JNCC Report 765

Annex 8: 2018 options for monitoring English inshore benthic habitats

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Edited by Yessica Griffiths and Karen Webb

August 2024

ISSN 0963 8091

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This report should be cited as:
Young, M.[1] 2024 Options for Monitoring UK Marine Birds. *JNCC Report 765 (Annex 8: 2018 options for monitoring English inshore benthic habitats)*, JNCC, Peterborough, ISSN 0963-8091.
https://hub.jncc.gov.uk/assets/923201e7-a076-4d9b-8588-f195261bc4c4

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Acknowledgments:
Thank you to the Healthy and Biologically Diverse Seas Evidence Group (HBDSEG) Benthic Habitat Subgroup, for contributing scientific expertise to the development of the monitoring options presented in this paper.

We would like to recognise the Marine Monitoring Team at JNCC for all their work to deliver options on future monitoring. We would like to thank Dr Steve Gibson who was instrumental in steering the development of the options for monitoring. Special thanks to Roger Proudfoot, the chair of the Healthy and Biologically Diverse Seas Evidence Group, for all his support in the delivery of this programme.

In addition to the marine monitoring team at JNCC, many individuals have contributed towards the review of evidence provided in this paper. We would like to acknowledge the contributions of all attendees at the workshops.

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Foreword

Yessica Griffiths and Dr Karen Webb, JNCC (2024)

This historical paper is part of an archival report series, produced between 2016 and 2018, which collectively presents options for monitoring UK marine biodiversity. These options for monitoring were evaluated at a series of workshops in 2017 and 2018, by scientific experts from the Healthy and Biologically Diverse Evidence Group (HBDSEG) and policy advisors from the four governments of the UK. The initial set of workshops provided a steer on political ambitions for monitoring specific aspects of marine biodiversity, while a final workshop garnered advice from scientific experts on the proposed monitoring across UK marine biodiversity. In 2019, the combined outcomes of these workshops formed advice for UK Governments on monitoring of UK marine biodiversity. The process for developing this advice is outlined in the summary paper (Webb *et al*. 2024).

Publication of this historical report series provides a publicly available audit of the information underpinning the 2019 advice to UK Governments on proposed marine biodiversity monitoring in UK waters. This information provides a solid foundation for developing updated future advice. At the time of publication (2024), many of the evidence gaps which have been highlighted remain and, in some instances, have increased.

This paper provides a snapshot in time of English inshore benthic habitat monitoring in 2017 and the collated viewpoints, on proposed monitoring, of HBDSEG and policy representatives in 2018. These viewpoints are historical and do not necessarily reflect viewpoints at the time of publication in 2024. All monitoring options developed and presented in this paper were dependent on the assumption that core UK monitoring programmes would continue at the same level of funding. Since 2018, further Marine Protected Areas (MPAs) have been added to the network. In parallel with decreasing resources, inflation has significantly increased the costs of marine monitoring, particularly those that were vessel based and as a result there has been ongoing, yearly erosion of core monitoring.

Greater understanding of inshore benthic ecosystems is required to provide evidence for tackling the biodiversity loss and climate crisis. Monitoring inshore benthic habitats provides valuable data on the overall ecosystem health and biodiversity, fulfilling legal obligations and informing decisions to ensure sustainable management and conservation of marine resources. Inshore benthic habitats are under threat from an ever-increasing array of anthropogenic pressures They provide a major dietary component for many commercially important fish species which feed on seabed invertebrates. Soft-bottom habitats play an important role in the recycling of energy and nutrients back into the water column, promoting productivity in overlying waters.

It should be noted that some of the legislative drivers which have been referenced in this report have been updated or superseded since 2017. In addition, new legislation and obligations have been introduced since 2017 and the focus has significantly broadened from MPA feature based assessments to include wider marine nature recovery. For clarity, '[2017]' has been included alongside all occurrences of the term 'current' (and its derivatives) and within all table and figure captions and headings, throughout this paper.

Contents

1. Revised Submission: Discussion of options for monitoring of English Inshore Benthic Habitats

1.1. Issue

The UK Marine Biodiversity Monitoring Programme (led by JNCC) has been tasked by UK Governments with developing recommendations for an integrated monitoring scheme for all marine biodiversity across all UK waters. We are not currently [2017] fulfilling our nature conservation obligations for monitoring and assessment in a strategic manner, and we are currently [2017] only able to able to provide limited evidence for marine management purposes.

JNCC and the Country Nature Conservation Bodies (CNCBs) have already worked together to develop monitoring options for consideration by policy colleagues for offshore marine habitats.

The generation of inshore benthic habitat monitoring options has been devolved to the respective CNCBs, and this document represents Natural England's proposals for inshore benthic habitat monitoring in English Inshore waters (i.e. from mean high water (MHW) to the 12 nautical mile boundary), hereafter referred to as English inshore benthic habitat (EIBH) monitoring options. These options have been developed by Natural England with input from JNCC and other SNCBs. They have been developed to address inshore English needs and circumstances it is anticipated that in due course Wales, Northern Ireland and Scotland will develop options addressing their own requirements; further integration between countries at a UK level, as well as between offshore and inshore environments is anticipated at this point to address strategic UK needs. Integration of targeted monitoring for benthic habitats with other biodiversity components (e.g. mobile species could possibly yield significant improvements in efficiency and it is therefore recommended that options are eventually considered together).

Determination of which monitoring option to implement will not be a purely scientific decision, as it will involve consideration of acceptable levels of risk of damage to benthic habitats and their associated natural capital if changes are not monitored sufficiently to enable timely management decisions to be made, set against the cost to society of obtaining better evidence for such decision making, reducing the risk of damage.

1.2. Progress

A workshop on 8 March 2018 discussed the English inshore benthic habitats monitoring options so that policy colleagues could understand them in detail. The English inshore benthic habitats options proposals were discussed and evaluated and the forward look and implications for producing inshore benthic habitats options was considered. It was not the purpose of the workshop to make a definitive option choice but rather to use criteria to discuss and score the risks and benefits of each and reach an initial option preference for further development.

The workshop facilitated greater understanding of the complexity of designing a monitoring programme for inshore marine habitats, provided a way of capturing a range of technical and policy views that will feed into future iterations and ultimately influence recommendations around the preferred options going forwards.

Now that costed options and preference policy choices are available for most biodiversity components, there will be the strategic evaluation and integration of preferences across all

ecosystem components, which will be taken forward at the 28 to 29 March 2018 HBDSEG workshop.

1.3. Background

JNCC and the CNCBs have been asked by the Governments of the UK for advice on options for marine biodiversity monitoring for the waters of the UK. This work forms part of the UK Marine Monitoring and Assessment Strategy (UKMMAS) and is being undertaken in partnership with the UK's Healthy and Biologically Diverse Seas Evidence Group (HBDSEG). The advice aims to cost-effectively encompass the UK's significant policy and statutory obligations, such as the:

- High Level Marine Objectives
- Marine and Coastal Access Act, Marine (Scotland) Act, Marine Act (Northern Ireland)
- OSPAR Convention
- EC Habitats Directive
- EC Marine Strategy Framework Directive (MSFD)

For benthic marine habitats, the task of developing monitoring options is extremely complex. This is because of the great diversity of benthic habitats occurring in UK waters (especially inshore), the paucity of data on the range, extent, and condition of most of these habitat types and the underdeveloped nature of suitable state and pressure indicators for monitoring.

The monitoring options include the following three types of monitoring that can be applied in various ways to collect evidence on habitats both within MPAs and in the wider marine environment:

- **Sentinel Monitoring of long-term trends (Type 1 monitoring)** – Objective: to measure rate and direction of long-term change.

This type of monitoring provides the context to distinguish directional trends from short-scale variability in space and time by representing variability across space at any one time and documenting changes over time. To achieve this objective efficiently, a long-term commitment to regular and consistent data collection is necessary; this means time-series must be established as their power in identifying trends is far superior to any combination of independent studies.

- **Operational Monitoring of pressure-state relationships (Type 2 monitoring)** – Objective: to measure state and relate observed change to possible causes.

This objective complements monitoring long-term trends and is best suited to explore the likely impacts of pressures on habitats and species and identify emerging problems. It leads to setting of hypotheses about processes underlying observed patterns. It relies on finding relationships between observed changes in biodiversity and observed variability in pressures and environmental factors. It provides inference but it is not proof of cause and effect. The spatial and temporal scale for this type of monitoring activity will require careful consideration of the reality on the ground to ensure inference will be reliable; for example, inference will be poor in situations where the presence of a pressure is consistently correlated to the presence of an environmental driver (e.g. a specific depth stratum).

- **Investigative Monitoring to determine management needs and effectiveness (Type 3 monitoring)** - Objective: to investigate the cause of change.

This monitoring type provides evidence of causality. It complements the above types by testing specific hypothesis through targeted manipulative studies. The design and statistical approach that can be used in these cases gives confidence in identifying cause and effect. It is best suited to test state/pressure relationships and the efficacy of management measures.

