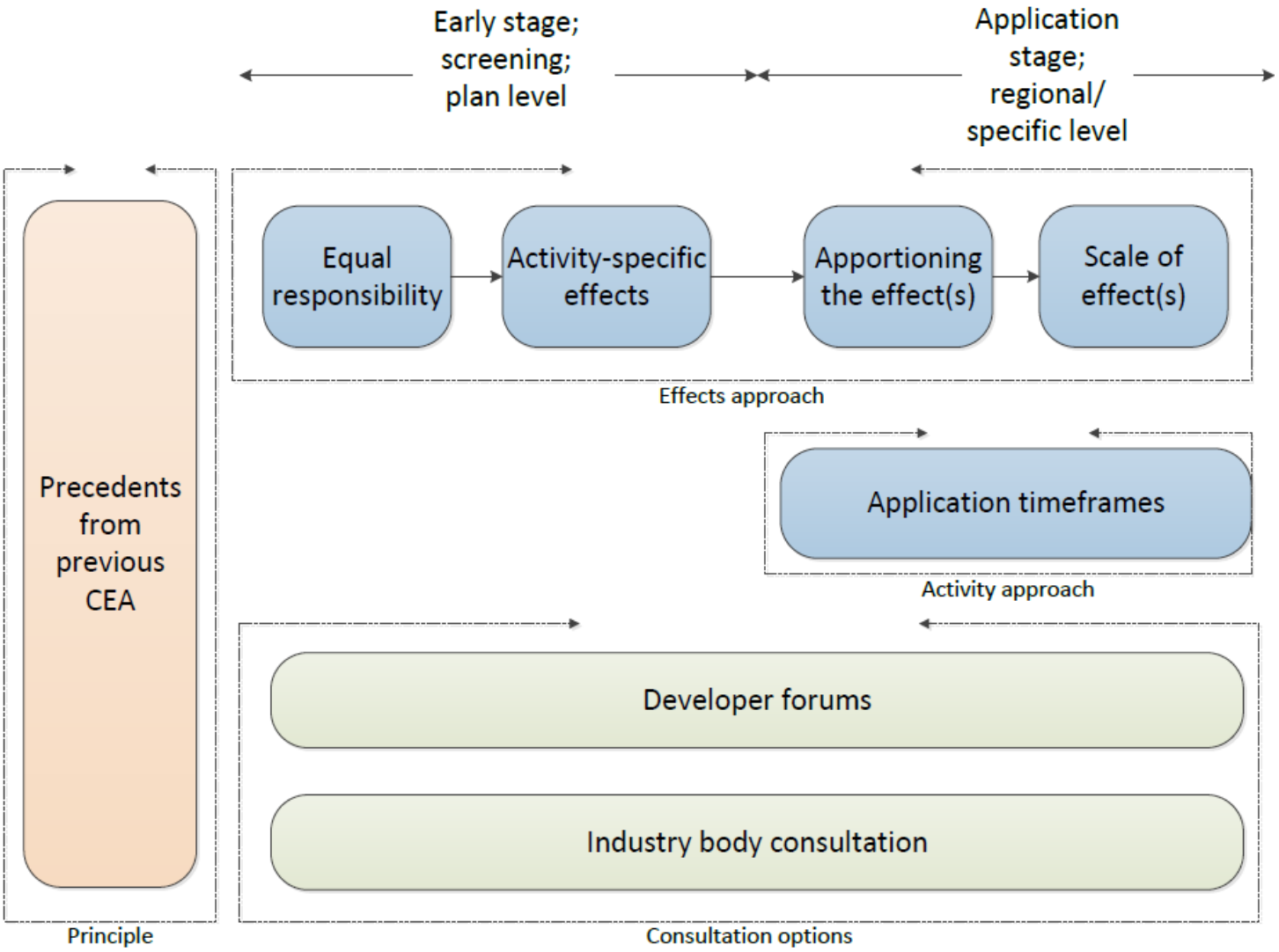
- CEA – whereby marine users may be required to provide information to enable better assessments and to promote cooperation with other marine users.
- Mitigation – where there is a significant cumulative effect, determining which marine user(s) is/are responsible for mitigating the effect.

Any decisions or assumptions made on this, in particular where further action is required (i.e. mitigation), need to follow a proportionate and risk-based approach supported by an appropriate level of evidence and advice from statutory bodies as required. Involvement of industry/sectors in these decisions can be crucial to developing a common understanding and agreement which will help to avoid potential future issues. Transboundary issues, where apparent, will also need to be addressed by liaison with regulatory counterparts in neighbouring countries.

Methods for managing cumulative effects vary and different approaches have been used across marine sectors. The most appropriate approach will necessarily vary on a case-by-case basis; however it must be appropriate to the situation under consideration. Care must be taken to ensure fulfilment of relevant legal obligations following the principles of Better Regulation, providing a transparent and proportionate response where an appropriate route is not clear in existing legislation/policy.

A series of options and approaches have been developed in this project that could be applied by MMO to fulfil these requirements (see Figure 8). The various options are intended as a tool to facilitate rapid assessment capability as part of the strategic level scoping of cumulative effects and can be supported by best practice principles and consultation exercises. In some cases, how contribution to potential cumulative effects is determined is clear and laid out in legislation. This series of options applies where current legislation and policy does not provide a clear answer but should take into consideration and support fulfilment of existing policy priorities.

Figure 8: Schematic showing various approaches to managing cumulative effects and when they might apply.



These options could be applied by MMO either as part of the CEA scoping framework or on their own. They are described in more depth through Sections 4.1-4.11.

In brief, the blue boxes within the 'effects' approach, presented in Figure 8, describe discrete options which could be used in isolation to support cumulative effects management. It is likely, however, that each would form part of a step-by-step process with increasing clarity on potential assumptions of responsibilities, based on the stage that the process is being applied and the information available. Movement between these options is possible through testing whether the information is available to complete the next step. The 'application time frames' option is a 'project' approach which could potentially be used in conjunction with the effects approach. Identifying future projects, and therefore likely CEA and mitigation requirements of developers, would provide more robust assumptions to underpin the effective management of cumulative effects.

The green boxes represent consultation approaches which could be used to inform any of the previous options, if appropriate. This is likely to be dependent on which sectors are involved and the level of representation within each sector. The orange box refers to the general principle of considering the use of precedents to inform best practice.

A decision tree for the cumulative effects management options (see Figure 9) which links these options with the scoping framework process can be navigated at various stages. This will assist in the determination of the most appropriate approach, which depends on the information available and the scale of the CEA.

Further details on each of these are provided below in Sections 4.1 to 4.11. There is potential for further options, approaches and principles to be added to this schematic as further experience with cumulative effects is captured.

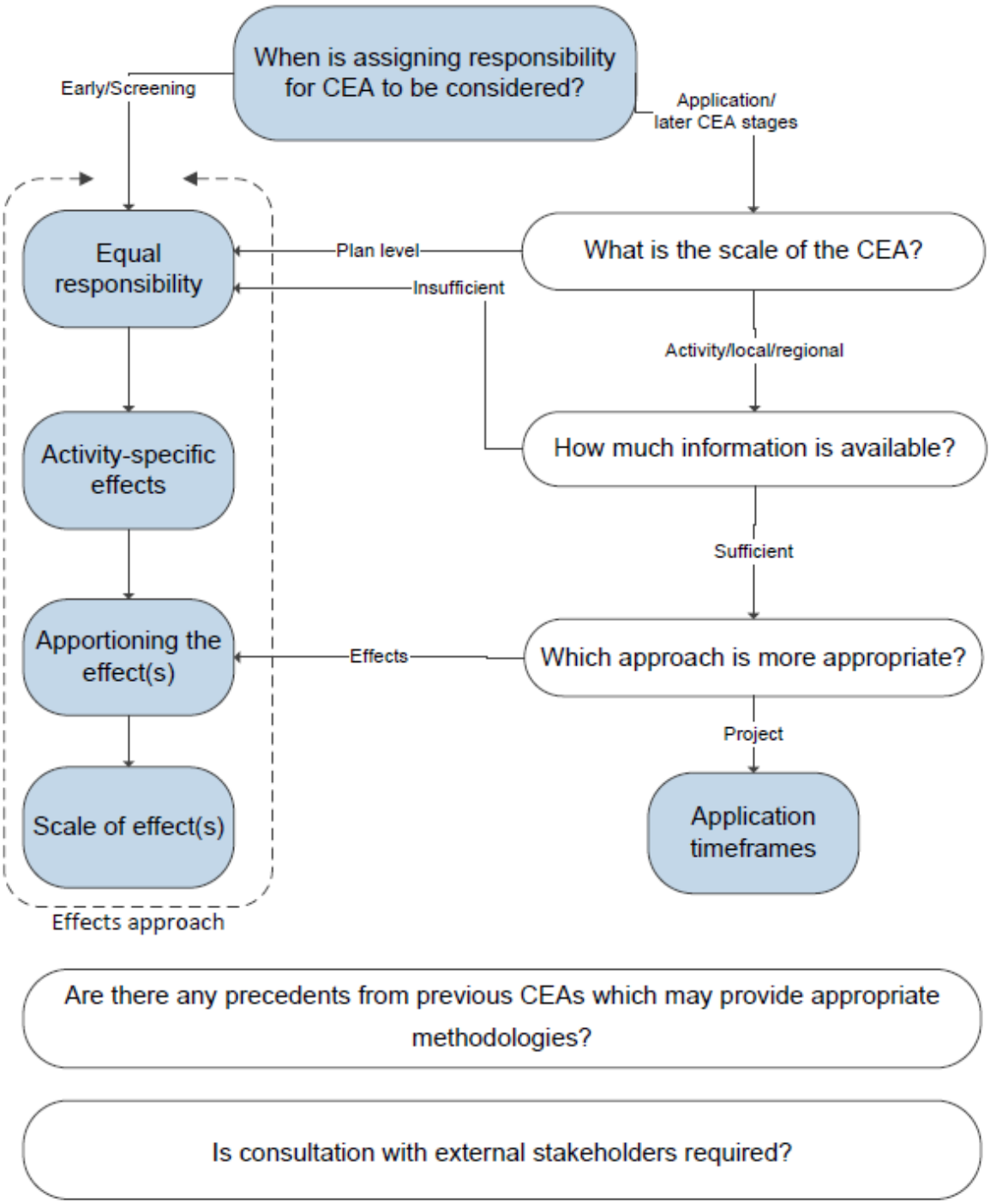
4.1 When is management of cumulative effects to be considered?

This first question can refer to two things: the stage of the cumulative effects scoping exercise (i.e. at which point in the framework described in Section 5); and/or the stage of development of the activity or activities in question.

It may be that the approach to considering management of cumulative effects in marine planning requires evaluation at an early stage in the scoping process, or it may be that at the project level consideration will be required at the screening stage of a project. For these examples, it is likely that the most appropriate approach would be to assume that all have 'equal responsibility' (see Section 4.7) and work through the options as more information is received.

Alternatively, later on in the scoping process and/or with a licence application, further consideration can be given to the scale and the evidence available, which may provide more meaningful assumptions for management of cumulative effects.

Figure 9: Decision tree to assist in determining the most appropriate approach to management of contribution to CEA and mitigation.



4.2 What is the scale of the CEA?

This question relates to the spatial scale of the CEA exercise. This can be a simple consideration, if the scale is very broad, i.e. the plan or regional level, it is probable that the most appropriate approach would be to assume 'equal responsibility' and to work through the 'effects' approach options. With a more refined scale, such as at

the project or local level the next question on how much information is available can be asked before determining which management option is the most appropriate.

4.3 How much information is available?

This question is inextricably linked to the question of scale. The smaller the spatial scale the more likely it is that there is more specific, useful information available as there are likely to be few activities involved. In addition, where existing activities are being considered, there is likely to be more information. For planning, as a forward looking function, there is more likely to be little information with low confidence.

The evidence and data which is available on the activity or activities under consideration may mean it is not possible to go beyond assuming 'equal responsibility' until further information is received. This is highly specific to the circumstances of the individual case, therefore some level of judgement is required in order to decide whether the information is sufficient to enable assumptions for management of effects beyond 'equal responsibility'. The type of information required is likely to be in relation to the potential effects and the spatio-temporal scale of the activity or activities. This can be tested by moving on to the next option (activity-specific effects) and attempting to determine contribution to a cumulative effect. If not possible, it is likely that there is insufficient information.

4.4 Which approach is more appropriate?

This question refers to the approach to cumulative effects management, where the scale is well refined and the level of information is sufficient, in accordance with the previous sections. If it is deemed more appropriate to consider the number, type and likelihood of cumulative effects, this suggests following an 'effects' approach and, as the scale and level of information to inform the management exercise should be sufficient at this stage, it is likely that it will be possible to begin by seeking to 'apportion the effect'. If the determining factor is the projects/activities with potential to contribute to cumulative effects, it may be more appropriate to consider the 'application time frames' approach. It is likely that consideration will need to be given to both of these approaches; however, it is useful to have the option to focus on one approach over the other if circumstances in an individual case dictate.

Judgement will be required to decide on the most appropriate course of action. For instance, it may be that a future scenario is considered for the purposes of marine planning where all possibilities are hypothetical and it would not be possible to assume when and where individual projects would submit applications. Therefore, it would be more appropriate to look at the activities as a whole and considering likelihood of a potential cumulative effect as a basis for management. Potentially, at this stage, consultation with relevant stakeholders may be appropriate.

4.5 Is consultation with external stakeholders required?

The question of whether consultation by MMO with stakeholders is required refers to whether it is necessary and/or beneficial to involve other sea users in the process. These approaches can be applied to any of the options, at any point in the process, depending on what is appropriate on a case-by-case basis. More detail on the

potential options for discussing management of cumulative effects through consultation is provided below.

4.5.1 Developer forums hosted by MMO

It may be useful to bring developers together to discuss specific cumulative effects. This would provide a unique and transparent opportunity for developers to discuss and agree how their respective activities may contribute to cumulative effects; appropriate mitigation measures; and how contributions to those mitigation measures might be managed. It also provides an opportunity for issues associated with mitigation to be raised if it is felt disproportionate burden is being placed on one industry. This would be particularly useful for discussions between different industries/parties if both sides were fully engaged in the process.

At the strategic level, these meetings may provide MMO with useful insight into future issues which will need consideration further down the line if cumulative effects become an issue. The forums would provide developers and sea users with the opportunity to work together, whether in terms of data collection and/or agreement on methodologies for any assessment required at a later stage.

Where there are difficulties in reaching agreement or issues of comparison between projects/developments, open debate can be invaluable. However, there are both time and financial implications to this approach.

4.5.2 Consultation with industry bodies or trade bodies

It is considered likely that consultation with industry or trade bodies (e.g. British Marine Aggregates Producers Association or RenewableUK) will be most effective and productive in discussing the appropriate mitigation for a cumulative effect where activities contributing to the cumulative effect(s) are within the same sector. Additionally, in the event that it has not been possible to apportion a cumulative effect using tried and tested methodology, or there is disagreement regarding apportioning effects or activity-pressure-receptor linkages, it may be necessary to seek consultation with industry bodies. This should be considered as appropriate for a long term view, although it may not be the most suitable approach when considering the short term. Therefore, at the marine plan level, consultation with industry bodies may provide useful insight into likely issues with the management of CEA and mitigation as part of consideration of higher level future scenarios. However, it is recognised that not all activities have active industry bodies. This should be taken into account when considering the use of this approach.

4.6 Are there any precedents from previous CEAs which may provide appropriate management approaches?

Previous experience of CEA may provide useful insight into how management of the contribution to cumulative effects and mitigation has been approached in the past. In such cases, it may be beneficial to review the processes used, where possible, and decide whether they would be appropriate best practice for other cases under consideration. This is a general principle, which could be applied at any stage in the process.

It is necessarily dependent on the information available and how applicable the specific cases are to other situations. This approach should be viewed as a way to guide the approach; individual circumstances of each case need to be the primary consideration.

4.7 Equal responsibility

It may be appropriate, in particular at an early stage of the planning or project development process, to assume 'equal responsibility' for a given cumulative effect for all contributing activities. In addition, where the spatio-temporal scale of the effect is not well defined it may be most straightforward to assume that all activities contribute equally until further information becomes available. This may be most applicable where there are larger numbers of smaller activities to consider.

It is highly unlikely that this option will be used in isolation, other than as an initial step to highlight where further information is required. The next options (Sections 4.8 – 4.11) should also be seen as steps to identify the most appropriate approach for management of cumulative effects.

This step may also identify where it may be possible to suggest a joined up approach to cumulative effects between activities to avoid industry/developers attempting to answer the same questions on cumulative effects in isolation. This could be achieved through developer forums or consultation with industry bodies. When the scale of the CEA has been refined and there is enough information to consider the sources and pathways of pressures from activities to receptors, it may be possible to consider an activity-specific effects approach.

This may be beneficial to marine planning when considering the potential burden on activities, in terms of assessment and mitigation of effects, and assessing how this might affect the ability of those activities to continue in the plan area.

4.8 Activity-specific effects

This approach to considering contribution to cumulative effects requires scoping out those activities for which there is no pathway between the source of the pressure and the receptor. For example, contribution to a cumulative collision risk for birds is not likely to be attributed to an aggregate extraction project. However, disturbance and/or loss of benthic habitats could be attributed to both offshore wind farms and to aggregate extraction schemes. By doing this, it is ensured that management of cumulative effects will fall to the right parties. Management of cumulative effects, considered as part of the strategic scoping framework (Section 5), will be informed to some extent through defining the sources and pathways of pressures from activities to receptors. In which case, it may be more appropriate to consider 'apportioning the effect' (see Section 4.9).

If being considered outside of the strategic scoping framework, using this approach is likely to require input from stakeholders and guidance from key advisors to ensure all relevant factors are taken into consideration. It should also be undertaken based on the evidence available in each case and following a precautionary approach

where insufficient/no evidence is available. Justification for any activities eliminated from further consideration in CEA using this approach should be provided.

When the relevant activities have been identified, it may then be possible to apportion the effect(s).

4.9 Apportioning the effect(s)

Where a cumulative effect is on a particular receptor group (e.g. marine mammals), or an individual species (e.g. harbour porpoise), then it may be possible to 'apportion the effect' between the contributing activities. An activity may emerge as the principal contributor to the effect, whilst other activities may contribute a proportionally lower effect in cumulative terms.

There may be circumstances where different types of activity contribute to the effect in different ways, for example where the activities exert similar pressures such as underwater noise produced by aggregate dredging is continuous, low frequency, whereas piling during wind farm construction is short bursts of low-mid frequency noise. These types of distinction need to be made to ensure like with like comparisons.

This option is likely to require a significant amount of input from each developer/marine user, and potentially an independent CEA in order to apportion the effect(s) in a sound and reasonable manner. At the project level, this process may be time consuming, and could require all projects/developments to have reached the point where EIA and/or HRA has been prepared with CEA. At the plan level, this would provide useful information when examining specific issues in more detail for spatially explicit policies, however is likely to require investing considerable resources. Alternatively, it may be appropriate to make assumptions with stakeholder input to provide initial direction which can then be adjusted later down the line; for example when project applications are submitted or when plan policies are reviewed.

Within this approach, consideration will need to be given to:

- Different stages of development (if at the project level)
- Cost/time implications for industries/marine users
- Responsibility for the management and coordination of this exercise
- The nature of the marine activities
- The level of information required from each activity involved to ensure that management of potential cumulative effects and mitigation is fair and proportionate
- Where the 'apportioning effects' approach identifies a principal contributor, this decision will need to be based on the level of contribution to an effect underpinned by robust evidence and through consultation with stakeholders
- At the plan level it may be necessary to make assumptions on the scale, frequency, etc. of an activity in order to make a risk-based assessment of the contribution to a cumulative effect for the purpose of informing marine planning.

There is unlikely to be enough evidence at the planning level to support this type of assessment in a robust manner and any assumptions made for this purpose may require input from relevant industry/sea users. If potential concerns/issues are highlighted at an early stage (e.g. through the marine planning process), this may encourage marine users to explore alternative ways to approach their activity, to try to reduce their contribution to any cumulative effects or even be prepared to provide a greater contribution to mitigation where necessary.

4.10 Scale of effect (spatial and/or temporal)

This approach follows naturally on from the previous, where it may be appropriate to take into account the spatial and temporal scale of an effect when considering allocating contribution to cumulative effects and mitigation. This requires more detailed and robust data on the receptors and effects, and will in turn allow more comprehensive consideration of contribution to cumulative effects to support management of mitigation measures.

Taking this approach to the management of mitigation of cumulative effects could include investigation using spatial analysis software (e.g. GIS), to visualise the extent of the potential cumulative effect which could make the apportioning of effects more accurate. This approach may also be useful where there are differences in the temporal extent of effects. For example the construction phase of a particular project is significantly longer than other projects/developments contributing to the cumulative effect.

4.11 Cumulative effects management based on application timeframe

The management of cumulative effects based on the stage of development of activities is useful in cases where a ‘project’ based approach is deemed appropriate. In particular, it may be useful for marine licensing where clear, detailed information is provided on the effects of an activity at the project level.

This approach cannot be taken until all activities with potential to contribute to a cumulative effect within an identified spatio-temporal footprint have been scoped in. Therefore, it would not be appropriate to use this option at earlier stages of the CEA framework.

Guidance issued by JNCC and Natural England in September 2013 suggested a number of tiers for CEA:

- Tier 1: built and operational projects
- Tier 2: projects under construction plus tier 1 projects
- Tier 3: projects that have been consented (but construction has not yet commenced) plus tiers 1 and 2
- Tier 4: projects that have an application submitted to the appropriate regulatory body that have not yet been determined, plus tiers 1-3
- Tier 5: projects that the regulatory body are expecting to be submitted for determination (e.g. projects listed under the Planning Inspectorate programme of projects), plus tiers 1-4

- Tier 6: projects that have been identified in relevant strategic plans or programmes plus tiers 1-5.

These tiers provide a hierarchical framework for CEA, and one which may also be useful in determining contribution to a particular cumulative effect (or portion thereof). However, as this was originally intended as a means to identify which activities to scope into a CEA, it should ideally be used in conjunction with the 'effects' approaches (Sections 4.1 to 4.4) to improve alignment with the principles of sustainable development. Consideration of the likelihood of the effects associated with these tiers overlapping in space and time will help ensure a justifiable and rounded approach to assigning contribution to CEA.

Marine plan policies will not place requirements on existing projects retrospectively, (Tiers 1-4), but MMO will need to consider the ability of future projects (Tiers 5-6) to utilise the marine environment during plan policy development. At the plan level, the tiered approach may provide useful insight into which activities should be included in the overarching assessment and highlight critical issues for future projects, particularly where issues may conflict with the principles of sustainable development. Using these tiers may help to identify where more information is needed to inform the management of cumulative effects.

5. High level framework for the identification of potential cumulative effects

5.1 Overview

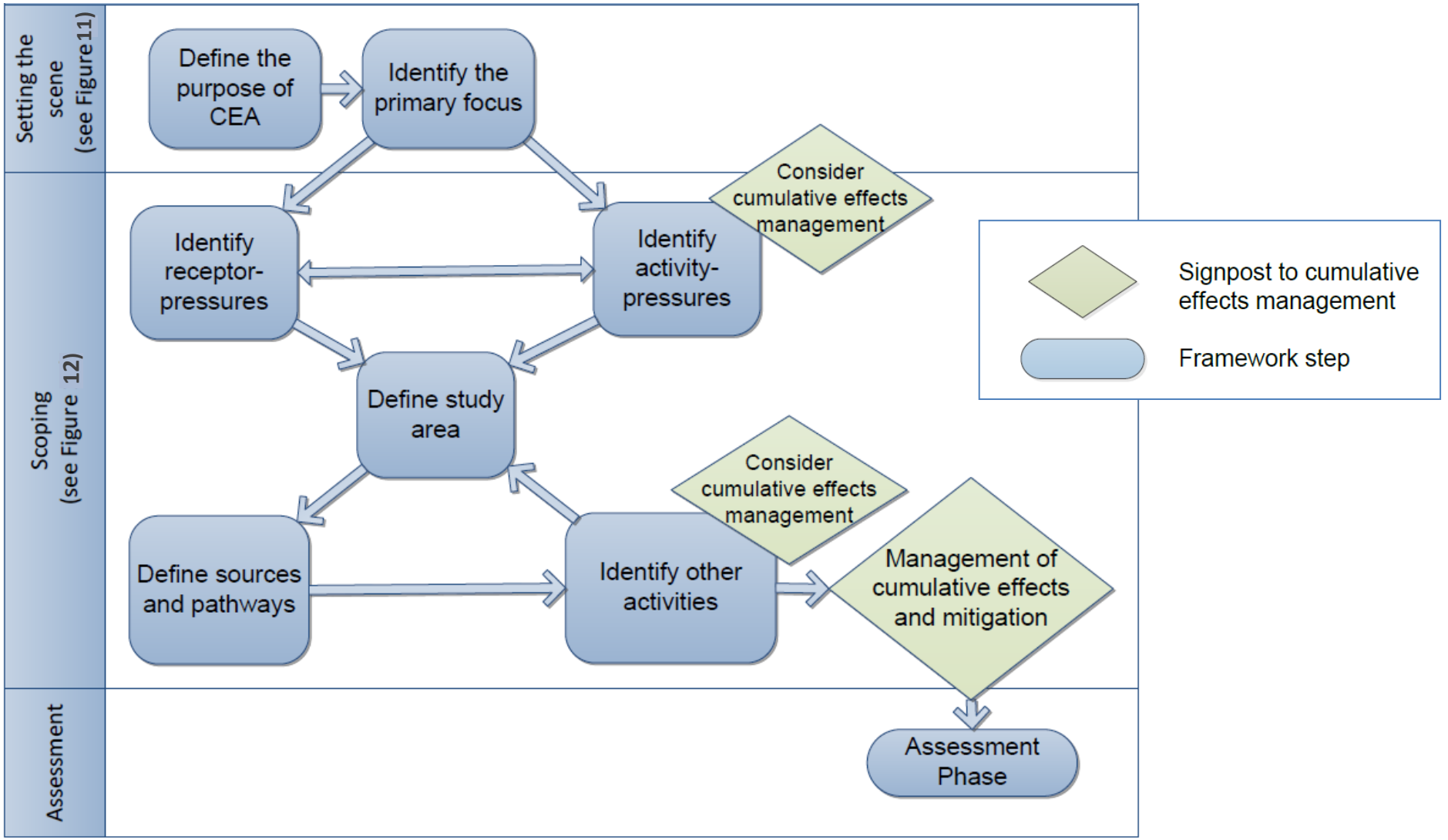
A high level framework has been developed during this project to provide MMO staff with an overarching approach for scoping potential cumulative effects (Figure 10). The direction of the framework is dependent on the reason for its use, for example, whether it is being used to review a CEA as part of a marine licence application, or looking at potential future scenarios for management of activities in relation to MPAs. The key questions within the framework aim to assist the user in navigating the process. This will support the capability for rapid initial assessment should it be required, and will avoid the framework being too prescriptive, allowing a degree of consistency of approach between different functions of MMO.

Due to the wide range of responsibilities across MMO functions, the framework is necessarily high level and broad in scope in order to be applicable at both the plan and project level and to allow flexibility in its application. It is systematic with clearly identified feedback loops introduced following consultation to allow an integrated and adaptive approach whilst retaining the sequential step-based process to ensure ease of navigation. This flexibility also ensures that the framework is applicable across the different scales for which MMO holds responsibility (e.g. plan project level).

The overall CEA process can be broken down into three phases: setting the scene, scoping and assessment. Although the framework shows the steps to be undertaken at each phase of the process, it focuses specifically on setting the scene and the scoping phases and provides a step-by-step approach to the initial identification of potential cumulative effects for further investigation. Therefore the framework outlines the initial steps in considering cumulative effects for MMO, prior to the full assessment itself. Where required, further investigation and consultation with necessary key advisors and stakeholders will be undertaken if appropriate in order to move forward into the assessment phase of the CEA process. Figure 10 also highlights points where management of the contribution of activities to mitigation may benefit from consideration.

CEA can be difficult to implement in practice, particularly in the marine environment where there are issues surrounding the availability of baseline data. There may be situations where there are no, or limited, data available. This does not necessarily preclude scoping since the high-level nature of the scoping exercise permits prediction of the potential effects based on previous experience and/or other data. However, it does mean that the feedback loops and iterative process of the proposed framework become more important as they will allow the exercise to be easily and quickly revised, if and when more information becomes available. The framework may also help to provide a focus on what specific information is required, thereby driving the collection of the most appropriate information to feed into the process. When using the framework for early stage screening, caveats with regards to the absence of specific data and assumptions made should be clearly outlined at the beginning of the process. These evidence gaps should be built upon throughout if required to ensure accountability and for due diligence purposes.

Figure 10: Strategic framework for scoping cumulative effects and management of responsibility for cumulative effects and mitigation.



5.2 Practical application of the framework

A full description of the practical application of the framework is provided in the following sections. The main output of this framework is a list of the common pressures between a set of activities with potential to cause an effect on a common receptor. The description focuses on environmental aspects of CEA. A broad description of how socio-economic aspects might be incorporated into CEA is provided in Annex 3.

The evidence database can be used in conjunction with the framework in order to scope cumulative effects based on activity-pressure-receptor interactions. Relevant points where the database may provide useful input are highlighted throughout the framework description.

The proposed framework has been applied to two test cases to demonstrate how it may work in practice at the project and/or plan level. The main focus within the case studies is on environmental assessment; however the framework could also be part of a social or economic assessment. The purpose of using case studies is to test and validate the framework. The case studies are for demonstrative purposes only using publically available information and the result of the case studies does not represent the view of MMO on any decision made in each case. The scenarios for each case study are presented below, with information on how the framework has been applied presented in boxes within each of the framework steps.

The application of the framework for the case studies is presented in brief throughout the description of each step of the process to show how the framework could be applied in practice and to also highlight the differences in the plan level and project level approach. The case studies are discussed in full under Annex 7.

5.2.1 Plan level: Large scale vs. small scale activity

This is a hypothetical scenario for future activities in a marine plan area, which requires the consideration of the potential for cumulative effects if the primary focus is a) a large scale activity, for example aggregate dredging, or b) a small scale activity, for example recreational sailing. The precise geographical location is unclear; however the scenario could provide useful information on likely issues stemming from multiple small scale activities versus individual large scale activities.

Sailing Club

The local sailing club was founded in 1955 and has grown rapidly since. They have a purpose built clubhouse and a number of club-owned training boats available to loan. The waters surrounding the clubhouse often experience heavy sailing traffic, with the majority of users opting for smaller-sized day boats and yachts. The club is located adjacent to a cruising route and recreational sailing area. The sport has grown increasingly popular in recent years and it is expected that the consistent growth of the club will continue.

Potential aggregate extraction site
Prospecting for marine aggregates in the area adjacent to the sailing activity area suggests that sand and gravel resources are present and there is potential for extraction zones to be applied for in the future.

5.2.2 Project level: Offshore wind developments, Greater Wash

This is a previous case with information available in the public domain. For the purposes of testing the framework, this is being treated as a new project.

Applications were made for three offshore wind farm developments in the Greater Wash area. The applications were supported by an EIA and HRA, which indicated there is potential for likely significant effects on European sites in the area.

Docking Shoal
The Docking Shoal offshore wind farm application, for a site with a maximum generating capacity of 540 MW, was submitted by Centrica (DSW) Limited to the Secretary of State in December 2008. Subsequent modifications submitted in July 2011 sought consent for an initial phase construction of up to 100 MW. The full 540 MW site comprises up to 108 turbines, in an area of around 75 km^2, with three offshore sub-stations and inter-array cabling linking the turbines and the offshore sub-stations.

Race Bank
The Race Bank offshore wind farm application, for a site with a maximum generating capacity of 620 MW, was submitted by Centrica (RBW) Limited in January 2009. Subsequent modifications submitted in July 2011 reduced the maximum capacity to 580 MW for a development comprising up to 116 turbines in an area of up to 65 km^2, 3 offshore sub-stations and inter-array cabling linking the turbines and offshore sub-stations.

Dudgeon
The Dudgeon offshore wind farm application, for a site with a maximum generating capacity of 560 MW, was submitted by Warwick Energy Limited in June 2009. The proposed development comprises up to 168 turbines in an area of around 35 km^2, 3 offshore sub-stations, 4 meteorological masts, inter-array cabling, and an accommodation platform.

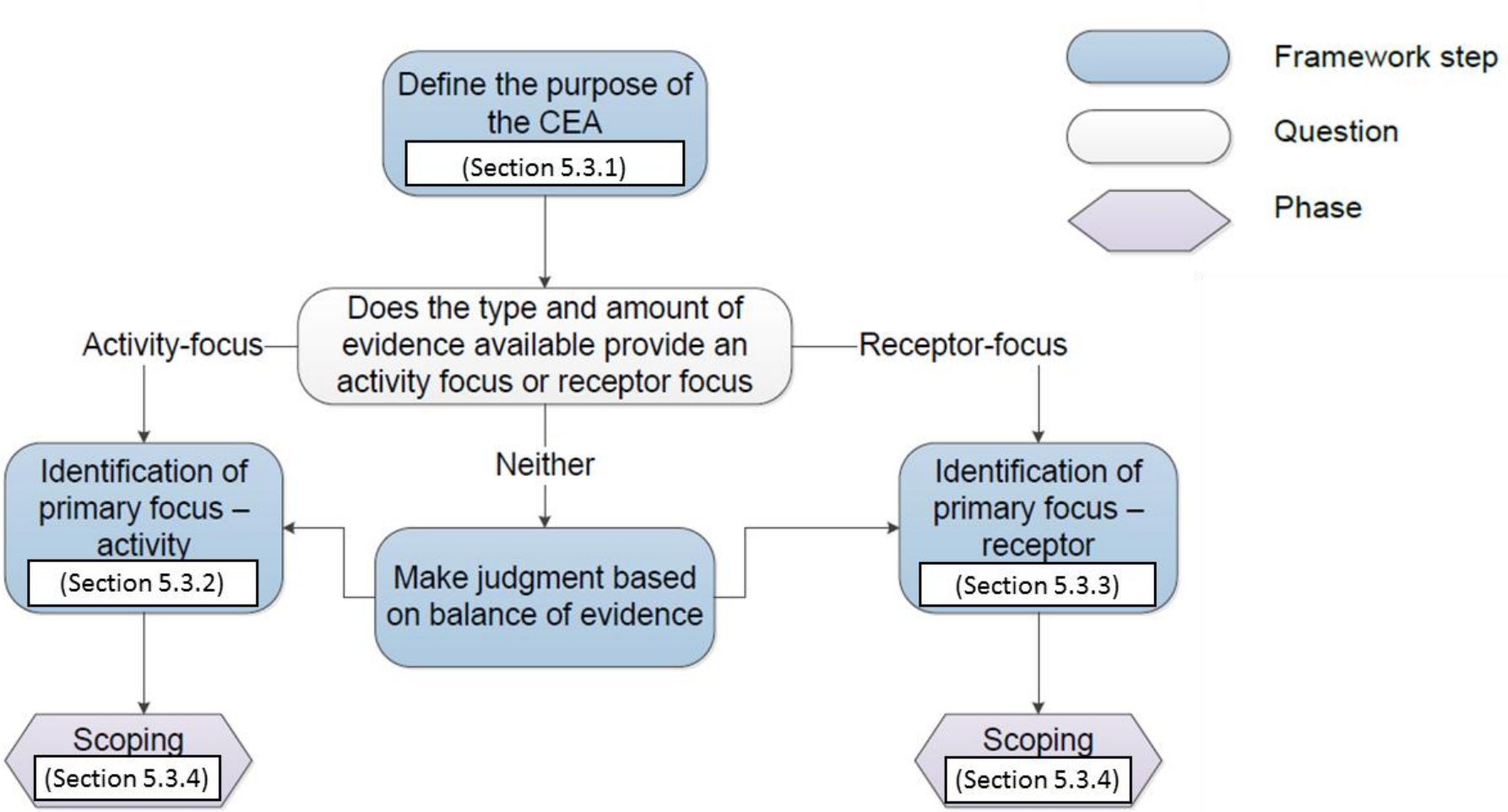
5.3 Setting the scene

The initial phase of the framework includes defining the purpose of the CEA as well as the identification of the primary focus of the CEA. Figure 11 provides an overview of this.

