JNCC Report
No: 540

A review of monitoring and assessment of seabed habitats in UK inshore Marine Protected Areas, 1999 - 2013

McBreen, F.[1], Jesus, A.[1], Camplin, M.[2], Clark, L.[3], Edwards, H.[4], Pirie, C.[5], James, B.[3], Young, M.[5], Steel, L.[3], Johnston, C.[1] & Hawkridge, J.[1]

November 2016

[1] Joint Nature Conservation Committee
[2] Natural Resources Wales
[3] Scottish Natural Heritage
[4] Department of Agriculture, Environment and Rural Affairs
[5] Natural England

ISSN 0963-8901

For further information please contact:

Joint Nature Conservation Committee
Monkstone House
City Road
Peterborough PE1 1JY
http://jncc.defra.gov.uk

This report should be cited as:

McBreen, F., Jesus, A., Camplin, M., Clark, L., Edwards, H., Pirie, C., James, B., Young, M., Steel, L., Johnston, C. & Hawkridge, J. 2016. A review of monitoring and assessment of seabed habitats in UK inshore Marine Protected Areas, 1999 – 2013. *JNCC Report No. 540*. JNCC, Peterborough.

Acknowledgements:

Many people have contributed to this report. Those who have made substantial contributions to the text have been listed as authors. Authors from the Country Nature Conservation Bodies are all past or present members of the inter-agency Marine Monitoring Group that comprises representatives from the Department of Agriculture, Environment and Rural Affairs, Natural England, Natural Resource Wales, Scottish Natural Heritage and the Joint Nature Conservation Committee.

The following people contributed to the report through interviews:
Chris Pirie, Mike Young, John Bleach, Debbie Russell, Rachel Williams, Kathryn Dawson and Benjamin Green (Natural England), Mike Camplin (NRW), Hugh Edwards (DAERA), and John Baxter and Laura Clark (SNH).

The following people provided comments on draft text:
Jon Davies, Beth Stoker, Hayley Hinchen, Emma Verling, Neil Golding, Cristina Herbon, David Vaughan, Laura Robson, Alexandra Cunha, Laura Cornick, Megan Parry, Becky Hitchin and Francesca Marubini (JNCC), Emma Foster, Jen Ashworth (Natural England), Joe Breen and Colin Armstrong (DAERA).

Eleonora Manca (JNCC) collated the data and designed the report catalogue. Abigayil Blandon and James Albrecht (JNCC) provided maps for the report.

This report is compliant with the JNCC Evidence Quality Assurance Policy http://jncc.Defra.gov.uk/default.aspx?page=6675.

Executive summary

This report focuses on the seabed habitat monitoring and assessments conducted by the UK Country Nature Conservation Bodies (CNCBs) during the period from 1999 - 2013 in inshore[1] marine protected areas (MPAs), namely SSSIs, ASSIs, SACs, Ramsar sites and SPAs. It aims to identify:

- how Common Standards Monitoring (CSM) Guidance has been implemented;
- how existing monitoring could inform a UK-wide monitoring programme to address all marine biodiversity obligations; and
- recommendations for future UK seabed habitat monitoring and assessments.

The outputs of this report will help to inform the development of options for monitoring seabed habitats both within MPAs and the wider environment to be presented to the UK Government and the Devolved Administrations. The options will consider whether existing monitoring programmes are sufficient to meet our marine biodiversity obligations and management requirements or whether additional monitoring is needed.

This report identifies which habitats have been monitored and how monitoring data are used to assess the condition of MPA habitats and fulfil reporting requirements.

The recommendations from the report are presented below:

Recommendations[2]	
M.1	Develop a multi-year resourcing/funding strategy for seabed habitat monitoring programmes to ensure the resources will be available to maintain long-term monitoring datasets and enable more cost effective planning.
M.2	Ensure UKDMOS is fit for purpose by: - improving the export facility; - identifying the input requirements for national MPAs, MSFD, WFD *etc*; - identifying in UKDMOS where data is held and in what form; - investigating whether more detailed monitoring information from the CNCBs' features, sub-features and monitoring metrics should be inputted into UKDMOS; - collating and inputting all CNCB monitoring data into UKDMOS; and - producing maps showing the scale of monitoring for selected seabed habitats across the UK to obtain a clear picture of the temporal and spatial resolution of the seabed habitat sampling within MPAs that are contributing towards the requirements of the MSFD (as required under Article 11 of the MSFD).
M.3	Develop new, and improve the use of existing, partnerships to deliver seabed habitat monitoring programmes, which will enhance cost effectiveness and provide added value. Explore the feasibility of collaborating with industry partners to collect and share data on monitoring.
M.4	Identify seabed habitat monitoring research questions that could be best answered through large scale research projects (e.g. via MASTS, NERC or EU funded research projects and programmes).
M.5	Consider how data collection through citizen science led projects can assist the delivery of seabed habitat monitoring programmes.

[1] Inshore MPAs occur within 12 nautical miles (nm) of the coast.
[2] Monitoring recommendations are labelled with an M, assessment recommendations with an A and evidence recommendations with an E.

Recommendations[2]	
M.6	Building on lessons learnt from previous monitoring, produce shared guidance on designing monitoring surveys for seabed habitats in MPAs and where appropriate hold joint training workshops on relevant topics. To include: - robust, realistic and cost effective sampling designs for delivering different types of monitoring/using different techniques; - experimental design to detect a meaningful level of change within an acceptable level of confidence, for seabed habitats; - power analyses (e.g. recommend appropriate levels of power and confidence); - the frequency and intensity of MPA monitoring for habitats subject to different levels of pressure/risk; and - most appropriate physical and chemical parameters to monitor in order to explain variations in the condition of seabed habitats.
M.7	Improve consistency in the application of different seabed habitat monitoring data collection methods and subsequent analyses by updating, where appropriate, existing technical guidelines and protocols. The following guidelines and protocols should be considered: - Marine Monitoring Handbook Procedural Guidelines; - MESH Recommended Operating Guidelines; - British, European and international standards; and - NRW Standard Operating Protocols.
M.8	Provide a central web-based portal (e.g. the Marine Monitoring Method finder on the JNCC website) to enable dissemination of the most up-to-date versions of all guidelines and protocols.
M.9	Promote accreditation for seabed habitat (monitoring) data collection and sample analysis where applicable through contribution to the production of NMBAQC guidelines for seabed habitat imagery collection, analysis and interpretation.
M.10	Use the results of targeted experimental monitoring case studies to improve our understanding of the relationships between different activity levels, the pressures they exert, and their effects on seabed habitats.
A.1	Identify existing issues and develop guidance to inform the setting of baselines and targets for seabed habitats. Where applicable, take into account the work done under WFD and MSFD, Hill *et al* (2012), and the recommendations in the OSPAR Advice Manual (OSPAR Commission 2012).
A.2	Maintain an overview of the ongoing seabed habitat indicator development work being undertaken by individual CNCBs that falls outside of the HBDSEG-led/coordinated process for developing seabed habitat indicators for MSFD.
A.3	Develop updated guidance on seabed habitat attributes to measure (including state, pressure and impact indicators) taking into account existing performance indicators and other metrics used by the CNCBs and relevant HBDSEG partners, the evolving MSFD indicators, and habitat conceptual ecological models (CEMs).
A.4	Further develop, using existing datasets, those attributes used by the CNCBs for seabed habitats that can detect impacts known to be occurring. Where applicable, take into account the work done under WFD and MSFD.
A.5	Produce shared guidance to inform seabed habitat condition assessments. The guidance should consider the scale at which assessments should be undertaken and how data can be aggregated from smaller to larger scales.

Recommendations[2]	
A.6	Undertake an intercalibration exercise to determine whether different condition classes are being assigned to seabed habitats comparably across the SNCBs (e.g. assess the condition of a given feature using the shared guidance developed under recommendation A.5). Produce assessment best practice guidelines based on lessons learnt.
E.1	Update and maintain the seabed habitat classification and develop tools to further improve consistency in the biotope assignment process. Consider development of a database of video and still images from seabed habitat surveys which can help to identify substrate and habitat/biotope type.
E.2	Continue to improve the quality, resolution and access to activities and pressures information to assist with monitoring and assessment of seabed habitats within MPAs.
E.3	Review the possibility of expanding the data storage functionality of Marine Recorder, and/or consider other options.
E.4	Make the catalogue of SNCB published and unpublished marine reports produced during the completion of this report available online through the JNCC website. Provide links to all SNCB report publication web pages for future marine survey and monitoring reports.

It is essential that the SNCBs and others with marine monitoring responsibilities in the Healthy and Biologically Diverse Seas Evidence Group (HBDSEG) partnership work closely to make the best use of the existing and any new marine biodiversity monitoring and assessment effort across the UK. Existing work is currently concentrated within MPAs.

JNCC in cooperation with the CNCBs developed the UK Marine Biodiversity Monitoring Strategy (Kröger & Johnston 2016) in order to design a scheme for monitoring different marine biodiversity components in a cost-efficient and integrative way. The findings of this review have informed the development of seabed habitat monitoring options, which are part of the UK Marine Biodiversity Monitoring Strategy. The progression of relevant report recommendations will be considered in the context of overall priorities for marine nature conservation work and align with resourcing decisions taken as part of the monitoring options process. A number of the recommendations are already being implemented by JNCC and the CNCBs.

Contents

1 Introduction

1.1 Purpose of the report

The Joint Nature Conservation Committee (JNCC) is leading a UK Marine Biodiversity Monitoring Research and Development (R&D) programme on behalf of the Statutory Nature Conservation Bodies (SNCBs) and other partners in the UK Marine Monitoring and Assessment Strategy (UKMMAS). The focus of the process is to design a monitoring programme to collect the evidence necessary to holistically inform the assessment processes required to fulfil marine biodiversity obligations and to provide timely and effective advice for the management of marine activities. This advice aims to encompass the significant policy and statutory obligations, such as the High Level Marine Objectives, OSPAR Convention, Habitats and Birds Directives, UK Post-2010 Biodiversity Framework, and the Marine Strategy Framework Directive (MSFD), in the most effective, holistic and cost-efficient manner. Proposing separate monitoring programmes to meet the needs of each obligation is not cost effective. The programme will advise on the development of a monitoring programme that can deliver information about the changing status and trends in biodiversity from a holistic perspective, based on understanding the structure and functioning of marine biodiversity and the human pressures impacting it in the UK. This advice will include costed options for monitoring marine biodiversity monitoring in all UK waters, including monitoring of seabed habitats both within Marine Protected Areas (MPAs) and the wider environment. The options will consider whether existing monitoring programmes are sufficient to meet existing marine biodiversity obligations or whether additional monitoring is needed.

In order to produce costed options for a UK wide seabed habitats monitoring programme, it is essential to have a thorough understanding of the seabed habitat monitoring within MPAs conducted by the UK Country Nature Conservation Bodies (CNCBs). It also important to understand how data collected through existing monitoring programmes has been used to inform assessments. In particular, it is important to identify which habitats have been monitored, how existing Common Standards Monitoring (CSM) guidance has been applied, how existing monitoring could inform the development of a UK wide biodiversity monitoring programme, and how monitoring data are used to assess the condition of MPA habitats and fulfil reporting requirements.

This report focuses on the seabed habitat monitoring and assessments conducted by the CNCBs during the period from 1999 – 2013 in inshore[3] MPAs, namely SSSIs, ASSIs, SACs, Ramsar sites and SPAs. It aims to:

- identify how CSM Guidance (JNCC 2004a) has been implemented;
- identify how existing monitoring could inform a UK wide monitoring programme to address all marine biodiversity obligations; and
- identify recommendations for future UK seabed habitat monitoring and assessments.

The outputs of this report will be used to help develop the options for the UK Government and the Devolved Administrations on marine seabed habitat monitoring across the UK and inform future work on national monitoring and assessments.

[3] Inshore MPAs occur within 12 nautical miles (nm) of the coast.

1.2 Method

JNCC staff visited each of the CNCBs between August and October 2012 to ask a series of questions related to the monitoring and assessment of seabed habitats undertaken in inshore MPAs. The current report summarises JNCC's conclusions from these meetings, supplemented by further discussions and additional information subsequently provided by the CNCBs.

The key questions discussed with the CNCBs were:

- Who undertook seabed habitat monitoring surveys?
- Which seabed habitats were monitored and where?
- When did seabed habitat monitoring surveys take place?
- How were seabed habitat monitoring surveys planned?
- How were seabed habitat monitoring surveys undertaken?
- How were the data analysed?
- How have seabed habitat assessments been undertaken?

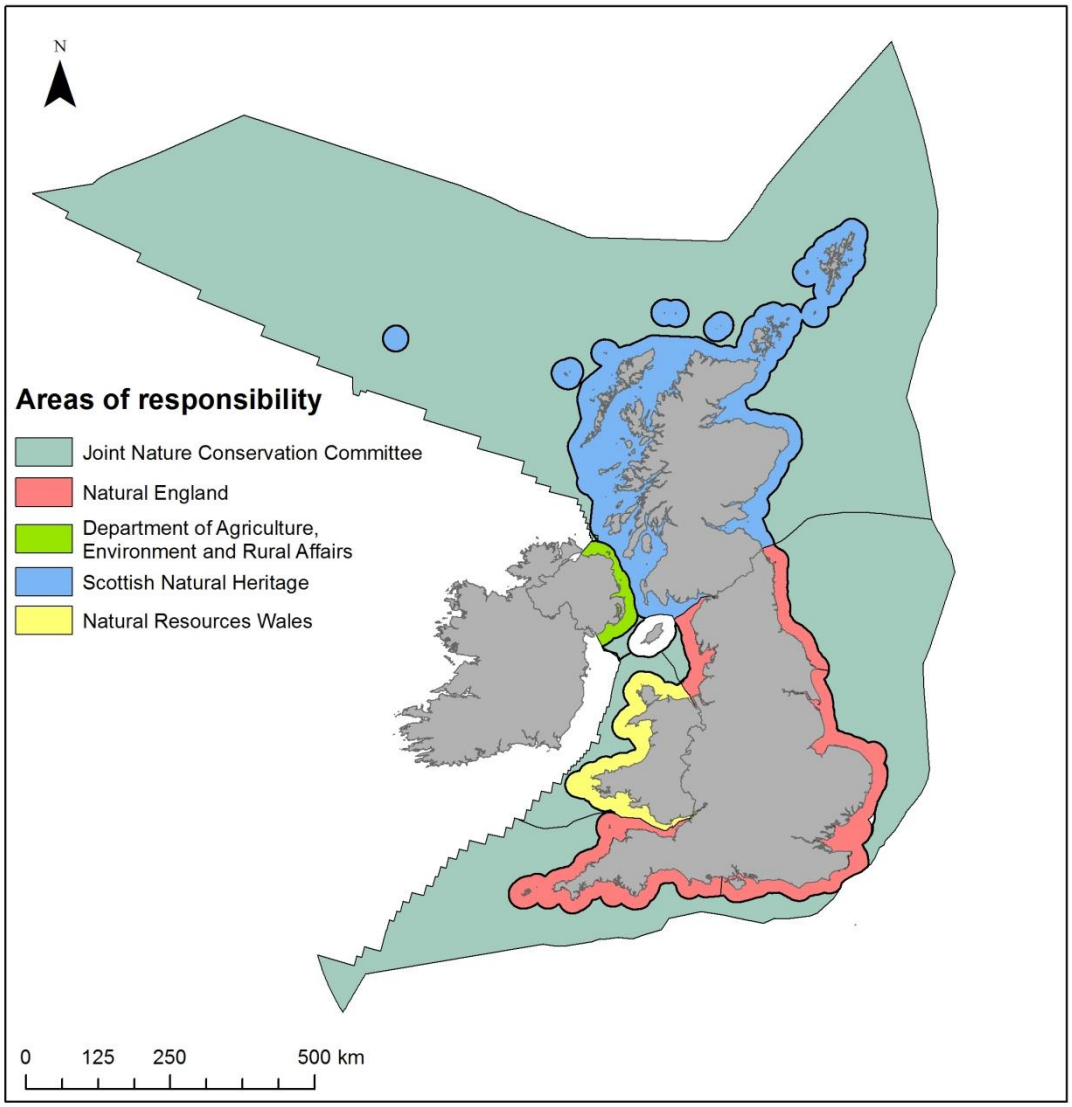
1.3 Background

The responsibilities of the SNCBs are split between inshore (and offshore waters[4]). The CNCBs are the SNCBs with inshore responsibilities: the Department of Agriculture, Environment and Rural Affairs (DAERA), Natural England (NE), Scottish Natural Heritage (SNH) and Natural Resources Wales (NRW). The JNCC has responsibility for nature conservation in UK offshore waters. The respective geographic areas of responsibility are shown in Figure 1. JNCC also has a role on behalf of the CNCBs to work on nature conservation issues that affect the UK as a whole and internationally.

The SNCBs have responsibilities to identify MPAs, and once the MPAs are designated, to identify conservation objectives and to subsequently assess and report on the condition of the designated habitats and species. Conservation objectives express the desired condition of the designated/notified feature(s) within the site[5].

[4] The offshore area is any part of the seabed and subsoil situated within areas covered by the Continental Shelf Act (2013) and any part of waters in the UK Exclusive Economic Zone (2013), except the internal waters of, and the territorial sea adjacent to, the United Kingdom, the Channel Islands and the Isle of Man.

[5] Note that the wording of conservation objectives varies between different types of MPAs and within the same MPA type between the different SNCBs (see example in Appendix 1).



Areas of responsibility. Contains Ordnance Survey, Marine Management Organistaion, and UK Hydrographic Office data. (c) Crown copyright (c) JNCC. Not to be used for navigation (c) JNCC 02/2015

Please note that no official limit between the territorial seas of Northen Ireland and the Republic of Ireland has been agreed upon. Therefore the area of responsibility of the Department of Agriculture, Environment and Rural Affairs is an approximation based on limits previously used to delineate the assessment areas of the Marine Strategy Framework Directive.

Figure 1. SNCB areas of responsibility.

MPAs describe a wide range of marine areas which have some level of restriction of activity to protect living, non-living, cultural and/or historic resources. In the UK, MPAs have primarily been set up to help conserve or recover nationally significant or representative examples of marine biodiversity, including threatened or declining species and habitats of European and national importance (Defra *et al* 2012a). The UK MPA network includes the following MPAs:

1. SSSIs originally notified under the National Parks and Access to the Countryside Act 1949 and re-notified under the Wildlife and Countryside Act 1981 to protect species, habitats and geological features of national importance in England, Wales and Scotland. SSSIs were the first protected sites to include coastal components.

2. Areas of Special Scientific Interest (ASSI) established under the Nature Conservation and Amenity Lands (Northern Ireland) Order 1985[6] to protect species, habitats and geological features of importance in Northern Ireland.

3. Special Areas of Conservation (SACs) established under UK regulations implementing the Habitats Directive (92/43/EEC), to protect natural habitat types (listed in Annex I) and species (listed in Annex II) of Community importance in UK waters.

4. Ramsar sites established under the 1971 Convention on Wetlands of International Importance especially as Waterfowl Habitat, to promote the conservation and wise-use of wetlands of international importance and their resources in UK waters (http://www.ramsar.org/).

5. Marine Nature Reserves (MNRs) established under the Wildlife and Countryside Act 1981 in UK waters[7].

6. Special Protection Areas (SPAs) established under the UK regulations implementing the Birds Directive (79/409/EEC) to protect birds listed under Annex I of the Directive and regularly occurring migratory species in UK waters. Habitats are not notified features of SPAs but the conservation objectives for the site may refer to supporting habitats for the species, e.g. in terms of maintaining, restoring or enhancing.

7. OSPAR Marine Protected Areas established under the OSPAR MPA identification and selection guidelines[8]. All sites must meet at least one of the OSPAR MPA ecological criteria[9]. Until 2013 all UK OSPAR MPAs were either SACs or SPAs.

8. Marine Conservation Zones (MCZs) established under the Marine and Coastal Access Act 2009 to protect nationally important marine wildlife, habitats, geology and geomorphology in English territorial waters and offshore waters adjacent to England, Wales, and Northern Ireland.

9. Nature Conservation Marine Protected Areas (NCMPAs) established under the Marine and Coastal Access Act (2009) (in offshore waters) and the Marine (Scotland) Act (2010) (in territorial waters) to protect nationally important marine wildlife, habitats, geology and geomorphology in Scottish territorial and offshore waters.

This report focuses on the inshore MPAs which were the focus of monitoring and assessment efforts from 1999 – 2013, namely SSSIs, ASSIs, SACs, Ramsar sites and SPAs. Offshore MPAs, OSPAR MPAs, MCZs and NCMPAs are excluded. Figures 2 - 5 show the MPAs which are considered in this report.

[6] This was largely superseded by the Environment (Northern Ireland) Order 2002.
[7] Lundy and Skomer Marine Nature Reserves (MNRs) have been converted to MCZs under the Marine and Coastal Access Act 2009, Strangford Lough MNR has been converted to an MCZ under the Marine Act (Northern Ireland) 2013. For the purposes of this report, Lundy, Skomer and Strangford Lough will be referred to as MNRs as they were MNRs in the period covered by this report. St Abbs Head voluntary MNR is not included as it is a non-statutory MPA.
[8] http://jncc.defra.gov.uk/PDF/OSPAR_03-17e_GuidelinesIdentificationMPA.pdf
[9] An area may be considered for contribution towards the OSPAR network of MPAs if it meets one or more of the OSPAR MPA ecological criteria. The OSPAR MPA criteria are not the same as criteria for selection of Natura sites (SACs or SPAs) under the Habitats and Birds Directives.

Initially all MPAs identified were close inshore within territorial waters, but since 2005 MPAs have been identified for seabed habitats away from the coast. The number of MPAs has increased considerably during the period covered by this report, i.e. 1999 - 2013[10]. By 1999, following the implementation of the Habitats Directive in UK inshore waters, there were three statutory MNRs, 233 SSSIs, 10 ASSIs and 54 candidate SACs with marine components (cSACs)[11] designated for marine habitats and 91 SPAs. By 2013[12], there were 254 SSSIs with marine components (Defra, 2012b; Scottish Government, 2012 and Welsh Government, 2012), 21 ASSIs (DAERA, personal communication), 76 SACs, 30 sites of Community Importance, 2 cSACs and 108 SPAs. These SSSI figures were published in 2012; work is ongoing to accurately identify the SSSIs and ASSIs that contribute to the MPA networkaccording to the marine components protected within them.

[10] Figures are based on information from the following sources:

1. SSSIs with marine habitats: Information from the CNCBs (Defra 2012b; Scottish Government 2012; Welsh Government 2012) and the Common Database on Designated Areas (http://cdr.eionet.europa.eu/gb/eea/cdda1/envuqm2ya/0);
2. ASSIs with marine habitats: interim list provided by DAERA and the Common Database on Designated Areas (http://cdr.eionet.europa.eu/gb/eea/cdda1/envuqm2ya/0);
3. SACs with marine habitats (sites with marine species only were removed) (http://jncc.defra.gov.uk/page-1461); and
4. SPAs (http://jncc.defra.gov.uk/Default.aspx?Page=4661).

[11] A site becomes a candidate Special area of Conservation (cSAC) once a Natura Data Form and GIS data for the site have been submitted by the contracting party to the European Commission (for further information see http://jncc.defra.gov.uk/page-4168).

[12] Prior to designation of Marine Conservation Zones (MCZs) under the Marine and Coastal Access Act (2009), Nature Conservation MPAs under the Marine Scotland Act (2010).

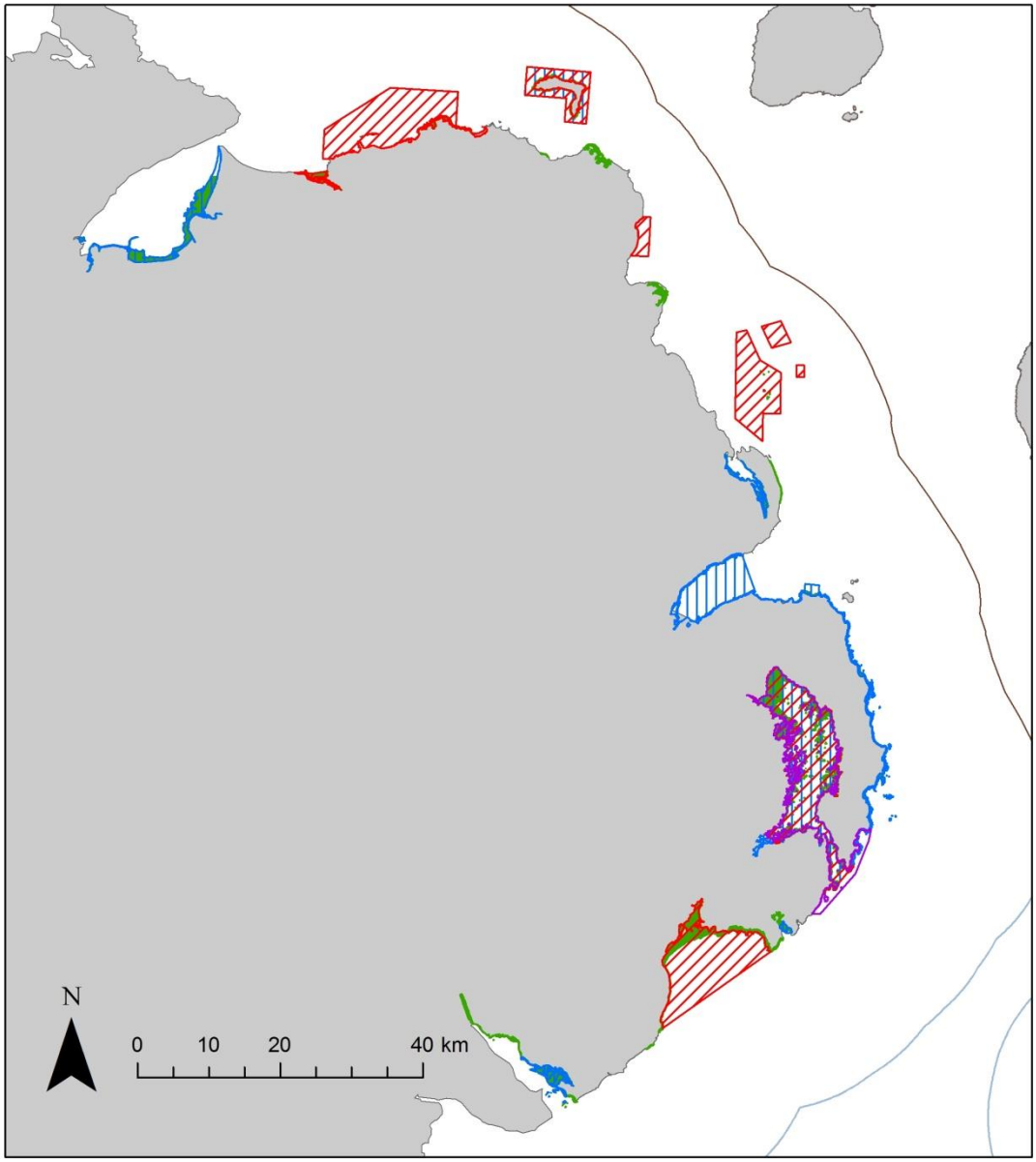


Figure 2. Northern Irish MPAs considered in this report (excluding Ramsar sites).

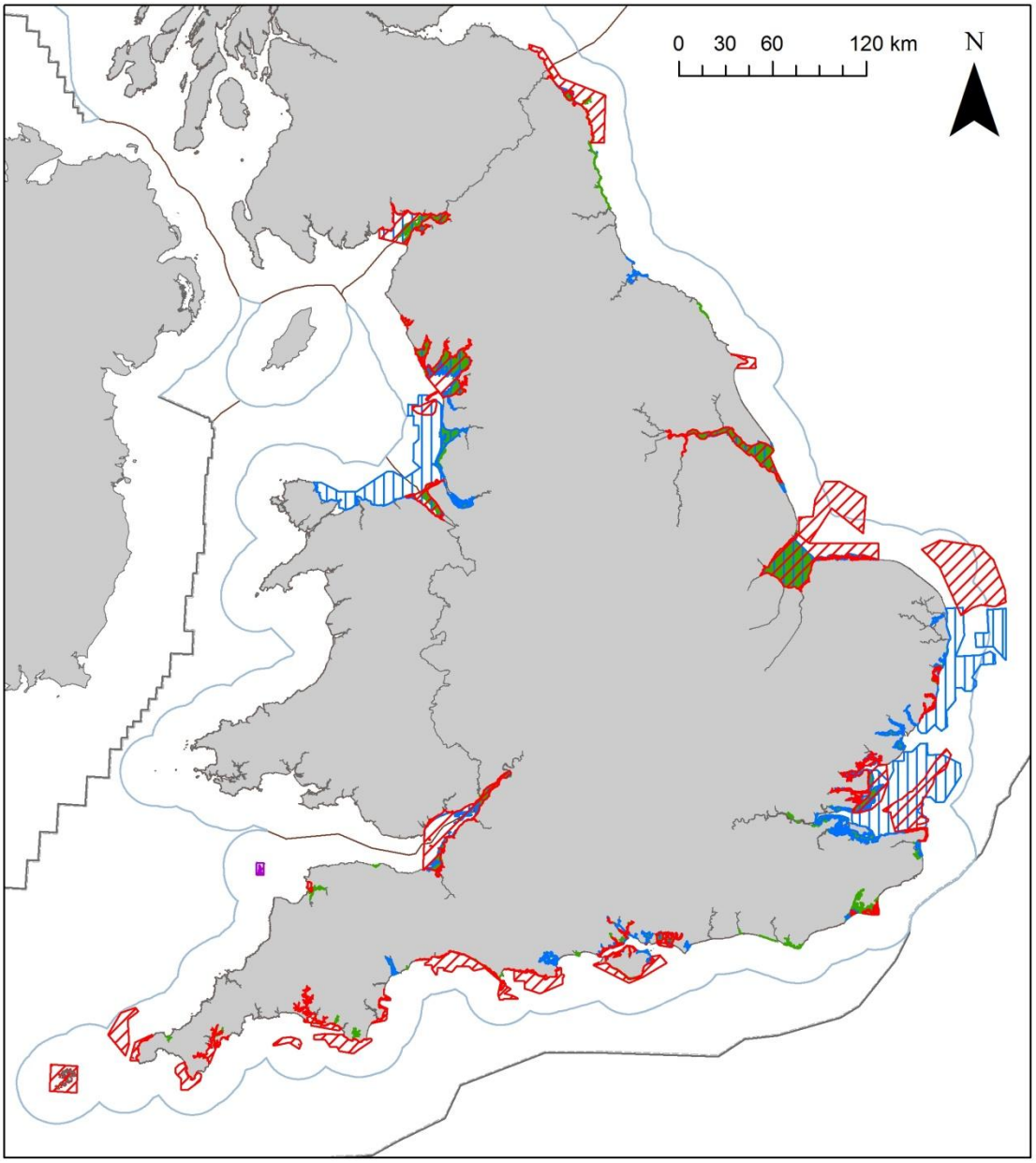


Figure 3. English MPAs considered in this report (excluding Ramsar sites).

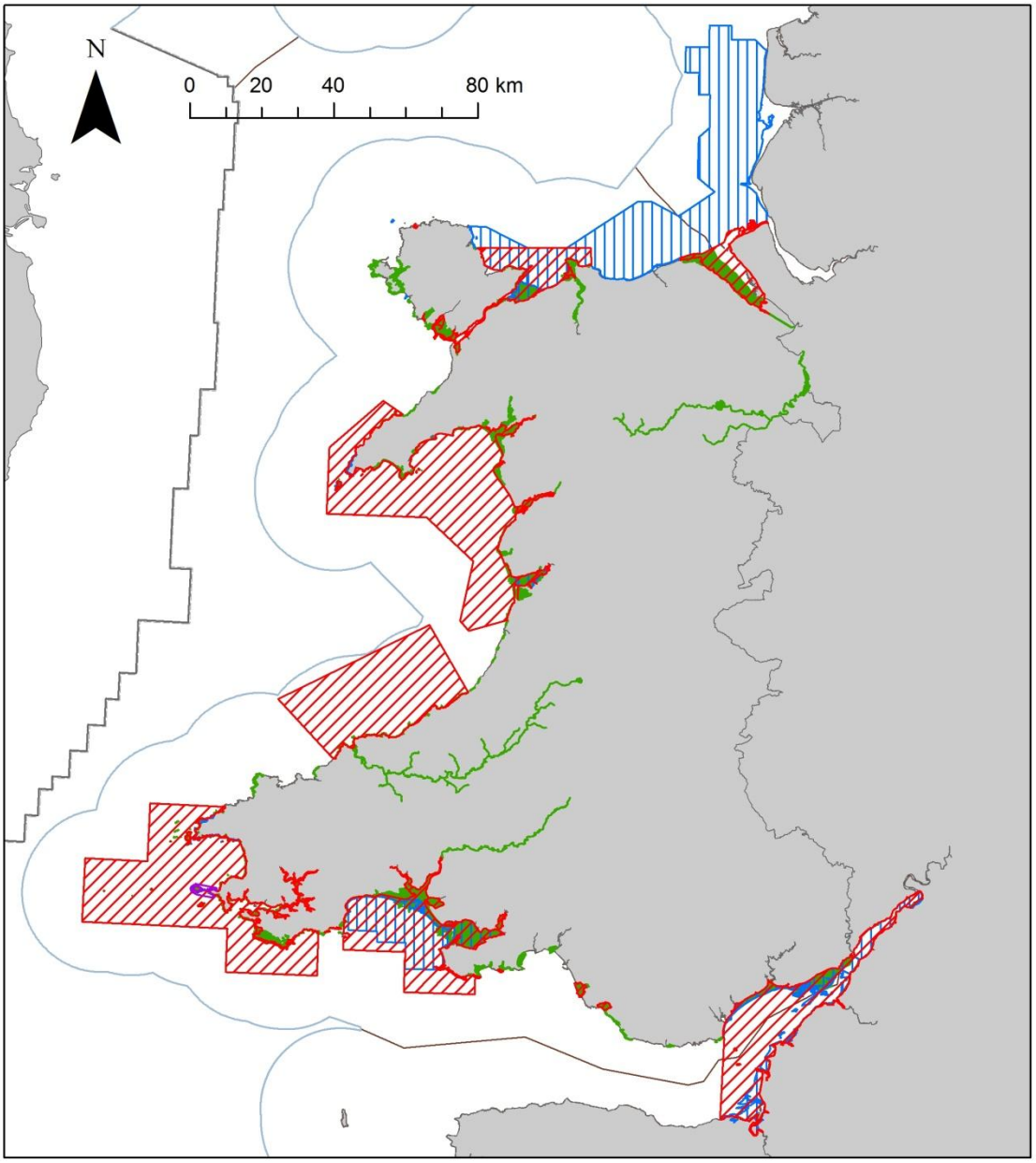


Figure 4. Welsh MPAs considered in this report (excluding Ramsar sites).

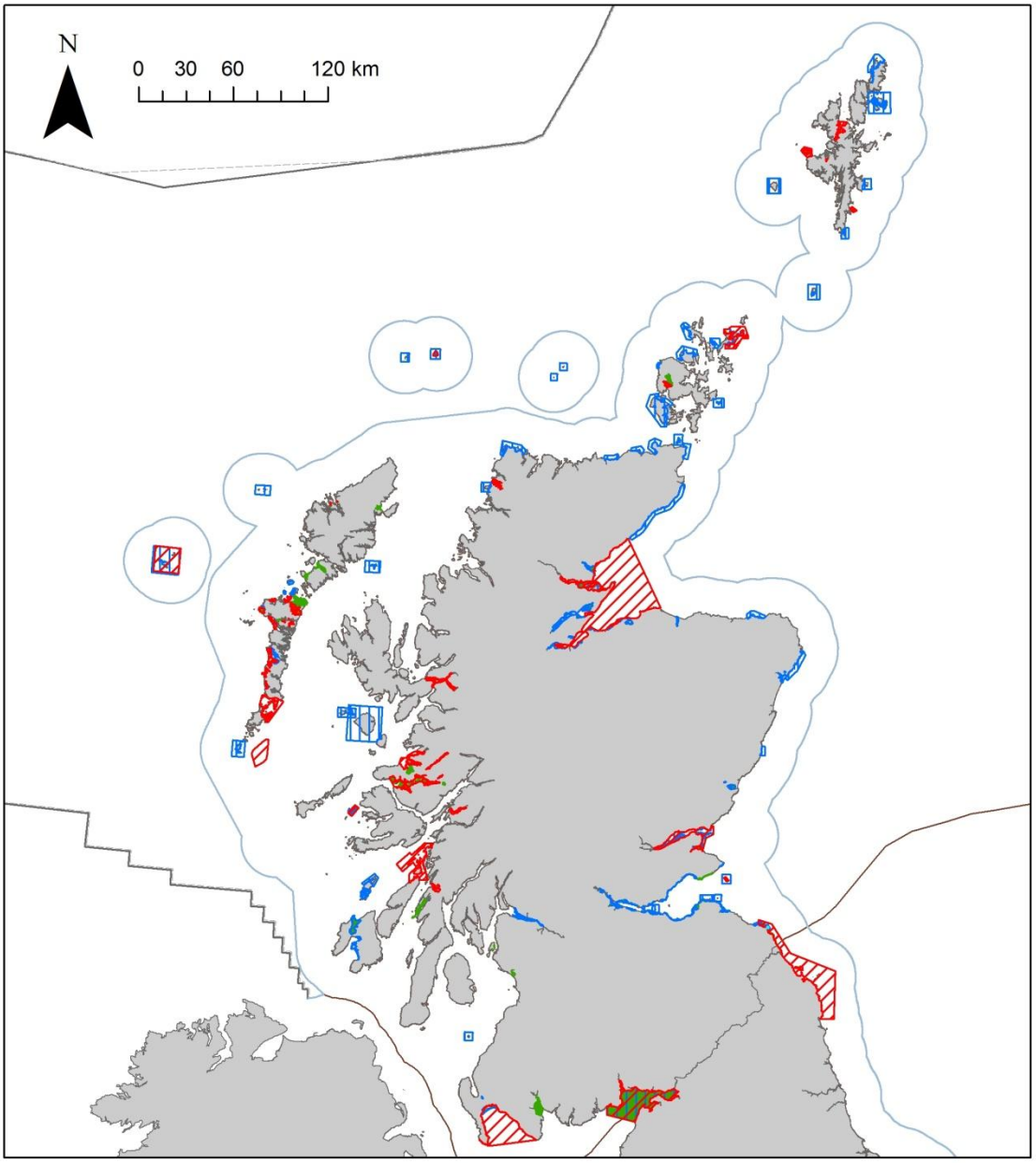


Figure 5. Scottish MPAs considered in this report (excluding Ramsar sites).

1.3.1 Why monitor and assess seabed habitats?

Monitoring of MPAs is necessary to collect the evidence needed to assess and report on the condition of designated features to fulfil national and international marine biodiversity status assessment obligations and to provide timely and effective advice for management of marine activities.

This section briefly outlines the main marine biodiversity obligations driving the need to monitor, assess and report on the condition of seabed habitats within inshore MPAs in UK waters, between 1999 and 2013.

For a more detailed and comprehensive review of the marine biodiversity assessment obligations in the UK see Hinchen (2014).

SACs
Assessing the condition of SAC habitats is essential to establish appropriate conservation measures to maintain or restore habitats at favourable conservation status (FCS) as stipulated under Article 6 (1) of the Habitats Directive, and to demonstrate that habitat deterioration is being avoided in accordance with Article 6 (2).

In addition, every six years, the Member States of the European Union are required under Article 17 to report on the implementation of the Directive. The first report was undertaken in 2000, followed by reports in 2006 and 2012. The reporting provides information on (i) the general implementation of the Directive (including information on monitoring schemes, the number of SACs and their area, proportion of sites with management plans and measures undertaken to ensure coherence of the Natura 2000 Network), and (ii) an assessment of the conservation status of all species and habitats listed under the Annexes of the Directive (including information on the conservation measures taken within the reporting period, i.e. importance, location and broad evaluation). Favourable Conservation Status (FCS) is assessed across all national territory and should consider the habitat or species both within the Natura 2000 network and in the wider countryside or sea (Evans & Arvela 2011). During the period in question, resource constraints have meant that direct monitoring of seabed habitats has been largely restricted to within MPAs[13].

Article 11 of the Habitats Directive explicitly requires Member States to undertake monitoring of the conservation status of the natural habitats and species listed in Annexes I, II, IV and V of the Directive over their entire range.

SPAs
Under the Birds Directive, there is a requirement to report on the implementation of the national provisions taken under the Directive, and in order to do so, monitoring and assessment of the habitats for birds, as well as bird numbers, is necessary at a site level across the suite of SPAs.

Under Article 10 of the Birds Directive, Member States are asked to encourage research and any work required as a basis for the protection, management and use of the population of all species naturally occurring in their European territories. Moreover, Article 12 of the Birds Directive require that Member States regularly prepare and submit national reports on progress made in implementing the directive.

Ramsar Sites
UK Government policy treats Ramsar Sites in the same way as SPAs.

[13] The assessment of conservation status in the wider marine environment falls outside the scope of this report.

SSSIs and ASSIs
The CNCBs have a number of duties and general responsibilities in relation to SSSIs/ASSIs, which include monitoring, assessing and reporting on their condition and providing management advice. These responsibilities are implicit in the following acts:

- England, Wales and Scotland: Wildlife and Countryside Act 1981
- Scotland: Nature Conservation (Scotland) Act 2004
- England and Wales: Natural Environment and Rural Communities Act 2006
- Northern Ireland: The Environment (Northern Ireland) Order 2002, amended in the Wildlife and Natural Environment Act (Northern Ireland) 2011

1.3.2 UK Marine SACs Project

The Inter-Agency Marine Monitoring Group (MMG), an inter-agency group of specialist monitoring staff from the conservation agencies (NRW (formerly CCW), DAERA (formerly Environment and Heritage Service [EHS] and the Department for the Environment Northern Ireland), SNH, Natural England (formally English Nature)) and JNCC, was set up in 1996 to oversee the delivery of monitoring tasks under the UK Marine SACs project (http://www.ukmarinesac.org.uk/) and oversee production of the Marine Monitoring Handbook (http://jncc.defra.gov.uk/MarineMonitoringHandbook).

The UK Marine SACs project was set up to establish management schemes on selected marine SACs. It focussed on twelve marine SACs around the UK coastline to build our knowledge and establish the best practise needed for the management and monitoring of marine sites. Following the end of the UK Marine SACs project in 2001, the MMG evolved into a more formal inter-agency group. MMG contributed to developing the Common Standards for Guidance for Marine features and the production of the Marine Monitoring Handbook.

The Marine Monitoring Handbook was one of the key outputs of the UK Marine SACs project and was to be used as guidance by the UK government's SNCBs and their key partners in drawing up monitoring schemes for marine SACs. The Marine Monitoring Handbook was developed by the UK Marine SACs project through a series of literature reviews, workshops and practical trials. The overall approach to monitoring taken in the Handbook was that adopted by the UK CNCBs in their Common Standards for Monitoring of designated sites. The Handbook provided guidance on the different options and their relative costs and benefits and describes best practice through a series of procedural guidelines for the common survey/monitoring techniques. It drew on the information gathered from extensive trials of different techniques and their deployment undertaken during the UK Marine SACs project to ensure all advice has a sound practical basis.

It was intended that the Marine Monitoring Handbook should be used as a toolkit to assist those with responsibility for monitoring to select and use appropriate methods. It was not prescriptive, but rather aimed to support good decision making in marine SAC monitoring in the light of resource availability and other practicalities.

1.3.3 Common Standards Monitoring Guidance

One of JNCC's 'special functions' performed on behalf of the three CNCBs (NRW, NE, SNH), is the establishment of common standards throughout Great Britain for the monitoring of nature conservation. The standards were developed by these CNCBs, together with the EHS (now DAERA) in Northern Ireland (JNCC 2004a).

The standards were intended to provide the basic framework required to ensure consistent monitoring throughout the UK, with implementation of the standards being the responsibility of the individual CNCBs. Standards for MPA monitoring were finalised and published in 2004 (JNCC 2004a, 2004b).

Common Standards Monitoring Guidance was intended to provide guidance on SSSI, ASSI, cSACs, SPAs and Ramsar sites (JNCC 2004a). The establishment of common standards was not intended to mean that monitoring had to be undertaken using prescriptive and rigidly-applied procedures (JNCC 2004a). The approach developed aimed to be sufficiently flexible to take into account natural geographical variation across the UK and to accommodate the varying requirements and operational practices of the country agencies (JNCC 2004a). However, standards needed to be sufficient to ensure that consistent judgements would be made by different staff (JNCC 2004a). The specific marine CSM guidance documents[14] recommend suggested techniques for monitoring each attribute listed. Each set of guidance aimed to identify a set of generic attributes to assess status of the feature, highlighting those attributes that should be used on all sites (mandatory), and those that are site-specific (discretionary) to be used to reflect local distinctiveness and provided advice on setting targets.