Monitoring within and outside of MPAs would be designed around these three types of monitoring. At this stage of the process, a detailed consideration of whether a habitat within or outside of an MPA would be suitable for Type 2 or 3 monitoring has not been possible in the time available. Wherever a habitat location is selected for monitoring (as determined by the option below), it is expected that this will conform to a Type 1 approach and will result in a determination of trends in feature condition. Type 2 and 3 monitoring approaches will be applied to a subset of habitat location, with the proportion of locations where these approaches are taken varying through the options. Any Type 2 or 3 monitoring designs that are required would ideally be nested within the Type 1 monitoring design for optimal efficiency.

1.4. Argument

1.4.1 Objective

This policy decision will begin to enable the Government to cost-effectively meet their national and international obligations for biodiversity monitoring, assessment and reporting of inshore benthic marine habitats, and to robustly inform advice on management of human activities in the inshore marine environment. Further detailed decisions will still be required regarding determining the effects of individual operations or management interventions.

1.4.2 Criteria

The Criteria that were used to evaluate the effectiveness of each potential offshore monitoring option, and that should therefore be applied to the EIBH monitoring options are below. These criteria now need to be considered considering our understanding of anticipated changes following EU Exit, as well as new government commitments within the 25 Year Environmental Plan.

1. **Maintaining and improving benthic habitat conservation status, ecosystem health, halting and reversing biodiversity loss**
    a) How confident are we that we will be able to detect changes in a range of offshore benthic habitats?
    b) When we do see changes, how confident are we that we can differentiate between natural and anthropogenic changes?

2. **National legal compliance**
    Is there a risk of non-compliance with national legislation and legal challenge?

3. **European / International Legal compliance**
    What is the risk of non-compliance under European derived or international legislation and legal challenge (or censure)?

4. **Compliance with policy**

   What is the risk of non-compliance with ministerial commitments?

5. **Public trust**

   Will the public trust that this is the best option?

6. **Stakeholder trust**

   Will stakeholders think this is a good option?

1.4.3 Context

The UK has monitoring obligations associated with various international conventions in addition to EU and UK environmental legislation. A list of the marine biodiversity obligations relevant to UK benthic habitats is provided in Table 2. Those obligations which are legally binding and explicit in their requirement for monitoring are the principal policy drivers for monitoring. The key instruments identified as requiring monitoring of benthic habitats are the EU Habitats and Marine Strategy Framework Directives, and their associated enacting UK regulations. Both Directives include explicit requirements for monitoring habitats to inform periodic assessment and reporting of environmental status. Both Directives are also likely to bear the largest risk of legal challenge if their implementation is assessed as being insufficient; however, this risk is likely to change when the UK exits the EU. In addition to the explicit monitoring requirements, under the Habitats Directive there is also an implicit need for monitoring to report on the impact of any conservation measures being established for Natura 2000 sites. Similarly, under the Marine Strategy Framework Directive (MSFD), monitoring is implicit to provide early warnings of deleterious change to allow the timely implementation of any management measures that would be required to achieve Good Environmental Status (GES). Under both Directives, environmental status will need to be assessed across the respective habitats covered by each Directive. This means that monitoring would need to be carried out both within Marine Protected Areas and the wider environment to provide quantitative data to assess the status of habitats against Favourable Conservation Status (FCS) and GES condition targets. Monitoring is also implicitly required under the national Marine Acts to allow the required reporting against whether MPA conservation objectives are being achieved.

The requirements for assessment and monitoring under national and international biodiversity policy instruments, such as the UK Government Vision for UK Seas (Defra, 2002), the Marine Policy Statement (Defra 2011) and the European Biodiversity Strategy (European Commission 2011), are less precisely defined. Therefore, these instruments have not been considered further in the development of monitoring options. Even under the UK Government Vision, which is the only instrument for which assessment requirements have formally been identified, separate monitoring is not expected to occur to support environmental assessments. Instead, existing, or new data collected to fulfil monitoring requirements under European and national legislation would be brought together to support any assessments required under the policy instruments.

Defra's new 25 year environment plan adopts a more rigorous approach than previous policy instruments. The plan is explicit that a framework will be produced specifying how progress towards the plan goals will be measured to improve monitoring and evaluation of policies. It identifies that existing monitoring systems will need to evolve to accommodate a greater emphasis on using a natural capital approach; and that a comprehensive set of metrics will be developed to measure progress. From a marine habitat perspective, key policy aspirations include:

- reversing the loss of marine biodiversity and, where practicable, restoring it;
- increasing the proportion of protected and well-managed seas, and better managing existing protected sites;
- making sure populations of key species are sustainable with appropriate age structures;
- ensuring seafloor habitats are productive and sufficiently extensive to support healthy, sustainable ecosystems.

Existing indicators which have been identified as being relevant to the overall goal of achieving 'Thriving plants and wildlife' include 'Extent and condition of protected sites on land and at sea'.

In addition to the biodiversity assessment obligations, there are various assessment and reporting requirements that must be met by Competent Authorities and developers for proposed plans or projects in the marine environment. These requirements include those under the EU Strategic Environmental Assessment (SEA) Directive, the EU Environmental Impact Assessment (EIA) Directive and the EU Habitats Directive, as well as the relevant UK regulations that transpose these requirements into UK law (Hinchen 2014).

Table 1. National and international obligations for monitoring of benthic habitats [table created in 2017].

Principal policy drivers

International & national obligations	Monitoring Requirement				Explanation
	Inshore	Offshore	MPA	Wider environment	
Habitats Directive (HD 1992)	Explicit	Explicit	Implicit	Explicit	Article 11 of the Habitats Directive explicitly requires Member States to implement surveillance of the conservation status of all natural habitat types listed in Annex I of the Directive. In addition, monitoring requirements are implicit in the need to report on the impact of any conservation measures being established for Special Areas of Conservation (SACs) to maintain or achieve set conservation targets (Article 17).

International & national obligations	Monitoring Requirement				Explanation
	Inshore	Offshore	MPA	Wider environment	
Marine Strategy Framework Directive (MSFD 2008)	Explicit	Explicit	Explicit	Explicit	Article 11 of the MSFD provides explicit requirements for Member States to establish and implement coordinated monitoring programmes to support the ongoing assessment of the environmental status and the progress in achieving related environmental targets. Monitoring programmes shall be compatible within marine regions or sub-regions and shall build upon, and be compatible with, relevant provisions for assessment and monitoring laid down by Community legislation, including the Habitats and Birds Directives, or under international agreements.
Water Framework Directive (WFD 2000)	Explicit	None	Explicit	Explicit	Article 8 sets out the requirements for the monitoring of surface water status, groundwater status and protected areas. States that monitoring programmes are required to establish a coherent and comprehensive overview of water status. For surveillance monitoring of surface waters Member States must monitor parameters indicative of all biological, hydro-morphological, and general physio-chemical quality elements. For operational monitoring, Member States are required to monitor quality elements most sensitive to the pressures to which that water body is subject.

International & national obligations	Monitoring Requirement				Explanation
	Inshore	Offshore	MPA	Wider environment	
Marine and Coastal Access Act (2009) Marine (Scotland) Act Marine Act (Northern Ireland)	Implicit	Implicit	Implicit	None	Monitoring of Marine Conservation Zones (MCZs) and Nature Conservation Marine Protected Areas (NCMPAs) is implicit in fulfilling the requirement of relevant authorities to assess and report on the extent to which conservation objectives for individual MPAs have been achieved within the reporting cycle (Section 124, Subsection 3 – MCAA; Sections 70 &103 – MSA, Section 21 - Marine Act NI). Under the Marine and Coastal Access Act, relevant authorities may direct the statutory nature conservation agencies to carry out monitoring of MPAs designated under the Act (Section 124).

Additional requirements and commitments

International & national obligations	Monitoring Requirement				Explanation
	Inshore	Offshore	MPA	Wider environment	
Wildlife and Countryside Act (WCA 1981)	Implicit	None	Implicit	None	The WCA consolidated previous national legislation to implement the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention. Section 28J implies the monitoring of SSSIs through the formation of a management scheme to conserve or restore the flora, fauna, or features of which the land (or the part of it to which the scheme relates) is of special interest. Some provisions of the W&C Act have been superseded by more recent national legislation (i.e. MCAA, MSA & Marine Act NI).
Common Fisheries Policy (CFP 2013)	Implicit	Implicit	Implicit	None	Although the CFP provides the basis for management of fishing activities, it does not provide regulations for the achievement of biodiversity targets for deep-sea benthic habitats, thus there are no formal monitoring requirements under the policy.

International & national obligations	Monitoring Requirement				Explanation
	Inshore	Offshore	MPA	Wider environment	
Common Fisheries Policy (CFP 2013)	Implicit	Implicit	Implicit	None	The European Commission favours the submission of joint recommendations for site based fisheries management measures. This requires all Member States with a vested fishing interest in the site under consideration to jointly develop proposals for fisheries management. EC guidance on submitting requests within MPAs, includes a list of 11 consideration points which include the need to measure, monitor and assess the maintenance and recovery of the features within the site (Point 9).
Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR 1998)	Explicit	Explicit	Explicit	Explicit	As a signatory to the OSPAR convention, delivery of the work programmes agreed under the convention is mandatory for the UK. Article 6 in conjunction with Annex IV (Article 2a) explicitly requires Contracting Parties to cooperate in carrying out monitoring programmes to support joint assessments of the quality status of the marine environment and to evaluate the effectiveness of the measures taken and planned for the protection of the marine environment.