5.3.1 Define the purpose of the CEA

The purpose of this first step is to determine whether CEA is required and to consider how it will inform decision making. This is important as the way in which the framework will be applied by MMO varies within and between functions. This initial step allows the user to outline the reasons why the CEA is being undertaken and what is required in order to effectively scope any potential cumulative effects.

Figure 11: Decision tree outlining the steps involved when setting the scene for the CEA.



Questions for determining context include:

- What is the purpose and aim of the CEA scoping exercise?
- What decision making is required?
- What is the role of MMO in the CEA?
- What are the legislative and policy drivers relevant to the assessment? For example, is it part of the EIA process or HRA process? This is important as some requirements differ between these: under The Conservation of Habitats and Species Regulations 2010 (as amended)[14] if a project has a significant effect alone, further consideration of potential effects in-combination with other plans or projects is not required.
- What is the broad scale of CEA e.g. plan level or project level?
- Are there any assumptions that need to be made at this stage? For example, with regard to what information is available or the scale of the activities or receptors?

This step should represent a relatively brief task which should give an indication of the extent and detail required from the scoping exercise. For example, if the basis for utilising the framework is an application for a marine licence, it is likely that all relevant evidence required will be available in the supporting application documentation. This may mean that it is possible to undertake more detailed consideration of the likely cumulative effects than might otherwise be possible. If the basis of the exercise is broader in scope, the outputs of the framework are likely to be broad also.

This step may highlight that it would be appropriate to consider taking guidance from the Natural England (2013) framework for informing CEA in relation to MPAs, particularly if the purpose of the scoping exercise is related to an HRA.

Outputs at the end of this step should include:

- A decision on whether a CEA is required and the role of MMO
- A brief description of the purpose of the CEA scoping exercise
- A list of any assumptions made with regard to the scale of the exercise and the available information.

Plan level: Large scale vs. small scale activity

The potential for cumulative effects of a large activity versus multiple small scale activities needs to be considered to understand how these activities should be facilitated within the marine plan area. In addition, consideration should be given to how the scoping of cumulative effects differs if large scale or multiple small scale activities are regarded as the primary focus. This case study could therefore help inform future assessment; for example the Marine Policy Statement suggests that within marine planning MMO to consider the potential cumulative impact of activities and use best available techniques to assess whether “a series of low impact

[14] http://www.legislation.gov.uk/uksi/2010/490/contents/made [Accessed 10/04/2014]

activities would have a significant cumulative impact which outweighs the benefit".

If there is potential for cumulative effects, careful consideration of the objectives for each activity within the marine plan policies will be required, including whether there are opportunities for co-existence through mitigation of potential effects. For the purposes of this case study, assumptions may need to be made on the potential for growth of the sailing club including:

- the amount of data available.
- the scale of the area which needs to be considered.

Consideration of the contribution to cumulative effects of activities and which marine users might be required to contribute to mitigation should take place at the appropriate stages within the scoping process. This should highlight where further information may be required and where collaboration between activities may prove beneficial to the environment and surrounding activities and communities.

Project level: Offshore wind developments, Greater Wash

It has been indicated within the HRA that there is potential for a likely significant effect on European sites in the Greater Wash area, as a result of the proposed projects combined. Therefore, CEA is required. As this is under the Habitats Regulations, cumulative effects should be defined as 'in-combination' effects on the integrity of designated sites.

In this scenario, the MMO licensing team were working with the Department of Energy and Climate Change (DECC), who are responsible in cases such as this for making the final decision on whether or not the application is acceptable. As such, a high level of understanding of the likely issues is required to ensure that all projects which MMO are aware of are included within the assessment.

Management of contribution to potential cumulative effects and mitigation has not been considered for this case study.

5.3.2 Identification of the primary focus of the CEA

Once the purpose has been defined, the user will be required to identify the primary focus of the CEA in order to decide on the next most appropriate step; identifying activity-pressures or identifying receptor-pressures. It is this primary focus that will provide the initial list of pressures to consider. By identifying activities which exert the same pressures on the same receptor, the potential for cumulative effects can then be determined.

The nature of the best available information will help the user determine whether the primary focus should be an activity or a receptor, i.e. the next step to follow in the framework (see Figure 11):

- What are the characteristics of the data available for CEA?
    - Establish the amount/type of evidence which is available: through the evidence database, the MMO data register (for spatial data) or other sources (e.g. case specific or as recommend by statutory advisors).
- Does the evidence suggest which receptor(s) is the focus of CEA?
- Does the evidence provide information that better explains the origin/activity/source of the pressure?

For example, where there are numerous activities and receptors in a given area and there is a great amount of available data on one particular receptor due to its status as a feature of an MPA, but there is little information on the activities; in this scenario the primary focus would be a receptor, moving first to the 'identify receptor-pressures' step in the framework (see Figure 11).

Where it is not clear what the primary focus of the CEA should be, a judgment needs to be made on the balance of the available evidence. In such instances, consideration should be given to the following:

- The purpose of the CEA, for example, would the aims be better met through the consideration of an activity or a receptor as the primary focus?
- The likelihood of further information becoming available during the CEA scoping process. If likely, will this be in relation to a receptor or activity?

Outputs at the end of this step should include a decision on what the primary focus of the CEA scoping exercise should be.

Plan level: Large scale vs. small scale activity

In this case, the scoping exercise needs to be undertaken twice: once with aggregate extraction as the primary focus and once with sailing as the primary focus. A comparison can then be made on the final outputs.

Therefore, the outputs for this case study would be:

- Primary focus – Extraction-aggregates.
- Primary focus – Recreational activities – sailing (yachting).

(see Annex 7)

Project level: Offshore wind developments, Greater Wash

The primary focus of this scoping exercise should be the potential for cumulative effects generated from offshore wind development. The evidence database provides the activity-pressures for offshore wind, with moderate confidence in the links, although there are some evidence gaps for some of the pressures and activities (see Annex 7).

5.4 Scoping

Following the initial setting the scene phase, the scoping phase incorporates all of the remaining steps in the framework, concluding at the identification of potential for cumulative effects to take forward into the assessment phase. The scoping phase can be broken down into two tasks:

1. Identification of activities, receptors and pressures.
2. Definition of potential interactions between these within a specific spatio-temporal scale.

Outputs of the initial phase, described in Section 5.3, will have indicated to the user whether the scoping exercise should be activity focused or receptor focused. Identification of the pressures linked to the primary focus is the first task in the scoping phase (Sections 5.5.1 and 5.5.2) along with identification of any pressures associated with the subsequent receptors (if the primary focus is an activity) or activities (if the primary focus is a receptor). This is highlighted in Figure 12.

Figure 12 also frames the key questions which need to be considered when ascertaining where to begin in defining the interactions between activities, receptors and pressures, and where information may be found to answer these questions. The most appropriate starting point will depend on the amount of information available in each specific case, the user will be required to judge which step to approach first.

5.5 Scoping task 1 – Identification of activities, receptors and pressures

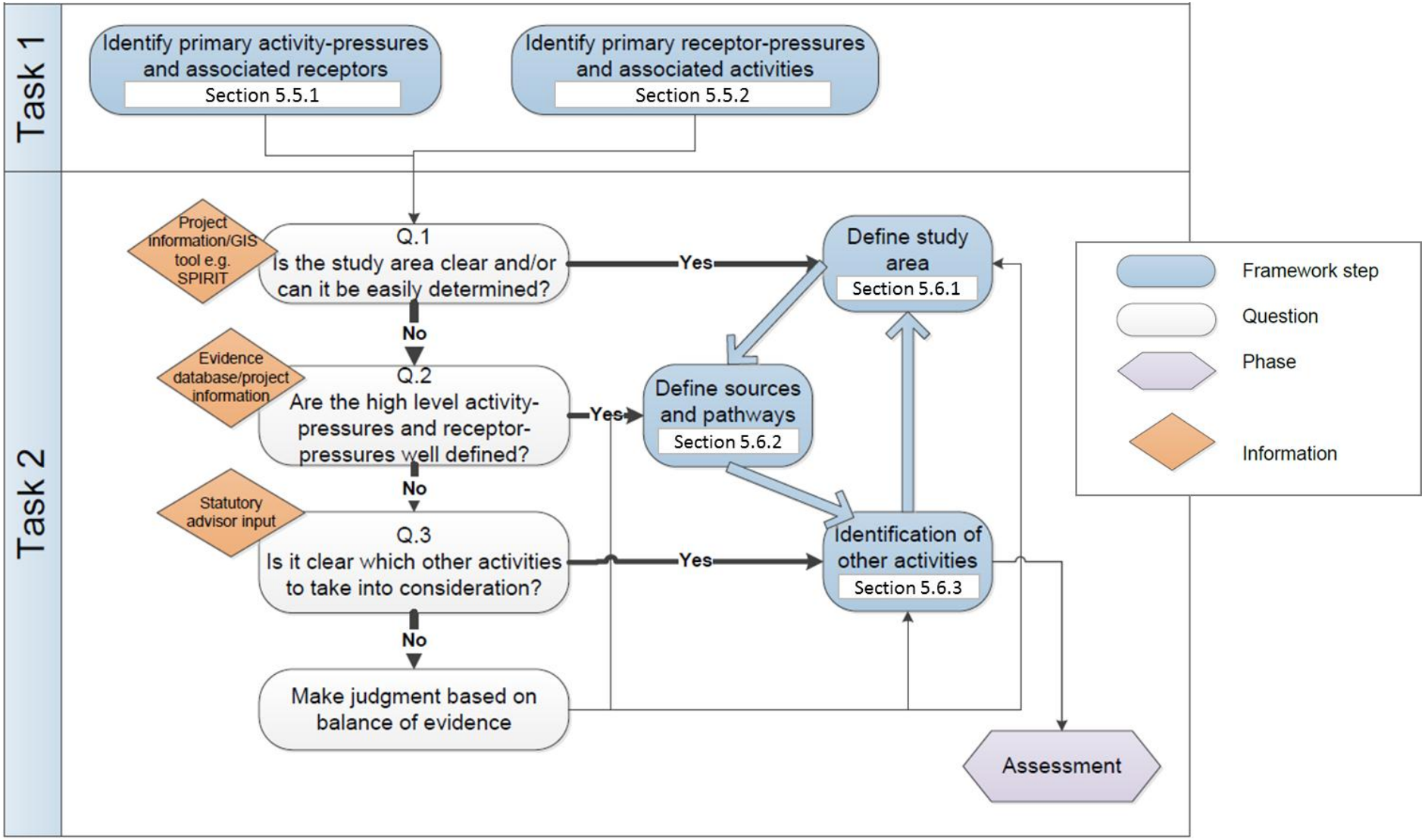
The first task in the scoping stage is to identify the activity-pressures and associated receptors (Section 5.5.1) or the receptor-pressures and associated activities (Section 5.5.2) depending on the primary focus.

5.5.1 Identification of the primary activity-pressures and associated receptors

This is the first step in the scoping process if the primary focus of the exercise is an activity. If the initial phase indicated that the primary focus should be a receptor, the appropriate starting point is Section 5.5.2.

The need to scope cumulative effects arises as a result of the presence or potential future presence of one or more activities in a given area. Identification of the primary activity is required in order to provide an initial list of pressures which may be exerted. This enables consideration of where and when other activities may exert the same pressures. This information may be outlined in the marine licence application or through consideration of activities for marine planning purposes. Any assumptions made with regard to the activity as the primary focus for the exercise should be considered during this step. Specific consideration of other activities is undertaken later in the process (see Figure 12).

Figure 12: Scoping framework decision tree indicating how to navigate the scoping phase and where information can be found.



The identification of the potential pressures associated with the primary activity is more complex. The evidence database will provide an initial list of the linkages between each activity and the broad environmental pressures they may have the potential to exert. As discussed in Section 2, further research is on-going with regards activity-pressure interactions and at the project level, more detailed information may also be available through consultation with statutory advisors. An excerpt of the activity-pressures table is provided in the project level case study below (Figure 13). The full tables for both case studies are provided in Annex 7.

The database will also allow the user to produce a table which links the broad pressures to the receptors which are potentially sensitive to those pressures. This provides an initial view of the receptor groups which may need to be considered in the scoping exercise. An extract of this table is provided for the project level case study below (Figure 14) and the full tables for both case studies are provided in Annex 7. Further scoping of receptors will be carried out during the latter stages of the process, when the study area is defined and the links between the source of each pressure and the relevant pathway to each receptor are considered.

As identified in the plan level case study, it may be appropriate to consider how activities might contribute to cumulative effects at this point in the scoping process and potential management of these effects. In particular, where the framework is applied for marine planning, legislative mechanisms for managing cumulative effects and mitigation may be lacking. Although this is early on in the process, there are steps which could be taken to form initial judgements (Section 4). This is true for potential environmental, social and economic effects.

Outputs at the end of this step should include:

- A table showing potential links between activity-pressures and receptors
- A list of any assumptions made in relation to the primary focus (the activity)
- If deemed appropriate, consideration of how contribution to cumulative effects might be managed at this early stage.

Plan level: Large scale vs. small scale activity

It should be noted that as more than one activity has been identified (‘aggregate-extraction and recreational–sailing (yachting)’), MMO may also need to consider how they might manage the contribution to any cumulative effects and mitigation between the projects at this stage. Following the management decision tree (Figure 9; Section 4), until information on other activities is received and further information on the potential cumulative effects has been explored it is prudent to start with assuming ‘equal responsibility’ for cumulative effects between aggregate extraction and recreational sailing, (see Section 4.7). Considering the management of responsibility at this point in the process may help to identify where further information may be required and may allow each activity to be involved in the discussions forming the basis of any decisions.

Project level: Offshore wind developments, Greater Wash

Figure 13: Excerpt of the activity-pressure linkage table for offshore wind activities (screenshot from evidence database).

Renewable energy - Wind - Construction	Barrier to species movement
	Physical loss
	Death or injury by collision
	Underwater noise changes - low and mid-frequency impulsive sounds
	Underwater noise changes - high frequency impulsive sounds
	Siltation rate changes
	Changes in suspended solids
	Disturbance of the substrate below the surface of the seabed
	Habitat structure changes - removal of substratum
	Physical change
Renewable energy - Wind - Decommissioning	Siltation rate changes
	Changes in suspended solids
	Physical damage

Project level: Offshore wind developments, Greater Wash continued

Figure 14: Extract of the summary table showing links between activity-pressures and sensitive receptors (screenshot from evidence database).

Activity	Pressure	Receptor
Renewable energy - Wind - construction	Barrier to species movement	Birds
Renewable energy - Wind - construction	Barrier to species movement	Fish and pelagic habitat (inc. plankton)
Renewable energy - Wind - construction	Barrier to species movement	Marine mammals and reptiles
Renewable energy - Wind - construction	Death or injury by collision	Birds
Renewable energy - Wind - construction	Death or injury by collision	Fish and pelagic habitat (inc. plankton)
Renewable energy - Wind - construction	Death or injury by collision	Marine mammals and reptiles
Renewable energy - Wind - construction	Disturbance of the substrate below the surface of the seabed	Benthic habitat and species
Renewable energy - Wind - construction	Disturbance of the substrate below the surface of the seabed	Hydrography
Renewable energy - Wind - construction	Disturbance of the substrate below the surface of the seabed	Topography/Bathymetry
Renewable energy - Wind - construction	Habitat structure changes - removal of substratum	Benthic habitat and species
Renewable energy - Wind - construction	Habitat structure changes - removal of substratum	Birds
Renewable energy - Wind - construction	Habitat structure changes - removal of substratum	Fish and pelagic habitat (inc. plankton)
Renewable energy - Wind - construction	Habitat structure changes - removal of substratum	Marine mammals and reptiles
Renewable energy - Wind - construction	Habitat structure changes - removal of substratum	Topography/Bathymetry

5.5.2 Identification of the primary receptor-pressures and associated activities

This is the first step in the scoping process if the primary focus of the exercise is a receptor. If the initial setting the scene phase indicated that the primary focus should be an activity, the appropriate starting point is Section 5.5.1. This approach may be better suited to some marine conservation or marine planning tasks. For example, when considering an area where the primary receptors at risk are clear, but the number/type of activities are less clear, or there are too many potential activities for one to provide the primary focus for the scoping exercise.

Identification of the primary receptor is required in order to provide an initial list of the pressures to which the receptor may be sensitive. This will enable consideration of which activities may exert those pressures. Any assumptions made with regard to the receptor chosen as the primary focus for the exercise, should be considered during this step.

The evidence database will provide a list of all potential environmental pressures on each receptor group. The receptor groups are high level and therefore the list of potential pressures for each is necessarily extensive (e.g. Figure 15). The database supporting this framework does not currently support the scoping of social and economic cumulative effects and requires the relevant information incorporating before this scoping could be undertaken.

The database will also allow the user to produce a table which links the receptor-pressures to the activities with the potential to exert those pressures. This provides an initial view of the activities which need to be considered in the scoping exercise (e.g. Figure 16). Further scoping out of activity-pressures will be considered later on in the process, when the study area is defined and when the links between the source of each pressure and the relevant pathway to each receptor are identified.

Outputs at the end of this step should include:

- A table showing potential links between receptor-pressures and activities
- A list of any assumptions made in relation to the primary focus (the receptor).

Figure 15: Extract of the summary receptor-pressure linkage table (screenshot from evidence database).

Receptor	Pressure
Benthic habitat and species	Transition elements & organo-metal contamination
	Emergence regime change
	Genetic modification & translocation of indigenous species
	Introduction of microbial pathogens
	Introduction or spread of non-indigenous species
	Deoxygenation
	Organic enrichment
	Nutrient enrichment
	Radionuclide contamination
	Introduction of other substances
	Water flow changes
	Hydrocarbon & PAH contamination
	Wave exposure changes
	Salinity changes
	Temperature changes
	Litter
	Removal of non-target species
	Removal of target species

Figure 16: Extract of summary table showing links between receptor-pressures and activities (screenshot from evidence database).

Activity	Pressure	Receptor
Aquaculture - Fin-fish	Deoxygenation	Benthic habitat and species
Aquaculture - Fin-fish	Genetic modification & translocation of indigenous species	Benthic habitat and species
Aquaculture - Fin-fish	Habitat structure changes - removal of substratum	Benthic habitat and species
Aquaculture - Fin-fish	Introduction of microbial pathogens	Benthic habitat and species
Aquaculture - Fin-fish	Introduction or spread of non-indigenous species	Benthic habitat and species
Aquaculture - Fin-fish	Litter	Benthic habitat and species
Aquaculture - Fin-fish	Nutrient enrichment	Benthic habitat and species
Aquaculture - Fin-fish	Organic enrichment	Benthic habitat and species
Aquaculture - Fin-fish	Removal of non-target species	Benthic habitat and species
Aquaculture - Fin-fish	Removal of target species	Benthic habitat and species
Aquaculture - Fin-fish	Siltation rate changes	Benthic habitat and species
Aquaculture - Fin-fish	Synthetic compound contamination	Benthic habitat and species
Aquaculture - Fin-fish	Transition elements & organo-metal contamination	Benthic habitat and species
Aquaculture - Fin-fish	Water flow changes	Benthic habitat and species

5.6 Scoping task 2 – Defining interactions within a specific scale

The next three steps of the scoping process form a feedback loop (see Figure 12). All three steps need to be considered during the process. These steps are:

- Determining the study area
- Defining sources and pathways
- Identifying other activities.

It is possible to start at any one of these points; Figure 12 frames the key questions to ascertain the most appropriate starting point within the feedback loop (see Q.1 – Q.3) and highlights where information to inform the answers to these questions may be found. Following this decision tree, if the study area is clear and/or can easily be determined based on the project information or by using appropriate GIS tools (e.g. SPIRIT), start with determining the study area (Section 5.6.1).

If the study area is not clearly identified, consideration of whether the activity-pressure-receptor linkages are well defined will be the next required action. If using the evidence database, it should be possible to start with defining sources and pathways (Section 5.6.2).

It is unlikely to be appropriate to start with identifying other activities (Section 5.6.3); however, it is possible in the event that there is limited or inappropriate information to proceed with either of the previous steps, or where advice has been provided by statutory advisors on what other activities should be included.

These three steps form an iterative approach, to refine where there may be potential for cumulative effects. This is particularly useful if new data or evidence has become available since the initial setting the scene phase. Given this, the iterative nature of this exercise ensures no steps are missed regardless of the initial step. Scoping out of activities, pressures and/or receptors should be conducted as each step is completed. The main output will be a list of activities which exert common pressures with potential to cause a cumulative effect on a common receptor.

5.6.1 Determining the appropriate study area (spatial and temporal)

Determination of the spatial and temporal scale is necessary to ensure that those activities with potential to contribute to a cumulative effect, but that do not occur within the same spatio-temporal scale as the receptors, are not scoped in for further consideration. This is achieved by determining a study area or ‘footprint’:

- The spatial and temporal extent of the primary focus (activity or receptor)
- The spatial and temporal extent of the pressures associated with the primary focus.

The spatial scale refers to the potential geographical extent of activity (e.g. a licensed aggregate dredging zone) and its respective pressures (e.g. the volume of potential physical loss of habitat from the aggregate dredging zone). However, it is also important to acknowledge the spatial extent of the receptor(s) within the scale of the exercise (e.g. total extent of habitat, or species distribution), as other activities may also exert pressures which may or may not be the same in adjacent areas. The

temporal scale of assessment refers to the duration of activities under consideration and any seasonal or annual variations in the distribution and/or life cycles of receptors.

Social and economic impacts also have spatial characteristics which may influence the choice of scale for the analysis. The level of social and economic effects may be linked directly to the scale selected for a receptor or activity (e.g. to the size of an aggregate dredging zone) but may also have wider effects such as, for example, where curtailment of dredging means local aggregates demand needs to be met by increased road transport. Social and economic effects may also be affected by temporal factors which differ from those relevant to the assessment of environmental impacts, because:

- There may be inherent seasonal and other time related factors (such as annual spawning) linked directly to socio-economic impacts (such as the size of a fishing fleet based far from the sites considered).
- Socio-economic impacts may persist after initial environmental changes.
- The permanence and resilience of economic and social systems more generally is often related to the duration of any change and the understanding by affected parties (e.g. hotel owners) of reasons for it. For example, if disruption is temporary or intermittent (e.g. for one tourist season or for certain states of the tide) then impacts may be reduced.

The spatio-temporal scale of social and economic effects can be based initially on the scale assessed according to environmental impacts and revised iteratively as the relevant factors are identified.

An initial consideration of scale should have been made in the very first step of the process, to provide context for the scoping exercise. For example, it may be that an entire plan area needs to be considered, or it may be that scoping is focused on one activity in a specific area in space and time.

Whether the spatio-temporal scale of activities, pressures or receptors is defined first depends on the data available, which in turn can depend on the purpose of the CEA scoping exercise. Geographical information may be highly specific and vary greatly, but it is likely that it will be possible to include spatial information on at least one of the categories of activity, pressure or receptor. For example: if marine licensing documentation indicates the activities are multiple offshore wind farms, then the individual maximum spatial extents of these will be known; or a planning policy might be applied to a specific spatial area, the extent of which would be known. If the primary focus is a species-specific receptor, then it may be possible to define the general distribution of this species.

There is detailed evidence available on specific receptors that cannot be provided by the database at this time, due to wide variations within the receptor groups (e.g. at the species/habitat level). Therefore, the guidance in Table 2 provides suggested references and data, which may provide further information to allow the consideration of spatio-temporal scale of receptors. Consultation with statutory advisors may also be appropriate on a case by case basis before using these data to

determine the spatio-temporal scale of a receptor, to ensure the most appropriate and up to date evidence is utilised.

Any assumptions made based on the availability and quality of the data should be detailed at this stage to ensure that any risks are fully taken into consideration in the subsequent steps.

At this stage, where the spatial scale has been defined, transboundary issues may arise leading to implications for regulators in other countries. At this point it is important to identify these issues and ensure relevant colleagues are aware and involved with any assessment and decision-making as appropriate.

Outputs at the end of this step should include:

- Definition of the study area
- Any assumptions made in order to define the study area.

Table 2: Determinants of spatio-temporal scale of receptors and potential data sources to define spatio-temporal scale.

Receptor	Determinant of spatio-temporal scale	References and data
Topography/ Bathymetry	Extent of the activity/plan/project; sediment transport	Shoreline management plans – http://www.environment-agency.gov.uk/research/planning/105014.aspx INSPIRE - http://www.environment-agency.gov.uk/research/planning/105014.aspx BODC - https://www.bodc.ac.uk/data/online_delivery/gebco/ JNCC data - http://portal.emodnet-hydrography.eu/# MEDIN - http://www.oceannet.org/online_data_by_theme/marine_geology_and_bathymetry/
Hydrography	Seasonal variations in temperature/chemical composition; Tidal excursion/ellipse	Cefas data including WaveNet - http://www.cefas.defra.gov.uk/our-science/observing-and-modelling/monitoring-programmes/wavenet.aspx
Fish and pelagos	Nursery/spawning grounds; migratory pathways; spawning periods	Coull *et al.* (1998) Ellis *et al.* (2010) Holland *et al.* (2005) Pawson (1995)
Benthic habitat and species	Tidal excursion/ ellipse; extent of the habitat	MarLIN - www.marlin.ac.uk MESH - http://jncc.defra.gov.uk/page-1542 EUSeaMAP - http://jncc.defra.gov.uk/page-5040
Seabirds	Foraging range; disturbance distance; breeding/non-breeding season; migration pathway.	JNCC Seabird monitoring database - http://jncc.defra.gov.uk/smp/ Birdlife International database - http://seabird.wikispaces.com/ BTO WeBS data - http://www.bto.org/volunteer-surveys/webs/data Thaxter *et al.* (2012)
Marine mammals and reptiles	Foraging range; disturbance distance; distribution;	JCP - http://jncc.defra.gov.uk/page-5657 SCANS II - http://biology.st-andrews.ac.uk/scans2/ SCOS - http://www.smru.st-andrews.ac.uk/pageset.aspx?psr=411 Reid *et al.* (2003)

Plan level: Large scale vs. small scale activity

Extraction Aggregates:
As the area is hypothetical, it is necessary at this stage to make some assumptions regarding the spatio-temporal scale. For example:

- The aggregate extraction activity will be conducted within a licensed area and will be applied for within 10 years
- The sediment plume from extraction activities will extend beyond the licensed zone.

As the pressures exerted by this activity have the potential to cause an effect on all receptor groups within the database and there is no further information on what receptors are present within the area, only minor assumptions can be made with regard to the spatio-temporal footprint for the exercise. For example:

- Potential effects on benthic habitats and species and topography/bathymetry will be within the aggregate extraction zone and sediment plume area
- The noise pressure may result in an increase to the footprint
- Mobile species, such as birds, marine mammals and fish may be affected beyond the aggregate extraction zone boundary and sediment plume.

Recreational activities – sailing (yachting)
Assumptions are also required about the hypothetical recreational activities. For example:

- Yachting will only occur within the recreational sailing area and cruising route adjacent to the boat house
- Underwater noise and sewerage discharge has the potential to extend beyond the designated sailing areas.

As the pressures exerted by this activity have the potential to cause an effect on all receptor groups within the database and there is no further information on what receptors are present within the area, only minor assumptions can be made with regard to the spatio-temporal footprint for the exercise. For example:

- Potential effects to benthic habitats and species and topography/bathymetry will be within the designated sailing area.
- Underwater noise and sewerage discharge pressures may result in an increase to the footprint.
- Mobile species, such as birds, marine mammals and fish may be affected beyond the increased footprint.

Project level: Offshore wind developments, Greater Wash

Spatial scale is well defined in the project documentation for this case study. Docking Shoal covers an area of 75 km^2, Race Bank 65 km^2 and Dudgeon 35 km^2. All three projects lie in the south of the Greater Wash:

- Docking Shoal lies approximately 14 km from the north Norfolk coast
- Race Bank lies approximately 27 km from the north Norfolk coast
- Dudgeon lies approximately 32 km from the north Norfolk coast.

There are three designated Marine Protected Areas (MPAs) located adjacent to the projects:

- The Wash and North Norfolk Coast SAC – designated for marine mammals and benthic habitats and species
- North Norfolk Coast SPA – designated for birds
- Inner Dowsing Race Bank and North Ridge cSAC – designated for benthic habitats.

Although additional receptors were identified in the previous step, based on this information it is appropriate to scope in birds, marine mammals and benthic habitats and species from the list of receptors in the database. This is because the purpose of the CEA is an in-combination assessment of the potential for adverse effects on the features of the designated sites.

Similarly, as the majority of the pressures identified through the process described in Section 5.5.1 are only exerted within the boundary of the wind farm site and cable corridor, it is not necessary to expand the footprint. The exception is underwater noise, which requires review of the noise modelling undertaken for each project (available within the Environmental Statements for the projects) and is only applicable during construction periods. The worst case distance for displacement of marine mammals has been modelled at 14 km for Docking Shoal; therefore this has been used for the purposes of this case study.

It is also appropriate to consider the scale of each receptor even though they are features of MPAs. Mobile receptors, such as marine mammals and birds, utilise areas outside of the MPA boundary which could overlap with the project boundaries in addition to the activity-pressures of each of the wind farm projects.
This suggests that both of these receptors could potentially overlap with the activity and activity-pressure spatial extents.

The temporal scales suggested in the project documentation are as follows:

- Docking Shoal –proposed commencement of construction 2016-17, operational from 2018
- Race Bank – proposed commencement of construction 2015-17, operational from 2015-17
- Dudgeon – proposed commencement of construction 2015, operational from 2016.

Project level: Offshore wind developments, Greater Wash

This suggests that there is potential for construction and operational pressures to occur at the same time, adjacent to the MPAs. There is no information available for decommissioning timeframes.

The overall footprint for the scoping exercise therefore includes:

- The proposed offshore wind farm boundaries plus a 14km zone around the boundary, to take account of potential effects of noise (during construction only)
- The proposed cable routes
- The boundaries of the MPAs.

5.6.2 Defining sources and pathways

The purpose of this step is to understand where effects could potentially occur by identifying the source of a pressure and the pathway to a receptor which may be sensitive to that pressure. An effective way of achieving this is to consider how pressures from each activity might cause an effect on a receptor; inputting further detail into the activity-pressure-receptor tables used earlier in the process (Sections 5.5.1 and 5.5.2). This step is highly specific to each case therefore expert judgement will be required. It is likely that consultation with statutory advisors will be appropriate at this stage in order to use their knowledge and experience in analysing the links between activities, pressures and receptors and to provide consistency.

In addition, utilising the evidence database as a guide when considering the sources of pressures will assist in ensuring a level of consistency between users, where the information is available. Where it can be demonstrated that there is no link between a specific activity-pressure and a given receptor, it can be scoped out at this stage. For example, ‘coastal tourist sites’ (activity) has the potential to cause physical loss (pressure), through the construction of car parking facilities (source). Marine mammals (receptor) are sensitive to physical loss of their habitat, due to indirect effects on prey species (pathway). However, there is no interaction between marine mammals and coastal tourist sites through this pressure, as the habitats affected/required are not the same.

General information on the sources of pressures is provided in the database, where available. An example is provided in Figure 17 and in addition more detailed information on the sources and pathways will be accessible through links to reference documents within the evidence database (currently only available for environmental effects). These can be used to populate activity-receptor-pressure tables produced under Scoping Task 1 (Section 5.5) and should be treated as a starting point for evaluating linkages between activities and receptors. Further guidance from statutory advisors may be sought by MMO as appropriate. The full tables for both case studies are provided in Annex 7, however an extract of this table is provided in Figure 18 for the project-level case study.

To ensure a risk-based approach, any assumptions that have been made based on the available evidence in the previous steps of the framework should be factored in

here and may necessitate a more precautionary view. It is crucial all assumptions are documented when scoping activity-pressures in or out for further assessment to ensure all decisions are fully auditable. The evidence database provides a level of confidence in links between activity-pressures and receptor-pressures and also a quality assessment of all references. This should allow the user to evaluate confidence in any assumptions made in relation to the sources and pathways between activity-pressure-receptors, to ensure that any assumptions made can be checked and reviewed for accuracy where necessary, further along the process.

Identification of sources and pathways for social and economic drivers, impacts and receptors need to be analysed on a case-by-case basis. The role of the framework is to guide the user throughout the process, providing standardised categories for social and economic impacts to that end. Once the social and economic activities, impacts and receptors have been incorporated into the evidence database, this step can be conducted.

Outputs at the end of this step should include:

- A table showing the sources of pressures from the primary activity and the pathways to each receptor or a table showing the sources of pressures from activities and the pathway to the primary receptor
- Any assumptions made in order to scope out activities, pressures and receptors.

Figure 17: Extract of database table showing the potential source of each pressure, linked to an activity (screenshot from evidence database).

Activity	Pressure	Source
Renewable energy - Wind - Construction	Physical change	The presence of machinery during the construction phase will result in a temporary disturbance and modification of seabed habitats (e.g. anchoring, presence of jack up vessels legs on the seabed)
Renewable energy - Wind - Construction	Physical loss	The presence of machinery during the construction phase will result in a temporary disturbance and modification of seabed habitats (e.g. anchoring, presence of jack up vessels legs on the seabed)
Renewable energy - Wind - Construction	Habitat structure changes - removal of substratum	Installation of foundations may require alteration to the seabed, for example seabed conditioning using suction dredgers (for gravity and tripod foundations) and extensive seabed levelling (for larger gravity based structures). This can result in loss of food resources

Project level: Offshore wind developments, Greater Wash

Figure 18: Extract of activity-pressure-receptor table, filtered for offshore wind activities and with the addition of 'source' and pathway' columns.

Activity	Source	Pressure	Pathway	Receptor
Renewable energy - Wind - construction		Barrier to species movement		Birds
Renewable energy - Wind - construction		Barrier to species movement		Fish and pelagic habitat (inc. plankton)
Renewable energy - Wind - construction		Barrier to species movement		Marine mammals and reptiles
Renewable energy - Wind - construction		Death or injury by collision		Birds
Renewable energy - Wind - construction		Death or injury by collision		Fish and pelagic habitat (inc. plankton)
Renewable energy - Wind - construction		Death or injury by collision		Marine mammals and reptiles
Renewable energy - Wind - construction		Disturbance of the substrate below		Benthic habitat and species
Renewable energy - Wind - construction		Disturbance of the substrate below		Hydrography
Renewable energy - Wind - construction		Disturbance of the substrate below		Topography/Bathymetry
Renewable energy - Wind - construction		Habitat structure changes - removal		Benthic habitat and species
Renewable energy - Wind - construction		Habitat structure changes - removal		Birds
Renewable energy - Wind - construction		Habitat structure changes - removal		Fish and pelagic habitat (inc. plankton)

5.6.3 Identify other activities

This step involves the identification of other activities which may contribute to a cumulative effect with the primary activity or on the primary receptor. It is unlikely that this step can be completed without due consideration of the study area and the sources and pathways between activities, pressures and receptors. However, it is possible to begin with this step in the event that there is limited or no appropriate information to proceed with in either of the previous steps. In particular, this may be the first step where advice has been provided by statutory advisors and/or where clear assumptions on the spatio-temporal scale of the exercise were made during the initial phase.

Consideration should be given to other activities that do not occur within the study area, but that have potential to exert pressures which overlap with the study area, in addition to those which produce temporally overlapping pressures or have the potential to overlap in the future. Consideration may also need to be given to activities that are not yet 'active'. At the strategic level, this will depend on the stage the activity is at and what evidence is available to support its inclusion in the exercise.