In arriving at agreed standards, the agencies used the definitions for monitoring and surveillance found in Table 1. Nowadays, the term 'monitoring' is used interchangeably by the CNCBs to encompass the definitions of monitoring and surveillance used in CSM Guidance. The same approach is used in this report.

Table 1. Definitions of monitoring and surveillance used in Common Standards Monitoring Guidance (JNCC 2004a).

Monitoring	*An intermittent (regular or irregular) series of observations in time, carried out to show the extent of compliance with a formulated standard or degree of deviation from an expected norm (Brown 2000). In line with this definition, we need to define the state desired in terms of objectives or targets, and then undertake monitoring to assess whether these objectives are being met.*
Surveillance	*Repeated survey using a standard methodology undertaken to provide a series of observations over time. Surveillance can yield valuable information on trends in the state of biodiversity and Earth science, but does not by itself establish whether objectives or standards have been met. Information derived from surveillance may be used to inform judgements on the condition of features on sites.*

The intended purpose of CSM is threefold (JNCC 2004a):

1. at the site level, indicate the degree to which current conservation measures are proving effective in achieving the objectives of the designation, and identify any need for further measures;
2. at the country level, indicate the effectiveness of conservation action and investment, and identify priorities for future action; and
3. at the UK level, enable Government to undertake its national and international reporting commitments in relation to designated sites, and more widely, and help identify any areas of shortfall in implementation.

The nature conservation component that is assessed is the feature(s) (i.e. habitat, species, or geomorphological feature) for which the site was designated, not the whole site itself (JNCC 2004a). The introductory chapter to CSM Guidance identifies key issues that need to be considered when setting objectives and selecting attributes to define the favourable

[14] http://jncc.defra.gov.uk/page-2236.

condition of an interest feature and offers generic advice on the process for assessing the condition of the feature against a target condition (JNCC 2004a). According to the guidance, if all the targets are met, the feature is deemed to be in favourable condition (JNCC 2004a). Some attributes are considered mandatory and should be monitored in all sites, whilst others are site-specific, or discretionary, to reflect local distinctiveness and provide advice on setting targets.

Sites may have multiple interest features in them, and each is assessed separately (JNCC 2004a). The CSM Guidance recommends that all interest features on all statutory sites are assessed at least once within a six-year period (JNCC 2004a) and should take into account human activities or other factors considered to be affecting the condition of the feature, including the conservation measures taken to maintain or restore the feature to favourable condition (JNCC 2004a). This timeline corresponds to the six-year reporting cycle of the EU Habitats Directive (92/43/EEC).

2 Monitoring of seabed habitats in MPAs

The next sections in this chapter describe: (i) the monitoring of seabed habitats within MPAs undertaken by the CNCBs from 1999 to 2013; and (ii) the contextual information also used to inform assessments of feature condition. Each section explains how it relates to CSM Guidance and the development of a UK wide biodiversity monitoring programme. Each section is followed by conclusions and recommendations. The conclusions are split by their applicability to CSM Guidance or to the development of a UK wide biodiversity monitoring programme to address all marine assessment obligations as appropriate.

It should be noted that all CNCBs identified the lack of sufficient resources as a barrier to their effective and full implementation of the seabed habitat monitoring in inshore MPAs. This chapter therefore documents progress given these acknowledged operational limitations.

2.1 Which seabed habitats are being monitored and where?

Common Standards Monitoring guidance was intended to provide guidance on SSSI, ASSI, cSACs, SPAs and Ramsar sites (JNCC 2004a). Within the CSM Guidance marine seabed features are divided into two categories (JNCC 2004b). These categories were been divided up into seven documents, three 'simple' features and four 'complex' features, designed to cover a mixture of BAP broad habitat and Habitats Directive Annex I features. ‘Simple features’ considered a single, albeit broad habitat type i.e. littoral sediments, littoral rock and inshore sublittoral rock, inshore sublittoral sediments, and sea caves. ‘Complex features’ covered broad physiographic units i.e. estuaries, large shallow inlets and bays, and lagoons. Complex features normally contain a range of simple features.

To support the development of costed options through the Marine Biodiversity Monitoring Research and Development (R&D) Programme it is important to identify, at the relevant stage, which seabed habitats are already being monitored and where. This will help to provide a clear understanding of any gaps across habitats and legislative requirements but also help to highlight any differences in the application of CSM Guidance between countries and where amendments may be desirable in the light of future monitoring requirements.

Table 2 summarises which types of MPAs are of relevance to different Agencies and progress with implementing regular monitoring. For all CNCBs, where the listed habitats within different MPAs types overlap, the habitats are only monitored once and where possible the information is used to assess that habitat against multiple drivers. It is not always possible. For example, NE monitor mudflats and sandflats to estimate the condition of the habitats for supporting overwintering assemblages of birds, but this does not coincide with the optimum time for monitoring overlapping SAC or WFD habitats.

Table 2. Summary of the MPAs in which the CNCBs conducted habitat surveys between 1999 and 2013.[15]

CNCB	SSSIs\ ASSIs	SACs	Ramsar sites	SPA habitats	MNR
DAERA	Initial monitoring surveys in progress	A mixture of baseline acoustic habitat monitoring and repeat spot	Yes (some indirect monitoring)	Limited to intertidal seagrass	Yes. Main focus is on monitoring of *Modiolus modiolus* biogenic reefs

[15] As these are aggregated to designation type the responses show best case only. i.e. the level of monitoring is not the same for all features and all sites , whether or not they fall within the same designation type. (SACs, Yes (repeat), does not mean all features are repeat monitored or that every SAC gets repeat monitoring).

CNCB	SSSIs\ ASSIs	SACs	Ramsar sites	SPA habitats	MNR
		dives at established sites			as part of a restoration package
NE	Initial monitoring surveys and some repeat monitoring.	Initial monitoring surveys and some repeat monitoring.	Yes (indirectly)	Yes (extent should already be considered)	Initial monitoring surveys and some repeat monitoring.
NRW	Repeat monitoring in SACs and MNR only, but MNCR Phase 1[16] of all intertidal habitats	Repeat monitoring	Some repeat monitoring	Repeat monitoring	Repeat monitoring
SNH	Preliminary broadscale mapping surveys followed-up by initial monitoring surveys on most sites. Repeat monitoring surveys expected to start in 2014).	Preliminary broadscale mapping surveys followed-up by initial monitoring surveys on most sites. Repeat monitoring surveys expected to start in 2014.	Preliminary broadscale mapping / initial monitoring surveys on sites where underpinned by SSSI.	No	N\A

2.1.1 SACs

The different types of Annex I habitat surveys that have taken place in inshore SACs are summarised as maps in Appendix 2. The aim of the maps is to illustrate the geographical spread of the monitoring for each habitat. Each map only includes the SACs which have been notified for that Annex I habitat. This information was collated directly from the CNCBs as this level of detail was not accessible through the United Kingdom Directory of Marine Observing Systems (UKDMOS)[17].

2.1.2 SSSIs and ASSIs

SSSIs and ASSIs have been notified over many years for predominantly specific local intertidal habitats. The Guidelines for the Selection of Biological SSSIs (Nature Conservancy Council 1989)[18] set out general principles, supplemented by detailed selection guidelines for different habitat types and species groups, which the SNCBs use to reach judgements regarding special scientific interest. England (Defra 2012b), Scotland (Scottish Government 2012) and Wales (Welsh Government 2012) have published lists of their SSSIs with marine interest features. Table 3 illustrates the range of seabed habitats in SSSIs and ASSIs that are being monitored by the CNCBs. Northern Ireland is undertaking a review of its ASSI

[16] MNCR Phase 1 surveys are broad habitat surveys aimed at identifying the range of habitats in an area, and may give an indication of their extent and distribution. This information can also be used to target the selection of more detailed Phase 2 surveys (Hiscock 1996).
[17] UKDMOS is an online searchable metadatabase of all marine monitoring conducted by UK organisations. (http://www.ukdmos.org/).
[18] These guidelines are currently under revision: http://jncc.defra.gov.uk/page-2303.

marine features and intends to publish a list at the end of the review, however an interim marine habitat list can be found in Table 3 (DAERA, personal communication). There was no requirement for a standard list of habitats to be used to select marine interest features in SSSIs or ASSIs. Each country has a different list of marine habitats which they monitor but these can all be aggregated up into higher level categories such as coastal saltmarshes or coastal lagoons for reporting purposes. For example, SNH has one category for saline lagoons whereas NE has five.

2.1.3 SPA and Ramsar sites

Habitat extent is the only habitat attribute that is mandatory for assessing condition of bird features in SPAs, SSSIs and Ramsar sites in the CSM Guidance for Birds and relates to the broad habitat type used by the species (JNCC 2004c). SPA marine habitat definitions can be quite broad and overlap with several of the Annex I habitats. The habitats are not specific interest features of SPAs but the CNCBs, with the exception of SNH, have conducted some monitoring as the conservation objectives for the sites may refer to the need to maintain, restore or enhance habitats for the bird species listed as interest features. All marine habitats in UK Ramsar sites overlap with areas either designated as an SAC or an SPA. Wetland types in Ramsar sites are normally monitored by the CNCBs as part of SAC, SPA or SSSI monitoring programmes.

Table 3. SSSI and ASSI marine habitat categories monitored by the CNCBs.

DAERA	NE	NRW	SNH
• Intertidal mudflats and sandflats • Intertidal *Mytilus edulis* on mixed and sandy sediments • Seagrass beds • Coastal saltmarsh • Saline lagoons • Intertidal rock • Littoral chalk communities • Tide swept channels • Sea caves • Annual vegetation of driftlines • *Salicornia* and other annuals colonising mud and sand • Intertidal underboulder communities • Sheltered muddy gravels • *Sabellaria alveolata* reef • Intertidal maerl and clean gravel communities • Intertidal *Modiolus modiolus* beds	• Estuaries • Exposed rocky shores (predominantly extremely exposed to wave action) • Isolated saline lagoons • Littoral rock and inshore sublittoral rock • Littoral sediment • Moderately exposed rocky shores • Moderately exposed sandy shores (with polychaetes and bivalves) • Muddy gravel shores • Percolated saline lagoons • Reefs • Saline coastal lagoons • Sheltered muddy shores (including estuarine muds) • Sheltered rocky shores (predominately sheltered to very sheltered from wave action) • Shores of mixed substrata (stones and sediment) • Silted saline lagoons • Sluiced saline lagoons • Wave exposed sandy shores (with burrowing crustaceans and polychaetes) • Zostera communities	Only monitored as a by-product of SAC monitoring where the habitats and different MPA designations overlap	• Eelgrass beds • Intertidal mudflats • Rocky shores • Saline lagoons • Intertidal sandflats • Sea caves • Tidal rapids • Saltmarsh

2.1.4 CNCB responses

Northern Ireland
Surveys have mostly been targeted at SACs and ASSIs or potential SACs and ASSIs. At those sites, MNCR Phase 2[19] type surveys have been carried out as a repeat of surveys carried out in the 1980s. At a smaller number of sites (mainly Strangford Lough SAC and Rathlin SAC) more frequent surveys have been carried out. In addition, much of the survey effort has been put into understanding the extent of features, wider surveys for potential damage or wider surveys to search for rare and threatened species and habitats.

In the last few years a rapid assessment method has been developed for rocky shores (including areas of boulders, cobbles and gravels), and established monitoring programmes already exist for saltmarsh, annual vegetation of driftlines, and seagrass beds. However for many of the other habitats, monitoring has not yet begun. Further rapid assessment methods are planned for those other habitats.

Northern Ireland has over recent years in partnership with Agri-Food and Biosciences Institute, Northern Ireland (AFBI), Maritime and Coastguard Agency (MCA), United Kingdom Hydrographic Office (UKHO) and the University of Ulster delivered an Acoustic Habitat Mapping programme for all of its SACs, producing high definition habitat maps. This mapping programme has been extended into non designated areas and will help in delivery of Article 17 reporting commitments.

England
NE conducted monitoring within its suite of MPAs. Prior to 2013, the monitoring of seabed habitats in England was centred on the monitoring of SACs.

In England, the funding and scheduling of monitoring in SSSIs is separate to other MPA monitoring programmes and surveys undertaken are usually less detailed as this element is run as part of the overall Integrated Site Assessment (ISA) programme. Historically, where SSSI's overlap (both spatially and in-terms of interest feature(s)), with an SAC and the site is part of the scheduled Annex I habitat monitoring programme, the units have been more robustly monitored. For example, in these situations, sediment cores will be taken and both Particle Size Analysis (PSA) and infaunal analysis undertaken – this is not standard for SSSI monitoring. The scheduled monitoring for the SSSIs which underpin SPAs has sometimes been extended to include information on the supporting SPA habitat.

The Natural England integrated site assessment programme (ISA), originated in the terrestrial environment but covers a number of habitats which are also considered to be marine. The revised (Nov 2014) ISA strategy acknowledged the difference between terrestrial and marine assessment and reporting obligations and stipulates that in overlapping habitats the ISA 'detailed' site assessments should be sufficiently robust so as to meet the requirement of the marine drivers.

Wales
NRW focuses its seabed habitat monitoring within SACs. SPAs and Ramsar sites are also covered where bird habitat and Annex I features coincide. The monitoring effort varies between habitats, sites and designation. Monitoring of marine habitats also occurs within Skomer MNR (now MCZ), where long-term monitoring programmes were established in the 1980s before the designation of marine SACs. Though the focus of the Skomer MNR

[19] MNCR Phase 1 surveys are broad habitat surveys which are used to target the selection of sites for more detailed Phase 2 surveys. MNCR Phase 2 surveys describe communities and their variation within habitats, thus providing information for assessing the natural heritage importance of sites (Hiscock 1996).

monitoring is on the habitats and species of the MNR, most of the habitats monitored are also Annex I habitats of the Pembrokeshire Marine SAC.

Due to resource limitations, NRW do not have a targeted monitoring programme for intertidal SSSIs. Intertidal SSSIs in Wales are only monitored where they fall within an SAC and the SAC monitoring can serve a dual purpose.

Scotland
SNH undertakes seabed habitat monitoring within the suite of different MPAs in Scottish territorial waters. The seabed habitat monitoring programme (excluding interests above Marine High Water Springs such as coastal saltmarsh) encompasses 30 out of 36 marine SACs and 43 of 53 SSSIs. The remaining SACs and SSSIs with marine features have been designated for harbour and/or grey seal mobile species interests only. A number of intertidal and shallow subtidal (to 6m below sea level) features within Ramsar sites are also encompassed by SNH's monitoring programme. Of these, only two sites (Inner Moray Firth Ramsar and Moray and Nairn Coast Ramsar) are not underpinned by SSSIs. The feature of interest within these two sites is *intertidal mudflats and sandflats*.

The majority of the marine SACs in Scottish territorial waters were formally designated in 2005. Two additional SACs were subsequently designated in 2011 (East Mingulay) and 2013 (Sound of Barra). Much of SNHs marine survey work between 1999 - 2005 focussed on building the case for designation of the SACs (supplementing MNCR studies in the 1980s and 1990s) and completing inventory mapping to inform site management discussions. Due to the number and widespread distribution of the initial tranche of marine SACs, these preliminary broadscale habitat mapping surveys continued well into the second reporting and assessment cycle too (North Rona SAC broadscale mapping was undertaken in 2008/2009 and due to adverse weather conditions a number of inventory sampling gaps still remain - see Axelsson *et al* 2010).

Monitoring studies got underway in parallel with the coarser resolution mapping work, with the first 'initial monitoring' surveys undertaken in 2002 (BMT Cordah Ltd. 2004) on a series of saline lagoon features within a number of existing SSSIs and overlapping possible SACs. The mixed survey programme was largely suspended between 2011 and 2014 when SNH redirected survey efforts towards delivering the information requirements of the Scottish MPA Project (SNH & JNCC 2012; SNH 2014a & 2014b). Future benthic habitat monitoring work (2015 and beyond) will need to incorporate additional features within at least 12 of the new Nature Conservation MPAs in Scottish territorial waters and this is likely to have a bearing on both monitoring frequency and resolution across the suite of sites (see also Section 2.3.2).

2.1.5 Conclusions

CSM

- CSM Guidance was developed for SSSI, ASSI, cSACs, SPAs and Ramsar sites. It does not, nor was it intended to, contain any guidance for features of new MPAs or monitoring of seabed habitats in the wider environments, e.g. MCZs and NCMPAs.

- Seabed habitat monitoring programmes were often restricted as financial, staff and logistical resources were diverted towards other areas of work such as the identification of new MPAs (e.g. SACs, MCZs in England and NCMPAs in Scotland).

- Where resources have allowed, the CNCBs have developed monitoring programmes for their MPAs to assess the condition of the habitats within the sites

and contribute to national/international reporting requirements. Seabed habitat monitoring has generally focused on designated habitats within SACs. NE, DAERA and SNH also have targeted SSSI\ASSI monitoring programmes. DAERA, NE and NRW have all conducted some monitoring of seabed habitats within SPAs. Repeat monitoring surveys have been conducted in all MNRs.

- In areas where there are overlaps between different MPA designations, where possible, the habitats are monitored once and the data are used many times to meet the requirements of several different reporting obligations.

- Repeat monitoring surveys have been conducted for all types of Annex I habitats (with the exception of Mediterranean and thermo-Atlantic halophilous scrubs *Sarcocornetea fruticosi* which only occurs in English waters) but have not been conducted by all CNCBs. The distribution of Annex I habitat repeat monitoring surveys within SACs varies geographically (see Appendix 2).

UK wide biodiversity monitoring R&D programme

- Easily accessible information on which habitats are being monitored across the UK is required in order to understand whether there are gaps in the monitoring of particular habitats over their geographic range. A complete and up-to-date catalogue of UK habitat monitoring activities is essential to allow the UK Marine Biodiversity Monitoring R&D programme to gain a full picture of the relevant monitoring programmes that could contribute to monitoring objectives and be used to assess against multiple drivers. A complete and up-to-date catalogue does not currently exist and the information is held by the individual CNCBs. The UKDMOS is the current metadatabase designed to hold metadata on UK monitoring programmes but it does not require organisations to submit the level of detail required to understand which habitats are being monitored by the SNCBs and where they are being monitored.

- Monitoring of habitats across their UK geographic range enables managers within each CNCB to understand more about the natural spatial variation of habitats. Not all designated seabed habitats are currently being monitored across their UK geographic range.

2.1.6 Recommendations

- Develop a multi-year resourcing/ funding strategy for seabed habitat monitoring programmes to ensure the resources will be available to maintain long-term monitoring datasets and enable more cost effective planning. (M.1).

- Ensure UKDMOS is fit for purpose by (M.2) (see also Section 4):

    - improving the export facility;
    - identifying the input requirements for national MPAs, MSFD, WFD *etc*;
    - identifying in UKDMOS where data is held and in what form;
    - investigating whether more detailed monitoring information from the CNCBs' features, sub-features and monitoring metrics should be inputted into UKDMOS;
    - collating and inputting all CNCB monitoring data into UKDMOS; and
    - producing maps showing the scale of monitoring for selected seabed habitats across the UK to obtain a clear picture of the temporal and spatial resolution of the seabed habitat sampling within MPAs that are contributing towards the requirements of the MSFD (as required under Article 11 of the MSFD).

2.2 Who undertook seabed habitat monitoring surveys in MPAs?

CSM Guidance (2004a) does not state who should undertake seabed habitat monitoring but this information has been included in this report as it is essential information for the development of an integrated UK wide biodiversity monitoring programme.

2.2.1 In-house staff and contractors

An in-house approach requires significant staff time to plan and execute surveys. The number of surveys which can take place are limited by the availability of the relevant staff with appropriate expertise. However, an in-house approach uses and builds on expertise within an organisation and reduces the use of staff time on drafting and managing of contracts. It builds valuable knowledge and understanding of habitats and methods of survey within the organisation which feeds into advice on site management. Consistent approaches are more likely to be adopted if the same staff members are involved in multiple surveys over time. Contracting work out increases the ability of the organisation to access detailed taxonomic and technical expertise; enables substantial additional staff resource to be drawn in; and can ensure that the responsibility to source equipment lies with the contractor. It also saves time as the project management of contracts can take less time than organising surveys, data analysis, report writing and production of associated deliverables. By targeting certain elements of monitoring for external contracts, both advantages described above can be maximised (e.g. contractors with specialist taxonomic skills can accompany in-house teams).

Northern Ireland
DAERA has small, in-house monitoring teams and specialist staff with which they complete most of their monitoring work. External specialist contractors are contracted to provide taxonomic expertise on difficult phyla as well as providing a training role for the in house team. DAERA worked in very close partnership with the Ulster Museum through embedding a museum member of staff within the in-house team.

England
NE contract out the majority of their marine monitoring work or deliver it in partnership with other organisations. For several years NE and NRW (formerly CCW), with the Environment Agency, have shared a framework contract for laboratory analysis of benthic samples including macrobenthic fauna and algae, and sediment granulometry. The framework contract for the infauna analysis has a four year lifespan and currently runs until 2018. NE have a rolling Memorandum of Agreement with the Environment Agency, which is updated annually, to complete PSA. More recently (2011 onwards), NE has also entered into a Memorandum of Understanding with Cefas and engaged on collaborative monitoring projects for sub-tidal MPA features.

In 2012, NE set up a Marine Monitoring Framework Agreement. The aim of the framework agreement was to have a number of contractors for specific lots to whom specifications for any specific relevant items of work could be sent during its lifespan (four years). The framework agreement aims to save resources by reducing the amount of staff time which is required to write tender specifications and evaluate responses as many aspects, such as technical capabilities, economic and financial ability and health and safety, have already been assessed during the initial tendering process. Prior to the Marine Monitoring Framework agreement (2012) the majority of survey work was undertaken as a series of individual contracts each let through and open competitive tendering process.

Wales
NRW has small, in-house monitoring team[20] and specialist staff with which they complete most of their monitoring work. Contractors are used to supplement the in-house monitoring team and are also employed to undertake specific monitoring projects. Where appropriate, contracts have been established for long periods (e.g. 4 - 5 years) to maximise continuity, efficiency and consistency between monitoring events.

Scotland
SNH contract out the majority of their marine monitoring work or deliver it in partnership with other organisations. SNH has a core monitoring and assessment team that focus on the delivery of benthic habitat survey work. This team has comprised between 2 - 3.5 posts since inception in 2002 (currently three posts in 2015) and is supported by other staff within SNH who coordinate work on marine mammals, coastal habitats and marine birds (mainly individual staff members for these discrete interests with the survey and monitoring work comprising one part of wider job plans). Prior to 2010 SNH's marine survey contracts tended to be constrained to sub-EC tender thresholds (~£140K) and run within discrete financial years around an annual bidding cycle. SNH monitoring staff established and managed multiple sub-threshold contracts each year. In 2011 SNH established a four-year procurement framework to cover all aspects of marine survey work (the framework was divided into thematic lots encompassing survey planning, fieldwork and all subsequent data analyses, interpretation and reporting tasks). In conjunction with changes to internal procurement procedures, SNH has been able to run multi-year, high value marine survey contracts through the framework which has greatly reduced the contract management burden and improved continuity and consistency between monitoring events.

SNH marine monitoring staff are all qualified diving marine biologists and they supplement contractors on some projects. Staff members often participate in the fieldwork aspects of the surveys they manage to maintain an oversight of the work and to provide consistency between suppliers. In addition to retaining an active scientific diving capability, SNH also own and operate a 6.5m RIB and a range of sampling equipment (drop-down video cameras, a mini-ROV and diver cameras *etc*). SNH equipment is deployed to support the delivery of annual monitoring projects.

2.2.2 Partnerships

Formal partnerships between the CNCBs and other organisations (public bodies and others) to complete seabed habitat monitoring are becoming more common (see Appendix 4 for specific examples). These partnerships result in the combination of resources and survey objectives (staff, expertise, time, vessels *etc*) and can lead to savings and increased efficiency across government bodies and other institutions.

2.2.3 Academia

Links with academia are important for the CNCBs for monitoring expertise and for the research and development of new monitoring methods. However, research and development work conducted by academic institutions needs to be well funded, directed towards the CNCB's needs and last for sufficient time to ensure the aims of the projects are met, as there is the risk that key staff will leave before the project is fully completed (as happened with the *Modiolus modiolus* Restoration Research Project in Northern Ireland). Examples of MPA seabed habitats monitoring research and development work that the CNCBs have been involved in are listed in Appendix 5.

[20] NRW have a centralised Marine Monitoring Team (MMT) plus the Skomer Marine Nature Reserve 'team' that undertake monitoring of the Reserve and contribute to the MMT's monitoring programme across Wales.

2.2.4 Volunteers

Volunteer projects can have offshoot benefits such as “buy-in” from recreational groups to principles of marine conservation. All of the CNCBs have links with the voluntary organisation Seasearch[21] and several of them contribute, or have contributed, funds to Seasearch.

Northern Ireland
DAERA has had several successful surveys conducted by Seasearch who they fund through Grant in Aid. DAERA has worked with Seasearch to ensure that these surveys complement the DAERA dive programme where possible, adding further information such as feature boundary mapping. Specific projects of an appropriate size and skill level are found to produce the best outcomes, e.g. a targeted seagrass survey. This example involved an initial course run for Seasearch members, which included training in survey methodology to enable divers to map boundaries using a Surface Marker Buoy (SMB) with a Global Positioning System (GPS) attached, and to use quadrats to assess the health and density of the seagrass in subtidal beds. This enhanced the skill and knowledge of Seasearch members and also resulted in a high quality survey which could be used as a baseline for future monitoring.

England
NE contributes funding to the Marine Biological Association (MBA) to lead the Shore Thing surveys alongside MarClim. The Shore Thing[22] is a Marine Life Information Network (MarLIN) initiative which works with schools and volunteer recorders to collect information on the marine life of rocky shores around Britain. A voluntary diving seagrass monitoring programme is run in the Isles of Scilly, this looks predominantly at density and condition. NE also contributes towards Seasearch funding, though principally this has been directed towards mobilising and quality assuring data once collected.

Wales
In Wales, volunteer monitoring projects take place at Skomer MNR. Volunteers monitor territorial fish communities, sea urchin populations, subtidal *Zostera marina* densities and record scallop population parameters, or provide support to MNR staff in the annual monitoring programme. NRW also provided funding for Seasearch, and targeted Seasearch projects have helped confirm sites as suitable for monitoring as well establishing extent baselines for *Zostera marina* and *Ostrea edulis* habitat.

2.2.5 Conclusions

CSM

- The CNCBs use a combination of approaches for undertaking seabed habitat monitoring surveys. In general, specialist staff within each CNCB define what needs to be monitored, where and how frequently. Staff allocate available budget and plan the overall monitoring programme for each agency, following CSM Guidance, adapted as appropriate to each country. Surveys themselves have been undertaken by a mixture of CNCB national and regional/local staff, contractors, volunteers and academic researchers. The use of contractors, academics and

[21] Seasearch (http://www.seasearch.org.uk/) is a project for volunteer recreational divers that aims to:
- encourage the participation of volunteer recreational divers in marine conservation through gathering data, particularly for areas where little data exist or where there is a conservation need;
- provide training in recording skills to enable volunteer recreational divers to participate in Seasearch;
- make Seasearch data available to partner organisations and the general public; and raise public awareness of the diversity of marine life and habitats in Britain and Ireland through the dissemination of information gathered and the identification of issues arising from it.

[22] http://www.marlin.ac.uk/shore_thing/.

partnerships with other organisations allows the CNCBs to bring in expertise in particular habitats and encourages innovation in monitoring methods. There is an increasing use of partnerships to share resources which can reduce costs and provide benefits to both parties.

UK wide biodiversity monitoring programme

- The success of volunteer surveys in addressing the needs of the CNCBs is linked to the level of input from CNCB staff and compliance with standards set by the CNCBs. Design of volunteer projects needs careful consideration to ensure reliable results from surveyors who do not necessarily have a background in marine biology. When CNCB staff have sufficient time to input into volunteer seabed habitat monitoring surveys, the value of the data collected by the volunteers increases and reduces the amount of time and money required by the CNCBs to collect data themselves, thus reducing the overall costs of the monitoring.

- Staff turnover within monitoring organisations and the need for external contracting processes means that it can be unusual for one individual/company to be involved in repeat surveys. Having the same contractor or staff undertake the same work several times can have benefits in terms of how smoothly the monitoring surveys proceed each time due to familiarity with all aspects of the work required (e.g. site location, taxonomy *etc*). When multiple contractors and different staff are used over time, issues can arise with the consistency of the datasets collected. Guidance, protocols and good quality assurance checks are required to ensure monitoring surveys are repeatable and that consistent data are collected to inform assessments of habitat condition over time.

- Different contractors may classify the same data into different biotopes as they are not clear on how to make best use of the Marine Habitat Classification of Britain and Ireland or they are unclear on what to do if they find a similar biotope outside the depth range of that described. The use of biotopes in a monitoring context should consider the limitations and current subjective nature of this classification system.

- Research and development work conducted by academic institutions, volunteers and CNCBs needs to be clearly specified, well managed and funded for sufficient time to ensure the aims of the research are met, to minimise the risk that it will not deliver what was intended.

2.2.6 Recommendations

- Develop new, and improve the use of existing, partnerships to deliver seabed habitat monitoring programmes, which will enhance cost effectiveness and provide added value. (M3)

- Identify seabed habitat monitoring research questions that could be best answered through large scale research projects (e.g. via MASTS, NERC or EU funded research projects and programmes) (M4).

- Consider how data collection through citizen science led projects can assist the delivery of seabed habitat monitoring programmes (M5).

- Update and maintain the seabed habitat classification and develop tools to further improve consistency in the biotope assignment process. (E1).

2.3 Monitoring cycle

2.3.1 When are seabed habitats in MPAs monitored?

CSM individual marine interest feature guidance recommends optimal and possible times for monitoring marine interest features. All of the CNCBs stated that they abide by the optimal and possible timing for monitoring of CSM marine interest features where possible and that they aim to conduct repeat seabed habitat monitoring surveys within individual MPAs at the same time of year as previous monitoring surveys

2.3.2 How often are habitats monitored and how are they prioritised?

This section focuses on how frequently the CNCBs monitor habitats, the criteria they use to decide how frequently to monitor those habitats and in what order of priority. The generic CSM Guidance recommends that each individual interest feature should be monitored ideally within the same year, and certainly within a three-year period (JNCC 2004a).

All of the CNCBS stated that if they were notified of a risk of damage to a designated habitat within a site, monitoring at the site in question would be given greater priority and targeted for more immediate monitoring.

Northern Ireland
MPAs are prioritised for monitoring according to vulnerability. Repeat monitoring is done according to resources. The aim is to undertake repeat surveys within SACs every six years, targeting sites where damage from human activities is known to have occurred or to be occurring. DAERA often requests detailed pre and post development seabed surveys as mitigation for a marine licence, especially if the development is within or adjacent to an MPA. This information can then be incorporated into the monitoring programme if the chosen contractors are deemed by the Department to be competent and demonstrate good QA/QC procedures. Some features such as caves are monitored less frequently if it is known that they are not subject to any anthropogenic risk. Caves are particularly difficult to survey due to health and safety considerations.

Strangford Lough biogenic reefs are being continually monitored as part of an ongoing restoration plan following significant damage by mobile fishing gear.

Seasonal monitoring is not routinely conducted by DAERA but may be picked up through targeted Academic research. The only exception to this is inshore fish population studies conducted by an in-house DOE team as part of the WFD monitoring programme.

England
NE's monitoring focused on attributes for each sub-feature, in accordance with CSM Guidance. The majority of attributes in the Favourable Condition Tables (FCTs)[23] are measured during biological surveys.

NE developed a risk-based approach to monitoring based on an assessment of the risk of damage from anthropogenic activity' faced by features. Their assumption is that if the current level of resourcing is maintained and the levels of risk of damage from anthropogenic activities stay the same or decrease, then all features should be monitored at least once every six years. Based on their risk assessment of European Marine Sites[24] (Coyle & Wiggins 2010), NE aim is to prioritise monitoring surveys to visit:

[23] Favourable Condition tables are used by NE. They outline the attributes, measures and targets for each designated feature (e.g. http://www.sssi.naturalengland.org.uk/Special/sssi/fct/FCT_1003576_C.pdf).
[24] European Marine Sites are comprised of SACs and SPAs.

1. features at relatively high risk of damage from marine activities within three years;
2. features at moderate risk of damage from marine activities within four-five years; and
3. features at low risk of damage from marine activities within six years.

This assessment involved consultation with relevant authorities and categorised risk as no risk, low, moderate or high risk. Risk and data priority scores were combined to achieve a survey priority score. Data priority scores were based on the length of time since the last survey. All sub-features\features were ranked based on projected priorities across a six-year period. This is initially done at the CSM Guidance attribute level resulting in a priority score per feature for a six-year period. The net effect is that all features should be monitored within a six-year period. If for some reason, a feature cannot be surveyed (e.g. due to bad weather) it will remain on the list for the following year.

Annual monitoring to date has been largely opportunistic but there are a few examples where more frequent monitoring of features within sites has been completed in partnership with a Non Governmental Organisation (NGO) or voluntarily by members of public. The best examples of features and sites which are more frequently monitored are seagrass in the Isles of Scilly Complex SAC and Solent EMS and sites surveyed through the MarClim and Shorething projects.

In addition to a risk-based approach to monitoring schedules NE also factors in other practicalities, such as cost, staff capacity, *etc*. Where it is more efficient to do so features will also be brought forward or moved back to allow groupings by site – hence reducing the time required to set up and manage monitoring contracts.

Wales
NRW prioritised their monitoring work according to risk of damage from human activities, practicalities and costs. A higher density and frequency of monitoring took place in areas where features were at greater risk. A number of factors have influenced the selection and location of NRW habitat monitoring stations, and the design and frequency of 'sampling', for example:

- putting greater effort into high risk areas;
- obtaining a wide spatial spread across the habitat;
- encompassing the range of existing habitat variation;
- encompassing as many ecologically isolated examples of a habitat as practically feasible (e.g. covering all Coastal Lagoons);
- building a sampling design that maximises the ability to detect and discriminate anthropogenic impacts;
- making best use of pre-existing sampling stations where historical data and methods are comparable and allow for consideration of an earlier 'baseline' (e.g. historical surveys, abandoned monitoring initiatives);
- avoiding duplication of ongoing sampling stations present as part of other monitoring initiatives where the data and methods are comparable (e.g. Skomer MNR and WFD sampling);
- matching sampling designs with adjacent Country Agencies where an MPA is shared across country boundaries; and
- financial and logistical constraints.

In its subtidal sediment monitoring programme design (e.g. Large Shallow Inlets and Bays) NRW sought to meet the need for both temporal and spatial spread of its sampling. The choice between whether to monitor less sampling stations more frequently or monitor more

stations less frequently is influenced by risk and available resources. A small number of stations with a high sample replication were visited every year (fine temporal replication to pick up a widescale impact quickly). A larger number of widespread stations with a low sample replication were visited every three-four years (fine spatial replication to pick up more localised impacts not addressed by the yearly sampling).

NRW attempted to visit their reef features every year in order to provide timely feedback for site management and to ensure sufficient power to detect a reasonable effect size; however, the weather constrained the frequency of visits to exposed sites. Reefs are sampled more regularly than sedimentary sites as the data is noisier due to techniques available (e.g. qualitative data such as seabed imagery) but the increased frequency is at the expense of visiting more stations. Locations further away from the coast tended to be visited less frequently. In Pembrokeshire Marine SAC, for example, there is a transect of subtidal monitoring stations which extends from sheltered estuarine waters to the exposed reefs of the 'Smalls' 30km offshore. It was only possible to get to the Smalls every three years but these stations were also deemed to be at lower risk of damage from human activities than stations closer to the coast and so such frequency was considered acceptable. There are fewer monitoring stations for reef features than for sediment features due to the differences in monitoring resource needs (as diving tends to be more expensive than grab sampling per unit of data gathered).

Scotland

SNH's corporate Site Condition Monitoring (SCM) programme started with the aspiration of trying to survey all features in all sites within each six-yearly reporting cycle (as proposed within the joint agency statement on common standards monitoring – JNCC 1998). However, this proved logistically and financially untenable for marine features in the first cycle (1999 - 2004) and changes were made to SNH's corporate approach in the second cycle (2005 - 2010). A statistically valid, randomly selected 67% sub-sample of marine features (benthic habitats and species) was identified for monitoring over this second six-year period (the feature selection process was able to take account of marine monitoring completed within the first cycle). This approach enabled reporting for feature classes (e.g. Annex I 'reefs' or 'subtidal sandbanks') on the basis of having sampled a proportion of these habitats in relevant Scottish MPAs. This approach also proved to be prohibitively expensive and initial monitoring was not completed on the full suite of sites before the corporate model was modified again in the third cycle (2011 - 2016).

In the third cycle, SNH's approach to monitoring is based on a randomised annual feature selection, with all features of a similar 'type' (e.g. all seabed habitats) surveyed within a defined timescale (which may span multiple six-yearly reporting rounds). The timescale is a variable parameter set on the basis of a coarse level risk assessment. The existing risk assessment for most benthic habitat features was defined at the grouped level of 'marine rock' and 'marine sediment' (with no distinction of more sensitive component biogenic habitats). The maximum time between monitoring events (actual survey work on features of a site) for marine habitat interests is currently three cycles (18 years). Different time intervals were adopted for different feature groupings (e.g. algae; molluscs; vascular plants; *etc*).

To reduce the risk of undetected deterioration (or loss) of protected features between monitoring visits, a process of 'Site Check' is being developed to complement the SNH MPA-related monitoring programme. The intention is that where appropriate, a light touch approach be developed that enables SNH marine monitoring staff to use information provided by external non-specialists, such as biological data from recreational divers or pressures information from regulators, to develop an overview of aspects of feature condition. This might allow remedial action to be identified and implemented (if appropriate) whilst probably also triggering the need for a more detailed survey.

Site Check isn't designed to determine feature condition, and a Site Check return will not change an existing assessment. It should serve as a 'check' on certain aspects of previous assessments or to log new pressures which may require attention. It is hoped that Site Check will maintain an overview of site condition such that no site would go more than a six-year period without either a full monitoring survey or a Site Check assessment. It is not yet clear how this will work in the marine environment due to the inaccessibility of many of the features and the disconnect between SNH and relevant activities managers, but the proposed approach is being explored under contract in 2015. The approach is likely to be suitable for most intertidal features but SNH can also envisage scenarios where biological observations from recreational divers could be canvassed to inform on discrete, tightly defined features such as subtidal sea caves (e.g. at the St Kilda SAC). Additional sites can be included for formal monitoring surveys within a six-yearly cycle if problems are highlighted through the Site Check process.

2.3.3 Conclusions

CSM

- The frequency of CNCB monitoring of habitats within MPAs ranges from one year to a maximum of 18 years and varies depending on the habitat type. NRW conducts repeated monitoring of their designated habitats within the time frame recommended by CSM Guidance (i.e. within a maximum of a three year cycle). NE and DAERA aim to conduct monitoring of designated habitats once every six years to align with reporting cycles, with NE monitoring any habitats at relatively high risk of damage from marine activities within three years. SNH aims to conduct repeat monitoring of all marine habitats within 18 years. Very infrequent monitoring intervals make it difficult to detect changes in the habitat condition in a timely manner and attribute any changes observed to a cause, e.g. natural change or damage from human activities. Conversely, the monitoring of resilient, highly dynamic or more sensitive habitats that are not exposed to pressures is required less frequently. Resources and MPA-related monitoring effort need to be targeted appropriately.

- In some cases, logistical issues such as the number, depth and remoteness of sites (e.g. St Kilda SAC) have limited the ability of the CNCBs to conduct regular seabed monitoring in their MPAs. The further away MPAs are from the coast, the more expensive surveys are likely to be.

UK wide biodiversity monitoring programme

- A multitude of factors are used to prioritise MPA seabed habitat monitoring surveys. Any habitats which are known or suspected to be at risk of damage will be prioritised for investigation.

- The location of the monitoring stations, the amount of replication (both spatially and temporally), the timing, the attributes measured, the type of analysis to be undertaken, the variability of the data, the planned effect size, power and significance all need to be considered. These factors are all interlinked and monitoring design should take account of all. Often, the full range of factors has not been accounted for in the initial design of seabed habitat monitoring surveys in MPAs.

2.3.4 Recommendations

- Building on lessons learnt from previous monitoring, produce shared guidance on designing monitoring surveys for seabed habitats in MPAs (M6). To include:
    - the frequency and intensity of MPA monitoring for habitats subject to different levels of pressure/risk.

2.4 How were seabed habitat monitoring surveys in MPAs planned?

The CSM Guidance for individual marine features contains limited information on planning a sampling programme and it was not intended to provide comprehensive guidance on sampling design for specific features (JNCC 2004a).

Section 2 of the Marine Monitoring Handbook (MMH)[25] provides some basic information on survey design (Davies *et al* 2001) (see also Section 1.3.2 for background on the MMH). Accuracy, precision, the location of sampling stations, sampling strategies and power analysis are briefly discussed in the MMH. Brown (2000) provides more detailed guidance on both sampling strategies and power analysis. The MMH recommends that a stratified random sampling strategy is used for locating Annex I habitat monitoring sampling stations, except where an estimation of spatial pattern/extent is required, in which case a systematic/grid sampling strategy should be adopted (Davies *et al* 2001).

The strong consensus from the CNCBs is that comprehensive guidance on sampling designs is lacking and would assist them to design their monitoring programmes, and in particular would help ensure consistency within and between countries, with the benefits of increased comparability of results and ability to detect trends at a regional/national scale.

Northern Ireland
Northern Ireland is a relatively small area geographically and its in-house survey teams are long established and well experienced with enhanced local knowledge. An extensive photographic and video database coupled with detailed MNCR recording forms enable the team to detect change early and to design targeted follow-up investigations into the cause of change**.** The Marine Monitoring team works in close collaboration with the in-house marine licensing team, marine rangers (site based conservation managers) and external Departments such as DARD Fisheries Division. The NI Marine Taskforce, a collective of NGOs with a marine agenda, regularly informs the Department of perceived issues likely to cause damage to specific sites which the Department will take into account when designing their monitoring programme.

DAERA mapping and characterisation surveys used to establish the extent of habitats have mostly used the standardised SACFOR abundance scale and the MNCR Phase 2 recording forms[26] in the surveys (Hiscock 1996). The SACFOR scale is a semi-quantitative abundance

[25] The Marine Monitoring Handbook (MMH) (Davies *et al* 2001) (http://jncc.defra.gov.uk/MarineMonitoringHandbook) was produced by the Marine SACs Project through a series of literature reviews, workshops and practical trials (Davies *et al* 2001). The Handbook is a toolkit for the monitoring of Marine SACs and is designed to offer assistance to a range of users, from those who need to be aware of the general approach to be taken in marine monitoring for Annex I marine habitats and Annex II species, to those who will need to design, commission or undertake the monitoring. When it was first put together, the Handbook was considered to be a live working document and future updates to it were recommended. However, no significant updates have been made to the Handbook since it was first published in March, 2001.
[26] For more information see http://jncc.defra.gov.uk/page-2683.

scale used for both littoral and sublittoral taxa[27]. DAERA believes it has the possibility to detect change across a larger area with this technique and is more likely to detect change in rare species that may occur in low densities in a location. DAERA re-visit sampling locations, re-locating them using digital GPS, site descriptions and sketches rather than permanent marks on the seabed.

DAERA has adapted the CSM and the Marine Monitoring Handbook. Rather than standardised fixed transects and replication, the methods employed are more reliant on videos and photographic evidence and expert judgement.

DAERA does not currently use power analyses to estimate the amount of sampling required. This is because the resources available are mostly too constrained to employ the type of sampling that could utilize power analysis effectively. The exceptions to this may be repeat quadrat work on *Modiolus modiolus* beds in Strangford Lough SAC or on maerl in Red Bay SCI.

England
In general, NE used stratified random (or stratified haphazard) survey designs in locations where previous surveys have determined the spatial distribution of broad scale habitats (normally though a combination of Phase 1 and Phase 2 MNCR surveys (Hiscock 1996)). Permanent transects have been established to monitor intertidal reef features at Lundy MNR. In other MPAs, intertidal reefs were monitored by stratified random sampling at fixed locations. Designs for video surveys were normally stratified by habitat and/or by depth. The classification level (of the Marine Habitat Classification of Britain and Ireland) used to stratify the habitats depended on the habitat maps available.

NE guidance to contractors undertaking monitoring between 1999 and 2013 drew on CSM Guidance attributes and provided standardised sampling design specifications. Since 2012, NE has routinely asked its contractors to consider the statistical power of new monitoring survey designs. Prior to this power analysis was used to inform a limited number of monitoring surveys. Contractors are requested to provide survey designs in their tenders. Where NE has previously employed a survey design considered effective (i.e. robust, repeatable and covering relevant attributes for the sub-feature or feature), the survey design is replicated. If previous designs are not considered adequate (e.g. limited replication due to limited budgets), NE work with contractors to build on existing sampling strategies to ensure that wherever possible, repeat surveys are comparable with previous data while sampling intensity/design is improved as required. Under the NE Marine Monitoring Framework contract (since 2012) and prior to the Marine Monitoring Framework (see Section 2.2.1), the adequacy of sampling plans suggested by contractors is a key evaluation criterion in the final decision on awarding the contract.