International & national obligations	Monitoring Requirement				Explanation
	Inshore	Offshore	MPA	Wider environment	
Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR 1998)	Explicit	Explicit	Explicit	Explicit	The work carried out under OSPAR on monitoring and assessment has become legally underpinned by the MSFD. Failings in delivering the MSFD will lead to failings in delivering OSPAR commitments. Several commitments under OSPAR have been transposed into UK legislation, e.g. the need to designate MPAs for threatened or declining habitats and associated assessment requirements have been legally embodied in the MCAA and the MSA.
Convention on Biological Diversity (CBD 1992)	Explicit	Explicit	Explicit	Explicit	As a signatory to the CBD, delivery of the work programmes agreed under the convention is mandatory for the UK. Article 7 explicitly requires Contracting Parties to monitor biological components important for the conservation of biological diversity and sustainable use, particularly for the purposes of delivering the provisions set out in Articles 8 to 10 (e.g. to support the regulation and management of biological resources within or outside MPAs).

International & national obligations	Monitoring Requirement				Explanation
	Inshore	Offshore	MPA	Wider environment	
Ramsar Convention on Wetlands (1975)	Explicit	None	None	Explicit	As a signatory of the Ramsar convention, delivery of the work programmes agreed under the convention is mandatory for the UK. Article 3, Section 2 implies the requirement for surveillance of any wetland sites included on the List so that any ecological changes to the site which have occurred, are occurring or likely to occur because of technological developments, pollution, or other human interference, can be recognised.

To develop a scientifically robust monitoring programme for English and UK benthic habitats, that can meet all relevant Government obligations without being designed for any specific programme, it is necessary to consider what monitoring is needed without being constrained by what is specified in individual policy obligations. Rather, considering the ecology of the benthic habitats in the UK and the human pressures and impacts which they are subject to both inside and outside of MPAs will allow the real needs for habitats monitoring to be identified in an objective and repeatable manner, as well as any gaps in what is existing or proposed for monitoring under currently [2017] developing obligations, such as the MSFD.

This does not, however, mean that each habitat location must be directly monitored and the variation in the options for monitoring which are presented to Governments will reflect this (i.e. options will be presented that meet UK assessment and reporting obligations to greater and lesser extents, allowing the benefits and risk of selecting each option to be determined). Instead, enough data must be collected through direct and indirect monitoring activities which can then be brought together in such a way as to allow the assessment and reporting of the status of habitat types, and to robustly inform their management.

The wider process of defining broad options for monitoring marine biodiversity components requires a consideration of what, where and how to monitor the component of interest e.g. benthic habitats, marine birds, etc. Considering these aspects of monitoring design allows cost estimates to be provided for different levels of ambition, expressed as monitoring effort and evidence provided for assessments and management. This level of detail can allow policy makers and science advisors to take an informed decision on a preferred option [for each marine biodiversity component] with associated evidence benefits, risks and broad costs but with a remaining level of flexibility. Subsequently, the preferred option will then be explored in more detail during a design and evaluation phase, where the details of implementation can be defined and tested.

The alternative, of developing fully designed, evaluated and implementable monitoring designs as part of the options process would reduce flexibility, be prohibitively time consuming and would result in resources being heavily invested in developing options to a high level of detail that are ultimately not selected.

1.5. English Inshore Benthic Monitoring Prioritisation

To define broad options for monitoring EIBHs, a detailed prioritisation process was undertaken to consider what, where and how to monitor each of the benthic habitats.

In December 2016, a technical workshop was held by JNCC, attended by, Natural England and Natural Resources Wales (with input from SNH and DAERA beforehand), to agree an approach to prioritising habitats and MPAs for monitoring in offshore environments. This workshop successfully agreed a detailed offshore approach and provided a 'template' structure that allowed a similar approach to be taken for inshore habitats, whilst incorporating specific inshore needs.

The EIBH prioritisation process, follows the generic 'model' devised by JNCC and the CNCBs for offshore benthic habitat, which is also predominantly focussed on MPAs, but contained variations to accommodate inshore complexity.

The high level EIBH prioritisation process consists of three elements; numbers in brackets below reflect potential 'score' resulting from each element:

1. **Habitat Risk (4–20)**

The level of risk [England Inshore] to each monitoring habitat within each MPA. The risk value is calculated through the Natural England Vulnerability Assessment Approach.

2. **Habitat Importance (0–10)**

Quantity of Monitoring Habitat resource within each MPA.

   a. Polygonal data (0–5)

   b. Point data (0–5)

3. **Historical Monitoring Importance (0–10)**

   a. Historical survey adequacy (0–5)

   b. Number of habitat specific survey Events (0–3)

   c. Age of most recent survey (0–2)

For the English inshore, 46 discrete benthic monitoring habitat types were identified and prioritised across a suite of 74 MPAs. This resulted in 635 habitat locations being prioritised (both collectively and within type) at a national scale, and then filtered and interrogated at a regional sea scale. The detail of the prioritisation process is described in the associated NE paper: Benthic habitat monitoring prioritisation process.

Within the options scenarios below, habitat monitoring locations were principally selected from the top of the prioritised rankings, however where 'control' locations were required, locations were selected using their 'risk' score, identifying 'low' risk examples to enable a comparison.

The detailed analysis of the 74 MPAs with 635 habitat locations, was used as the basis of the wider prioritisation and costed option calculation. However, it must be noted, that in the English inshore there are currently [2017] another 193 MPA designations which have benthic habitat features (or supporting features) not yet fully covered by the analysis above (either spatially or in terms of additional techniques required). In additional to these 193 MPA designations, there are some 33 further SSSIs with benthic features that are wholly covered by these 74 MPAs (both spatially and technically) and are therefore not included in subsequent analysis. In addition, there will be a further tranche of MCZs to consider, and whilst we do not have the detail, this paper has modelled the inclusion of some 200 new benthic habitat's locations arising from an estimated 40 Tranche 3 MCZ additions (either new sites, or sites with additional features). All these sites and features form part of the overall MPA habitat resource to be monitored.

Table 2. (Image) Summary of MPA habitat locations lying outside the spatial footprint of the SAC and T1/2 MCZ pilot analysis, and how these elements were incorporated into the option analysis [table created in 2017].

designation type	number of MPAs	number of habitat locations	explanation	inclusion in optionsanalysis for;	
				Costs	% of habitat locations monitored
SSSI	104	203	Features examples lying outwith the geographical footprint of the detailed process	no	yes
SSSI	33	60	comtaining feature examles wholly covered by overlying SAC designation.	no	no
SPA	49	116	SPA supporting habitats within the footprint, but requiring additional resourcing consideration	yes	yes
		60	SPA habitat locations lying outwiththe footprint and requiring full consideration.	yes	yes
Ramsar	40	122	Ramsar features - wholly covered by SPA requirements	no	no
T3 MCZ	40	200	Potential T3 MCZs. New sites and new features in existing sites.	no	estimated

Note: Precise monitoring habitat numbers were gathered from individual citations. Those that qualified as a benthic monitoring habitat were incorporated for further analysis. The number of T3 MCZ sites suggested is estimated. Numbers of features stated for T3 MCZs are approximate based on an anticipated average of five benthic habitat features per new site.

1.6. English Inshore Benthic Monitoring: Costed option approach

The detail of the costed options, in terms of which habitat location are identified to populate the different monitoring options is based on the following stepwise approach.

All examples of monitoring habitat locations were assigned a Priority score (4–40), based on Risk (4–20), Habitat importance (0–10) and Historical monitoring importance (0–10).

All monitoring habitats were then assigned an MES (monitoring efficacy score: 1, 2 or 3), which is a categorisation based on expert judgement regarding how likely monitoring the habitat is to deliver meaningful results taking account of factors such as inherent natural variability, exposure, and practical ability to monitor (see Appendix A).

The MES score was used to assign a [maximum] number of replicate surveys for each habitat type in each CP2 region, and for each option (see Table 3).

The number of replicates was multiplied by an average survey cost (assuming on average a single survey would monitor 3 habitats), obtained from analysing real costs since 2013, with habitats being assigned to broad technique-based survey groups, such as inter-tidal hard substrate survey, or subtidal soft substrate grab survey. etc.

The habitat specific survey event costings were then multiplied by the number of times the habitat would need to be monitored in each 6 year reporting cycle (0.5 to 6). This step was again based on expert judgement, considering natural variability, and utilising our understanding of habitats specific power analysis where available (see Appendix A).

The survey costings per habitat, per CP2 region, were then summed for each option scenario, to provide an indicative value (based on SAC and T1 & T2 MCZ feature data).

For Options 2 to 5 costs were increased (see Table 10) to take account of the need for more robust monitoring (Type 2/3), across pressure/ management gradient.

This the produced a final costed options founded on a replicate based approach.

The final stage of interpretation was to present the costed options in terms of the proportion of designated benthic habitat examples that would be monitored across all designations under each option scenario. Thus, at this point MPA benthic habitat features of SSSIs (104), SPAs (49) and Ramsar sites (40) were incorporated, with additional estimation of the impact of T3 MCZs (40).