This consideration of future activities is a crucial element to scoping cumulative effects. This step can cause issues with individual project CEA due to the lack of a consistent approach to CEA across and within sectors. This framework provides MMO with an approach to scoping cumulative effects, which can be used across all functions, therefore, a 'one size fits all' approach to scoping in other activities would not be suitable here, nor would it be appropriate to suggest that all developers consider this in one particular way.

The broadest possible approach to this is to scope in all activities present or potentially present within the study area, with the presumption that those without potential to contribute to any cumulative effects will be scoped out when defining the sources and pathways for these additional activities.

Decisions with regards to scoping in additional activities may be further informed by consideration of responsibility for cumulative effects and, if appropriate, the decision tree in Section 4 (Figure 9) should be consulted. It may also be appropriate to consider responsibilities at this stage where, for example, data sharing or joint working would improve the robustness of the outcome of the scoping exercise, or where early consideration of this would help to inform later decisions. This is highly dependent on the purpose of the CEA scoping exercise

Outputs at the end of this step should include:

- A list of activities with potential to exert similar pressures which overlap with those of the primary focus
- Any assumptions made in order to scope out activities.

Plan level: Large scale vs. small scale activity

For the purposes of this scenario, it is necessary to make assumptions about activities within the area. In addition to the sailing club, other activities in the area include:

- A port development 10 km along the coast from the sailing club.
- A military flying zone over the same area as the aggregate resource.
- A tourist site, popular with birdwatchers adjacent to the sailing club.

It may be possible to think further at this stage as to how the management of contribution to cumulative effects and mitigation may be undertaken, based on any new information or assumptions made. Additional activities have been identified and they can now be considered in the management exercise. These assumptions can then be used to assess the impact of the CEA and mitigation requirements on the identified activities.

This is a later stage of the scoping exercise and there is further detail on the study. Following the decision tree in Section 4 (Figure 9), it may therefore be possible to consider how the management of contribution to cumulative effects will affect marine activities and the consequences for the communities in that region, in a more refined way than by assuming equal responsibility. However, until the sources and pathways between activities and receptors are established, it will not be possible to do so.

Project level: Offshore wind developments, Greater Wash

All three developments considered within the spatio-temporal footprint should be scoped in at this stage. The identification of other activities has been undertaken using data on the Marine Planning Portal for the purposes of this project. Please note that in reality, MMO would more likely use internal data sources, such as SPIRIT, which are regularly updated and contain GIS co-ordinates of each plan, project or activity.

Other activities identified within this footprint, using the Marine Planning Portal data and activity categories, include:

- Military practice areas – within the SAC
- Aggregate dredging – outside of the SPA/SAC sites, further offshore
- Inshore fisheries – mobile and static gear – within the SAC
- Recreation:
    - RYA – cruising routes, racing areas and sailing areas.
    - Sightseeing
    - Horse riding beaches
    - Boat launch slipways.

5.6.4 Iterative feedback loop

Once Sections 5.6.1 to 5.6.3 have been completed it is likely to be necessary to revisit the steps again (these steps may form a feedback loop as described in Figure 12) to ensure that the appropriate study area is used and so that all the relevant pathways and interaction between activities, pressures and receptors are considered for the other activities with potentially overlapping pressures. This section describes how this might work in practice.

Reconsider the study area

If the primary focus of the exercise is an activity, the spatio-temporal scale should not be affected by any other activities identified in the step detailed in Section 5.6.3. However, where sources and pathways identify no link between an activity and a pressure and/or receptor, the spatio-temporal extent of these can be removed from the study area.

If the primary focus of the exercise is a receptor, the study area may need to be expanded where potential pressures of activities identified in Section 5.6.3 extend beyond the original study area. The study area may be refined where sources and pathways identify no link between activities, pressures and the receptor or where there is no overlap.

This process will be the same whether environmental, social and/or economic cumulative effects are being scoped for assessment.

Outputs at the end of this step should include:

- Definition of the study area, including potential revisions
- Any assumptions made in order to define the study area.

Defining the sources and pathways for all activities

The purpose of this step is to understand where effects could potentially occur. This is done by pinpointing the source of the pressures from the other activities under consideration (Section 5.6.3), that overlap with those of the primary activity, and the pathway to the receptor(s) which may be sensitive to those pressures (activity-focused). Or, where the primary focus is a receptor, determining the source of the pressures from the activities identified (Section 5.6.3) and the pathways to that primary receptor. This step should follow the same process as detailed in Section 5.6.2, using the appropriate tables in the evidence database, filtering for the other activities identified and focusing on those pressures which overlap with the primary focus.

The pathways for the additional activity-pressures should consider whether there is a link with the pressure from the primary focus. If it is unclear whether there is a link, a precautionary approach should be taken. Full tables for the case studies are presented in Annex 7. As detailed in Section 5.6.2, this step is highly specific to each case therefore there is a requirement for expert judgement. It is likely that consultation with statutory advisors will be appropriate at this stage in order to use their knowledge and experience in analysing the links between activities, pressures and receptors and to improve consistency. In addition, utilising the evidence

database as a guide when considering the sources of pressures will assist in ensuring a level of consistency between users, where the information is available.

The outputs of this step will highlight where there is potential for a cumulative effect arising from the interaction of pressures between activities. The decision on which potential cumulative effects are to be scoped in for further assessment should be based on: this initial high level consideration; any advice from statutory advisors; consideration of any assumptions made during the process; and confidence levels of the outputs.

Plan level: Large scale vs. small scale activity

It may be possible to think further at this stage as to how the management of cumulative effects assessment and mitigation may be undertaken based on any new information or assumptions made.

Using the management decision tree in Section 4 (Figure 9), the later stage of the scoping exercise and the further detail on the study suggest it may be possible to allocate responsibility for potential cumulative effects in a more refined way than by assuming equal responsibility, by eliminating activities with no potential for effect on the receptors. This is discussed further in the full case study (Annex 7).

5.6.5 Final outputs

The final outputs at the end of the framework process should include:

- A table showing
  - Overlaps between sources of pressures from the other activities and the pathways to each receptor with those of the primary activity, OR
  - The sources of pressures from activities and the pathway to the primary receptor.
- Clarification of assumptions made in order to scope out activities, pressures and receptors.
- A level of confidence in the outputs based on the MMO QA process.

The potential for cumulative effects arising from the interaction of pressures on common receptors between activities has been identified for each of the case studies and are presented in Annex 7.

Framework outputs could be used as a starting point for assessment of the potential cumulative effects by MMO, if required. Alternatively, they could provide a basis for testing various future scenarios in a comparable, systematic way for marine planning. Prior to continuing into the full assessment phase, consideration should be given to any advice from statutory advisors, assumptions made during the process and confidence levels of the outputs. The framework should be used in conjunction with expert judgement and cumulative effects should be considered on a case by case basis.

5.6.6 Potential cumulative effects - further assumptions

In some cases, it may be appropriate to provide further refinement to the scoping of cumulative effects; for example in the later stages of a licence application. In such circumstances, data will be required to demonstrate the magnitude and scale of pressures to ascertain where they might interact to cause a significant cumulative effect on a given receptor. In the absence of case-specific data, it is possible that some high level assumptions can be made through existing generic information in order to approximate the pressures.

It may be appropriate to take guidance from the Natural England (2013) framework for informing cumulative impact assessment in relation to MPAs. In particular, if the purposes of the scoping exercise are to inform the scope of an HRA.

One approach to building assumptions for pressures in the absence of suitable data is to consider the pressures in a similar way to an ecological impact assessment. The Chartered Institute of Ecology and Environmental Management (CIEEM) produced guidelines in 2010 (IEEM, 2010), which recommend consideration of certain parameters to quantify impacts. These can be broadly applied to environmental pressures for the purposes of this framework, if they are framed as assumptions which have been made in order to form the process. Where there is an uncertainty regarding any of these assumptions, it is likely to be appropriate to consider the worst case scenario for each of these, to ensure a precautionary approach. In order to do this, a number of factors need to be taken into consideration:

- Is the pressure **positive or negative**?
- What is the **magnitude** ('size' or 'amount') of the pressure? This can be qualitative if there is no further information available.
- What is the **extent** of the pressure? The worst case scenario in relation to receptors will be available in the database; however, this could be refined depending on what further information is available on the activity and/or receptor.
- What is the expected **duration** of the pressure?
- Is the pressure **reversible** i.e. temporary vs. permanent?
- Is the **timing** of the pressure a factor in how it will affect the receptor i.e. at a critical life cycle stage?
- Is the **frequency** of an activity (and therefore the pressure it exerts) a factor. For example, a single dog-walker may not cause disturbance to coastal birds, however numerous dog-walkers which cause frequent disturbance over the course of a given period will result in increased potential for effect.
- The above should be supported by an evaluation of the **level of confidence** in those predictions.

An alternative approach which could be used is presented by Robinson and Knights (2011), who discuss a pressures assessment based on the output of the ODEMM project. This assessment seeks to weight pressures in order to assess the actual threat associated with an activity-pressure on any receptor. Key steps when using this method to outline assumptions are:

- The total **extent** of the pressure

- The **frequency of occurrence** of the pressure where there is overlap with a receptor in an average year
- The generic **degree of impact** of pressure on the receptor
- The generic **resilience** of the receptor within the region being assessed based on its current status
- The **persistence** of the pressure i.e., the length of time that the pressure continues to occur after cessation of the activity causing it.

Further details on how to assign weighting to each of these categories are provided in Robinson and Knights (2011).

6. Conclusions and recommendations

Objective 1 of this project required the collation of current evidence relating to potential high level drivers, pressures and pathways on receptors, resulting from marine activity. The high level nature of the work at this stage has meant that there is potential for expansion and adaptation of the database as new evidence and knowledge of interactions within the marine environment becomes available. The current status of the evidence database includes activity-pressure links for all the activities as identified in ODEMM, however further work is required to review these links against additional evidence.

There is a significant amount of on-going work to more clearly and comprehensively establish links between activities and pressures. For example, in 2013 JNCC undertook a review of the five most significant pressure/activity matrices (Tyler-Walters *et al*., 2003; Tillin *et al*., 2010; Koss *et al*., 2011; ABPmer, 2012; FEAST, 2013) and produced a combined matrix. This was presented to both HBDSEG and the UKMMAS. Once the evidence base supporting the activity-pressure links identified within this matrix is fully developed, this could also be incorporated and used to support pressure-activity links underpinning the framework developed in this project.

Objective 2 was to develop a series of potential options for the management of CEA to provide MMO with a tool kit of possibilities. The discrete options that were initially developed have become a process outlining approaches to the management of cumulative effects and their mitigation. A decision tree for these approaches is supported by guidance text for each option, providing more information on their application in different scenarios and when they might best be applied.

Objective 3 involves the creation of summary tables, using the evidence database to produce an overview of potential for cumulative effects within and between activities. The evidence database provides multiple individual tables linking activities to pressures and receptors to pressures. It is possible to use the database to produce a number of summary matrices which highlight activities with the potential to exert common pressures on a receptor, i.e. activities that may cause cumulative effects.

Objective 4 was to devise a framework to provide MMO staff with a methodology for scoping of cumulative effects at a high level. This may include considering CEA as part of a marine licence application or looking at potential future scenarios for management of activities through marine plan policies. A consistent, flexible framework has been developed, through consultation with MMO staff, to ensure high level requirements of each function can be met by the framework. The framework allows scoping of potential cumulative effects at a high level, by identifying the common pressures between a set of activities with potential to cause an effect on a specific receptor or group of receptors.

6.1 Evidence Gaps

Evidence gaps in environmental cumulative effects have been identified throughout development of the evidence database and framework. These are set out clearly at

the activity-specific level within the evidence database, where there is a low level of confidence in the evidence supporting the link between activity-pressures and receptor pressure linkages. Annex 8 outlines environmental evidence gaps in detail. In brief, evidence gaps relating to environmental pressure types, which have been highlighted include:

- Physical loss and physical damage pressures:
  - These were understood for the majority of the activities, however there was difficulty in identifying which activity could have the greater influence on receptors affected if multiple were present in the same area. This could potentially impact the management of cumulative effects, making the process more challenging.
- Litter:
  - This was reported to be produced by a number of marine activities in literature. However, it was often difficult to identify the source of litter, and evidence was usually not accompanied by quantification.
- Pollution pressures:
  - These were identified for a number of activities, especially in the case of synthetic compounds, transition elements and organo-metal contamination. However, quantification was often not available and literature raised some concerns on the lack of information on interaction of pollutants arising from different activities.
- Underwater noise:
  - The implications of its effects on sensitive receptors, particularly related to behavioural effects, were identified as poorly understood.
- Genetic modification and translocation of indigenous species:
  - This pressure was found to be poorly understood at a wider biodiversity level.
- Visual disturbance:
  - This was also linked to various activities, however, its quantification was extremely difficult, and it should be identified on a case-by-case basis.

A number of social and economic evidence gaps have been highlighted through MMO (2014a). Further work will be required before consideration of socio-economic impacts in CEA can be undertaken.

6.2 Recommendations

The aim of this framework, the supporting evidence database and summary tables is to outline guidance that could assist MMO in ensuring a consistent approach to CEA at a high level.

CEA can be difficult to implement in practice, particularly in the marine environment, where there are issues surrounding the availability of baseline data. This framework is intended as a first step in scoping potential cumulative effects; however there is potential to update and redefine the framework in the future as new evidence and/or guidance becomes available. There is also potential to increase the level of detail within the internal guidance/guiding tools.

This project provides a suggested framework for MMO to use in scoping cumulative effects. Alongside this, a number of recommendations for how the information within this report might be used and potentially expanded in the future to better fulfil MMO requirements are provided below.

6.3.1 Evidence requirements

1. In the short term, there is a need to review the remaining activity-pressure links against additional evidence, which is required to provide a level of confidence in the link. It is recommended to continue with the list of activities, elaborating on detail as desired, following the same methodology to ensure consistency. Annex 9 outlines the current status of information within the database.

2. In the longer term, the evidence database might be expanded to incorporate information on the likely spatio-temporal scale of activity-pressures and pressures-receptor. This should include further review of available data and literature on the spatial and temporal scale of each pressure (as linked to each activity or receptor), to provide an evaluation of the 'worst case scenario' extent of each pressure. This will enable more accurate and consistent approach to defining the study area during the scoping exercise. This could potentially be accompanied by a qualitative explanation of how the spatio-temporal scale of activity-pressures or pressures-receptor differs in different situations.

3. Receptor categories are currently very high level and as more evidence becomes available it is recommended the groups are refined and links to pressures re-established, to make the scoping exercise more meaningful. UKMMAS (2010) suggests further refined categories linked to pressures, which could be used to improve the evidence database. However, at this time there may not be sufficient evidence available to support receptor-pressure linkages at such a detailed level.

4. Recommendations 2 and 3 are highly dependent on available evidence, and it is therefore vital that MMO is aware of the progress of projects such as ODEMM, JNCC (on activities-pressures) and CEFAS (pressure layers). Similarly, it is also a responsibility of funders and researchers to ensure that the work undertaken is of practical use for regulators. It is, therefore, important to ensure these researchers have an understanding of the evidence requirements of MMO and legislative requirements of regulators.

5. It is recommended that the database is updated as and when new evidence becomes available to ensure the framework is underpinned by robust evidence. Future work on activity-pressure-receptor interactions in the marine environment should be closely followed and drawn on to enhance the supporting evidence and framework. The framework should also be reviewed on a regular basis in order to ensure that the most up to date information is being utilised and continues to be appropriate for MMO's needs. Gaps in environmental evidence relating to this work were highlighted in Section 6.1.

6. Further consideration should be given to the social and economic pressures and effects and how these could be incorporated into the evidence database in the most appropriate way. Progress should be based on final outputs of the MMO report on “Social impacts and interactions between marine sectors” (MMO, 2014a) as well as previous reports such as MMO (2013b, 2013c, 2014b). This may require collection of additional evidence to support integration.

6.3.2 Framework requirements and recommendations:

7. In the short term, it is recommended that MMO review and considers implementation of the framework to support the planning, licensing, and conservation and enforcement functions. Training should be provided in order to ensure that all users are confident in working through the steps in the process and it is used in a consistent way.

8. In the longer term, consideration could be given to the update of the evidence database and framework to incorporate the differences between types of cumulative effects, such as indirect effects and interactions between effects. The evidence within the database could be used to highlight where there might be interactions between overlapping pressures on the same sensitive receptor, which may have potential to cause a cumulative effect.

9. It is recommended that further testing of the use of the different approaches to considering management of cumulative effects and mitigation be carried out in consultation with stakeholders as appropriate. In addition, it is recommended consultation is undertaken on how to refine approaches which may require input from marine industries and sea users. This is particularly relevant for marine planning. Collation and evaluation of case studies where these approaches have been used previously would help to strengthen the methodologies and develop best practice.

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Conservation Committee from the Marine Life Information Network (MarLIN). Plymouth: Marine Biological Association of the UK. [Contract no. F90-01- 639].

UKMMAS (2010). Charting Progress 2 Feeder Report Productive Seas. Department for Environment Food and Rural Affairs on behalf of UKMMAS (Eds. Saunders, J. and McKie, J.) 472pp Annex 4: Project Development.

Annex 1: Database reference list

Table A1.1: References used to populate evidence database.

Database code	Short reference	Full reference
A1	TCE, 2012	Aldridge, J., van de Molen, J. and Forster, R. (2012). 'Wider ecological implications of Macroalgae cultivation' The Crown Estate, 95 pages. ISBN: 978-1-906410-38-4.
A2	OSPAR, 2009	McCormack, E. and Roche, C. (2009). Assessment of impacts of mariculture. OSPAR Commission 442.
A3	FAO, 1991	Phillips M.J. (1991) Environmental Aspects of Seaweed Culture, FAO Technical resource Paper.
A4	Forrest, 2007	Forrest, B., Keely, N., Gillespie, P., Hopkins, G., Knight, B., Govier, D. (2007). Review of the ecological effects of marine finfish aquaculture. Final report. Prepared for Ministry of Fisheries. Cawthron Report No. 1285. 71p.
A5	Tett & Edwards, 2002	Tett, P. and Edwards, V. (2002). Review of harmful algal blooms in Scottish coastal waters. Report to SEPA. School of Life Sciences, Napier University. Edinburgh, 120p.
A6	National Oceans Office, 2001	National Oceans Office (2001). Impact of aquaculture. South-east Regional Marine Plan. Department of the Environment, Australian Government.
A7	Goldburg *et al*., 2001	Goldburg, R.J., Elliot, M.S., Naylor, R.L. (2001). Marine aquaculture in the United States: Environmental Impacts and Policy Options. Arlington, Virginia: Pew Oceans Commission, 2001.
A8	Sievanen *et al*., 2005	Sievanen, L., Crawford, B., Pollnac, R., Lowe, C. (2005). Weeding through assumptions of livelihood approaches in ICM: Seaweed farming in the Philippines and Indonesia. Ocean and Coastal Management 48, 297-313.
A9	Burg *et al*., 2012	Van den Burg, S., Stuiver, M., Veenstra, F., Bikker, P., Lopez Contreras, A., Palstra, A., Broeze, J., Jansen, H., Jak, R., Gerritsen, A., Harmsen, P., Kals, J., Blanco, A., Brandenburg, W., Van Krimpen, M., Van Duijn, A.P., Mulder, W., Van Raamsdonk, L. (2012). A triple P review of the feasibility of sustainable offshore seaweed production in the North Sea. Wageningen, Wageningen UR (University & Research Centre), LEI Report 13-077.
CCS1	IPCC, 2005	IPCC. (2005). Carbon Dioxide Capture and Storage. Metz, B., Davidson, O., De Coninck, H., Loos, M., Meyer, L. (Eds.). Cambridge University Press, UK. pp431.

Database code	Short reference	Full reference
CCS2	Turley *et al*., 2004	Turley, C., Nightingale, P., Riley, N., Widdicombe, S., Joint, I., Gallienne, C., Lowe, D., Goldson, L., Beaumont, N., Mariotte, P., Groom, S., Smerdon, G., Rees, A., Blackford, J., Owens, N., West, J., Land, P., Woodason, E. (2004). Literature review: Environmental impacts of a gradual or catastrophic release of CO_2 into the marine environment following carbon dioxide capture. Final report to Defra.
CCS3	Environment Agency, 2002	Environment Agency (2002). Scoping the environmental impacts of Carbon Capture, Transport and Storage.
CCS4	de Vries *et al*., 2013	de Vries, O., Tamis, J.E., Foekema, E.M., Klok, C., Murk, A.J. (2013). Towards quantitative ecological risk assessment of elevated carbon dioxide levels in the marine environment. Marine Pollution Bulletin 73, 516-523.
CCS5	Blackford *et al*., 2013	Blackford, J.C., Torres, R., Cazanave, P., Aritoli, Y. (2013). Modelling dispersion of CO_2 plumes in sea water as an aid to monitoring and understanding ecological impact. Energy Procedia 37, 3379-3386.
CCS6	OSPAR, 2012	OSPAR (2012) Specific guidelines for the assessment of carbon dioxide for disposal into sub-seabed geological formations. OSPAR Convention.
CM1	DUAP, 1996	Department of Urban Affairs and Planning (1996). EIS Guideline. Marinas and related facilities. Pubs No 96/50.
CP2	CP2, 2010	United Kingdom Marine Monitoring and Assessment Strategy (UKMMAS) (2010). Charting Progress 2 Feeder Report Productive Seas. Department for Environment Food and Rural Affairs on behalf of UKMMAS (Eds. Saunders, J. and McKie, J.) 472pp.
D1	Tillin *et al*., 2011	Tillin, H. M., Houghton, A. J., Saunders, J. E. & Hull, S. C. (2011). Direct and Indirect Impacts of Marine Aggregate Dredging. Marine ALSF Science Monograph Series No. 1. MEPF 10/P144. (Edited by R. C. Newell & J. Measures). 41pp.
D2	PDE & Hill, 2001	Posford Duvivier Environment & Hill, M.I. (2001). Guidelines on the impact of aggregate extraction on European Marine Sites. Countryside Council for Wales (UK Marine SACs Project.
D3	Royal Haskoning, 2005	Royal Haskoning (2005). Marine Aggregate Environmental Impact Assessment: Approaching Good Practice. Posford Haskoning SAMP 1.031.
D4	Lauwaert *et al*., 2011	Lauwaert, B., Delgado, R., Derweduwen, K., Devriese, L., Fettweis, M., Hostens, K., Janssens, J., Martens, C., Robbens, J., Timmermans, S., VanHoey, G., Verwaest, T. (2011). Synthesis report on the effects of dredged material disposal on the marine environment (licensing period 2010-2011). VLIZ.

Database code	Short reference	Full reference
D5	OSPAR, 2009	OSPAR Commission (2009). Assessment of the environmental impact of dredging for navigational purposes. ISBN 1-904426-50-6.
D6	TCE, 2013	The Crown Estate (2013). Marine aggregate dredging and the coastline: a guidance note. Best practice guidance for assessment, evaluation and monitoring of the possible effects of marine aggregate extraction on the coast - a Coastal Impact Study.
F1	NOAA, 2003	Dieter, B.E., Wion, D.A., McConnaughey. (2003). Mobile fishing gear effects on benthic habitats: a bibliography (second edition). U.S. Dep. Commer., NOAA Tech Memo. NMFS-AFSC-135, 206 p.
F2	Norse, 1999	Norse, E.A. (1999). Impacts of mobile fishing gear: the biodiversity perspective. American Fisheries Society Symposium 22, 31-40.
F3	Gerritsen *et al*., 2013	Gerritsen, H.D., Minto, C., Lordan, C. (2013). How much of the seabed is impacted by mobile fishing gear? Absolute estimates from Vessel Monitoring System Point data. ICES Journal of Marine Science: 70(3), 523-531.
F4	UKMSAC, 1999	Gubbay, S., Knapman, P.A. (1999). A review of the effects of fishing within UK European marine sites. English Nature (UK Marine SACs Project). 134 pages.
F5	Lokkeborg, 2005	Lokkeborg, S. 2005. Impact of trawling and scallop dredging on benthic habitats and communities. FAO Fisheries Technical Paper 472. Food and Agriculture Organization of the United Nations. Rome.
G1	GOC, 2013	Global Ocean Commission (2013). Bioprospecting and marine genetic resources in the high seas. A series of papers on policy options, prepared for the third meeting of the Global Ocean Commission, 4.
H1	Kelly *et al*., 2001	Kelly, L., Collier, L., Costello, M.J., Diver, M., McGarvey, S., Morrissey, J., Guiry, M.D. (2001). Impact Assessment of Hand and Mechanical Harvesting of *Ascophyllum nodosum* on Regeneration and Biodiversity. Marine Resource Series No. 19.
JNCC	JNCC, Draft	JNCC (draft). Progress towards the development of a standardised UK pressure-activities matrix. Briefing paper to UKMMAS evidence groups. Presented 10/10/2013.
M1	JNCC & NE, 2011	JNCC,NE (2011). General advice on assessing potential impacts of and mitigation for human activities on MCZ features, using existing regulation and legislation. Advice from the Joint Nature Conservation Committee and Natural England to the Regional MCZ Projects. June 2011. 107pp.
M2	Eastwood *et al*., 2007	Eastwood, P.D., Mills, C.M., Aldridge, J.N., Houghton, C.A., Rogers, S.I. (2007). Human activities in UK offshore waters: an assessment of direct, physical pressure on the seabed. ICES Journal of Marine Science, 64, 453-463.
M3	Parsons *et*	Parsons, E.C.M., Birks, I., Evans, P.G.H., Gordon, J.C.D., Shrimpton, J.H., Pooley, S. (2000). The

Database code	Short reference	Full reference
	al., 2000	possible impacts of military activity on cetaceans in west Scotland. European Research on Cetaceans 14, 185-191.
M4	DeMarco *et al*., 1996	DeMarco, R.A. and Quinn, J.P. (1996). The impact of War and Military Operations other than war on the Marine Environment: Policy Making on the Frontiers of Knowledge. Grunawalt, R.J., King, J.E. and McClain, R.S. (Eds) International Law Studies - Volume 69 Protection of the Environment During Armed Conflict (pp 87-98).
M5	Active Army, 2001	United States Marine Corps (2001). Environmental considerations in military operations. Field Manual No 3-100.4
MP1	EN, 2006	Gubbay, S. (2006). Marine Protected Areas. A review of their use for delivering marine biodiversity benefits. English Nature Research Reports 688.
MP2	Agardy *et al*., 2011	Agardy, T., Notarbartolo di Sciara, G., Christie, P. (2011). Mind the gap: Addressing the shortcomings of marine protected areas through large scale marine spatial planning. Marine Policy 35, 266-232.
MP3	Halpern, 2003	Halpern. B.S. (2003). The impact of marine reserves: do reserves work and does reserve size matter? Ecological Applications, 13 (1) Supplement, S117-S137.
MP4	OSPAR, 2009	Jackson, L.F., Buceta Miller, J.L. (2009). Assessment of construction or placement of artificial reefs. OSPAR Commission 438.
MP5	NOAA, 2007	National Oceanic and Atmospheric Administration (2007). National Artificial Reef Plan (as Amended). Guidelines for Siting, Construction, Development and Assessment of Artificial Reefs. United States Department of Commerce. National Oceanic and Atmospheric Administration.
MP6	London Convention, 2009	London Convention and Protocol/UNEP (2009). London Convention and Protocol/UNEP Guidelines for the Placement of Artificial Reefs. London, UK, 100pp.
ODEMM	ODEMM	Koss, R.S., Knights, A.M., Eriksson, A., Robinson, L.A. (2011). Options for Delivering Ecosystem-Based Marine Management. Linkage tables.
OW1	OSPAR, 2006	OSPAR Commission (2006). Review of the current state of knowledge on the environmental impacts of the location, operation and removal/disposal of offshore wind-farms. Status report. Biodiversity series. ISBN 1-905859.
OW2	Zucco *et al*., 2006	Zucco, C., Wende, W., Merck, T., Köchling, I., Köppel, J. (2006). Ecological Research on Offshore Wind Farms: International Exchange of Experiences. PART B: Literature Review of Ecological Impacts (eds.).

Database code	Short reference	Full reference
OW3	MMO, 2013	MMO (2013). Evaluation of the current state of knowledge on potential cumulative effects from offshore wind farms (OWF) to inform marine planning and marine licensing. A report produced for the Marine Management Organisation, pp 71. MMO Project No: 1009. ISBN: 978-1-909452-07-7.
OW4	BWEA, 2001	English Nature, RSPB, WWF-UK,BWEA. (2001). Wind farm development and nature conservation. A guidance document for nature conservation organisations and developers when consulting over wind farm proposals in England. British Wind Energy Association, London.
OW5	Defra, 2005	Defra (2005). Nature Conservation Guidance on Offshore Windfarm Development. A guidance note on the implication of the EC Wild Birds and Habitats Directives for developers undertaking offshore windfarm developments.
OW6	DEA *et al*., 2013	Danish Energy Agency (2013). Danish Offshore Wind. Key Environmental Issues. A follow up. The Environmental Group: The Danish Energy Agency, The Danish Nature Agency, DONG Energy and Vattenfall.
OW7	Hiscock *et al*., 2002	Hiscock, K., Tyler-Walters, H. and Jones, H. (2002). High Level Environmental Screening Study for Offshore Wind Farm Developments. Marine Habitats and Species Project. Report from the Marine Biological Association to The Department of Trade and Industry New & Renewable Energy Programme. (AEA Technology, Environment Contract: W/35/00632/00/00.).
OW8	Lindeboom *et al*., 2011	Lindeboom, H.J., Kouwenhoven, H.J., Bergman, M.J.N., Bouma, S., Brasseur, S., Daan, R., Fijn, R.C., de Haan, D., Dirksen, S., van Hal, R., Lambers, R.H.R., der Hofstede, R, Krijgsveld, R.L., Leopold, M., Scheidat, M. (2011). Short-term ecological effects of an offshore wind farm in the Dutch coastal zone. A compilation. Environmental Research Letters 6, 13pp.
OW9	Nedwell and Howell, 2004	Nedwell, J. and Howell, D. (2004). A review of offshore wind farm related underwater noise sources. Report No. 544 R 0308. A report commissioned by COWRIE, Oct 2004.
R1	OSPAR, 2008. Recreation	OSPAR Commission. (2008). Assessment of impacts of tourism and recreational activities. OSPAR Commission 369.
R2	UK CEED, 2000	UK CEED (2000). A review of the effects of recreational interactions within UK European marine sites. Countryside Council for Wales (UK Marine SACs Project) pp 264.
R3	Davenport & Davenport, 2006	Davenport, J. & Davenport, J. (2006). The impact of tourism and personal leisure transport on coastal environments: A review. Estuarine, coastal and shelf science 67, 280-292. DOI: 10.1016/j.ecss.2005.11.026.

Database code	Short reference	Full reference
R4	Pickering *et al*., 2010	Pickering, C.M., Hill, W., Newsome, D., Leung, Y. (2010). Comparing hiking, mountain biking and horse riding impacts on vegetation and soils in Australia and the United States of America. Journal of Environmental Management 91, 551-562.
Sub1	OSPAR, 2012	OSPAR Commission (2012). Guidelines on Best Environmental Practice (BEP) in Cable Laying and Operation. OSPAR 12/22/1, Annex 14.
Sub2	OSPAR, 2009	Merck, T., Wasserthal, R. (2009). Assessment of the environmental impacts of cables. OSPAR Commission 437.
Sub3	UNEP, 2009	Carter, L., Burnett, D., Drew, S., Marle, G., Hagadorn, L., Barlett-McNeil, D., Irvine, N. (2009). Submarine Cables and the Oceans- Connecting the world. UNEP-WCMC Biodiversity Series No. 31. ICPC/UNEP/UNEP-WCMC.
Sub4	Vattenfall, 2010	Olsson, T., Larsson, A., Bergsten, P., Nissen, J. (2010). Impact of electric and magnetic fields from submarine cables on marine organisms. Report for Vattenfall Ocean Energy Programme 3080100.
Sub5	OCS, 2011	Normandeau, Exponent, Tricas, T., Gill, A. (2011). Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement, Pacific OCS Region, Camarillo, C.A. OCS Study BOEMRE 2011-09.
T1	NPS Ports, 2012	Department of Transport (2012). National Policy Statement for Ports.
T2	OSPAR Shipping, 2009	OSPAR Commission (2009). Assessment of the impacts of shipping on the marine environment.
T3	Paipai, 1999	Paipai, E. (1999). Guidelines for port environmental management. HR Wallingford Report SR 554.
T4	ABP, 1999	ABP Research (1999). Good practice guidelines for ports and harbours operating within or near UK European marine sites. English Nature, UK Marine SACs Project, pp 120.
Tid1	NOAA, 2011	Polagye, B., B. Van Cleve, A. Copping, K. Kirkendall (editors) (2011). Environmental effects of tidal energy development. U.S. Dept. Commerce, NOAA Tech. Memo. F/SPO-116, 181 p.
Tid2	DTI, 2002	Department of Trade and Industry. (2002). A scoping study for an environmental impact field programme in tidal current energy. DTI Pub/URN 02/882.
Tid3	Wolf *et al*., 2009	Wolf, J., Walkington, I.A., Holt, J., Burrows, R. (2009). Environmental impacts of tidal power schemes. P Civil Eng, 162, pp. 165–177.

Database code	Short reference	Full reference
Tid4	DECC, 2010	DECC (2010). Severn Tidal Power. Feasibility study conclusions and summary report. URN 10D/808.
Tid5	Swansea Bay, 2012	Tidal Lagoon (Swansea Bay) Ltd. (2012). Proposed Tidal Lagoon Development in Swansea Bay, South Wales. Environmental Impact Assessment Scoping Report.
W1	TCE, 2014	Aquatera Ltd. (2014). Consolidation of wave and tidal EIA/HRA issues and research priorities. Technical report to The Crown Estate.
W2	Michel *et al*., 2007	Michel, J., Dunagan, H., Boring, C., Healy, E., Evans, W., Dean, J.M., McGillis, A., Hain, J. (2007). World Wide synthesis and analysis of existing information regarding environmental effects of alternative energy uses on the outer continental shelf. Herndon, VA: U. S. Department of the Interior, Minerals Management Service.
W3	Hagerman *et al*., 2004	Hagerman, G. (2004). Offshore Wave Power in the US: Environmental Issues. EPRI report E2I Global EPRI-007-US.
W4	NOAA, 2008	Boehlert, G.W., G.R.McMurray, C.E. Tortorici (editors) (2008). Ecological effects of wave energy in the Pacific Northwest. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-92, 174 p.
W5	ABPmer, 2005	ABPmer (2005). Potential Nature Conservation and Landscape Impacts of Marine Renewable Energy Developments in Welsh Territorial Waters. CCW Policy Research Report Series No. 04/8.
W6	ABPmer, 2006	ABPmer (2006). The potential nature conservation impacts of wave and tidal energy extraction by marine renewable developments. CCW Policy Research Report No 06-7.

Annex 2: Activity, and Environmental Pressure and Receptor Descriptions

Table A3.1: Activity descriptions. This table includes relation between activities adapted from the JNCC draft activity list used within the database and the activities considered under the UK Marine Policy Statement. References provide literary sources of activity descriptions.