Power analysis was not routinely used by Natural England prior to 2012. Where sufficient previous site specific data was available for repeat surveys, power to detect change via a repeat, and/or enhanced survey was considered, but in most instances historic data was lacking. Therefore in the majority of situations, survey design was based on NE local staff expert judgement in combination with expert knowledge from key local stakeholders and tailored in such a way as to take account of any known or predicted site or habitat specific risks.

Where available, NE has provided all relevant historic data to the contractors and has assessed their resultant bids in-terms of predicted ability to detect a reasonable level of change with an acceptable level of confidence [in respect to the desired metric(s)]. As the results of these contracts have become available, NE has undertaken in-house power

[27] for more information see http://jncc.defra.gov.uk/page-2684.

analyses across the range of habitats and sites and using multiple indices. The initial results of these analyses have already been used to improve the experimental design of subsequent surveys.

Since 2012, NE have sent the majority of new or large scale sample designs produced by contractors for review by independent statisticians to ensure the design being put forward is likely to be robust enough to detect a reasonable level of change with an acceptable level of confidence. Feedback is given to the contractors and in some cases this becomes an iterative process taking account of power and available resources. If necessary the overall scope of the work is reduced to allow reasonable power in the analyses undertaken based on the available resources.

For example, using the multi-metric AMBI index, NE is becoming more confident about the resourcing efficacy of using an 80% chance of detecting a 20% change in finer sediments habitats (at a site level). For coarse sediments, the sampling intensity required to meet the same tests would be too high. In this instance NE would consider lower thresholds, as these latter habitats are more species poor, and subject to higher degrees of natural variation. For the most species poor and mobile examples, NE would probably limit surveys to the minimum required effort to determine presence and gather some associated extent data.

Wales

Stations for monitoring reefs were largely fixed. Permanent bolts were used to mark quadrat and tape locations for accurate repositioning. Where the sampling station location was defined by the biota (e.g. monitoring a specific reef species such as a *Parazoanthus* colony), then the monitoring station was allowed to move with the colony, i.e. the colony is photographed even if it moves around from year to year. The rationale for the use of predominantly permanent stations on reef is that there is high heterogeneity over small distances on reefs and that for use of random sampling a very high sample replication would be required to achieve an acceptable level of statistical power to detect community change (rather than apparent change due to spatial differences in community composition). The random placing of quadrats to obtain community composition data (i.e. by divers) is considered by NRW to be impracticable in areas of complex topography. Fixed reef quadrats, NRW believes, do help ensure that the changes observed are real temporal changes, but there are associated disadvantages: how well the fixed locations represent the wider reef community and change caused by repeated interaction with the diver recorders. Representativity is handled by ensuring a reasonable level of sample replication and by covering a range of reef types and biological subzones (e.g. upper and lower infralittoral, upper and lower circalittoral).

With limited budgets, it is only possible to visit a few representative reef locations by diving leading to reduced spatial coverage. More stations are positioned in areas of higher risk in order to help identify localised impacts. Focussing on whole community data helps this further (enabling finer levels of change to be picked out and the multispecies analysis potentially helping with cause determination e.g. through traits/functional groups analysis).

NRW consider drop-down video of reef habitats is more suited to random and stratified random sampling designs, and have trialled gathering it in this way, though the species data gathered are of far lower quality. Drop down video can cover more locations and assist in giving the spatial coverage needed for localised impacts, but the reduced level of data detail and the need for random sampling introduces less precise data and more spatial variation noise – so the ability to detect a change of reasonable effect size with reasonable certainty is much reduced. If adjacent infauna are likely to be affected by the impact, sediment sampling positioned near reef could help identify localised reef impacts.

Most sediment sampling stations were initially positioned using a stratified approach. Repeat sampling was generally (but not always) fixed to these locations but within-station samples (replicates) were random around the fixed location.

NRW used power analysis in population monitoring (e.g. *Parazoanthus axinellae*), and has undertaken some retrospective power analysis of its existing monitoring programmes. Power analysis of multivariate analyses is difficult to achieve, so for multivariate designs (e.g. sediment infauna and rocky benthos with community analysis), NRW has typically ensured that there was sufficient replication to enable a meaningful analysis of similarities (ANOSIM) test (permutation test in PRIMER) at the scale required. As a by-product of addressing these Type I error needs, this will also have improved the design's power. As a fall back, some power analysis of univariate outputs of these designs has also been undertaken (e.g. species abundance and diversity indexes). The combination of power analysis driven sampling strategies and limited resources will invariably result in compromises having to be made in the range of monitoring questions that can be asked and how well they can be answered.

Scotland
Between 1999 and 2013, SNH required contractors to provide sample survey designs in their tenders guided by SNH's requirements for the site and by previous survey methods and approaches. SNH gave contractors some flexibility in survey design to accommodate site-specific variation. Targeted repeat sampling of historical survey stations (e.g. MNCR or as undertaken in preliminary broadscale mapping studies) and stratified random sampling were routinely employed together with the establishment of relocatable or permanent sampling stations on some reef features.

SNH has not routinely used power analyses to determine the amount of sampling effort required in advance of undertaking initial monitoring surveys. In general, such surveys designed for SNH have been informed by the contractor's expert judgement. Retrospective power analyses are provided in relation to some methodologies within some reports, for example to determine the power of quadrat sampling to detect changes in intertidal and subtidal rocky reef communities (e.g. Moore *et al* 2009a & 2009b).

Prospective power analyses have been undertaken for specific benthic habitat features in a small number of sites (e.g. horse mussel beds in Loch Duich, Long and Alsh SAC - see Thomas & New 2006) and relevant studies have informed subsequent repeat monitoring survey design (Marine Bio-images 2007).

2.4.1 Conclusions

UK wide biodiversity monitoring programme

- There is no agreed UK guidance outlining best practice for designing MPA seabed habitat monitoring surveys and the CBBs have not developed their own strategic guidance. Sampling designs need to be affordable and generate data required to make assessments of habitat condition and detect change in the condition of habitats.

- Natural spatial and temporal variability poses a challenge as it is difficult to attribute any change detected to an anthropogenic cause (that could then be managed) if the natural variability of the habitat is not understood. CNCB staff require adequate statistical training on sampling designs and analysis of data to plan surveys, conduct data analyses if required and review contracts.

- For the majority of the period in question, power analyses were not widely used to inform detailed survey design by identifying the number of samples required to detect change with a defined degree of precision and certainty; where they were used they sometimes suggest that very intensive sampling is required to obtain high power and high confidence, which is beyond the current resources of the CNCBs to deliver across the suite of sites, but may be required in specific locations as part of a strategic CNCB or UK monitoring programme. The CNCBs therefore did not always know before undertaking the surveys what level of change they would be able to detect or the level of confidence they would have in any changes observed. It is possible to conduct post-hoc tests on the data collected to see, for example, how many samples would be required to detect different levels of change. The more samples that are required, the more expensive and time consuming the collection and processing of data will be.

2.4.2 Recommendations

- Building on lessons learnt from previous monitoring, produce shared guidance on designing monitoring surveys for seabed habitats in MPAs and where appropriate hold joint training workshops on relevant topics (M6). To include:

    - developing robust, realistic and cost effective sampling designs for delivering different types of monitoring/using different techniques;
    - experimental design to detect a meaningful level of change within an acceptable level of confidence, for seabed habitats; and
    - power analyses (e.g. recommend appropriate levels of power and confidence).

2.5 How were seabed habitat monitoring surveys in MPAs undertaken?

2.5.1 Protocols for data collection

There are now a variety of different protocols available to the CNCBs to assist with undertaking seabed habitat monitoring, including the MMH which was intended to be used as a toolkit to assist those with responsibility for monitoring marine SACs to select and use appropriate methods. The main protocols are described in the subsections below.

In the past, there may have been differences between monitoring methods used by regional offices within the CNCBs. For example in NE, offices used a regional management structure in the past, which could result in variations in methods of data collection between regions. Similarly at NRW, different methods of data collection have historically been used in different parts of Wales, but there is a move in both England and Wales to replicate methods nationally, to improve data compatibility, comparability and internal QC across the board.

Marine Monitoring Handbook
The MMH addressed the principles behind, and the procedures for, monitoring the habitats and species within marine SACs in UK waters to assess their condition. The most important and widely used part of the Marine Monitoring Handbook were the Procedural Guidelines, which lie in Section 6 of the Handbook (Davies *et al* 2001) (http://jncc.defra.gov.uk/PDF/MMH-Section%206.pdf). The aim of these guidelines was to provide a range of techniques to assist practitioners in monitoring CSM marine interest features and recommends particular procedural guidelines from the MMH to measure CSM attributes. The MMH indicates whether the Procedural Guidelines are useful for monitoring programmes.

The MMH Procedural Guidelines are undergoing a wider review by JNCC to identify gaps and guidelines that need to be updated. All CNCBs have used the MMH Procedural Guidelines but the consensus was that many need to be updated. In some cases CNCBs have developed their own Standard Operating Procedures (SOPs) to fulfil specific requirements or where there was no MMH equivalent. For example, in 2012 NRW produced a draft manual of SOPs for monitoring subtidal reefs in Welsh waters (Irving *et al* 2012a). The SOPs protocols are site and equipment specific and are operating procedures rather than just a description of methodology. SOPs are produced to cover the things that the MMH does not (e.g. how to find the site, what it looks like, where to sample, the items of equipment to use, what to record *etc*). NRW has used the MMH Procedural Guidelines where applicable (e.g. some of the sediment protocols). In situations where the MMH did not provide a protocol, NRW will often generate an SOP or procedural guidance to cover it.

Mapping European Seabed Habitats Recommended Operating Guidelines (MESH ROGs)

The MESH ROGs (http://www.emodnet-seabedhabitats.eu/default.aspx?page=1939) describe how best to use different techniques to produce marine habitat maps. These guidelines are used by the CNCBs in addition to the MMH Procedural Guidelines. It must be recognised that the MESH ROGs were produced specifically for habitat mapping purposes and therefore may or may not always be suitable for monitoring. Not all CNCBs require the MESH ROGs to be used for monitoring surveys but ask staff or contractors to take account of them where relevant. In recent years, NE has required contractors to adhere to MESH ROGs where relevant to the survey at hand, and require any departure from these to be discussed/ explained and agreed. NRW find the MESH ROGs are not really relevant to their monitoring surveys and do not require that they are adhered to.

British, European and International standardised methods for biological monitoring

Development of and adherence to relevant national[28], European[29] or international standardised methods (where they exist) is a statutory requirement in the WFD (2000/60/EC) (Addison 2010) but is not a statutory requirement under the Habitats Directive. Annex V of the WFD lists specific standards. Under the MSFD, the Commission are empowered to lay down criteria and methodological standards to be used by the Member States and to adopt specifications and standardised methods for monitoring and assessment but by 2013 no standards had been specified. It is envisaged that the adoption of standardised methods such as those developed by the NMBAQC scheme will ensure consistency between organisations and allow for the production of data of equivalent scientific quality and comparability (Addison 2010). The Standard Operating Procedures developed to date are not always very prescriptive but where they are, they are not always practical for seabed habitat monitoring (e.g. BS EN 16260:2012 suggests that for trend monitoring there should be a marker at the bottom for every photo taken which is not practical, using remotely operated or towed video gear). For the period up to 2013, it is clear that the CNCBs did not routinely require strict adherence to the British, European and International guidance on standardised methods for biological monitoring (listed in Appendix 6).

However since 2013, individual CNCBs have been more rigorously and consistent in adopting the recommendations set out within these guidance documents. For example, post 2012 the vast majority of Natural England's marine monitoring is undertaken either through collaborative partnerships (predominantly with Cefas and the Environment Agency) or via its marine monitoring framework. Both NE's marine delivery partners (including all

[28] A full list of British and standards on biological methods can be found here: http://standardsdevelopment.bsigroup.com/Home/Committee/50002180?type=m&field=Status.

[29] A full list of European standardised methods relating to water quality can be found here: http://www.cen.eu/cen/Sectors/TechnicalCommitteesWorkshops/CENTechnicalCommittees/Pages/Standards.aspx?param=6211&title=Water%20analysis.

subcontracting parties) and framework contractors are required to be both members of the NMBAQC and participants in the appropriate rings tests. This requirement ensures that, wherever applicable, NE's marine monitoring adheres to the standards listed in Appendix 6 as well as others.

2.5.2 Data Collection Quality Assurance

The MMH does not provide detail on recommended QA and QC but states that the above schemes "*provide a potential model for establishing quality assurance measures in SAC monitoring".*

Adherence to quality assurance and quality control schemes are important to ensure consistency in data collection and data analysis for a UK wide biodiversity monitoring programme.

Participation in an external QC or Analytical Quality Control (AQC) scheme is mandatory for most organisations involved in national monitoring programmes such as the Clean Seas Environment Monitoring Programme (CSEMP) and WFD to ensure comparability of data quality across multiple organisations (Addison 2010). In the UK, all Competent Monitoring Authority laboratories and their contractors undertaking statutory marine monitoring programmes such as the WFD monitoring programmes are required to participate in the NMBAQC. The MPA monitoring conducted by the CNCBs is not currently part of a monitoring programme for which this is mandatory, but may become so if it forms a component of the monitoring to meet the requirements of the MSFD. It is a Department for Environment, Food and Rural Affairs (Defra) requirement that any consultant wishing to tender for marine biological work from government bodies (including the SNCBs) must be a member of a QC scheme.

NMBAQC
The NMBAQC scheme is a Quality Assurance (QA) scheme developed on behalf of the UK competent monitoring authorities (http://www.nmbaqcs.org/). Its principal aim is to provide quality assessments of marine biological data contributing to UK national or European monitoring programmes. The scheme also aims to develop and promote best practice in relation to sampling and analysis procedures through a range of training exercises, workshops and literature guides. For example, the scheme is currently working with the CNCBs and JNCC to develop guidelines for the collection and analysis of video and photographic stills data for epibiota monitoring. Many of the guidelines and standards produced to date have been focused on requirements under the WFD and some may not necessarily be practical in deeper waters.

The NMBAQC scheme provides a source of external QC for laboratories engaged in the collection and analysis of marine biological samples. The scheme is made up of six distinct biological components and one physical component, each run by separate scheme administrators and contract managers. The relevant components for seabed habitats are:

- epibiota;
- fish;
- invertebrates;
- macroalgae; and
- particle size analysis.

Northern Ireland
DAERA participate in the NMBAQC scheme for WFD monitoring and this applies where grab samples or algae records are used to help assess the condition of MPAs. DAERA dive team

and ROV operators have also participated in the epibenthic video NMBAQC trials and will implement those recommended procedures when and where applicable. The DAERA dive team have used the MNCR Phase 2 forms as a standardised recording format together with associated video and still photography for their surveys. When the forms were completed after each dive the images and specimens collected on that dive were viewed by as many of the survey team as possible to ensure consistency and an accurate identification (internal QC). A similar procedure is followed for intertidal surveys where at least two competent surveyors are required providing an element of on-site internal QC. Where necessary, images and specimens have undergone external QC, being sent to experts to confirm identification. Specimens and images are usually only externally verified where some doubt exists about their identity, however all images are archived and a few specimens collected and preserved allowing for future QC should this be required. For diving surveys DAERA does not require contractors to be NMBAQC accredited but does require them to supply their QC procedures which should align with NMBAQC standards.

England
NE's monitoring programme is delivered through three main routes as explained below. Whatever the mechanism used, post field work and post submission review meetings are held to identify any lessons learnt.

Partnership delivery
This is almost exclusively completed through the Environment Agency and Cefas. These partners have robust SOPs for data acquisition (be this acoustic, chemical, fishery, particle size analysis, infauna, digital stills or digital video), which fully comply with the QC and QA requirements of NMBAQC.

Framework contract delivery
The national monitoring team have a role to either manage these contracts or to provide support to regional site leads in their delivery of survey projects. This contributes to delivering a nationally consistent approach and sharing of best practice between areas.

As part of this support, national staff review specifications, assess tender returns, survey plans and reports. All contractors are scored on their QA and QC policies, provided with data collection best practice guidance and full participation and adherence to NMBAQC SOP's (where applicable) is explicit. All methods applied are detailed in survey reports. In recent years NE has also insisted that all contractors include NE staff within survey teams, which further promotes consistency and understanding.

In-house monitoring
NE does not have its own specific SOPs, but where monitoring was undertaken 'in-house' a similar approach was used, with national and regional staff working in collaboration, referring to the same guidance and standards, to ensure that the survey will deliver what is required to the appropriate standard. In terms of in-house quality control protocols, these were not as robust prior to 2013. Since 2013 NE has not conducted any wholly in-house benthic habitat surveys, but has rather worked in partnership with framework contractors. However in any wholly in-house surveys they would follow the same SOPs and quality control protocols. All methods applied are detailed in survey reports.

Similarly to NRW (for diving surveys, but also a standard approach for all in-house surveys including driftline vegetation, inter-tidal rocky shore surveys, *etc*), the field component of NE's surveys begins with a familiarisation and standardisation period. This is between a half and one day, and aims to standardise species identification and the interpretation of monitoring methodologies across the individuals undertaking the survey. At the end of this period, results from different people are compared and discussed and remedial actions put in place should they be required.

Where sediment samples are taken, these are done so in accordance with SOPs and analysed through the EA framework as mentioned above.

QC and QA of externally sourced data
As well as the three main routes above, NE has always strived to make the best possible use of data provided by third parties, but this has sometimes been compromised by data and metadata quality issues. In recent years, NE has issued advice to improve the quality of data submitted by data providers.

Wales
NRW have national and regional staff involved in marine monitoring. NRW uses Standard Operating Procedures (SOPs) and/or Procedural Guidance (PG) for much of its monitoring, particularly diving work.

When diving, NRW typically completes a day of recording dives for QC purposes at the start of each survey period (e.g. for familiarisation with the site, species ID, and fine tuning of the method). At the end of this day, results from different people recording information from the same quadrats are compared and fed back. The data are analysed in PRIMER and any outliers are identified. If issues exist, these are discussed amongst the field team so that recording and identification can be improved. Analyses have shown that individuals tend to record more consistently with themselves, with the differences between individuals being greater. Examination of the data have shown that this was largely down to time-limited recording causing people to record a different number of species within the time available. The use of recording protocols has reduced but not eliminated this effect. Solutions to this problem include allowing people more time to conduct the survey (this introduces logistical difficulties – available breathing gas and decompression time) or reducing the data quality and quantity (e.g. use a reduced species list for recording). Divers are also asked to record their confidence in the quality of their recording and to provide information on the environmental conditions affecting recording, as differences over time may be due to differing environmental conditions during surveys.

Scotland
SNH's small in-house marine monitoring team manages delivery of all MPA-related seabed habitat survey work. Members of the team take part in aspects of most of the contracted monitoring surveys in order to maintain an overview and try and ensure consistency in methodologies used between contractors and at different sites. SNH have not developed feature or site-specific SOPs but this may be required as repeat benthic habitat monitoring surveys get underway. The formal start of repeat monitoring of benthic habitat features took place in 2014 within the Sound of Arisaig SAC, 11 years after the initial monitoring event (reported in Moore *et al* 2004) and 20 years after initial broadscale habitat mapping was undertaken (Davies & Hall-Spencer 1996). SNH requires that all contractors have internal QA/QC procedures in place for all aspects of data collection. SNH requests details of the internal QC procedures as part of the contractor's tender submission.

2.5.3 Contextual information

CSM Guidance (JNCC 2004a) states that:

'*the interpretation of condition assessments made using common standards monitoring approaches will often require access to contextual data. This enables the monitoring assessments to be viewed in a broader geographical or temporal perspective (e.g. by comparing results for a particular feature with trends in the wider environment in the UK or beyond). Contextual information may be collected by the conservation agencies or may be provided by the activities of other institutions*.'

A UK-wide monitoring programme also needs to consider contextual information which can be used to inform assessments of habitat condition and prioritise the needs for monitoring.

This report has considered two types of contextual information, environmental and physical parameters and the monitoring or recording of human activities.

Environmental and physical parameters

CSM Guidance for marine interest features provides advice on relevant environmental and physical parameters that can assist with the interpretation of evidence from condition monitoring of marine features (JNCC 2004b). An understanding of the environmental and physical parameters is required to understand the cause of any changes in habitat condition observed.

In general, environmental and physical parameters suggested by CSM are not recorded as standard by the CNCBs. Where available, relevant data collected through monitoring for the Water Framework Directive (e.g. by EA, DAERA and NRW WFD monitoring teams and the Scottish Environmental Protection Agency (SEPA)) is used as contextual data to inform assessments on the condition of the habitats. In addition to reporting under the Habitats Directive, the Water Framework Directive (WFD) (2000/60/EC) requires Member States to establish programmes monitoring the status of protected areas, to gauge whether the water related ecological requirements (e.g. water quality) of the MPAs are being met. Therefore, in order to be able to report on the status of habitats against the various legislative drivers, both direct and indirect monitoring at different geographic scales is required, covering the listed habitats

Northern Ireland

In Northern Ireland, most of the environmental parameters monitored come from the WFD monitoring (which extends out to 1nm with two monitoring buoys further out). These parameters are measured using CTD (Conductivity, Temperature, Depth) loggers with an additional fluorometer. The only exception to this is the seven sites in Strangford Lough SAC where data loggers for temperature, salinity, turbidity and fluorometry plus sediment traps have been deployed from 2008 onwards as a part of the *Modiolus modiolus* Restoration Research Project.

England

Monitoring of some of the parameters suggested by CSM is not possible in a meaningful way at, e.g. in Morecambe Bay where water clarity can range from 2 metres to 2 centimetres, it would be difficult and uneconomic to attempt to detect changes in natural variability and therefore impossible to attribute any changes observed to a cause.

Where relevant environmental or physical data for CSM attributes has been collected by other organisations (e.g. the EA), the data is fed into NE assessments. NE had a memorandum of agreement (MoA) with the EA covering Operational Monitoring which assists in creating a more efficient joint monitoring programme and this includes some physio-chemical monitoring, this has been in place since 2009. Prior to 2012 (Marine Monitoring Framework) MPA monitoring in England was less strategically organised, and run as a set of individual isolated contracts. Surveys were also designed almost entirely at a site specific level in accordance with the relevant conservation objectives. This meant that key physio-chemical parameters recommended in CSM Guidance were monitored at some sites (in accordance with available budget), but not in a strategic sense.

There was limited use of data loggers in England, however Plymouth University deployed one in the Isles of Scilly and there are longer term data collected for NE in the Fleet Lagoon.

Wales
The parameters that NRW are able to measure practically are limited and some of them come with logistical constraints. The main parameters measured are sediment granulometry, temperature, salinity, water clarity, suspended solids, nutrient levels, contaminant levels, and meteorological values (wind strength and direction – for sea state, rainfall, temperature, and sunlight hours). Tidal streams are possible but expensive and less likely to show change. Measuring turbidity is possible but the equipment requires lots of frequent maintenance. Satellite data can be used to collect data on some environmental parameters (e.g. sea surface temp, turbidity and wave height and direction) at a lower resolution.

NRW collected environmental parameter data (temperature and salinity mostly) at some fixed monitoring sites. They have data loggers in lagoons and at all coastal subtidal reef sites. At Skomer MNR, environmental data including sea temperature, water clarity, sediment deposition and meteorological records have been recorded since 1982, and a data buoy logging multiple environmental parameters has been operational for several years. NRW also use of all relevant physio-chemical data gathered for WFD monitoring and other environmental quality related Directives.

Scotland
SNH has deployed CTD data loggers in small number of saline lagoon sites in the Western Isles but do not routinely collect data on supplementary physical parameters within MPAs. SNH will continue working with SEPA and others to improve the coordination of the collection and sharing of environmental data to inform future MPA condition assessments.

Monitoring or recording of human activities in MPAs
CSM Guidance states that an important part of monitoring is the potential for relating observed changes in the condition of the interest features to the reasons for such changes (JNCC 2004a). As part of the monitoring process, it recommends that the following should be recorded:

- threats occurring on, or near, the site which may be driving features into unfavourable condition or preventing them from achieving favourable condition;
- management measures which may result in improvements to the condition of features or maintain features in favourable condition.

Monitoring or recording human activities in the marine environment may provide the direct evidence to help explain biological and environmental changes in the attributes that are being monitored within a site but it may not be possible to attribute cause and effect from the information gained during monitoring, in which case further investigation may be required (JNCC 2004a).

CSM Guidance for individual marine features states but does not provide guidance on how to conduct monitoring in order to correlate the change with the cause or prove the cause of change. Neither the MMH nor CSM Guidance provides advice or guidance on when or how to monitor pressure-state relationships.

The CNCBs generally do not undertake monitoring or recoding of human activities themselves; that is largely collected by other organisations such as the EA, SEPA, the Inshore Fisheries Conservation Authorities (IFCAs), local authorities, Crown Estate, Government departments, Marine Scotland, Welsh Government, and the Marine Management Organisation (MMO). However, spatial data on the distribution and intensity of human activities and pressures are extremely valuable not only for direct MPA monitoring, but also for future marine assessments, marine spatial planning, development of most cost-effective approaches to monitoring (e.g. risk-based considerations), and development of cumulative impact assessment approaches.

Northern Ireland
As part of its monthly seal count programme, observers are asked to record human disturbance such as dog walking, jet skis, bait digging and shellfish collection. Fishing vessel activity is also recorded during constant effort cetacean monitoring.

There is increasing concern about the number of cruise ships visiting Rathlin Island SAC and the fact that Maerl and Seagrass occur close to where these ships generally anchor. Working with the MCA and local harbour master who analysed Automatic Identification System (AIS) data, the Department has advised the harbour master to direct visiting ships towards two anchorages in the SAC which both protects the SACs feature and does not inconvenience the cruise ship operators.

In Northern Ireland in 2012, SeaFish[30] trialled a new enhanced Vessel Monitoring System (VMS) called Succorfish. Succorfish will ping every 15 seconds (rather than the two hours of standard VMS). It can be used to tag pots (or other fishing gear) which get swiped as they come up/get deployed (web system). It was a voluntary scheme and five boats had it installed. Fishermen seemed to be in favour of it in Strangford Lough perhaps as a way of demonstrating that the remaining fisheries were sustainable. This is relevant to the monitoring of Strangford Lough SAC, and potentially to other SACs, as it demonstrates the potential to map intensities of fishing pressure at a very local and accurate level and relate those pressures to habitat condition.

Wales
NRW record a log of predicted and measured impacts due to new developments or activities identified through casework. At Skomer MNR recreational and commercial activity has been routinely collected there since the 1980s. With the exception of Skomer MNR, NRW generally does not measure the intensity of activities within marine sites, but they will prioritise monitoring of a site or initiate investigatory work if they are notified of particular risks to the site from activities. Examples of activities which have been monitored in MPAs include:

- ship anchoring (Pembrokeshire Marine, St Bride's Bay & Milford Haven);
- potting and fixed netting intensity (Skomer MNR);
- recreational activities (numbers of boats, divers, anglers) (Skomer MNR); and
- scallop dredging (*Modiolus* reef and deep mud, Pen Llyn a'r Sarnau SAC).

In Milford Haven, examples of information logged (in GIS if possible) include, capital and maintenance dredging, jetty works, new slips and coastal defences, illegal fishing activity, intertidal ploughing (in Zostera) and new discharges.

With the exception of scallop dredging, no direct analyses have been undertaken to relate biological monitoring to activities data. The data has sometimes been used to initiate investigations. For example, NRW are undertaking repeated monitoring of ship anchoring location and frequency using AIS in order to develop an experimental BACI design to determine if the increasing anchoring is having a measurable effect on the sediment biota of St Bride's Bay. The frequency of dredge marks are recorded as a proxy for amount of damage to determine the consequences of dredging in *Modiolus modiolus* reefs.
Scotland

[30] SeaFish (http://www.seafish.org/about-seafish/) was founded in 1981 by an Act of Parliament and is funded by a levy on the first sale of seafood landed and imported in the UK. It aims to support and improve the environmental sustainability, efficiency and cost-effectiveness of the fishing industry, as well as promoting sustainably-sourced seafood (http://www.seafish.org/about-seafish/).

SNH does not routinely monitor human activities taking place within MPAs. However, SNH do log[31] any casework that may have bearing on the designated sites (e.g. statutory consultations on planning applications, discharge consents, EIA, HRA *etc*) and this information is used in the condition assessment process. SNH has also commissioned or collaborated on specific studies to review activities data collected by others (e.g. analysis of VMS fisheries data within SACs such as that presented in Palmer 2007) and to determine the effects of human activities on the benthic habitats within MPAs. For example, SNH have commissioned work to explore the impacts of marine fish farm deposition on maerl beds (Haskoning UK Ltd. 2006) and part-funded a number of studies that assessed the direct and indirect effects of demersal fisheries on SAC features of interest in collaboration with Marine Scotland Science (e.g. Dale *et al* 2011).

Filtered and anonymised VMS fisheries data for vessels >15m in length only became accessible to SNH for all marine SACs and the new Nature Conservation MPAs in 2014. Prior to this access was tightly controlled and rather sporadic in nature. Benthic sampling design to date has therefore not been guided by a detailed understanding of the distribution and intensity of this key human activity.

2.5.4 Conclusions

CSM

- CSM Guidance suggests several techniques from the MMH for the same attribute. This could lead to the CNCBs choosing different techniques to collect data and different assessments of habitat condition being made depending on the data collection techniques used.

- Environmental attributes (including those recommended by CSM Guidance) are not always monitored (e.g. due to expense, impracticality, lack of appropriate equipment, lack of information on which variables are the most relevant) and, in some instances, may hamper the ability to distinguish the causes of changes in the condition of a habitat. On the other hand, the measurement of some environmental attributes recommended by CSM Guidance is not always practical or believed to be necessary.

UK wide biodiversity monitoring programme

- Some methods in the MMH have been superseded (e.g. MESH ROGs) or new technologies have emerged (e.g. video and still analysis) but the handbook has not been updated. This can lead to different methods being used across the CNCBs, who may have to develop their own guidance in the absence of updated guidelines. Nevertheless there is a degree of coordination in place through the Inter-agency Marine Monitoring Group (MMG).

- There is a need to deliver data consistent with previous datasets while at the same time improving techniques for data collection. The CNCBs are at different stages in implementing their monitoring programmes. For those that are already well established, any change in methods needs to be managed to ensure comparability between monitoring surveys. This could be achieved by calibrating any new methods against existing methods.

- Seabed habitat field data need to be quality assured to ensure that datasets collected over different time periods are comparable. QA is required to ensure that any conclusions in terms of possible management actions are correct. If there is an

[31] The log of casework, site management agreements (including Inshore Fishing Orders) and grants relating to all Scottish designated areas are available to view on SNH SiteLink web pages - http://gateway.snh.gov.uk/sitelink/.

issue with the data, inappropriate management may be applied. The relatively long time between repeat monitoring visits in some sites/countries pose additional challenges to ensuring that sampling approaches employed and associated QA processes are undertaken in a consistent manner. This could lead to incomparable datasets being collected over time.

- Effective means of logging environmental parameters are needed and a better understanding of how to compare large volumes of continuous environmental data (e.g. from data loggers) with point source biological data.

- To date acquiring biological data has often been seen as the priority. The cost of measuring environmental parameters is often a limiting factor, e.g. the cost of equipment, its maintenance and deployment, visits to download data and the need to develop a strategic approach for where to collect this information. However, for some habitats, were these operational constraints (and institutional in some cases) can be tackled, the monitoring of environmental parameters as a proxy for biological health may actually represent a more cost-effective long-term solution to aspects of CSM delivery.

2.5.5 Recommendations

- Improve consistency in the application of different seabed habitat monitoring data collection methods and subsequent analyses by updating, where appropriate, existing technical guidelines and protocols. The following guidelines and protocols should be considered (M7):

    - Marine Monitoring Handbook Procedural Guidelines;
    - MESH Recommended Operating Guidelines;
    - British, European and international standards; and
    - NRW Standard Operating Protocols.

- Provide a central web-based portal (e.g. the Marine Monitoring Method finder on the JNCC website) to enable dissemination of the most up-to-date versions of all guidelines and protocols (M8).

- Promote accreditation for seabed habitat (monitoring) data collection where applicable through contribution to the production of NMBAQC guidelines for seabed habitat imagery collection (M9).

- Building on lessons learnt from previous monitoring, produce shared guidance on designing monitoring surveys for seabed habitats in MPAs and where appropriate hold joint training workshops on relevant topics (M6). To include:

    - most appropriate physical and chemical parameters to monitor in order to explain variations in the condition of seabed habitats.

2.6 How were seabed habitat monitoring data analysed?

This section covers

- the quality assurance of sample analysis (e.g. PSA or species identification); and
- the statistical methods used to analyse data once it has been collected, the samples analysed and quality assured.

2.6.1 Sample Analysis Quality Assurance

The NMBAQC guidelines (see section 2.5.2) and ring tests which exist or are in development are listed in Appendix 3. NMBAQC have previously run an Epibiota Ring Test and for a number of years have been undertaking work to assist with the development of a Best Practice Guide to the Collection and Analysis of Epibiota data.

Northern Ireland
DAERA ensured that all contract work for WFD is carried out by contractors participating in the NMBAQC scheme. This also applies to any infaunal or PSA analysis undertaken for Habitats Directive. Dive survey contracts must adhere to the principles of NMBAQC but formal participation is not mandatory.

England
As previously mentioned, NE delivers monitoring through three main delivery routes:

Partnership delivery
Our monitoring delivery partners fully comply with NMBAQC SOPs. In some instances further additional QA procedures have been put in place. For example video and still analysis undertaken by subcontractors to Cefas undergoes a full NMBAQC compliant QC and QA process before the results are provided to Cefas. Cefas undertakes an additional QA of approximately 10% of the data to ensure standards are maintained, and that consistency is being applied when delineating broad scale habitat types from digital imagery.

Framework contract delivery
All bidding contractors under the framework are scored on their QA and QC policies, provided with data collection best practice guidance and full participation and adherence to NMBAQC SOP's (where applicable) is explicit. All sediment grab sample (psa and/or infaunal) are processed through the EA framework under a MoA, thus it is mandatory for these laboratories to participate in an analytical quality control schemes

Templates and full guidance on all steps involved in delivering a marine monitoring contract are made available to all staff and further improve QA and QC. For example NE now has specific 'Marine Evidence QA guidance' which staff utilise to QA the quality of Marine Recorder and Medin metadata submissions by all contractors. All issues and remedial actions are recorded in 'issue logs'.

To further improve consistency within NE, all stages of the contract (from initial specification to final report) are required to be reviewed by at least one additional staff members including a local and national lead. Fundamental issues are referred to the senior marine specialist or procurement lead and remedial action agreed. This could for example result in a request for a contractor to re-analyse samples.

In-house monitoring
Sample analysis quality assurance steps are have been less robust for in-house surveys when entirely conducted internally, though this now represents a small part of our programme. For rocky shore surveys sample analysis QA is done in the field on the familiarisation visit, with the potential to remove specimens for lab identification at a later date. Natural England is working to improve QA for in-house monitoring surveys.

Wales
NRW ensures that most of their sediment analysis work is NMBAQC compliant, all infaunal analysis work is NMBAQC compliant and NRW maintains NMBAQC scheme membership with checks on invertebrate infaunal and algal scrape fauna samples. One supplier used to complete the particle size analysis is not NMBAQC compliant but NRW are aiming for all

suppliers to be compliant. Although NRW do not require all contractors to maintain NMBAQC scheme membership with checks on invertebrate and algal samples, NRW check samples analysed by contractors through the NMBAQC scheme (i.e. they check samples analysed by contractors) and also maintain awareness of NMBAQC checks (of labs they use) resourced by the EA by examining QC results not only from NRW but also from partners.

If there is a QC failure, then first step is to investigate try to understand the cause. It may be a one-off or something inherent in the contractors' procedures. If it is not a one-off incident, then measures are implemented to prevent it occurring again. If the issues are resolved, NRW continue to use the lab. Analysis of further samples may be put on hold until the issues are resolved. Where there is an insurmountable QC failure then NRW would most likely shift to another lab.

Scotland
All SNH contractors must have a QA system in place. Information regarding both internal and external QC procedures must be submitted by the contractor as part of the tendering process. Further QA/QC is also carried out by the SNH project manager and data officer upon receipt of all project deliverables. NMBAQC accreditation has not been an explicit requirement to date because a number of experienced suppliers were not originally registered with the scheme. However, SNH are currently reviewing this requirement as almost all suppliers used in the last five years have been NMBAQC accredited. Voucher specimen collections from all surveys are lodged with the National Museums of Scotland. SNH do not undertake any WFD sampling (SEPA lead on this in Scottish waters).

2.6.2 Use of statistical methods to analyse data from monitoring surveys

Northern Ireland
DAERA has analysed data from *Modiolus* monitoring in Strangford Lough SAC using multi-dimensional scaling (MDS) analysis and a variety of other statistical techniques. Northern Ireland sub-littoral monitoring data from regular repeat temporal dive surveys has been analysed in using a range of univariate and multivariate analysis as well as ground-truthing of acoustic seabed habitat classification. These datasets have also been used in climate change studies e.g. the recent appearance of *Maja brachydactyla* (spider crab), *Hexadella racovitzae* and *Caloria elegans* into Northern Ireland waters are indicative of rising sea temperatures (Goodwin *et al 2*013).

England
NE primarily employs the same contractors responsible for collecting data to analyse it, and then produce reports and data deliverables using a standard data format. Most statistical analysis employed by contractors look at temporal and spatial statistics, community changes and some univariate indices. NE asks contractors to consider a series of standard questions including the ability to distinguish between changes caused by different variables affecting features within different parts of a site.

Wales
NRW hold an annual workshop with staff, monitoring contractors and statisticians from PRIMER E to look at NRW monitoring data and to refresh skills in analytical techniques. NRW uses a range of data analysis techniques appropriate to the monitoring question. NRW identifies changes, patterns and trends over multiple years and where appropriate, attempts to assign causality. However, apart from some notable exceptions, a full analysis of the marine monitoring data, including use of meta-analyses of multiple data sets, had not been undertaken prior to the 2013 Habitats Directive reporting round. NRW is now planning to undertake this more detailed analysis on an annual basis but this would be contingent on the availability of staff resources.

Scotland
SNH usually employs the same contractors responsible for collecting data to analyse them. A range of statistical analyses are applied routinely to infaunal samples, whether collected as part of broadscale mapping or monitoring surveys. Standard parameters calculated include: total number of species at each stations (s); total abundance of individuals at each station (A); Margalef's index of species richness (d); Shannon's diversity index (H'); and Pielous's evenness (J). Multivariate analysis of species abundance data is carried out in order to describe the main patterns and assemblages within the survey area following standard methodologies (Clarke & Warwick 2001). Classification (cluster analysis) of the data is undertaken followed by a non-metric MDS (multi-dimensional scaling) ordination - both using the PRIMER package.

SNH commissioned a discrete review (Thomas & New 2006) of the statistical analyses presented in the initial monitoring survey of the horse mussel beds feature in the Lochs Duich, Long and Alsh SAC in 2004 (Emu Ltd. 2006) to determine whether there had been a significant change in the number of mussels between sampling events in 1999 and 2004. The review concluded that the decline was highly statistically significant and multiple different analysis methods are outlined that agreed with this finding. A prospective power analysis (see also Section 2.4.2) was undertaken to indicate the likely power to detect different levels of change and to determine the implications for future sampling of this feature (sampled using point intersection counts within strung 0.25m^2 quadrats). The statistics review informed the design of subsequent repeat monitoring undertaken in 2007 (Marine Bio-images 2007).

Whilst just beyond the scope of this current review, in the 2014 Sound of Arisaig SAC repeat monitoring survey infaunal species composition was shown to vary between sites and temporally at each site (between sampling undertaken in 2014 and 2003 at five maerl beds) using multivariate techniques, including ANOSIM testing. Temporal changes in univariate measures, such as species richness, were explored using General Linear Model ANOVA or non-parametric equivalents (Moore *et al* 2015).

2.6.3 Conclusions

UK wide biodiversity monitoring programme

- There is a lack of UK guidance on survey design to help identify the appropriate statistical techniques to be applied in relation to specific sampling designs/data types. The CNCBs have not developed their own strategic guidance.

- Data need to be analysed quickly to feedback to site management in a useful timeframe. This does not always happen. If data are not analysed quickly then there is a risk that changes in habitat condition will not be identified until it's too late to identify the cause and implement management measures to prevent further deterioration of the habitat.

- Datasets for the same seabed habitat may not be comparable across the UK if different methods are being used to collect the data.

- Sample and data analyses need to be quality assured to ensure that datasets collected over different time periods are comparable. If sample and data analyses are not quality assured there is a possibility that inaccurate assessments of current habitat condition or change in habitat condition over time will be made.

- While there are existing QA guidelines for infaunal and PSA samples, there are no existing QA guidelines for the analysis of seabed habitat video and stills data. This

omission leads to issues with comparability between datasets (e.g. species are identified to different taxonomic levels by different people\organisations) and datasets of different qualities (e.g. high or low resolution video and stills images) being used to make assessments of habitat condition. There is a desire for QA guidelines for this type of data to be produced via NMBAQC.

2.6.4 Recommendations

- Promote accreditation for seabed habitat sample analysis where applicable through contribution to the production of NMBAQC guidelines for seabed habitat imagery analysis and interpretation (M9).

- Consider development of a database of video and still images from seabed habitat surveys which can help to identify substrate and habitat/biotope type. (E1).

- See recommendation M.6 in section 2.4.

2.7 Monitoring outside of MPAs

In order to be able to tell whether a particular management regime[32] within an MPA is having an effect, it is important to have control sites beyond the area affected by the management to assess whether any changes observed are due to the management regime.

Similarly the same applies to other aspects of determining the causes for changes in condition such as trying to differentiate between an anthropogenic activity affecting a site and natural change. The CNCBs have not monitored seabed habitats outside of MPAs to serve as control sites. However, they do use data gathered by other organisations to inform assessments at the site scale (e.g. data gathered for WFD).

England
Control sites have been used at specific sites/for specific interventions in MPAs such as the Lyme Bay closure. Some shellfish grounds in the Solway are inaccessible to vehicular access and so provide 'control' areas for shellfish extraction. In reality though, examples (1999-2013) of the full Before-After-Control-Impact (BACI) approach are few and far between. This can result from both a lack of resource and a lack of similar habitat outside designated areas. Often local NE staff are aware of proposed management activities and bespoke monitoring is set up to assess the impacts of proposed management activities identified by local NE staff.

NE also gathers a lot of comparable and relevant habitat and species specific data from EIA monitoring work. NE have utilised a large body of industry data including oil and gas industry data and the wind industry (via The Crown Estate and COWRIE[33]) and individual applicant pre-application baseline data.

Wales
NRW uses third party data to assess feature condition as much as possible. Examples include WFD data, University data (e.g. Bangor University infaunal data), MarClim, the Milford Haven Waterway Environmental Surveillance Group (MHWESG) data for Milford

[32] A management regime may either involve active measures (e.g. restrictions) or no active measures because it is not required.
[33] COWRIE (Collaborative Offshore Wind Research into the Environment) was set up by The Crown Estate as an independent body to carry out research into the impact of offshore wind farm development on the environment and wildlife, evolving into a charity which has gained global recognition for its scientific and educational work (http://www.thecrownestate.co.uk/energy-and-infrastructure/downloads/cowrie/).

Haven, Environmental Impact Assessment sampling for developments, baseline and post consent validation monitoring (e.g. Pembroke Power Station), and fish stock assessments from Cefas, aerial imagery *etc*.

Due to the lack of management measures, control sites have not been used to determine the effectiveness of conservation management. However, they have been used to identify or assess the effect of anthropogenic impacts.

Other UK monitoring programmes
Some examples of other monitoring programmes undertaken outside of MPAs conducted by other organisations which could be used as control sites by the CNCBs include:

- The Marine Environmental Change Network (MECN)[34] is a collaboration between organisations in England, Scotland, Wales, Isle of Man and Northern Ireland and it is coordinated by the MBA. The MECN collects long-term time series information for marine waters, including measurements of temperature, salinity, oxygen, nutrients, zooplankton, phytoplankton, chlorophyll and benthos. The aim of MECN is to provide 'contextual monitoring' that informs 'compliance monitoring'. The time series being maintained by MECN partners are some of the longest of any marine time series in the world (decadal to multi-decadal). The goal of the network is to use long-term marine environmental data from around the British Isles and Ireland to separate natural fluctuations from global, regional and local anthropogenic impacts.

- The MarClim project[35] was a four year multi-partner funded project (2001 – 2005) that investigated the effects of climatic warming on marine biodiversity. The project recorded key intertidal species, whose abundances had been shown to fluctuate with changes in climatic conditions, as indicators of changes occurring in the intertidal and offshore. The project used historic time series data, from the 1950s onwards, and contemporary data to provide evidence of changes in the abundance, range and population structure of intertidal species and relate these changes to recent rapid climatic warming. Sampling sites used within this project may be located within or outside MPAs.