Figure 1. Flow diagram illustrating the generic process for generating costed options.

This approach has now been applied to English inshore benthic habitats and MPAs to identify a selection of habitat locations, MPAs and areas of the wider environment which have been prioritised for monitoring under the five options presented. The detail of the options is discussed in the following paragraphs, but in summary the options are as follows:

- Option 1: No targeted benthic biodiversity monitoring by Natural England or other Defra bodies.
- Option 2: Recent monitoring level. Modelling of the impact of using NE's recent monitoring effort (2014 to 2017), based on respective Grant in Aid settlement, on monitoring delivery across the entire suite of MPAs.
- Option 3: High priority MES MPA features monitored in high priority locations. Taking account of additional designations this represents a monitoring cost reduction of ~55%, per unit area of designated MPA since 2010–2011.
- Option 4: Priority MPA features monitored with substantive wider seas monitoring. Taking account of additional designations this represents a monitoring cost reduction of ~40%, per unit area of designated MPA since 2010–2011.
- Option 5: All MPA habitats monitored, with a balanced MPA/wider seas survey design. Taking account of additional designations this represents a comparable monitoring cost per unit area of designated MPA with 2010–2011.

1.6.1. Replication levels, proportion of features monitored and spread of monitoring effort

Summary information on the spread of monitoring effort, the proportion of features monitored, levels of replication proposed, and levels of statistical power achieved alter with progression through the option scenarios as presented in Tables 9 to 12. There is no clear guidance on the minimum acceptable levels of replication required, as this is a function of target levels for the effect size to be detected, the balance of Type 1 and 2 error, and the variance of the dataset. Three replicates are often used as a minimum, (for t-tests, ANOVA, and regression analysis), but only where variance is low, and these levels rarely pass peer review. Therefore, Natural England has proposed that a minimum of four habitat feature replicates is used per stratification where we would seek to provide a statistically defensible interpretation of the data. Four feature location examples (where possible), per inshore regional sea should allow an evidenced regional assessment of condition to be made.

Replication levels were assigned to the various habitats in accordance with their MES (Monitoring Efficacy Score), and the respective option. These are shown in Table 3.

In choosing the number of replicates proposed in each region Natural England has used the following overarching logic.

- One replicate – provides a single experimental data set per stratification (i.e. region, within MPA). This:
    - Provides sites specific understanding of pressure-state interactions, and/or efficacy of management measures at the highest risk habitat location within the region.
    - Provides a dataset that ***cannot*** be extrapolated to a regional level interpretation.
    - Provides a maximum of five habitat replicates at a national level, from which (dependant on variation) it should be ***possible*** to formulate a national level interpretation. Note: though possible, such a national interpretation would

have very low confidence because of variance between the regions, and that this sampling level provides no understanding of regional variance levels.

- Two replicates – provides two experimental data set per region. This:
    - Provides sites specific understanding of pressure-state interactions, and/or efficacy of management measures at the two highest risk habitat location within the region.
    - Provides a dataset that ***cannot*** be extrapolated to a regional level interpretation but gives us more interpretative information.
    - Provides a maximum of 10 habitat replicates at a national level, from which (dependant on variation) it would be ***likely*** that a national level interpretation could be formulated. Note: though likely, such a national interpretation could still have limited confidence because of a poor understanding of regional variance.
- Four replicates - provides four experimental data set per region. This:
    - Provides sites specific understanding of pressure-state interactions, and/or efficacy of management measures at the four highest risk habitat location within the region.
    - Provides a dataset, from which it is ***possible*** (dependant on variance) to formulate a statistically defensible, regional extrapolation of condition and trends.
    - *Note:* Provides a maximum of 20 habitat replicates at a national level, from which a national level interpretation ***can*** be formulated. This number of replicates would result in a high confidence result on the basis that national and regional variance would be well understood.

Where additional replicates have been added, this is where additional comparative elements are being introduced. These are:

- Five replicates – this is used under Option 3 for high MES habitats. Four of the replicates are as described above, but a fifth habitat example is introduced per region. The fifth example is the lowest 'risk' example of the habitat within the region. The inclusion of a low risk habitat gives a single low risk [unimpacted control] dataset to compare with the high priority data sets. This ***cannot*** be interpreted from more widely at a regional level but may ***possibly*** be used for national level interpretation.
- Eight replicates – this consists of the four highest priority and four lowest risk examples. This configuration:
    - Provides a ***possibility*** of statistical comparison of condition (and trends) between high priority and low risk examples at a regional scale.
    - Provides a dataset from which a national comparison of differential condition trends ***can*** be undertaken.

Replication levels per regional sea zone were fixed for each option scenario to allow for various levels of analysis, and associated confidence therein, to be obtained. Analysis of the breakdown of total MPA area and number of individual MPAs tended to support this approach, as proportionate to unit MPA area, the sampling intensity is relatively even across the regions – see Appendix E.

When considering wider sea replicates, these are again proposed as 1, 2, or 4 (dependant of the habitat's MES and the option. The logic behind how these datasets may be used is the same as described above.

Under each of the option descriptions, there is a table illustrating the forms of analysis that would be supported by the various replication levels. Within the Tables 5 to 7:

- No = no analysis or interpretation possible.
- Possible = statistically defensible analysis possible, but confidence will vary in accordance with: metric chosen, balance of Type 1 and 2 errors used, and the inherent habitat variability.
- Yes = statistically defensible analysis is likely, and that this should be accompanied by moderate or high confidence.

In describing the options below in more detail, we also illustrate how the various costed option would deliver for NE's vision of an integrated holistic English inshore marine biodiversity monitoring strategy, summarised in Appendix 4, and explained in more detail the NE paper entitled: Creating a Natural England marine monitoring programme: Strategic Overview.

Table 3. (Image) Maximum levels of replication per monitoring habitat, per CP2 region, per option [table created in 2017].

Option	Description	benthic habitat feature replicates (per CP2 region)							
		Within the MPA network				wider Sea			
		High MES	Mod MES	Low MES	total (max)	High MES	Mod MES	Low MES	total (max)
Option 1	do nothing	0	0	0	0	0	0	0	0
Option 2	funding status quo	2	0	0	2	0	0	0	0
Option 3	High Value MPA	5	2	1	8	1	1	0	2
Option 4	MPA and wider sea	8	4	4	16	4	**2**	2	8
Option 5	all	all	all	all	?	Replication out to match inside.			

2. Options summaries

2.1. Option 1: No targeted benthic biodiversity monitoring

No targeted benthic biodiversity monitoring by Natural England, or other Defra partners, except for monitoring undertaken by the Environment Agency under the Water Framework Directive. This option would rely on data collected for other purposes such as non-biodiversity targeted monitoring programmes (Table 4), vessels of opportunity and modelled data. It would not include the establishment of a coordinated and integrated monitoring programme. Notwithstanding the monitoring programmes identified in Table 4, we conclude that insufficient monitoring will be in place to deliver even a basic Type 1 assessment of change for any habitat across its English range, except for seagrass.

Table 4. Summary of indirect benthic biodiversity monitoring in English Inshore waters [table created in 2017].

Organisation	Survey focus	Applicability for biodiversity status assessments
EA Operational monitoring. (Note: EA programme undergoing strategic review in face of declining resources)	Seagrass	Delivers much of what is required for intertidal sea grass; good coverage.
	Blue mussel	Monitoring focusses on contaminants, but could be augmented to include metrics more useful to NE.
	Sediment infauna	Coverage restricted to coastal & transitional waters only (i.e. selected locations within 1 nm). Replication levels also insufficient for all NE purposes. Joint working already in progress.
	Opportunistic macro-algae	Indicator of a single pressure only. This element is an attribute for a suite of monitoring habitats but will not deliver enough for condition assessment of any specific one.
	Rocky-shore macro-algae	Very limited spatial coverage, therefore of limited use.
IFCAs	Small fish surveys	Ad hoc with indirect relationship to benthic habitats.
	Mussel stock assessment	Monitoring focusses solely on stock size, restricted national coverage. Limited value for wider biodiversity monitoring purposes.
	cockle stock assessment	Monitoring focusses solely on stock size, restricted national coverage. Limited value for wider biodiversity monitoring purposes.
CoCoast	Citizen science surveys of intertidal habitats	Helpful though evidence collection would need to be refined and augmented to provide long term status assessment; funding expires in 2019.
SeaSearch	Diver records	Helpful to assess broadscale habitat distribution but insufficient / requires significant augmentation to support long term status assessment.

Note: MarClim Rocky Shore monitoring is another potentially valuable programme, but as this is principally funded by Natural England, it is assuming that option 0 would result in its cessation.

2.2. Option 2: Recent monitoring level

Real terms funding for inshore benthic habitats monitoring has declined by 15–20% since 2010. Over the same period the area of designated benthic habitat has increased by 800% - with a further tranche of MCZs expected to be consulted upon this year. Therefore, taking these two elements together, there has already been an 88% reduction in resourcing for benthic habitats per unit area. In identifying and modelling this option, we have relied upon an anticipated funding scenario for 2018–2019 (of £900k - anticipated that some 40% will be routed from Cefas Grant in Aid through the work of the Marine Protected Area Group (MPAG)) and proposed how we would best deploy the available resource, to deliver monitoring across the entire designated MPA network.