UK Marine Policy Statement Activities	Activity (adapted from JNCC activity list)	Description	Reference
Aquaculture	Aquaculture - Finfish	Aquaculture is the farming of aquatic organisms, including fin-fish. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding and protection from predators. In finfish aquaculture, larvae or 'fry' are produced in hatcheries by controlled reproduction. Following hatching, fry are conditioned to take artificial feed in tanks before they are transferred to grow-out facilities at sea (e.g. cages and pens). Cages can be either inshore or offshore and either floating, fixed or submerged.	Goldburg *et al*., 2001; McCormack and Roche, 2009
	Aquaculture - Shellfish	Aquaculture is the farming of aquatic organisms, including shellfish (molluscs and crustaceans). The principle species cultivated are mussels, oysters, scallops and clams. There are a variety of methods used for shellfish mariculture. Larvae or spat (seed) are collected from areas of natural settlement using purpose-built structures or collected from the intertidal zone. Alternatively, seed is produced by artificial fertilization in hatcheries. Shellfish seed are on-grown in a number of ways depending on the species, and include: suspended culture, vertical or rack culture and bottom culture.	McCormack and Roche, 2009
	Aquaculture - Macro-algae	Aquaculture is the farming of aquatic organisms, including aquatic plants and algae. Macro-algae (seaweeds) can be either cultured as a single species (monoculture), together with bivalves (co-culture), or be part of an integrated production system with fin-fish as the principal components (Integrated multitrophic aquaculture). There are different methods, and each of them will	Phillips, 1991; Forrest *et al*., 2007

UK Marine Policy Statement Activities	Activity (adapted from JNCC activity list)	Description	Reference
		interact with the environment in different ways, depending on the surface area (and three dimensional volume) of the farm, and the site where the farm is located.	
Fisheries	Fishing - mobile gears	Fishing activity includes commercial, recreational, and subsistence fisheries. However, the majority of information reviewed relates to commercial fisheries. In this category, mobile gear includes bottom trawls and dredges towed along the seafloor.	Galbraith and Rice, 2004.
	Fishing - static gears	Fishing activity includes commercial, recreational and subsistence fisheries. However, the majority of information reviewed relates to commercial fisheries. Static or fixed gears are mainly used to target demersal fish species and shellfish (e.g. lobster, crabs, whelks). They may consist of vertically hung curtains of netting which enmesh or entangle the fish, and are fixed to the seabed with anchors or weights and held upright with a float (fixed nets), baited traps (e.g. potting), or long lines with baited hooks (long-lining).	Galbraith and Rice, 2004.
	Harvesting - seaweed and other sea-based food	Harvesting activity includes the extraction of seaweed and other sea-based food such as shellfish from marine and coastal habitats. Harvesting seasons may be designated in order to restrict the activity and reduce the impact on marine biota. There are different techniques utilised for harvesting, including mechanical (e.g. pump) and non-mechanical methods (e.g. hand harvesting).	Kelly *et al*., 2001
	Extraction of genetic resources	'Extraction of marine genetic resources' encompasses the activities of bio-prospecting, which requires the collection of a limited amount of biomass for initial discovery, and collection of individuals (with potential return).	Global Ocean Commission, 2013
Ports and shipping	Shipping - port operations	'Port operations' encompass different activities, ranging from cargo loading and discharging, industrial services in port, combining and separating cargoes, shrink and wrapping, labelling, weighting or repackaging, and moving, berthing and unberthing of ships and other marine craft within the limits and approaches of a harbour authority. Environmental pressures resulting from these will therefore depend on the commercial/recreational	Department for Transport, 2013

UK Marine Policy Statement Activities	Activity (adapted from JNCC activity list)	Description	Reference
		activities taking place. Construction of ports is considered under "Coastal docks, ports & marinas", and maintenance of the port is considered in "Navigational dredging".	
	Shipping - general activities	General activities surrounding the operation of vessels include the discharge of ships' ballast water, litter, noise and light production as a result of ships activity.	OSPAR Commission, 2009
	Coastal docks, ports & marinas	This activity includes the construction and maintenance of coastal docks, ports and marinas (although potential dredging operations related should be considered under 'Extraction - navigational dredging). Coastal docks, ports & marinas refer to shoreline facilities as well as land-based facilities for the boats and the users. The facilities may include berthing, mooring and docking (such as jetties, wharves, pontoons, moorings, wet berths, ramps, holing piles), boat maintenance, repair and construction facilities and services such as refuelling, waste collection, treatment or disposal activities. Note that commercial storage facilities and cargo handling are considered under 'Shipping - port operations'.	Department of Urban Affairs and Planning (New South Wales), 1996
Energy production and infrastructure development	Renewable energy - wind - construction	Wind energy construction activities involve the introduction of foundation structures and installation of towers and scour protection upon the seabed, which require the operation of large vessels for transportation, construction vessels on site (including transport, jack-up and drilling barges), site preparation and foundation installation. Cable installation will be considered separately under ''submarine cable and pipeline operations''.	OSPAR Commission, 2006
	Renewable energy - wind - operation	Environmental pressures associated with offshore wind operation are predominantly derived from the physical presence of the turbine towers both in the sediment and the water column. Operation of power cables is not considered under this category but included under ''submarine cable and pipeline operations''.	OSPAR Commission, 2006
	Renewable energy	Existing offshore wind farms have an operational design life of about 20	OSPAR

UK Marine Policy Statement Activities	Activity (adapted from JNCC activity list)	Description	Reference
	- wind - decommissioning	years. Decommissioning will require the removal of the respective components which constitute the offshore development. This will include the removal of: foundation structures, towers, turbines, blades, offshore substation structures, inter-array cables between the turbines and the export cable to shore.	Commission, 2006
	Renewable energy - wave - construction	Wave energy devices convert kinetic wave energy to electricity. Several technologies are in developmental stages, including three wave energy converter designs: 'floating', 'oscillating water column' and 'overtopping'. Most of these consist of floating structures that are held in position by anchors and floats. Cable installation will be separately considered under ‘’submarine cable and pipeline operations’’.	ABPmer, 2006
	Renewable energy - wave - operation	To date, there are no full-scale wave energy projects operational in the UK marine environment. There are three wave energy converter designs being developed: floating, oscillating water column and overtopping (see wave-construction for further details). Potential impacts associated with the operation phase are similar for each of these.	ABPmer, 2006
	Renewable energy - wave - decommissioning	Decommissioning of wave energy devices includes the detachment of fixed structures on the sea floor and the gradual removal of floating platforms in stages (e.g. if there is evidence of use as haul-out space by seals and sea lions or colonization by seabirds).	ABPmer, 2006
	Renewable energy - tidal stream - construction	Tidal stream energy uses the energy of moving masses of water, mainly produced by tides, to push turbine blades and transfer kinetic energy. Construction activities involve the use of vessels for in-situ construction and the introduction of artificial structures on the seabed with the use of varying machinery. It therefore implies: the physical presence of installation equipment, piling of foundations (if required) and the grouting/cementing of material during installation. Cable installation will be separately considered under ‘’submarine cable and pipeline operations’’.	ABPmer, 2006

UK Marine Policy Statement Activities	Activity (adapted from JNCC activity list)	Description	Reference
	Renewable energy - tidal stream - operation	Operation of a tidal stream device includes movement of the turbine blades in the tidal current and the conversion of mechanical energy into electricity for transmission to shore.	ABPmer, 2006
	Renewable energy - tidal stream - decommissioning	Decommissioning of tidal stream energy devices includes the physical removal of the piles, towers, nacelles, blades and other infrastructure. This involves the presence of decommissioning vessels.	ABPmer, 2006
	Renewable energy - tidal range - construction	Tidal range is a form of potential energy associated mostly with established low head hydro technologies such as barrages and lagoons. Construction of a tidal barrage would be similar to the construction of a dam or causeway, and would require: clearing and grading, construction of the dam to hold water in the basin, construction of the intake system and construction of associated infrastructure in land. Cable installation will be separately considered under ‘’submarine cable and pipeline operations’’.	ABPmer, 2006
	Renewable energy - tidal range - operation	Operation and maintenance of a tidal barrage would be similar to that required for a low-head hydroelectric dam.	ABPmer, 2006
	Renewable energy - tidal range - decommissioning	Decommissioning of tidal range energy devices includes the detachment of fixed structures on the sea floor and the gradual removal of parts.	ABPmer, 2006
	Marine hydrocarbon extraction - operation	Marine hydrocarbon extraction refers to the harvesting of oil and gas from an identified reservoir (which requires a previous exploratory phase) through formation pressure, artificial lift, and possibly advanced recovery techniques until economically feasible reserves are depleted. This involves offshore drilling, which can use self-contained mobile offshore drilling units (MODUs) . If the exploratory drilling has discovered commercial quantities, a wellhead valve assembly may be installed.	E&P Forum and UNEP, 1997
	Marine hydrocarbon	Decommissioning of a marine hydrocarbon extraction site involves the sealing of open rock formations with cement plugs to prevent upward migration of	E&P Forum and UNEP,

UK Marine Policy Statement Activities	Activity (adapted from JNCC activity list)	Description	Reference
	extraction - decommissioning	wellbore fluids. The casing wellhead and the top joint of the casings are usually cut below the ground level and capped with a cement plug.	1997
	Gas storage operations - exploration	Carbon dioxide capture and storage is a process consisting of the separation of CO_2 from industrial and energy-related sources, the transportation of the CO_2 to a storage location, and the consequential long-term isolation of the CO_2 from the atmosphere. Exploration activities include those developed for site selection and performance prediction, which are crucial for successful geological storage. Techniques developed for the exploration of oil and gas reservoirs, natural gas storage sites, and liquid waste disposal sites, are suitable for characterising geological storage sites for CO_2. Examples include seismic imaging, pumping tests and cement integrity logs.	IPCC, 2005
	Gas storage operations - construction	Gas storage construction activities are those involved in the construction of carbon dioxide tankers, which use a storage technology and mechanisms similar to those applied in the oil and gas exploration and production industry (well drilling, injection, monitoring methods, etc.). Construction activities also include the introduction of CO_2 pipelines, both onshore and underwater; however these are considered under 'Submarine cable and pipeline operations'.	IPCC, 2005
	Gas storage operations - operation	Gas storage operation activities include liquid CO_2 loading and unloading (at the destination site), which requires pipeline operation, monitoring and maintenance. Transportation activities, which involve temporal storage on land and a loading facility, and ship transportation (if considering ocean storage). The CO_2 tanker will return to port in ballast and dry-docking.	Environment Agency, 2002; IPCC, 2005
Energy production & infrastructure development/ Telecommunic	Submarine cable and pipeline operations	Submarine cable and pipeline operations include operational submarine cables utilised for telecommunications and electricity transportation, and operational submarine pipelines which are used for the transportation of materials within UK waters and from overseas, including hydrocarbons or gas. Telecommunication cables are fibre optic cables that use pulses of light to	Merck and Wasserthal, 2009

UK Marine Policy Statement Activities	Activity (adapted from JNCC activity list)	Description	Reference
ations cabling		transport information, whilst power cables are deployed to transport electrical energy and may have a capacity of several hundred megawatts (MW). Submarine cables and pipelines can be buried to minimise the risk of damage by other activities, or covered with mechanical protection (e.g. rock armour).	
Marine Protected Areas	Conservation and environmental protection - MPA	Marine Protected Areas (MPAs) have been defined by the International Union for the Conservation of Nature as “any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment”. There are many different types of MPAs with the management arrangements ranging from multiple-use to strict protection within “no-take zones” or “Highly Protected Marine Reserves”. Conservation and environmental protection activities in this context refer to the designation of marine protected areas.	WWF, 2005
	Conservation and environmental protection - artificial reefs	This activity category includes the introduction of artificial reefs in the marine environment, which provide an enhanced hard bottom habitat to areas that may or may not be limited in habitat. They provide space that is quickly colonised by sessile organisms and new food sources and provide protection for juveniles and potential spawning areas. Artificial reefs can be designated as marine protected areas (either for a certain stock or for protection against all consumptive uses). They may also be used to mitigate the destruction or degradation of various marine habitats due to coastal development or catastrophic loss. In addition, they may provide enhanced opportunities for other marine activities (e.g. recreation, fishing).	NOAA, 2007
N/A	Cultural and heritage sites	Cultural and heritage sites comprise elements of the historic environment (e.g. wrecks, sculptures, foundations, landscapes, etc.) which result from a range of historical human activities and are alien to the natural environment. However, at the same time, cultural and heritage sites may exert environmental pressures related to their nature and introduction to the marine	Defra, 2011; Ramirez-Llodra *et al*., 2011

UK Marine Policy Statement Activities	Activity (adapted from JNCC activity list)	Description	Reference
		environment; different materials may degrade with time and/or release pollutants.	
Marine aggregates and marine dredging & disposal	Extraction - aggregates	Aggregate extraction involves the collection of material from the sea bed, and bringing it up to the surface. The unloading of material is considered under 'dredge and spoil disposal' activities. There are two types of aggregate dredging techniques used in the UK: static dredging (where vessels are anchored) and trailer suction dredging (where the draghead is trailed along the seabed). For the purposes of the database, this section includes extraction of sand, gravel, rock and mineral.	European Dredging Association, n.d.; Tillin *et al*., 2011.
	Extraction - navigational dredging	Navigational dredging includes maintenance dredging, which is ensuring existing watercourses, harbour basins, etc. remain at the required nautical and/or hydrological depth by removing siltation. Negative environmental issues increase when the material to be dredged is polluted. Capital dredging is also considered under this category, and can be defined as the creation of new civil engineering works by means of dredging, such as harbour basins, canals, etc., and the deepening of existing waterways or approach channels. Capital dredging is carried out in virgin soil, which is generally unpolluted.	European Dredging Association, n.d.; Posford Duvivier Environment & Hill, 2001; OSPAR, 2009.
	Extraction - water	Water extraction from estuarine and coastal waters involves taking water from the sea, via a pipe, using it for industrial purposes and then returning it to the sea. Most extracted water is used for cooling.	The Scottish Government, n.d.
	Dredge and spoil disposal	Following extraction, dredged material is may be disposed at sea except when the quality is suitable for beach nourishment. This can be done by direct disposal or use of pipelines.	Posford Duvivier Environment & Hill, 2001; Royal Haskoning, 2005.

UK Marine Policy Statement Activities	Activity (adapted from JNCC activity list)	Description	Reference
Tourism and recreation	Coastal tourist sites	Coastal tourist sites are considered to be coastal locations where tourist activities are undertaken by humans. These activities include: walking, hiking, dog-walking, bird-watching and passive water-based pursuits (such as swimming, diving or surfing). Activities which require the presence of infrastructure are considered under 'recreational activities'.	N/A
	Recreational activities - sailing (yachting)	Yachting falls under recreational activities. The term "yacht" can include power boats, but for the purposes of the database, they have been defined as sailing boats only. Yachts can range from 33 feet to hundreds of feet and, in general, all but the smallest boats will require slipways or moorings for access. Sailing yachts only use auxiliary engine for lengthy voyages or under adverse wind conditions.	Stillman *et al*., 2009; 2012
	Recreational activities - sailing (dinghy)	Dinghy sailing is a type of sailing using dinghies which are small boats, which may include outboard motors, although, in general, they are rowboats. They have shallow hulls that allow access to shallower waters. Slipways or moorings are not necessary for access, although they can be used. Craft are also kept at sailing clubs or carried by car to access points.	Stillman *et al*., 2009; 2012; Pickering *et al*., 2010
	Recreational activities - horse riding	Horse riding can be undertaken by owner riders and those who ride through local trekking or horse clubs. The former are likely to ride alone or in pairs. The latter are likely to ride in larger groups.	Stillman *et al*., 2009; 2012
Defence and National Security	Military activities	Military defence activities in the marine environment include military training (which may involve live weapons firing, torpedo testing and submarine exercises), surveillance and monitoring, and transport.	JNCC and NE, 2011
N/A	Marine research	Marine research is the general term most often used to describe those activities undertaken in the ocean to expand scientific knowledge of the marine environment. This includes physical and chemical oceanographical research, marine biological research, fisheries research, scientific ocean drilling and coring as well as other activities involving scientific data collection. Marine research activities may vary according to the type of work, locations,	NOAA, n.d.

UK Marine Policy Statement Activities	Activity (adapted from JNCC activity list)	Description	Reference
		operations and functions of the research vessels (if used).	
N/A	Coastal defences - construction	Coastal defences include coastal protection against erosion and sea defence against flooding. There are a number of different 'hard' defence methods that can be utilised, such as sea walls, breakwaters and groynes, as well as 'soft' methods, such as beach replenishment. Depending on the type of defence introduced, different materials will be used (e.g. timber, concrete, rock armour, etc.) and different machinery will be needed.	Defra, 2006
	Coastal defences - operation	Operation of coastal defences refers to the implications of the presence of coastal defences during their operational life with regard to coastal processes and management, including society. Depending on the type of defence being considered, the operational life can vary between 5 (e.g. timber groynes) to 100 years (e.g. concrete seawalls).	Defra, 2006
	Land reclamation - construction	Land reclamation is the movement of the land-sea boundary seaward, thus gaining land from the sea or coastal wetlands. This could be undertaken for agricultural purposes, industrial use, port expansions or as a method of coastal management. Land reclamation activities are often closely related to coastal defence projects and extraction of sand and gravel, these are considered under 'Coastal defences'. The construction phase of land reclamation activities usually includes dredging operations for acquiring the hydraulic fill, transporting the material and placing it in the desired location (this will likely involve the use of vessels). Different types of equipment will be used for different type of materials and location characteristics. Ground improvement may be necessary, requiring soil replacement and compaction. The aim of the land reclamation project will determine the characteristics and construction needs.	OSPAR, 2008; Kolman and van't Hoff, 2012
	Land reclamation - operation	Operation of land reclamation refers to the maintenance of the reclaimed land site and its interaction with the surrounding environment and social	OSPAR, 2008; Kolman and

UK Marine Policy Statement Activities	Activity (adapted from JNCC activity list)	Description	Reference
		community.	van't Hoff, 2012
Surface water management & waste water treatment & disposal	Waste gas emissions	Waste gas emissions may result from various commercial and industrial activities. The nature of emissions and interaction with the surrounding environment and society will depend on the activity producing them.	Bogner *et al*., 2007
	Industrial and agricultural liquid discharges	Industrial and agricultural liquid discharges are produced by a number of human activities, for example coastal industry, farming and agriculture. The source of the discharge will determine the composition of effluents. Discharges can be introduced into the marine environment through sources that are relatively easy to localise and control, however, they may also be introduced through diffuse water pollution, e.g. erosion and chemical runoff, land drains to surface water or leaching.	Defra, 2004
	Sewerage disposal	Sewerage disposal is the disposal of waste material into the marine environment. It includes the regulated discharge of wastewater and the disposal of hazardous and non-hazardous waste. 'Municipal waste' has been included here and can be described as the process following sewage collection, transport through the cities and other inhabited areas, and treatment against pollution.	UKMMAS, 2010
	Power station thermal and nuclear discharges	Power station thermal and nuclear discharges includes discharges resulting from a power station's cooling water system and other industrial processes. During the normal operation of a nuclear power plant, small planned and controlled discharges (mainly of neutron activation products) may be released into the sea with the out-flowing cooling water. Water abstraction to facilitate this is considered under 'Extraction – water'.	Ilus, 2009

Table A3.2: Pressure descriptions. Descriptions of pressures were obtained from OSPAR (2011). The only modification to the original pressure list was the differentiation of underwater noise changes in high frequency impulsive sounds, low and mid-frequency impulsive sounds and low frequency impulsive sounds, following MMO's request.

Pressure	Description
Temperature changes	Events or activities increasing or decreasing local water temperature. This is most likely from thermal discharges, e.g. the release of cooling waters from power stations. This could also relate to temperature changes in the vicinity of operational subsea power cables. This pressure only applies within the thermal plume generated by the pressure source. It excludes temperature changes from global warming which will be at a regional scale.
Salinity changes	Events or activities increasing or decreasing local salinity. This relates to anthropogenic sources/causes that have the potential to be controlled, e.g. freshwater discharges from pipelines that reduce salinity, or brine discharges from salt caverns washings that may increase salinity. This could also include hydro-morphological modification, e.g. capital navigation dredging if this alters the halocline, or erection of barrages or weirs that alter freshwater/seawater flow/exchange rates. The pressure may be temporally and spatially delineated derived from the causal event/activity and local environment.
Water flow changes	Changes in water movement associated with tidal streams (the rise and fall of the tide, riverine flows), prevailing winds and ocean currents. The pressure is therefore associated with activities that have the potential to modify hydrological energy flows, e.g. Tidal energy generation devices remove (convert) energy and such pressures could be manifested leeward of the device, capital dredging may deepen and widen a channel and therefore decrease the water flow, canalisation &/or structures may alter flow speed and direction; managed realignment. The pressure will be spatially delineated. The pressure extremes are a shift from a high to a low energy environment (or vice versa).
Sediment transport changes	Linked to the previous pressure, the biota associated with these extremes will be markedly different as will the substrate, sediment supply/transport and associated seabed elevation changes. The potential exists for profound changes (e.g. coastal erosion/deposition) to occur at long distances from the construction itself if an important sediment transport pathway was disrupted. As such these pressures could have multiple and complex impacts associated with them.

Pressure	Description
Emergence regime change	Changes in water levels reducing the intertidal zone (and the associated/dependant habitats). The pressure relates to changes in both the spatial area and duration that intertidal species are immersed and exposed during tidal cycles (the percentage of immersion is dependent on the position or height on the shore relative to the tide). The spatial and temporal extent of the pressure will be dependent on the causal activities but can be delineated. This relates to anthropogenic causes that may directly influence the temporal and spatial extent of tidal immersion, e.g. upstream and downstream of a tidal barrage the emergence would be respectively reduced and increased, beach re-profiling could change gradients and therefore exposure times, capital dredging may change the natural tidal range, and managed realignment and saltmarsh creation may also lead to changes. Such alteration may be of importance in estuaries because of their influence on tidal flushing and potential wave propagation. Changes in tidal flushing can change the sediment dynamics and may lead to changing patterns of deposition and erosion. Changes in tidal levels will only affect the emergence regime in areas that are inundated for only part of the time. The effects that tidal level changes may have on sediment transport are not restricted to these areas, so a very large construction could significantly affect the tidal level at a deep site without changing the emergence regime. Such a change could still have a serious impact. This excludes pressure from sea level rise which is considered under the climate change pressures.
Wave exposure changes	Local changes in wave length, height and frequency. Exposure on an open shore is dependent upon the distance of open seawater over which wind may blow to generate waves (the fetch) and the strength and incidence of winds. Anthropogenic sources of this pressure include artificial reefs, breakwaters, barrages and wrecks that can directly influence wave action or activities that may locally affect the incidence of winds, e.g. a dense network of wind turbines may have the potential to influence wave exposure, depending upon their location relative to the coastline.
Transition elements & organo-metal contamination	The increase in transition elements levels compared with background concentrations, due to their input from land/riverine sources, by air or directly at sea. For marine sediments the main elements of concern are Arsenic, Cadmium, Chromium, Copper, Mercury, Nickel, Lead and Zinc. Organo-metallic compounds such as the butyl tins (Tri butyl tin and its derivatives) can be highly persistent and chronic exposure to low levels has adverse biological effects, e.g. Imposex in molluscs. This includes those priority substances listed in Annex II of Directive 2008/105/EC.

Pressure	Description
Hydrocarbon & PAH contamination	Increases in the levels of these compounds compared with background concentrations. Naturally occurring compounds, complex mixtures of two basic molecular structures: (Includes those priority substances listed in Annex II of Directive 2008/105/EC). - straight chained aliphatic hydrocarbons (relatively low toxicity and susceptible to degradation) - multiple ringed aromatic hydrocarbons (higher toxicity and more resistant to degradation). These fall into three categories based on source (includes both aliphatics and polyaromatic hydrocarbons): - petroleum hydrocarbons (from natural seeps, oil spills and surface water run-off) - pyrogenic hydrocarbons (from combustion of coal, woods and petroleum) - biogenic hydrocarbons (from plants & animals). Ecological consequences include tainting, carcinomas, growth defects, and some are acutely toxic.
Synthetic compound contamination	Includes increases of pesticides, antifoulants, pharmaceuticals, and those priority substances listed in Annex II of Directive 2008/105/EC levels compared with background concentrations. Compounds are synthesised from a variety of industrial processes and commercial applications. Chlorinated compounds include polychlorinated biphenols (PCBs), dichlor-diphenyl-trichloroethane (DDT) & 2,3,7,8-tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD) are persistent and often very toxic. Pesticides include insecticides, herbicides, rodenticides & fungicides and vary greatly in structure, composition, environmental persistence and toxicity to non-target organisms. Pharmaceuticals and Personal Care Products originate from veterinary and human applications compiling a variety of products including, over the counter medications, fungicides, chemotherapy drugs and animal therapeutics, such as growth hormones. Due to their biologically active nature, high levels of consumption, known combined effects, and their detection in most aquatic environments they have become an emerging concern. Ecological consequences include physiological changes (e.g. growth defects, carcinomas).
Introduction of other substances	Includes solids, liquids or gases. The 'systematic or intentional release of liquids, gases …' (from MSFD Annex III Table 2) is being considered e.g. in relation to produced water from the oil industry. It should therefore be considered in parallel with transition element & organo-metal contamination, hydrocarbon & PAH contamination, and synthetic compound contamination.

Pressure	Description
Radionuclide contamination	Introduction of radionuclide material, raising levels above background concentrations. Such materials can come from nuclear installation discharges, and from land or sea-based operations (e.g. oil platforms, medical sources). The disposal of radioactive material at sea is prohibited unless it fulfils exemption criteria developed by the International Atomic Energy Agency (IAEA), namely that both the following radiological criteria are satisfied: (i) the effective dose expected to be incurred by any member of the public or ship's crew is 10 μSv (micro-Seivert) or less in a year; (ii) the collective effective dose to the public or ship's crew is not more than 1 man Sv per annum, then the material is deemed to contain *de minimis* levels of radioactivity and may be disposed at sea pursuant to fulfilling all the other provisions under the Convention. The individual dose criteria are placed in perspective (i.e. very low), given that the average background dose to the UK population is ~2700 μSv/a. Ports and coastal sediments can be affected by the authorised discharge of both current and historical low-level radioactive wastes from coastal nuclear establishments.
Nutrient enrichment	Increased levels of the elements nitrogen, phosphorus, silicon (and iron) in the marine environment compared to background concentrations. Nutrients can enter marine waters by natural processes (e.g. decomposition of detritus, riverine, direct and atmospheric inputs) or anthropogenic sources (e.g. waste water runoff, terrestrial/agricultural runoff, sewage discharges, aquaculture, atmospheric deposition). Nutrients can also enter marine regions from 'upstream' locations, e.g. via tidal currents to induce enrichment in the receiving area. Nutrient enrichment may lead to eutrophication (see also organic enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.
Organic enrichment	Resulting from the degraded remains of dead biota & microbiota (land & sea); faecal matter from marine animals; flocculated colloidal organic matter and the degraded remains of: sewage material, domestic wastes, industrial wastes etc. Organic matter can enter marine waters from sewage discharges, aquaculture or terrestrial/agricultural runoff. Black carbon comes from the products of incomplete combustion (PIC) of fossil fuels and vegetation. Organic enrichment may lead to eutrophication (see also nutrient enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.
Deoxygenation	Any deoxygenation that is not directly associated with nutrient or organic enrichment. The lowering, temporarily or more permanently, of oxygen levels in the water or substrate due to anthropogenic causes (some areas may naturally be deoxygenated due to stagnation of water masses, e.g. inner basins of fjords).. This is typically associated with nutrient and organic enrichment, but it can also derive from the release of ballast water or other stagnant waters (where organic or nutrient enrichment may be absent). Ballast waters

Pressure	Description
	may be deliberately deoxygenated via treatment with inert gases to kill non-indigenous species.
Physical loss	The permanent loss of marine habitats (to land or freshwater habitat). Associated activities are land claim, new coastal defences that encroach on and move the Mean High Water Springs mark seawards, the footprint of a wind turbine on the seabed, dredging if it alters the position of the halocline. This excludes changes from one marine habitat type to another marine habitat type.
Physical change (to another seabed type)	The permanent change of one marine habitat type to another marine habitat type, through the change in substratum, including to artificial (e.g. concrete). This therefore involves the permanent loss of one marine habitat type but has an equal creation of a different marine habitat type. Associated activities include the installation of infrastructure (e.g. surface of platforms or wind farm foundations, marinas, coastal defences, pipelines and cables), the placement of scour protection where soft sediment habitats are replaced by hard/coarse substrate habitats, removal of coarse substrate (marine mineral extraction) in those instances where surficial finer sediments are lost, capital dredging where the residual sedimentary habitat differs structurally from the pre-dredge state, creation of artificial reefs, mariculture i.e. mussel beds. Protection of pipes and cables using rock dumping and mattressing techniques. Placement of cuttings piles from oil & gas activities could also fit this pressure type, however, there may be additional pressures, e.g. "pollution and other chemical changes" theme. This pressure excludes navigation dredging where the depth of sediment changes locally but the sediment typology is not changed.
Habitat structure changes - removal of substratum	Unlike the "physical change" pressure type where there is a permanent change in sea bed type (e.g. sand to gravel, sediment to a hard artificial substrate) the "habitat structure change" pressure type relates to temporary and/or reversible change, e.g. from marine mineral extraction where a proportion of seabed sands or gravels are removed but a residual layer of seabed is similar to the pre-dredge structure and as such biological communities could re-colonise; navigation dredging to maintain channels where the silts or sands removed are replaced by non-anthropogenic mechanisms so the sediment typology is not changed.
Disturbance of the substrate below the surface of the seabed	The disturbance of sediments where there is limited or no loss of substrate from the system including abrasion. This pressure is associated with activities such as anchoring, taking of sediment/geological cores, cone penetration tests, cable burial (ploughing or jetting), propeller wash from vessels, certain fishing activities, e.g. scallop dredging, beam trawling. Agitation dredging, where sediments are deliberately disturbed and gravity & hydraulic dredging where sediments are deliberately disturbed and moved by currents could also be associated with this pressure type. Compression of sediments, e.g. from the legs of a jack-up

Pressure	Description
	barge could also fit into this pressure type. Abrasion relates to the damage of the sea bed surface layers (typically up to 50cm depth) Activities associated with abrasion can cover relatively large spatial areas and include: fishing with towed demersal trawls (fish & shellfish); bio-prospecting such as harvesting of biogenic features such as maerl beds where, after extraction, conditions for recolonisation remain suitable or relatively localised activities including: seaweed harvesting, recreation, potting, aquaculture. Change from gravel to silt substrate would adversely affect herring spawning grounds.
Changes in suspended solids	Changes in water clarity from sediment & organic particulate matter concentrations. It is related to activities disturbing sediment and/or organic particulate matter and mobilising it into the water column. Could be 'natural' land run-off and riverine discharges or from anthropogenic activities such as all forms of dredging, disposal at sea, cable and pipeline burial, secondary effects of construction works, e.g. breakwaters. Particle size, hydrological energy (current speed & direction) and tidal excursion are all influencing factors on the spatial extent and temporal duration. This pressure also relates to changes in turbidity from suspended solids of organic origin (as such it excludes sediments - see the "changes in suspended sediment" pressure type). Salinity, turbulence, pH and temperature may result in flocculation of suspended organic matter. Anthropogenic sources are mostly short lived and over relatively small spatial extents.
Siltation rate changes	Includes smothering (depth of vertical sediment overburden) and increase/decrease in the natural rates of siltation. Siltation (or sedimentation) is the settling out of silt/sediments suspended in the water column. Activities associated with this pressure type include mariculture, land claim, navigation dredging, disposal at sea, marine mineral extraction, cable and pipeline laying and various construction activities. It can result in short lived sediment concentration gradients and the accumulation of sediments on the sea floor. This accumulation of sediments is synonymous with "light" smothering, which relates to the depth of vertical overburden. “Light” smothering relates to the deposition of layers of sediment on the seabed. It is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the sea bed. For “light” smothering most benthic biota may be able to adapt, i.e. vertically migrate through the deposited sediment. “Heavy” smothering also relates to the deposition of layers of sediment on the seabed but is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the sea

Pressure	Description
	bed. This accumulation of sediments relates to the depth of vertical overburden where the sediment type of the existing and deposited sediment has similar physical characteristics because, although most species of marine biota are unable to adapt, e.g. sessile organisms unable to make their way to the surface, a similar biota could, with time, re-establish. If the sediments were physically different this would fall under 'Physical change (to another seabed type)'. Eleftheriou and McIntyre, 2005 describe that the majority of animals will inhabit the top 5-10 cm in open waters and the top 15 cm in intertidal areas. The depth of sediment overburden that benthic biota can tolerate is both trophic group and particle size/sediment type dependant (Bolam, 2010). Recovery from burial can occur from: • planktonic recruitment of larvae • lateral migration of juveniles/adults • vertical migration Spatial scale, timing, rate and depth of placement all contribute the relative importance of these three recovery mechanisms. As such the terms "light" and "heavy" smothering are relative and therefore difficult to define in general terms.
Litter	Marine litter is any manufactured or processed solid material from anthropogenic activities discarded, disposed or abandoned (excluding legitimate disposal) once it enters the marine and coastal environment including: plastics, metals, timber, rope, fishing gear, etc. and their degraded components, e.g. microplastic particles. Ecological effects can be physical (smothering), biological (ingestion, including uptake of microplastics; entangling; physical damage; accumulation of chemicals) and/or chemical (leaching, contamination).
Electromagnetic changes	Localised electric and magnetic fields associated with operational power cables and telecommunication cables (if equipped with power relays). Such cables may generate electric and magnetic fields that could alter behaviour and migration patterns of sensitive species (e.g. sharks and rays).
Underwater noise changes - high frequency impulsive	Increases over and above background noise levels (consisting of environmental noise (ambient) and incidental man-made/anthropogenic noise (apparent)) at a particular location. Species known to be affected are marine mammals and fish. The theoretical zones of noise influence are temporary or permanent hearing

Pressure	Description
sounds	loss, discomfort & injury; response; masking and detection. In extreme cases noise pressures may lead to death. The physical or behavioural effects are dependent on a number of variables, including the sound pressure, loudness, sound exposure level and frequency. High frequency impulsive sounds (between 10 kHz to 200 kHz), high amplitude low and mid-frequency impulsive sounds (10 kHz to 10kHz) and low frequency continuous sound (due to increased shipping activity) less than 10 kHz are of greatest concern for effects on marine mammals and fish. Some species may be responsive to the associated particle motion rather than the usual concept of noise. Noise propagation can be over large distances (tens of kilometres) but transmission losses can be attributable to factors such as water depth and sea bed topography. Noise levels associated with construction activities such as pile-driving are typically significantly greater than operational phases (i.e. shipping, operation of a wind farm).
Underwater noise changes - low and mid-frequency impulsive sounds	
Underwater noise changes - low frequency and continuous sounds	
Introduction of light	Direct inputs of light from anthropogenic activities, i.e. lighting on structures during construction or operation to allow 24 hour working; new tourist facilities, e.g. promenade or pier lighting, lighting on oil & gas facilities, etc. Ecological effects may be the diversion of bird species from migration routes if they are disorientated by or attracted to the lights. It is also possible that continuous lighting may affect algal growth.
Barrier to species movement	The physical obstruction of species movements and including local movements (within & between roosting, breeding, feeding areas) and regional/global migrations (e.g. birds, eels, salmon, whales). Both include upriver movements (where tidal barrages & devices or dams could obstruct movements) or movements across open waters (offshore wind farm, wave or tidal device arrays, mariculture infrastructure or fixed fishing gears). Species most affected are birds, fish, and mammals.
Death or injury by collision	Injury or mortality from collisions of biota with both static and/or moving structures. Examples include: Collision with rigs (e.g. birds) or screens in intake pipes (e.g. fish at power stations) (static) or collisions with wind turbine blades, fish and mammal collisions with tidal devices and shipping (moving). Activities increasing number of vessels transiting areas, e.g. new port development or construction works will influence the scale and intensity of this pressure.
Visual disturbance	The disturbance of biota by anthropogenic activities, e.g. increased vessel movements, such as during construction phases for new infrastructure (bridges, cranes, port buildings, etc.), e.g. increased personnel movements, increased tourism, and increased vehicular movements on shore disturbing bird roosting areas, and seal haul out areas.