- The Clean Seas Environmental Monitoring Programme (CSEMP)[36] (formerly known as the National Marine Monitoring Programme (NMMP)) was started in the 1980's. The Programme aims to detect long-term trends in the quality of the marine environment by collecting high quality, standardised data. It has approximately 1000 core stations which are monitored to determine long-term trends around the UK coastline. Data are also collected from a number of opportunistic stations increasing the spatial coverage of the monitoring network. Contaminants are measured in waters, sediments and biota to assess their distribution and fate in the environment. Biological effects are also measured to determine the response of organisms to contaminants. Data is stored in the Marine Environment Monitoring and Assessment National (MERMAN) database.

- EIA sampling by industries such as renewable, oil and gas and aggregates for developments, baseline and post consent validation monitoring.

- Monitoring conducted to meet the requirements of the WFD by the EA, SEPA and DAERA and NRW WFD monitoring teams.

[34] http://www.mba.ac.uk/mecn/about.htm.
[35] http://www.mba.ac.uk/marclim/.
[36] http://www.bodc.ac.uk/projects/uk/merman/project_overview/.

2.7.1 Conclusions

UK wide biodiversity monitoring programme

- Industry monitoring data are not always available to the CNCBs. Access to industry monitoring data would provide the CNCBs with information on the impact of pressures on habitats and ensure they do not waste resources collecting data where data are already available. Northern Ireland often makes provision of such data a condition of a marine licence.

- Relevant and appropriate data from the wider environment are not always available to provide a context for any assessment of change in habitat condition in areas with management measures.

- It can be difficult to determine whether a change in habitat condition is due to the management regime unless environmental variables and the implementation of the management measures (within and outside the sites if applicable) are considered.

2.7.2 Recommendations

- Use the results of targeted experimental monitoring case studies to improve our understanding of the relationships between different activity levels, the pressures they exert, and their effects on seabed habitats (M10).

- Explore the feasibility of collaborating with industry partners to collect and share data on monitoring (M3).

3 Assessment of seabed habitats in MPAs

Assessment can be defined as the interpretation of observations collected through a monitoring system to produce indicators and ecologically meaningful targets which can be used to robustly determine the status of the marine environment.

An assessment process for MPAs generally tries to answer the following key questions:

- What is the status and trend of a feature in a defined geographic location?
- What is/are the cause(s) of that status and trend?
- Are the feature's conservation objectives being achieved?
- Are there issues that need management action or research attention?
- Are the management measures being effective?

CSM Guidance refers to assessment as the process of judging condition but a precise definition is not provided. CSM Guidance for marine features recognises that the process of condition assessment of marine features was a novel activity for most CNCBs at the time of its publication in 2004 (JNCC 2004b). There was limited experience to draw upon to develop unambiguous guidance and thus the need to apply a high level of expert judgement in subsequent years was acknowledged (JNCC 2004b).

The next sections describe the work undertaken by the CNCBs between 1999 and 2013 to assess and report on the condition of seabed habitats in MPAs, as well as the challenges they faced. Underlying these challenges are the generic issues of an incomplete ecological understanding of marine biodiversity, the lack of detailed guidance and limited resources for site monitoring.

3.1 Assessment requirements

UK CNCBs assess the condition of seabed habitats within MPAs to meet the following requirements:

- Fulfil marine biodiversity assessment and reporting obligations; and
- Inform conservation advice, which can include:
    - Setting conservation objectives.
    - Identifying conservation measures.
    - Assessing the effectiveness of conservation measures.
    - Determining the environmental effects of a plan or project.

For information on the key national and international legislative and policy instruments driving the condition assessments of seabed habitats within MPAs between 1999 and 2013 see section 1.3.1.

3.1.1 Assessment scale

Assessments of seabed habitats undertaken by the CNCBs within MPAs are made at the scale of the habitat or sub-habitat feature across the site, as recommended by the CSM Guidance (JNCC 2004a, 2004b) (Table 4). In most cases, it has been necessary to assume that the limited spatial sampling conducted within the MPA is representative of the whole extent of the habitat when making an assessment at the site level.

In intertidal SSSIs, NE assesses the condition of seabed habitats across small management units[37] to facilitate the provision of more targeted management advice and better monitor the effectiveness of management actions. Management units are small areas nested within site boundaries that are defined according to the physiography and hydrology of the site.

Table 4. Scale of the MPA assessments carried out by the CNCBs.

CNCB	Assessment scale	
	Feature across SITE	**Feature across UNIT (smaller)**
DAERA	✓	-
NE	✓	✓ (SSSIs only)
NRW	✓	-
SNH	✓	-

3.1.2 Assessment and reporting cycle

According to CSM Guidance, all interest features within protected sites should be assessed and their condition reported at least once every six years, to comply with the six-year reporting cycle stipulated by the Habitats Directive. All CNCBs meet this requirement for SACs (see Table 5).

Northern Ireland
DAERA has a six-year rolling programme of monitoring and assessment for SACs and ASSIs.

In addition, the management objective of restoring the Strangford Lough *Modiolus modiolus* beds has an associated programme of monitoring and assessment to determine the effectiveness of the closed area and the effectiveness of the restoration trials. This restoration plan and monitoring project is overseen by a working group comprised of Government Departments, Academics, Environmental NGOs and the fishing industry. Progress is reported regularly to the European Commission. Regular review of progress has resulted in revision of the restoration plan. It is still too early to determine the success of the closed area.

DAERA assesses and reports on the condition of SPA supporting habitats on an ad hoc basis.

England
SAC monitoring and assessment is generally done on a six-year cycle. Nevertheless, as NE employs a risk-based approach to determine the annual suite of features and attributes to be monitored, the need for more frequent monitoring (and assessment) can be accommodated if needed. Annual reports covering specific work over the preceding year are provided to site management groups (where these exist), which are composed of the relevant authorities. NE is looking into procedures for updating full site condition assessments on an annual basis and communicating this in the annual report.

NE has in place a rolling programme of assessments of environmental features and their management in SSSIs that includes intertidal sites. This is known as Integrated Site Assessment (ISA) programme and is underpinned by CSM Guidance. The frequency of assessments (recorded at the management unit level) varies with the sensitivity of the features being monitoring and the risks to their condition from damaging human activities, and takes place on average every seven years (Natural England 2013a; 2012). Not all units in a site are assessed in the same year. This programme is in place to deliver NE's statutory duty to monitor and report on the condition of SSSIs and ensure SSSIs contribute to

[37] Note that these SSSI units will sometimes overlap with and contain SAC features.

Government objectives on nature conservation, as outlined in the 2011 'Natural Environment White Paper'[38] and the 2011 'Biodiversity 2020: A strategy for England's wildlife and ecosystem services'[39] (Natural England 2012).

The assessment and reporting of SPA habitats is done on a case-by-case risk basis. Most SPAs (and Ramsar) units are also designated as either SSSIs or both SSSIs and SACs. Therefore, information on the condition of SPA supporting habitats is taken from the SAC/ SSSI underpinning benthic unit habitat assessment. Specific detailed community and prey availability analysis of SPA supporting habitats is only done as part of investigative studies triggered by casework, or Red Alerts in relation to SPA designated bird declines.

Wales
SAC habitat condition assessments are undertaken on a six-yearly basis as a minimum as recommended in CSM, though monitoring studies to support these assessments may be more frequent, depending on resource availability, monitoring costs, risk to feature, power necessary to detect meaningful change, and the ability to manage the pressures causing deleterious changes in condition. Article 17 reporting drives the need to have at least one meaningful set of monitoring data for a feature every six years, but in most cases NRW aims to achieve a far higher frequency of monitoring – ideally at a level useful for site management. On that basis some sites and/or features get less attention due to lower risk of damage (e.g. Cardigan Bay, for all features except bottlenose dolphins), whilst areas at higher perceived risk get more attention (e.g. Milford Haven in Pembrokeshire Marine SAC). Where there are known high-risk management issues, both monitoring and 'light' condition assessments are carried out more frequently than every six years (e.g. reporting back from yearly sidescan monitoring of *Modiolus* beds where damage to the habitat from fisheries is an issue). NRW recognises the importance of providing prompt and frequent feedback of monitoring results to site managers and so this is a key driver in monitoring frequency. Monitoring data are examined as soon as possible after collection and any significant concerns are reported to relevant authorities as they appear. The detailed data analysis, formal assessment and reporting still lag behind the intended timescale of every one to two years. This is primarily a resourcing issue (available staff). In the future, NRW's intention is to assess and report on SAC feature condition at a more regular interval of every one to two years.

Within Skomer MNR the condition of most features is assessed and reported every year. For the features that are monitored less frequently, the reporting is generally done on a four year cycle.

NRW does not have a marine SSSI monitoring programme, and consequently, intertidal SSSIs are only monitored incidentally as part of SAC monitoring. Due to the lack of funds to resource a SSSI monitoring programme, no intertidal SSSI specific assessment and reporting takes place in Wales.

NRW monitors bird food availability and habitat condition annually in two SPAs - Burry Inlet SPA and Carmarthen Bay SPA - where these habitats are also SAC features. Assessment results are provided in field contractor reports.

Scotland
SNH has a six-year rolling assessment and reporting programme that encompasses all MPA features. The most recent survey and/or monitoring data (which may be up to 18 years old for seabed habitat features) are used to inform six yearly site assessments and reporting obligations, regardless of which reporting round it was collected in. To date, assessment and

[38] Natural Environment White Paper, The Natural Choice: Securing the Value of Nature.
[39] Biodiversity 2020: A strategy for England's wildlife and ecosystem services.

reporting have been informed by preliminary broadscale habitat mapping and inventory surveys as well as more detailed monitoring studies. Information collected during 'site checks' (see Section 2.3.2) is used to supplement existing detailed survey data between formal monitoring visits.

SNH does not currently assess or report on the condition of SPA supporting habitats.

Table 5. Frequency in which the CNCBs assess and/or report on the condition of seabed habitats within MPAs (irrespectively of what is specified by the legislation).

CNCB	SSSIs\ ASSIs	SACs	Ramsar sites	SPA supporting habitats	MNR
DAERA	Every six years	Every six years	Ad hoc	Ad hoc	Every six years
NE	Unit (or habitat) specific assessments carried out on average every seven years (ISA programme). Reporting to Defra annually.	Every six 6 years or more frequently	Ad hoc	Ad hoc, or carried out as part of SAC/SSSI monitoring	Every six years
NRW	N/A	Every six years or more frequently	Ad hoc	Annually[40]	Annually
SNH	Every six years	Every six years	Every six years	N/A	-

3.1.3 Conclusions

CSM

- Most CNCBs assess the condition of seabed habitats at the scale of the habitat or sub-habitat feature across the site, as recommended in CSM Guidance. In most cases, this implies making the assumption that the limited spatial sampling conducted within the MPA is representative of the whole extent of the habitat when making an assessment at the site level, resulting in assessments of low confidence.

- All CNCBs have been able to assess and/or report on the condition of SAC habitats every six years (or more frequently in some cases) to fulfil the reporting obligation under Article 17 of the Habitats Directive and to provide management advice for habitats at a higher risk of deterioration and/or loss.

3.1.4 Recommendations

- See recommendation M.6 in sections 2.3 and 2.4.

3.2 Baselines

There are several different interpretations of the definition, use and role of a 'baseline' within a biodiversity assessment framework. CSM Guidance does not provide specific advice on setting baselines, and as a result the concept of baseline has been interpreted and applied differently by the CNCBs.

[40] However, not since 2011.

A baseline can be defined as a specific value of state (or pressure/impact) against which subsequent values are compared: essentially the standard (articulated in terms of both quality and/or quantity) against which environmental targets can be set (OSPAR Commission 2012).

Approaches to setting baselines include those outlined by the OSPAR Commission (2012):

a. **Reference state:** Baselines can be set as a state in which the anthropogenic influences on species and habitats are absent or negligible.

b. **Past state:** Baselines can be set as a state in the past, based on a time-series dataset for a specific species or habitat, selecting the period in the dataset which is considered to reflect least impacted conditions.

c. **Current state:** The date of introduction of an environmental directive or policy (or the first assessment of state) can be used as the baseline state. Since this may represent an already deteriorated state of biodiversity, the associated target should typically include an expression of no further deterioration or a requirement for recovery from this state (i.e. trend-based target).

It is important to emphasise that the desired state (target) is not always the same as the baseline, as the target can be set as a deviation from the baseline or as a trend towards or from the baseline (Moffat *et al* 2011; OSPAR Commission 2012). Setting appropriate targets should begin with determining a relevant baseline, as this will likely affect what state targets might look like (Moffat *et al* 2011; OSPAR Commission 2012) (see Figure 6).

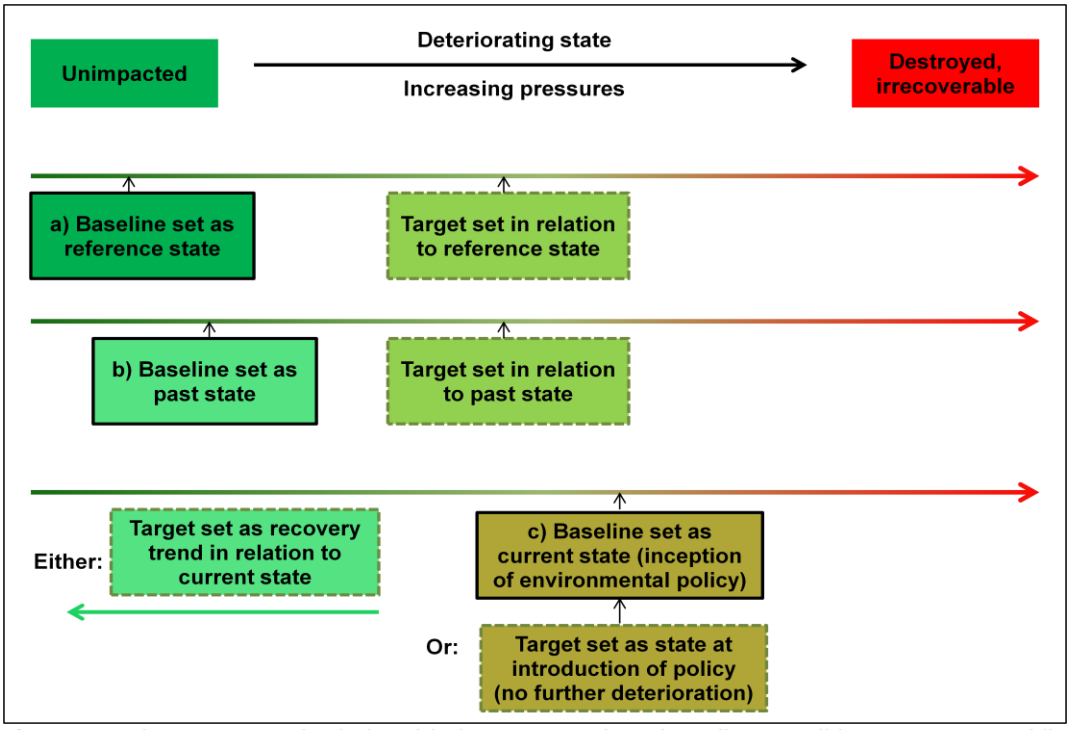


Figure 6. The conceptual relationship between various baseline conditions, targets and limits (adapted from Moffat *et al* 2011).

Where possible, baselines should be ecologically relevant, i.e. based on reliable data and reflecting a state of biodiversity when not impacted by human pressures. Baselines identified in such a way will prevent the phenomenon of 'shifting baselines' where each successive generation has an increasingly degraded view of the ecosystem that is then

reflected in the choice of baselines for assessment (Pauly 1995, *cited in* Moffat *et al* 2011). For advice on how to set reference conditions for seabed habitats see Hill *et al* (2012).

However, it is recognised that the use of 'current state' baselines may be the only practical option against which to set targets, given the current lack of information on reference conditions or past state for most marine habitats (Moffat *et al* 2011). Such an approach was used in the context of the Habitats Directive, where the date when the Directive came into force nationally was used by many Member States, including the UK (i.e. 1994), as the baseline for favourable reference values[41] for range and area for the habitat types in Annex I of the Directive (Moffat *et al* 2011; OSPAR Commission 2012). This type of baseline is typically used with the aim of preventing any further deterioration from the current state, or there can additionally be a target to improve the state from such a baseline (towards a reference state) (OSPAR Commission 2012).

Similarly, CNCBs have often adopted 'current state' baselines for their MPA features, either representing feature condition at the time of site submission/designation, just before, or some time thereafter (see Table 6). Where current state baselines are found to represent an impacted state, the CNCBs generally have set targets as recovery trends in relation to the baseline condition.

Northern Ireland
DAERA considers baselines to be those available from the earliest reliable and comprehensive surveys (i.e. past state). In most cases these date from the late 1970s and early to mid 1980s, particularly from the Northern Ireland Sub-littoral Survey (1982 - 1986) conducted by the Ulster Museum on behalf of DAERA. A total of 999 dives in a stratified range of depths was the precursor to the MNCR and is the earliest such comprehensive National survey within Europe. A full report, archived specimen collection and photographic database combined with site descriptions and SACFOR species lists are all accessible through Marine Recorder and held in CEDaR. The baseline is utilised by Departments, developers and academics.

England
NE interprets baselines as the relevant datasets relating to the condition of a feature at the time of submission/designation, just before, or shortly thereafter when the first assessment of state is undertaken (i.e. current state). NE also uses past state information to inform baseline (and target) setting, e.g. for seagrass extent, extent of and hydrogeomorphological characteristics of saltmarsh (using remote sensing information).

Baselines are used as a reference point for comparing subsequent survey information against, to measure and assess whether targets have been achieved. However setting baselines has been extremely difficult for two primary reasons. Firstly available baseline information is often composed of data from disparate sources, incomplete, or even wholly absent. Secondly, NE has yet to undertake a strategic evaluation of the available data across their suite of MPAs to determine whether collated datasets could indeed be considered robust for forming a baseline for (at least) a subset of features or sub-features.

[41] Favourable reference values for range and area for the habitat types in Annex I of the Directive (i.e.) must be at least the range (in size and configuration) and the surface area occupied by the habitat at the biogeographic level when the Directive came into force (Evans & Arvela 2011). If these are known to be insufficient to support favourable status of a particular habitat, this should be taken into account and larger values should be set to ensure the long-term viability of the habitat type (Evans & Arvela 2011). Historic data and expert judgement may be used to help define these values (Evans & Arvela 2011). It is recognised that favourable reference values may have to change between reporting cycles as better understanding and further data become available (Evans & Arvela 2011).

Wales
NRW uses baselines as a set of reference values (e.g. community composition, habitat extent, contaminant concentration, species abundance) against which subsequent monitoring results can be compared to assess current condition. The baselines used by NRW vary depending on the quality of the information available and the purpose they serve.

For SACs, as a minimum, NRW treats the condition of a habitat at the time of submission of the Natura 2000 standard data forms[42] (i.e. current state) as the basis for determining compliance with Article 6.2 of the Habitats Directive, i.e. a point to measure deterioration against[43]. Baselines set using monitoring data typically represent the first useable data gathering exercise. However, where there are reliable data that better reflects a state of biodiversity not impacted by human pressures (e.g. Environmental Quality Standards[44]) such data may be used instead or in addition, depending on the requirements (i.e. reference state). NRW have reviewed some historical data (e.g. biological surveys, aerial imagery) to establish more appropriate baselines (i.e. past state) from which to measure change or to provide context for baselines that use more recently established data. For example, when only recently gathered data are of sufficient quality to set a robust baseline, historical information may at least indicate the degree to which this baseline represents a degraded environment, even if it is of insufficient quality itself to define the baseline.

NRW have no formal baseline for its Intertidal SSSI (outside SAC) as they have been unable to resource a SSSI monitoring programme.

Skomer MNR baselines tend to represent the first monitoring event (i.e. current state). Where there is evidence that this represents a degraded state (e.g. scallop populations) the target may represent an improved condition rather than no deterioration.

Scotland
SNH sets the baseline for the assessment of SAC features as the condition at the time of submission of the Natura 2000 standard data forms (i.e. current state). However, a number of these sites have only been mapped at a broad scale level. As such, the baseline is more often set to the condition of the feature at the time of the first useful data gathering exercise.

Table 6. Assessment baselines used by the CNCBs.

CNCB	Reference state/ condition	Past state	Current state
DAERA	-	✓	-
NE	-	✓	✓
NWR	✓	✓	✓
SNH	-	-	✓

3.2.1 Conclusions

CSM

- The CNCBs use a range of approaches to setting baselines for assessing the condition of seabed habitats within MPAs, which include ‘reference state’, ‘past state’ and ‘current state’ baselines.

[42] Site information format for proposed Natura 2000 sites (see Commission Implementing Decision of 11 July 2011).
[43] Where changes have been made (i.e. area extensions and addition of new features) to already designated SACs, the site Natura 2000 standard data forms would have been updated and resubmitted, which means that those new features and extensions may have a more recent baseline than the designation date.
[44] For more information see Directive 2008/105/EC on Environmental Quality Standards.

- The CNCBs have experienced difficulties in defining robust baselines that represent condition at the time of designation (or some earlier point in time), due to lack of appropriate data.

- Difficulty in determining the degree to which 'current condition' baselines represent degraded conditions.

3.2.2 Recommendations

- Identify Identify existing issues and develop guidance to inform the setting of baselines and targets for seabed habitats. Where applicable, take into account the work done under WFD and MSFD, Hill *et al* (2012), and the recommendations in the OSPAR Advice Manual (OSPAR Commission 2012) (A.1).

3.3 Condition classes

The first step when judging the condition of MPA interest features is to determine whether they are in favourable or unfavourable condition (JNCC 2004a). If a feature is assessed as being in unfavourable condition, the second step judges whether it is recovering, stable, or declining compared to the baseline or previous assessment. This second step is critical to inform decisions about the management of sites. For this reason, the condition classes framework agreed as part of CSM Guidance includes sub-classes relating to trends in feature condition (JNCC 2004a) (see Table 7).

The CNCBs have broadly adopted the condition classes proposed in CSM Guidance in their assessment work. The exceptions are SNH, who has one extra class of 'favourable – declining' (SNH 2012), and NE who applies a more detailed definition of 'unfavourable – recovering' than the one proposed by the CSM Guidance (see Table 7).

The way in which NE applies the 'unfavourable – recovering' category is described in a mandatory guidance document aimed at NE advisers (Natural England 2013b). The difference between the two definitions centres on whether a feature must have 'begun to show' signs of recovery (CSM definition) or whether it is sufficient for the necessary management mechanisms to be in place for it to be considered 'unfavourable – recovering' (Natural England 2013b).

Table 7. Condition classes proposed in the CSM Guidance and more refined condition classes adopted by NE and SNH.

Condition classes	CSM Guidance	SNH guidance	NE guidance
Favourable - maintained	An interest feature should be recorded as *maintained* when its conservation objectives were being met at the previous assessment, and are still being met.		The designated feature(s) within a unit are being adequately conserved and the results from monitoring demonstrate that the feature(s) in the unit are meeting all the mandatory site specific monitoring targets set out in the Favourable Condition Table (FCT). The FCT sets the minimum standard for favourable condition for the designated features and there may be scope for the further (voluntary) enhancement of the features/unit. A unit can only be considered favourable when all the component designated features are favourable.
Favourable - recovered	An interest feature can be recorded as having *recovered* if it has regained favourable condition, having been recorded as unfavourable on the previous assessment.		
Favourable - declining		The attribute targets set for the natural features have been met, but evidence suggests that condition will worsen unless remedial action is taken.	
Unfavourable - recovering	An interest feature can be recorded as *recovering* after damage if it has begun to show, or is continuing to show, a trend towards favourable condition.		Units/features are not yet fully conserved but all the necessary management mechanisms are in place. At least one of the designated feature(s) mandatory attributes are not meeting their targets (as set out in the site specific FCT). Provided that the recovery work is sustained, the unit/feature will reach favourable condition in time.
Unfavourable - no change	An interest feature may be retained in a more-or-less steady state by repeated or continuing damage; it is unfavourable but neither declining nor recovering. In rare cases, an interest feature might not be able to regain its original condition following a damaging activity, but a new stable state might be achieved.		The unit/feature is not being conserved and will not reach favourable condition unless there are changes to the site management or external pressures and this is reflected in the results of monitoring over time, with at least one of the mandatory attributes not meeting its target (as set out in the site specific FCT) with the results not moving towards the desired state. The longer the SSSI unit remains in this poor condition, the more difficult it will be, in general, to achieve recovery. At least one of the designated feature(s) mandatory attributes and targets (as set out in the site specific FCT) are not being met.

Condition classes	CSM Guidance	SNH guidance	NE guidance
Unfavourable - declining	Decline is another possible consequence of a damaging activity. In this case, recovery is possible and may occur either spontaneously or if suitable management input is made.		The unit/feature is not being conserved and will not reach favourable condition unless there are changes to site management or external pressures. The site condition is becoming progressively worse, and this is reflected in the results of monitoring over time, with at least one of the designated features mandatory attributes not meeting its target (as set out in the site specific FCT) with the results moving further away from the desired state. The longer the SSSI unit remains in this poor condition, the more difficult it will be, in general, to achieve recovery.
Partially destroyed	It is possible to destroy sections or areas of certain features or to destroy parts of sites with no hope of reinstatement because part of the feature itself, or the habitat or processes essential to support it, has been removed or irretrievably altered.		Lasting damage has occurred to part of the designated feature on the unit such that it has been irretrievably lost and will never recover (no amount of management will allow the feature to ever reach favourable condition). Conservation work may be needed on the residual interest of the unit. If more than one feature occurs in a unit, but only one is considered part destroyed, consideration should be given to reunitising out the destroyed area.
Destroyed	The recording of a feature as destroyed will indicate the entire interest feature has been affected to such an extent that there is no hope of recovery, perhaps because it's supporting habitat or processes have been removed or irretrievably altered.		Lasting damage has occurred to an entire designated feature on the unit such that the feature has been irretrievably lost (no amount of management will bring this feature back). This feature will never recover in the unit, e.g. a finite mineralogical feature has been totally removed from its surroundings without consent and is therefore lost forever.

3.3.1 Conclusions

CSM

- The CNCBs have broadly adopted the condition classes proposed in CSM Guidance in their assessment work. The exceptions are SNH, who has one extra class of 'favourable – declining', and NE who applies a more specific definition of 'unfavourable – recovering'.

3.4 Assessment indicators (attributes)

The majority of the biodiversity indicators used by the CNCBs are state (condition) indicators drawn from CSM Guidance for marine features and are referred to as 'attributes'. CSM Guidance uses the term 'attribute' to refer to a characteristic of an interest feature that describes its condition, either directly or indirectly.

For each interest feature CSM Guidance identifies a core set of attributes which should be used to help define favourable condition on every site, i.e. mandatory attributes, plus a set of additional attributes from which some or all can be used to highlight any local distinctiveness, i.e. discretionary attributes. CSM attributes generally reflect both physical and biological components of the system. According to CSM Guidance for marine features, attributes should (JNCC 2004b):

- help to define condition;
- be capable of clearly identifying a change in condition;
- be measurable;
- be capable of being monitored practically and economically.

The majority of CSM attributes have only been measured (if at all) once or twice for individual habitats in England, Scotland and Northern Ireland between 1999 and 2013; whilst in Wales some CSM attributes have been measured more frequently.

It is broadly recognised by the CNCBs that further development is required before the set of attributes proposed by CSM Guidance fully satisfies the above mentioned criteria. Several of the CSM attributes not practical and economic to measure on a regular basis (e.g. extent of rocky reef in a large site) and others (if monitored) are not particularly sensitive to detecting change.

Future CSM development should focus on identifying attributes that are sensitive to anthropogenic impacts to allow for the differentiation between natural and anthropogenic influenced change to be made.

The way in which individual CNCBs make use of indicators, including the attributes recommended by CSM Guidance varies as described and summarised in Tables 19 - 22 below.

Northern Ireland
The CSM attributes which DAERA has found more practical to measure and useful in defining feature and/or sub-feature condition are described in Table 8.

Table 8. CSM attributes found by DAERA to be most and less useful and practical to measure per interest feature.

Marine interest feature	Most useful attributes and why	Less useful attributes and why
Littoral rock and inshore sublittoral rock	Condition. Measurable and change can potentially be attributed to causes.	Extent. This is unlikely to change to any great degree.
Littoral sediment flats (mud\sand flats)	Condition. Extent of Zostera beds is also useful where applicable.	Distribution. This is unlikely to change to any great degree.
Inshore sublittoral sediment (sandbanks)	Condition. For maerl beds extent and distribution are also useful.	None.
Sea Caves	Condition.	Extent. Difficult to measure and most changes are difficult to detect unless e.g. gross damage by coastal defence work which may also change distribution.
Estuaries	Condition of component features. Extent and distribution of component features may also be subject to change.	Distribution. Not expected to change.
Inlets and Bays	Condition of component features. Extent may also potentially be changed by coastal works. Extent and distribution of component features may also be subject to change.	Distribution. Not expected to change.
Lagoons	Condition of component features. Extent and distribution may also be subject to change. Extent and distribution of component features may also be subject to change.	None.

England

NE measures both mandatory and discretionary CSM Guidance attributes, as well as some additional indicators recommended by academics and contractors doing the survey and/or monitoring work. The attributes (and targets) used by NE to describe the condition of individual MPA features are recorded in site-specific Favourable Condition Tables.

In applying CSM Guidance, NE has found some CSM attributes to be more practical to measure and useful in defining feature and/or sub-feature condition than others (see Table 9). For example, NE has found the attribute 'species composition' to be one of the most useful CSM attributes, particularly when applied in specific areas or within a specific sub-set of representative or notable communities, despite this only being a discretionary CSM attribute. On the other hand, NE has not been able to draw significant conclusions from measuring the 'extent' of habitats (mandatory attribute) such as subtidal sedimentary habitats or *Sabellaria spinulosa* biogenic reefs given their inherent natural variability[45]. For more information on the CSM attributes which NE found more practical to measure and useful in defining feature and/or sub-feature condition see Table 9.

[45] In 2014 - 15 JNCC let a contract to identify the sources and range of errors associated with detecting change in the area of selected benthic habitats to inform the development of an MSFD habitat area indicator (Defra tender reference ME5318).

Table 9. CSM attributes found by NE to be most and least useful and practical to measure per interest feature. Mandatory attributes are labelled with an 'M' and discretionary attributes are labelled with a 'D'.

Marine interest feature	Most useful attributes and why	Least useful attributes and why
Littoral rock and inshore sublittoral rock	**Extent (M) –** Generally simple to calculate. Occasionally more problematic to set a target – e.g. cobble skears in Solway Firth SAC, which from season to season may be either littoral rock, biogenic reef, or totally inundated by sediment as a result of natural movement of sediment around the estuary. **Extent of sub-features (D) –** Useful for selected accurately measurable sub-features that are biologically meaningful to be measured. The extent of a chosen subset of sub-features should be monitored in conjunction with distribution. **Presence of representative communities (D) –** Useful as a quick and simple tool for rapid assessment purposes. **Species composition (D) –** Is useful for assessing condition and direction of change in specific localities or within a specific sub-set of representative or notable communities. The detailed level of understanding [of a community or location] that comes from detailed community analysis will provide a greater level of evidence on which to base NE's advice. As such this attribute is essential, but just not 'across the board'. **Presence and/or abundance of specified species (D) –** This is valuable but needs to be addressed on a site-by-site basis. Can be really useful in tracking specific trends and tends to be straight forward to do and cost effective.	**Distribution of Biotopes (M) –** Not particularly helpful as (other than broad zonation) they tend to occur as complex interspersed mosaics, and are apt to move. This means that a detailed biotope distribution map may be out of date very quickly. Better to look at arrangement and relative abundance of the mosaic of biotopes/habitats/community complexes present at 'baseline' to look for any directional shifts. **Extent of sub-features (D) –**Time consuming and for some features meaningless in the context of the noise of natural variability. **Biotope composition (M) –** This can be useful, but sticking to biotopes can be problematic. For example a biotope can remain from one survey to another 6 years later, but the quality of the biotope (diversity and abundance of component species and proportion of positive and negative indicators) may have undergone significant deterioration. Thus biotope mapping and comparison alone could easily miss impacts and would not in itself be a good tool for assessing condition across a physically stable habitat. It would be better to focus more on habitats and community complexes, so that community analysis can be undertaken. Repeat surveys are more straightforward if previous communities are known and described in detail (adequate 'baseline'). Difficulties can arise in selecting a sub-set to be re-assessed during repeat surveys when resources are limited. Consideration is needed as to which EUNIS level is required. **Species composition (D) –** We estimate that 75% of the cost of the survey goes on this attribute. Across a varied and heterogeneous site the sampling intensity (to cover all features and sub-features) is often unfeasibly high. Analysis can often require complex statistical methodologies; these two factors mean that achieving a 'statistically robust baseline' for the feature as a whole is often not realistically possible.

Littoral sediment flats (mud\sand flats)	**Extent (M) –** What is possible to gather is the boundary of the upper extent of mud and sand flats. This is the area where the most direct habitat extent changes may be expected to occur (impacts of sea defences, land reclamation saltmarsh expansion *etc*). **Biotope composition (M) –** It may be that for characteristic and more stable biotopes (e.g. zostera beds, cockle beds) a change in biotope composition does indicate an impacted situation. But sufficient monitoring intensity (temporal and spatial) is required to understand perceived change within the context of natural variability. **Species population measures (D) –** Good for providing further information on impacts from pressures. **Species composition/community analysis (D) –** Listed as a non-mandatory attribute, i.e. Species composition of representative or notable biotopes. NE is of the opinion that species composition (species present and their abundance) is probably the most useful data set for assessing condition/change/impact. This data can and should (for example for mapping purposes) be transcribed into biotopes, but there is much more that can be done using a variety of analysis techniques, from a range of single diversity indices to multi-metric indices to functional and biological traits analysis. Different tests will lend themselves different purposes, for example a diversity index such as species richness or Margalef may be used to identify the number of samples required to permit a reasonable chance of detecting an impact of a given scale (for example for Runswick Bay, NE have calculated that 36 infaunal mud grabs would be required to ensure that we have an 80% chance of detecting a 20% change in the community). But then different forms of analysis of the same data (i.e. biological traits or functional group analysis) may reveal a subset of species that have changed in abundance which may in turn lead to the suggestion of the nature of the impact. Also potential very useful for looking at SPA supporting feature condition – prey availability/ carrying capacity *etc*. (The analysis starts to fall under species population measures). **Sediment character: organic carbon content (D) –** Useful for specific investigative monitoring.	**Extent (M) –** Accurate total extent is expensive and difficult to obtain due to the methodological problems of calibrating the tide elevation values when integrating multiple remote sensing surveys undertaken different times. In some instances remote sensing in not sufficient to discriminate between mudflat and pioneer saltmarsh or other littoral sediment communities. **Biotope composition (M) –** Highly spatially and temporally variable – does a change in biotope necessarily tell us a site is impacted? For the majority of polychaete/amphipod biotopes found across vast areas of littoral mudflats, such as the Wash and Morecambe Bay, a change in biotope cannot easily be interpreted as significant, as a result of high natural variability and other factors. Biotopes themselves are quite subjective to the person analysing the data. NE has encountered so called temporal variations, which on further investigation were likely to be a result of different interpretation of the community data. In some instances the broad biotope categories assigned to some features may not be the most biologically meaningful/useful way of assessing the feature. Thus NE is moving toward community analysis. **Sediment character: oxidation-reduction profile (Redox layer) (D) –** (see Estuaries) There is a large spatial and temporal variation in redox, which means that the amount of data collected on an average intertidal mudflat survey (i.e. with a haphazard or random stratified sampling design designed for PSA and biological monitoring would not be likely to yield significance in terms of redox). Surveys need to be carefully designed to pick up differences. Ideally better as a tool for investigative monitoring. **Topography (D) –** Topographical features could be mapped as a cartographic exercise (GIS, aerial photo analysis, remote imaging, bathymetry data, etc) supported by additional remote sensing (LiDAR) and hydrographic (swath bathymetry) data if necessary. Analysing the change could be done in intertidal elevation between two epochs using LIDAR data. However, NE is not yet clear how the threshold would be defined, or how change could be defined as anthropogenic impact without clear records of new disturbance, or a sediment tracer study, so targets for assessment are not available. One possibility is that a number of topographic line profiles could be established at chosen

		locations across the saltmarshes and tidal flats around the estuary. These cross-section lines would be monitored to establish trends in the change in estuary form. The location of the profiles should as a minimum include the mouth of each estuary. One would hope that this information would be collected as part of repeat morphological equilibrium assessments should these be affordable.
Inshore sublittoral sediment (sandbanks)	*See littoral sediments*	
Sea Caves[46]	**Summary:** Overall, all sea cave attributes are useful. **Biotope composition (D) –** are relatively easy to measure and understand, though it may again be more useful to revert to community composition analysis to gather an early warning of potential change, as it is likely that trends in relative species presence and abundance with be picked up through community analysis before they trigger a wholesale shift in biotope. **Presence and/or abundance of specified species (D) –** may be appropriate in some instances to gage the changes in notable species over time, or the relative shift in abundance on negative indicators *etc*.	
Estuaries	**Summary:** For estuaries/inlets and bays a simple assessment of form and function (tidal regime, morphology, topography, sediment movements sources and sinks, sediment composition, energy and exposure regimes, connectivity and ecosystem services) is needed, plus an understanding of the diversity of habitats and communities found across the various estuarine gradients, and an understanding of habitat distribution range and substrate affinity throughout the site. **Redox, salinity (M), tubidity, water density –** Potentially useful in investigative/recovery monitoring situations and possibly where the existence of specific spatially restricted notable communities is	**Redox, salinity (M), turbidity, water density –** By their nature these attributes are highly variable both spatially and temporally. NE will never have the resources to monitor these attributes sufficiently frequently or at sufficient spatial resolution to make the data meaningful in any significant way across an entire estuary system. **Extent (M) & Distribution/spatial pattern of habitats (M) –** Obtaining a clear understanding of distribution and extent of estuarine sub-features across a complex estuarine site, that is detailed enough to allow for discrimination of potential anthropomorphic change from the background of natural variability, is unlikely to be possible. Thus any

[46] All CSM attributes for sea caves were deemed discretionary (JNCC, 2004d).

	defined by these attributes. **Extent (M) & Distribution/spatial pattern of habitats (M) –** On a site and sub-feature case-by-case basis it may be possible to gather statistically meaningful information on the distribution and extent of specific sub-features/habitats. In these instances these data would be invaluable to assessing condition, direction of change and potential anthropomorphic impacts. **Morphological equilibrium (D) –** This could be a useful attribute if further developed. NE has let multiple contracts during the 2014/15 financial year to further develop this attribute and better understand the interaction of its component elements (tidal regime, morphological equilibrium and estuarine topography) and how effectively we can use this attribute to determine estuarine health. The issues still appear to revolve around level of data required to make a meaningful assessment, frequency of assessment and ability to detect and attribute change.	assessment of distribution and extent will inevitably be down to expert judgement using available data.
Inlets and Bays[47]	*See Estuaries* **Diversity of component habitats (M) –** This is viewed as a useful high–level assessment tool. Almost a first step cross-check to ascertain if there have been any major changes in diversity across the site. **Distribution/spatial pattern of habitats (M) –** For a subset of more stable habitats (i.e. inter-tidal reef) this attribute may be fundamental.	**Water quality (M) –** Inherent (short, medium and long-term) spatial and temporal variability across an estuarine site, will often mean that this attribute can never realistically be monitored in a meaningful way (i.e. that would allow discrimination between natural variability and anthropomorphic impact). **Distribution/spatial pattern of habitats (M) –** Case-by-case dependant on habitat. Natural variability ensures that this is not a useful attribute for many habitats as sampling intensity to determine any effects above the noise of natural variability will not be achievable.
Lagoons	**Extent (M)** **Isolating barrier - presence and nature (M)** **Salinity regime (M)** – essential to understand the communities present, but must be gathered using continuous monitoring systems – such as used by NRW. NE currently does not have the resources to	**Extent of sub-feature or biotopes –** not relevant for English lagoons. **Biotope composition (M) –** There is no agreed MNCR or peer-reviewed biotope classification to adhere to. Lagoon species presence and abundance is being recorded. **Salinity regime (M)** – salinity monitoring as part of a six year cycle is

[47] All CSM attributes for inlets and bays are mandatory (JNCC 2004d).

	do this. **Species population measures (D) –** Potential most useful, but NE have not undertaken much research in this area.	effectively meaningless as we have no site specific indication of natural variability.

Wales

CSM was not the driving force for the selection of the indicators used by NRW. NRW uses indicators that it believes best represent the condition of the feature. These include mandatory and discretionary CSM attributes. However, several CSM attributes are not monitored as part of NRW's monitoring programme due to logistical or resource constraints.

To ensure that the site's conservation objectives are not limited by organisational monitoring limitations, assessment indicators used by NRW are kept separate and referred to as 'performance indicators'. Performance indicators are a suite of attributes and targets that are used to determine, as best as reasonably practicable, whether the site's conservation objectives have been achieved. They encompass all aspects of Favourable Conservation Status (Range, Extent, Structure, Function, Typical Species, Future Prospects (e.g. security of management))[48]. As the site's conservation objectives allow for natural change, the performance indicators incorporate, as far as possible, the need to determine the cause of change (rather than relying on ineffective retrospective investigatory studies once a feature is determined to be unfavourable).

Keeping conservation objectives and performance indicators separate allows the conservation objectives to act effectively in guiding delivery of Article 6(1), 6(2) and 6(3) of the Habitats Directive, and not be limited to the achievement of monitored attributes and targets. Judgements about whether or not the conservation objectives are being met are supported by use of all available and relevant information sources, including: the results of the monitoring of feature condition, casework records, third party data, general contextual information and knowledge about the security and suitability of management.

Similarly to NE, NRW considers habitat species composition (species present and their abundance) to be the single most useful CSM attribute, despite this being a discretionary attribute (see Table 10). NRW is unable to effectively measure and assess several of the key mandatory CSM attributes on a six-year cycle due to logistical difficulties and costs required to deliver meaningful results, e.g. overall habitat extent (reef), distribution of biotopes (reef), biotope richness (all except lagoons). NRW considers that some of these attributes may remain impracticable indefinitely.

For more information on the CSM attributes which NRW found more practical to measure and useful in defining feature and/or sub-feature condition see Table 10.

[48] As described in the guidelines for Article 17 reporting under the *Habitats Directive* (Evans & Arvela 2011).

Table 10. CSM attributes found by NRW to be most and least useful and practical to measure per interest feature. Mandatory attributes are labelled with an 'M' and discretionary attributes are labelled with a 'D'.

Marine interest feature	Most useful attributes & why	Less useful attributes and why
Littoral rock and inshore sublittoral rock	**Extent** (subtidal, restricted) **(M)** – Important. Good for examples of restricted extent (e.g. biogenic reef) where costs and logistics (e.g. sidescan) are feasible and risk level makes it worthwhile. **Extent of sub-features/notable biotopes (D)** – Useful and practical for distinct biotopes/communities of limited extent e.g. Kelp forest (we don't do it as it's too widespread), *Sabellaria alveolata, Modiolus modiolus* (see above). **Species composition of representative or notable biotopes (D)** – Important. Moderately possible to accomplish, but expensive (diving). Data is quantitative and moderately precise, though sampling consistency requires strong controls. Data relatively easy to analyse. Multivariate analysis is sensitive to small changes and enables complex queries that can help determine cause of change. Limited number of stations means it's better for identifying wider impacts (e.g. water quality, climate change *etc*) rather than localised impacts. Typically requires fixed stations in order to minimise confounding effects of spatial heterogeneity when analysing for temporal changes. Can also be used to ground truth broader, remote sensed video/acoustic data and results applied at the remote sensed scale. **Presence and/or abundance of specified species (D)** – Useful for dominant/key/structuring species at different levels in the food chain. E.g. kelp, echinoderms, large crustacea, fish. Where changes to the abundance of these is likely to affect, or be the consequence of, significant changes in the ecosystem. Useful also for species that may indicate specific changes (e.g. temp). Currently, other than several species covered within Skomer MNR (e.g. *Eunicella* sp*, Pentapora* sp), we cover *Halidrys siliquosa* (Sarn reefs), *Parazooanthus axinellae*, *Modiolus modiolus*, *Sabellaria alveolata*. Note that for some sessile species this attribute can also be effectively covered by 'biotope species composition' (above).	**Extent** (intertidal) **(M)** – Only useful to monitor extent if it responds to a pressure. I.e. it only really works by identifying losses through developments e.g. from casework records or aerial imagery. Can't otherwise practically measure it (cost and trouble defining the seaward edge) nor easily distinguish between natural and anthropogenic changes. **Extent** (subtidal, general) **(M)** – Important. Overly expensive in most cases (acoustics, multibeam) and repeats are unlikely in a useful timeframe. **Biotope composition & distribution (M)** – Species community analysis is more sensitive to change. Trials, to cover a greater area than what can be afforded for species community analysis, have not proved particularly successful (power). Can be practical at a small scale (e.g. 50m x 50m) to map habitat/biotope, but value questionable. Used primarily by NRW to identify areas for algal richness monitoring, but some biotope composition and extent data gathered as a consequence (see NRW diving SOPs 8 & 9). Community composition data gathered at fixed station sites can be used to assess localised biotope change. **Presence of representative/notable biotopes (D)** – None are rare and at risk in Wales to make this worthwhile. NRW did undertake this for a period for several uncommon intertidal habitats - but value/cost ratio was not beneficial.