In trying to model the impact of this restricted funding scenario on the ability to effectively monitor across the suite of MPA designations and monitoring habitats, we have presumed that:

- only high Monitoring Efficacy habitats will be monitored,
- inshore benthic habitat biodiversity monitoring will only be undertaken within the MPA network;
- that Type 2 or 3 monitoring approaches (as appropriate) will be applied in all locations, to maximise our ability to interpolate and extrapolate from findings.

Please refer to Tables 9 to 12 for a more detailed comparison of the option components.

Table 5 Illustrates what forms of analysis are supported (for monitored features) because of replication levels and coverage applied. Note: Only 14% of all MPA benthic habitat locations (as summarised in Table 2) would be monitored under this option.

Table 5. (Image) Analysis possible under Option 2 scenario [table created in 2017].

	option 2					
	Inside MPA			Outside MPA		
Key questions supported by analysis	High MES habitat	Mod MES habitat	Low MES habitat	High MES habitat	Mod MES habitat	Low MES habitat
Determine condition trends at particular habitat locations monitored.	yes	no	no	no	no	no
Statistically support a determination of feature condition trends at a national level.	yes	no	no	no	no	no
Statistically support determination of feature condition trends at a Regional level, enabling inter-regional	no	no	no	no	no	no
Understand pressure-state, interactions at specific feature locations where monitoring is undertken.	yes	no	no	no	no	no
Under stand pressure-state interactions at a regional scale, allowing inter-regional comparison.	no	no	no	no	no	no
Understand management effectiveness at specific feature locations where monitoring is undertken.	yes	no	no	no	no	no
statistically support a comparison of MPA and non MPA condition at a national scale	no	no	no	no	no	no
condition at a regional scale, enabling inter-regional comparison.	no	no	no	no	no	no

Under this scenario, 14% of habitat locations (overall) are monitored, and this is limited to high MES habitats only. 100% of effort is located within the MPA network, and maximum of 2 habitat examples are monitored per region.

This option will provide:

- condition trend determination at particular monitoring locations (where monitoring is undertaken), for high MES habitats;
- condition trend determination at a national level, for high MES habitats;
- an understanding of key pressure-state interaction/and or management efficacy at specific locations (where monitoring is undertaken), for high MES habitats.

This option will not provide:

- any direct monitoring information to assess condition or inform management for 86% of feature locations within the MPA network;
- any direct monitoring information to assess condition or inform management for any of the moderate or low MES habitat types;
- any ability to determine feature condition trends at a regional level, or to undertake comparisons between regions;
- an understanding of pressure-state interaction and management efficacy at a regional or national level;
- any information on benthic habitats outside the MPA network.

As this option has stringent prioritisation of high MES habitats, there will be instances where feature locations at high risk of deleterious anthropogenic impacts are not monitored. These will comprise Moderate and Low MES habitats within the MPA network and all habitats location in the wider sea, these only begin to be targeted from Option 3.

2.3. Option 3: High priority MPA habitats in high priority locations

The principal aim of this option is to obtain a statistically valid set of data for a subset of high-value monitoring habitats within the MPA network, with subsidiary aims to introduce some degree of monitoring for all benthic habitats within the MPA network, and to introduce a basic level of wider sea habitat monitoring. Table 6 provides a summary of what can be achieved under this option.

In summary, under Option 3:

- 32% of habitat locations within the MPA network will be monitored;
- monitoring extends to all MES habitats within the MPA network. Suggested effort between high, moderate and low MES habitats is split 60:30:10;
- wider seas habitat monitoring is undertaken for high and moderate MES habitats, with 80% of overall effort within the MPA network and 20% outside;
- Type 2 and 3 monitoring is undertaken for all high MES habitat examples monitored within the MPA network, or 50% of the habitat examples monitored within MPAs under this option.

Please refer to Tables 9 to 12 for a more detailed comparison of the option components.

Table 6. (image) Analysis possible under Option 3 scenario [table created in 2017].

	option 3					
	Inside MPA			Outside MPA		
Key questions supported by analysis	High MES habitat	Mod MES habitat	Low MES habitat	High MES habitat	Mod MES habitat	Low MES habitat
Determine condition trends at particular habitat locations monitored.						
Statistically support a determination of feature condition trends at a national level.						
Statistically support determination of feature condition trends at a Regional level, enabling inter-regional						
Understand pressure-state, interactions at specific feature locations where monitoring is undertken.						
Under stand pressure-state interactions at a regional scale, allowing inter-regional comparison.						
Understand management effectiveness at specific feature locations where monitoring is undertken.						
statistically support a comparison of MPA and non MPA condition at a national scale						
condition at a regional scale, enabling inter-regional comparison.						

This option will provide:

- condition trend determination at monitoring locations including examples of all MES habitat types, with the exception of low MES habitats outside the MPA network;
- condition trend determination at a national level for both high and moderate MES habitats within the MPA network, where monitoring is undertaken;
- possible condition trend determination for low MES habitats within the MPA network and for high and moderate MES habitats in the wider seas, where monitoring is undertaken;
- an understanding of key pressure-state interaction/ and or management efficacy at particular locations (where monitoring is undertaken), for high MES habitats, and information supporting a regional understanding;
- an understanding of pressure-state interactions at a feature location level (where monitoring is undertaken), with a possibility of pulling together a regional understanding.

This option will not provide:

- any direct monitoring information to assess condition or inform management for 68% of feature locations within the MPA network;
- any condition trend information for low MES habitats in the wider sea;
- feature condition trends at a regional level for any habitats outside the MPA network, or for moderate and low MES habitats within the network;
- an understanding of pressure state interaction for any habitats except for high MES habitats within the network.

- a definitive national assessment of feature condition between MPAs and the wider sea for any benthic habitats.

In summary, Option 3 delivers direct monitoring evidence for some instances of all habitat types within the MPA network and provides a limited amount of direct evidence of wider sea benthic habitat condition for comparative purposes.

Option 3 delivers a ~55% reduction in monitoring costs, per unit area of MPA, from that of 2010–2011 largely because of new site designation since this point.

2.4. Option 4: High and moderate priority MPA feature locations with substantive wider sea component.

This option expands monitoring across all MES habitats and significantly increases wider sea effort. For high MES habitats a regional low risk replicate group is introduced to greatly enhance our understanding of a greater range key pressure-state interaction. Effort on moderate and low MES habitat is also increased to deliver great statistical power at the site, regional and national scale – see Table 7.

In summary, under Option 4:

- 43% of habitat locations within the MPA network will be monitored;
- monitoring extends to all MES habitats within the MPA network. Effort between high, moderate and low MES habitats is split 50:25:25;
- wider seas habitat monitoring is undertaken for high and moderate MES habitats, with 67% of effort within the MPA network and 33% outwith;
- Type 2 or 3 monitoring is undertaken for at 33% of all monitoring locations, with 50% of moderate and high MES habitat locations inside the MPA network having Type 2 or 3 monitoring and 50% of high MES habitat locations outside the network also having Type 2 or 3 monitoring;
- additional effort associated with the monitoring of four SPAs per regional sea area will be incorporated. Four SPA replicates selected in accordance with the reasoning provided above.

Please refer to Tables 9 to 12 for a more detailed comparison of the option components.

This option will provide:

- condition trend determination for high, moderate and low MES habitats at all locations monitored;
- condition trend assessment at a national level for all habitats monitored;
- regional assessment of trends for high MES habitats, supporting inter-regional comparative analysis;
- an understanding of pressure state interaction and management efficacy at a feature location level for all high MES habitats and for moderate MES habitats within the MPA network (where monitoring is undertaken);
- an understanding of pressure-state interactions at a regional level for high MES habitats (where monitoring is undertaken), supporting inter-regional comparative analysis;

- a statistically robust comparison between feature condition within and outside the MPA network for all MES habitats nationally, and for high and moderate MES habitats at a regional scale;
- an assessment of the condition of SPA supporting habitats at four SPAs, which can be aggregated to provide a national condition picture.

This option will not provide:

- any direct monitoring information to assess condition or inform management for 57% of feature locations within the MPA network;
- any ability to assess pressure-state interaction or the efficacy of management measures for low MES habitats, within the MPA network, at a regional or national level;
- any ability to assess condition trends, pressure-state interaction or the efficacy of management measures for low and moderate MES habitats, in the wider sea, at a regional or national level;
- a comparison of low MES feature condition trends within and outside the MPA network at a regional or national scale.

Table 7. (Image) Analysis possible under Option 4 scenario [table created in 2017].

	option 4					
	Inside MPA			Outside MPA		
Key questions supported by analysis	High MES habitat	Mod MES habitat	Low MES habitat	High MES habitat	Mod MES habitat	Low MES habitat
Determine condition trends at particular habitat locations monitored.						
Statistically support a determination of feature condition trends at a national level.						
Statistically support determination of feature condition trends at a Regional level, enabling inter-regional						
Understand pressure-state, interactions at specific feature locations where monitoring is undertken.						
Under stand pressure-state interactions at a regional scale, allowing inter-regional comparison.						
Understand management effectiveness at specific feature locations where monitoring is undertken.						
statistically support a comparison of MPA and non MPA condition at a national scale						
condition at a regional scale, enabling inter-regional comparison.						