Pressure	Description
Genetic modification & translocation of indigenous species	Genetic modification can be either deliberate (e.g. introduction of farmed individuals to the wild, GM food production) or a by-product of other activities (e.g. mutations associated with radionuclide contamination). The former may be related to escapees or deliberate releases e.g. cultivated species such as farmed salmon, oysters, scallops if GM practices employed. Scale of pressure compounded if GM species "captured" and translocated in ballast water. Mutated organisms from the latter could be transferred on ships hulls, in ballast water, with imports for aquaculture, aquaria, live bait, species traded as live seafood or 'natural' migration. Movement of native species to new regions can also introduce different genetic stock.
Introduction or spread of non-indigenous species	The direct or indirect introduction of non-indigenous species, e.g. Chinese mitten crabs, slipper limpets, Pacific oyster and their subsequent spreading and out-competing of native species. Ballast water, hull fouling, stepping stone effects (e.g. offshore wind farms) may facilitate the spread of such species. This pressure could be associated with aquaculture, mussel or shellfishery activities due to imported seed stock imported or from accidental releases.
Introduction of microbial pathogens	Untreated or insufficiently treated effluent discharges & run-off from terrestrial sources & vessels. It may also be a consequence of ballast water releases. In mussel populations or shellfisheries where seed stock is imported, 'infected' seed could be introduced, or it could be from accidental releases of effluvia. Escapees, e.g. farmed salmon could be infected and spread pathogens in the indigenous populations. Aquaculture could release contaminated faecal matter, from which pathogens could enter the food chain.
Removal of target species	The commercial exploitation of fish & shellfish stocks, including smaller scale harvesting, angling and scientific sampling. The physical effects of fishing gear on sea bed communities are addressed by the ‘Disturbance of the substrate below the surface of the seabed’ pressure type, so ‘Removal of target species’ addresses the direct removal/harvesting of biota. Ecological consequences include the sustainability of stocks, impacting energy flows through food webs and the size and age composition within fish stocks.
Removal of non-target species	By-catch associated with all fishing activities. The physical effects of fishing gear on sea bed communities are addressed by the ‘Disturbance of the substrate below the surface of the seabed’ pressure type so ‘Removal of non-target species’ addresses the direct removal of individuals associated with fishing/harvesting. Ecological consequences include food web dependencies, population dynamics of fish, marine mammals, turtles and sea birds (including survival threats in extreme cases, e.g. harbour porpoise in the Central and Eastern Baltic).

Table A3.3: Receptor descriptions. Categories were obtained from ODEMM project (Koss *et al*. 2011), which are based on those defined by MSFD.

Receptor	Description
Topography/ Bathymetry	This receptor group has been included within the framework, based upon the ODEMM list of 'Ecological characteristics' within the ODEMM linkage framework. The ODEMM list was originally derived from the list of characteristics described in Annex III of the Marine Strategy Framework Directive, in which 'Topography/Bathymetry' is listed as a characteristic of the environment. Topography: The three-dimensional surface and the geomorphological character of a landform or a series of landforms and geological features above sea-level within the shore-face and coastal plain areas, including the shoreline, cliff-complexes; and associated hinterland. Constitutes a range of physical features which are either solid boundary features (e.g. hard-rock cliffs) or those which are spatially and temporally transient in nature as a product of natural meteorological, fluvial and oceanographic processes (e.g. beach). Common receptors include; beach and dune features; the coastline; cliff-faces/cliff-complexes; designated geological interest features (including geological stratigraphy); paleo-features (such as raised beaches); and coastal/marine process features (e.g. spits). Bathymetry: The three-dimensional surface and the geomorphological character of the landforms which exist below sea-level, including the lower shore-face and the continental shelf. Constitutes a range of physical features which are either static boundary features (e.g. hard bedrock features) or those which are spatially and temporally transient in nature as a product of oceanographic processes. Common receptors include reef features; designated sand-bank features; various sediment types; sand wave features and navigation channels.
Hydrography	This receptor group has combined 4 ecological characteristics which have been listed within the ODEMM linkage framework (temperature; salinity; nutrients & oxygen; and pH, $pC0_2$), to form a single receptor group termed as 'Hydrographic Conditions', which encompasses all 4 of these ecological characteristics. The ODEMM linkage framework originally derived the four respective ecological characteristics that it uses from Annex III of the Marine Strategy Framework Directive. The hydrographic conditions which characterise a given area; receptor features include the physical and chemical characteristics of a body of water (e.g. temperature, salinity, nutrient levels & oxygen levels; pH

Receptor	Description
	of the water column; $pC0_2$ levels, organic content of the water column, contaminant levels, and electromagnetic field levels).
Fish and pelagos	This receptor group has combined five ecological characteristics which have been listed within the ODEMM linkage framework (Fish, Plankton, Predominant Habitat Types, Special Habitat Types and Species Listed Under Community Legislation or Conventions). With regards to the inclusion of 'Predominant Habitat Types', 'Special Habitat Types' and 'Species listed under Community Legislation or Conventions' as receptors, these are only considered where they concern the pelagic environment in the respect of fish and plankton. The ODEMM list was originally derived from the list of characteristics described in Annex III of the Marine Strategy Framework Directive. This concerns the populations of fish species, phytoplankton, zooplankton and bacterioplankton which reside within the pelagic zone (i.e. the entirety of the water column of the oceans up to the landward margin of the sub-tidal zone) and their associated habitat. Pelagic habitat is ephemeral, constantly changing, and is not restricted by clear habitat boundaries, whereas many other types of habitat (e.g. benthic) constitute a uniform set of environmental conditions with a clearly defined boundary in which these conditions show a marked change or terminate. The predominant habitat type for a pelagic species can be defined by the water column habitat type, based upon the physical and chemical characteristics of the habitat (e.g. water depth, water temperature regime, currents and hydrodynamics and salinity, etc.). Special pelagic habitat types include pelagic habitats which have been identified and mapped as being of special scientific or biodiversity interest or those that have been recognised or identified under Community legislation as a Special Area of Conservation (SAC) designated area under the Habitats Directive, with a pelagic species as a primary qualifying feature for designation) or those habitats designated under international conventions. Species listed under Community Legislation or Conventions may include a particular species such as Atlantic salmon (*Salmo salar*) which is designated as an Annex II fish species under the Habitats Directive.

Receptor	Description
Benthic habitat and species	This receptor group has combined four ecological characteristics which have been listed within the ODEMM linkage framework (Bottom fauna and flora, Predominant Habitat Types, Special Habitat Types and Species listed under Community Legislation or Conventions). With respect to the inclusion of 'Predominant Habitat Types', 'Special Habitat Types' and 'Species listed under Community Legislation or Conventions' as receptors, these are only considered where they concern the benthic environment. The ODEMM list of ecological characteristics was originally derived from the list of characteristics described in Annex III of the Marine Strategy Framework Directive. This concerns the ecological and biological components which characterise a location's benthic zone (i.e. the substrate which lies at the bottom of the water column, including the substrate surface and sub-surface layers). The benthic zone extends from the landward boundary of the subtidal zone seawards, and includes the continental shelf and the abyssal plain. Benthic species receptors include the epifauna (i.e. the animals living attached to or immediately above the seabed substrate surface) and infauna (i.e. the animals living buried with the seabed substrate and sub-surface layers) and the respective species of benthic flora (e.g. kelp, algae and coral, etc.). Benthic habitat receptors constitute a range of seabed habitats which can either be broadly defined, based upon areas of uniform sedimentary, geological and biological character (e.g. circalittoral coarse sediment, high energy circalittoral rock, infralittoral mixed sediments, etc.) or to a higher level of detail (e.g. *S. spinulosa* on stable circalittoral mixed sediment). The predominant habitat type consists of the principal seabed type, and the associated habitat conditions which govern the spatial and temporal distribution of the benthic flora and fauna which reside within the habitat, such as: depth, light availability and water temperature. Special benthic habitat types include seabed habitats which have been identified and mapped as being of special scientific or biodiversity interest (e.g. a seagrass protection area), of those that have been recognised or identified under Community legislation (e.g. Rocky and Stony (geogenic) Reef Annex I habitat under the Habitats Directive) or those habitats designated under international conventions, whilst species listed under Community Legislation or Conventions may include a particular species.

Receptor	Description
Seabirds	This receptor group has combined two ecological characteristics which have been listed within the ODEMM linkage framework ('Seabirds and 'Species listed under Community Legislation or Conventions (e.g. Habitats Directive)'. With respect to the inclusion of 'Species listed under Community Legislation or Conventions', this only includes seabird species. The ODEMM list of ecological characteristics was originally derived from the list of characteristics described in Annex III of the Marine Strategy Framework Directive. The seabird and migrant seabird species populations which are known to reside, feed or to migrate in a given area. Receptors include species of seabirds (e.g. cormorant, fulmar, gannet, Manx shearwater), whilst an example of a seabird species which is listed under community legislation might be the Balearic shearwater (*Puffinus mauretanicus*) which is designated as an Annex I protected species under the Birds Directive.
Marine mammals and reptiles	This receptor group has combined two ecological characteristics which have been listed within the ODEMM linkage framework ('Marine Mammals & Reptiles' and 'Species listed under Community Legislation or Conventions (e.g. Habitats Directive)'. With respect to the inclusion of 'Species listed under Community Legislation or Conventions', this only includes marine mammal and reptile species. The ODEMM list of ecological characteristics was originally derived from the list of characteristics described in Annex III of the Marine Strategy Framework Directive. The marine mammal and reptile species populations which are known to reside or to travel through a given area. Marine mammal receptors include species of cetaceans (e.g. whales, dolphins and porpoises) and pinnipeds (e.g. seals, walruses and sea lions). Reptile species receptors include a range of extant marine reptile species (e.g. sea turtles). An example of a marine mammal species which is listed under community legislation might be the bottlenose dolphin (*Tursiops truncates*) which is designated as an Annex II protected species under the Habitats Directive.

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Annex 3: Social and Economic Application of the Framework

The concept of Total Economic Value (TEV) could be used to analyse social and economic implications of cumulative effects for the purposes of high level scoping using the framework proposed within this report. TEV is defined as the "sum of the use, option and existence value of a good: a term used primarily in environmental economics" (HM Treasury, 2014) and is often used to assess the costs and benefits resulting from environmental pressures, traditionally at a project level (Crookes and De Wit, 2009). In short, it identifies the value of goods and services (provided by a given 'ecosystem') – placing a monetary value based on valuation of human preferences towards a natural system rather than an intrinsic value of the goods and services themselves. The TEV is the result of summing different categories of values or benefits differentiated when eliciting the value of environmental resources.

Marine activities have benefits and costs that can be economic, social and environmental. Environmental costs and benefits are related to pressures exerted from marine activities on an environmental resource. Following the DPSIR framework, social and economic drivers exert pressure on the environment. This leads to a change in the state of the environment and subsequent effects on environmental receptors which can lead to societal and economic impacts that feed back into the drivers.

The direct and indirect typology of the TEV framework helps to identify those different categories of values associated with environmental impacts. It provides an encompassing assessment of the total economic value (including both direct and indirect values) of any environmental resource that is impacted by a marine activity. A change in resource would, therefore, affect the values that citizens perceive to be embodied in the environment.

The assessment of environmental effects using TEV requires identifying the pressures which can impact the use and non-use values:

- Use values encompass direct and indirect use as well as option use where possible use may be made in the future. They may include:
    - **Direct use values** refer to goods and services that are used directly by human beings. They include the value of consumptive uses such as harvesting of food products, and the value of non-consumptive uses such as the enjoyment of recreational and cultural activities. Direct use values are most often enjoyed by people visiting or residing in the 'ecosystem' itself.
    - **Indirect use values** include values of services in a particular ecosystem which provides benefits beyond that particular ecosystem. Examples include the flood protection function of coastal wetlands which benefits coastal properties and infrastructure, and carbon sequestration from seaweed, which benefits the entire global community by abating climate change.

    - **Option (use) values** represent future possible values to be used by oneself (option values which can be direct or indirect) or by others/heirs (bequest values which may also be non-use values).
- Non-use values include **existence values** which are the value of knowing that something continues to exist, even if the citizen does not expect to make any practical use of it. Bequest values may be included under Non-use values as well as Use values.

Non-use values (like existence values) reflect the moral reasons behind environmental protection, independently of any present or future use. An example may be the value derived from the continued protection of ecosystems.

The TEV approach can be used to translate environmental pressures from marine activities into values that citizens perceive to be embodied in the environment. Examples of TEV value categories in the context of marine environmental pressures are provided in Table A3.1.

Unlike environmental effects, which science may not be able to detect, social and economic effects can be more easily identified, although their implications are very often difficult to predict. In practice, however, the estimation of significance is probably a greater difficulty. MMO (2014a) collated existing information from literature on social impacts and where possible estimates significance. However, it is recommended that social impacts are assessed on a case by case basis to ensure they are correctly attributed. The project also revealed that data is lacking on social impacts for assessment in the marine environment and further specific research is encouraged. This information would support consideration of social and economic costs and benefits under CEA.

Table A3.1: Total Economic Value categories and examples of environmental pressures leading to impacts on these values

Value category	Example	Examples of environmental pressure leading to impact.
Direct use value	Changes in the level of provisioning of commercial resources. Goods taken from or 'provided' by nature are the clearest example of a direct use value. Examples include fish and aggregates.	A combination of new dredging and fishing practices may lead to a reduction in the practical size of nursery areas for fish, reducing the level of provisioning of commercial resources.
Indirect use value	Change in the level of environmental resource with non-consumptive use. Non-consumptive uses range from transport (sea lanes) to cultural and recreational activities (e.g. sailing).	Avoidance of an area by a particular species, as a result of a marine activity might cause a reduction of wildlife tourism for birds or whale watching.

Value category	Example	Examples of environmental pressure leading to impact.
Option (use) value	Changes in access to non-consumptive resources	Physical changes affecting access to areas of beach or even to certain landscape views may affect its overall desirability as a tourist destination.
Existence value	Changes in environmental resource with non-use value. Environmental pressures affecting non-use values can have effects on economic receptors.	Some marine development could exert an environmental pressure on the existence of species, habitats and ecosystems. This would lead to an impact on the value that the public holds from the knowledge of the continued existence of those species, habitats and ecosystems.

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Annex 5: Development of consultation options

The following text is an extract from the Consultation Report which was provided to MMO, the project's focus group and the wider stakeholder group. Individuals were then invited to comment either online or via telephone interview during the first round of consultation.

A5.1. Objective 2 Options: Assigning responsibility for cumulative effects assessment

MMO is guided by regulations (e.g. EIA and Habitats Regulations) and policy (e.g. MPS) for undertaking CEA. For projects that have potential to adversely affect Natura 2000 sites, MMO, as the competent authority for many of these cases, is required to carry out AA utilising information provided by the applicant. In other cases, developers are required to complete a CEA as part of the application for a marine licence, which the marine licensing teams are responsible for making a judgement on. The only exception to this is for disposal at sea, where the responsibility for CEA lies with the marine licensing team. In all scenarios, the onus is on the developer to provide information to MMO, either as a CEA or to inform an in-combination assessment.

Therefore, considering who might be responsible for CEA and mitigation of cumulative effects in the marine environment is a crucial element of MMO's role, in particular for the marine planning and marine licensing teams. There are a number of aspects to this 'responsibility' in relation to cumulative effects, these include responsibility for:

- The assessment itself – each project is responsible for its own CEA, as is MMO, however, consideration needs to be given to what is required within an assessment.
- Contribution to an assessment – whereby developers may be required to provide information to enable better assessments and to promote cooperation with other developers.
- Mitigation – where there is a significant cumulative effect, which developer(s) is/are responsible for mitigating the effect.

This section presents a number of suggested options for how responsibility may be assigned depending on the circumstances of each individual case. The development of options for this objective has been guided by experience of working with marine developers and experience of negotiating and completing CEA, primarily as part of the EIA and consenting processes. Discussions with MMO personnel, in addition to in-house experience of working in regulatory environments, have provided insight into how and when MMO may need to consider who is responsible for CEA.

This document has been prepared in order to gather feedback on the options developed to date, presented in Sections A5.1.1 to A5.1.8, and as such, comments and suggestions are welcomed in the feedback questionnaire provided. Further guidance will be provided in the final report following consultation and refinement of

the options into a range of applicable options from which case officers can select the most appropriate on a case by case basis.

A5.1.1 Equal responsibility

It may be appropriate to allocate equal responsibility for a given effect to all contributing applicants/developers. This approach is likely to be applied at an early stage in determining/assigning responsibility for a cumulative effect (i.e. an early stage in project development). Where the spatial/temporal effect is not well defined, it may be most straightforward to assume that all projects/developments contribute equally, until further information becomes available. This may be applicable where there are larger numbers of smaller activities to consider.

In general, individual projects/developments will be working towards developing a project-specific understanding of the cumulative effect. As this work develops, it is likely to become possible to consider apportioning of the effects (see Section A5.1.3).

A5.1.2 Activity-specific effects

This means of allocating responsibility for cumulative effects is based on a process of elimination of those projects for which there is no linkage between project-specific activity and the effect. For example, responsibility for any contribution to a cumulative collision risk for birds is not likely to be attributed to an aggregate extraction project. However, disturbance and/or loss of benthic habitats could be attributed to both offshore wind farms and to aggregate extraction schemes. When the relevant projects/developments have been identified, it may then be possible to apportion the effect(s).

A5.1.3 Apportioning the effect(s)

Where the cumulative effect is on a particular receptor type (e.g. birds), or an individual receptor (e.g. lesser black-backed gull), then it may be possible to apportion the effect between the contributing projects/developments (e.g. the proportion of the cumulative collision risk attributable to each project/development). It may then be appropriate to allocate responsibility for the effect on a proportional basis (i.e. a project/development may emerge as the principal contributor to the effect, whilst other projects/developments may contribute a proportionally insignificant effect in cumulative terms).

This option is likely to require a significant amount of input from each developer, and potentially an independent cumulative assessment in order to apportion the effect in a sound and reasonable manner. This process may be time consuming, and could require all projects/developments to have reached the point where cumulative EIA and/or HRA has been prepared.

A5.1.4 Scale of effect (spatial and/or temporal)

This option is similar to apportioning the effect(s), but may be more applicable to effects on receptors where the procedure for direct apportioning of effects is less well defined than for ornithological effects (e.g. cumulative collision risk, for which there are best practice accepted procedures for assessment). Such effects may include underwater noise (e.g. the extent of the underwater noise contour) or seabed habitat

loss/disturbance. Allocating responsibility for a proportion of a cumulative effect in this way could include investigation using spatial analysis software (e.g. GIS).

Allocation of responsibility based on the scale of effect may also be useful where, for example, the construction phase of a particular project is significantly longer than other projects/developments contributing to the cumulative effect. The nature of the development and the construction methodology should be taken into account here: a protracted aggregate extraction scheme is unlikely to produce underwater noise contours as large as those associated with the installation of monopile foundations for wind turbines.

A5.1.5 Allocation of responsibilities based on application timeframe

Guidance issued by JNCC and Natural England in September 2013 suggested tiers for cumulative impact assessment. These tiers are as follows:

- Tier 1: built and operational projects
- Tier 2: projects under construction plus tier 1 projects
- Tier 3: projects that have been consented (but construction has not yet commenced) plus tiers 1 and 2
- Tier 4: projects that have an application submitted to the appropriate regulatory body that have not yet been determined, plus tiers 1-3
- Tier 5: projects that the regulatory body are expecting to be submitted for determination (e.g. projects listed under the Planning Inspectorate programme of projects), plus tiers 1-4
- Tier 6: projects that have been identified in relevant strategic plans or programmes plus tiers 1-5.

These tiers provide a hierarchical framework for CEA, and one which may also be useful in allocating responsibility for a particular cumulative effect (or portion thereof). An example is a situation where a number of projects for which reliable data are available (e.g. tiers 1-4) contribute to a cumulative effect which is not considered significant in EIA terms, but after the inclusion of a tier 5 or 6 project, the magnitude of the cumulative effect becomes significant (in EIA terms). Given the potential status of a tier 5 or 6 project (i.e. with data limitations), it is likely to be difficult to define or meaningfully apportion the contribution to the cumulative effect. It might therefore be considered best to determine current responsibilities for the cumulative effect in the absence of the project(s) not yet submitted or consented, and to wait until tier 5/6 projects are submitted before determining responsibilities in respect of them.

A5.1.6 Precedents in previous development applications

Where a project/development activity has been undertaken previously at different sites/by different developers, then it may be beneficial, where possible, to review the processes used in cumulative effects assessment in these applications. The success of previous applications and the reasons for the choice of assessment approach can be a good sense check for current applications, and may help to determine allocation of responsibilities.

A5.1.7 Developer forums hosted by MMO

MMO, on reviewing the number and type of 1) cumulative effects and 2) individual contributing projects/developments, and at any point in the timeline, may deem it useful to bring developers together to discuss specific cumulative effects. This would

provide a unique and transparent opportunity for developers to discuss their individual approaches to impact assessment, and to highlight any key differences in methodology that might have consequences for the allocation of responsibility for a given cumulative effect. There are both time and financial implications to this approach: however, where there are difficulties in reaching agreement or issues of comparison between projects/developments, open debate may be invaluable.

A5.1.8 Consultation with industry bodies

It is considered likely that consultation with industry bodies will be most appropriate and productive in discussing the appropriate mitigation for a cumulative effect. However, in the event that it has not been possible to apportion a cumulative effect using tried and tested methodology (e.g. collision risk), or there is disagreement regarding apportioning or activity-effect-receptor linkages, it may necessary to seek consultation with industry bodies (e.g. BMAPA or The Crown Estate) regarding allocating responsibility for a cumulative effect.

Disputes regarding the contribution to a cumulative effect made by projects/ developments are likely to be resolved through the normal course of project-specific assessment work (e.g. underwater noise modelling).Therefore, it should be mutually agreed that applicants have exhausted this avenue before consultation is sought regarding the allocation of responsibility, which cannot be carried out in the absence of reliable data and analyses. Even so, expert industry advice/opinion could be useful where projects/developments which are very different in character have completed impact assessment, are contributing to a cumulative effect, and agreement has yet to be reached regarding apportioning/responsibility. For example, consider a complex theoretical case where an offshore wind farm may contribute to bird mortality through collision risk, whilst a nearby aviation scheme may contribute to mortality in the same population by bird strike, and another coastal recreation development may have the potential to impact population productivity through habitat removal. These different mechanisms for the effect (an impact on a given population of birds) make comparison of analyses/outputs difficult.

A5.2. Objective 4 Options: Establishing a cumulative effects assessment framework

The following section describes three potential options for a strategic framework for identifying and scoping cumulative effects. A range of information on similar such frameworks is available in published scientific literature, and a number of reviews of this literature have been carried out (e.g. Natural England 2013, MMO 2013, RenewableUK 2013).

The development of framework options for this project has been guided by the available literature and tailored to meet the needs of MMO. Discussions with MMO personnel from each function have also provided information on these requirements.

CEA can be undertaken in a number of ways. The circumstances under which CEA is carried out means that a variety of methods and tools could potentially be used. Therefore, it was considered prudent to suggest various potential approaches, outlining the possible implications for each MMO function.

Three options are presented in this section. The concept for each option is described, and the applicability to each MMO function is presented. In summary, the options are:

1. A 'top down' approach, considering CEA beginning with the individual effects of a plan, project or activity
2. Similar to Option 1, but discusses a more flexible method following the DPSIR[15] model
3. A 'bottom up' or systems approach, starting with a receptor and considering all potential effects from all possible sources.

There are similarities between the options and each has positives and negatives, the aim of this consultation is to determine which is the best fit for MMO (if any) and to gather information and ideas on where improvements could be made.

This document has been prepared in order to gather feedback on the options developed to date, presented in Sections A5.2.1 to A5.2.3, and as such, comments and suggestions are welcomed in the feedback questionnaire provided. Further, definitive guidance will be provided in the final report once the framework has been refined and fully developed following consultation.

A5.2.1 Option 1

Option 1 is for a source-led approach which starts with the information available on the effects of one particular activity. This option is based on an understanding of the role of MMO as a regulatory body, responsible for ensuring sustainable development within the marine environment and considering cumulative effects of human activities. The information required by MMO in performing these functions is provided by applicants/developers through EIA and HRA, and is required as part of applications for marine licenses. Therefore, a source-led approach is suited to the way the MMO marine licensing team currently operate.

A similar approach is discussed in Natural England (2013), which suggests a generic framework for CEA of human activities in MPAs. This framework was developed for use by Natural England case officers and based on a literature review of existing frameworks. Information from this literature review and the guidance provided has been reviewed and, whilst it is not wholly applicable to the requirements of MMO, the general approach and understanding behind it has proven a useful starting point. Another example is suggested by MacDonald (2000), who proposes a linear, step-by-step process, but suggests that, whilst all steps must be carried out in order for the CEA to be completed effectively, in practice the assessment should be iterative and not necessarily carried out in the sequence provided.

The concept for Option 1 has been based on a wide view of available literature, and it is considered that the source-led approach would consist of a number of steps to be undertaken in order to effectively identify cumulative effects. However, the sequence of these steps is applicable in general terms, and may not necessarily be the most appropriate order for every application. Whilst Option 1 provides a

[15] Driver, Pressure, State, Impact, Response

prescriptive method, it also means that the tool is less flexible and may tend to require the user to input a substantial amount of information, making it less user-friendly.

This approach provides a clear methodology which ensures a consistent approach across MMO. For marine licensing, this option provides a clear process in line with the current application process, although the amount of effort required may not be practical when considering that this is a strategic level tool. This approach may also prove to be too prescriptive for marine planning and marine conservation teams. When considering a plan area, it is not possible to be specific, as there are insufficient data available at this scale to effectively make a judgement. In addition, a source-led approach might prove difficult for the marine conservation team, who's approach to CEA is receptor focused.

Step 1: Outline the goals of CEA
The role of MMO varies to some extent within and between functions. Therefore, the initial step in the Option 1 framework allows flexibility by identifying the goals of CEA on a case-by-case basis. For example, by:

- Describing the purpose and aim of the application and the relevant MMO function
- Identifying the legislation and policy drivers relevant to the assessment
- Clarify definitions of relevant terms, for example, 'cumulative', etc.

Step 2: Define activity pressures
The potential pressures which the plan/project/activity exerts need to be identified. Activity/pressure matrices are a potential means of achieving this. This will provide a basis for the scoping of cumulative effects.

Step 3: Spatio-temporal scale of receptors and pressures
The spatial and temporal scale of the plan/project/activity in question and the extent of the pressures identified should be determined. Next, the scale at which the potential pressures may have effect on a receptor should be determined. Standardised guidelines (e.g. foraging range for birds) on how this will apply at the strategic level will be provided, based on the latest, best available evidence. This information then allows the spatio-temporal scale at which each receptor may be affected to be identified. This is the 'footprint' for the cumulative effects scoping exercise.

Step 4: Identify receptor-pressure interactions
Source-pathway-receptor tables are an effective means of identifying receptor-pressure interactions. These will help the user to understand where effects are likely to occur, by identifying the pathways between the source of an effect and any receptors which may be affected. This step is also useful as an early screening stage in the process.

Table 5.1 provides a few examples of how receptor-pressure interactions can be visualised in this way.

Table 5.1: Example representation of source-pathway-receptor interactions.

Activity	Source	Pathway	Receptor
Offshore Wind Farm	Piling during construction	Underwater noise pressure	Cetaceans
Aggregate extraction	Removal of substrate	Removal of habitat	Benthic species
Aggregate extraction	Removal of substrate	Removal of prey species	Fish species

Step 5: Identify other plans/projects/activities
Within the footprint identified in Step 3 and considering the relevant receptor/pressure interactions identified in Step 4, other plans/projects/activities which may contribute to an effect should be identified. In addition, consideration should be given to other projects that may have potential to contribute to an effect but may be outside of the spatial footprint, the tiered approach detailed in Section A5.1.5 would be one way to approach this.

Step 6: Revise spatio-temporal scale
If appropriate, it may be necessary to revise the footprint of the scoping exercise, based on previous steps, where other activities extend beyond the original spatio-temporal scale or where receptors and/or pressures are screened out as a result of the source-pathway-receptor tables.

Step 7: Receptor/pressure interactions of all plans/projects/activities
This step involves considering the pathways between sources and receptors for all plans/projects/activities to be considered in CEA (see Step 5). Any additional pressures identified through consideration of multiple plans and projects, in addition to the initial subject of the exercise, should be highlighted at this stage and scoped in for further assessment. The effects on receptors may extend beyond purely environmental impacts and include, for example, social and economic impacts.

Step 8: Identify all potential cumulative effects
The receptor-pressures interactions identified in Step 7 should highlight where there are impacts on receptors. This step ensures that those impacts which interact to result in the potential for a cumulative effect are identified to be taken forward to the assessment stage.

Step 9: Consider which developer is responsible for significant cumulative effects and mitigation
A particular issue for MMO in CEA is the process of assigning responsibility for the effects. Therefore, the strategic framework will indicate at which point in the process the issue of responsibility should be considered (see Section A5.1). This will be the final step in the process, before considering the assessment process, as it will depend on which plans/projects/activities have been scoped into the CEA.

A5.2.2 Option 2

Option 2 is guided by the European Environment Agency DPSIR (Drivers – Pressures – State – Impact – Response) model, allowing for the interactions of effects between human activities and the environment to be considered. It has

previously been recommended that this model could be adapted to create a suitable tool for CEA for MMO, facilitating targeting of issues to be included in the assessment (MMO, 2013a). Whilst allowing for a simplified framework that could be utilised effectively by all MMO personnel, this method has the most potential for future-proofing, due to its flexibility. However, this may also mean that more is left open to interpretation, which may have greater potential for error in its application or inappropriate use. In order to avoid this, clear and uniform definition of the framework components will need to be established (Sekovski, Newton & Dennison, 2012).

According to the DPSIR framework there is a chain of causal links starting with 'drivers' or social and economic and socio-cultural forces driving human activities that create a series of 'pressures' on the 'state' of the environment, resulting in a change. The state change is considered to involve an 'impact' if certain effects thresholds are exceeded. This will eventually lead to policy actions or 'responses' by society to the impacts.

This option (Option 2) for the strategic framework is described in more detail in the following sections. The option is framed in a series of questions, which lead the user to consider the interactions between the DPSIR components in a way that is relevant to how MMO operates. The intention is that this would be an iterative approach, with feedback loops throughout the process. These will be considered further, should this option be taken forward.

In a similar way to Option 1, this approach is driven by the source of an effect, which is suited to the way the MMO marine licensing team currently operate. However, the consideration is at a much higher level, allowing for flexibility in the amount of information required. In this way, the framework can be used effectively across the relevant MMO functions. The marine licensing team, using more specific information provided in an application; the marine planning team, by considering the questions more broadly and; the marine conservation team, as the framework it intended to be iterative and flexible.

Step 1: What is the issue?
Determining the nature of the issue is, in the context of the DPSIR model, the identification of the drivers. This requires the definition of the project/plan/activity in as much detail as possible by gathering/signposting as much detail as possible, for example through a marine licence application or sustainability appraisal. As for Option 1, defining the goals of the CEA will greatly assist the user in setting the scene for the CEA, for that particular case.

Step 2: What pressures occur as a result?
Depending on the nature of the activity identified, the resulting pressures should be determined; for example, through activity/pressure matrices (see Option 1). This will provide a base from which the scoping of cumulative effects can begin.

Step 3: Which receptors are affected?
Following the DPSIR model, the state or the characteristics of the environment and ecological receptors need to be identified. The production of source-pathway-

receptor tables (as described in Option1) may facilitate this process. These may also screen out some of the pressures identified in Step 2.

Step 4: Define spatio-temporal boundary
To provide a footprint for the interaction between the drivers, pressures and state, a spatial and temporal boundary is required. Standardised guidelines on how this will apply at the strategic level will be provided, based on the latest, best available evidence.

Step 5: What other activities have the potential to contribute to any effect?
Within the footprint identified in Step 4 and considering the relevant receptor/pressure interactions identified in Step 3, other plans/projects/activities which may contribute to an effect should be identified. In addition, consideration should be given to other projects that may have potential to contribute to an effect but may be outside of the spatial footprint, the tiered approach detailed in Section A5.1.5 would be one way to approach this. It would be important at this stage to identify any additional pressures based on these other activities.

Step 6: What are the potential effects scoped into the assessment?
According to the DPSIR model, pressures can result in a change in state, which can be considered to be an impact. Impacts may include environmental and social and economic changes. For the purposed of the MMO framework, this stage will also apply to the cumulative effect, as suggested in MMO (2013a). This step ensures that those impacts which interact to result in the potential for a cumulative effect are identified to be taken forward to the assessment stage.

Step 7: Who is responsible?
This is part of the response to the effect. Mitigation and other measures may be put in place to control the level of effect (MMO, 2013a). This would need to be considered as the last stage of the process, once all plans/projects/activities have been identified as contributing to a potential cumulative effect and before considering the assessment process.

A5.2.3 Option 3

Option 3 outlines the potential for scoping of cumulative effects taking a ‘bottom up’ or systems approach. From consultation with MMO personnel from different functions, it is clear that this framework will need to be extremely flexible and cover a broad range of activities/purposes. Marine planning are required to take a strategic view of the marine environment, and may be more interested in taking a systems approach to cumulative effects, which looks at potential for effects more broadly, rather than considering the effects of a single project or activity and then identifying what other human activities may contribute to that effect. The marine conservation team also need to consider CEA as a receptor-led approach. This method may be less intuitive for the marine licensing team, as the focus will need to shift from the activity in question to the receptor of an effect. This information should be available within marine licence applications; however, it may prove more time consuming to extract the relevant information.

According to Therivel and Ross (2007), cumulative effects are different to impacts from a single plan or project in that they focus on the receptor rather than the activity.

Option 3 has been developed with this in mind, to initially consider the system or the 'receptor' as the key input to the framework at the outset (hence the 'bottom-up' approach).

At the strategic level this approach may not prove to be the most appropriate. The scale for a receptor and any pressures could be much broader than any plan/project/activity with potential to exert pressures on that receptor; resulting in a lengthy process to screen out plans/projects/activities which will not contribute to an effect.

Step 1: Define goals for CEA
As for the previous options, this will help to set the scene for the CEA, on a case by case basis. For this option, this step will involve considering the aims and the purpose of the CEA, including recognition of policy and legislative drivers and defining terms to be used, however, the focus will inevitably be on the environmental, social and/or economic receptors. Receptors to consider may be identified from, for example, marine licence applications or through the Sustainability Appraisal process. As there could potentially be more than one receptor to consider, the following steps need to be carried out for each one identified.

Step 2: Identify potential pressures on each receptor
The pressures which have potential to cause an effect on the receptors identified should be determined. This could be carried out in a similar way to the activity/pressure matrices for the previous options. In addition, there may be more focused information available, for example, in the marine licence application, which may provide further insight into the pressures with potential to cause an effect.

Step 3: Define spatio-temporal scale of receptor/pressures
To provide a footprint for identifying receptor/pressure interactions (step 4), the spatial and temporal scales of the receptors and pressures require determination. This may cause complications as the scale for a receptor and any pressures could be much broader than any plan/project/activity with potential to exert pressures on that receptor, resulting in a lengthy process to screen out plans/projects/activities which will not contribute to an effect.

Step 4: Receptor/pressure interactions
Source-pathway-receptor tables, as described in Option 1, are an effective means of identifying receptor-pressure interactions. These will help the user to understand where effects are likely to occur, by identifying the pathways between the source of an effect and any receptors which may be affected. This step is also useful as a screening stage in the process.

Step 5: Identify plans/projects/activities that may contribute to an effect
Within the footprint identified in step 3 and considering the relevant receptor/pressure interactions identified in step 4, all plans/projects/activities which may contribute to an effect should be identified. In addition, consideration should be given to other projects that may have potential to contribute to an effect but may be outside of the spatial footprint, the tiered approach detailed in Section A5.1.5 would be one way to approach this.