Littoral sediment flats (mud\sand flats)	**Extent of sub-feature or representative/notable biotopes (D)** – Works for some only. Generally those easy to distinguish from adjacent biotopes without excessive point sampling and lab analysis. E.g. *Zostera*. **Species composition of representative or notable biotopes (D)** – Easy to accomplish. Data is quantitative and relatively precise, and sampling is consistent. Data relatively easy to analyse. Multivariate analysis is sensitive to small changes. **Species population measures (D):** ***Population structure of a species*** (other sediments, age/size class) – Large/long-lived species can usefully be covered (e.g. *Ensis* spp, cockles, *Alitta virens*), generally less logistical problems with effective sampling than for subtidal (e.g. could dig/rake over a large area). ***Species Abundance*** – Very useful particularly when combined to form community multivariate data. Enables a wide variety of analyses and greatest potential for determining cause of change. ***Biomass*** – Useful, particularly when combined to form community multivariate data, particularly useful when combined with abundance (AB curves, mean mass, *etc*). **Sediment character: sediment type (M)** (representative locations) – Important and simple to sample and analyse. Quantitative nature of data enables precise analysis and identification of small changes. **Sediment character: oxidation-reduction profile (Redox layer) (D)** – Has potential for certain obvious impacts. Has had value for investigative work. Not a top liner.	**Extent (M)** – Only really works by identifying losses through developments e.g. from casework records or aerial imagery. Can't otherwise practically measure it (cost and trouble defining the seaward edge) nor easily distinguish between natural and anthropogenic changes. **Extent of sub-feature or representative/notable biotopes (D)** – As above. Works for some only (see left column). Otherwise costly and hard to accomplish with a useful level of precision. If we had a particularly notable biotope we would probably ensure that it was sampled for community composition, but generally not extent. **Distribution of biotopes (M)** – Would require a lot of expensive sampling and analysis. *In-situ* sampling less expensive. Still do not have an effective method that works well. Not regarded as a sensitive attribute, gross changes only. **Biotope composition (M)** – Very coarse measure of change (lots of reasons). Expensive if covering whole feature. Other measures are more sensitive to impacts that would result in this (i.e. species composition). Doesn't particularly help to distinguish natural from anthropogenic causes of observed change. **Presence or abundance of specified species (D)** – No important and sensitive species identified for which this would be relevant and the species specific effort worth the expense. May change. May work with invasive non-natives. **Sediment character: sediment type (M)** (change in distribution across whole feature) – Too costly. **Sediment character: organic carbon content (D)** – Uncertain as yet. Have just started analysing for organic carbon and nutrients within some intertidal grab samples in excessive macroalgae problem areas. **Topography (D)** – Important, but expensive to cover the entire feature (LIDAR, laser scanning). May get covered in the long-term, currently just use anecdotal observations and casework.

Inshore sublittoral sediment (sandbanks)	**Extent of sub-feature or representative/notable biotopes (D)** – Works for some only. Generally those easy to distinguish from adjacent biotopes without excessive point sampling and lab analysis. E.g. *Zostera*, maerl. **Species composition of representative/notable biotopes (D)** – Easy to accomplish. Data is quantitative and relatively precise, and sampling is consistent. Data relatively easy to analyse. Multivariate analysis is sensitive to small changes. **Species population measures (D):** ***Population structure of a species*** (other sediments, age/size class) – Long-lived species could usefully be covered (e.g. molluscs) but there are logistical problems with effective sampling of large infauna (try anchor dredge, hydraulic dredge perhaps?). However, attribute works great for scallops – could work for similar large epibenthic species (oysters, seapens?). ***Species Abundance*** – Very useful particularly when combined to form community multivariate data. Enables a wide variety of analyses and greatest potential for determining cause of change. ***Biomass*** – Very useful particularly when combined to form community multivariate data, particularly useful when combined with abundance (AB curves, mean mass, *etc*). **Sediment character: sediment type (M)** (representative locations) – Important and simple to sample and analyse. Quantitative nature of data enables precise analysis and identification of small changes.	**Extent** (sandbanks) **(M)** – Important attribute, but costly to measure (acoustics) to a useful level of precision (multibeam). **Extent of sub-feature or representative/notable biotopes (D)** – As above. If we had a particularly notable biotope we would probably ensure that it was sampled for community composition, but not extent unless it was practical (see left). **Distribution of biotopes (M)** – Would require a lot of expensive sampling and analysis. Not regarded as a sensitive attribute. **Presence or abundance of specified species (D)** – No important and sensitive species identified for which this would be relevant and the species specific effort worth the expense. May change. May work with invasive non-natives. **Species population measures (D)** (sandbanks, age/size class) – Not seen as a sensitive indicator for Welsh sandbanks (no relevant species other than fish really). **Sediment character: sediment type (M)** (change in distribution across whole feature) – Too costly. **Topography (M)** – Important but costly to measure to a useful level of precision (multibeam). Sidescan is OK for visual, but less measurable parameters.
Sea Caves[46]	**Extent of cave(s) (D)** – Workable when identifying obvious losses through casework records (e.g. engineering works to reduce coastal erosion and protect national infrastructure). **Numbers of caves in site (D)** – Workable when identifying obvious losses through casework records (e.g. engineering works to reduce coastal erosion and protect national infrastructure).	**Summary:** Overall, most of the cave attributes – and cave monitoring in general – are not practicable due to resource requirements and logistics. In light of the low risk, it's simpler to look at the bigger picture of cave damage/loss through casework and use condition of adjacent monitored features as a proxy to cover wider anthropogenic influences. If it were practicable we would probably focus on species/community composition and abundance for the caves perceived to be at highest risk, as for other habitats. **Extent of cave(s) (D)** – Impracticable to measure other than for a very few caves. Resource intensive, with significant inaccuracy, particularly

		underwater. Potential for laser scanning techniques to improve this above water – but still a lot of work for little gain. **Numbers of caves in site (D)** – Impracticable to count them all. Intertidal caves could be counted but this would take too many resources particularly for repeats. Subtidally, far trickier as we don't know where they all are. **Biotope composition of a cave (D)** – Impractical to provide a representative level of monitoring (too many caves) though some very limited baseline data has been gathered. **Presence of representative/notable biotopes (D)** – Impractical to provide a representative level of monitoring (too many caves) though some very limited baseline data has been gathered. **Species composition of representative or notable biotopes (D)** – Impractical to provide a representative level of monitoring (too many caves) though some very limited baseline data has been gathered. **Presence and/or abundance of specified species (D)** – Impractical to provide a representative level of monitoring (too many caves) though some very limited baseline data has been gathered for species such as *Palludinella litorina*.
Estuaries	**Extent (M)** – Achieved by identifying areas of anthropogenic loss from casework or remote sensing (aerial imagery) rather than measuring the actual area against a target value. The development of less obvious non-natural changes is covered by reference to changes in other indicators. **Distribution/spatial pattern of habitats** (Intertidal) **(M)** – Limited infaunal sampling of representative/notable habitats provides good data to support this attribute but lacks the spatial coverage. Could improve by more formally combining with aerial imagery (gross changes), i.e. a variant on remote sensing with ground truthing. Casework records with the quantitative infaunal sampling provide the primary useful data.	**Distribution/spatial pattern of habitats** (Intertidal) **(M)** – Monitoring for this has not worked well for us. It takes a lot of effort for a relatively poor spatial resolution (grids or transects with *in situ* infaunal sampling). Hard to detect changes unless they are large, hard to separate natural and non-natural change without further investigatory work due to the coarser level of data gathered (to enable the wide spatial coverage). We tend to get more useful data from a limited range of sampling stations within representative/notable habitats and then looking at them in more detail (change in community composition & biomass). **Distribution/spatial pattern of habitats** (subtidal) **(M)** – Several estuaries are remote from a safe haven and largely drying at low tide. Subtidal sediment sampling is logistically difficult and not carried out in these locations.

	Distribution/spatial pattern of habitats (subtidal) **(M)** – Whilst only some of our estuaries are sampled subtidally (four with a good degree of open water at low tide) these have a reasonable spatial cover of infaunal grab sampling. This provides excellent data for assessing this and other attributes. **Salinity (M)** – Long-term trends are of use in detecting significant long-term changes, but need to determine best aggregation method (i.e. annual average, number of peak days above or below value x, mean by month *etc*). Targeted use in locations where anthropogenic change is predicted/noted (e.g. new developments) has been of use. **Water Quality (M)** – Useful. Easy to record. Supplies data for multiple drivers (e.g. WFD). EQS provide evidence based targets/thresholds. **Other Attributes** – Those 'useful' attributes of other encompassed features are also used and may form the majority contribution to an Estuaries CSM assessment (e.g. those shown for Inshore sublittoral sediment (sandbanks), Littoral sediment flats (mud\sand flats), and Littoral rock and inshore sublittoral rock).	**Salinity (M)** – Relatively easy to record, but the limited spatial replication, the large volumes of data, and determining a meaningful approach to analysis have limited the usefulness of monitoring data. Short term use in targeted locations (where anthropogenic change is predicted or noted) has greater value. **Morphological equilibrium (D)** – Not currently monitored.
Inlets and Bays[47]	**Extent (M)** – Small, distinct, high value or high risk sub features can be covered this way (e.g. seagrass, biogenic reefs). Otherwise, achieved by identifying areas of anthropogenic loss from casework or remote sensing (aerial imagery) rather than measuring the actual area against a target value. The development of less obvious non-natural changes is covered by reference to changes in other indicators. **Diversity of component habitats (M)** & **Distribution/spatial pattern of habitats (M)** – A limited degree of wider spatial coverage sampling is undertaken and this provides good data but replication and therefore power to detect change is lowered. These attributes are therefore covered indirectly by repeat community recording at selected stations. In some but not all cases (due to limited resources) the stations cover a representative suite of the habitats present (though with low replication). Analysis focuses on changes to community and species parameters and thus outputs inform changes in habitat diversity and spatial pattern.	**Extent (M)** – Cannot practically measure extent for the whole feature and compare against a target value. More effective to log and to seek anthropogenic losses (e.g. via casework). **Diversity of component habitats (M)** & **Distribution/spatial pattern of habitats (M)** – Not directly measured or assessed. Not all habitats can be covered or covered well (cost).

	Water quality (M) – Useful. Easy to record. We gather both sediment and water quality data. Supplies data for multiple drivers (e.g. WFD). EQS provide evidence based targets/thresholds. **Other attributes** – Those 'useful' attributes of other encompassed features are also used and may form the majority contribution to an 'Inlets & Bays' CSM assessment (e.g. those shown for Inshore sublittoral sediment (sandbanks), Littoral sediment flats (mud\sand flats), and Littoral rock and inshore sublittoral rock).	
Lagoons	**Extent of basin (M)** – Important and relatively easy to record though state of tide and level of rainfall need to be accounted for. **Extent of water (D)** – Gives a clear indication of a barrier problem. Welsh lagoons are shallow and small water depth changes show as big extent changes. Only conduct repeated monitoring of this. **Species composition of representative or notable biotopes (D)** – Important. Easy to accomplish. Data is quantitative and relatively precise, and sampling is consistent. Data relatively easy to analyse. Multivariate analysis is sensitive to small changes. **Species population measures: population structure of a species (D)** – Only do for *Cerastoderma glaucum.* Simple to sample (set effort, net sweeps) and gives easy to interpret results, abundance and size/year class. **Species population measures (M)** (i.e. barrier status) – Important and easy to monitor. **Salinity regime (M)** – Important and easy to monitor. But hard to set targets for the fluctuating values. Useful to have pressure and temperature recorded simultaneously as clarifies influence of seawater and freshwater inundation and draining regimes.	**Extent of sub-feature or representative/notable biotopes (D)** – We don't have any. **Biotope composition (M)** – Doesn't tell a lot about the condition unless it's disastrously affected. Requires a lot of sampling in small sensitive lagoons (NRW lagoons would probably only have one biotope). **Distribution of biotopes (D)** – Lack of biotopes means lagoon extent probably = biotope extent. Would require a lot of sampling in small sensitive lagoons. **Species population measures: Presence or abundance of specified species (D)** – Important for lagoon specialists, but logistically tricky. Tend to sample some destructively and hard to avoid trampling the feature during searches. Hit and miss presence even with high effort searches means that confidence of absence is typically low. **Water depth (D)** – Perhaps easy to monitor with a stick or post, better with a logger, but we find the small depth changes are not suited to the loggers level of precision (cm). Data is useful, but perhaps not great from a monitoring point of view.

Scotland

SNH has generally collected data on CSM mandatory and discretionary attributes and other additional indicators (depending on the site and the habitat) on their broadscale mapping surveys and/or initial monitoring surveys. The CSM attributes that SNH found most useful to date are attributes which relate to specific sub-features/biotopes, such as seagrass beds or mussel beds, as they are more targeted and discrete as well as spatially distinct.

Table 11. CSM attributes found by SNH to be most and least useful and practical to measure per interest feature. Mandatory attributes are labelled with an 'M' and discretionary attributes are labelled with a 'D'.

Marine interest feature	Most useful attributes and why	Least useful attributes and why
Littoral rock and inshore sublittoral rock	**Extent** (biogenic reef habitats/friable reef/sub-features) **(D)** – A valid attribute for monitoring the status of biogenic reef habitats and potentially other sub-features. **Biotope composition** (& **Distribution of biotopes**) **(M)** - Allows for assessment of general site character/status at a coarse resolution (insensitive attribute) with basic comparisons between sampling events (in terms of inventory/nos. of biotopes recorded and their geographic distribution). In the absence of a detailed understanding of activities taking place within sites or where there are limited concerns about anthropogenic pressures (whether due to active management or not) such sampling may be sufficient for assessment purposes. However, the resultant data in isolation will not yield information about changes in the qualities of the habitats (more subtle shifts in condition that require community/species composition analyses). May be measured within 'parts' of a site depending upon feature scale. **Species composition of representative or notable biotopes (D)** - Finer resolution biological community attributes provide an insight into the health/condition of specified biotopes. Applicable to component biotopes of biogenic reef habitats (incl. abundance of characterising species). However, the work is time consuming and expensive (especially in the subtidal if divers are used). Detailed information collected from small areas within often very extensive areas, so carefully targeted application required within other representative or notable biotopes and sampling design should be informed by activities info. May be linked to *Presence and/or abundance of specified species* attribute. **Other physical and environmental parameters** - an understanding of local hydrographic conditions and effects on sedimentation; site exposure and associated meteorological conditions; and aspects of	**Extent** (non-friable bedrock and stony reefs - whole feature) **(M)** – It is important to determine the extent of the feature and its distribution across a site at the outset. However, this is likely to have been undertaken as part of the initial case for designation/inventory mapping to inform future management needs. Reef SAC features often cover extensive areas and the basic extent attribute would be an expensive and rather uninformative attribute for condition monitoring purposes. Targeted site-specific application of finer resolution attributes considered more useful. **Spatial arrangement of biotopes at specified locations (M)** - Monitoring the spatial pattern of biotopes (e.g. zonation down a shore/ diver transect or juxtaposition across a shore in relation to a mapping event) allows you to gain some insights into the scale of cyclical change over time but more detailed sampling (e.g. community-level/species composition attributes) would be required to ascertain the significance of any shifts (e.g. between biotopes) and additional information would be needed to place the changes into context. **Presence and/or abundance of specified species (D)** - Population measures for specified species may be appropriate in some instances (including the presence/absence of invasive non-native species; species to indicate climate change e.g. MarClim protocols *etc* in a subset of the sites to give a network perspective on these issues) and may represent a more rapid/ cost effective approach than full species composition sampling. However, the role of indicator species to inform on reef health as part of condition monitoring in Scottish SACs needs further investigation (see conclusions of Moore *et al* (2006b) where the density of anthozoans and axinellid sponges were recorded on diver transects).

	water quality (nutrient inputs, water clarity *etc*), may be needed to put unexpected changes in other attributes into context (see Perry, 2010). Not routinely collected.	
Littoral sediment flats (mud\sand flats)	**Extent of sub-features or representative/notable biotopes (D)** - Appropriate for seagrass/blue mussel beds *etc*. **Species composition of representative or notable biotopes** (incl. those of sub-features) **(D)** - Finer resolution biological community analyses provide an insight into the health/condition of specified biotopes. Targets need to avoid adherence to specified biotope names (so if tags change this isn't automatically seen as a problem) and look at the significance of changes in characterising species (and associated diversity metrics *etc*) as to whether indicative of habitat degradation. Linked to sediment character analyses. **Species population measures (D)** - Likely to be linked to sampling undertaken in relation to the species composition attribute of specified biotopes attribute but with targets set in relation to the continued presence or abundance of positive indicator species at sampling stations (e.g. *Cerastoderma edule*, *Arenicola marina*, *Hediste diversicolor*). Seagrass density/cover. Presence and abundance of invasive non-native species noted. **Sediment character: Sediment type (M)** - Detailed PSA analyses needed to provide context for any core samples but *in-situ* sediment characterisation suitable for dig-overs. Should be undertaken but can vary significantly within perceived natural change so not particularly sensitive. **Other physical and environmental parameters** - Presence of algal mats should be noted. Contaminants information not routinely collected but such work might be triggered if concerns were identified in other attributes.	**Extent** (of whole feature) **(M)** - Important to determine this initially (as part of designation/inventory mapping *etc*). May be interesting to repeat occasionally or if concerns are raised about major changes but should not be a mandatory attribute. **Biotope composition** (& **Distribution of biotopes**) **(M)** - As for reefs but with potentially greater spatial and temporal variability. Attribute allows for a coarse resolution assessment of site character and comparisons between previous sampling events (which may include mapping surveys - in terms of inventory/nos. of biotopes recorded and their geographic distribution). Depending upon sampling approaches (e.g. stations along pre-determined transects down the shore) information on these attributes may be collected for 'parts' of a site only and be accompanied by more detailed species composition analyses. **Sediment character: oxidation-reduction profile (Redox layer) (D)** - Attribute is routinely sampled to provide additional context when collecting cores for species composition analyses/dig overs for determining the presence of specified species but depth of layer can vary quite widely so not particularly informative in isolation (but data collection is rapid and should still be undertaken). **Sediment character: organic carbon content (D)** - not undertaken routinely. **Topography (D)** - We have been doing this along shore transects but change detection capability of this method is probably quite coarse and alternative full coverage remote sensing prohibitively expensive/ unnecessary at all individual sites. Appropriate to look at national coastal change signals from studies using LiDAR *etc* and great if discussions can lead to protected areas with sediment flats features being included in wider monitoring networks *etc*.

Inshore sublittoral sediment (sandbanks) Inshore sublittoral sediment (sandbanks)	**Extent** (sub-features) **(D)** - Appropriate for some sub-features. Precision may vary between features and sites depending upon applicable methods (e.g. drop-video rather than acoustic methods to assess extent of 15m+ maerl beds vs. remote aerial techniques for <10m seagrass beds on west coast). **Species composition of representative or notable biotopes (D)** - (incl. those of sub-features) - As for littoral sediment habitats - finer resolution biological community analyses provide an important insight into the health/condition of specified biotopes. Quantitative data amendable to multivariate statistical analyses. Sampling likely to be targeted as analysis costs not insignificant. Linked to sediment character parameters (see below). **Species population measures (D)** - Cover of live maerl; seagrass shoot density *etc*. Attribute may have a more significant role to play for other subtidal sedimentary habitats in new MPAs (e.g. seapen or fireworks anemone abundance in burrowed mud habitats *etc*). Future sampling might encompass fish species (e.g. sandeels) in some areas. **Sediment character: sediment type (M)** - Detailed PSA analyses undertaken to provide context for grab or diver core samples. Temporal changes and spatially variable sediments (where heterogeneous seabed sediments combine with lower precision sampling compared to repeat transects on shore sediment flats) so attribute data not used in isolation.	**Extent** (whole feature) **(M)** - As for reefs. Important to have indicative 'whole feature' extent and distribution information to guide casework response/management advice. Subsequent monitoring of extent is unrealistic and not necessary. **Biotope composition** (& **Distribution of biotopes - M**) - Useful initially (in mapping context to inform management) and for occasional or coarse resolution 'checking' (insensitive attribute). Unlikely to inform on the qualities of the sandbank habitats in isolation. Requirement for infaunal sampling (full analyses or 'kick-over' on deck) to aid biotope assignment make feature-wide application potentially prohibitively expensive for limited return (compared to coarser resolution remote video sampling used to guide reef biotope assignments). Biotope information therefore likely to be derived from finer resolution targeted species composition sampling in discrete areas/biotopes and the finer resolution data are more useful in monitoring context. **Topography (M)** - Explored at discrete repeat monitoring stations (DDV and grab sampling) - relatively coarse resolution but fit for purpose (see Moore *et al* 2015). Do not envisage repeat bathymetric surveys to derive this information.

Sea Caves[46]	**<u>Moderately</u> useful attributes and why** *An initial detailed SCM exercise should be undertaken on a selection of caves within a site. After that, due to the robust and dynamic nature of the caves and lack of perceived anthropogenic threats in most sites in Scottish waters, monitoring would likely to be restricted to 'Site Check' type rapid assessments using visual reference materials for previously monitored and readily accessible partially submerged sea caves only. Information on submerged sea caves would be collected from recreational diving community where practicable. Beyond this, subsequent monitoring of submerged sea caves would be responsive investigative work triggered by concerns about anthropogenic impacts (development casework* etc*).* **Number of caves in site (D)** - Useful context to inform casework advice provision and to inform the selection of sites for initial application of any finer resolution attributes but not one for regular monitoring. **Extent of cave(s) (D)** - Established for a small number of caves within a site as part of an initial (baseline) SCM exercise using appropriate mapping techniques where practicable to do so. Subsequent assessments would not require repeat extent mapping but might compare imagery (e.g. of the cave entrance between visits looking for gross change). **Biotope composition of a cave (D)** & **Presence of representative/notable biotopes (D)** & **Species composition of representative or notable biotopes (D)** - Cave biotopes area poorly defined but descriptive text supported by site-specific imagery is probably sufficient in many cases for film/crust dominated habitats. Surge gully/cave entrance biotopes more readily ascribed. Working within these limitations, the biotope composition within subset of caves should be established during an initial SCM exercise from a series of sampling stations along a relocatable transect. Surveyor observations supplemented by still images and video footage to determine presence and species composition of representative or notable biotopes. *Site Check* rapid assessments or future detailed investigative monitoring would be based on change against initial observations on these finer resolution attributes but not monitored routinely. **Other** - Awareness of regional coastal erosion status/susceptibility and notable storm events/impacts *etc* - to inform assessment process where available but information collection not being driven by marine SCM interests.

Estuaries	*(Use of attributes reflects application for component Annex I features)* **Extent (M)** (sub-features) **Species composition of representative or notable biotopes** (incl. those of sub-features) **Sediment character: sediment type** **Species population measures** - Could usefully also encompass migratory fish and bird species. Not undertaken at present.	**Extent (M)** (whole feature) - At outset as for other Annex I habitats to inform site management decisions but area not determined on routine basis. Potential for remote sensing data of whole or parts of site to be collected to provide context for other finer resolution attributes/ assessment of component features (e.g. to put changes in habitat distribution/species composition of biotopes into context if sediment flats/ sand bars migrate *etc*). However, casework to inform on possible changes to extent value. **Distribution/spatial pattern of habitats (M)** [akin to **Biotope composition** (& **Distribution of biotopes**)] – coarse resolution information may be collected on an ongoing basis as part of remote sensing work to put finer resolution attribute information (at sub-feature/ notable biotope level) into context. **Salinity (M)** - We would not undertake routine monitoring of salinity levels within an estuary but would want to take salinity gradients into account in terms of monitoring programme design. Information at this coarse indicative level already exists for Scottish estuary SACs. **Water quality (M)** [& **other physical and environmental parameters**] - Water quality and chemistry data from other sources could be useful context but we would look to others e.g. SEPA for these data and they may not be being routinely assessed within all estuary SACs. SNH could collect the same water quality/chemistry parameters in any additional locations but not undertaken at present. **Morphological equilibrium (D)** - Not explored to date. Not required where there is a lack of anthropogenic impact on the equilibrium of the estuary (such as land reclamation). Interested in the conclusions of NE work on this topic.

Inlets and Bays[47]	(*Use of attributes reflects application for reefs and / or subtidal sandbanks features)* **Extent** (sub-features) **Species composition of representative or notable biotopes** (incl. those of sub-features) **Sediment character: sediment type** **Species population measures** - As for subtidal sandbanks and more relevant to seapens in mud biotopes in some SACs. **Water quality (M)** [& **other physical and environmental parameters**] - as for reefs - not routinely undertaken but likely to be sought where concerns in other attributes arise.	**Extent of entire feature (M)** **Diversity of component habitats (M)** & **Distribution/spatial pattern of habitats (M)** [akin to **Biotope composition** (& **Distribution of biotopes**)]
Lagoons	**Isolating barrier - presence and nature (M)** - Fundamental requirement, site-specific and easy to monitor. **Salinity regime (M)** - Important but not feasible to undertake on an ongoing basis in all sites. Loggers will be used to improve our understanding of variation in salinity throughout the year in a selection of geographically distributed subset sites that will be undertaken to hopefully provide an insight into possible effects of climate change (e.g. salinity increases across series in relation to sea level rise). **Species population measures**: **presence or abundance of specified species (D)** - Sampling undertaken to determine the presence and abundance of marine algae and invertebrates at seaward end of lagoon basin (charting ingress of marine species which may outcompete near-relative lagoon specialists - incl. salinity may give competitive edge) and of brackish algae and invertebrates present in the main basin. Draft list of eight lagoonal indicator species for Scottish lagoons. Any targets allow for heterogeneity of occurrence e.g. failure to record *Tolypella* on three separate occasions might trigger water chemistry analyses (see below). Status of any invasive non-native species must be assessed and	**Extent of basin (M)** - Important to have indicative 'whole feature' extent and distribution information to guide casework responses/management advice. Subsequent monitoring of extent is not necessary (primarily rock basins on west coast and changes to sediment barriers in Northern Isles would be picked up via application of finer resolution attributes). **Biotope composition (M)** - Lagoonal biotopes poorly defined. Occurrence of characterising species highly temporally and spatially variable across lagoons making this attribute inappropriate/insensitive in a monitoring context. **Extent of sub-feature or representative/notable biotopes (D)** - Not pursuing a biotope approach to lagoon monitoring. **Extent of water (D)** - Not clear on the value of this one at this stage. Scottish lagoon systems do not dry out and none go hypersaline as far as we are aware so do not feel that measuring this highly variable attribute on a repeat basis would be beneficial in addition to metrics currently proposed. **Distribution of biotopes (D)** - Not pursuing a biotope approach to lagoon monitoring - can have large annual/temporal variations across a site.

	reported. **Other physical and environmental parameters** - Qualitative assessment of surrounding land use (greener fields, empty fertiliser bags observed *etc*) and water column status (algal blooms *etc*) supported by photography. Concerns would trigger more detailed water sample collection for chemical analyses.	**Species composition of representative or notable biotopes (D)** - Not taking a biotope approach and focusing on the presence/abundance of specified species (other column). Variable nature of species occurrence and distribution and likely frequency of sampling would make 'composition' metrics challenging compared to presence/abundance. **Species population measures: population structure of a species (D)** - Could be undertaken for species such as *Cerastoderma glaucum* but species has a highly variable 'appearance' and distribution (reasons unknown but an absence at good sites does not necessarily mean there is a concern and the species can appear again in high numbers on other occasions). **Water depth (D)** - Can be measured and gaining in insight over an annual cycle provides interesting context for site series but due to significant variation in water levels not considered a useful monitoring attribute.

3.4.1 Conclusions

CSM

- Generally, all CNCBs collect data on mandatory and discretionary CSM attributes, as well as on other indicators, and use these data to inform their habitat condition assessments.

- CNCBs have found some CSM attributes very difficult and costly to measure (e.g. extent, topography, morphological equilibrium) and do not think their measurement is always achievable or necessary every six years.

- Several of the CSM attributes (if monitored) are not particularly sensitive to detecting change. Future CSM development should focus on identifying attributes that are sensitive to anthropogenic impacts to allow for the differentiation between natural and anthropogenic influenced change to be made.

- Overall, the CNCBs have developed their knowledge around what attributes may be more practical to measure and helpful in understanding habitat condition.

3.4.2 Recommendations

- Maintain an overview of the ongoing seabed habitat indicator development work being undertaken by individual CNCBs that falls outside of the HBDSEG-led/coordinated process for developing seabed habitat indicators for MSFD. (A.2).

- Develop updated guidance on seabed habitat attributes to measure (including state, pressure and impact indicators) taking into account existing performance indicators and other metrics used by the CNCBs and relevant HBDSEG partners, the evolving MSFD indicators, and habitat conceptual ecological models (CEMs) (A.3).

- Further develop, using existing datasets, those attributes used by the CNCBs for seabed habitats that can detect impacts known to be occurring. Where applicable, take into account the work done under WFD and MSFD (A.4).

3.5 Indicator targets/thresholds

According to CSM Guidance, a target is intended to reflect the desired condition of the attribute for a feature on a designated site (JNCC 2004b). In addition, targets can also be expressed in terms of the desired limits for levels of impact on biodiversity and for the desired limits for levels of pressure on biodiversity (OSPAR Commission 2012). Approaches to setting targets include those outlined by the OSPAR Commission (2012):

1. Directional or trend-based targets
    a. direction and rate of change
    b. direction of change only
2. Targets set as the baseline
3. Targets set as a deviation from a baseline

According to the OSPAR Commission (2012), state targets for seabed habitats should ideally be defined as a deviation from a baseline (target-setting method 3), with that baseline set as reference state. This is considered to be the most scientifically robust approach, and one that aims for a target level of recovery of destroyed and/or impacted features in line with prevailing physiographic, geographic and climatic conditions. The specific state targets

which are set should account for the natural variability of the habitat and its potential for recovery (JNCC 2004b; OSPAR Commission 2012).

Favourable Conservation Status (FCS), the overall aim of the Habitats Directive, can be described as a situation where a habitat type or species is prospering (in both quality and extent/population) and with good prospects to do so in the future. The target of the Directive is set out in positive terms, oriented towards a favourable situation, which needs to be defined, reached and maintained. As a result, targets for SAC features should be set to ensure that habitats and species populations are maintained in, or restored to, a condition which is likely to be sustained over the foreseeable future, in line with the principles of FCS as defined in Articles 1(e) and 1(i) of the Habitats Directive (JNCC 2004a).

CSM Guidance for marine features recognises that for many marine attributes, there are insufficient data to establish unambiguous target conditions (JNCC 2004b).

Most of the targets set by the CNCBs to date have been set initially as the 'current state' baseline (target-setting method 2) with the aim of preventing any further deterioration from current state[49]; or as directional trend-based targets (target-setting method 1.b), which encourage an improvement towards a more desirable state (see Figure 6). The latter approach is relatively practical and straightforward and it does not require a great deal of historical data. Its weakness lies in the fact that it doesn't allow for clear assessments of condition because no end point is specified (OSPAR Commission 2012). It also does not allow for a clear assessment of whether favourable condition has been achieved, because a slight improvement in trend might be seen as 'meeting the target', but it might still be very far off from reaching favourable condition. Depending on the state of development of the indicator and data availability, this could be overcome by expressing an improving trend up to a defined limit (e.g. the carrying capacity of a species) and then an acceptable deviation from this higher limit (OSPAR Commission 2012).

Northern Ireland
DAERA sets its targets as a deviation from the baseline, where the target level of recovery of destroyed and/or impacted features is in line with prevailing physiographic, geographic and climatic conditions accounting for the habitat's natural variability and recovery potential. As such it is often difficult to set numerical targets at an early stage as the prevailing conditions, natural variability and levels of potential for recovery may only be apparent over time once management measures have been put in place together with appropriate monitoring of the effectiveness of those measures and of the other relevant variables.

England
In the past, most of the attribute targets set by NE were qualitative, i.e. 'attribute x should not deviate significantly from an established baseline, subject to natural change (baselines to be established during the first reporting cycle)'. Sites designated in or after 2010 generally benefited from more detailed targets due to better biological and physical information, i.e. the targets set were site specific and more directional. Nonetheless there is still a lack of complete and robust baseline data for all attributes and a lack of understanding of the scale of natural variation to be able to set meaningful targets for all MPA habitats. This shortfall coupled with the limited availability of monitoring data, meant that in the last Article 17 reporting round (2007-2012) NE was not able to consistently assess habitat attributes against precise targets, resulting in a significant amount of 'not assessed' or low confidence assessments.

[49] I.e. state at the time of the introduction of an environmental directive/policy, or the first assessment of state.

Wales
NRW applies a mixture of qualitative, quantitative and logical (yes/no) targets to describe the desired condition of the attributes of its MPA habitat features, also known as Performance Indicators. Examples of quantitative targets applied by NRW are the Environmental Quality Standards (EQS) used for water contaminants and nutrients, and the Infaunal Quality Index (IQI) used to describe changes in the benthic invertebrate community in response to anthropogenic pressures[50], both used under WFD. Qualitative targets used by NRW include various trend analyses, and logical targets include scoring a 'no' for something like 'new debris discarded from civil engineering operations' or 'long-term increase in quantity of anthropogenic debris recorded in caves'.

Scotland
SNH starts by applying qualitative attribute targets, i.e. 'no change from established baseline taking into account natural change'; and as their knowledge-base improves for specific site features these targets are refined. For example, 'no increase in the abundance of *Heterosiphonia japonica* along the three transects'. Similarly to NE, SNH recognises the majority of targets are poorly specified due to incomplete, poor or absent baseline data and a lack of understanding of natural variation.

Table 12. Different types of targets used by the CNCBs.

CNCB	Directional or trend-based targets	Targets set as the baseline	Target set as a deviation from a baseline
DAERA	-	-	✓
NE	✓	✓	-
NRW	✓	✓	✓
SNH	✓	✓	✓

3.5.1 Conclusions

CSM

- Most of the targets set by the CNCBs to date have been set initially as the 'current state' baseline with the aim of preventing any further deterioration from current state, or as directional trend-based targets, which encourage an improvement towards a more desirable state.

- Overall, the CNCBs experience difficulties in setting targets which allow for natural variation whilst flagging anthropogenic deterioration.

- Some of the targets used by the CNCBs are poorly specified due to incomplete, poor quality or even absent baselines.

3.5.2 Recommendations

- See recommendation A.1 in section 3.2.

3.6 The process of assessing condition

CSM Guidance suggests that an interest feature should meet all mandatory attributes for it to be considered in favourable condition; this is the default-based approach to assessment (JNCC 2004a, 2004b). For features subject to dynamic natural processes, the guidance recognises that it may be appropriate to use a weighted approach based on expert

[50] Note that NRW uses the actual values and examines change over time rather then using the WFD 'good ecological status' categories.

judgement to determine each attribute's relative contribution to the overall assessment in relation to the specific conservation interest of a feature of a site (JNCC 2004b). The decision to use a weighted approach must be fully documented and include the relevant evidence that underpins the down-weighting of an attribute in relation to the conservation interest of the feature.

Since the formal adoption of the CSM approach in 1999[51], the CNCBs have only been through two complete six-year assessment cycles. This period has been characterised by an incomplete ecological understanding of marine biodiversity and ecological processes, and limited availability of monitoring data due to limited financial and staff resources. Assessments have, of necessity, been based on expert judgement, in some cases with limited empirical evidence of feature condition to back them up.

The sections below describe the process adopted by individual CNCBs to assess the condition of seabed habitats in MPAs between 1999 and 2013.

3.6.1 Who completes the assessments

All CNCBs assess the condition of their designated features in-house. However, when survey work is contracted out, contractors often provide a summary of key findings with respect to the attributes monitored and may provide provisional statements on what they mean for the condition of the seabed habitats and why.

3.6.2 What information is used

The CNCBs use a wide-range of evidence and information to assess habitat condition. These generally include:

- survey data (including data collected by third parties);
- environmental assessments, e.g. Environmental Impact Assessments (EIAs), WFD water body classification assessments;
- technical reports;
- primary scientific literature (e.g. findings of peer reviewed papers);
- human activities/pressures data;
- evidence of damage;
- habitat sensitivity information; and
- expert judgment.

3.6.3 How information is analysed

Northern Ireland
The assessments undertaken by DAERA to date have been mostly descriptive and driven by expert judgment. These make use of available evidence from rapid survey techniques, photographs, video and known pressures, rather than being a statistical result or calculated value against a formal 'indicator'. An example of this approach is the assessment of the Rathlin SAC reef feature in 2011, which concluded unfavourable condition (Goodwin *et al* 2011) based on repeat monitoring using MNCR Phase II type diving surveys. Comparisons were made of condition in 1984 to condition in 2009 (comparison of species lists, descriptions and photographs) as well as current evidence of pressures comparing sites clearly trawled (trawl scars and overturned boulders visible) to untrawled/unimpacted sites on the same dive (protected from fishing gear by their proximity to a wreck or steep boulder slope).

[51] Following a pilot year in 1998 (JNCC 2004a).

In contrast to this expert judgement approach, the work done in Strangford Lough on *Modiolus* beds, a type of Annex I reef under the Habitats Directive used data from the Strangford Lough *Modiolus* Restoration Research Project 2008-2011. It involved a series of different surveys, several of which were directly comparable to datasets dating back to 1977, allowing for an assessment of 'unfavourable – declining' to be made with some confidence. The 1977 surveys included quadrat samples giving densities of *Modiolus* and other species. These quadrats were repeated in 2003 and 2009/2010 allowing for statistical analysis and a high degree of confidence. Without this time series, including various surveys from 2003 onwards, the element of 'declining' would have been difficult to ascertain and the feature would have probably been assessed as 'unfavourable – no change' on the assumption that the ban on the use of mobile fishing gears in 2003 would have halted the decline. The continued decline of *Modiolus* beds after the cessation of mobile fishing gear was more subtle than the changes up to 2003 and could only be confirmed by statistically robust monitoring.

England
The assessments undertaken by NE involve both data analysis and expert judgement. NE considers monitoring results in the context of previous reports to look for any changes. Throughout the assessment process all available sources of information are evaluated to see if they can be used, and determine what weight they should be given in the assessment. Judgements are made initially for each attribute; all the data and reports used are cited and confidence in the judgement recorded. When no direct measurements are available NE may make use of information on sensitivity and exposure to pressures to assess feature vulnerability to these pressures. In such cases, the confidence in the assessment will be necessarily lower. Once individual attributes have all been assessed, an overall judgment is made for each sub-feature. An assessment is only deemed 'complete' when based on all the mandatory CSM Guidance attributes. Nevertheless, partially 'incomplete' assessments are undertaken when information is not available for all mandatory attributes. Further aggregation processes are required to determine feature condition at the site level based on the sub-feature condition and the spatial extent of different sub-features across the site.

Wales
The assessments undertaken by NRW also involve both data analysis and expert judgement. These assessments combine information collected on performance indicators, including CSM Guidance attributes and other available data, to assess whether targets have been met (i.e. whether there has been deterioration of features due to anthropogenic pressures or whether restoration targets have been met). The assessments are assigned a confidence score based on the quality of the evidence available and the level of certainty given to the results of the data analyses. Decisions are aggregated to inform an overall assessment for each feature within a site.

Scotland
The assessments undertaken by SNH are mostly driven by expert judgment. SNH examines the attribute information alongside any extra available information for the site, e.g. human activities, evidence of damage. It is often hard to judge condition across the whole site for some of the attributes and it normally requires a considerable change or obvious issue for a feature to be considered in unfavourable condition. There is a lot of dialogue between project managers who undertake the assessments, area officers, and contractors. Up until 2013, SNH did not consider uncertainty, accuracy and confidence when using/comparing multiple data sets.

3.6.4 Aggregation rules

Aggregation is defined here as "any rule or rules which exist to standardise the bringing together of data at different spatial or temporal scales, or across different ecosystem

components or aspects of the assessment" (Barnard & Strong 2014). The choice of aggregation rules can have a significant effect on the assessment outcome.

CSM Guidance recommends using the default approach of 'one-out, all-out' for aggregating the judgements on multiple attributes to give a feature assessment, i.e. if one attribute is deemed unfavourable, the entire feature is assessed as unfavourable (JNCC 2004a, 2004b). Generally, all CNCBs follow the 'one-out, all-out' approach.

Northern Ireland
DAERA follows the CSM Guidance default approach, whereby if one attribute is deemed unfavourable then the entire feature is assessed as unfavourable. In aggregating a feature's overall condition across different sites for the 2007-2012 Article 17 Assessment, a feature would be deemed unfavourable if more than 5% of its area/range/structure and functions were deemed unfavourable across the whole of Northern Irish waters. A lack of data in many cases (particularly with regard to 'area') meant that expert judgement was often required.

England
NE uses the 'one-out, all-out' rule recommended by CSM Guidance as the basis for aggregating assessments for multiple attributes, alongside considerations around the relative importance of individual attributes and the confidence in individual attribute assessments.

For the 2007-2012 Article 17 Assessment, NE developed a new method to aggregate assessments from sub-feature to feature level. Assessments were made at the attribute level and then aggregated up to sub-feature level using a semi-automated process. At this stage comments from site leads were used to quality assure the results, which were then aggregated up to feature level by assessment coordinators. The aggregation rules used in this process were complex and NE is reviewing them. Once the method is reviewed by a dedicated internal review panel, a draft revised version will be circulated and trialled internally by NE regional staff when undertaking condition assessments at the site level.

Wales
NRW uses the 'one-out, all-out' method proposed in CSM Guidance to aggregate assessments for multiple attributes and different parts of each habitat. If one attribute fails to meet its target then the habitat is likely to be assessed as unfavourable overall. All assessments incorporate a quality assurance element to ensure the rule set does not introduce unreasonably positive or pessimistic outcomes, particularly where confidence is low, the attribute (or parameter measured) is of relatively low importance[52], or the extent of the habitat assessed is proportionally small. In addition, the level of confidence in the assessment conclusion and its significance are influenced by the number of failing attributes and the percentage of the feature over which the target failure is considered to occur.

Scotland
SNH does not apply specific aggregation rules. Aggregation is done on a case-by-case basis and takes into account things like the size and type of change, likelihood of it continuing, sensitivity of feature, and recoverability. In the 2007-2012 Article 17 Assessment, SNH assessed all individual sub-features and then aggregated the assessments together to obtain an overall condition assessment for the Annex I habitats in Scottish inshore waters.

3.6.5 Quality assurance and control

In general, the CNCBs are still working towards putting in place appropriate systems to

[52] I.e. contributes little, either directly or indirectly, to overall feature condition.

control and ensure the quality and consistency of their habitat condition assessments across different MPAs.

Northern Ireland
To date, DAERA has had no formal process in place to ensure assessments are kept consistent. However having only a small number of staff involved in the process reduces inconsistency across sites and across different features. Reasoning and evidence allows decision processes to be understood in context. Future assessments are anticipated to have an increased element of quality assurance and quality control.

England and Wales
Both NRW and NE keep an up-to-date audit trail of the rationale behind each judgement to help ensure consistency across sites.

In addition, NE has developed internal guidance for staff undertaking the assessments. The application of this guidance should ensure consistency in the assessment approach used across all MPAs. The guidance does not include data analysis.

Scotland
SNH records the rationale behind each judgement made in habitat condition assessments. The decisions relating to feature attributes and targets are taken by national marine monitoring staff and are informed by the conclusions of survey reports provided mainly by external contractors. SNH area staff who may be more familiar with the sites also engage in the condition assessment process by providing information on activities and pressures (including from relevant casework), and on existing management measures. The assessment process is undertaken within SNH's corporate Site Condition Monitoring IT system (see also Section 4.1) which helps to provide consistency in the definitions/ categories used and the level of information required.

3.6.6 Conclusions

CSM

- All CNCBs assess the condition of their MPA designated habitats in-house using a wide-range of available evidence and information.

- The condition assessments undertaken by the CNCBs are often reliant on expert judgement, in some cases with limited empirical evidence of feature condition to back them up.

- Generally, all CNCBs follow the 'one-out, all-out' approach to aggregate the judgements on multiple attributes into an overall habitat condition assessment.

- The CNCBs are working towards putting in place appropriate systems to control and improve the quality and consistency of their habitat condition assessments across different MPAs.

3.6.7 Recommendations

- Produce shared guidance to inform seabed habitat condition assessments. The guidance should consider the scale at which assessments should be undertaken and how data can be aggregated from smaller to larger scales (A.5).