2.5. Option 5: Monitoring all MPA designated habitat examples with a balanced in/out experimental design.

This option is presented to represent the cost of a comprehensive monitoring package. All MPA habitat's locations will be monitored, with an equal amount of effort given to wider seas monitoring. Funding at this level will deliver statistically robust evidence on condition status trends, pressure state interactions and the efficacy of management measures for all MPAs and in the wider seas.

In summary, under Option 5:

- 100% of habitat locations within the MPA network will be monitored;
- monitoring effort in the wider sea will match that for the MPA network;
- Type 2 or 3 monitoring will be undertaken at 50% of locations (as not all situations will be amenable to this approach);
- under this option, the additional monitoring costs associated with monitoring of all SPA (and Ramsar) supporting features are incorporated.

Table 8. (Image) Table illustrates what forms of analysis are supported (for monitored features) because of replication levels and monitoring frequency – Option 5 [table created in 2017].

	option 5					
	Inside MPA			Outside MPA		
Metric	High	Mod	Low	High	Mod	Low
determine trends in feature condition at a feature location level						
statistically support a determination of feature condition trends at a national level						
statistically support a determination of feature condition trends at a Regional level						
Understand pressure-state, interactions at a feature location level						
Under stand pressure-state interactions at a regional scale						
Understand management, effectiveness at a feature location scale						
statistically support a comparison of MPA and non MPA condition at a national scale						
statistically support a comparison of MPA and non MPA condition at a regional scale						

This option will provide:

- condition trend determination at all monitoring habitat locations inside and outside the MPA network;
- condition trend assessment at a regional and national level for all habitats monitored;
- an ability to statistically compare the performance of condition trends for all habitats within and out-with the MPA network at a regional and national scale;
- regional assessment of trends for high MES habitats;
- provide statistically robust data to assess the condition of SPA and Ramsar supporting habitats at a site, regional and national level.

Elements that Option 5 does not cover:

- an understanding of pressure state interaction in all situations. In inshore waters, many of the 39 pressures stemming from 101 activities are overlapping, no attempt has been made to cost the monitoring of more than one pressure in each location. In addition, the funding level expressed for the option does not include any estimation for investigative monitoring linked to novel impacts.

2.6. Summary comparison of the various elements delivered under each option

The following section summarises the changes in a few elements as we move through the options using several tables. The elements which vary through the options are:

- levels of habitat replication (Table 3);
- the relative proportions of monitoring effort the different MES habitats (Table 9);
- the number and proportion of monitored habitat locations that will be monitored using a more detailed Type 2 or 3 design (Table 10);
- the relative proportions of monitoring effort targeted inside and outside the designated MPA network (Table 11);
- an indicative comparison of feature proportion monitoring effort between the NE options and the JNCC options (Table 12).

2.7. Spread of effort across High, Mod & Low MES habitats.

Natural England is taking a risk-based approach to allocating the proportion of available monitoring resources. In the most restricted of scenario monitoring is limited to high MES habitats only, as better funded scenarios are presented, we propose spreading the effort to include moderate and low MES habitats – so that we have direct evidence with which to underpin assessment and reporting for all monitoring habitats. However, the highest resources portion is always targeted at high MES habitats.

Table 9. Monitoring effort (as a percentage of overall effort) given to features with differing Monitoring Efficacy Values [table created in 2017].

Option number	Description	Monitoring effort (%)		
		High MES	Mod MES	Low MES
Option 1	no targeted benthic biodiversity monitoring	0	0	0
Option 2	funding status quo	100	0	0
Option 3	High Value / MPA	60	30	10
Option 4	MPA and wider sea	50	25	25
Option 5	all	-	-	-

2.8. Use of Type 2 or 3 monitoring approach

Whenever a habitat is selected to be monitored, there will be a Type 1 approach taken. However, to understand pressure-state interactions, and investigate the impact of pressures, or the efficacy of management measures, a Type 2 or 3 approach is required. In the complex inshore zone, it is expected that the typologies will be nested in an overarching survey design. For assigning costs, we have assumed that a Type 2 or 3 approach would result in a doubling of survey costs. This is conservative as it would only encompass one stratification.

Understanding pressure state interactions or management measure effectiveness is a crucial output from a monitoring programme, allowing interpolation, extrapolation, and the

provision of evidence to underpin management advice. Table 8 shows how we proposed to target Type 2 or 3 monitoring. Under Option 2 there are very few replicates, so it is essential that we undertake Type 2 or 3 in all locations to generate the best dataset from these. As we move up through the options, the proportion of Type 2 or 3 monitoring decreases (although the number of incidences increases). This assumes that we can effectively extrapolate from a suitable subset of locations. For Option 5 (do all), the proportion is increased again.

Table 10. (Image) Instances of Type 2 or 3 monitoring across the options [table created in 2017].

Option	Description	number of replicates with type 2/3 monitoring (per CP2 region)								
		Within MPA network				outside MPA network				combined
		High MES_in	Mod MES_in	Low MES_in	% with type 2/3 monitoring	High MES_out	Mod MES_out	Low MES_out	% with type 2/3 monitoring	total % with type 2/3 monitoring
Option 1	do nothing	0	0	0		0	0	0		
Option 2	funding status quo	2(2)	0	0		0	0	0		
Option 3	High Value MPA	4(5)	0(2)	0(1)		0(1)	0(1)	0		
Option 4	MPA and wider sea	4(8)	2(4)	0(4)		2(4)	0(2)	0(2)		
Option 5	all	all	all	all		match inside MPA level.				

Note: numbers in parentheses refer to total number of replicates.

2.9. Spread of effort between MPA and wider seas

In moving through the options, NE have increased the proportion of wider seas monitoring, so that the big questions, such as 'are MPAs delivering biodiversity benefits?' can be addressed.

Table 11. Monitoring effort split between MPAs and wider sea area, for the different options [table created in 2017].

Option number	Description	Monitoring effort (%)	
		MPA	Wider Sea
Option 1	no targeted benthic biodiversity monitoring	0	0
Option 2	funding status quo	100	0
Option 3	High Value / MPA	80	20
Option 4	MPA and wider sea	67	33
Option 5	all	50	50

2.10. Proportion of feature examples to be monitored.

Table 12. Summary of proportion of habitat examples (from within the MPA network) monitored, monitored under each option. Note italicised cell represents policy preference for the offshore benthic option [table created in 2017].

Option	% of MPA habitat examples monitored	
	NE inshore habitats	JNCC offshore habitats ***
Option 1	0.5 *	-
Option 2	14 **	54
Option 2.5	-	*54*
Option 3	32	70
Option 4	42	-
Option 5	100	-

* Best guess.

** Modelled.

*** Note that offshore and inshore options are not directly comparable. This figure simply illustrates how the options effect the proportion of habitat examples monitored.

2.11. Indicative costs and coverage across options

The generic process of generation the costed options is presented in in Figure 1.

Once each monitoring habitat type had been assigned a Monitoring Efficacy Score (MES), the number of replicates per option was selected, in accordance with figures in Table 7.

Within each habitats type, prioritisation and risk scores were used to identify which habitats would be monitored in each MPA for each of the options. Note this detailed prioritisation was undertaken for the 634 habitat locations found within the 74 SACs and Types 1 and 2 MCZ (of the 74 SACs and Types 1 and 2 MCZs).

Within each MPA, the habitats selected for monitoring were clustered by the 'monitoring technique/approach' required, and a single survey event costed for to cover all clustered habitats in each site, in accordance with the costings in Table 12. Survey costs were extracted from NE let monitoring contracts from 2012–2017 and reflect costs of delivery through partnership agreement (such as with the Environment Agency) and are thus err towards the economical side.

So, for example: Under Option 3, 13 benthic habitats within Dover to Deal MCZ were selected for monitoring. Five of these habitats were found on intertidal hard substrate, resulting in a costing for a single survey for all five features. Using the table below, this was costed at £18k for the 'core' survey (to cover mobilisation and one feature, and 4*£5k, to cover the four additional habitats. Thus, an intertidal hard substrate survey (of five features) was costed at £38k.

The survey costs were then multiplied by the habitat specific required frequency as outlined in Appendix A. Not all the habitats within a 'monitoring technique' cluster will have the same required frequency, so for generating the required 'survey' frequency, these were averaged – column 4, Table 12. Thus, continuing the same example, £38k *2.3 = £87.4k per reporting cycle or £14.5k per annum in total, or £3k per feature per annum.