Step 6: Consider which developer is responsible for significant cumulative effects and mitigation

A particular issue for MMO in CEA is the process of assigning responsibility for the effects. Therefore, the strategic framework will indicate at which point in the process the issue of responsibility should be considered (see Section A5.1). This will be the final step in the process, before considering the assessment process, as it will depend on which plans/projects/activities have been scoped into the CEA.

A5.3 References

Sekovski, I., Newton, A., Dennison, W.C. (2012). Megacities in the coastal zone. Using a drier-pressure-state-impact-response framework to address complex environmental problems. Estuarine, Coastal and Shelf Science 96, 48-59. DOI: doi:10.1016/j.ecss.2011.07.011.

Therivel, R. and B. Ross (2007) Cumulative effects assessment: Does scale matter? Environmental Impact Assessment Review Volume 27: 365 – 385.

Annex 6: Analysis of consultation outputs

Table A6.1: Summary analysis of consultation responses from MMO personnel.

Options	General comments on each option	Number of participants indicating option potentially suitable
Objective 2: Options for assigning responsibility for Cumulative Effects assessment and mitigation		
Option 1: Equal responsibility	Limited in use unless followed by further responsibility assigning. May trigger mitigation measures across multiple projects that may be unnecessary in isolation; may be difficult to gain developers' support.	Planning: 1, Licensing: 0
Option 2: Activity-specific effects	Should be part of a major process, serving as an initial scoping step.	Planning: 4, Licensing:1
Option 3: Apportioning the effect(s)	Fairest approach but has embedded issues and high cost implied. Could be only applied after cumulative impacts assessment is completed.	Planning: 2, Licensing:1
Option 4: Scale of effect	Issues would arise when deciding who causes the biggest impact and how this is decided, considering that projects rarely run to the same timeframe. Could only be applied after cumulative impacts assessment is completed.	Planning: 2, Licensing: 2
Option 5: Allocation of responsibility based on application timeframe	Potential useful approach if applied at a project level. Decisions should be made on a bespoke basis. Similar to current process utilised by licensing teams, where only consented projects are considered for mitigation contribution.	Planning: 2, Licensing: 2
Option 6: Precedents in previous development applications	Should be a recommendation to always apply rather than an option itself. However, common methodology should be sought. May be more applicable at a project level.	Planning: 1, Licensing:1

Options	General comments on each option	Number of participants indicating option potentially suitable
Option 7: Developer forums hosted by MMO	Useful approach that might feed into planning process and policy-making. Resources available may be a key constraint. May be more applicable at a project level.	Planning: 1, Licensing:1
Option 8: Consultation with industry bodies	Would require a method to select appropriate industry bodies to consider.	Planning: 3, Licensing: 0
General comments	With the exception of option 1, the rest of options were thought to be useful in different situations and could be part of an overall decision-process. In any case, option(s) chosen would have to be supported by stakeholders and compelling evidence.	
Objective 4: Options for a framework to identify and scope-in cumulative effects at the strategic level		
Option 1: Source-led approach	Flexible approach that may be applied to different scenarios. Easier and faster to scope factors in and out. A pressure/project orientated method would be an efficient option for stakeholder use. It is similar to current process used, making it straightforward to navigate in. There are some issues related to its application at a strategic planning scale without drowning in evidence.	Planning: 1, Licensing:2
Option 2: DPSIR approach	Appears to be more strategic and theoretical. Most robust and flexible option for both plan and project levels combined. May lack detail for licensing use.	Planning: 2, Licensing:1
Option 3: Bottom-up approach	Most likely to be useful in developing and supporting policy. May be best option for planning but only if evidence on receptors' sensitivity was available. Due to the lack of underlying evidence, it has been deemed not robust enough on the strategic scale.	Planning: 1, Licensing: 0
General comments	It was suggested that options 1 and 3 could be merged into the same framework flow diagram, as they could be used depending on the situation, e.g. concerns raised about a particular receptor or a particular activity.	

Table A6.2: Summary table of consultation results from telephone interviews and online responses.

N.B. These responses were received from a range of regulators, statutory nature conservation bodies, advisors, industry bodies, developers and two anonymous sources.

Industry areas represented include marine aggregates, renewable energy, oil and gas, ports, recreational boating and submarine cables.

Objective 1: Collate current evidence relating to potential high level drivers, pressures and pathways/effects on receptors resulting from marine activities		
Input from consultees	**Description**	
Clarification required	Consultation results showed a need to clarify certain terms to be used in the framework, including differences between cumulative and in-combination effects, sector and activity and criteria to incorporate socio-economic aspects in the database.	
Recommended sources of information	Participants recommended different sources of information that could be used to populate the database, including technical reports, ongoing projects and future work that should be chased. Specifically, the work of JNCC on marine activity lists and pressure descriptions was highlighted and recommended to use in order to ensure a standardised methodology fitting with other projects.	
General comments on consultation process	Consultation analysis showed a general level of confusion regarding the purpose of the framework and implication for developers and other consulted sectors.	
Objective 2: Options for assigning responsibility for Cumulative Effects assessment and mitigation		
Options	**General comments on each option**	**Preferred option and no. of participants (number of participants)**

Option 1: Equal responsibility	Those in favour of using this approach stated that it would only be appropriate to use at an early screening/scoping stage, when information is limited. However, most participants thought that this first option seemed unrealistic, requiring unnecessary input from developers and favouring larger projects.	To use in combination with other options: 3
Option 2: Activity-specific effects	Fine approach already used in industry that leads responsibility assigning. However, some qualified it as simplistic and unfair, and would need to be followed by apportioning tools	To use in combination with other options: 9
Option 3: Apportioning the effect(s)	Sensible and fair approach although requiring a lot of information that could delay projects. Further guidance was recommended by some consultees in terms of means and criteria for enforcement, in order to avoid disagreement between parties. The need for an appeals process in case of disagreement accompanying the option was highlighted.	To use in combination with other options: 8
Option 4: Scale of effect	Applicable at a high level, this was considered the most transparent and fair approach. Some recommendations when applying this option were raised, including the distinction between short and long-term effects and consideration of the effects' magnitude.	To use as a sole option: 5
Option 5: Allocation of responsibility based on application timeframe	Familiar approach to some participants. Helpful approach in providing a hierarchical framework, although availability of information for tier 5 and 6 projects could be a key issue. Would require more flexibility.	To use with some amendments: 4
Option 6: Precedents in previous development applications	Should be a recommendation to always apply rather than a standalone option. Should seek acceptability from SNCBs in terms of information to be used. Other respondents stated the unsuitability of using precedents that may be irrelevant because of regulatory changes.	To use in combination with other options: 6
Option 7: Developer forums hosted by MMO	Useful approach that goes beyond one sector and provides numerous benefits to developers when sharing information. However, guidance on the way they are conducted was proposed to be included, and some claimed that general methodologies would be preferred.	To use in combination with other options: 7

Option 8: Consultation with industry bodies	Could potentially mediate/facilitate discussions regarding the allocation of responsibility within each industry. However, if the allocation needs to occur between industries, where achieving agreement is likely to be difficult, then an independent party may be needed.	To use in combination with other options: 5
General comments	In general, consultees agreed on the importance of further guidance on whether options would be suitable at a project or at a strategic plan level, and the need to rely on stakeholders support. Most of the options where claimed to be appropriate according to certain circumstances and should be combined.	
Objective 4: Options for a framework to identify and scope-in cumulative effects at the strategic level		
Options	**General comments on each option**	**Preferred option and no. of participants**
Option 1: Source-led approach	Logical, systematic and practical approach that matches current practice. It can be used flexibly and provides robust outcomes. Defined parameters in terms of spatio-temporal scale would be needed in order to reduce effort. Statutory advisors could provide guidance on required information and obtaining throughout the process. May be more appropriate for licensing than for planning, and guidance differing how to apply it at these two levels was recommended. A weakness of this option was related to the potential lack of information needed.	5
Option 2: DPSIR approach	Flexible approach that can be used by all parties. May be more suitable at a plan level because of lack of detail.	5
Option 3: Bottom-up approach	Considers all receptors providing a solid evidence base to scope cumulative effects, would deliver technically sound outcomes. Considered suitable for the planning team; however issues on lack of available information were raised.	3
General comments	It was suggested that options 1 and 3 could form an hybrid option where clear guidance on how to use the framework and in which situations would be provided.	

Table A6.3: Summary analysis of comments during workshop testing the framework.

Workshop with stakeholders- Session 1: Testing the framework	
Framework characteristics	**Comments**
Robustness	Robustness of the framework was thought to be heavily reliant upon the underlying database, which users could not test at this stage of the project. Robustness could be weakened by the wish to stretch it over all MMO functions.
Flexibility	The framework was thought to be flexible, able to work at different levels of detail permitting to adjust the level of scoping to available information. The ability to start on the framework from either activity-pressure or receptor-pressure identification was felt to be useful and sensible given potential gaps on information. In general, participants were inclined to think that it would be more suitable at a high level.
Effectiveness	The framework was thought to be effective for screening and scoping exercises for both planning and licensing functions
Suitability across MMO functions	The licensing team would need to apply the framework in early stages and refer back to it throughout the process. They may need a more prescriptive approach. In the case of planning, it was said that it would be useful to incorporate the interface with land use planning (and potentially with other regulators) Conservation functions in MMO could also benefit for the framework thanks to its ability to be a receptor-driven process.
Framework process. Discussion themes	**Comments**
Navigation	Further guidance and inclusion of some examples of outputs expected on each step were recommended to facilitate decision-making throughout the framework, e.g. when a user should start by activity-pressure or receptor-pressure identification. Use of additional steps for clarification or diagrams distinguishing the use of the framework for both planning and licensing functions respectively were seen as necessary. The scoping phase diagram was thought to be confusing, or wrongly allocated within the main framework, as it did not scope in or out pressures, but served as a process to decide where to start in the framework.

Concerns on application of the framework	There were concerns on how the use of the framework would affect the developer. Whether information provided by the tool would be a duplication of that provided by the developer, and whether it would be too late to rise issues not addressed by developers but already submitted in applications. Concerns that the process was too similar to the EIA process, and differences would need to be highlighted. Concerns that the level of workload for developers would increase.
Concerns on database outputs and use	Reliance on database and available information could be inadequate. Criteria to make judgement on evidence provided by database. Elaboration of guidelines on which pathways should be considered when using the framework and database outputs was recommended.
General comments	Clear and useful process that provides MMO personnel to use a common methodology, improving transparency when scoping cumulative effects. The tool should be used at early stages in the application process. Further guidance is needed in order to ensure that the tool is used in the same way by any user, and that would provide same results.
Workshop with stakeholders- Session 2: Validating the framework, using case studies	
Planning case study	**Comments**
Concerns	Outcomes of the exercise would depend on the user deciding which pressures to consider or not. What would be the subsequent steps after the scoping exercise? How would you reduce the list of common pressures? The process could lead to too much being scoped in unnecessarily and only ‘no potential for effect’ would be scoped out.
Recommendations	To emphasize the importance of answering the first step in the process clearly, what is the goal of the scoping exercise and the expected outcome, ensuring a smooth navigation throughout the framework. Receptor-pressure identification was seen as an easier and more sensible starting point for planning, permitting to only consider pressures that affect important species. Confidence in the data used and provided by the database is required. Clarify terminology used across the framework; highlight differences in EIA/HRA
Licensing case study	**Comments**

Concerns	The process works but participants questioned its usefulness at such a high level. The lack of guidance or information on the spatio-temporal scale of pressures could be a key constraint. Tool proved to be useful in scoping pressures in, but not out. Time required to use the framework, additional cost for applicants.
Recommendations	To test the framework with actual pilot projects. Requires further work to ensure the process is sped up, and projects are not held up. The evidence in the database needs to be checked and updated regularly.

Annex 7: Practical application of the framework – case studies and supporting tables

The proposed framework has been applied to two case studies to demonstrate how it may work in practice at the project and/or plan level. The focus within the case studies is on environmental assessment; however the framework could also be applied to a social or economic assessment once this aspect has been fully developed. The purpose of using case studies is to test and validate the strategic framework but they also provide a practical example of its functionality highlighting the differences in the plan and project level approaches. The scenarios have been chosen as the information required for each is in the public domain or realistic assumptions can be made. The result of the case studies does not represent the view of MMO on any decision made in each case. The scenarios for each case study are presented below, with information on how each of the framework steps have been applied.

A7.1 Project level: Offshore wind developments, Greater Wash

A7.1.1 Practical application of the framework

This is a previous case with information available in the public domain through the MMO public register. Applications were been made for three offshore wind farm developments in the Greater Wash area. The applications are supported by an EIA and HRA, which indicate there are likely significant effects of the proposed activities on European sites in the area.

Docking Shoal

The Docking Shoal offshore wind farm application, for a site with a maximum generating capacity of 540 MW, was submitted by Centrica (DSW) Limited to the Secretary of State in December 2008. Subsequent modifications submitted in July 2011 sought consent for an initial phase construction of up to 100 MW. The full 540 MW site comprises up to 108 turbines, in an area of around 75 km^2, with 3 offshore sub-stations and inter-array cabling linking the turbines and the offshore sub-stations.

Race Bank

The Race Bank offshore wind farm application, for a site with a maximum generating capacity of 620 MW, was submitted by Centrica (RBW) Limited in January 2009. Subsequent modifications submitted in July 2011 reduced the maximum capacity to 580 MW for a development comprising up to 116 turbines in an area of up to 65 km^2, 3 offshore sub-stations and inter-array cabling linking the turbines and offshore sub-stations.

Dudgeon

The Dudgeon offshore wind farm application, for a site with a maximum generating capacity of 560 MW, was submitted by Warwick Energy Limited in June 2009. The proposed development comprises up to 168 turbines in an area of around 35 km^2, 3 offshore sub-stations, 4 meteorological masts, inter-array cabling, and an accommodation platform.

Setting the scene

A7.1.2 Define the purpose of the CEA

It has been indicated within the HRA that there is potential for a likely significant effect on European sites in the Greater Wash area, as a result of the in-combination effects of the proposed projects. Therefore, CEA is required. As this is under the Habitats Regulations, cumulative effects should be defined as 'in-combination' effects on the integrity of designated sites.

In this scenario, the MMO licensing team would work with the Department of Energy and Climate Change (DECC), who are responsible for making the final decision on the consents. As such, a high level of understanding of the likely issues is required to ensure that all projects which MMO are aware of are included within the assessment.

A7.1.3 Identification of the primary focus of the CEA

The primary focus of this scoping exercise should be the potential for cumulative effects generated from offshore wind development.

Scoping

A7.1.4 Identification of the primary activity-pressures

The evidence database will provide a list of the linkages between each activity and the pressures they have the potential to exert. Figure A7.1 provides an example of an activity-pressure linkage table for the construction of offshore wind farms.

Figure A7.1: Project level case study: Offshore Wind Farms, Greater Wash - activity-pressure linkages (screenshot from evidence database).

Renewable energy - Wind - Construction	Underwater noise changes - low and mid-frequency impulsive sounds
	Transition elements & organo-metal contamination
	Physical loss
	Habitat structure changes - removal of substratum
	Disturbance of the substrate below the surface of the seabed
	Changes in suspended solids
	Siltation rate changes
	Underwater noise changes - high frequency impulsive sounds
	Death or injury by collision
	Physical change
	Barrier to species movement

Renewable energy - Wind - Operation	Introduction of light
	Wave exposure changes
	Transition elements & organo-metal contamination
	Sediment transport changes
	Changes in suspended solids
	Physical loss
	Physical change
	Introduction or spread of non-indigenous species
	Habitat structure changes - removal of substratum
	Water flow changes
	Siltation rate changes
	Barrier to species movement
	Death or injury by collision
	Underwater noise changes - low and mid-frequency impulsive sounds
Renewable energy - Wind - Decommissioning	Physical change
	Underwater noise changes - high frequency impulsive sounds
	Changes in suspended solids
	Physical damage
	Sediment transport changes
	Siltation rate changes

A7.1.5 Identification of the primary receptor-pressures

The database will also allow the user to produce a table which links the activity-pressures to the receptors which are sensitive to those pressures. This provides an initial view of the receptor groups which need to be considered in the scoping exercise. An excerpt of this table is provided for the project level case study (see Figure A7.2).

Project level: Offshore wind developments, Greater Wash

Figure A7.2: Extract of the summary table showing links between activity-pressures and sensitive receptors (screenshot from evidence database).

Activity	Pressure	Receptor
Renewable energy - Wind - construction	Barrier to species movement	Birds
Renewable energy - Wind - construction	Barrier to species movement	Fish and pelagic habitat (inc. plankton)
Renewable energy - Wind - construction	Barrier to species movement	Marine mammals and reptiles
Renewable energy - Wind - construction	Death or injury by collision	Birds
Renewable energy - Wind - construction	Death or injury by collision	Fish and pelagic habitat (inc. plankton)
Renewable energy - Wind - construction	Death or injury by collision	Marine mammals and reptiles
Renewable energy - Wind - construction	Disturbance of the substrate below the surface of the seabed	Benthic habitat and species
Renewable energy - Wind - construction	Disturbance of the substrate below the surface of the seabed	Hydrography
Renewable energy - Wind - construction	Disturbance of the substrate below the surface of the seabed	Topography/Bathymetry
Renewable energy - Wind - construction	Habitat structure changes - removal of substratum	Benthic habitat and species
Renewable energy - Wind - construction	Habitat structure changes - removal of substratum	Birds
Renewable energy - Wind - construction	Habitat structure changes - removal of substratum	Fish and pelagic habitat (inc. plankton)
Renewable energy - Wind - construction	Habitat structure changes - removal of substratum	Marine mammals and reptiles
Renewable energy - Wind - construction	Habitat structure changes - removal of substratum	Topography/Bathymetry

A7.1.6 Determining the appropriate study area (spatial and temporal)

Spatial scale is well defined in the project documentation. Docking Shoal covers an area of 75 km^2, Race Bank 65 km^2 and Dudgeon 35 km^2. All three projects lie in the south of the Greater Wash:

- Docking Shoal lies approximately 14 km from the north Norfolk coast
- Race Bank lies approximately 27 km from the north Norfolk coast
- Dudgeon lies approximately 32 km from the north Norfolk coast.

There are three designated Marine Protected Areas (MPAs) located adjacent to the projects:

- The Wash and North Norfolk Coast SAC – designated for marine mammals and benthic habitats and species
- North Norfolk Coast SPA – designated for birds
- Inner Dowsing Race Bank and North Ridge cSAC – designated for benthic habitats.

Although additional receptors were identified in the previous step, based on this information it is appropriate to scope in birds, marine mammals and benthic habitats and species from the list of receptors in the database. This is because the purpose of the CEA is an in-combination assessment of the potential for adverse effects on the features of the designated sites.

Similarly, the majority of the pressures identified are only exerted within the boundary of the wind farm site and cable corridor, therefore, it is not necessary to expand the footprint. The exception is underwater noise, which requires review of the noise modelling undertaken for each project (available within the ES) and is only applicable during construction periods. The worst case distance for displacement of marine mammals has been modelled at 14 km for Docking Shoal, therefore, this has been used for the purposes of this case study. It is also appropriate to consider the scale of each receptor even though they are features of MPAs. Mobile receptors such as marine mammals and birds utilise areas outside of the MPA boundary which could overlap with the project boundaries.

This suggests that both of these receptors could potentially overlap with the activity and activity-pressure spatial extents.

The temporal scales suggested in the project documentation are as follows:

- Docking Shoal –proposed commencement of construction 2016-17, operational from 2018
- Race Bank – proposed commencement of construction 2015-17, operational from 2015-17
- Dudgeon – proposed commencement of construction 2015, operational from 2016.

This suggests that there is potential for construction and operational pressures to occur at the same time, adjacent to the MPAs. There is no information available for decommissioning timeframes.

The overall footprint for the scoping exercise therefore includes:

- The proposed offshore wind farm boundaries plus a 14km zone around the boundary, to take account of potential effects of noise (during construction only)
- The proposed cable routes
- The boundaries of the MPAs.

A7.1.7 Defining sources and pathways

The purpose of this step is to understand where effects could potentially occur by identifying the source of a pressure and the pathway to a receptor which may be sensitive to that pressure. An effective way of achieving this is to consider how pressures from each activity might cause an effect on a receptor; inputting further detail into the activity-pressure-receptor tables used earlier in the process.

The database allows the user to export the activity-pressure-receptor tables, produced by the database earlier in the process, to Excel. Once in Excel, the user is able to filter the table to view the relevant data for the primary focus and can add ‘source’ and ‘pathway’ columns to the table. Full source-pathway tables for the Great Wash offshore wind farms case study are provided in Table A7.1.

A description of ‘no pathway’ within the tables indicates that although the broader pressure can potentially have an effect on the receptor group, the more specific aspect of the pressure resulting from the activity in question has no known pathway to influence the receptor group. Following this, that pressure can be scoped out of the assessment.

Table A7.1: Project level case study: Offshore Wind Farms, Greater Wash – activity-pressure-receptor table for primary activity. Grey cells indicate that receptors may be scoped out of the process. Confidence levels are available in the database.

Activity	Source	Pressure	Pathway	Receptor
Renewable energy - Wind - construction	Physical presence of construction works	Barrier to species movement	Displacement from feeding areas	Birds
	Increased suspended sediment concentrations or noise	Barrier to species movement	Avoidance of wind farm area	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Vessel movements associated with construction activities	Death or injury by collision	No pathway	Birds
				Fish and pelagic habitat (including plankton)
			Death or injury by collision with moving vessels	Marine mammals and reptiles
	Preparation of the seabed requires dredging operations	Disturbance of the substrate below the surface of the seabed	Seabed disturbance and material extraction	Benthic habitat and species
			Hydrographical changes	Hydrography
			Extraction of sediment may affect local bathymetry	Topography/ Bathymetry
		Habitat structure changes - removal of substratum	Seabed disturbance and material extraction	Benthic habitat and species
			No pathway	Birds
				Marine mammals and reptiles
			Potential effect on spawning/nursery grounds	Fish and pelagic habitat (including plankton)

Activity	Source	Pressure	Pathway	Receptor
Renewable energy - Wind - construction	Preparation of the seabed will require dredging operations	Habitat structure changes - removal of substratum	Extraction of sediment may affect local bathymetry	Topography/ Bathymetry
	Temporary disturbance and modification of seabed habitats (e.g. anchoring, presence of jack up vessels legs on the seabed)	Physical loss	Habitat disturbance, abrasion	Benthic habitat and species
			Loss of feeding resources	Birds
			Temporary displacement	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			No pathway	Topography/ Bathymetry
	Disturbance of seabed	Siltation rate changes	Smothering potential after deposition of sediments	Benthic habitat and species
			Effect on respiration	Fish and pelagic habitat (including plankton)
			Effect on respiration	Marine mammals and reptiles
	Remobilisation of contaminants in the sediment	Transition elements & organo-metal contamination	Biota disturbance	Benthic habitat and species
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			Feed on prey affected by pollutants	Birds
			Water quality	Hydrography
	Piling noise and machinery	Underwater noise changes - high	Underwater noise	Fish and pelagic habitat (including plankton)

Activity	Source	Pressure	Pathway	Receptor
Renewable energy - Wind - construction		frequency impulsive sounds	Underwater noise	Marine mammals and reptiles
	Vessel traffic	Underwater noise changes - low and mid-frequency impulsive sounds	Underwater noise	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
Renewable energy - Wind - operation	Physical presence of the wind farm	Barrier to species movement	Avoidance of wind farm area	Birds
			No pathway	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Operation of the wind farm	Death or injury by collision	Birds striking turbine towers, nacelles or rotors	Birds
			No pathway	Fish and pelagic habitat (including plankton)
			Collision with maintenance vessels	Marine mammals and reptiles
	Presence of turbine foundations producing scour	Habitat structure changes - removal of substratum	Habitat disturbance	Benthic habitat and species
			No pathway	Birds
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			Sediment transport may be affected	Topography/ Bathymetry
	Light used to alert boats of	Introduction of light	Disorientation	Birds

Activity	Source	Pressure	Pathway	Receptor
Renewable energy - Wind - operation	wind farm presence	Introduction or spread of non-indigenous species	No pathway	Benthic habitat and species
				Fish and pelagic habitat (including plankton)
	Placement of turbine foundations and any scour protection where required	Physical loss	Habitat loss	Benthic habitat and species
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			Loss of feeding opportunities	Birds
			Sediment transport may be affected	Topography/ Bathymetry
	Scour effects may lead to removal of seabed sediment by hydrodynamic forces, impact on slope processes and may potentially lead to a decrease in sediment supply to intertidal habitats	Sediment transport changes	Sediment transport may be affected	Topography/ Bathymetry
	Scour can lead to high turbidity and increased suspended sediment concentration	Siltation rate changes	Biological disturbance	Benthic habitat and species
			Affects visibility and respiration	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles

Activity	Source	Pressure	Pathway	Receptor
Renewable energy - Wind - operation	Contaminants may be released in accidental pollution events involving maintenance vessels	Transition elements & organo-metal contamination	Biota disturbance	Benthic habitat and species
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			Feed on prey affected by pollutants	Birds
			Water quality	Hydrography
	Operational wind turbines	Underwater noise changes - low and mid-frequency impulsive sounds	Underwater noise	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Change to the water flow across the sediment due to the presence of tower and foundations	Water flow changes	Habitat changes	Benthic habitat and species
			No pathway	Birds
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			Effects on water movement	Hydrography
			Effects on sediment transport	Topography/ Bathymetry
	Wave shape, form and direction can be affected by the presence of the wind farm	Wave exposure changes	Habitat changes	Benthic habitat and species
			No pathway	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles

Activity	Source	Pressure	Pathway	Receptor
Renewable energy - Wind - operation	Wave shape, form and direction can be affected by the presence of the wind farm	Wave exposure changes	Wave energy changes	Hydrography
			Effects on sediment transport	Topography/ Bathymetry
Renewable energy - Wind - decommissioning	Removal of an array of foundations	Sediment transport changes	Effects on sediment transport	Topography/ Bathymetry
	Disturbance of the seabed	Siltation rate changes	Biota disturbance	Benthic habitat and species
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Use of explosives	Underwater noise changes - high frequency impulsive sounds	Underwater noise	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Removal of foundations	Physical change	No pathway	Topography/ Bathymetry
			Water flow changes	Hydrography
			Removal of habitats that grew on foundations	Benthic habitat and species

A7.1.8 Identify other activities

All three developments considered within the spatio-temporal footprint should be scoped in at this stage. For the purposes of this project, the identification of other activities has been undertaken using data on the Marine Planning Portal. Please note that in reality, MMO would use internal data sources, such as SPIRIT, which are regularly updated and contain GIS co-ordinates of each plan, project or activity.

Other activities identified within this footprint using the Marine Planning Portal data and activity categories:

- Military practice areas – within the SAC.
- Aggregate dredging – outside of the SPA/SAC sites, further offshore.
- Inshore fisheries – mobile and static gears – within the SAC.
- Recreation:
    - RYA – cruising routes, racing areas and sailing areas.
    - Sightseeing.
    - Horse riding beaches.
    - Boat launch slipways.

A7.1.9 Reconsider spatio temporal scale

As the primary focus of the exercise is an activity, the spatio-temporal scale should not be increased by any other activities identified. However, where sources and pathways identify no link between an activity and a pressure and/or receptor, the spatio-temporal extent of these can be removed from the study area.

Upon reconsideration, the study area did not require any changes.

A7.1.10 Defining the sources and pathways for all activities

The purpose of this step is to understand where effects could potentially occur by pinpointing the source of the pressures from the other activities under consideration which overlap with those of the primary activity and the pathway to the receptor(s) which may be sensitive to those pressures (activity-focused).

Table A7.3 shows the sources and pathways for the activity-receptor-pressure links for the other activities scoped into the exercise.

Table A7.3: Project level case study: Offshore Wind Farms, Greater Wash – activity-pressure-receptor table for all activities scoped in. Where there is potential for cumulative effect (PCE), these are highlighted in pink. The primary activity is included for reference and is highlighted in green. Confidence levels are available in the database.

Activity	Source	Pressure	Pathway	Receptor
Coastal tourist sites	Trampling of coastal areas	Disturbance of the substrate below the surface of the seabed	No pathway	Benthic habitat and species
		Disturbance of the substrate below the surface of the seabed	No pathway	Hydrography
		Disturbance of the substrate below the surface of the seabed	No overlap between offshore wind farm area, therefore no PCE	Topography/Bathymetry
	Car parking facilities for sightseeing	Physical loss	PCE if potential for displacement from breeding areas on coast in addition to foraging habitat of offshore wind farm	Birds
			No pathway	Benthic habitat and species
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			No overlap between offshore wind farm area, therefore no PCE	Topography/Bathymetry
Extraction - Aggregates	Increase in suspended sediment concentration	Barrier to species movement	No link to offshore wind farm area, therefore no PCE	Birds
	Increase in suspended sediment	Barrier to species movement	No link to offshore wind farm area, therefore no PCE	Fish and pelagic habitat (including plankton)

Activity	Source	Pressure	Pathway	Receptor
Extraction - Aggregates	concentration			Marine mammals and reptiles
	Presence and movement of large vessels	Death or injury by collision	No pathway	Birds
				Fish and pelagic habitat (including plankton)
			Death or injury by collision with moving vessels	Marine mammals and reptiles
	Abrasion from the pass of the dredge head	Disturbance of the substrate below the surface of the seabed	No overlap between offshore wind farm area, therefore no PCE	Benthic habitat and species
				Topography/Bathymetry
			No link to offshore wind farm area, therefore no PCE	Hydrography
	Removal of seabed	Habitat structure changes - removal of substratum	No overlap between offshore wind farm area, therefore no PCE	Benthic habitat and species
			Changes to prey availability	Birds
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			No overlap between offshore wind farm area, therefore no PCE	Topography/ Bathymetry
	Removal of material may cause drawdown of material from elsewhere	Sediment transport changes	PCE if links between aggregate and offshore wind farm areas	Topography/ Bathymetry
	Increase in turbidity, due to sediment plume	Siltation rate changes	No link to offshore wind farm area, therefore no PCE	Benthic habitat and species
			PCE for mobile species, may be displaced from both aggregate extraction and offshore wind farm	Fish and pelagic habitat (including plankton)
				Marine mammals and

Activity	Source	Pressure	Pathway	Receptor
Extraction - Aggregates			areas	reptiles
	Minor possibility through discarded litter	Transition elements & organo-metal contamination	No link to offshore wind farm area, therefore no PCE	Benthic habitat and species
			No pathway	Birds
				Fish and pelagic habitat (including plankton)
				Hydrography
				Marine mammals and reptiles
	Presence and movement of large vessels	Underwater noise changes - low and mid-frequency impulsive sounds	PCE for mobile species, may be displaced from both aggregate extraction and offshore wind farm areas	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Removal of seabed	Water flow changes	No pathway	Benthic habitat and species
				Birds
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			No link to offshore wind farm area, therefore no PCE	Hydrography
				Topography/Bathymetry
		Wave exposure changes		Benthic habitat and species
			PCE if links between aggregate and offshore wind farm areas	Fish and pelagic habitat (including plankton)
				Hydrography
				Marine mammals and reptiles

Activity	Source	Pressure	Pathway	Receptor
			No overlap between offshore wind farm area, therefore no PCE	Topography/Bathymetry
Fishing - mobile gears	Abrasion from towing fishing gear	Disturbance of the substrate below the surface of the seabed	No link to offshore wind farm area, therefore no PCE	Benthic habitat and species
				Hydrography
				Topography/Bathymetry
	Fishing gear, crushing, burying and exposing benthic organisms	Habitat structure changes - removal of substratum	No link to offshore wind farm area, therefore no PCE	Benthic habitat and species
			Changes to prey availability	Birds
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Fishing gear, crushing and changes to seabed	Habitat structure changes - removal of substratum	No link to offshore wind farm area, therefore no PCE	Topography/Bathymetry
	Towing fish gear causing suspension of sediment	Siltation rate changes	No link to offshore wind farm area, therefore no PCE	Benthic habitat and species
			PCE for mobile species, may be displaced from both aggregate extraction and offshore wind farm areas	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
Fishing - static gears	Abrasion due to disturbance from anchor systems or weights	Disturbance of the substrate below the surface of the seabed	No link to offshore wind farm area, therefore no PCE	Benthic habitat and species
				Hydrography
				Topography/Bathymetry
Military activities	Artillery testing, presence/movement of vessels	Death or injury by collision	No pathway	Birds

Activity	Source	Pressure	Pathway	Receptor
Military activities	Artillery testing, presence/movement of vessels	Death or injury by collision	Death or injury of individuals through collision with vessels/artillery	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
		Siltation rate changes	No link to offshore wind farm area, therefore no PCE	Benthic habitat and species
			Changes in prey availability	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Discarded artillery testing paraphernalia	Transition elements & organo-metal contamination	No link to offshore wind farm area, therefore no PCE	Benthic habitat and species
				Fish and pelagic habitat (including plankton)
				Hydrography
				Marine mammals and reptiles
			Feed on prey affected by pollutants	Birds
	Artillery testing, presence/movement of vessels	Underwater noise changes - high frequency impulsive sounds	PCE for mobile species, may be displaced from both aggregate extraction and offshore wind farm areas	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Movement of larger vessels	Underwater noise changes - low and mid-frequency impulsive sounds	PCE for mobile species, may be displaced from both aggregate extraction and offshore wind farm areas	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
Recreational activities - horse riding	Trampling of coastal areas, riding along beaches	Habitat structure changes - removal of substratum	No pathway	Benthic habitat and species

Activity	Source	Pressure	Pathway	Receptor
Recreational activities - horse riding	Trampling of coastal areas, riding along beaches	Habitat structure changes - removal of substratum	No pathway	Birds
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
				Topography/Bathymetry
Recreational activities - sailing (yachting)	Presence and movement of yachts	Death or injury by collision	No pathway	Birds
				Fish and pelagic habitat (including plankton)
			Possible collision with small, high speed vessels	Marine mammals and reptiles
	Launching of craft and anchor drag	Disturbance of the substrate below the surface of the seabed	No link to offshore wind farm area, therefore no PCE	Benthic habitat and species
				Hydrography
				Topography/Bathymetry
	Turbidity due to boat movements	Siltation rate changes	No link to offshore wind farm area, therefore no PCE	Benthic habitat and species
			Changes in prey availability	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Anti-fouling paint	Transition elements & organo-metal contamination	No link to offshore wind farm area, therefore no PCE	Benthic habitat and species
				Birds
				Fish and pelagic habitat (including plankton)
				Hydrography
				Marine mammals and reptiles

Activity	Source	Pressure	Pathway	Receptor
Recreational activities - sailing (yachting)	Use of auxiliary engines	Underwater noise changes - high frequency impulsive sounds	PCE for mobile species, may be displaced from both aggregate extraction and offshore wind farm areas	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
Renewable energy - Wind - construction	Increased suspended sediment concentrations or noise	Barrier to species movement	Physical presence of works, displacement from feeding areas	Birds
			Avoidance of wind farm area	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Vessel movements associated with construction activities	Death or injury by collision	Death or injury by collision with moving vessels	Marine mammals and reptiles
	Preparation of the seabed will require dredging operations	Disturbance of the substrate below the surface of the seabed	Seabed disturbance/extraction	Benthic habitat and species
			Hydrographical changes	Hydrography
			Extraction of sediment may affect local bathymetry	Topography/Bathymetry
		Habitat structure changes - removal of substratum	Seabed disturbance and material extraction	Benthic habitat and species
			Potential effect on spawning/nursery grounds	Fish and pelagic habitat (including plankton)
			Extraction of sediment may affect local bathymetry	Topography/Bathymetry
	Temporary disturbance and modification of seabed habitats (e.g. anchoring, presence of jack up vessels legs on the seabed)	Physical loss	Habitat disturbance, abrasion	Benthic habitat and species
			Loss of feeding resources	Birds
			Temporary displacement	Fish and pelagic habitat (including plankton)
			Temporary displacement	Marine mammals and reptiles

Activity	Source	Pressure	Pathway	Receptor
Renewable energy - Wind - construction	Disturbance of seabed	Siltation rate changes	Smothering potential after deposition of sediments	Benthic habitat and species
			Effect on respiration	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Remobilisation of contaminants in the sediment	Transition elements & organo-metal contamination	Biota disturbance	Benthic habitat and species
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			Feed on prey affected by pollutants	Birds
			Water quality	Hydrography
	Piling noise and machinery	Underwater noise changes - high frequency impulsive sounds	Underwater noise	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Vessel traffic	Underwater noise changes - low and mid-frequency impulsive sounds	Underwater noise	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
Renewable energy - Wind - operation	Physical presence of the wind farm	Barrier to species movement	Avoidance of wind farm area	Birds
	Operation of the wind farm	Death or injury by collision	Birds striking turbine towers, nacelles or rotors	Birds
			Collision with maintenance vessels	Marine mammals and reptiles

Activity	Source	Pressure	Pathway	Receptor
Renewable energy - Wind - operation	Presence of turbine foundations producing scour	Habitat structure changes - removal of substratum	Habitat disturbance	Benthic habitat and species
			Sediment transport may be affected	Topography/Bathymetry
	Light used to alert boats of wind farm presence	Introduction of light	Disorientation	Birds
	Placement of turbine foundations and any scour protection where required	Physical loss	Habitat loss	Benthic habitat and species
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			Loss of feeding opportunities	Birds
			Sediment transport may be affected	Topography/Bathymetry
	Scour effects may lead to removal of seabed sediment by hydrodynamic forces, impact on slope processes and may potentially lead to a decrease in sediment supply to intertidal habitats	Sediment transport changes	Sediment transport may be affected	Topography/Bathymetry
	Scour can lead to high turbidity and increased suspended sediment concentration	Siltation rate changes	Biological disturbance	Benthic habitat and species
		Siltation rate changes	Affects visibility and respiration	Fish and pelagic habitat (including plankton)
		Siltation rate changes	Affects visibility and respiration	Marine mammals and

Activity	Source	Pressure	Pathway	Receptor
Renewable energy - Wind - operation				reptiles
	Contaminants may be released in accidental pollution events involving maintenance vessels	Transition elements & organo-metal	Biota disturbance	Benthic habitat and species
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			Water quality	Hydrography
			Feed on prey affected by pollutants	Birds
	Operational wind turbines	Underwater noise changes - low and mid-frequency impulsive sounds	Underwater noise	Fish and pelagic habitat (including plankton)
	Operational wind turbines	Underwater noise changes - low and mid-frequency impulsive sounds	Underwater noise	Marine mammals and reptiles
	Change to the water flow across the sediment due to the presence of tower and foundations	Water flow changes	Habitat changes	Benthic habitat and species
			Effects on water movement	Hydrography
			Effects on sediment transport	Topography/Bathymetry
	Wave shape, form and direction can be affected by the presence of the wind farm	Wave exposure changes	Habitat changes	Benthic habitat and species
			Wave energy changes	Hydrography
			Effects on sediment transport	Topography/Bathymetry
Renewable energy - Wind - decommissioning	Removal of an array of foundations	Sediment transport changes	Effects on sediment transport	Topography/Bathymetry

Activity	Source	Pressure	Pathway	Receptor
Renewable energy - Wind - decommissioning	Disturbance of the seabed	Siltation rate changes	Biota disturbance	Benthic habitat and species
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Use of explosives	Underwater noise changes - high frequency impulsive sounds	Underwater noise	Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
	Removal of foundations	Physical change	Water flow changes	Hydrography
			Removal of habitats that grew on foundations	Benthic habitat and species

A7.1.11 Management of potential cumulative effects and mitigation measures

Although not discussed in relation to this case study, the management of CEA and mitigation of cumulative effects in the marine environment is a crucial element of MMO's role. In some cases, how to manage the contribution of different projects is laid out clearly within legislation. Where legislation doesn't provide a clear solution, the framework considers 'responsibility' in the following ways:

- Contribution to an assessment – whereby developers may be required to provide information to enable better assessments and to promote cooperation with other developers.
- Mitigation – where there is a significant cumulative effect, facilitating identification of which developer(s) is/are responsible for mitigating the effect.