- Undertake an intercalibration exercise to determine whether different condition classes are being assigned to seabed habitats comparably across the SNCBs (e.g.

assess the condition of a given feature using the shared guidance developed under recommendation A.5). Produce assessment best practice guidelines based on lessons learnt (A.6).

3.7 Links to management

CSM Guidance for marine features suggests that when an attribute fails to meet the target condition for a feature it will require further investigation to ascertain if any management response is needed to ensure the feature returns to favourable condition at future date. The way in which the CNCBs have been using their assessment results to inform management advice is summarised below.

Northern Ireland
Within DAERA's territorial waters most management measures have arisen directly from the survey evidence rather than from the results of the six-yearly condition assessments. Management measures are rightly considered using the most up-to-date monitoring and survey evidence as soon as it becomes available. Changes in condition of a feature may be evident immediately and directly from photographs and video or may become evident slightly later upon statistical analysis of comparative surveys. Irrespective of how change in condition is detected, it can be communicated immediately to allow for appropriate management measures to be considered.

Nonetheless, assessing a feature as 'unfavourable' may give added impetus to the implementation of management measures, particularly where this is combined with the threat of infraction fines from the European Commission. An example of this is Strangford Lough SAC where the 'unfavourable' status (confirmed by a rigorous ecological change investigation study by Roberts *et al* (2004)) combined with the threat of infraction prompted a mobile fishing gear ban in 2003 followed by further restrictions on pot fishing, diving and anchoring in 2011. Another example is Rathlin Island SAC, where the local Fisheries Division proactively reacted to reports of damage to Rathlin reefs, following a survey conducted by the Agri-Food and Biosciences Institute (AFBI) and a Habitats Regulations Assessment (HRA)[53], and decided to introduce a ban on the use of mobile fishing gear within the SAC.

England
In English waters, the evidence collected and the habitat condition assessments undertaken are used by NE regional advisors on a case-by-case basis when providing advice on areas such as:

- fisheries bylaws and management measures for SACs;
- advice to EMS management groups;
- seeking funding for research into feature or sub-feature decline. One particular example from the North East is the use of the results of the last two rounds of condition reporting to model changes in habitat condition over time and to correlate this with an observed reduction in fishing effort, in order to assess both recovery and scale of original impacts.

Some of the challenges faced by NE in providing feedback from assessments to inform management advice include:

[53] The Habitats Regulations (which transpose the Habitats and Birds Directives into national law) set out a consenting procedure requiring all competent authorities to carry out an appropriate assessment (AA) of a plan or project, if that plan or project is likely to have a significant effect (LSE) on a Natura 2000 site. This is known as Habitats Regulations Assessment (HRA).

- not always having the evidence available and in useable formats for the regional advisors and stakeholders;
- low confidence in some assessment results due to issues discussed in previous sections; and
- the fact that monitoring surveys are not conducted frequently enough.

Wales
In Wales, the links between condition assessments and management are largely informal, due to a lack of frequent formal reporting. One of the main reasons for infrequent formal reporting has been the focus on national reporting deadlines (i.e. six-yearly Article 17 Assessment) rather than reporting at a frequency that is useful in a site management context (e.g. yearly). Outside the formal reporting timetable, any assessments and field observations of concern are immediately reported back to site managers, with issue-specific reports being generated in important cases (e.g. sidescan observations of damage to *Modiolus* beds). However, many management issues in Wales are picked up through other means, often direct observation. This typically triggers issue-specific investigatory work (some eventually forming part of the on-going monitoring programme) with direct feedback to site managers and the ability to monitor the effects of management actions.

Scotland
SNH's routine monitoring surveys are not currently seen as a mechanism that, in isolation or in their basic form, will necessarily determine the effectiveness of changes to management for seabed habitat features. Preliminary broadscale habitat mapping surveys often inform initial management decisions based on the geographic distribution of the protected features within the sites and their sensitivity to relevant activities. Subsequent monitoring surveys are undertaken to gauge the condition or ongoing health of these features.

Initial monitoring surveys undertaken to date have had to be designed 'blind' in the absence of a clear understanding of the distribution and intensity of pressures arising from key human activities taking place within the sites (other than conspicuous and/or licensed activities). The surveys only cover a small proportion of many features[54] due to their scale and the considerable expense of the sampling. In conjunction with the possibility that any repeat work may only occur up to 18 years later (see Section 2.3.2 in relation to monitoring frequency), SNH realistically only expects routine 'un-targeted' repeat monitoring surveys to flag-up substantial/widespread change between individual sampling events. Any trends would potentially only emerge after a number of monitoring cycles, which could be in 50 - 80 years' time.

That is not to say that monitoring surveys have not influenced site management action but thus far, adverse effects from human activities have only been detected within biogenic habitats using wide area acoustic mapping techniques rather than from any finer resolution infaunal, video or diver sampling methodologies. For example, the damage observed to the serpulid reefs feature within the Loch Creran SAC using sidescan sonar imaging (Moore *et al* 2006a) was attributable to demersal fishing gear and aquaculture and recreational boat moorings. Management action triggered by the initial monitoring survey included relocating moorings, developing a moorings code of practice to guide future requirements, introducing a ban on dredging in the loch, and the zoning of creeling.

Management measures within other MPAs have been refined in response to known issues or direct observations of activities that overlap with the features of interest rather than necessarily as a direct result of monitoring surveys. SNH's monitoring work in the Firth of

[54] SNH estimated that the initial monitoring survey undertaken in the Firth of Lorn SAC in 2005 only physically sampled approximately 0.68% of the total area of Annex I reef habitat - for survey details see Howson *et al* 2006).

Lorn SAC in 2005 (Howson *et al* 2006) did not record evidence of impacts to the reef features of interest from demersal fisheries and a substantial body of more detailed work was subsequently commissioned to explore concerns raised about this issue (e.g. Boulcott & Howell 2011; Dale *et al* 2011; Boulcott *et al* 2014).

The suitability of SNH's generic 18-year maximum interval between monitoring events for seabed habitats is currently under review.

3.7.1 Conclusions

CSM

- Overall, the CNCBs have had insufficient resources (i.e. tools, people, funds) to collect, collate and analyse monitoring information at a frequency and spatial scale that enables condition assessments to be consistently used to provide timely and robust management advice. As a result, most (not all) refinements to existing management measures so far have arisen from direct field observations (e.g. clear evidence of damage such as visible damage to biogenic reef habitats, rather than changes in more subtle parameters such as infaunal taxon abundance *etc*).

3.7.2 Recommendations

- Continue to improve the quality, resolution and access to activities and pressures information to assist with monitoring and assessment of seabed habitats within MPAs. (E.2).

4 Storage and accessibility of data

The storage and accessibility of monitoring and assessment data is not covered by CSM Guidance but is important for the development a UK wide integrated monitoring programme.

Monitoring data
The CNCBs have several methods of storing\submitting their seabed habitat monitoring data and\or metadata:

- internal data storage systems accessible by CNCB staff;
- Marine Recorder;
- Marine Environmental Data and Information Network (MEDIN) Data Archive Centres (DACs); and
- UKDMOS.

This requires the CNCBs to separately submit data and\or enter metadata from their monitoring surveys multiple times, e.g. into Marine Recorder, to the appropriate DACs and into UKDMOS. Different types of monitoring data (habitat mapping, biological data, seabed images, physio-chemical data and activities information) are stored in different locations making it an onerous task to obtain all the data required to give a simple overview of the condition of a habitat. Table 13 lists the various external locations where the CNCBs submit data collected from Marine Monitoring Programmes. MEDIN (http://www.oceannet.org/) promotes the sharing of marine environmental data. The ultimate aim is for CNCBs to mobilise all of their survey data through MEDIN Data Archive Centres (DACs) (e.g. sample data, acoustics *etc*). The CNCBs can upload metadata but not data to the appropriate MEDIN DACs through online systems. MEDIN DACs aim to provide:

- secure long-term management of marine data sets by setting up a network of DACs;
- improved access to authoritative marine data held in this network, through a central discovery metadata portal;
- an agreed set of common standards for metadata, data format and content maintained and supported by partners; and
- guidelines, contractual clauses and software tools to support standards and best practice data management

Table 13. External locations for storing CNCB marine seabed habitat monitoring data and metadata.

Data types	Data or metadata	Organisation	MEDIN DAC
UKDMOS: marine monitoring programme metadata	Metadata	British Oceanographic Data Centre (BODC)	No
Seabed and sub-seabed geology, geophysics data	Metadata & data	British Geology Survey (BGS)	Yes
Flora, fauna and habitat data	Metadata & data	The Archive for Marine Species and Habitats Data (DASSH)	Yes
Water column oceanographic data	Metadata & data	British Oceanographic Data Centre (BODC)	Yes
Bathymetry data	Metadata & data	United Kingdom Hydrographic Office (UKHO)	Yes

Data types	Data or metadata	Organisation	MEDIN DAC
Marine meteorological (metocean) data	Metadata & data	The Met Office	Yes
Marine historic environmental data	Metadata & data	Archaeology Data Service	Yes
Marine fisheries data	Metadata & data	Cefas Marine Scotland Science (MSS)	Yes
Habitat Maps	Metadata & data	European Marine Observation and Data Network (EMODNET) data portal[55]	No

Assessment data
Information used by the CNCBs to make assessments of habitat condition and how they were made (e.g. how the assessments were made, details of relevant literature and the condition class attributed to a habitat in a specific location) are stored internally by the CNCBs. There are no requirements to submit this data to external DACs or centralised databases.

4.1 United Kingdom Directory of the Marine-observing Systems (UKDMOS)

The United Kingdom Directory of the Marine-observing Systems (UKDMOS) is an online searchable metadatabase of all marine monitoring conducted by UK organisations, including MPA monitoring by the CNCBs. The maintenance of the tool and management of the data is funded by the Defra and Scottish Government. The aim is to provide information to assist with the coordination of monitoring activities across different organisations and minimise duplication. The CNCBs submit metadata from their monitoring programmes to UKDMOS but the CNCBs have reported problems with the format and difficulties in entering metadata. UKDMOS includes high-level metadata on CNCB monitoring programmes, but does not include detailed information on the specific habitats or attributes being monitored by the CNCBs. The parameter groups are at a very high level and consist of attributes such as zoobenthos taxonomy-related counts and habitat characterisation.

Although UKDMOS does show the location of the CNCB's habitats monitoring programmes the data displayed does not provide detailed information as to the type of habitats monitored and the information is often out of date. Although sampling points are provided in some cases, very often only a box representing a protected site or a broader area is given and no further information is provided as to the location of sampling points, the frequency or nature of the monitoring carried out. It was necessary to gather more detailed information on which seabed habitats in SACs were being monitored and where directly from the CNCBs rather than through UKDMOS.

4.2 Marine Recorder

Marine Recorder (http://jncc.defra.gov.uk/marinerecorder) is a database application used by JNCC and the CNCBs to store marine benthic sample data including species identified, physical attributes and biotope assignments. The data are stored in a format that makes it compatible with the MEDIN Archive for Marine Species and Habitats Data (DASSH) and the

[55] http://www.emodnet-seabedhabitats.eu/webgis

National Biodiversity Network (NBN) gateway[56]. Through entering data into Marine Recorder, information on species recorded during MPA monitoring surveys are made publicly available online through the NBN gateway. Marine Recorder modules and tools enable stored data to be filtered, reported, queried, disseminated, and merged with other Marine Recorder datasets. Selected most commonly used data are extracted from the full Marine Recorder database into a simpler Microsoft Access database known as the Marine Recorder Snapshot. JNCC periodically compiles and combines all local Marine Recorder databases from the CNCBs and others into a single UK-wide version and then creates a refreshed snapshot for all to use.

Experience of the CNCBs suggests the Marine Recorder system has limitations for storing and analysing monitoring data.

4.3 Internal data storage systems

The internal data storage systems used by the CNCBs to store both their monitoring and assessment information are outlined below.

Northern Ireland
DAERA holds a database for ASSI features which is currently being updated to reflect a reviewed list of marine features. For subtidal habitats a fit-for-purpose database is currently being developed to hold appropriate information on the full suite of MPAs and to meet all marine biodiversity and conservation reporting requirements.

England
Historically, NE's marine monitoring data and metadata holdings were disparate, with the majority of data being held in the monitoring sections of regional servers, and on portable media devices sitting in both regional and national offices.

Since 2013, NE has been collating all (in-house, commissioned surveys and relevant third party) marine monitoring metadata into a single marine metadatabase. As part of this process the data has been standardised, and MESH confidence scores generated where relevant. In association with this, all historical archived data is being stored on TRIM and contracts let to ensure that all data and metadata is uploaded to the correct Data Archive Centre (DAC) and MEDIN metadata portal respectively.

Parallel to this NE's Designated Sites System (DSS), is being rebuilt and extended so that by the end of F/Y 2015-16 it will hold information on all our currently designated sites, terrestrial and marine in a single, integrated system. The DDS will link with the marine metadatabase, and once fully operational DSS will contain (or link to) all our key evidence used for monitoring, assessment and advice. External stakeholders should then be able to view condition reports and find the supporting evidence via the externally facing web portal and will be able to access maps and GI data via MAGIC[57]. This should meet both NE's published evidence standards and INSPIRE Directive (2007/2/EC) requirements.

Wales
NRW collects, archives, documents and catalogues their internally stored monitoring data following appropriate standards (e.g. MEDIN, GEMINI 2.1 metadata standards, Marine Recorder). These data include field data, interpreted data and associated metadata. These

[56] The NBN is a national project that is building a UK network of biodiversity information. It is a union of organisations that are collaborating to create a biodiversity information network available through the internet. It is used in the same way as a normal search engine to help find biodiversity information which has been published on the websites of NBN partners. It allows access to raw biodiversity datasets on species, habitats and sites.
[57] http://magic.defra.gov.uk.

data cover sub-features and the features themselves and indicate the attributes and parameters measured. The data may directly or indirectly relate to a CSM attribute, or they may not. Whilst sampling metadata goes to UKDMOS, an internal metadata database provides a means of locating the internally archived and stored data. Relevant records (not imagery or GIS files) are stored using an Electronic Records Management System. Relevant raw data are entered into Marine Recorder, either directly or following processing of the data. Following the amalgamation of CCW and the EA into NRW, NRW marine data systems are undergoing change to store and archive analyses, assessments and reports of marine SAC feature condition.

Scotland
SNH has developed an in-house *Site Condition Monitoring Information Technology* (SCM IT) system to record the details and results of all terrestrial and marine protected area feature assessments. It provides tools to plan and track the progress of these assessments (which in turn informs the scheduling of associated monitoring work) that can be shared across the organisation. The application is accessed by SNH staff via an intranet portal. Information is collected at the level of individual attributes for each discrete protected area feature. Standard (following agreed CSM guidance) and site-specific (tailored to fit) targets are defined for all feature attributes and the results of new monitoring surveys are recorded against these targets together with conclusions about whether they have been met or not. The dates of monitoring visits are recorded with links to relevant research reports stored within SNHs corporate Electronic Records Data Management System.

Additional information used in the condition assessment process is also captured including details of known activities/pressures, remedies, details of owners/occupiers and any overlapping/adjacent features. In addition, site management notes can also be recorded and previous site management notes and recommendation accessed through the database. The SCM database does not hold the details of sampling records (species, biotopes present *etc*) but it is used to archive the conclusions of any rapid *Site Check* assessments (including photographs taken and sample positions - see Section 2.3.2 for details of SNHs Site Check assessment process). The summary conclusions of the protected area condition assessment process (site name, feature, site visit date and last assessed condition) are fed to SNH's Site Link[58] web pages which are accessible to the public.

SNH are currently building an internal metadata database to provide a means of cross-referencing internally (and externally) archived and stored data from all marine surveys (including additional GIS deliverables such as habitat extent polygons that are not held within Marine Recorder or any of the UK DACs - see below).

4.4 Conclusions

UK wide biodiversity monitoring programme

- All CNCBs have internal systems in place for storing their monitoring and assessment data or are in the process of developing them. In addition, all CNCBs export species and habitat sample data (and associated metadata) into Marine Recorder. This means much of the fundamental biological sampling information is stored in a standardised way at a UK level and can be exported easily to DASSH (the appropriate Data Archive Centre).

- UKDMOS requires a completely different metadata form from those used for MEDIN. This needs to be submitted directly to the British Oceanographic Data Centre (BODC) by email. The CNCBs struggle to regularly submit the data and

[58] See - http://gateway.snh.gov.uk/sitelink/

metadata when staff resources are diverted to other high priority tasks, e.g. planning and implementing marine monitoring surveys.

- UKDMOS does not contain the detailed metadata that would be most useful to inform an integrated UK monitoring programme, e.g. detail on the habitats and attributes being monitored. More detailed information must be requested directly from the CNCBs.

- The process of submitting the relevant CNCB data and metadata into Marine Recorder, the relevant multiple DACs and UKDMOS is time intensive and requires appropriate staff time. MEDIN metadata can be submitted online and data need to be sent directly to the appropriate DAC. By submitting their data to a DAC, the intention is that the CNCBs can then direct any external enquires for data or metadata directly to the DAC.

- Limitations to the type of data that can be stored in Marine Recorder (e.g. the inability to store biomass data or complex polygon data) mean that not all of the relevant species and habitat data from a survey can be stored in one central location. Anyone requesting these data would have to request it directly from the relevant CNCB.

- Data from external organisations used to inform assessments of habitat condition may not be stored in the same form as CNCB data and may require substantial formatting before they can be used. Metadata from external organisations are inputted into MEDIN and UKDMOS but data from other organisations are rarely stored in Marine Recorder.

4.4.1 Recommendations

- See reccomendation M2 in Section 2.1.6.

- Review the possibility of expanding the data storage functionality of Marine Recorder, and/or consider other options. (E.3).

5 Report catalogue

A complete and up to date catalogue of UK benthic monitoring activities does not currently exist, but is essential to allow the UK Marine Biodiversity Monitoring R&D programme to gain a full picture of the relevant monitoring programmes that could contribute to any monitoring objectives identified.

NE, NRW and SNH have separate online catalogues of their published reports[59] (unpublished reports are not included). DAERA is currently developing an online catalogue. The accessibility of these online catalogues and the quality of the search engines vary. These catalogues only contain published reports. To support the Marine Biodiversity Monitoring R&D Programme, an easily accessible combined catalogue of the SNCB seabed habitat monitoring reports from 1999 - 2013 was produced by JNCC as part of this review (see Appendix 5). The catalogue enables the SNCBs to share the extensive volume of work which they have produced and to easily search the catalogue on meaningful search times. The reports can be searched for using terms such as MPA name, geographic location, survey type and listed species or habitats (see Appendices 7 and 8 for more details). The catalogue contains metadata for 849 published and unpublished reports. This literature will be used to assist in the development of a UK wide integrated monitoring programme. While the focus of this report is on inshore monitoring of seabed habitats, reports on species and JNCC reports of offshore seabed habitat surveys were also included.

5.1 Conclusions

UK wide biodiversity monitoring programme

- The CNCBs have conducted a large amount of research and development work, seabed habitat monitoring surveys and assessments from 1999 – 2013. Currently there is no single metadata system (e.g. in UKDMOS) that can be used to search through all the relevant SNCB marine monitoring reports. Details of reports associated with the data in Mariner Recorder can be entered into Marine Recorder but it is not comprehensive and there is no indication of what type of reports they are, e.g. monitoring reports, mapping reports *etc*. An easily searchable catalogue with meaningful fields enhances the ability of all the SNCBs to build on existing work and learn from each other.

- For the report catalogue to be useful in the future, it would need to be updated at regular intervals as otherwise it will only provide a snapshot in time.

5.1.1 Recommendations

- Make the catalogue of SNCB published and unpublished marine reports produced during the completion of this report available online through the JNCC website. Provide links to all SNCB report publication web pages for future marine survey and monitoring reports. (E.4).

[59] NE: http://publications.naturalengland.org.uk/; NRW: http://naturalresourceswales.gov.uk/about-us/library-and-information-service/?lang=en; and SNH: http://www.snh.gov.uk/publications-data-and-research/publications/search-the-catalogue/

6 Conclusions and Recommendations

The Common Standards for Monitoring initiative concentrated on establishing a consistent approach to assessing the condition of features in protected areas rather than stipulating that monitoring and assessment had to be undertaken using prescriptive and rigidly-applied procedures (JNCC 2004a). The approach aimed to be sufficiently flexible to take into account natural geographical variation across the UK and to accommodate the varying requirements and existing operational practices of the CNCBs (JNCC 2004a). This inevitably led to the CNCBs adopting different approaches to the collection of seabed habitat monitoring data used to inform assessments of habitat condition across the CNCBs.

With regards to monitoring, these differences may be minor in many cases but in others, such as the frequency with which MPAs are monitored, they are more fundamental. These differences relate to many factors including available staff and financial resources and the number and remoteness of MPAs in some countries. Monitoring of seabed habitats undertaken by the CNCBs does not fully achieve the aims of CSM Guidance but rather reflects what has been achievable by the CNCBs to date with limited resources.

Several topics were raised in this review which the CNCBs felt would benefit from a common UK-wide approach. It may be appropriate for some of the issues to be explored through the JNCC-led Marine Biodiversity Monitoring R&D programme or by other appropriate organisations, such as the NMBAQC. CSM Guidance needs to be updated, to take account of the different approaches required for different habitats; this should be practical, fit for purpose and realistic, and take account of existing experience in monitoring and assessing MPAs to date. Protocols on data collection, analysis and quality assurance need to be updated to take account of new methods and technologies. Guidance on aspects which are not fully covered and were never intended to be covered by the MMH and CSM Guidance such as sampling design, experimental design, power analyses, and which environmental parameters to measure is required.

The CNCBs have made a concerted effort to build partnerships with government bodies and other organisations to make the best use of resources and improve contracting procedures to save staff time and financial resources. Competing demands from other work areas, uncertainty over available funding and staff resources means that the CNCBs can face difficulties in planning and implementing their monitoring programmes. It is difficult to maintain long term monitoring programmes or know how often it will be possible to monitor seabed habitats without knowing what resources will be available on a much longer term basis than the current annual funding model.

There are differences between the stages of the CNCB monitoring programmes. NE and NRW have established monitoring programmes in place for a range of seabed habitats. SNH have just begun to revisit their MPAs for a second time. To date, DAERA have mainly conducted monitoring in Strangford Lough although they have revisited many sites which were first visited in the 1980s, as part of their SAC/NCZ designation and review of Marine Conservation Priority Species programmes. The effect of any recommended changes to existing methods or techniques on existing time series would need to be evaluated.

CNCBs adopt similar approaches to decide how often seabed habitats should be monitored. The monitoring frequency for a particular habitat or site varies from annual up to a maximum of 18 years (supplemented by a ‘Site Check’ process in each six-yearly reporting period - see Section 3.2.2 for details). An agreement regarding the principles for prioritising monitoring and a more detailed consideration of how often different seabed habitats actually need to be monitored in different circumstances (from biological and pressures perspectives) may help to resolve/justify some of these differences. The main factors influencing the

frequency of monitoring habitats are currently determined by the risk of damage to the habitat and available resources (this is consistent across all CNCBs).

In terms of condition assessments, CSM Guidance recognised that it was a novel activity for most CNCBs at the time of its publication in 2004. The period between 1999 and 2013 was characterised by a huge effort made by the CNCBs to assess the condition of seabed habitats within MPAs, undertaken with limited resources and detailed guidance. In association with an incomplete understanding of marine biodiversity and ecological processes, this resulted in assessments of feature condition, in some cases, of low confidence and highly reliant on expert judgment. Nevertheless, all CNCBs have made assessments of the condition of Annex I habitats to enable reporting on Article 17 and the provision of management advice for habitats at a higher risk of deterioration and/or loss.

Table 14 summarises the conclusions and recommendations from each section. Related recommendations have been combined where appropriate.

Table 14. Summary of conclusions and recommendations.

Section	Conclusions	Recommendations[60]	Priority
2.1: Which seabed habitats are being monitored and where?	**CSM** • CSM Guidance was developed for SSSI, ASSI, cSACs, SPAs and Ramsar sites. It does not, nor was it intended to, contain any guidance for features of new MPAs or monitoring of seabed habitats in the wider environments, e.g. MCZs and NCMPAs. • Seabed habitat monitoring programmes were often restricted as financial, staff and logistical resources were diverted towards other areas of work such as the identification of new MPAs (e.g. SACs, MCZs in England and NCMPAs in Scotland). • Where resources have allowed, the CNCBs have developed monitoring programmes for their MPAs to assess the condition of the habitats within the sites and contribute to national/international reporting requirements. Seabed habitat monitoring has generally focused on designated habitats within SACs. NE, DAERA and SNH also have targeted SSSI\ASSI monitoring programmes. DAERA, NE and NRW have all conducted some monitoring of seabed habitats within SPAs. Repeat monitoring surveys have been conducted in all MNRs. • In areas where there are overlaps between different MPA designations, where possible, the habitats are monitored once and the data are used many times to meet the requirements of several different reporting obligations. • Repeat monitoring surveys have been conducted for all types of Annex I habitats (with the exception of Mediterranean and thermo-Atlantic halophilous scrubs *Sarcocornetea fruticosi* which only occurs in English waters) but have not been conducted by all CNCBs. The distribution of Annex I habitat repeat monitoring surveys within SACs varies geographically (see Appendix 2). **UK-wide biodiversity monitoring programme** • Easily accessible information on which habitats are being monitored across the UK is required in order to understand whether there are gaps in the monitoring of particular habitats over their geographic range. A complete and up-to-date catalogue of UK habitat monitoring activities is essential to allow the UK Marine Biodiversity Monitoring R&D programme to gain a full picture of the relevant monitoring programmes that could contribute to monitoring objectives and be used to assess against multiple drivers. A complete and up-to-date catalogue does not currently exist and the information is held by the individual CNCBs. The UKDMOS is the current metadatabase designed to hold metadata on UK monitoring programmes but it does not require organisations to submit the level of detail required to understand which habitats are being monitored by the SNCBs and where they are being monitored. • Monitoring of habitats across their UK geographic range enables managers within each CNCB to understand more about the natural spatial variation of habitats. Not all designated seabed habitats are currently being monitored across their UK geographic range.	M.1 Develop a multi-year resourcing/ funding strategy for seabed habitat monitoring programmes to ensure the resources will be available to maintain long-term monitoring datasets and enable more cost effective planning.	H
		M.2 Ensure UKDMOS is fit for purpose by: - improving the export facility; - identifying the input requirements for national MPAs, MSFD, WFD *etc*; - identifying in UKDMOS where data is held and in what form; - investigating whether more detailed monitoring information from the CNCBs' features, sub-features and monitoring metrics should be inputted into UKDMOS; - collating and inputting all CNCB monitoring data into UKDMOS; and - producing maps showing the scale of monitoring for selected seabed habitats across the UK to obtain a clear picture of the temporal and spatial resolution of the seabed habitat sampling within MPAs that are contributing towards the requirements of the MSFD (as required under Article 11 of the MSFD).	H
2.2: Who undertook seabed habitat monitoring surveys in MPAs?	**CSM** • The CNCBs use a combination of approaches for undertaking seabed habitat monitoring surveys. In general, specialist staff within each CNCB define what needs to be monitored, where and how frequently. Staff allocate available budget and plan the overall monitoring programme for each agency, following CSM Guidance, adapted as appropriate to each country. Surveys themselves have been undertaken by a mixture of CNCB national and regional/local staff, contractors, volunteers and academic researchers. The use of contractors, academics and partnerships with other organisations allows the CNCBs to bring in expertise in particular habitats and encourages innovation in monitoring methods. There is an increasing use of partnerships to share resources which can reduce costs and provide benefits to both parties. **UK-wide biodiversity monitoring programme** • The success of volunteer surveys in addressing the needs of the CNCBs is linked to the level of input from CNCB staff and compliance with standards set by the CNCBs. Design of volunteer projects needs careful consideration to ensure reliable results from surveyors who do not necessarily have a background in marine biology. When CNCB staff have sufficient time to input into volunteer seabed habitat monitoring surveys, the value of the data collected by the volunteers increases and reduces the amount	M.3 Develop new, and improve the use of existing, partnerships to deliver seabed habitat monitoring programmes, which will enhance cost effectiveness and provide added value. Explore the feasibility of collaborating with industry partners to collect and share data on monitoring.	M
		M.4 Identify seabed habitat monitoring research questions that could be best answered through large scale research projects (e.g. via MASTS, NERC or EU funded research projects and programmes).	M
		M.5 Consider how data collection through citizen science led projects can assist the delivery of seabed habitat monitoring programmes.	M

[60] Monitoring recommendations are labelled with an M, assessment recommendations with an A and evidence recommendations with an E.

	of time and money required by the CNCBs to collect data themselves, thus reducing the overall costs of the monitoring. • Staff turnover within monitoring organisations and the need for external contracting processes means that it can be unusual for one individual/company to be involved in repeat surveys. Having the same contractor or staff undertake the same work several times can have benefits in terms of how smoothly the monitoring surveys proceed each time due to familiarity with all aspects of the work required (e.g. site location, taxonomy *etc*). When multiple contractors and different staff are used over time, issues can arise with the consistency of the datasets collected. Guidance, protocols and good quality assurance checks are required to ensure monitoring surveys are repeatable and that consistent data are collected to inform assessments of habitat condition over time. • Different contractors may classify the same data into different biotopes as they are not clear on how to make best use of the Marine Habitat Classification of Britain and Ireland or they are unclear on what to do if they find a similar biotope outside the depth range of that described. The use of biotopes in a monitoring context should consider the limitations and current subjective nature of this classification system. • Research and development work conducted by academic institutions, volunteers and CNCBs needs to be clearly specified, well managed and funded for sufficient time to ensure the aims of the research are met, to minimise the risk that it will not deliver what was intended.	See recommendation E1.	H
2.3: Monitoring Cycle	**CSM** • The frequency of CNCB monitoring of habitats within MPAs ranges from one year to a maximum of 18 years and varies depending on the habitat type. NRW conducts repeated monitoring of their designated habitats within the time frame recommended by CSM Guidance (i.e. within a maximum of a three year cycle). NE and DAERA aim to conduct monitoring of designated habitats once every six years to align with reporting cycles, with NE monitoring any habitats at relatively high risk of damage from marine activities within three years. SNH aims to conduct repeat monitoring of all marine habitats within 18 years. Very infrequent monitoring intervals make it difficult to detect changes in the habitat condition in a timely manner and attribute any changes observed to a cause, e.g. natural change or damage from human activities. Conversely, the monitoring of resilient, highly dynamic or more sensitive habitats that are not exposed to pressures is required less frequently. Resources and MPA-related monitoring effort need to be targeted appropriately. • In some cases, logistical issues such as the number, depth and remoteness of sites (e.g. St Kilda SAC) have limited the ability of the CNCBs to conduct regular seabed monitoring in their MPAs. The further away MPAs are from the coast, the more expensive surveys are likely to be. **UK-wide biodiversity monitoring programme** • A multitude of factors are used to prioritise MPA seabed habitat monitoring surveys. Any habitats which are known or suspected to be at risk of damage will be prioritised for investigation. • The location of the monitoring stations, the amount of replication (both spatially and temporally), the timing, the attributes measured, the type of analysis to be undertaken, the variability of the data, the planned effect size, power and significance all need to be considered. These factors are all interlinked and monitoring design should take account of all. Often, the full range of factors has not been accounted for in the initial design of seabed habitat monitoring surveys in MPAs.	M.6 Building on lessons learnt from previous monitoring, produce shared guidance on designing monitoring surveys for seabed habitats in MPAs and where appropriate hold joint training workshops on relevant topics. To include: - developing robust, realistic and cost effective sampling designs for delivering different types of monitoring/using different techniques; - experimental design to detect a meaningful level of change within an acceptable level of confidence, for seabed habitats; - power analyses (e.g. recommend appropriate levels of power and confidence); - the frequency and intensity of MPA monitoring for habitats subject to different levels of pressure/risk; and - most appropriate physical and chemical parameters to monitor in order to explain variations in the condition of seabed habitats.	H
2.4: How were seabed habitat monitoring surveys in MPAs planned?	**UK-wide biodiversity monitoring programme** • There is no agreed UK guidance outlining best practice for designing MPA seabed habitat monitoring surveys and the CBBs have not developed their own strategic guidance. Sampling designs need to be affordable and generate data required to make assessments of habitat condition and detect change in the condition of habitats. • Natural spatial and temporal variability poses a challenge as it is difficult to attribute any change detected to an anthropogenic cause (that could then be managed) if the natural variability of the habitat is not understood. CNCB staff require adequate statistical training on sampling designs and analysis of data to plan surveys, conduct data analyses if required and review contracts. • For the majority of the period in question, power analyses were not widely used to inform detailed survey design by identifying the number of samples required to detect change with a defined degree of precision and certainty; where they were used they sometimes suggest that very intensive sampling is required to obtain high power and high confidence, which is beyond the current resources of the CNCBs to deliver across the suite of sites, but may be required in specific locations as part of a strategic CNCB or UK monitoring programme. The CNCBs therefore did not always know before undertaking the surveys what level of change they would be able to detect or the level of confidence they would have in any changes observed. It is possible to conduct post-hoc tests on the data collected to see, for example, how many samples would be required to detect different levels of change. The more samples that are required, the more expensive and time consuming the collection and processing of data will be.	See recommendation M6.	

2.5: How were seabed habitat monitoring surveys in MPAs undertaken?	**CSM** • CSM Guidance suggests several techniques from the MMH for the same attribute. This could lead to the CNCBs choosing different techniques to collect data and different assessments of habitat condition being made depending on the data collection techniques used. • Environmental attributes (including those recommended by CSM Guidance) are not always monitored (e.g. due to expense, impracticality, lack of appropriate equipment, lack of information on which variables are the most relevant) and, in some instances, may hamper the ability to distinguish the causes of changes in the condition of a habitat. On the other hand, the measurement of some environmental attributes recommended by CSM Guidance is not always practical or believed to be necessary. **UK-wide biodiversity monitoring programme** • Some methods in the MMH have been superseded (e.g. MESH ROGs) or new technologies have emerged (e.g. video and still analysis) but the handbook has not been updated. This can lead to different methods being used across the CNCBs, who may have to develop their own guidance in the absence of updated guidelines. Nevertheless there is a degree of coordination in place through the Inter-agency Marine Monitoring Group (MMG). • There is a need to deliver data consistent with previous datasets while at the same time improving techniques for data collection. The CNCBs are at different stages in implementing their monitoring programmes. For those that are already well established, any change in methods needs to be managed to ensure comparability between monitoring surveys. This could be achieved by calibrating any new methods against existing methods. • Seabed habitat field data need to be quality assured to ensure that datasets collected over different time periods are comparable. QA is required to ensure that any conclusions in terms of possible management actions are correct. If there is an issue with the data, inappropriate management may be applied. The relatively long time between repeat monitoring visits in some sites / countries pose additional challenges to ensuring that sampling approaches employed and associated QA processes are undertaken in a consistent manner. This could lead to incomparable datasets being collected over time. • Effective means of logging environmental parameters are needed and a better understanding of how to compare large volumes of continuous environmental data (e.g. from data loggers) with point source biological data. • To date acquiring biological data has often been seen as the priority. The cost of measuring environmental parameters is often a limiting factor, e.g. the cost of equipment, its maintenance and deployment, visits to download data and the need to develop a strategic approach for where to collect this information. However, for some habitats, were these operational constraints (and institutional in some cases) can be tackled, the monitoring of environmental parameters as a proxy for biological health may actually represent a more cost-effective long-term solution to aspects of CSM delivery.	M.7 Improve consistency in the application of different seabed habitat monitoring data collection methods and subsequent analyses by updating, where appropriate, existing technical guidelines and protocols. The following guidelines and protocols should be considered: - Marine Monitoring Handbook Procedural Guidelines; - MESH Recommended Operating Guidelines; - British, European and international standards; and - NRW Standard Operating Protocols.	H
		M.8 Provide a central web-based portal (e.g. the Marine Monitoring Method finder on the JNCC website) to enable dissemination of the most up-to-date versions of all guidelines and protocols.	H
		M.9 Promote accreditation for seabed habitat (monitoring) data collection and sample analysis where applicable through contribution to the production of NMBAQC guidelines for seabed habitat imagery collection, analysis and interpretation.	M
		See recommendation M6.	M
2.6: How were seabed habitat monitoring data analysed?	**UK-wide biodiversity monitoring programme** • There is a lack of UK guidance on survey design to help identify the appropriate statistical techniques to be applied in relation to specific sampling designs/data types. The CNCBs have not developed their own strategic guidance. • Data need to be analysed quickly to feedback to site management in a useful timeframe. This does not always happen. If data are not analysed quickly then there is a risk that changes in habitat condition will not be identified until it's too late to identify the cause and implement management measures to prevent further deterioration of the habitat. • Datasets for the same seabed habitat may not be comparable across the UK if different methods are being used to collect the data. • Sample and data analyses need to be quality assured to ensure that datasets collected over different time periods are comparable. If sample and data analyses are not quality assured there is a possibility that inaccurate assessments of current habitat condition or change in habitat condition over time will be made. • While there are existing QA guidelines for infaunal and PSA samples, there are no existing QA guidelines for the analysis of seabed habitat video and stills data. This omission leads to issues with comparability between datasets (e.g. species are identified to different taxonomic levels by different people\organisations) and datasets of different qualities (e.g. high or low resolution video and stills images) being used to make assessments of habitat condition. There is a desire for QA guidelines for this type of data to be produced via NMBAQC.	See recommendation M6.	
		See recommendation M9.	H H
		See recommendation E1.	M
2.7: Monitoring outside of MPAs	**UK-wide biodiversity monitoring programme** • Industry monitoring data are not always available to the CNCBs. Access to industry monitoring data would provide the CNCBs with information on the impact of pressures on habitats and ensure they do not waste resources collecting data where data are already available. Northern Ireland often makes provision of such data a condition of a marine licence.	M.10 Use the results of targeted experimental monitoring case studies to improve our understanding of the relationships between different activity levels, the pressures they exert, and their effects on seabed habitats.	H

	• Relevant and appropriate data from the wider environment are not always available to provide a context for any assessment of change in habitat condition in areas with management measures. • It can be difficult to determine whether a change in habitat condition is due to the management regime unless environmental variables and the implementation of the management measures (within and outside the sites if applicable) are considered.	See recommendation M3.	M
3.1 Assessment requirements	**CSM** • Most CNCBs assess the condition of seabed habitats at the scale of the habitat or sub-habitat feature across the site, as recommended in CSM Guidance. In most cases, this implies making the assumption that the limited spatial sampling conducted within the MPA is representative of the whole extent of the habitat when making an assessment at the site level, resulting in assessments of low confidence. • All CNCBs have been able to assess and/or report on the condition of SAC habitats every six years (or more frequently in some cases) to fulfil the reporting obligation under Article 17 of the Habitats Directive and to provide management advice for habitats at a higher risk of deterioration and/or loss.	See recommendation M.6.	
3.2 Baselines	**CSM** • The CNCBs use a range of approaches to setting baselines for assessing the condition of seabed habitats within MPAs, which include 'reference state', 'past state' and 'current state' baselines. • The CNCBs have experienced difficulties in defining robust baselines that represent condition at the time of designation (or some earlier point in time), due to lack of appropriate data. • Difficulty in determining the degree to which 'current condition' baselines represent degraded conditions.	A.1 Identify existing issues and develop guidance to inform the setting of baselines and targets for seabed habitats. Where applicable, take into account the work done under WFD and MSFD, Hill *et al* (2012), and the recommendations in the OSPAR Advice Manual (OSPAR Commission 2012).	H
3.3 Condition classes	• The CNCBs have broadly adopted the condition classes proposed in CSM Guidance in their assessment work. The exceptions are SNH, who has one extra class of 'favourable – declining', and NE who applies a more specific definition of 'unfavourable – recovering'.	See recommendation A1.	
3.4 Assessment indicators (attributes)	**CSM** • Generally, all CNCBs collect data on mandatory and discretionary CSM attributes, as well as on other indicators, and use these data to inform their habitat condition assessments. • CNCBs have found some CSM attributes very difficult and costly to measure (e.g. extent, topography, morphological equilibrium) and do not think their measurement is always achievable or necessary every six years. • Several of the CSM attributes (if monitored) are not particularly sensitive to detecting change. Future CSM development should focus on identifying attributes that are sensitive to anthropogenic impacts to allow for the differentiation between natural and anthropogenic influenced change to be made. • Overall, the CNCBs have developed their knowledge around what attributes may be more practical to measure and helpful in understanding habitat condition.	A.2 Maintain an overview of the ongoing seabed habitat indicator development work being undertaken by individual CNCBs that falls outside of the HBDSEG-led/coordinated process for developing seabed habitat indicators for MSFD.	M
		A.3 Develop updated guidance on seabed habitat attributes to measure (including state, pressure and impact indicators) taking into account existing performance indicators and other metrics used by the CNCBs and relevant HBDSEG partners, the evolving MSFD indicators, and habitat conceptual ecological models (CEMs).	H
		A.4 Further develop, using existing datasets, those attributes used by the CNCBs for seabed habitats that can detect impacts known to be occurring. Where applicable, take into account the work done under WFD and MSFD.	M
3.5 Indicator targets / thresholds	**CSM** • Most of the targets set by the CNCBs to date have been set initially as the 'current state' baseline with the aim of preventing any further deterioration from current state, or as directional trend-based targets, which encourage an improvement towards a more desirable state. • Overall, the CNCBs experience difficulties in setting targets which allow for natural variation whilst flagging anthropogenic deterioration. • Some of the targets used by the CNCBs are poorly specified due to incomplete, poor quality or even absent baselines.	See recommendation A.1.	
3.6 The process of assessing condition	**CSM** • All CNCBs assess the condition of their MPA designated habitats in-house using a wide-range of available evidence and information. • The condition assessments undertaken by the CNCBs are often reliant on expert judgement, in some cases with limited empirical	A.5 Produce shared guidance to inform seabed habitat condition assessments. The guidance should consider the scale at which assessments should be undertaken and how data can be aggregated from smaller to larger scales.	H

	evidence of feature condition to back them up. • Generally, all CNCBs follow the 'one-out, all-out' approach to aggregate the judgements on multiple attributes into an overall habitat condition assessment. • The CNCBs are working towards putting in place appropriate systems to control and improve the quality and consistency of their habitat condition assessments across different MPAs.	A.6 Undertake an intercalibration exercise to determine whether different condition classes are being assigned to seabed habitats comparably across the SNCBs (e.g. assess the condition of a given feature using the shared guidance developed under recommendation A.5). Produce assessment best practice guidelines based on lessons learnt.	M
3.7 Links to management	**CSM** • Overall, the CNCBs have had insufficient resources (i.e. tools, people, funds) to collect, collate and analyse monitoring information at a frequency and spatial scale that enables condition assessments to be consistently used to provide timely and robust management advice. As a result, most (not all) refinements to existing management measures so far have arisen from direct field observations (e.g. clear evidence of damage such as visible damage to biogenic reef habitats, rather than changes in more subtle parameters such as infaunal taxon abundance *etc*).	E.2 Continue to improve the quality, resolution and access to activities and pressures information to assist with monitoring and assessment of seabed habitats within MPAs.	H
4 Storage and accessibility of data	**UK-wide biodiversity monitoring programme** • All CNCBs have internal systems in place for storing their monitoring and assessment data or are in the process of developing them. In addition, all CNCBs export species and habitat sample data (and associated metadata) into Marine Recorder. This means much of the fundamental biological sampling information is stored in a standardised way at a UK level and can be exported easily to DASSH (the appropriate Data Archive Centre). • UKDMOS requires a completely different metadata form from those used for MEDIN. This needs to be submitted directly to the British Oceanographic Data Centre (BODC) by email. The CNCBs struggle to regularly submit the data and metadata when staff resources are diverted to other high priority tasks, e.g. planning and implementing marine monitoring surveys. • UKDMOS does not contain the detailed metadata that would be most useful to inform an integrated UK monitoring programme, e.g. detail on the habitats and attributes being monitored. More detailed information must be requested directly from the CNCBs. • The process of submitting the relevant CNCB data and metadata into Marine Recorder, the relevant multiple DACs and UKDMOS is time intensive and requires appropriate staff time. MEDIN metadata can be submitted online and data need to be sent directly to the appropriate DAC. By submitting their data to a DAC, the intention is that the CNCBs can then direct any external enquires for data or metadata directly to the DAC. • Limitations to the type of data that can be stored in Marine Recorder (e.g. the inability to store biomass data or complex polygon data) mean that not all of the relevant species and habitat data from a survey can be stored in one central location. Anyone requesting these data would have to request it directly from the relevant CNCB. • Data from external organisations used to inform assessments of habitat condition may not be stored in the same form as CNCB data and may require substantial formatting before they can be used. Metadata from external organisations are inputted into MEDIN and UKDMOS but data from other organisations are rarely stored in Marine Recorder.	See recommendation M2.	H
		E.3 Review the possibility of expanding the data storage functionality of Marine Recorder, and/or consider other options.	M
5 Report catalogue	**UK-wide biodiversity monitoring programme** • The CNCBs have conducted a large amount of research and development work, seabed habitat monitoring surveys and assessments from 1999 – 2013. Currently there is no single metadata system (e.g. in UKDMOS) that can be used to search through all the relevant SNCB marine monitoring reports. Details of reports associated with the data in Mariner Recorder can be entered into Marine Recorder but it is not comprehensive and there is no indication of what type of reports they are, e.g. monitoring reports, mapping reports etc. An easily searchable catalogue with meaningful fields enhances the ability of all the SNCBs to build on existing work and learn from each other. • For the report catalogue to be useful in the future, it would need to be updated at regular intervals as otherwise it will only provide a snapshot in time.	E.4 Make the catalogue of SNCB published and unpublished marine reports produced during the completion of this report available online through the JNCC website. Provide links to all SNCB report publication web pages for future marine survey and monitoring reports.	L

7 Next steps

It is essential that the SNCBs and others with marine monitoring responsibilities in the Healthy and Biologically Diverse Seas Evidence Group (HBDSEG) partnership work closely to make the best use of the existing and any new marine biodiversity monitoring and assessment effort across the UK. Existing work is currently concentrated within MPAs.