Table 13. (Image) Unit survey costs and survey frequency - used to build up the costed options [table created in 2017].

survey technique grouping	core survey cost	cost per additional feature surveyed	average frequency per reporting cycle
Intertida hard substrate	18	5	2.3
Intertidal soft substrate	20	7	2.3
Infralittoral rock	25	7	1.3
circalittoral rock	25	7	2.2
subtidal sediments	25	7	2.5
Dive	25	20	4.5
intertidal seagrass	3		6.0
other	20	7	3.4

For Options 4 and 5, an element of additional costs for the monitoring of SPA (and Ramsar) supporting features was introduced. Over the 49 SPAs, there were an average of three supporting benthic habitats per SPA that consisted of two intertidal soft sediment and a single intertidal hard substrate. NE assumed that for the intertidal hard substrate there would be negligible additional cost to obtain the SPA supporting information, but that there would be additional costs for soft substrates. For soft substrate SPA supporting habitats, additional infaunal analysis is required, and we suggest that two surveys be included in this option within the target survey year. Thus, for SPA supporting habitats:

- where that spatially overlapped with SAC and MCZ habitats already targeted for intertidal soft substrate surveys (66%), then an additional survey cost for two features was included;
- where the SPA supporting habitat is outside the footprint of the SACs and Types 1 and 2 MCZ (34%), a costing for two surveys for two features was added.

Under Option 4, SPA monitoring for four SPAs per CP2 region was applied, and for Option 5, all 49 SPA costs were applied.

The steps above generated the costed options presented in Figure 2, however, it is also necessary to describe what proportion of MPA habitat examples are covered by these costs. In generating these monitoring habitat proportion, it is assumed that:

- SSSI MPA benthic habitats that lie within the SAC and Types 1 and 2 MCZ footprint require no additional consideration;
- Ramsar benthic supporting habitats are fully covered by SPAs, and again require no further consideration.

Therefore, when considering the final proportions of MPA benthic habitat location covered by each option, NE are considering MPA benthic feature location from:

- 104 SSSI (203 habitat locations), which fall falling outside the spatial footprint of the detailed SAC and Type 1 and 2 processes;
- 49 SPAs (176 habitat locations), both within and outside the spatial footprint. Incorporated into the process within Options 4 and 5;
- 40 Ramsar (122 habitat locations), covered by inclusion of SPA habitats;

- 40 estimated potential Type 3 MCZs (200 estimated habitat locations).

Important note: the costed options do not include Natural England staff costs. NE staff time will need to be factored into all scenario (including Option 1). For Option 1, staff costs would need to be predominantly directed to modelling, third party data collation, increased engagement a range of partners from academia to industry to citizen science. For Option 2, staff costs would be targeted at a combination of contract management and partnership engagement. Under Options 3 to 5, staff costs would be predominantly on contract management and survey delivery. Staff costs associated with assessment and reporting will be required for all options.

It is assumed that staff costs would remain broadly at the current [2017] level for Options 1 and 2, but that these would begin to increase for Option 3 and continue through Options 4 and 5. As we look to Options 3, 4 and 5, associated staff costs would represent a small proportion of the additional budget required.

2.12. Final costed options – headline figures

Figure 2 illustrates the headline costs for the 5 options, with a more detailed breakdown of the various components presented in Figure 3.

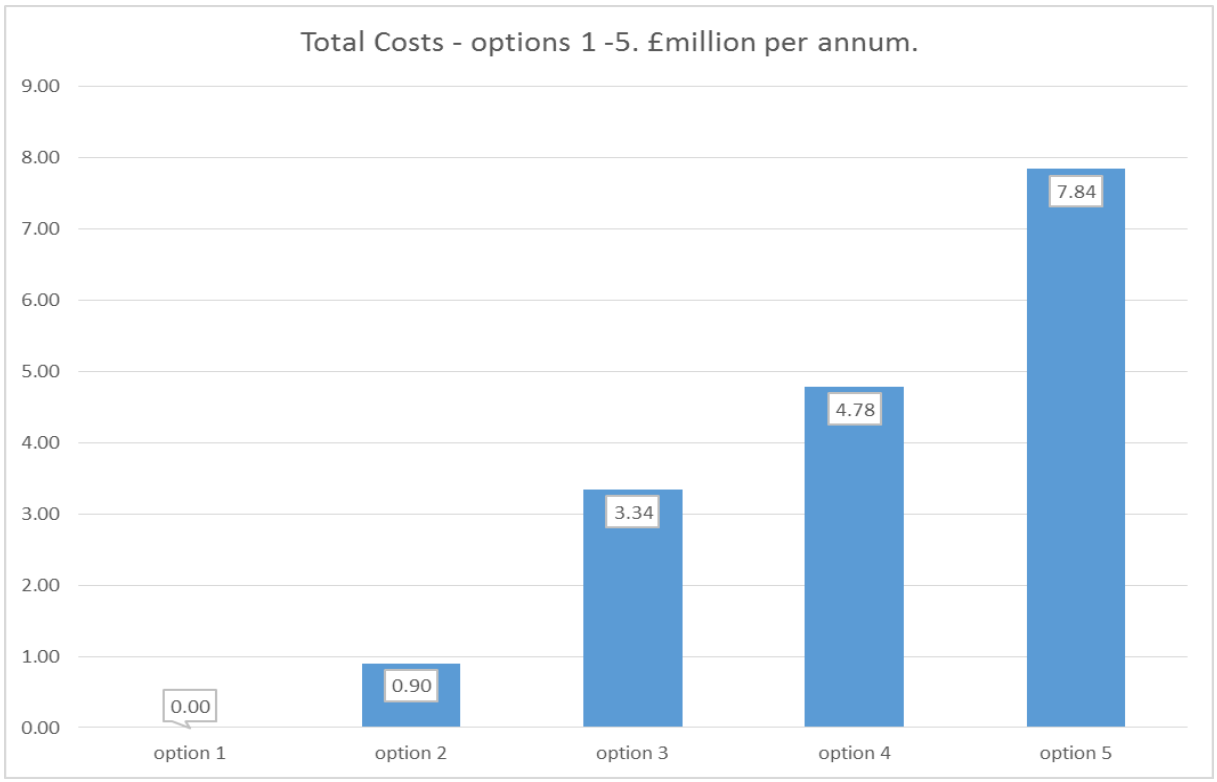

Figure 2. Costs of direct benthic habitat monitoring (per annum) associated with Options 1 to 5. Note: Natural England staff costs are not included in these costings [figure created in 2017].

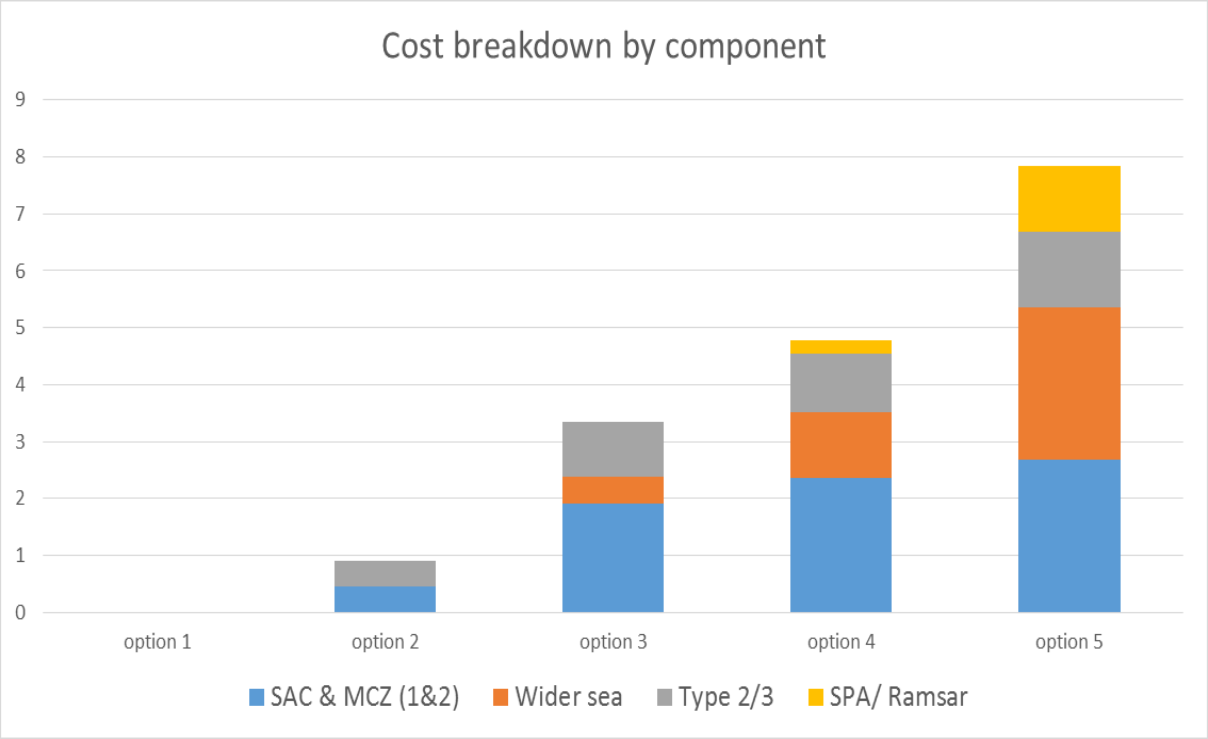

Figure 3. Option costs broken down into their constituent components. Note staff costs note included [figure created in 2017].

Figure 4 illustrates the proportion of total MPA benthic habitat locations that would be directly monitored under each option. Figure 5 illustrates the proportion of MPAs visited.