Any decisions made on how to manage this, in particular where further action is required (i.e. mitigation), need to be based on a proportionate and risk based approach supported by appropriate level of evidence and advice from statutory bodies as appropriate. Involvement of industry/sectors in these decisions can be crucial to develop a common understanding and agreement which will help to avoid potential future issues. Transboundary issues, where they become apparent, will also need to be addressed by liaison with regulatory counterparts in neighbouring countries, as appropriate.

Within this case study, the approach taken was 'apportioning the effects' (see Section 4.9) where the levels of contribution of each activity to the effect were used to apportion mitigation requirements accordingly.

A7.1.12 Assessment

At this point, the activities, pressures and receptors have been identified and scoped in/out and more detailed assessment of the effects can begin.

A7.2 Plan level: Large scale vs. small scale activity

A7.2.1 Practical application of the framework

This is a hypothetical future scenario for marine planning, which aims to facilitate consideration of whether the cumulative effects relating to a large number of small-scale activities are greater than or less than the cumulative effects relating to a small number of large-scale activities. Work of this nature could, for example, help identify whether there is a need to consider measures to highlight and reduce cumulative effects resulting from small or large scale activities through the marine plans where appropriate if net benefits are outweighed by the net adverse effects.

The case study requires the evaluation of the potential for cumulative effects where the primary focus is a) a large scale activity, aggregate dredging, and b) a small scale activity, recreational sailing. The precise geographical location is unclear, however, there is a need to test how to approach such a scenario, as there is an indication that this could be a particular issue across all activities in the future.

Use of the framework to inform marine planning would be undertaken with information on actual activities within marine plan areas where available.

Sailing club
The local sailing club was founded in 1955 and has grown rapidly since. They have a purpose built clubhouse and a number of club-owned training boats available to loan. The waters surrounding the clubhouse often experience heavy sailing traffic, with the majority of users opting for smaller-sized day boats and yachts. The club is located adjacent to a cruising route and recreational sailing area. The sport has grown increasingly popular in recent years and it is expected that the consistent growth of the club will continue.

Potential aggregate extraction site
Prospecting for marine aggregates in the area adjacent to the sailing club activity suggests sand and gravel resources are present and there is potential for extraction zones to be applied for in the future.

Setting the scene

A7.2.2 Define the purpose of the CEA

The potential for cumulative effects of a large activity versus multiple small scale activities needs to be considered, to understand how these activities need to be accounted for within the marine plan for the area. In addition, consideration should be given to how the scoping of cumulative effects differs if large scale or small scale activities are regarded as the primary focus. If there is potential for cumulative effects, careful consideration of the objectives for each activity within the marine plan policies will be required, including whether there are opportunities for co-existence through mitigation of potential effects.

Assumptions may need to be made on the potential for growth of the sailing club, including:

- The amount of data available.
- The scale of the area which needs to be considered.

Consideration of the contribution to cumulative effects and which activities might be required to provide mitigation measures should be considered throughout the scoping process at the appropriate stages. This will highlight where further information may be required and where collaboration between activities may prove beneficial to the environment, surrounding activities and communities.

A7.2.3 Identification of the primary focus of the CEA

In this case, the scoping exercise needs to be undertaken twice: once with aggregate extraction as the primary focus and once with sailing as the primary focus. A comparison can then be made on the final outputs. Therefore, the outputs for this case study would be:

- Primary focus – Extraction-aggregates
- Primary focus – Recreational activities – sailing (yachting).

Scoping

A7.2.4 Identification of the primary activity-pressures

The evidence database will provide a list of the linkages between each activity and the pressures they have the potential to exert. Table A7.4 provides an example of the linkages between the activity of 'Extraction-aggregates' and the respective pressures associated with this. Table A7.5 provides an example of the linkages between the activity of 'Recreational activities-sailing (yachting)' and the pressures relevant to this.

Table A7.4: Planning level case study: Extraction-aggregates as primary focus - activity-pressure linkages (screenshot from evidence database).

Extraction - Aggregates	Radionuclide contamination
	Sediment transport changes
	Organic enrichment
	Deoxygenation
	Transition elements & organo-metal contamination
	Synthetic compound contamination
	Underwater noise changes - low and mid-frequency impulsive sounds
	Visual disturbance
	Removal of non-target species
	Water flow changes
	Wave exposure changes
	Emergence regime change
	Barrier to species movement
	Siltation rate changes
	Changes in suspended solids
	Disturbance of the substrate below the surface of the seabed
	Habitat structure changes - removal of substratum
	Death or injury by collision

Table A7.5: Planning level case study: Recreational activities-sailing (yachting) as primary focus - activity-pressure linkages (screenshot from evidence database).

Recreational activities - sailing (yachting)	Deoxygenation
	Introduction or spread of non-indigenous species
	Transition elements & organo-metal contamination
	Visual disturbance
	Synthetic compound contamination
	Siltation rate changes
	Litter
	Organic enrichment
	Disturbance of the substrate below the surface of the seabed
	Underwater noise changes - low frequency continuous sounds
	Death or injury by collision
	Underwater noise changes - high frequency impulsive sounds

A7.2.5 Identification of the primary receptor-pressures

The database will also allow the user to produce a table which links the activity-pressures to the receptors which are potentially sensitive to those pressures. This provides an initial view of the receptor groups which need to be considered in the scoping exercise. Table A7.6 provides an example of an 'activity-pressure-receptor' table with 'Extraction-aggregates' as the primary focus, whilst Table A7.7 considers 'Recreational activities-sailing (yachting)' as the primary focus.

A7.2.6 Determining the appropriate study area (spatial and temporal)

Extraction – aggregates:

As, for the purposes of this example, the area is hypothetical, it is necessary at this stage to make some assumptions regarding the spatio-temporal scale. For example:

- The aggregate extraction activity will be conducted within a licensed area and will be applied for within 10 years
- The sediment plume from extraction activities will extend beyond the licensed zone.

As the pressures exerted by this activity have the potential to cause an effect on all receptors within the database (Table A7.6) and there is no further information on what receptors are present within the area, only minor assumptions can be made with regard to the spatio-temporal footprint for the exercise. For example:

- Potential effects on benthic habitats and species and topography/bathymetry will be within the aggregate extraction zone and sediment plume area.
- The noise pressure may result in an increase to the footprint.
- Mobile species, such as birds, marine mammals and fish may be affected beyond the aggregate extraction zone boundary and sediment plume.

Recreational activities – sailing (yachting)

As the area is hypothetical for the purposes of this example, it is necessary at this stage to make some assumptions regarding the spatio-temporal scale. For example:

- Yachting will only occur within the recreational sailing area and cruising route adjacent to the boat house.
- Underwater noise and sewerage discharge has the potential to extend beyond the designated sailing areas.

As the pressures exerted by this activity have the potential to cause an effect on all receptors within the database (Table A7.7) and there is no further information on what receptors are present within the area, only minor assumptions can be made with regard to the spatio-temporal footprint for the exercise. For example:

- Potential effects to benthic habitats and species and topography/bathymetry will be within the designated sailing area.
- Underwater noise and sewerage discharge pressures may result in an increase to the footprint.
- Mobile species, such as birds, marine mammals and fish may be affected beyond the increased footprint.

A7.2.7 Defining sources and pathways

The purpose of this step is to understand where effects could potentially occur by identifying the source of a pressure specific to the activity in question and the pathway to a receptor which may be sensitive to that pressure. An effective way of achieving this is to consider how pressures from each activity might cause an effect on a receptor; inputting further detail into the activity-pressure-receptor tables used earlier in the process.

The database allows the user to export the activity-pressure-receptor tables, produced by the database earlier in the process, to Excel. Once in Excel, the user is able to filter the table to view the relevant data for the primary focus and can add ‘source’ and ‘pathway’ columns to the table. Table A7.6 provides the ‘activity-pressure-receptor’ table for this case study with ‘Extraction-aggregates’ as the primary focus, with the ‘source’ and ‘pathway’ columns included. Table A7.7 considers ‘Recreational activities-sailing (yachting)’ as the primary focus, and provides the ‘activity-pressure-receptor’ table for this case study with the ‘source’ and ‘pathway’ columns included.

A description of ‘no pathway’ within Tables A7.6 and A7.7 indicates that although the broader pressure can potentially have an effect on the receptor group, the more specific aspect of the pressure resulting from the activity in question has no known pathway to influence the receptor group. Following this, that pressure can be scoped out of the assessment.

Table A7.6: Planning level case study: Extraction-aggregates as primary focus - activity-pressure-receptor table for primary activity. Grey cells indicate that receptors may be scoped out of the process. Confidence levels are available in the database.

Activity	Source	Pressure	Pathway	Receptor
Extraction - Aggregates	Increase in suspended sediment concentration	Barrier to species movement	No pathway	Birds
			Short term barrier to migration pathways	Fish and pelagos
				Marine mammals and reptiles
	Presence and movement of large vessels	Death or injury by collision	No pathway	Birds
				Fish and pelagos
			Death or injury of individuals through collision with vessels	Marine mammals and reptiles
	Substances which reduce oxygen may be released into water column	Deoxygenation	Death of flora and fauna due to critical level of oxygen	Benthic habitat and species
				Fish and pelagos
			Changes to hydrographic conditions due to decreased level of oxygen	Hydrography
	Abrasion from the pass of the dredge head	Disturbance of the substrate below the surface of the seabed	Removal of flora and fauna	Benthic habitat and species
			No pathway	Hydrography
			Changes to bathymetry	Topography/Bathymetry
	Removal of seabed	Emergence regime change	Changes in habitat due to changes in bathymetry	Benthic habitat and species
			Changes to prey availability due to changes in bathymetry	Birds
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles

Activity	Source	Pressure	Pathway	Receptor
Extraction - Aggregates	Removal of seabed	Emergence regime change	Changes in hydrographic conditions	Hydrography
			Changes in bathymetry	Topography/Bathymetry
		Habitat structure changes - removal of substratum	Removal of flora and fauna	Benthic habitat and species
			Removal of prey species	Birds
				Marine mammals and reptiles
			Removal of individuals and prey species	Fish and pelagos
			Changes to bathymetry	Topography/Bathymetry
	Sediment plumes cause increase in concentrations of organic material	Organic enrichment	Minor/local increases in organic material, increase in nutrients	Benthic habitat and species
				Fish and pelagos
			Changes to hydrographic conditions	Hydrography
	Dredging of contaminated material	Radionuclide contamination	Localised death of individuals	Benthic habitat and species
				Fish and pelagos
				Marine mammals and reptiles
	Direct uptake of individuals through dredge head	Removal of non-target species	Removal of individuals and prey species	Benthic habitat and species
				Fish and pelagos
			No pathway	Birds
				Marine mammals and reptiles
	Removal of material may cause drawdown of material from elsewhere	Sediment transport changes	Changes in deposition/drawdown of material	Topography/Bathymetry

Activity	Source	Pressure	Pathway	Receptor
Extraction - Aggregates	Increase in turbidity, due to sediment plume	Siltation rate changes	Avoidance of area covered by sediment plume by prey species	Benthic habitat and species
			Avoidance of area covered by sediment plume	Fish and pelagos
				Marine mammals and reptiles
	Minor possibility through discarded litter	Synthetic compound contamination	No pathway	Benthic habitat and species
				Birds
				Fish and pelagos
				Hydrography
				Marine mammals and reptiles
		Transition elements & organo-metal contamination	No pathway	Benthic habitat and species
				Birds
				Fish and pelagos
				Hydrography
				Marine mammals and reptiles
	Presence and movement of large vessels	Underwater noise changes - low and mid-frequency impulsive sounds	Avoidance of the area	Fish and pelagos
				Marine mammals and reptiles
	Increase in turbidity, due to sediment plume	Visual disturbance	Reduced visibility - although may increase prey availability	Birds
			Reduced light levels cause individuals to move up the water column	Fish and pelagos
			Reduced visibility	Marine mammals and reptiles

Activity	Source	Pressure	Pathway	Receptor
Extraction - Aggregates	Removal of seabed	Water flow changes	No pathway	Benthic habitat and species
				Birds
				Fish and pelagos
				Marine mammals and reptiles
			Changes in hydrographic conditions	Hydrography
			Changes to bathymetry	Topography/Bathymetry
			Changes to bathymetry	Topography/Bathymetry
		Wave exposure changes	Changes in habitat type	Benthic habitat and species
			Changes in prey availability	Fish and pelagos
			Changes in hydrographic conditions	Hydrography
			Changes in prey availability	Marine mammals and reptiles
			Changes in bathymetry	Topography/Bathymetry

Table A7.7: Planning level case study: Recreational activities-sailing (yachting) as primary focus - activity-pressure-receptor table for primary activity. Confidence levels are available in the database.

Activity	Source	Pressure	Pathway	Receptor
Recreational activities - sailing (yachting)	Presence and movement of yachts	Death or injury by collision	No pathway	Birds
				Fish and pelagos
			Possible collision with small, high speed vessels	Marine mammals and reptiles
	Sewerage discharge	Deoxygenation	Reduced oxygen availability causes death of individuals	Benthic habitat and species
	Sewerage discharge	Deoxygenation	Reduced oxygen availability	Fish and pelagos

Activity	Source	Pressure	Pathway	Receptor
Extraction - Aggregates			causes death of individuals and/or prey species	
			Changes in hydrographic conditions	Hydrography
	Launching of craft and anchor drag	Disturbance of the substrate below the surface of the seabed	Trampling and scouring of habitat and death of individuals	Benthic habitat and species
			No pathway	Hydrography
			Minor changes to topography/bathymetry	Topography/Bathymetry
	Exposure to good conditions for establishment and subsequent spread of fouling flora and fauna	Introduction or spread of non-indigenous species	Displacement of native flora and fauna	Benthic habitat and species
			Displacement of prey species	Fish and pelagos
	Irresponsible behaviour of boat users	Litter	Smothering	Benthic habitat and species
			Potential biological/chemical damage	Birds
				Fish and pelagos
				Marine mammals and reptiles
			Presence of litter	Topography/Bathymetry
	Sewerage discharge	Organic enrichment	Minor/local increases in organic material, increase in nutrients	Benthic habitat and species
				Fish and pelagos
			Changes in hydrographic conditions	Hydrography
	Turbidity due to boat movements	Siltation rate changes	Smothering	Benthic habitat and species
	Turbidity due to boat	Siltation rate	Minor avoidance of area	Fish and pelagos

Activity	Source	Pressure	Pathway	Receptor
Extraction - Aggregates	movements	changes		Marine mammals and reptiles
	Maintenance of craft on water or mud/sand flats at low tide	Synthetic compound contamination	Minor/local death of flora and fauna	Benthic habitat and species
				Birds
			No pathway	Fish and pelagos
				Marine mammals and reptiles
			Changes in hydrographic conditions	Hydrography
	Anti-fouling paint	Transition elements & organo-metal contamination	Minor/local death of flora and fauna	Benthic habitat and species
				Birds
				Fish and pelagos
				Marine mammals and reptiles
			Changes in hydrographic conditions	Hydrography
	Use of auxiliary engines	Underwater noise changes - high frequency impulsive sounds	Minor/local avoidance of area	Fish and pelagos
				Marine mammals and reptiles
	Use/movement of sails	Visual disturbance	Minor/local avoidance of area, some species may be attracted	Birds
			No pathway	Fish and pelagos
				Marine mammals and reptiles

A7.2.8 Identify other activities

For the purposes of this scenario, it is necessary to make assumptions about activities within the area. As noted previously, where used to inform scenarios within marine plan areas, this framework would incorporate actual information on activities within the areas. In addition to the sailing club, other activities in the area include:

- A port development 10 km along the coast from the sailing club
- A military flying zone over the same area as the aggregate resource
- A tourist site, popular with birdwatchers adjacent to the sailing club.

It may be possible to further consider the management of contribution to cumulative effects and mitigation at this stage, based on any new information or assumptions made. Additional activities have been identified and they can now be considered in the management exercise. These assumptions can then be used to inform an assessment of the potential impact of the CEA and mitigation requirements on the identified activities as well as potential future activities should this be relevant.

Using the management decision tree (Figure 9; Section 4), the later stage of the scoping exercise and the further detail on the study suggest it may be possible to allocate responsibility for potential cumulative effects in a more refined way than by assuming equal responsibility. However, the sources and pathways between activities and receptors must first be established.

A7.2.9 Reconsider the study area

As the primary focus of the exercise is the two activities, the spatio-temporal scale should not be affected by any other activities identified. However, where sources and pathways identify no link between an activity and a pressure and/or receptor, the spatio-temporal extent of these can be removed from the study area.

Upon reconsideration, the study area does not require any changes.

A7.2.10 Defining the sources and pathways for all activities

The purpose of this step is to understand where effects could potentially occur by pinpointing the source of the pressures from the other activities under consideration, which overlap with those of the primary activity, and the specific pathway to the receptor(s) which may be sensitive to those pressures (activity-focused).

Table A7.8 shows the sources and pathways for the activity-receptor-pressure links for the other activities scoped into the exercise, with Extraction-aggregates as the primary focus.

Table A7.9 shows the sources and pathways for the activity-receptor-pressure links for the other activities scoped into the exercise, with Recreational activities - sailing (yachting) as the primary focus.

It may be possible to think further at this stage as to how the management of cumulative effects assessment and mitigation may be undertaken based on any new information or assumptions made.

Using the management decision tree (Figure 9; Section 4), the later stage of the scoping exercise and the further detail on the study suggest it may be possible to allocate responsibility for potential cumulative effects in a more refined way than by assuming equal responsibility by eliminating activities with no potential for effect on the receptors. However, as this is a hypothetical scenario it is unlikely that detailed apportioning of the potential effect between the activities will be appropriate without substantially more information.

Table A7.8: Planning level case study 'Extraction-aggregates' as primary focus - activity-pressure-receptor table for all activities scoped in. Where there is potential for cumulative effect (PCE), these are highlighted in pink. The primary activity of 'Extraction-aggregates' is included for reference and is highlighted in green. Confidence levels are available in the database.

Activity	Source	Pressure	Pathway	Receptor
Coastal docks, ports & marinas	Presence of port infrastructure	Barrier to species movement	No PCE – no link to proposed extraction area	Fish and pelagos
	Navigational dredging for port access	Emergence regime change	PCE if changes occur to same tidal currents	Benthic habitat and species
				Birds
				Fish and pelagos
				Hydrography
				Marine mammals and reptiles
				Topography/Bathymetry
		Habitat structure changes - removal of substratum	Likely to be different habitat type, therefore no PCE	Benthic habitat and species
			Removal of prey species	Birds
				Fish and pelagos
				Marine mammals and reptiles
			No PCE – no link to proposed extraction area	Topography/Bathymetry
		Physical loss	No PCE – no link to proposed extraction area	Benthic habitat and species
			Removal of prey species	Birds
				Fish and pelagos
				Marine mammals and reptiles
			No PCE – no link to proposed extraction area	Topography/Bathymetry

Activity	Source	Pressure	Pathway	Receptor
Coastal docks, ports & marinas	Navigational dredging for port access	Sediment transport changes	PCE if sediment transport mechanisms are linked	Topography/Bathymetry
		Siltation rate changes	No PCE - no link to proposed extraction sediment plume	Benthic habitat and species
				Fish and pelagos
				Marine mammals and reptiles
	Vessel traffic	Underwater noise changes - low and mid-frequency impulsive sounds	PCE for mobile species, may be displaced from both port and aggregate extraction areas	Fish and pelagos
				Marine mammals and reptiles
	Navigational dredging for port access and vessel traffic causing increased turbidity	Visual disturbance	No PCE - no link to proposed extraction sediment plume	Birds
				Fish and pelagos
				Marine mammals and reptiles
		Water flow changes	PCE if water flow mechanisms are linked	Hydrography
				Topography/Bathymetry
Coastal tourist sites	No source for bird watching	Disturbance of the substrate below the surface of seabed	No pathway	Benthic habitat and species
				Hydrography
				Topography/Bathymetry
		Physical loss	No pathway	Benthic habitat and species
				Birds
				Fish and pelagos
				Marine mammals and reptiles
				Topography/Bathymetry
		Visual disturbance	No pathway	Birds
				Fish and pelagos
				Marine mammals and reptiles

Activity	Source	Pressure	Pathway	Receptor
Extraction - Aggregates	Increase in suspended sediment concentration	Barrier to species movement	Short term barrier to migration pathways	Fish and pelagos
				Marine mammals and reptiles
	Presence and movement of large vessels	Death or injury by collision	Death or injury of individuals through collision with vessels	Marine mammals and reptiles
	Substances which reduce oxygen may be released into water column	Deoxygenation	Death of flora and fauna - critical level of oxygen	Benthic habitat and species
				Fish and pelagos
			Changes to hydrographic conditions due to decreased level of oxygen	Hydrography
	Abrasion from the pass of the dredge head	Disturbance of the substrate below the surface of seabed	Removal of flora and fauna	Benthic habitat and species
			Changes to bathymetry	Topography/Bathymetry
	Removal of seabed	Emergence regime change	Changes in habitat due to changes in bathymetry	Benthic habitat and species
			Changes to prey availability due to changes in bathymetry	Birds
				Fish and pelagic habitat (including plankton)
				Marine mammals and reptiles
			Changes in hydrographic conditions	Hydrography
			Changes in bathymetry	Topography/Bathymetry
		Habitat structure changes - removal of substratum	Removal of flora and fauna	Benthic habitat and species
			Removal of prey species	Birds
				Marine mammals and reptiles

Activity	Source	Pressure	Pathway	Receptor
Extraction - Aggregates		Habitat structure changes - removal of substratum	Removal of individuals and prey species	Fish and pelagos
			Changes to bathymetry	Topography/Bathymetry
	Sediment plumes cause increase in concentrations of organic material	Organic enrichment	Minor/local increases in organic material, increase in nutrients	Benthic habitat and species
				Fish and pelagos
			Changes to hydrographic conditions	Hydrography
	Removal of seabed	Physical loss	Removal of flora and fauna	Benthic habitat and species
			Removal of prey species	Birds
				Marine mammals and reptiles
			Removal of individuals and prey species	Fish and pelagos
			Changes to bathymetry	Topography/Bathymetry
	Dredging of contaminated material	Radionuclide contamination	Localised death of individuals	Benthic habitat and species
				Fish and pelagos
				Marine mammals and reptiles
	Direct uptake of individuals through dredge head	Removal of non-target species	Removal of individuals and prey species	Benthic habitat and species
				Fish and pelagos
	Removal of material may cause drawdown of material from elsewhere	Sediment transport changes	Changes in deposition/drawdown of material	Topography/Bathymetry
	Increase in turbidity, due to sediment plume	Siltation rate changes	Avoidance of area covered by sediment plume by prey species	Benthic habitat and species

Activity	Source	Pressure	Pathway	Receptor
Extraction - Aggregates	Increase in turbidity, due to sediment plume	Siltation rate changes	Avoidance of area covered by sediment plume	Fish and pelagos
				Marine mammals and reptiles
	Presence and movement of large vessels	Underwater noise changes - low and mid-frequency	Avoidance of the area	Fish and pelagos
				Marine mammals and reptiles
	Increase in turbidity, due to sediment plume	Visual disturbance	Reduced visibility - although may increase prey availability	Birds
			Reduced light levels cause individuals to move up the water column	Fish and pelagos
			Reduced visibility	Marine mammals and reptiles
	Removal of seabed	Water flow changes	Changes in hydrographic conditions	Hydrography
			Changes to bathymetry	Topography/Bathymetry
		Wave exposure changes	Changes in habitat type	Benthic habitat and species
			Changes in prey availability	Fish and pelagos
				Marine mammals and reptiles
			Changes in hydrographic conditions	Hydrography
			Changes to bathymetry	Topography/Bathymetry
Military activities	No source for military fly-zone	Death or injury by collision	No pathway	Marine mammals and reptiles
		Habitat structure changes - removal of substratum	No pathway	Benthic habitat and species

Activity	Source	Pressure	Pathway	Receptor
Military activities	No source for military fly-zone	Habitat structure changes - removal of substratum	No pathway	Birds
				Fish and pelagos
				Marine mammals and reptiles
				Topography/Bathymetry
		Radionuclide contamination	No pathway	Benthic habitat and species
				Fish and pelagos
				Marine mammals and reptiles
		Siltation rate changes	No pathway	Benthic habitat and species
				Fish and pelagos
				Marine mammals and reptiles
Recreational activities - sailing (yachting)	Presence and movement of yachts	Death or injury by collision	Possible collision with small, high speed vessels	Marine mammals and reptiles
	Launching of craft and anchor drag	Disturbance of the substrate below the surface of the seabed	No anchoring in proposed aggregate extraction area, no PCE	Benthic habitat and species
				Topography/Bathymetry
	Sewerage discharge	Deoxygenation	No sailing in proposed aggregate extraction area, no PCE	Benthic habitat and species
			Reduced oxygen availability - death of individuals and/or prey	Fish and pelagos
		Organic enrichment	No sailing in proposed aggregate extraction area, no PCE	Benthic habitat and species
				Hydrography
			Minor/local increases in organic material, increase in nutrients	Fish and pelagos

Activity	Source	Pressure	Pathway	Receptor
Recreational activities - sailing (yachting)	Turbidity due to boat movements	Siltation rate changes	PCE, due to smothering	Benthic habitat and species
			PCE for mobile species, may be displaced from both sailing and aggregate extraction areas	Fish and pelagos
				Marine mammals and reptiles
	Use/movement of sails	Visual disturbance	PCE for mobile species, may be displaced from both sailing and aggregate extraction areas, some species may be attracted	Birds
			No pathway	Fish and pelagos
				Marine mammals and reptiles

Table A7.9: Planning level case study 'Recreational activities - sailing (yachting)' as primary focus - activity-pressure-receptor table for all activities scoped in. Where there is potential for cumulative effect (PCE), these are highlighted in pink and the primary activity of 'Recreational activities - sailing (yachting)' is included for reference and is highlighted in green.

Activity	Source	Pressure	Pathway	Receptor
Coastal docks, ports & marinas	Navigational dredging for port access, removal of seabed	Siltation rate changes	No sailing near the port, therefore no PCE	Benthic habitat and species
			PCE for mobile species, may be displaced from both port and sailing areas	Fish and pelagos
				Marine mammals and reptiles
	Presence of port infrastructure	Visual disturbance	No sailing near the port, therefore no PCE	Birds
Coastal tourist sites	Navigational dredging for port access, removal of seabed	Disturbance of the substrate below the surface of seabed	No pathway	Benthic habitat and species
			No pathway	Topography/Bathymetry

Activity	Source	Pressure	Pathway	Receptor
Coastal tourist sites	Litter potentially discarded by birdwatchers	Litter	Potential biological/chemical damage	Birds
			No pathway	Benthic habitat and species
				Fish and pelagos
				Marine mammals and reptiles
			No link with sailing area, therefore no PCE	Topography/Bathymetry
	Birdwatcher presence	Visual disturbance	No pathway	Birds
Extraction - Aggregates	Collision with larger vessels	Death or injury by collision	Death or injury of individuals through collision with vessels, PCE	Marine mammals and reptiles
	Substances which reduce oxygen may be released into water column	Deoxygenation	Death of prey species due to critical level of oxygen	Fish and pelagos
			No overlap between aggregate extraction and sailing areas, no PCE	Benthic habitat and species
				Hydrography
	Abrasion from the pass of the dredge head	Disturbance of the substrate below the surface of seabed	No overlap between aggregate extraction and sailing areas, no PCE	Benthic habitat and species
				Topography/Bathymetry
	Sediment plumes cause increase in concentrations of organic material	Organic enrichment	No overlap between aggregate extraction and sailing areas, no PCE	Benthic habitat and species
				Hydrography
			Minor/local increases in organic material, increase in nutrients	Fish and pelagos
	Increase in turbidity	Siltation rate changes	Avoidance of area, sediment plume might overlap with sailing areas	Benthic habitat and species
				Fish and pelagos
				Marine mammals and reptiles

Activity	Source	Pressure	Pathway	Receptor
Extraction - Aggregates	Minor possibility through discarded litter	Synthetic compound contamination	No pathway	Benthic habitat and species
				Birds
				Hydrography
		Transition elements & organo-metal contamination	No pathway	Benthic habitat and species
				Birds
				Fish and pelagos
				Hydrography
				Marine mammals and reptiles
	Increase in turbidity	Visual disturbance	Reduced visibility - may increase prey availability	Birds
Military activities	No source for military fly-zone	Death or injury by collision	No pathway	Marine mammals and reptiles
		Litter	No pathway	Benthic habitat and species
				Birds
				Fish and pelagos
				Marine mammals and reptiles
				Topography/Bathymetry
		Siltation rate changes	No pathway	Benthic habitat and species
				Fish and pelagos
				Marine mammals and reptiles
		Transition elements & organo-metal contamination	No pathway	Benthic habitat and species
				Birds
				Fish and pelagos
				Hydrography
				Marine mammals and reptiles

Activity	Source	Pressure	Pathway	Receptor
Military activities	No source for military fly-zone	Underwater noise changes - high frequency impulsive sounds	No pathway	Fish and pelagos
				Marine mammals and reptiles
Recreational activities - sailing (yachting)	Presence and movement of yachts	Death or injury by collision	Possible collision with small, high speed vessels	Marine mammals and reptiles
	Sewerage discharge	Deoxygenation	Reduced oxygen availability causes death of individuals	Benthic habitat and species
			Reduced oxygen availability causes death of individuals and/or prey species	Fish and pelagos
			Changes in hydrographic conditions	Hydrography
	Launching of craft and anchor drag	Disturbance of the substrate below the surface of seabed	Trampling and scouring of habitat and death of individuals	Benthic habitat and species
			Minor changes to topography/bathymetry	Topography/Bathymetry
	Exposure to good conditions for establishment and subsequent spread of fouling flora and fauna	Introduction or spread of non-indigenous species	Displacement of native flora and fauna	Benthic habitat and species
			Displacement of prey species	Fish and pelagos
	Irresponsible behaviour of boat users	Litter	Smothering	Benthic habitat and species
			Potential biological/chemical damage	Birds
				Fish and pelagos
				Marine mammals and reptiles
			Presence of litter	Topography/Bathymetry

Activity	Source	Pressure	Pathway	Receptor
Recreational activities - sailing (yachting)	Sewerage discharge	Organic enrichment	Minor/local increases in organic material, increase in nutrients	Benthic habitat and species
				Fish and pelagos
			Changes in hydrographic conditions	Hydrography
	Turbidity due to boat movements	Siltation rate changes	Minor avoidance of area	Benthic habitat and species
				Fish and pelagos
				Marine mammals and reptiles
	Maintenance of craft on water or mud/sand flats at low tide	Synthetic compound contamination	Minor/localised death of flora and fauna	Benthic habitat and species
				Birds
			Changes in hydrographic conditions	Hydrography
	Anti-fouling paint	Transition elements & organo-metal contamination	Minor/local death of flora and fauna	Benthic habitat and species
			Minor/local death of prey species	Birds
				Fish and pelagos
				Marine mammals and reptiles
			Changes in hydrographic conditions	Hydrography
	Use of auxiliary engines	Underwater noise changes - high frequency impulsive sounds	Minor/local avoidance of area	Fish and pelagos
				Marine mammals and reptiles
	Use/movement of sails	Visual disturbance	Minor/local avoidance of area, some species may be attracted	Birds

A7.2.11 Management of potential cumulative effects and mitigation measures

Although not discussed in depth in relation to this case study, considering the management of CEA and mitigation of cumulative effects in the marine environment is a crucial element of MMO's role. In some cases, legislation does not clearly lay out how the contribution of different projects should be managed. The framework proposed within this report considers 'responsibility' in these situations through consideration of:

- Contribution to an assessment – whereby developers may be required to provide information to enable better assessments and to promote cooperation with other developers.
- Mitigation – where there is a significant cumulative effect, which developer(s) is/are responsible for mitigating the effect.