JNCC in cooperation with the CNCBs developed the UK Marine Biodiversity Monitoring Strategy (Kröger & Johnston 2016) in order to design a scheme for monitoring different marine biodiversity components in a cost-efficient and integrative way. The findings of this review have informed the development of seabed habitat monitoring options, which are part of the UK Marine Biodiversity Monitoring Strategy. The progression of relevant report recommendations will be considered in the context of overall priorities for marine nature conservation work and align with resourcing decisions taken as part of the monitoring options process. A number of the recommendations are already being implemented by JNCC and the CNCBs.

8 References

ADDISON, P. 2010. NMBAQC Epibiota Questionnaire Summary - A review of current video analysis techniques in the UK, June 2010.

ADDISON, P. 2010. Quality Assurance in Marine Biological Monitoring. A report prepared for the Healthy Diverse Seas Evidence Group and the National Marine Biological Analytical Quality Control Scheme.

ADDISON, P. 2011. A global review of long-term Marine Protected Area monitoring programmes: The application of a good framework to marine biological monitoring. A report prepared for the Joint Nature Conservation Committee.

ALLEN, J.H., BOYES, S. & BURLINSON, F. 2008a Intertidal Monitoring of muddy gravels in Menai Strait and Conwy Bay SAC. CCW Marine Monitoring report No 45.

ALLEN, J.H., THOMSON, S. & BRAZIER, D.P. 2008b. Intertidal monitoring of biotope distributionin Carmarthen Bay and Estuaries SAC in 2005. CCW Marine Monitoring report No 52.

ATTRILL, M.J., FOWELL, S., HALL-SPENCER, J., HATTAM, C., JACKSON, E.L., LANGMEAD, O., MANGI, S., MARSHALL, C., MUNRO, C., REES, S., RODWELL, L., SHEEHAN, E.V. & STEVENS, T.F. 2009. Lyme Bay – a case-study: measuring recovery of benthic species; assessing potential "spillover" effects and socio-economic changes, Annual Report, December 2009. Report to the Department of Environment, Food and Rural Affairs from the University of Plymouth-led consortium. Plymouth: University of Plymouth Enterprise Ltd. 70 pages.

ATTRILL, M.J., BAYLEY, D.T.I., GALL, S.C., HATTAM, C., JACKSON, E.L., LANGMEAD, O., MANGI, S., MARSHALL, C., MUNRO, C., REES, S., RODWELL, L., SHEEHAN, E.V., STEVENS, T.F. & STRONG, S. 2010. Lyme Bay – a case-study: measuring recovery of benthic species; assessing potential "spillover" effects and socio-economic changes, Annual Report, December 2010. Report to the Department of Environment, Food and Rural Affairs from the University of Plymouth-led consortium. Plymouth: University of Plymouth Enterprise Ltd. 53 pages.

AXELSSON, M., DEWEY, S. & DORAN, J. 2010. Broad scale mapping of the North Rona Special Area of Conservation (SAC). *Scottish Natural Heritage Commissioned Report No. 386*. Available online from: http://www.snh.org.uk/pdfs/publications/commissioned_reports/386.pdf

BARNARD, S. & STRONG, J. 2014. Reviewing, refining and identifying optimum aggregation methods for undertaking marine biodiversity status assessments. The Institute of Estuarine and Coastal Studies, University of Hull report for JNCC. *JNCC Report No. 536.* JNCC, Peterborough.

BOULCOTT, P. & HOWELL, T.R.W. 2011. The impact of scallop dredging on rocky-reef substrata. *Fisheries Research*, 110, 415-420.

BOULCOTT, P., MILLAR, C.P. & FRYER, R.J. 2014. Impact of scallop dredging on benthic epifauna in a mixed substrate habitat. *ICES Journal of Marine Science*. Available online from: http://icesjms.oxfordjournals.org/content/early/2014/01/03/icesjms.fst197.full.pdf+html (doi:10.1093/icesjms/fst197).

BOYES, S., HEMINGWAY, K. & MAZIK, K. 2009a. Intertidal monitoring of a sand-scoured rockpools in the Cardigan Bay SAC. CCW Marine Monitoring Report No 55.

BOYES, S. 2009. Intertidal monitoring of sea caves in Pen Llyn a'r Sarnau SAC, 2004. CCW Marine Monitoring Report No 54.

BOYES, S., MAZIK, K. & SANDERSON, W.G. 2009b. Intertidal monitoring of piddocks in Carmarthen Bay and Estuaries SAC. CCW Marine Monitoring Report No 63.

BRAZIER, D.P. & BUNKER, F. StP. D. 2010. Intertidal SAC monitoring, Carmarthen Bay and Estuaries SAC, September 2008. CCW Marine Monitoring Report No: 72, 80pp + vi, Countryside Council for Wales, Bangor.

BROWN, A. 2000. Habitat monitoring for conservation management and reporting. 3: Technical Guide. CCW: Bangor.

BUNKER, F. StP. D. 2010. Intertidal SAC monitoring Pen-y-holt, Pembrokeshire Marine 2007 to 2010. CCW Marine Monitoring Report No: 74, 90pp + xi, Countryside Council for Wales, Bangor.

BURTON, M., LOCK, K. & NEWMAN, P. 2002. Skomer Marine Nature Reserve Monitoring Method Development: Yellow Trumpet Anemone *Parazoanthus axinellae*. CCW West Area Report CCW WA 14.

BURTON, M., LOCK, K., NEWMAN, P. & GIBBS, R. 2008. Skomer Marine Nature Reserve Project Status Report 2007/08. CCW Regional Report CCW/WW/08/3

BURTON, M., LOCK, K., NEWMAN, P. & GIBBS, R. 2011. Skomer Marine Nature Reserve Project Status Report 2010/11. CCW Regional Report CCW/WW/10/8.

CLARKE, K.R. & WARWICK, R.M. 2001. Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition. PRIMER-E: Plymouth.

COGGAN, R.A., CURTIS, M., BULAT, J., DELEU, S., FOSTER-SMITH, B., JAMES, C., MESDAY, C., MITCHELL, A.J., PASSCHIER, S., PIEL, S., POPULUS, J., SMIT, C.J., VAN LANCKER, V., VIZE, S. & WHITE, J. 2007. Review of standards and protocols for seabed habitat mapping. Available online from: http://www.searchmesh.net/PDF/050401%20MESH_REVIEWS_2_1_V2.2.pdf

COYLE, M.D. & WIGGINS, S.M. 2010. European Marine Site Risk Review. Natural England Research Reports, Number 038.

CRUMP, R. 1993. Skomer Marine Nature Reserve Littoral Monitoring Project (Permanent Quadrats). CCW Science Report No. 003.

CRUMP, R. & BURTON, M. 2002. Skomer Marine Nature Reserve Littoral monitoring Development of methods. CCW West Area Report CCW/WA/27.

CSEMP. 2012. Clean Seas Environment Monitoring Programme Green Book: http://www.cefas.defra.gov.uk/media/510362/greenbookv15.pdf

DALE, A.C., BOULCOTT, P. & SHERWIN, T.J. 2011. Sedimentation patterns caused by scallop dredging in a physically dynamic environment. *Marine Pollution Bulletin*, 62, 2433-2441. Available online from: http://dx.doi.org/10.1016/j.marpolbul.2011.08.024

DAVIES, J. & HALL-SPENCER, J. 1996. Mapping of the benthic biotopes in the proposed Sound of Arisaig Special Area of Conservation. *Scottish Natural Heritage Research, Survey and Monitoring Report, No. 83*.

Defra. 2012a. UK Contribution to Ecologically Coherent MPA Network in the North East Atlantic. Joint Administrations Statement. http://www.gov.scot/Resource/0041/00411304.pdf

Defra. 2012b. Report to Parliament on the Marine Protected Areas Network. Available online from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69623/pb13856-marine-protected-areas.pdf

DETR. 1998. European Marine Sites in England & Wales: A guide to the Conservation (Natural Habitats *etc*) Regulations 1994 and to the Preparation and Application of Management Schemes.

DUNCAN, C. 2003. Lamlash Bay Seasearch 2003. Interim report by the Marine Conservation Society to Scottish Natural Heritage.

Envision. 2010. Development of the NMBAQC Video Ring Test. A report to the NMBAQC and scheme participants, 33pp. March 2010.

ECOSCOPE. 2000. A species and habitats monitoring handbook, Volume 1: Designing a monitoring programme.Research, Survey and Monitoring Review No. [XX]. Scottish Natural Heritage, Edinburgh.

EMU LTD. 2006. Site Condition Monitoring: Surveys of biogenic and rocky reefs in the Lochs Duich, Long and Alsh cSAC. *Scottish Natural Heritage Commissioned Report No.240*. Available online from: http://www.snh.org.uk/pdfs/publications/commissioned_reports/Report%20No240.pdf

EUROPEAN COMMISSION. 2013. Interpretation manual of European Union habitats – EUR28.

EVANS, D. & ARVELA, M. 2011. Assessment and reporting under Article 17 of the Habitats Directive – Explanatory Notes & Guidelines for the period 2007-2012. Final version, July 2011. European Topic Centre on Biological Diversity. Available to download at http://bd.eionet.europa.eu/article17/reference_portal.

FOSTER SMITH, R.L. & HENDRICK, V.J. 2003. *Sabellaria spinulosa* reef in The Wash and North Norfolk cSAC and its approaches: Part III, Summary of knowledge, recommended monitoring strategies and outstanding research requirements. English Nature Research Report No. 543.

GOODWIN, C.E., STRAIN, E.M., EDWARDS, H., BENNETT, S.C., BREEN, J.P. & PICTON, B.E. 2013. Effects of two decades of rising sea surface temperatures on sublittoral macro-benthos communities in Northern Ireland, UK. Marine Environmental Research, 85, 33-44.

HALL, D.J. 2010. National Marine Biological Analytical Quality Control Scheme. Description of Scheme Standards for the Benthic Invertebrate Component From Scheme Year 8 (2001/02). Report to the NMBAQC Scheme participants. 4pp, February 2010.

HASKONING UK Ltd. 2006. Investigation into the impact of marine fish farm deposition on maerl beds. *Scottish Natural Heritage Commissioned Report No. 213*. Available online from: http://www.snh.org.uk/pdfs/publications/commissioned_reports/ReportNo213.pdf

HEMINGWAY, K., ALLEN, J.H., BOYES, S. & BRAZIER, P. 2008. Intertidal Monitoring of a muddy gravel community (VsenMtru) in Pen Llŷn a'r Sarnau SAC in 2004. CCW Marine Monitoring report No 47.

HEUBECK, M. & MELLOR, M. 2009. SOTEAG Ornithological Monitoring Programme 2008 Summary Report.

HEUBECK, M. & MELLOR, M. 2010. SOTEAG Ornithological Monitoring Programme 2009 Summary Report.

HEUBECK, M. & MELLOR, M. 2011. SOTEAG Ornithological Monitoring Programme 2010 Summary Report.

HEUBECK, M. & MELLOR, M. 2012. SOTEAG Ornithological Monitoring Programme 2011 Summary Report.

HILL, J.M., EARNSHAW, S., BURKE, C. & GALLYOT, J. 2012. Reviewing and recommending methods for determining reference conditions for marine benthic habitats in the North-East Atlantic Region. Marine Ecological Surveys Ltd - A report for the Joint Nature Conservation Committee. *JNCC Report No. 464*. JNCC, Peterborough. Available online from: http://jncc.defra.gov.uk/page-6195

HINCHEN, H. 2014. Review of marine biodiversity assessment obligations in the UK. Part I: A summary of the marine biodiversity assessment obligations stipulated within national and international legislative and policy instruments. *JNCC Report No. 497*. JNCC, Peterborough. Available online from: http://jncc.defra.gov.uk/page-6673

HISCOCK, K. (ed). 1996. Marine Nature Conservation Review: rationale and methods. (Coasts and seas of the United Kingdom. MNCR series) JNCC, Peterborough.

HM GOVERNMENT. 2012. Report of the Habitats and Wild Birds Directives Implementation Review. Available online from: http://www.defra.gov.uk/publications/files/pb13724-habitats-review-report.pdf

HOSKIN, M.G., COLEMAN, R.A . & VON CARLSHAUSEN, L. 2009. Ecological effects of the Lundy No-Take Zone: the first five years (2003-2007). Report to Natural England, Defra and WWF-UK. Available online from: http://www.lundymcz.org.uk/docs/public/CMER_Lundy%20NTZ_First%205%20Years.pdf.

HOSKIN, M., VON CARLSHAUSEN, L. & COLEMAN, R.A. 2008. Monitoring the Lundy No-Take Zone: the first five years (2003-2008). Report to Natural England, Defra and WWF-UK. CMER, Plymouth.

HOWARTH, L.M. 2010. Is there early evidence of the Lamlash Bay No Take Zone providing scallop fishery benefits?

HOWARTH, L.M., WOOD, H.L., TURNER, A.P. & BEUKERS-STEWART, B.D. 2011. Complex habitat boosts scallop recruitment in a fully protected marine reserve. Marine Biology (158) pp 1767-1780.

HOWSON, C., MERCER, T. & BUNKER, F. 2003. Flamborough Head sublittoral monitoring 2002. English Nature contract no. FST20-46-16.

HOWSON, C.M., MERCER, T. & MOORE, J.J. 2006. Site Condition Monitoring: survey of rocky reefs in the Firth of Lorn marine Special Area of Conservation. *Scottish Natural*

Heritage Commissioned Report No. 190. Available online from: http://www.snh.org.uk/pdfs/publications/commissioned_reports/F05AC701.pdf

HOWSON, C.M., MERCER, T.S. & BRAZIER, D.P. 2009. Intertidal monitoring of Pen Llŷn a'r Sarnau SAC, August 2007. CCW Marine Monitoring Report No: 59, 61pp, Countryside Council for Wales, Bangor.

HOWSON, C.M. & MOORE, J. 2010. Across-Wales intertidal SAC monitoring, Menai Strait & Conwy Bay SAC, June 2008. CCW Marine Monitoring Report No: 70, pp89 + vi, Countryside Council for Wales, Bangor.

HOWSON, C.M. 2012. *Intertidal SAC monitoring, Carmarthen Bay SAC, September 2009.* CCW Marine Monitoring Report No. 79, 147pp + x, Countryside Council for Wales, Bangor.

HULL, S.L., TOBIN, M.L., MUSK, W.A. & BRAZIER, D.P. 2008. Intertidal Monitoring of rockyreefs in Milford Haven, Pembrokeshire Marine SAC. CCW Marine Monitoring report No 42.

IRVING, R.A. 2005. Lundy cSAC and MNR Literature Review. A report to English Nature (Exeter) by Sea-Scope, Marine Environmental Consultants, Bampton, Devon.

IRVING, R.A. & NORTHERN, K.O. 2012. *Isles of Scilly SAC Diving Monitoring Studies, 2011*. Natural England Commissioned Reports, Number 104.

IRVING, R.A., STANWELL-SMITH, D., HOLT, R.H.F., NORTHERN, K.O., MORRIS, E., GOUDGE, H., LINDENBAUM, C., STRINGWELL, T., CAMPLIN, M. & SANDERSON, W.G. 2012a. Across-Wales Diving Monitoring Project, 2007-2011: Standard Operating Procedures. Report for the Countryside Council for Wales by Sea-Scope Marine Environmental Consultants and Pelagial Marine Consultants.

IRVING, R.A., STANWELL-SMITH, D., HOLT, R.H.F., NORTHERN, K.O., MORRIS, E., GOUDGE, H., LINDENBAUM, C., STRINGWELL, T., CAMPLIN, M. & SANDERSON, W.G. 2012b. Across-Wales Diving Monitoring Project, 2007-2011: Site Manuals. Report for the Countryside Council for Wales by Sea-Scope Marine Environmental Consultants and Pelagial Marine Consultants.

JACKSON, D.L. & MCLEOD, C.R. (Editors). 2000. ARCHIVED Handbook on the UK status of EC Habitats Directive interest features: provisional data on the UK distribution and extent of Annex I habitats and the UK distribution and population size of Annex II species, Revised 2002. Superceded 2008. *JNCC Report No. 312*. JNCC, Peterborough. ISSN 0963-8091

JACKSON, E.L., LANGMEAD, O., BARNES, M., TYLER-WALTERS, H. & HISCOCK, K. 2008. *Identification of indicator species to represent the full range of benthic life history strategies for Lyme Bay and the consideration of the wider application for monitoring of Marine Protected Areas*. Report to the Department of Environment, Food and Rural Affairs from the Marine Life Information Network (*MarLIN*). Plymouth: Marine Biological Association of the UK. Defra Contract No. MB101 Milestone 2.

JNCC. 1998. A statement on common standards monitoring. JNCC, Peterborough. Available online from: http://jncc.defra.gov.uk/page-2198

JNCC. 2013. Assessment Obligations Review Part III: Recommendations for harmonisation across marine biodiversity assessment obligations and suggested further work. Version 2.4. IN DRAFT.

JNCC. 2004a. Guidance for Common Standards Monitoring Introduction Text. JNCC, Peterborough. Available online from: http://jncc.defra.gov.uk/page-2199

JNCC. 2004b. Common Standards Monitoring Guidance for Marine, Version August 2004. JNCC, Peterborough. ISSN 1743-8160. Available online from: http://jncc.defra.gov.uk/page-2236

JNCC. 2004c. Common Standards Monitoring Guidance for Birds, Version August 2004, JNCC, Peterborough. ISSN 1743-8160. Available online from: http://jncc.defra.gov.uk/pdf/CSM_birds_incadditionalinfo.pdf.

JNCC. 2004d. Common Standards Monitoring Guidance for Sea Caves, Version August 2004. JNCC, Peterborough. ISSN 1743-8160. Available online from: http://jncc.defra.gov.uk/page-2199

JNCC & Defra (on behalf of the Four Countries' Biodiversity Group). 2012. UK Post-2010 Biodiversity Framework. July 2012. Available from: http://jncc.defra.gov.uk/page-6189

LOCK, K., BURTON, M., GIBBS, R. & NEWMAN, P. 2010. Skomer Marine Nature Reserve Project Status Report 2009/10. CCW Regional Report CCW/WW/10/5.

LOCK, K., BURTON, M., NEWMAN, P. & JONES, J. 2012. Skomer Marine Nature Reserve Project Status Report 2011/12. CCW Regional Report CCW/WW/11/4.

LUDDINGTON, L. & BUNKER, F. 2007. Algal monitoring in Skomer MNR and other sites around Wales. A report to the Countryside Council for Wales. CCW Marine Monitoring Report No. 033.

MARINE BIO-IMAGES. 2007. Repeat monitoring of the 'unfavourable-declining' *Modiolus* biogenic reef feature of the Lochs Duich, Long and Alsh SAC. *Scottish Natural Heritage Commissioned Report No. 297*. Available online from: http://www.snh.org.uk/pdfs/publications/commissioned_reports/297.pdf

MASON, C. 2011. NMBAQC's Best Practice Guidance. Particle Size Analysis (PSA) for Supporting Biological Analysis. National Marine Biological AQC Coordinating Committee, 72pp, December 2011.

MAZIK, K. & BOYES, S. 2009. Intertidal monitoring of eelgrass *Zostera noltii* in the Burry Inlet, Carmarthen Bay and Estuaries SAC. CCW Marine Monitoring Report No 53.

MERCER, T.S. & BRAZIER, D.P. 2009. Intertidal SAC monitoring, Intertidal Monitoring of rocky reefs in Milford Haven, Pembrokeshire Marine SAC, August 2007. CCW Marine Monitoring Report No: 60, Aquatic Survey & Monitoring Ltd. Bollihope, Co. Durham.

MERCER, T.S. 2010. Across-Wales intertidal SAC monitoring, Pen Llyn a'r Sarnau SAC August 2008. CCW Marine Monitoring Report No: 73, pp 60 +vi, Aquatic Survey & Monitoring Ltd. Bollihope, Co. Durham.

MERCER, T.S. 2011a. Across-Wales intertidal SAC monitoring, Pen Llyn a'r Sarnau SAC July 2009. CCW Marine Monitoring Report No 78, pp 61 + viii, Aquatic Survey & Monitoring Ltd. Bollihope, Co. Durham.

MERCER, T.S. 2011b. Across-Wales intertidal SAC monitoring, Pen Llyn a'r Sarnau SAC July 2010. CCW Marine Monitoring Report No: 88, pp 70 + vii, Aquatic Survey & Monitoring Ltd. Bollihope, Co. Durham.

MOFFAT, C., AISH, A., HAWKRIDGE, J.M., MILES, H., MITCHELL, P.I. & MCQUATTERS-GOLLOP, A. 2011. *Advice on United Kingdom biodiversity indicators and targets for the Marine Strategy Framework Directive.* Healthy and Biologically Diverse Seas Evidence Group Report to the Department for Environment, Food and Rural Affairs. 210pp.

MOORE, C.G., LYNDON, A.R. & MAIR, J.M. 2004. The establishment of site condition monitoring of marine sedimentary habitats in the Sound of Arisaig cSAC. *Scottish Natural Heritage Commissioned Report No. 071*. Available online from: http://www.snh.org.uk/pdfs/publications/commissioned_reports/CommissionedReportNo071.pdf

MOORE, C.G., SAUNDERS, G.R., HARRIES, D.B., MAIR, J.M., BATES, C.R. & LYNDON, A.R. 2006a. The establishment of site condition monitoring of the subtidal reefs of Loch Creran Special Area of Conservation. *Scottish Natural Heritage Commissioned Report No. 151*. Available online from: http://www.snh.org.uk/publications/on-line/commissionedreport/F02AA409_part1_2.asp

MOORE, C.G., SAUNDERS, G., MAIR, J.M. & LYNDON, A.R. 2006b. The inauguration of site condition monitoring of marine features of Loch Maddy Special Area of Conservation. Scottish Natural Heritage Commissioned Report No. 152 (ROAME No. F02AA409). Available online from: http://www.snh.org.uk/pdfs/publications/commissioned_reports/ReportNo152-%20Chapts%201-5.pdf

MOORE, C.G., EDWARDS, D.C.B., HARRIES, D.B. & LYNDON, A.R. 2009a. The establishment of site condition monitoring of the rocky reefs of the Isle of May Special Area of Conservation. *Scottish Natural Heritage Commissioned Report No. 301*. Available online from: http://www.snh.org.uk/pdfs/publications/commissioned_reports/301.pdf

MOORE, C.G., EDWARDS, D.C.B., HARRIES, D.B. & MAIR, J.M. 2009b. The establishment of site condition monitoring of the rocky reefs of the Treshnish Isles Special Area of Conservation. *Scottish Natural Heritage Commissioned Report No. 302*. Available online from: http://www.snh.org.uk/pdfs/publications/commissioned_reports/302.pdf

MOORE, C.G., HARRIES, D.B., COOK, R.L., SAUNDERS, G.R., ATKINSON, R.J.A. & SANDERSON, W.G. 2015. 2014 site condition monitoring survey of marine sedimentary habitats in the Sound of Arisaig SAC. *Scottish Natural Heritage Commissioned Report No. 807*. Available online from: http://www.snh.gov.uk/publications-data-and-research/publications/search-the-catalogue/publication-detail/?id=2379

MOORE, J. 2002. Monitoring baseline for sediment surface and burrowing macro and mega−fauna in Skomer Marine Nature Reserve. CCW West Area Report CCW WA 60.

MOORE, J. 2009a. Across-Wales intertidal SAC monitoring, Menai Strait & Conwy Bay SAC, September 2007. CCW Marine Monitoring Report No: 56, 73pp + vi, Countryside Council for Wales, Bangor.

MOORE, J. 2009b. Intertidal SAC monitoring, Cardigan Bay SAC, May 2007. CCW Marine Monitoring Report No: 57, 69pp + vi, Countryside Council for Wales, Bangor.

MOORE, J. 2009c. Intertidal SAC monitoring, Carmarthen Bay and Estuaries SAC, June 2007. CCW Marine Monitoring Report No: 58, 55pp + xi, Countryside Council for Wales, Bangor.

MOORE, J. 2009d. *Survey of the rocky shores in the region of Sullom Voe, Shetland, August 2009.* A report to SOTEAG from Aquatic Survey & Monitoring Ltd., Cosheston, Pembrokeshire. 29 pp + v.

MOORE, J. 2010a. Intertidal SAC monitoring, Cardigan Bay SAC, May 2008. CCW Marine Monitoring Report No: 71, 51pp + vi, Countryside Council for Wales, Bangor.

MOORE, J. 2010b. *Survey of the rocky shores in the region of Sullom Voe, Shetland, July /August 2010.* A report to SOTEAG from Aquatic Survey & Monitoring Ltd., Cosheston, Pembrokeshire. 29 pp + iv.

MOORE, J. 2012. *Survey of the rocky shores in the region of Sullom Voe, Shetland, August 2011.* A report to SOTEAG from Aquatic Survey & Monitoring Ltd., Cosheston, Pembrokeshire. 32 pp + v.

MOORE, J., BRAZIER, D.P. & HOBBS, E. 2010. Across-Wales intertidal SAC monitoring, Menai Strait & Conwy Bay SAC, June 2009. CCW Marine Monitoring Report No: 82, 85pp + vii, Countryside Council for Wales, Bangor.

MOORE, J.J. & GUBBINS, M.J. 2010. *Surveys of dogwhelks* Nucella lapillus *in the vicinity of Sullom Voe, Shetland, August 2009.* A report to SOTEAG from Aquatic Survey & Monitoring Ltd., Cosheston, Pembrokeshire and Marine Scotland Science, Aberdeen. 56 pp +iv.

MOORE, J.J. & GUBBINS, M.J. 2012. *Surveys of dogwhelks* Nucella lapillus *in the vicinity of Sullom Voe, Shetland, August 2011.* A report to SOTEAG from Aquatic Survey & Monitoring Ltd., Cosheston, Pembrokeshire and Marine Scotland Science, Aberdeen. 44 pp +iv.

NATURE CONSERVANCY COUNCIL. 1989. Guidelines for selection of biological SSSIs. NCC, Peterborough. Available online from: http://jncc.defra.gov.uk/page-2303.

NATURAL ENGLAND. 2012. Natural England Standards: Sites of Special Scientific Interest. External version 15/10/2012 final V1.

NATURAL ENGLAND. 2013a. Integrated Site Assessments: Carrying out a Detailed Site Assessment (habitats, general) Instruction. Version 1.2

NATURAL ENGLAND. 2013b. Guidance on establishing an Unfavourable condition category. November 2013

OSPAR. 2010. Quality Status Report 2010. Available online from: http://qsr2010.ospar.org/en/media/chapter_pdf/QSR_complete_EN.pdf.

OSPAR Commission. 2012. OSPAR's MSFD Advice Manual on Biodiversity: Approaches to determining good environmental status, setting of environmental targets and selecting indicators for Marine Strategy Framework Directive descriptors 1, 2, 4 and 6. Prepared by the OSPAR Intersessional Correspondence Group on the Coordination of Biodiversity Assessment and Monitoring (ICG COBAM) under the responsibility of the OSPAR Biodiversity Committee (BDC).

OSPAR INTERSESSIONAL CORRESPONDENCE GROUP ON THE COORDINATION OF BIODIVERSITY ASSESSMENT AND MONITORING (ICG COBAM) under the responsibility of the OSPAR Biodiversity Committee (BDC). Version 3.2, March 2012.Available online from: http://www.ospar.org/documents/dbase/publications/p00581_advice%20document%20d1_d2_d4_d6_biodiversity.pdf

PALMER, D.W. 2007. Scallop Dredging in the Firth of Lorn Special Area for Conservation: A review of Scallop fishing activity. Final Report to Scottish Natural Heritage. CEFAS, UK.

PARRY, M., TIERNEY, M., WOOD, L., STANWELL-SMITH, D., NORTHEN, K., ABDULLA, A., CORRIGAN, C., GASSNER, P. & FLETCHER, L. 2012. Review of international Marine Protected Area seabed monitoring and assessment of 'good practice' to inform application within UK waters. *JNCC Report No. 460*. JNCC, Peterborough.

PERRY, C. 2010. Scottish Marine and Freshwater Science Volume 1 No 19. Sedimentation in The Firth of Lorn, marine Special Area of Conservation. November 2010. Marine Scotland Science. Available online from: http://www.gov.scot/resource/doc/295194/0107877.pdf

ROBERTS, D., DAVIES, C., MITCHELL, A., MOORE, H., PICTON, B., PORTIG, A., PRESTON, J., SERVICE, M., SMYTH, D., STRONG, D. & VIZE, S. 2004. Strangford Lough Ecological Change Investigation (SLECI). Report to Environment and Heritage Service by the Queen's University, Belfast.

ROBSON, L. 2014. Monitoring, assessment and reporting of UK benthic habitats: A rationalised list. *JNCC Report No. 499*. JNCC, Peterborough.

ROSTRON, D. 1996. Sediment Interface Studies in the Skomer Marine Nature Reserve: Establishment of Monitoring Sites and Baseline Survey. CCW Science Report No. 133.

ROWE, G.A. 2006. Carmarthen Bay SAC Sediment Flats Monitoring 2005: Intertidal Core Analysis. A report to the Countryside Council for Wales by Emu Ltd, Durley, Southampton. CCW Marine Monitoring Report No: 46. pp.89

SAUNDERS, G., VELTEROP, R. & PIZZOLLA, P. 2010. Design of Monitoring Programme for Lundy.

SCOTT, S. 1994. Skomer marine nature reserve recommendations for monitoring of algal populations. CCW Science Report No. 063.

SCOTTISH GOVERNMENT. 2012. Report to the Scottish Parliament on Progress to Identify a Scottish Network of Marine Protected Areas. Available online from: http://www.scotland.gov.uk/Resource/0041/00410766.pdf

SNH. 2012. Site Condition Monitoring (SCM) Application Guide. Version 3.0.

SNH. 2014a. SNH's advice on selected responses to the 2013 Marine Scotland consultation on Nature Conservation Marine Protected Areas (MPAs). *Scottish Natural Heritage Commissioned Report No. 747*. Available online from: http://www.snh.org.uk/pdfs/publications/commissioned_reports/747.pdf

SNH. 2014b. Further advice to Scottish Government on the selection of Nature Conservation Marine Protected Areas for the development of the Scottish MPA network. *Scottish Natural Heritage Commissioned Report No. 780*. Available online from http://www.snh.org.uk/pdfs/publications/commissioned_reports/780.pdf

SNH & JNCC. 2012. Advice to the Scottish Government on the selection of Nature Conservation Marine Protected Areas (MPAs) for the development of the Scottish MPA network. *Scottish Natural Heritage Commissioned Report No. 547*. Available online from: http://www.snh.org.uk/pdfs/publications/commissioned_reports/547.pdf

THOMAS, L. & NEW, L. 2006. Review of statistics relating to a survey of horse mussel *Modiolus modiolus* beds within Lochs Duich, Long and Alsh Reefs Special Area of Conservation. *Scottish Natural Heritage Commissioned Report No. 241*. Available online from: http://www.snh.org.uk/pdfs/publications/commissioned_reports/Report%20No241.pdf

TURNER, J. 2008. Chemical and Macrobenthic Monitoring in Sullom Voe Sediments – 2008. A report to SOTEAG from M-Scan Limited 81pp.

TURNER, J. 2011. Chemical and Macrobenthic Monitoring in Sullom Voe Sediments – 2010. A report to SOTEAG from M-Scan Limited 81pp.

UKMMAS. 2007. UKMMAS: A Strategy for Marine Monitoring and Assessment. Report of the Marine Monitoring Co-ordination Group (amended), now a working document of the Marine Assessment and Reporting Group: http://archive.defra.gov.uk/environment/marine/documents/science/ukmas/ukmmas-strategy.pdf

UKMMAS. 2010. Charting Progress 2: An assessment of the state of UK seas. Available online from: http://chartingprogress.defra.gov.uk.

UNDERWOOD, A.J. 1990. Experiments in ecology and management - their logics, functions and interpretations. Australian Journal of Ecology, 15: 365-389.

WARWICK, R. 2009. Monitoring intertidal sandflats of the Isles of Scilly Special Area of Conservation: Survey of the infaunal organisms of St. Martin's sedimentary shore, September 2009. Natural England Commissioned Reports, Number 42.

WARWICK, R.M. & CLARKE, K.R. 1993. Comparing the severity of disturbance: a meta-analysis of marine macrobenthic community data. Mar Ecol Prog Ser 92, 221-23.

WELSH GOVERNMENT. 2012. Report to the National Assembly for Wales on Marine Protected Areas in Wales. Available online from: http://www.assembly.wales/Laid%20Documents/GEN-LD9150%20-%20Report%20to%20the%20National%20Assembly%20for%20Wales%20on%20Marine%20Protected%20Areas%20in%20Wales%20-21122012-241812/gen-ld9150-e-English.pdf

WHITTINGTON, M.W., HOLT, R., IRVING, R.A., NORTHEN, K.O. & STANWELL-SMITH, D. 2006. Across-Wales Diving Monitoring Project Volume 2: Standard Operating Procedures. CCW Marine Monitoring Report No: 25b.

Appendix 1: Example of existing conservation objectives for Annex I reefs in SACs in UK inshore waters

CNCB	Site	Published date	Conservation Objective
DAERA	Skerries and Causeway SAC	January 2011	To avoid deterioration of the qualifying habitats (**reefs**) and species thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving Favourable Conservation Status for the qualifying interest. To ensure for the qualifying habitats that the following are maintained in the long term, subject to natural change: • Extent of the habitats on site • Distribution of the habitats within the site • Structure and function of the habitats • Processes supporting the habitats • Distribution of typical species of the habitats • Viability of typical species as components of the habitat • No disturbance of typical species of the habitat
NE	Lyme Bay and Torbay cSAC	April 2013	Subject to natural change, maintain or restore the **reefs** in/to favourable condition, in particular the sub-features: • Bedrock reef communities • Stony reef communities • Biogenic reef communities Favourable condition of the reefs will be determined through assessment that the following are maintained in the long term in the site: • Extent of the habitat • Diversity of the habitat and its component species • Community structure of the habitat (e.g. population structure of individual notable species and their contribution to the functioning of the ecosystem)

CNCB	Site	Published date	Conservation Objective
			• Natural environmental quality (e.g. water quality, suspended sediment levels, etc.) • Natural environmental processes (e.g. biological and physical processes that occur naturally in the environment, such as water circulation and sediment deposition should not deviate from baseline at designation).
NRW	Menai Strait and Conwy Bay SAC	February 2009	**Vision statement** The long term vision for the Menai Strait and Conwy Bay SAC to be a healthy, productive and biologically diverse maritime area, supporting resilient marine ecosystems and communities. The **reef** feature should continue to comprise a variety of habitats and their associated biological communities, occurring on hard substrate of different types throughout the site. Substrate types range from limestone and clay habitats, through to areas of tide-swept sublittoral hard substrata, including boulders and bedrock. Some areas of reef feature, such as intertidal boulder habitats are expected to improve in quality and become more diverse under appropriate management. Other areas will be expected to either maintain their condition or improve. **Conservation objectives** To achieve Favourable Conservation Status all the following, subject to natural processes, need to be fulfilled and maintained in the long-term. If these objectives are not met restoration measures will be needed to achieve Favourable Conservation Status. • <u>Range</u> The overall distribution and extent of the habitat features within the site, and each of their main component parts is stable or increasing. For the **reef** feature these include: • Reef communities in high energy wave-sheltered, tide-swept conditions • Under-boulder, overhang and crevice communities • Limestone reef communities • Clay outcrop reef communities • <u>Structure and function</u> The physical biological and chemical structure and functions necessary for the long-term maintenance

CNCB	Site	Published date	Conservation Objective
			and quality of the habitat are not degraded. Important elements include: • geology; • sedimentology; • geomorphology; • hydrography and meteorology; • water and sediment chemistry; • biological interactions. This includes a need for nutrient levels in the water column and sediments to be: • at or below existing statutory guideline concentrations; • within ranges that are not potentially detrimental to the long term maintenance of the features species populations, their abundance and range. Contaminant levels in the water column and sediments derived from human activity to be: • at or below existing statutory guideline concentrations; • below levels that would potentially result in increase in contaminant concentrations within sediments or biota; • below levels potentially detrimental to the long-term maintenance of the features species populations, their abundance or range. Restoration and recovery: • This includes the need for restoration of some reef features such as underboulder, overhang and crevice communities. • <u>Typical species</u> The presence, abundance, condition and diversity of typical species is such that habitat quality is not degraded. Important elements include:

CNCB	Site	Published date	Conservation Objective
			• species richness; • population structure and dynamics; • physiological heath; • reproductive capacity; • recruitment; • mobility; • range. As part of this objective it should be noted that: • populations of typical species subject to existing commercial fisheries need to be at an abundance equal to or greater than that required to achieve maximum sustainable yield and secure in the long term; • the management and control of activities or operations likely to adversely affect the habitat feature, is appropriate for maintaining it in favourable condition and is secure in the long term.
SNH	St Kilda SAC	March 2006	To avoid deterioration of the qualifying habitats (**reefs**) thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving Favourable Conservation Status for each of the qualifying interests. To ensure for the qualifying habitats that the following are maintained in the long term: • Extent of the habitat on site • Distribution of the habitat within site • Structure and function of the habitat • Processes supporting the habitat • Distribution of typical species of the habitat • Viability of typical species as components of the habitat • No significant disturbance of typical species of the habitat

Appendix 2: Inshore SAC Annex I habitat surveys

Table 15. Definition of the different survey types used in Appendix 2. Percentages in the maps are defined by number of MPAs.

Survey type	Definition
No survey	There has been no survey in the MPA for the notified habitat.
Broadscale mapping survey	A survey has taken place to verify the presence and extent of the habitat within the MPA.
Initial monitoring survey	A survey has taken place which was planned as a monitoring survey for this habitat and was intended to be the first point in a time series of monitoring events at the site.
Repeat monitoring survey	More than one monitoring survey has taken place for this habitat in the MPA.

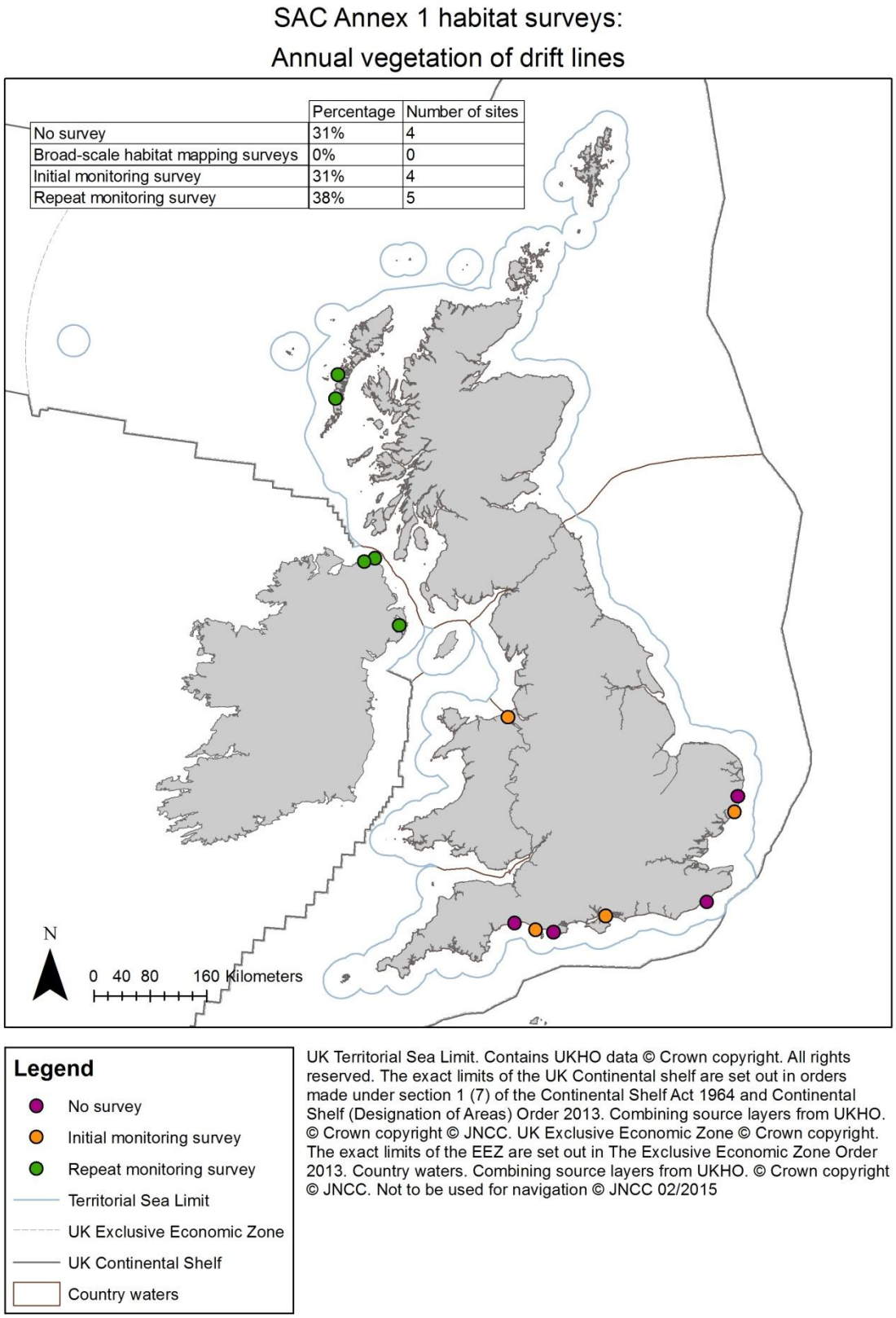


Figure 7. Types of Annual vegetation and drift lines surveys which were conducted in SACs by the CNCBs.

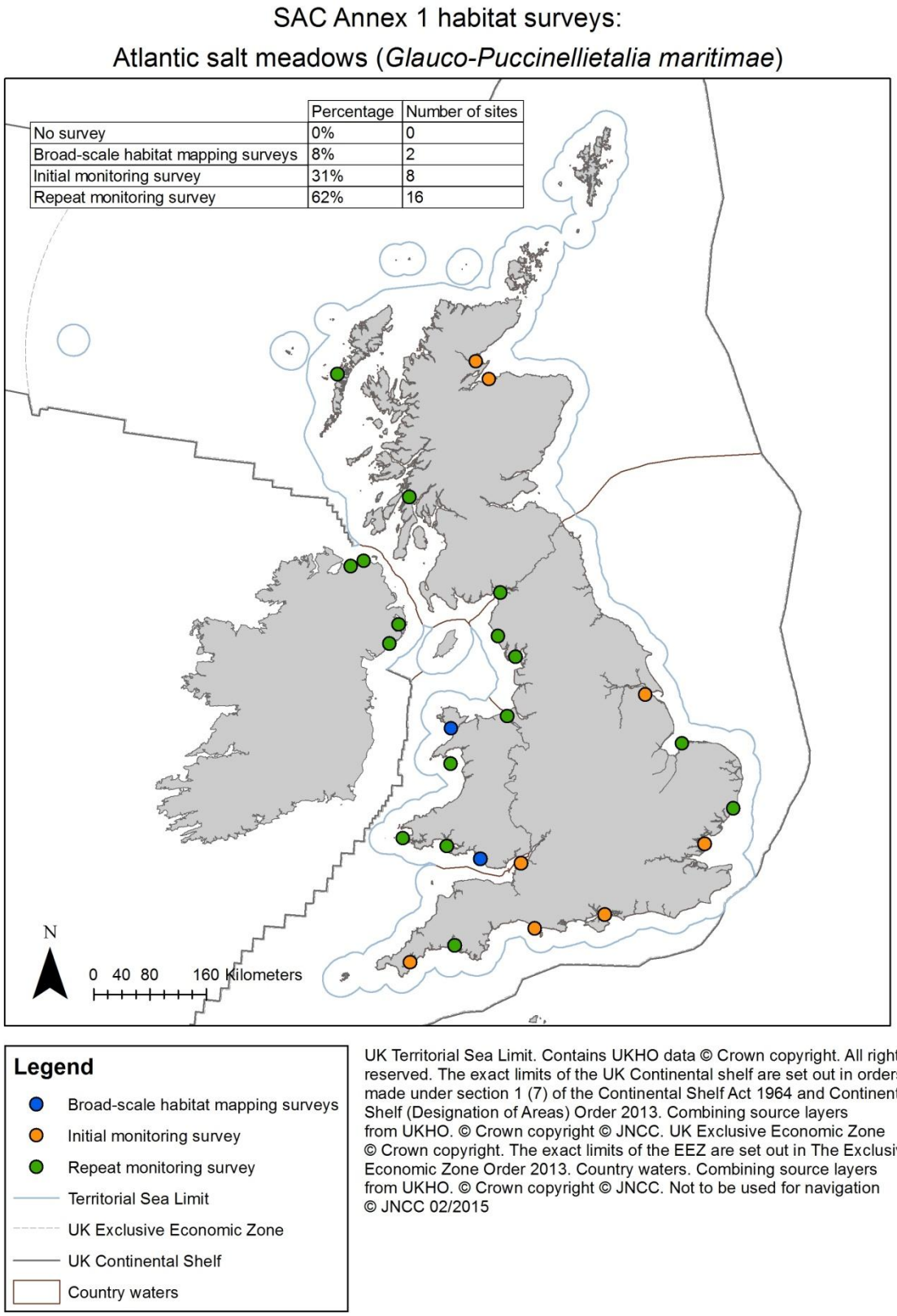


Figure 8. Types of Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) habitat surveys which were conducted in SACs by the CNCBs.

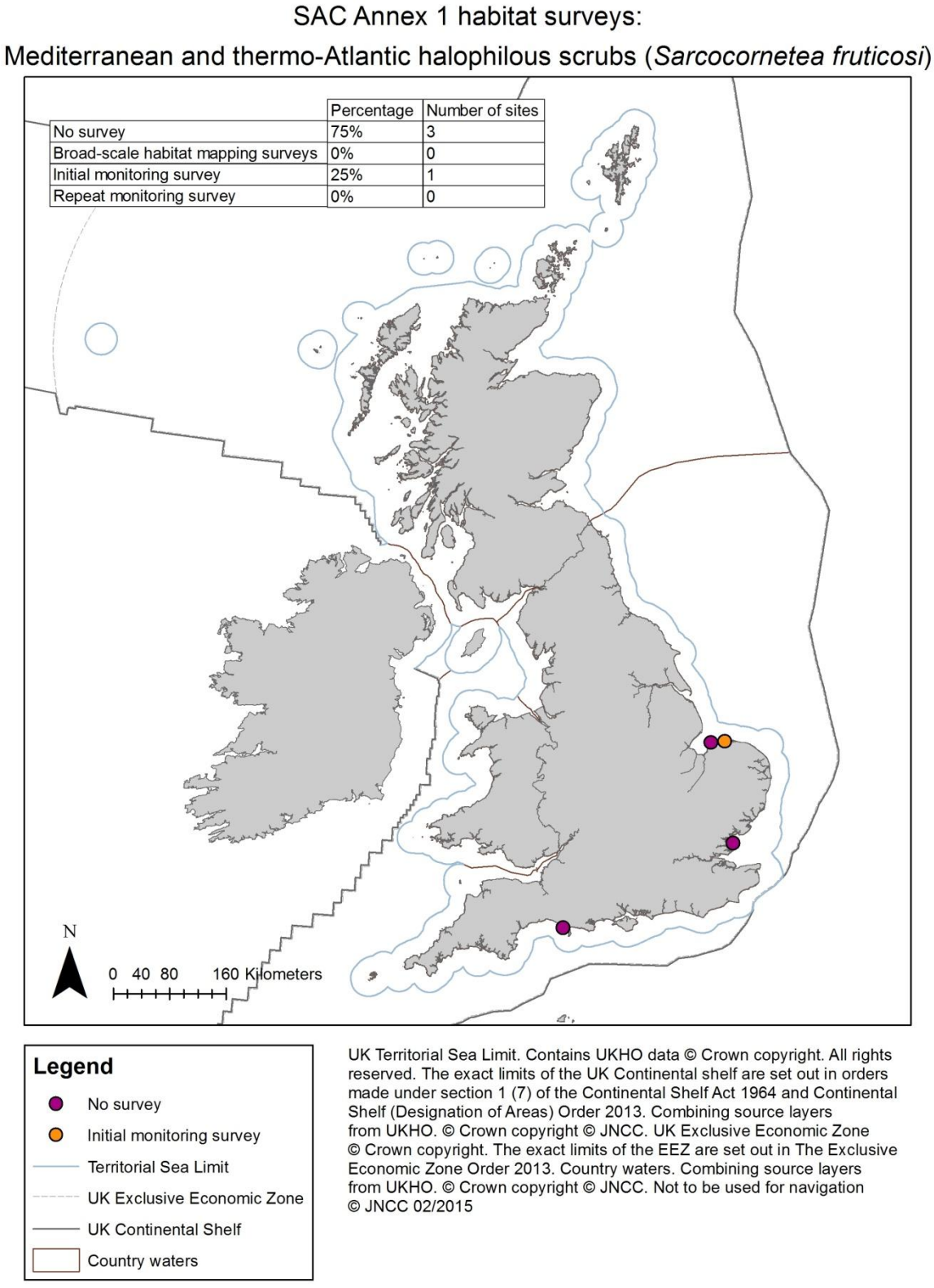


Figure 9. Types of Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) habitat surveys which were conducted in SACs by the CNCBs.

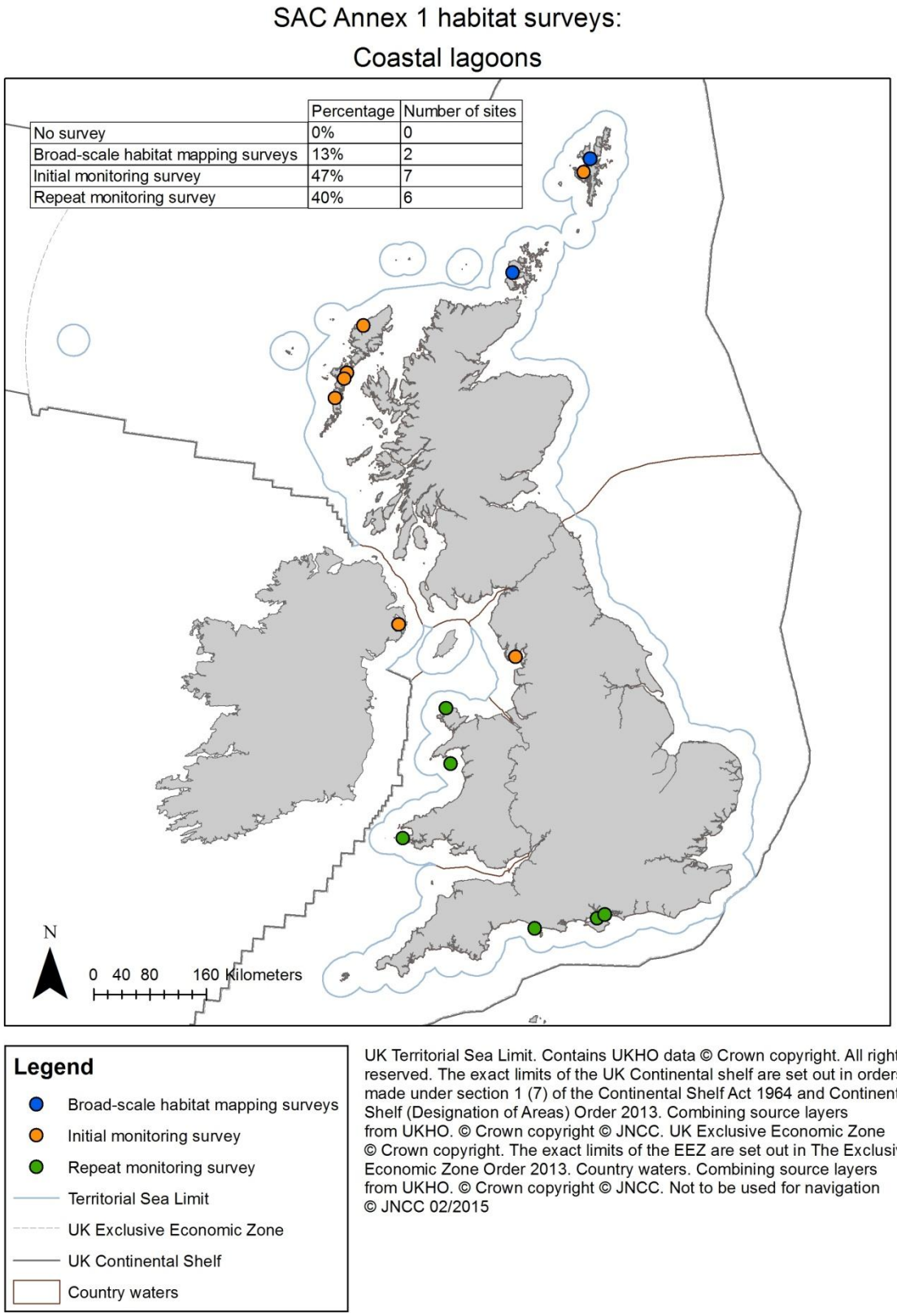


Figure 10. Types of Coastal lagoon habitat surveys which were conducted in SACs by the CNCBs.

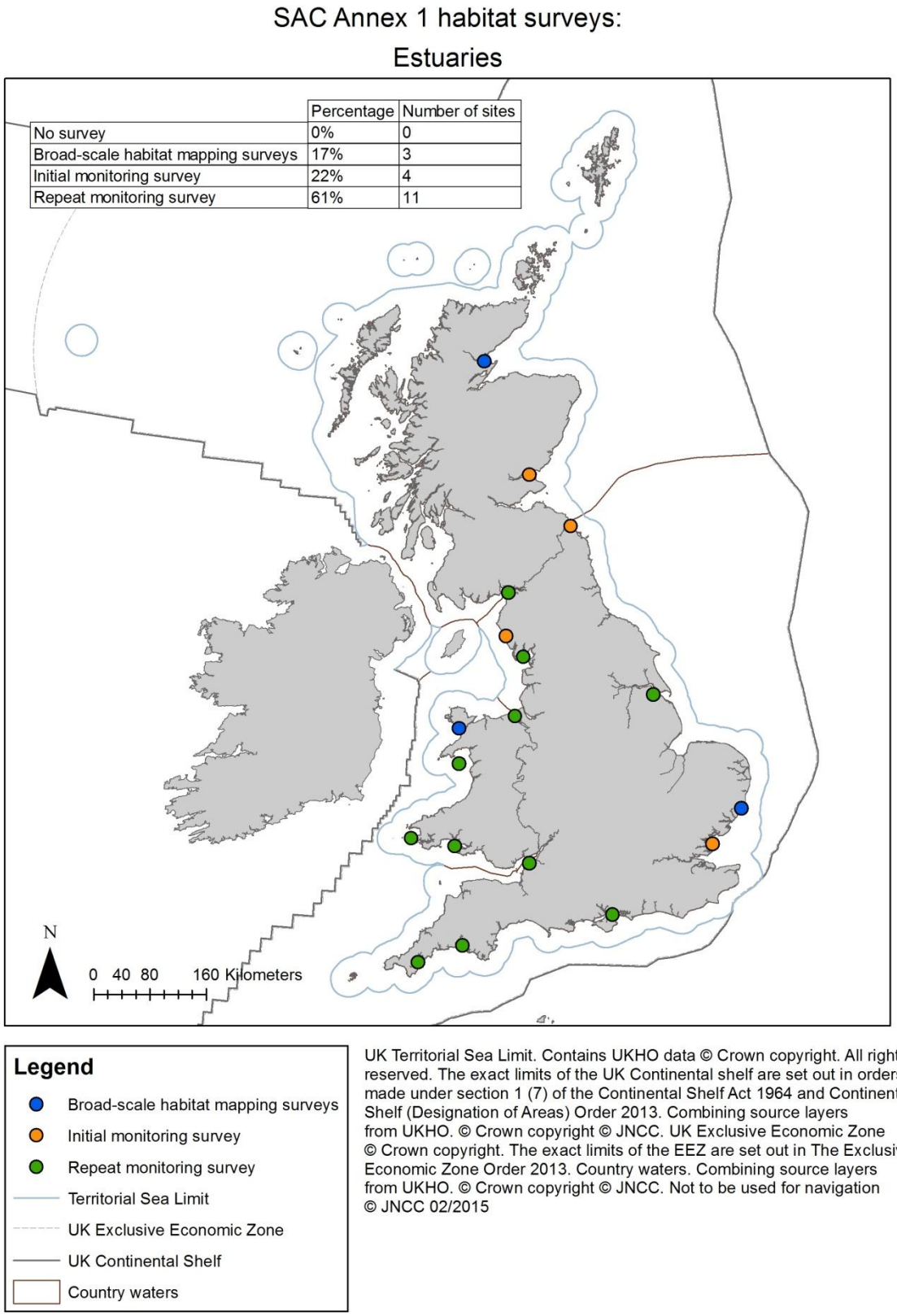


Figure 11. Types of Estuary habitat surveys which were conducted in SACs by the CNCBs.

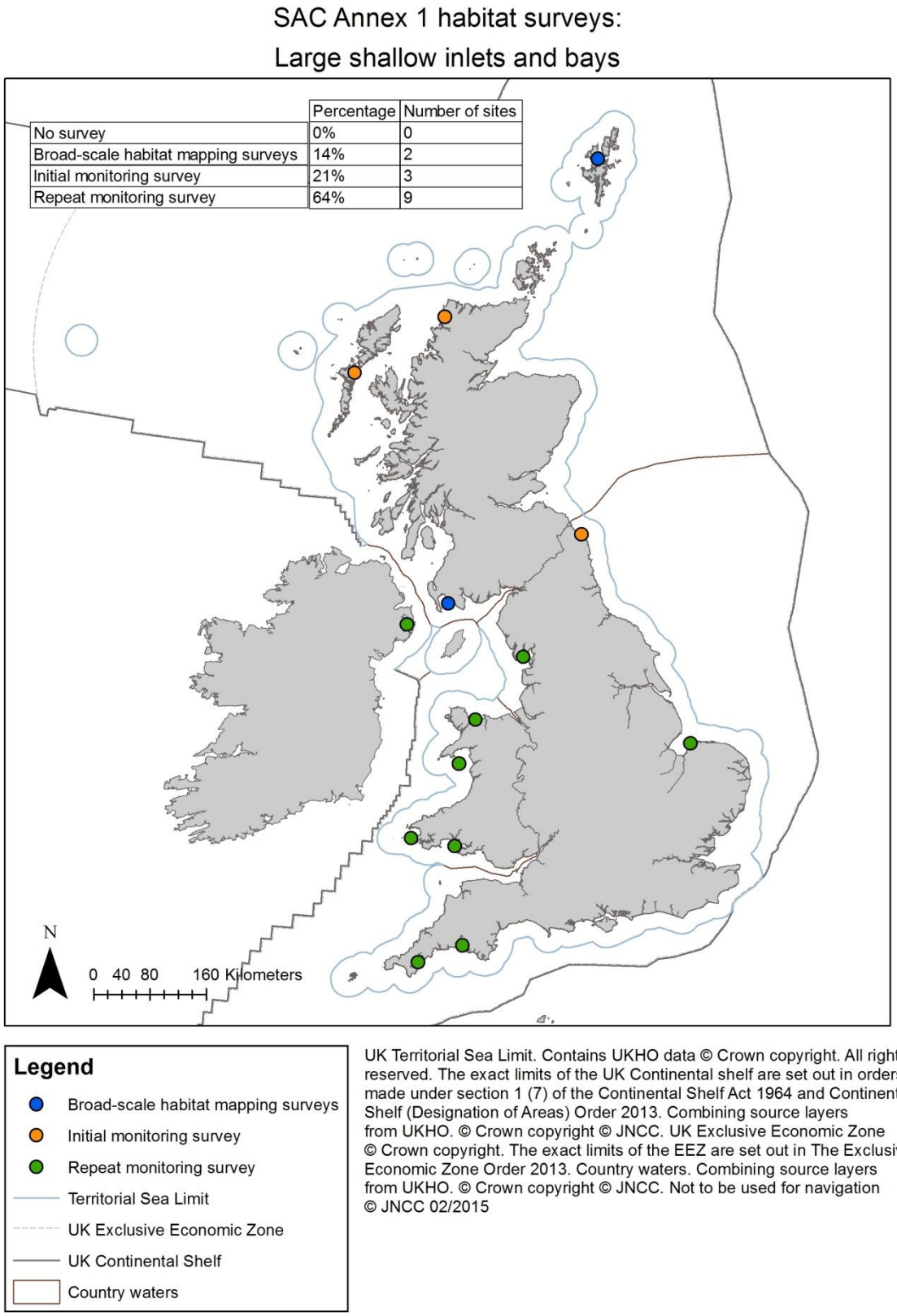


Figure 12. Types of Large Shallow Inlet and Bays habitat surveys which were conducted in SACs by the CNCBs.

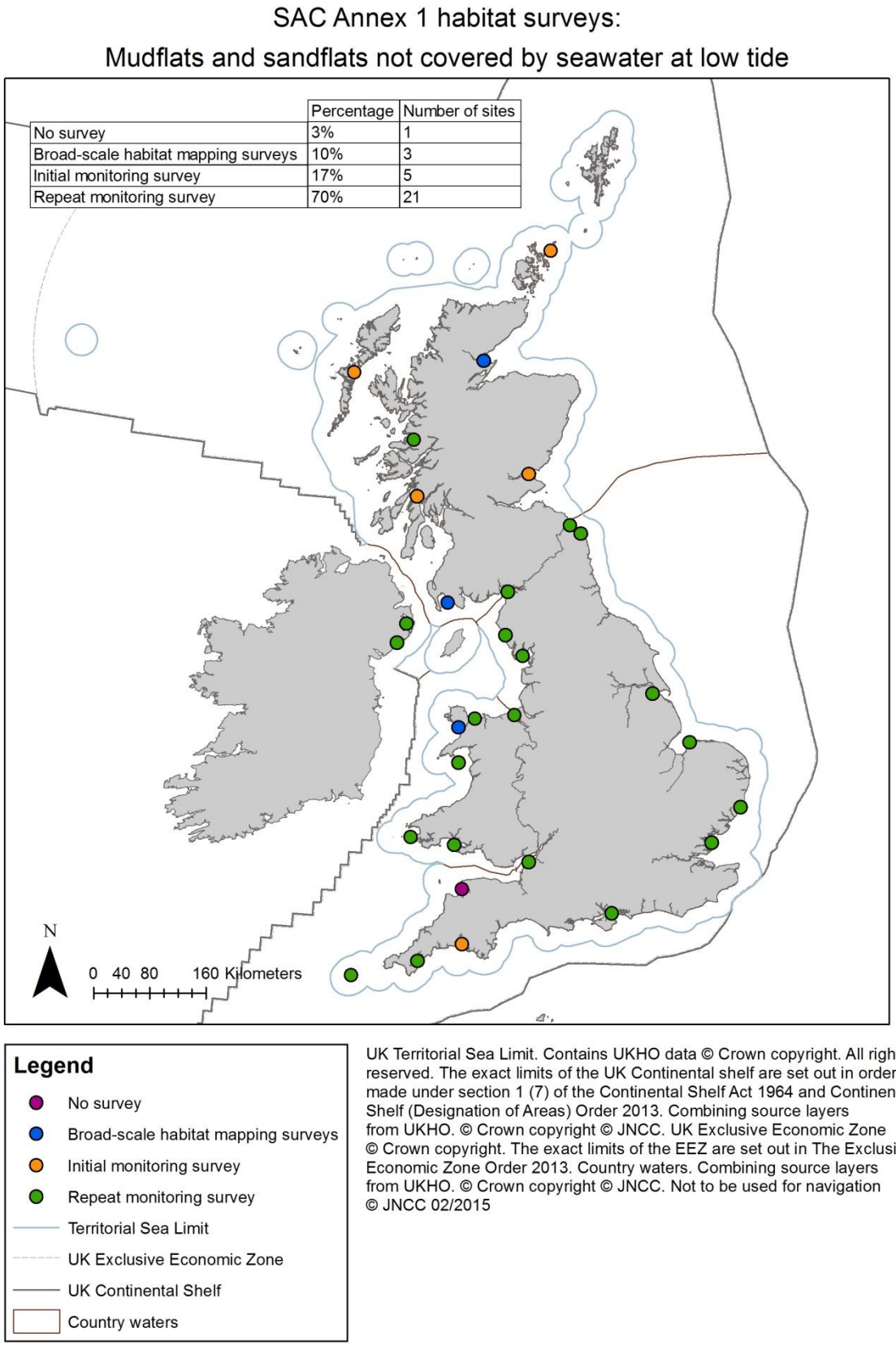


Figure 13. Types of Mudflats and sandflats not covered by seawater at low tide habitat which were conducted in SACs by the CNCBs.

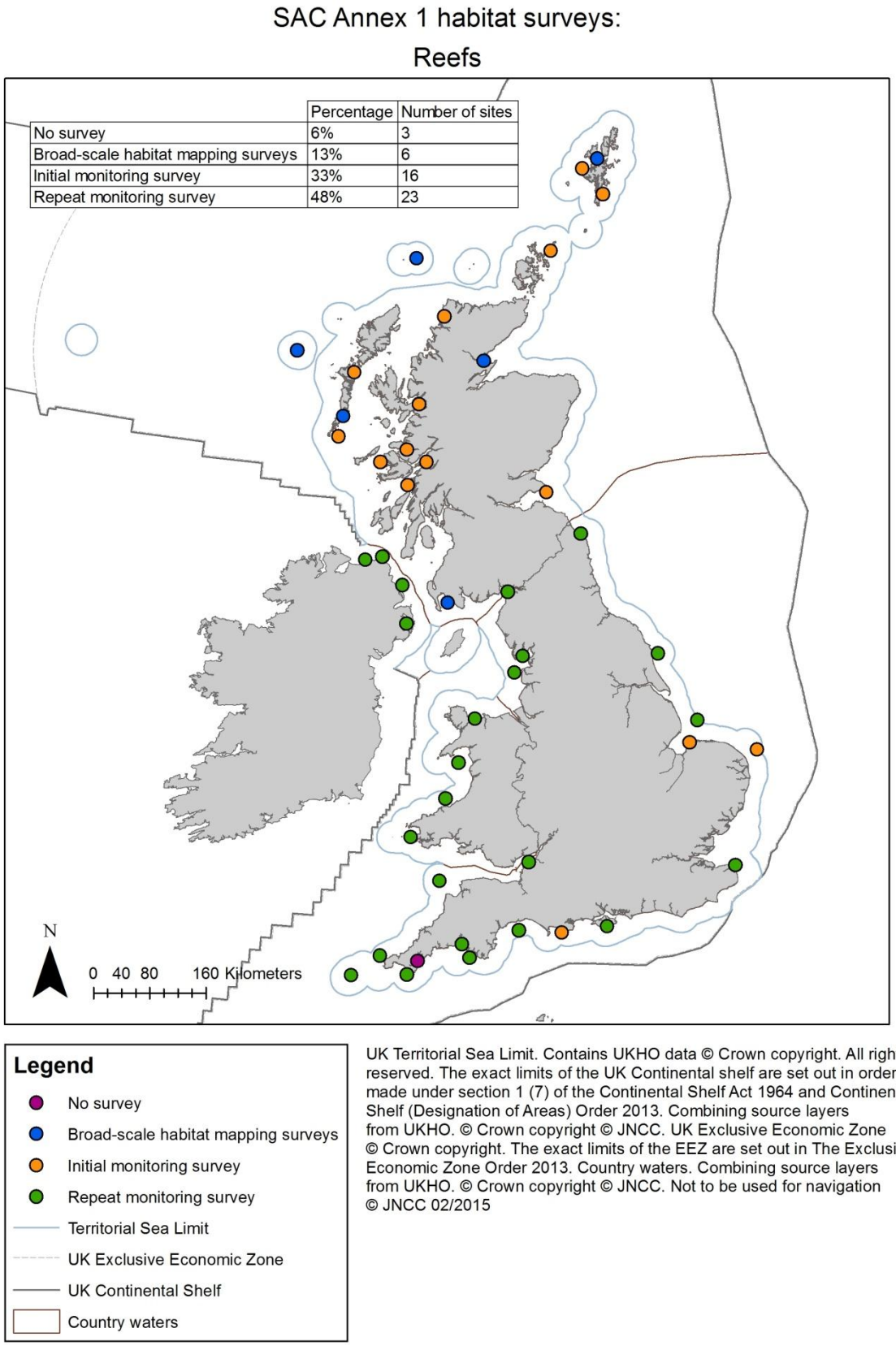


Figure 14. Types of Reef habitat which were conducted in SACs by the CNCBs.

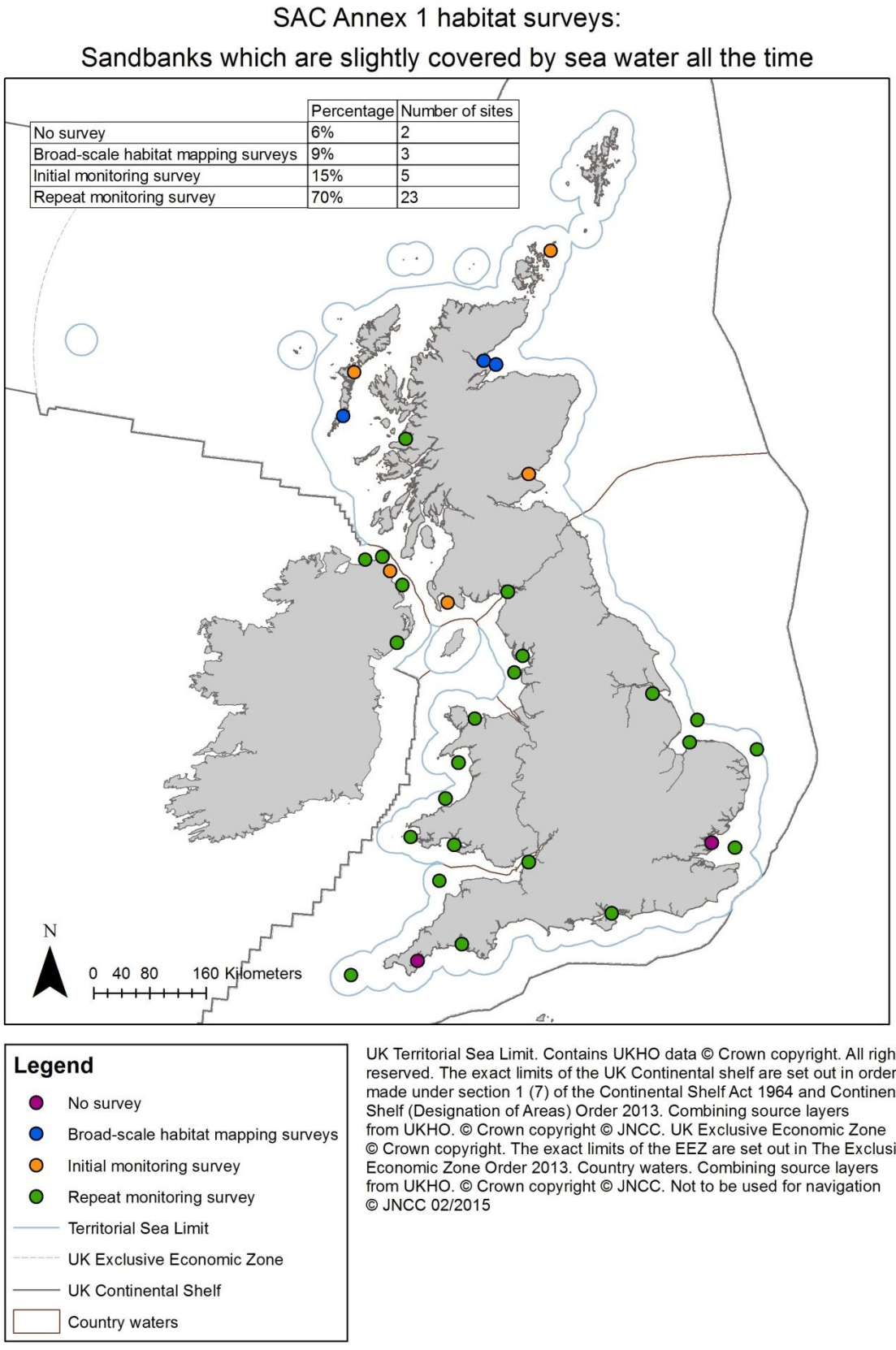


Figure 15. Types of Sandbanks which are slightly covered by water habitat which were conducted in SACs by the CNCBs.

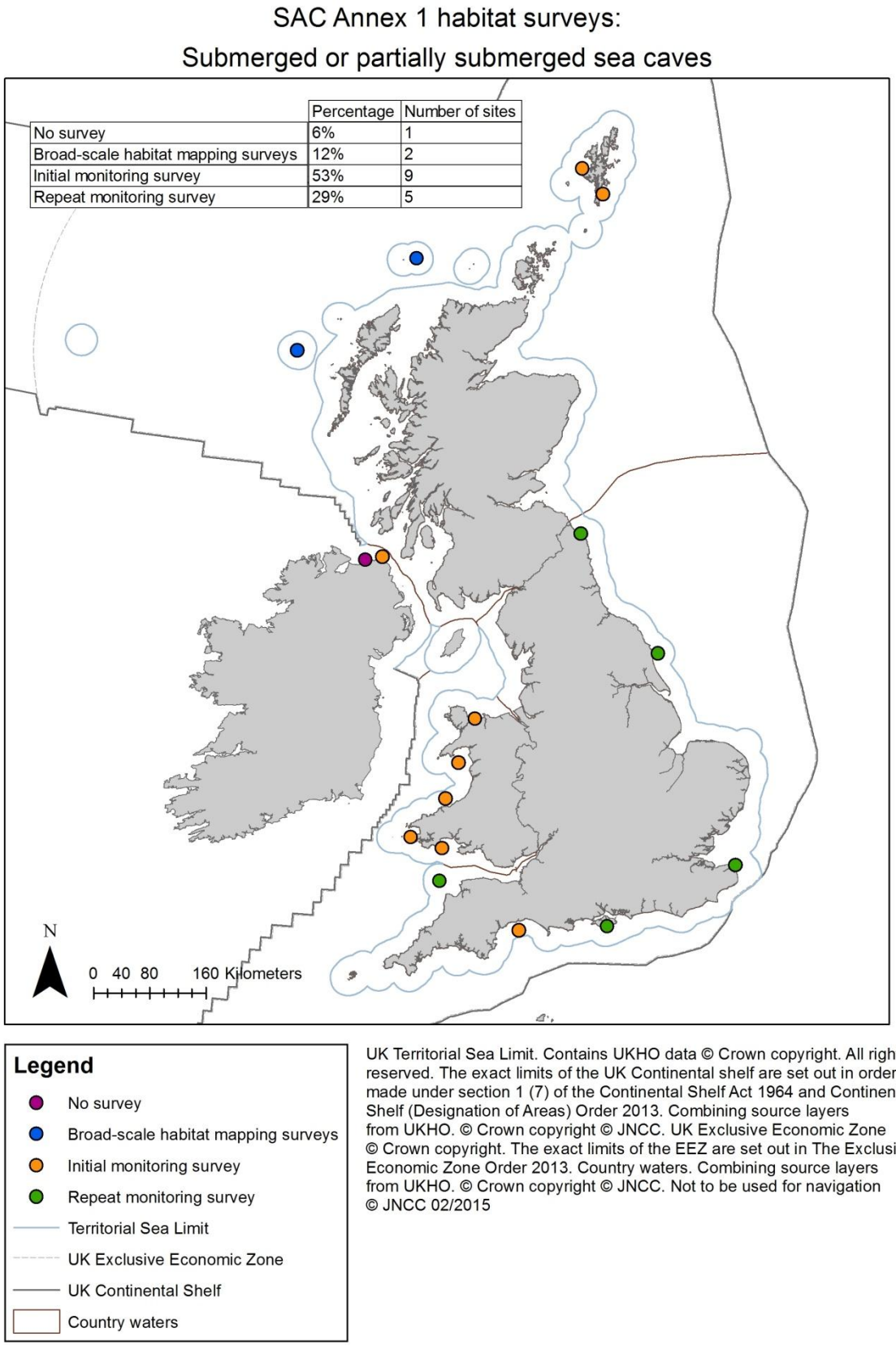


Figure 16. Types of Submerged or partially submerged sea cave habitat which were conducted in SACs by the CNCBs.

Appendix 3: NMBAQC guidelines and ring tests for components relevant to seabed habitat monitoring data collection and analysis.

Biological scheme component	Guidelines	Ring tests[61]
Epibiota	These are being drafted by JNCC, with input from the CNCBs and NMBAQC partners.	The NMBAQC's Epibiota Video Ring Test Pilot took place in 2008/2009. It involved three tests and a concluding workshop. There have been no subsequent ring tests.
Invertebrates	NMBAQC. Description of Scheme Standards for the Benthic Invertebrate Component From Scheme Year 8 (2001/02) (Hall 2010). NMBAQC. Review of Standard Operating Procedures. EN ISO 16665:2005 (Working Document). NMBAQC. Production of Processing Requirements Protocol and Taxonomic Discrimination Protocol for WFD benthic invertebrate samples (work in progress).	There are two Ring Test circulations supplied by the contractor to participating labs: • Standard Ring Test of 25 invertebrate taxa from a broad range of marine or estuarine phyla. • Targeted Ring Test of 25 invertebrate taxa from a specific fauna group or from a particular habitat
Macroalgae	Not available.	There are two Ring Test circulations supplied by the contractor to participating labs: • Rockyshore Macroalgae Identification. A photographic ring test of twenty specimens is sent out to participating laboratories on a disc. • Opportunistic Macroalgae/Seagrass Percentage Cover and Biomass. Fifteen photographs of quadrats of macroalgal blooms and 15 photographs of quadrats of seagrass beds are sent to participating labs for the Macroalgae and Seagrass Percentage Cover Ring Test Three mock algal samples are circulated to each participating laboratory for the Biomass ring

[61] Ring tests refer to occasions when certified material is circulated between different organisations for analysis to assess whether each organisation is meeting the same standard.

Biological scheme component	Guidelines	Ring tests[61]
		test for macroalgae only.
Particle size analysis	NMBAQC. Description of Scheme Standards for the Particle Size Analysis Component From Scheme Year 8 (2001/02) to Year 16 (2009/10) (Hall 2010). NMBAQC's Best Practice Guidance. Particle Size Analysis (PSA) for Supporting Biological Analysis (Mason 2010).	Particle size samples are derived from either aggregate material or natural marine sediments. In each case a random subsample of the prepared replicates (14 in total) are divided for analysis using two laboratories to ensure sample replicate consistency and illustrate variations between analysis techniques and/or methodology.

Appendix 4: Examples of CNCB partnerships

Partnerships involving more than one CNCB

- Cross border partnerships between different CNCBs where MPAs extend between jurisdictions, e.g. the Severn Estuary SAC (NE and NRW), Berwickshire and North Northumberland Coast SAC and the Solway Firth SAC (NE and SNH).
- Partnerships between NE, NRW[62] and the EA, collaborating on the Water Framework Directive and Habitats Directive monitoring programmes in English and Welsh waters.
- Memorandum of Understanding on the exchange of multibeam bathymetric survey data and planning future surveys between AFBI, British Geological Survey (BGS), Centre for the Environment, Fisheries and Aquaculture Science (Cefas), the Department of Environment, Food and Rural Affairs (Defra), JNCC, NE, NRW, SNH, Crown Estate, the United Kingdom Hydrographic Office (UKHO), the Ministry of Defence, Marine Scotland and Scottish Government.

Northern Ireland

- DAERA partnership with the Ulster Museum which results in a combined DAERA and Ulster Museum dive team, the archiving of specimens by the Ulster Museum, and input of the seabed habitat monitoring data into Marine Recorder by the Centre for Environmental Data and Recording (CEDaR) (a part of the Ulster Museum).
- DOE has developed a special working relationship with AFBI and the work programme is managed through a Service Level Agreement. Seabed habitat mapping is the key work-stream of direct benefit to DOE's marine monitoring programme. AFBI also run NI's only offshore Research Vessel capable of deploying a wide range of seabed sampling tools, water sampling, observation buoy deployment/recovery, cameras and multibeam mapping.
- In the recent years JNCC and other country agencies have participated in Northern Ireland surveys both in a Quality Assurance role and knowledge transfer of specialist skills.

England

- NE partnership with the EA covering the collation of seabed acoustic survey (limited), sediment grabbing (for particle size analysis and infaunal species analysis), benthic video and stills photography, and the production of broadscale habitat maps of the seabed in inshore waters.
- NE partnership with Cefas to collect acoustic and ground-truthing (grab/video/stills) data to produce both modelled and ground truthed habitat maps of the seabed.
- NE partnership with the Marine Coastguard Agency (MCA) for seabed acoustic data acquisition and the interpretation of corresponding drop down video, for sedimentary areas in MPAs outside of the EA's remit (i.e. beyond 1nm).

Wales

- NRW partnership with industry and regulators around Milford Haven forming the Milford Haven Waterway Environmental Surveillance Group (MHWESG) that contributes to a strategic monitoring programme for the estuary.

Scotland

- SNH and JNCC submit annual bids for time on Marine Scotland Science's marine research vessels *MRV* Scotia and *MRV* Alba na Mara and are each usually awarded up to 20 days cruise time. Availability is dependent upon other core statutory sampling obligations in any year.

[62] The partnership was set up before CCW and the EA Wales became part of NRW.

- Marine Scotland established *Memorandum of Agreement* (MoAs) with a range of vessel provider's in 2011/2012 and whilst to date these have primarily support delivery of sampling to inform the identification of Nature Conservation MPAs, the agreements remain in place and offer the potential for supporting MPA-related monitoring in the future.

Appendix 5: Examples of seabed habitat monitoring research and development work with MPA

Northern Ireland
DAERA work in partnership through contracts with both local Universities particularly in the field of *Modiolus* restoration, archaeology and coastal processes. Some work is contracted as specific projects/contracts while others are delivered through studentships. DAERA works with the Loughs Agency who are delivering a large range of water based research MPhils and PhDs through the INTERREG IV IBIS project in partnership with Glasgow and Queens Universities.

England
NE works with academic institutions (and other partners) to support a number of studentships. These include funding M Phil studentships and MSc research projects and part funding PhD studentships. Many of these were focussed on the assessment of pressures or activities within MPAs rather than the monitoring of seabed habitats and the assessment of their condition.

Wales
NRW funds student bursaries for 15-month periods to allow students to train as part of the organisation's marine monitoring team. The last three months of a bursary overlaps with next student bursary. Through this process, full time undergraduates spend 15 months with NRW and often use the information from projects they have been involved in for their dissertations. NRW also funds separate MSc research projects and support PhDs by working with four to five universities through MOAs. Examples of projects which produced outputs to inform assessment of monitoring data include: *Pentapora foliacea* (Aberystwyth University), *Eunicella verricosa* (Exeter University), sessile species settlement (Institute of Warsaw – Natural History Museum), *Crepidula fornicata* (Bangor University), *Pecten maximus* and *Modiolus modiolus* (Heriot Watt University) and the MarClim project (Marine Biological Association).

Appendix 6: British, European and International Standards which could apply to seabed habitat monitoring

NMBAQC biological scheme component	Standard Operating Procedure
Epibiota	BS EN 16260:2012. Water quality - Visual seabed surveys using remotely operated and towed observation gear for collection of environmental data.
	EN ISO 19493:2007. Water quality - Guidance on marine biological surveys of hard-substrate communities.
Invertebrates	EN ISO 16665: 2013. Water quality - Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna.
Particle size analysis	BS EN ISO 5667-19:2004. Water quality - Part 19: Guidance on sampling in marine sediments.
	BS 1377:1975. Methods of test for soils for civil engineering purposes. BS 1377: 1975 has since been withdrawn, and replaced by a series of standards BS 1377-X 1990.
	ISO11277:1998. Soil quality - Determination of particle size distribution in mineral soil material - Method by sieving and sedimentation
General	EN ISO 5667-1:2006. Water quality - Sampling - Part 1: Guidance on the design of sampling programmes and sampling techniques (ISO 5667-1:2006)
	EN ISO 5667-1:2006/AC:2007. Water quality - Sampling - Part 1: Guidance on the design of sampling programmes and sampling techniques (ISO 5667-1:2006)

Appendix 7: Catalogue of SNCB monitoring and assessment literature

See excel spreadsheet 121219 Appendix 7 SNCB Report Catalogue v4 presented on the report webpage under supplemental information.

Appendix 8: Table of fields used in the report catalogue with associated definitions or categories

Report Catalogue Field	Definition\categories
Catalogue ID	Catalogue ID number
Report title	Report title
Author	List of authors
Publication date	Date report was published
Format	Format of report, e.g. pdf, online,
SNCB holder	DAERA, JNCC, NE, NRW or SNH
General Location (if not in MPA or in many MPAs)	Free text field
SAC Name	Selected from drop down menu of all SACs
SAC_site_code	Selected from drop down menu of all SCA codes
SPA Name (with marine components)	Selected from drop down menu of all SPAS
SPA_site_code	Selected from drop down menu of all SPA codes
English SSSI Name	Selected from drop down menu of all English SSSIs
ASSI/SSSI- NOT ENGLISH	Free text field
RAMSAR	Free text field
MCZ	Free text field
MNR	Free text field
Theme	Selected from the following drop down list: Assessment Habitat classification Habitat mapping Methods paper Modelling Monitoring Pressure Research Review n/a
MSFD depth zones	Selected from the following drop down list: Littoral Sublittoral - shallow Sublittoral - shelf Bathyal - slope/upper Bathyal - mid/lower Abyssal n/a
HBDSEG biodiversity subgroup components	Selected from the following drop down list: Birds Mammals & reptiles Fish & Cephalopods Pelagic Rock & biogenic reef

Report Catalogue Field	Definition\categories
	Sediment n/a
Listed Species (Latin)	Listed species selected from a drop down list
Listed habitats	Listed Habitat of Principal Importance or SAC habitat feature from a drop down list

Appendix 9: Acronyms

ABPmer	ABP Marine Environmental Research Ltd
AFBI	Agri-Food and Biosciences Institute, Northern Ireland
ASSI	Area of Special Scientific Interest
BACI	Before-After-Control-Impact
BAP	Biodiversity Action Plan
BGS	British Geological Survey
CCW	Countryside Council for Wales
CEDaR	Centre for Environmental Data and Recording (Ulster Museum)
Cefas	Centre for Environment, Fisheries and Aquatic Science
CNCB	Country Nature Conservation Body
COWRIE	Collaborative Offshore Wind Research into the Environment
cSAC	Candidate Special Area of Conservation
CSM	Common Standards Monitoring
DAERA	Department of Agriculture, Environment and Rural Affairs
Defra	Department for Environment Food and Rural Affairs
EA	Environment Agency
EEC	European Economic Community
EHS	Environmental Heritage Service
EMODNET	European Marine Observation and Data Network
EMS	European Marine Site
FCS	Favourable Conservation Status
FCT	Favourable Condition Table
GES	Good Environmental Status
GIS	Geographic Information System
HBDSEG	Healthy and Biologically Diverse Seas Evidence Group
JNCC	Joint Nature Conservation Committee
MarClim	Marine Biodiversity and Climate Change
MarLIN	Marine Life Information Network
MCA	Maritime and Coastguard Agency
MCZ	Marine Conservation Zone
MECN	Marine Environmental Change Network
MESH	Mapping European Seabed Habitats
MMG	Inter-Agency Marine Monitoring Group

MMH	Marine Monitoring Handbook
MNR	Marine Nature Reserve
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
MSS	Marine Scotland Science
NBN	National Biodiversity Network
NCMPA	Nature Conservation Marine Protected Area
NE	Natural England
NIEA	Northern Ireland Environment Agency
NMBAQC	National Marine Biological Analytical Quality Control Scheme
NRW	Natural Resources Wales
NTZ	No Take Zone
OSPAR	Oslo Paris Convention
PSA	Particle Size Analysis
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
ROG	Recommended Operating Guideline
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SAMS	Scottish Association of Marine Science
SCM	Site Condition Monitoring
SEPA	Scottish Environmental Protection Agency
SNCB	Statutory Nature Conservation Body
SNH	Scottish Natural Heritage
SOP	Standard Operating Procedure
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
UKDMOS	United Kingdom Directory of Marine Observing Systems
UKHO	United Kingdom Hydrographic Office
UKMMAS	UK Marine Monitoring and Assessment Strategy
VMCA	Voluntary Marine Conservation Area
VMS	Vessel Monitoring System
WFD	Water Framework Directive