Any decisions made on management, in particular where further action is required (i.e. mitigation), need to be based on a proportionate and risk based approach supported by appropriate level of evidence and advice from statutory bodies and other stakeholders as appropriate. Involvement of industry/sectors in these decisions can be crucial to develop a common understanding and agreement which will help to avoid potential future issues. Transboundary issues, where they become apparent, will also need to be addressed by liaison with regulatory counterparts in neighbouring countries, as appropriate.

The management decision tree (Figure 9, Section 4) should be reviewed to ascertain how the contribution to cumulative effects and mitigation could be approached, based on the level of information and assumptions made.

When evaluating issues relating to cumulative effects following the marine planning case study example above, MMO may consider potentially appropriate management approaches to assess whether future activities might be excluded from specific areas as a result of high mitigation requirements. Where this may occur, marine plans could include guidance or policies in line with marine plan area priorities to ensure activities of importance to the local area are not excluded. Management approaches would need to be driven on a risk-based evaluation of likely impacts of cumulative effects and the management measures options on the environment and surrounding activities.

Where sources/pathways can be identified through existing data or validated assumptions, the activity-specific effects approach could be used to assume e.g. management measures are required only for activities shown to have potential to cause the cumulative effects. It may also be possible to consider apportioning the effects; however within marine planning at a regional scale this would be resource intensive and would require significant stakeholder input to agree likely proportions of cumulative effects.

It is highly unlikely that it would be feasible to use the scale of effects approach within marine planning for a case study as this; however other planning scenarios may allow a level of data input that would negate the need for potentially misleading assumptions to be made.

A7.2.12 Assessment

At this point, the activities, pressures and receptors have been identified and scoped in/out. The next step is taking forwards a more detailed assessment of the potential cumulative effects and this requires input of significant site/case-specific information and/or well defined and agreed assumptions.

Annex 8: Evidence Gaps – Environmental pressures

Table A8.1 outlines the evidence gaps identified within the database. Areas are highlighted as evidence gaps where there is a low level of confidence in the established link between the activity and pressure. Where more information is available on the reason for the low level of confidence, this is provided in the confidence description.

Table A8.1: Evidence gaps.

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Aquaculture - Fin-fish	Litter	Low	Litter leading to marine mammals entanglement has been reported but not proved to be produced by finfish farming activities
	Removal of non-target species	Low	
	Water flow changes	Low	The mechanism for this interaction has been well studied for a range of engineering applications but little research has been conducted in relation to marine farms.
	Wave exposure changes	Low	The extent of impact will be dependent on the size and type of the farm, the design of the farm (e.g. arrangement of cages), the water depth of the farm and distance from shore. This information is unknown
Aquaculture - Macro-algae	Introduction of microbial pathogens	Low	
	Introduction or spread of non-indigenous species	Low	Impacts on biological systems through spread of seaweed species are less well understood
	Genetic modification & translocation of indigenous species	Low	Impacts on wider biodiversity poorly understood
	Removal of non-target species	Low	

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Aquaculture - Shellfish	Synthetic compound contamination	Low	Chemical usage on shellfish farms is minimal. Chromium, copper and arsenic treated pine is frequently used for intertidal racking, however the treatment process prevents the accumulation of these heavy metals in the environment
	Introduction or spread of non-indigenous species	Low	Impacts on biological systems through escaped invasive species are less well understood
	Genetic modification & translocation of indigenous species	Low	Impacts on wider biodiversity poorly understood
	Water flow changes	Low	Hydrodynamic alterations caused by shellfish culture have been rarely documented
Coastal defences - construction	Underwater noise changes	Low	
	Disturbance of the substrate below the surface of the seabed	Low	
	Changes in suspended solids	Low	
	Habitat structure changes - removal of substratum	Low	
	Physical change	Low	
Coastal defences - operation	Water flow changes	Low	
	Emergence regime change	Low	
	Changes in suspended solids	Low	
	Sediment transport changes	Low	
	Wave exposure changes	Low	
Coastal docks, ports & marinas	Water flow changes	Low	
	Barrier to species movement	Low	

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Coastal docks, ports & marinas	Visual disturbance	Low	
	Underwater noise changes - low and mid-frequency impulsive sounds	Low	
	Siltation rate changes	Low	
	Habitat structure changes - removal of substratum	Low	
	Physical change	Low	
	Physical loss	Low	
	Sediment transport changes	Low	
	Emergence regime change	Low	
Conservation and environmental protection - Artificial reefs	Introduction or spread of non-indigenous species	Low	
	Sediment transport changes	Low	
	Water flow changes	Low	
Cultural and heritage sites	Introduction of other substances	Low	
	Siltation rate changes	Low	
	Genetic modification & translocation of indigenous species	Low	
	Visual disturbance	Low	
	Death or injury by collision	Low	
	Barrier to species movement	Low	
	Introduction of light	Low	
	Underwater noise changes	Low	
	Transition elements & organo-metal contamination	Low	
	Litter	Low	

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Cultural and heritage sites	Synthetic compound contamination	Low	
	Changes in suspended solids	Low	
	Hydrocarbon & PAH contamination	Low	
	Habitat structure changes - removal of substratum	Low	
	Physical change	Low	
	Physical loss	Low	
	Organic enrichment	Low	
	Nutrient enrichment	Low	
	Deoxygenation	Low	
	Disturbance of the substrate below the surface of the seabed	Low	
	Electromagnetic changes	Low	
Dredge and soil disposal	Changes in suspended solids	Low	
	Underwater noise changes - low and mid-frequency impulsive sounds	Low	
	Synthetic compound contamination	Low	
	Transition elements & organo-metal contamination	Low	
	Radionuclide contamination	Low	
	Habitat structure changes - removal of substratum	Low	
	Organic enrichment	Low	
	Siltation rate changes	Low	

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
	Water flow changes	Low	
Dredge and soil disposal	Sediment transport changes	Low	
	Physical change	Low	
Extraction - Aggregates	Water flow changes	Low	
	Removal of non-target species	Low	
	Visual disturbance	Low	
	Synthetic compound contamination	Low	
	Transition elements & organo-metal contamination	Low	
	Deoxygenation	Low	
	Habitat structure changes - removal of substratum	Low	Long-term impacts on dynamic seabed habitats are complex and difficult to distinguish from any preceding bottom-trawling activities
	Disturbance of the substrate below the surface of the seabed	Low	
	Changes in suspended solids	Low	Long-term impacts on dynamic seabed habitats are complex and difficult to distinguish from any preceding bottom-trawling activities
	Barrier to species movement	Low	
	Underwater noise changes - low and mid-frequency impulsive sounds	Low	
	Death or injury by collision	Low	
	Wave exposure changes	Low	
	Organic enrichment	Low	
	Radionuclide contamination	Low	

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
	Siltation rate changes	Low	
Extraction - Navigational dredging	Underwater noise changes - low and mid-frequency impulsive sounds	Low	
	Removal of non-target species	Low	
	Siltation rate changes	Low	
	Changes in suspended solids	Low	
	Disturbance of the substrate below the surface of the seabed	Low	
	Habitat structure changes - removal of substratum	Low	
	Organic enrichment	Low	
	Barrier to species movement	Low	
	Death or injury by collision	Low	
	Radionuclide contamination	Low	
	Synthetic compound contamination	Low	
	Synthetic compound contamination	Low	
	Physical loss	Low	
Extraction of genetic resources	Organic enrichment	Low	
	Siltation rate changes	Low	
	Removal of non-target species	Low	
	Removal of target species	Low	
	Water flow changes	Low	
	Deoxygenation	Low	
	Nutrient enrichment	Low	

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
	Physical change	Low	
Extraction of genetic resources	Habitat structure changes - removal of substratum	Low	
	Disturbance of the substrate below the surface of the seabed	Low	
	Introduction of microbial pathogens	Low	
	Visual disturbance	Low	
	Underwater noise changes	Low	
	Changes in suspended solids	Low	
	Barrier to species movement	Low	
	Physical loss	Low	
Fishing - mobile gears	Underwater noise changes - low frequency continuous sounds	Low	
	Introduction of microbial pathogens	Low	
	Introduction or spread of non-indigenous species	Low	
	Hydrocarbon & PAH contamination	Low	
Gas storage operations - construction	Salinity changes	Low	
	Underwater noise changes - low and mid-frequency impulsive sounds	Low	Knowledge improving but long-term effect on biology of species poorly understood
	Death or injury by collision	Low	Knowledge improving but long-term effect on biology of species poorly understood
Gas storage operations -	Death or injury by collision	Low	Knowledge improving but long-term effect on biology of species poorly understood

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
exploration	Underwater noise changes - high frequency impulsive sounds	Low	Knowledge improving but long-term effect on biology of species poorly understood
Gas storage operations - operation	Salinity changes	Low	
	Synthetic compound contamination	Low	There has not been a systematic and comprehensive assessment of how these additional constituents would affect the risks associated. In addition the cumulative effect of different contaminants interaction is unknown
	Death or injury by collision	Low	Knowledge improving but long-term effect on biology of species poorly understood
Harvesting - Seaweed and other sea-based food	Habitat structure changes - removal of substratum	Low	
	Changes in suspended solids	Low	
	Removal of target species	Low	
	Water flow changes	Low	
	Physical change	Low	
Industrial and agricultural liquid discharges	Litter	Low	
	Introduction of microbial pathogens	Low	
	Nutrient enrichment	Low	
	Radionuclide contamination	Low	
	Transition elements & organo-metal contamination	Low	
	Changes in suspended solids	Low	
	Temperature changes	Low	
	Salinity changes	Low	
	Water flow changes	Low	

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
	Synthetic compound contamination	Low	
Land claim protection - construction	Underwater noise changes	Low	
	Physical change	Low	
	Habitat structure changes - removal of substratum	Low	
	Changes in suspended solids	Low	
	Disturbance of the substrate below the surface of the seabed	Low	
Land claim protection - operation	Emergence regime change	Low	
	Wave exposure changes	Low	
	Sediment transport changes	Low	
	Water flow changes	Low	
Marine hydrocarbon extraction - Decommissioning	Barrier to species movement	Low	
	Water flow changes	Low	
	Salinity changes	Low	
	Underwater noise changes	Low	
	Physical change	Low	
	Changes in suspended solids	Low	
	Physical loss	Low	
Marine hydrocarbon extraction - Operation	Underwater noise changes	Low	
	Death or injury by collision	Low	
	Changes in suspended solids	Low	
	Litter	Low	
	Hydrocarbon & PAH contamination	Low	
	Organic enrichment	Low	

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
	Introduction of microbial pathogens	Low	
	Transition elements & organo-metal contamination	Low	
	Physical loss	Low	
	Synthetic compound contamination	Low	
Marine research	Underwater noise changes	Low	
	Changes in suspended solids	Low	
	Physical change	Low	
	Removal of target species	Low	
	Death or injury by collision	Low	
	Synthetic compound contamination	Low	
Military activities	Siltation rate changes	Low	Can be difficult to distinguish from other impacts on sedimentation processes on coast
	Litter	Low	There is very little information on the incidence of marine litter from defence activities within exercise areas.
Power station thermal and nuclear discharges	Water flow changes	Low	
	Radionuclide contamination	Low	
	Changes in suspended solids	Low	
	Salinity changes	Low	
	Synthetic compound contamination	Low	
	Transition elements & organo-metal contamination	Low	
	Temperature changes	Low	

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Recreational activities - horse riding	Introduction or spread of non-indigenous species	Low	Requires further research
Recreational activities - sailing (yachting)	Introduction or spread of non-indigenous species	Low	Research has been concentrated on large commercial vessels. However, small leisure vessels have recently been shown to have a significant role in the introduction of non-indigenous species transmission
Renewable energy - Tidal range - Construction	Habitat structure changes - removal of substratum	Low	
	Physical loss	Low	
	Physical change	Low	The potential wider or secondary effects on protected or sensitive seabed communities due to installation of tidal energy converters and associated moorings or support structures is poorly understood
	Barrier to species movement	Low	
	Underwater noise changes - High frequency impulsive sounds	Low	Knowledge of effects on certain receptors during construction is incomplete (e.g. diving birds, marine mammals, fish)
	Transition elements & organo-metal contamination	Low	
	Death or injury by collision	Low	Lack of understanding around the possible cause of death to seals with ‘corkscrew’ injuries
Renewable energy - Tidal range – Decommissioning	Siltation rate changes	Low	
	Disturbance of the substrate below the surface of the seabed	Low	
	Physical change	Low	
	Underwater noise changes	Low	Knowledge of effects on certain receptors during decommissioning is incomplete (e.g. diving birds, marine mammals, fish)

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Renewable energy - Tidal range - Decommissioning	Habitat structure changes - removal of substratum	Low	
	Synthetic compound contamination	Low	
	Death or injury by collision	Low	Lack of understanding around the possible cause of death to seals with 'corkscrew' injuries
	Changes in suspended solids	Low	
Renewable energy - Tidal range - Operation	Introduction or spread of non-indigenous species	Low	Unknown interaction, concern raised within regulatory and advisory bodies
	Barrier to species movement	Low	It is uncertain whether tidal developments will cause a barrier to movement for certain receptors (e.g. marine mammals, basking sharks, migratory fish). Experience from barrages schemes worldwide may provide further information.
	Death or injury by collision	Low	The nature of any potential interactions between certain receptors and tidal turbines is uncertain (e.g. diving birds, marine mammals, basking sharks, migratory fish). Further development of suitable instrumentation and methodologies for monitoring
	Underwater noise changes	Low	It is required to agree best practice approaches for measuring ambient and operational noise in high energy tidal environments. There is a lack of available acoustic data from operational tidal devices, and knowledge of effects on certain receptors
	Sediment transport changes	Low	
Renewable energy - Tidal stream –	Underwater noise changes - High frequency impulsive sounds	Low	Knowledge of effects on certain receptors during construction is incomplete (e.g. diving birds, marine mammals, fish)

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Construction Renewable energy - Tidal stream - Construction	Disturbance of the substrate below the surface of the seabed	Low	
	Death or injury by collision	Low	Lack of understanding around the possible cause of death to seals with 'corkscrew' injuries
	Physical change	Low	The potential wider or secondary effects on protected or sensitive seabed communities due to installation of wave energy converters and associated moorings or support structures is poorly understood
	Introduction of light	Low	
Renewable energy - Tidal stream - Decommissioning	Physical change	Low	
	Underwater noise changes	Low	Knowledge of effects on certain receptors during decommissioning is incomplete (e.g. diving birds, marine mammals, fish)
	Synthetic compound contamination	Low	It is unclear what antifouling biocides will be used by the industry
	Death or injury by collision	Low	Lack of understanding around the possible cause of death to seals with 'corkscrew' injuries
Renewable energy - Tidal stream – Operation	Disturbance of the substrate below the surface of the seabed	Low	
	Underwater noise changes - low and mid-frequency impulsive sounds	Low	It is required to agree best practice approaches for measuring operational noise in high energy tidal environments. There is a lack of available acoustic data from operational tidal devices, and knowledge of effects on certain receptors during opera
	Death or injury by collision	Low	The nature of any potential interactions between certain receptors and tidal turbines is uncertain (e.g. diving birds, marine mammals, basking sharks, migratory fish). Further development of suitable instrumentation and methodologies for monitoring

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Renewable energy - Tidal stream - Operation	Introduction or spread of non-indigenous species	Low	Unknown interaction, concern raised within regulatory and advisory bodies
	Water flow changes	Low	Lack of baseline field data to inform hydrographic models. Effects on magnitude and scale of hydrodynamic changes are not well understood. Interactions are difficult to study in dynamic tidal environments
	Barrier to species movement	Low	It is uncertain whether tidal developments will cause a barrier to movement for certain receptors (e.g. marine mammals, basking sharks, migratory fish).
	Sediment transport changes	Low	Lack of baseline field data to inform hydrographic models. Effects on magnitude and scale of hydrodynamic changes are not well understood. Interactions are difficult to study in dynamic tidal environments
	Wave exposure changes	Low	Lack of baseline field data to inform hydrographic models. Effects on magnitude and scale of hydrodynamic changes are not well understood. Interactions are difficult to study in dynamic tidal environments
	Electromagnetic changes	Low	State of knowledge on the EMF contributions from any tidal current power generation systems (generator, power electronics) is non-existent in the public literature
	Introduction of light	Low	
	Physical change	Low	The potential wider or secondary effects on protected or sensitive seabed communities due to installation of tidal energy converters and associated moorings or support structures is poorly understood

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Renewable energy - Wave – Construction	Physical change	Low	The potential wider or secondary effects on protected or sensitive seabed communities due to installation of wave energy converters and associated moorings or support structures is poorly understood
	Transition elements & organo-metal contamination	Low	
	Death or injury by collision	Low	Lack of understanding around the possible cause of death to seals with ‘corkscrew’ injuries
	Underwater noise changes - High frequency impulsive sounds	Low	Knowledge of effects on certain receptors during construction is incomplete (e.g. diving birds, marine mammals, fish)
	Habitat structure changes - removal of substratum	Low	The potential wider or secondary effects on protected or sensitive seabed communities due to installation of wave energy converters and associated moorings or support structures is poorly understood
Renewable energy - Wave - Decommissioning	Physical change	Low	
	Disturbance of the substrate below the surface of the seabed	Low	
	Habitat structure changes - removal of substratum	Low	
	Underwater noise changes	Low	Knowledge of effects on certain receptors during decommissioning is incomplete (e.g. diving birds, marine mammals, fish)
	Synthetic compound contamination	Low	
	Death or injury by collision	Low	Lack of understanding around the possible cause of death to seals with ‘corkscrew’ injuries
	Physical loss	Low	

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Renewable energy - Wave - Operation	Transition elements & organo-metal contamination	Low	
	Sediment transport changes	Low	Lack of data related to shoreline change caused by modified wave climates
	Physical change	Low	The potential wider or secondary effects on protected or sensitive seabed communities due to installation of wave energy converters and associated moorings or support structures is poorly understood. Limited data to enable an understanding of the
	Introduction or spread of non-indigenous species	Low	Unknown interaction, concern raised within regulatory and advisory bodies
	Underwater noise changes - Low frequency continuous sounds	Low	It is required to agree best practice approaches for measuring ambient and operational noise in high energy wave environments. There is a lack of available acoustic data from operational wave devices, and knowledge of effects on certain receptors du
	Death or injury by collision	Low	Further development of suitable instrumentation and methodologies for monitoring wildlife behaviour around wave devices arrays and for detection of any collision events is required.
	Introduction of light	Low	
Renewable energy - Wind - Construction	Underwater noise changes - low and mid-frequency impulsive sounds	Low	The response of marine species to frequent boat traffic is not well understood
	Death or injury by collision	Low	Documentation of ship strikes on different species is variable. E.g. In the case of porpoises is very low
Renewable energy - Wind - Operation	Underwater noise changes - low and mid-frequency impulsive sounds	Low	Potential effect of operational noise from offshore wind farms remains largely unknown

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Renewable energy - Wind - Decommissioning	Underwater noise changes - high frequency impulsive sounds	Low	
Sewerage disposal	Temperature changes	Low	
	Physical change	Low	
	Introduction of microbial pathogens	Low	
	Water flow changes	Low	
	Organic enrichment	Low	
	Nutrient enrichment	Low	
	Transition elements & organo-metal contamination	Low	
	Synthetic compound contamination	Low	
	Deoxygenation	Low	
	Changes in suspended solids	Low	
	Siltation rate changes	Low	
	Salinity changes	Low	
Shipping - General activities	Litter	Low	
	Death or injury by collision	Low	
	Introduction or spread of non-indigenous species	Low	Impacts on biological systems through escaped invasive species are not well understood
	Physical change	Low	
	Underwater noise changes - low and mid-frequency impulsive sounds	Low	

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Shipping - Port operations	Litter	Low	
	Disturbance of the substrate below the surface of the seabed	Low	Little research has been undertaken to investigate the potential impacts of vessel movements and ships' wash
	Changes in suspended solids	Low	Little research has been undertaken to investigate the potential impacts of vessel movements and ships' wash
	Underwater noise changes - low and mid-frequency impulsive sounds	Low	Little research has been undertaken to investigate the potential impacts of vessel movements and ships' wash
	Barrier to species movement	Low	
	Organic enrichment	Low	Can be difficult to distinguish from other impacts on sedimentation processes on coast
	Nutrient enrichment	Low	Can be difficult to distinguish from other sources (including terrestrial)
	Introduction or spread of non-indigenous species	Low	Impacts on biological systems through escaped invasive species not well understood
	Habitat structure changes - removal of substratum	Low	It can be difficult to distinguish from other impacts on sedimentation processes on the coast.
	Siltation rate changes	Low	Little research has been undertaken to investigate the potential impacts of vessel movements and ships' wash
Submarine cable and pipeline operations	Visual disturbance	Low	
	Underwater noise changes - low and mid-frequency impulsive sounds	Low	There is only little information on potential noise impacts due to installation (or removal) and operation of sub/sea cables. In addition, there are no clear indications that underwater noise caused by the installation of subsea cables poses a high
Waste gas emissions	Synthetic compound contamination	Low	
	Transition elements & organo-	Low	

Activity group	Pressure	Activity-pressure confidence	Activity-pressure confidence description (where available)
Waste gas emissions	metal contamination		
	Hydrocarbon & PAH contamination	Low	
	Radionuclide contamination	Low	
	Changes in suspended solids	Low	
	Siltation rate changes	Low	

Annex 9: Database status and recommendations

Table A9.1: Database status and recommendations according to activities being considered. This output focuses specifically on environmental cumulative effects. Recommendations relating to social impacts are provided in MMO (2014).

Activity (adapted from JNCC activity list)	Database status and recommendations
Aquaculture - finfish	Pressures were identified using a range of literary sources. However, it is recommended to seek additional sources of information to support the activity-pressure links found, especially in terms of hydrological pressures and removal of non-target species (which may only be relevant for few cases). Fin-fish aquaculture could be differentiated based on the targeting of different fish species and/or methods used, if a more detailed pressure identification is desired.
Aquaculture - shellfish	Pressures were identified using a limited number of literary sources, and it is recommended to seek additional sources of information to support the activity-pressure links found. This is especially the case in respect of: hydrological pressures, contamination associated with the activity (resulting from the use of synthetic products for production enhancement or maintenance), and the spread of non-indigenous species and potential genetic changes which may or may not be of especial relevance in the UK. Shellfish aquaculture may use various techniques, and pressures related to these could therefore be further differentiated for a more precise scoping exercise.
Aquaculture - macro-algae	Pressures were identified using a range of literary sources. However, it is recommended to seek additional sources of information to support the activity-pressure links found, especially in terms of the spread of non-indigenous species and potential genetic effects, and the removal of non-target species, as these may be pressures of low significance. Different macro-algae cultivation methods may result in different pressures, and therefore further research is required to evaluate this.
Fishing - mobile gears	Pressures were identified using a limited number of literary sources, and it is recommended to seek

Activity (adapted from JNCC activity list)	Database status and recommendations
Fishing - static gears	additional sources of information to support the activity-pressure links found. The activities draft list provided by JNCC proposed the differentiation of fishing activities by: ‘demersal trawling’ , ‘dredging’, ‘pelagic trawling’, ‘traps’ (potting/creeling), ‘recreational fishing’, ‘nets’ (static), ‘lines’ and ‘seines’. Pressures could also be distinguished according to the target of the fishing activity (for which fishing techniques may differ, as well as variations in temporal and spatial scales), if a receptor-led scoping exercise is to be used. It is therefore recommended that a distinction is made between the pressures that these different techniques may exert for an accurate scoping exercise.
Harvesting - seaweed and other sea-based food	Pressures were sourced from ODEMM linkage tables. Pressures and sources related to these links need to be supported by additional evidence. Further differentiation of harvesting activities may be possible. For instance, the ODEMM linkage tables differentiate harvesting activities by: seaweed and saltmarsh vegetation harvesting, bait digging, bird eggs collection, shellfish hand collecting, peels (boulder turning) and curios.
Extraction of genetic resources	Pressures were sourced from ODEMM linkage tables. Pressures and sources related to these links need to be supported by additional evidence
Shipping - port operations	Pressures were identified using a range of literary sources. However, it is recommended that additional sources of information are sought to support the activity-pressure links found, especially in terms of barriers to species movement, for which the link was found to be weak.
Shipping - general activities	Pressures were identified using a limited number of literary sources, and it is recommended that additional sources of information are sought to support the activity-pressure links found, especially in terms of physical change as a result of cargo loss at sea, which may not be relevant for some commercial vessels. The significance of the pressures will differ according to the size of the vessel and further differentiation could therefore help to scope in and out some of the pressures related to this activity.
Renewable energy - wind -	Pressures were identified using a range of literary sources. Construction of offshore wind farm may

Activity (adapted from JNCC activity list)	Database status and recommendations
construction	use different techniques depending on the type and size of foundation used. Specific pressures for the general types of foundations used in the UK could be identified, providing a more detailed and accurate scoping exercise.
Renewable energy - wind - operation	Pressures were identified using a range of literary sources. Regarding this activity, it is recommended that information is kept up-to-date where possible; new information may become available and new methods might be used to assess some of the pressures, especially in terms of underwater noise changes and collision risk. Different pressures could be identified according to the selected design.
Renewable energy - wind - decommissioning	Pressures were identified using a range of literary sources. Regarding this activity, it is recommended that information is kept up-to-date as new information becomes available and new methods are used to assess these pressures.
Renewable energy - wave - construction	Pressures were identified using a range of literary sources. However, new technologies and designs could be developed and construction needs for each could vary, resulting in different pressures. At the moment, these are difficult to identify because they are still under development and are likely to be modified to improve performance. Further differentiation should be made as knowledge becomes available.
Renewable energy - wave - operation	Pressures were identified using a range of literary sources. However, new technologies and designs could be developed, and operation functioning of each could vary, resulting in different pressures. Presently, these are difficult to identify because they are still under development and are likely to be modified to improve performance. Further differentiation should be made as information becomes available.
Renewable energy - wave - decommissioning	Pressures were identified using a range of literary sources. However, due to the novelty of the technology and lack of experience with the decommissioning phase, pressures are mostly

Activity (adapted from JNCC activity list)	Database status and recommendations
	theoretical, and will need to be updated as information becomes available.
Renewable energy - tidal stream - construction	Pressures were identified using a range of literary sources. However, new technologies and designs could be developed, and construction needs for each could vary, resulting in different pressures. At the moment, these are difficult to identify because they are still under development and are likely to be modified to improve performance. Further differentiation should be made as knowledge becomes available.
Renewable energy - tidal stream - operation	Pressures were identified using a range of literary sources. However, new technologies and designs could be developed, and operational functioning of each could vary, resulting in different pressures. At the moment, these are difficult to identify because they are still under development and are likely to be modified to improve performance. Further differentiation should be made as information becomes available.
Renewable energy - tidal stream - decommissioning	Pressures were identified using a range of literary sources. However, due to the novelty of the technology and lack of experience with the decommissioning phase, pressures are mostly theoretical, and will need to be updated as information becomes available.
Renewable energy - tidal range - construction	Pressures were identified using a range of literary sources. However, new technologies and designs could be developed and construction needs for each could vary, resulting in different pressures. At the moment, these are difficult to identify because they are still under development and are likely to be modified to improve performance. Further differentiation should be made as knowledge becomes available.
Renewable energy - tidal range - operation	Pressures were identified using a range of literary sources. However, new technologies and designs could be developed, and operational functioning of each could vary, resulting in different pressures. At the moment, these are difficult to identify because they are still under development and are likely to be modified to improve performance. Further differentiation should be made as information

Activity (adapted from JNCC activity list)	Database status and recommendations
	becomes available.
Renewable energy - tidal range - decommissioning	Pressures were identified using a range of literary sources. However, due to the novelty of the technology and lack of experience with the decommissioning phase, pressures are mostly theoretical, and will need to be updated as information becomes available.
Marine hydrocarbon extraction - operation	Pressures were sourced from the ODEMM linkage tables. It is recommended that a distinction is made between the extraction of gas and oil, and exploration and construction phases are included as activities.
Marine hydrocarbon extraction - decommissioning	Pressures were sourced from the ODEMM linkage tables. It is recommended that a distinction is made between the extraction of gas and oil, and exploration and construction phases.
Submarine cable and pipeline operations	Pressures were identified using a range of literary sources. However, it is recommended that additional sources of information are sought to support the activity-pressure links found, especially in terms of visual disturbance (which was found to be related to maintenance vessels only). It was noted that separate activity sections for power and telecommunication cables and pipelines should be established, at least during operational phases (due to the different pressures that could be exerted). A separate activity for submarine cable and pipeline installation should also be considered.
Gas storage operations - exploration	Pressures were identified using a range of literary sources. However, it is recommended that additional sources of information are sought to support the activity-pressure links found.
Gas storage operations - construction	Pressures were identified using a range of literary sources. However, it is recommended that additional sources of information are sought to support the activity-pressure links found, especially in terms of physical change (which may involve those already being considered under the operational stage of the activity) and salinity changes. Installation of required pipelines should be considered under a separate section, which could be allocated in the previously proposed "submarine cable and

Activity (adapted from JNCC activity list)	Database status and recommendations
	pipeline installation" activity section.
Gas storage operations - operation	Pressures were identified using a range of literary sources. However, it is suggested that additional sources of information should be sought in order to support the activity-pressure links found. It is also recommended that an activity section for "gas storage operations - decommissioning" is included.
Conservation and environmental protection - MPA	Given the list of pressures provided by OSPAR, which only considers negative pressures, the identification of all environmental pressures caused by MPAs was a challenging process. "Physical change" in the MPA ecosystem composition resulting from its protection (i.e. increased biodiversity, variation of species composition), was the only pressure identified within the database. Consideration of MPAs as human activities is questionable, as it may only be relevant to social and economic impact assessments (e.g. displacement of other human activities caused by MPAs designations). Simultaneously, MPAs could be considered as receptors, susceptible to other marine activities' environmental pressures. There is, therefore, a need to include positive pressures within the pressure list before tackling MPAs as human activities. Further refinement of MPAs, in terms of the different types of designations that exist, could target beneficial pressures associated with certain receptor groups. A different point to consider is, whether or not there is scope to include pressures resulting from incorrect management of MPAs.
Conservation and environmental protection - artificial reefs	Pressures were identified using a limited number of literary sources, and it is recommended that additional sources of information are sought to support the activity-pressure links found. Further differentiation of the pressures exerted by artificial reefs introduction based on their purpose is also recommended.
Cultural and heritage sites	Pressures were sourced from ODEMM linkage tables. Pressures and sources related to these links need to be supported by additional evidence. It must be considered that cultural and heritage sites may also be identified as receptors. 'Heritage assets' are those that have been positively identified

Activity (adapted from JNCC activity list)	Database status and recommendations
	as holding a degree of significance meriting consideration, they are often irreplaceable resources that can be vulnerable to a wide range of activities and natural processes (Defra, 2011).
Extraction - aggregates	Pressures were identified using a range of literary sources. However, it is recommended that additional sources of information are sought to support the activity-pressure links found. More detailed categories for extraction activities could be created. For example, ODEMM linkage tables differentiate between the extraction of inorganic mine and particulate waste, maerl, rock and mineral, and sand and gravel aggregates.
Extraction -navigational dredging	Pressures were identified using a range of literary sources. However, it is recommended that additional sources of information are sought to support the activity-pressure links found, especially in terms of barrier to species movement and pollution.
Extraction - water	Pressures were identified using a limited number of literary sources, and it is recommended that additional sources of information are sought to support the activity-pressure links found.
Dredge and spoil disposal	Pressures were identified using a limited number of literary sources, and it is recommended that additional sources of information are sought to support the activity-pressure links found.
Coastal tourist sites	Pressures were identified using a limited number of literary sources, and it is recommended that additional sources of information are sought to support the activity-pressure links found. Further work is recommended and differentiation between different activities should be applied. Grouping only those that present similar characteristics in terms of environmental and social/economic pressures. For the purpose of coastal tourist sites activities categorisation and related pressures, it is recommended that the work undertaken within the Solent Disturbance and Mitigation Project is used (Stillman *et al*., 2009; 2012).
Recreational activities -	Pressures were identified using a range of literary sources. However, it is recommended that additional sources of information are sought to support the activity-pressure links found. For the

Activity (adapted from JNCC activity list)	Database status and recommendations
sailing (yachting)	purpose of recreational activities categorisation and related pressures, it is recommended that the work undertaken within the Solent Disturbance and Mitigation Project is used (Stillman *et al*., 2009; 2012).
Recreational activities - sailing (dinghy)	Pressures were identified using a range of literary sources. However, it is recommended that additional sources of information are sought to support the activity-pressure links found. For the purpose of recreational activities categorisation and related pressures, it is recommended that the work undertaken within the Solent Disturbance and Mitigation Project is used (Stillman *et al*., 2009; 2012).
Recreational activities - horse riding	Pressures were identified using a range of literary sources. However, it is recommended that additional sources of information are sought to support the activity-pressure links found. For the purpose of recreational activities categorisation and related pressures, it is recommended that the work undertaken within the Solent Disturbance and Mitigation Project is used (Stillman *et al*., 2009; 2012).
Military activities	Pressures were identified using a range of literary sources. However, it is recommended that additional sources of information are sought to support the activity-pressure links found, especially in terms of contamination. Spatial and temporal assessment of pressures caused by military activities may be hampered by the lack of information regarding exact locations utilised for training and other military activities.
Marine research	Pressures were sourced from ODEMM linkage tables. Pressures and sources related to these links need to be supported by additional evidence. Further differentiation of marine research activities may be possible.
Coastal defences - construction	Pressures were sourced from the ODEMM linkage tables. Pressures and sources related to these links need to be supported by additional evidence. Further differentiation between hard and soft engineering coastal defence options, or between different types of structures could be undertaken. It

Activity (adapted from JNCC activity list)	Database status and recommendations
	is recommended that guidance for shoreline management plans (SMPs) or the SMPs themselves are used (see https://www.gov.uk/government/publications/shoreline-management-plans-smps).
Coastal defences - operation	Pressures were sourced from the ODEMM linkage tables. Pressures and sources related to these links need to be supported by additional evidence. Further differentiation between hard and soft engineering coastal defence options, or between different types of structures could be undertaken. It is recommended that guidance for shoreline management plans (SMPs) or the SMPs themselves are used (see https://www.gov.uk/government/publications/shoreline-management-plans-smps).
Land reclamation - construction	Pressures were sourced from the ODEMM linkage tables. Pressures and sources related to these links need to be supported by additional evidence. The original list of activities facilitated by JNCC considered 'Land claim protection', however, this term is not clearly defined in literature, and it is proposed for it to be substituted by 'Land reclamation'.
Land reclamation - operation	Pressures were sourced from the ODEMM linkage tables. Pressures and sources related to these links need to be supported by additional evidence. The original list of activities facilitated by JNCC considered 'Land claim protection', however, this term is not clearly defined in literary, and it is proposed for it to be substituted by 'Land reclamation'.
Coastal docks, ports & marinas	Pressures were identified using a limited number of literary sources, and it is recommended to seek additional sources of information to support the activity-pressure links found.
Waste gas emissions	Pressures were sourced from the ODEMM linkage tables. Pressures and sources related to these links need to be supported by additional evidence.
Industrial and agricultural liquid discharges	Pressures were sourced from the ODEMM linkage tables. Pressures and sources related to these links need to be supported by additional evidence.

Activity (adapted from JNCC activity list)	Database status and recommendations
Sewerage disposal	Pressures were sourced from the ODEMM linkage tables. Pressures and sources related to these links need to be supported by additional evidence. Sewerage disposal' has included the activity 'Municipal waste' (part of JNCC activity list) because of their similarity.
Power station thermal and nuclear discharges	Pressures related to 'Power station thermal and nuclear discharges' are sourced from the ODEMM linkage tables. Pressures and sources related to these links need to be supported by additional evidence. It is recommended that ‘nuclear discharges’ are separated from ‘power station discharges’, as pressures are likely to be different.