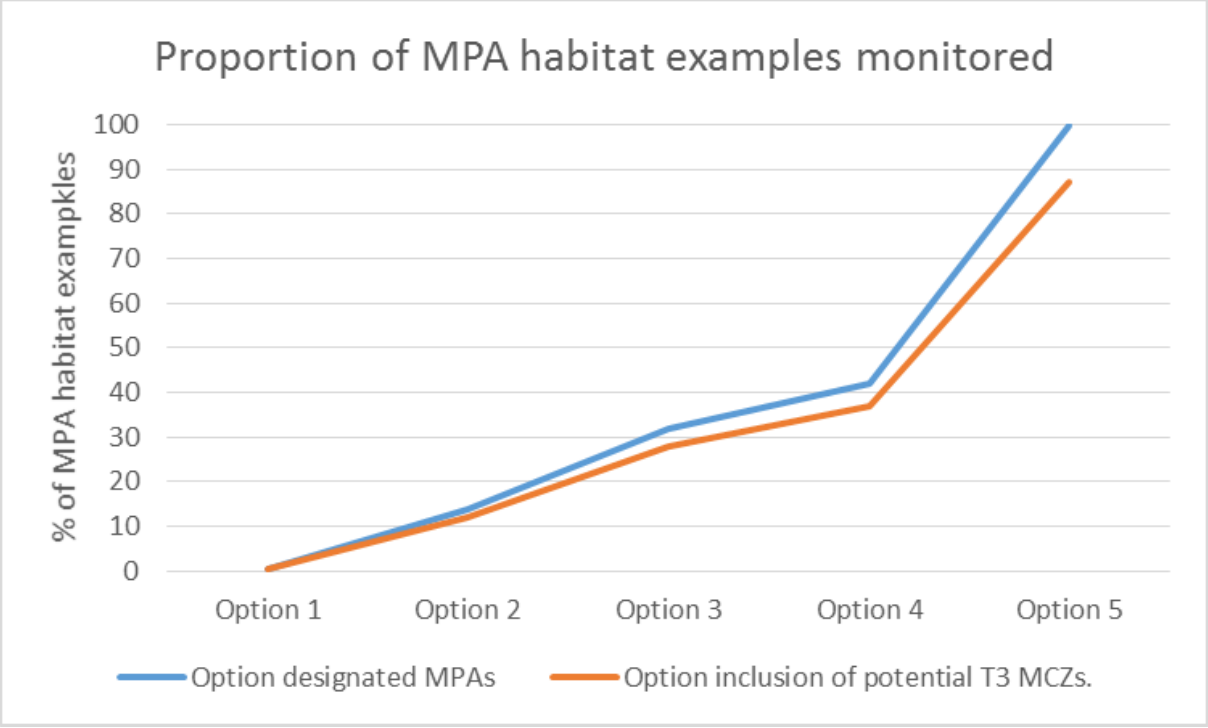

Figure 4. Proportion of features directly monitored [figure in 2017].

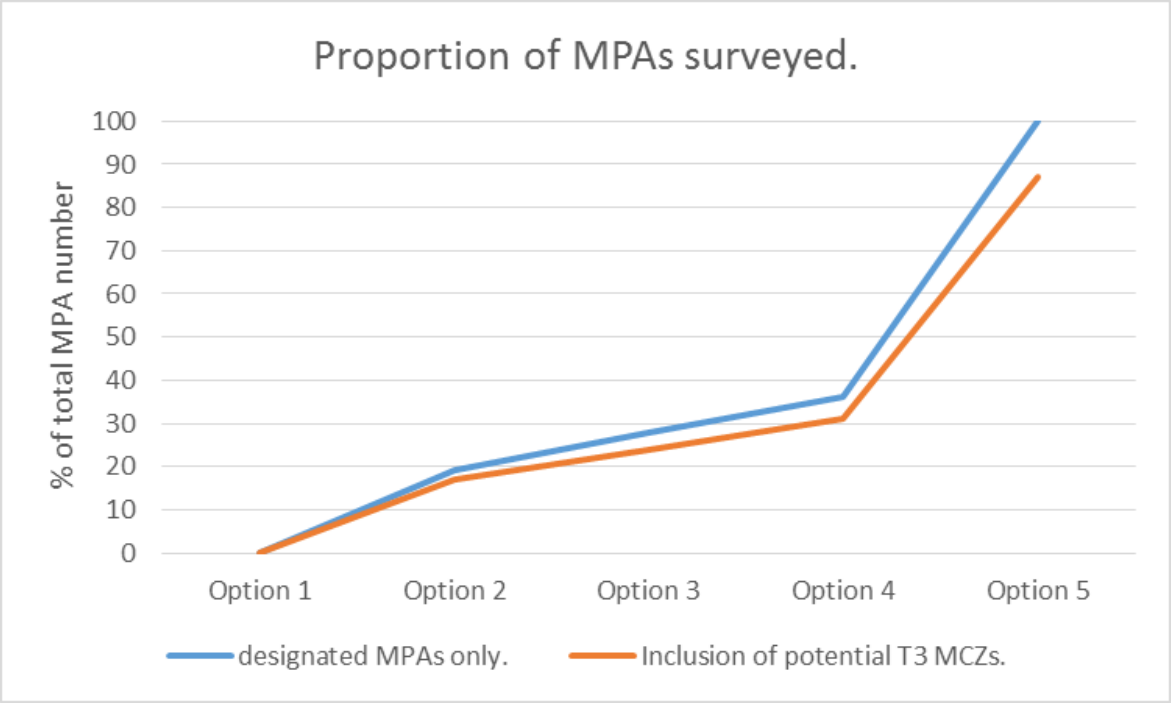

Figure 5. Proportion of MPAs surveyed under each option, and potential impact of possible Type 3 designations [figure created in 2017].

Figures 6 to 10 illustrate how the various option scenario result in feature level monitoring across the designated MPA network. All designated MPAs are represented by a small pie-chart, subdivide by the number of benthic monitoring habitats in each site. When a monitoring habitat is NOT monitored, it is red, when partially monitored it is amber, and when fully monitored it is green.

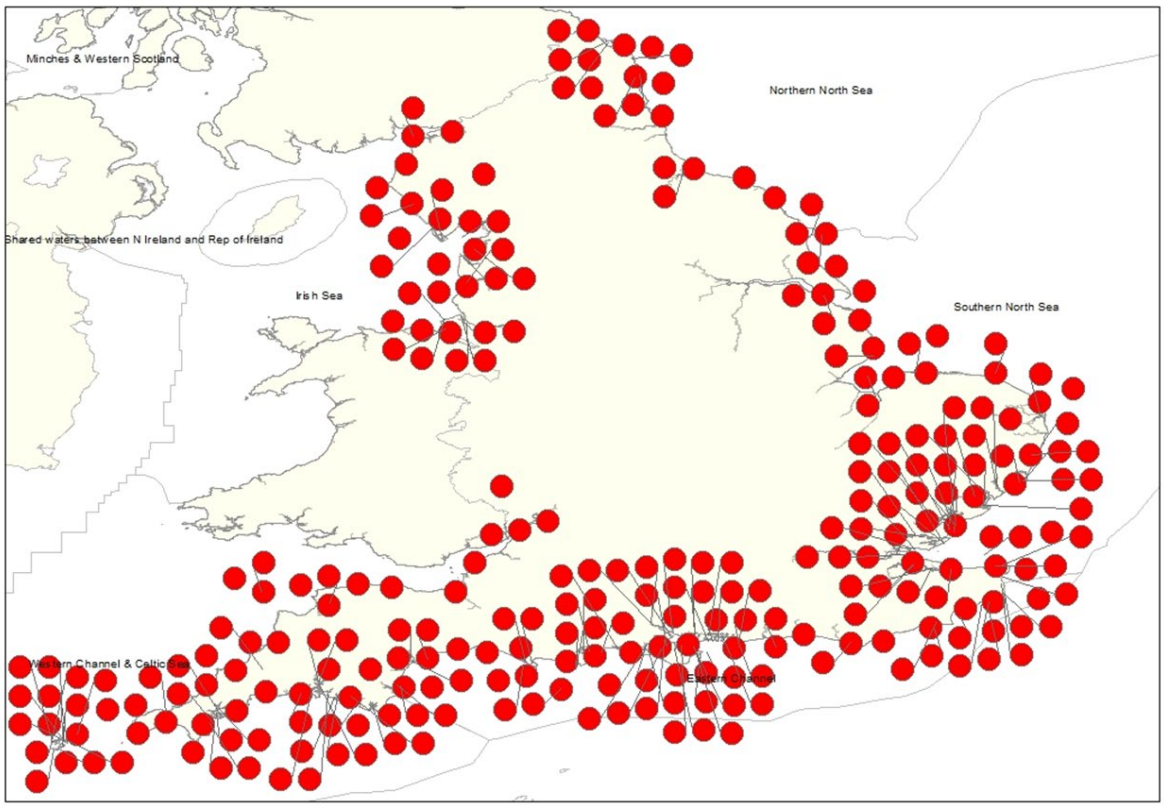

Figure 6. MPA site/habitat monitoring – Option 1 [figure created in 2017].

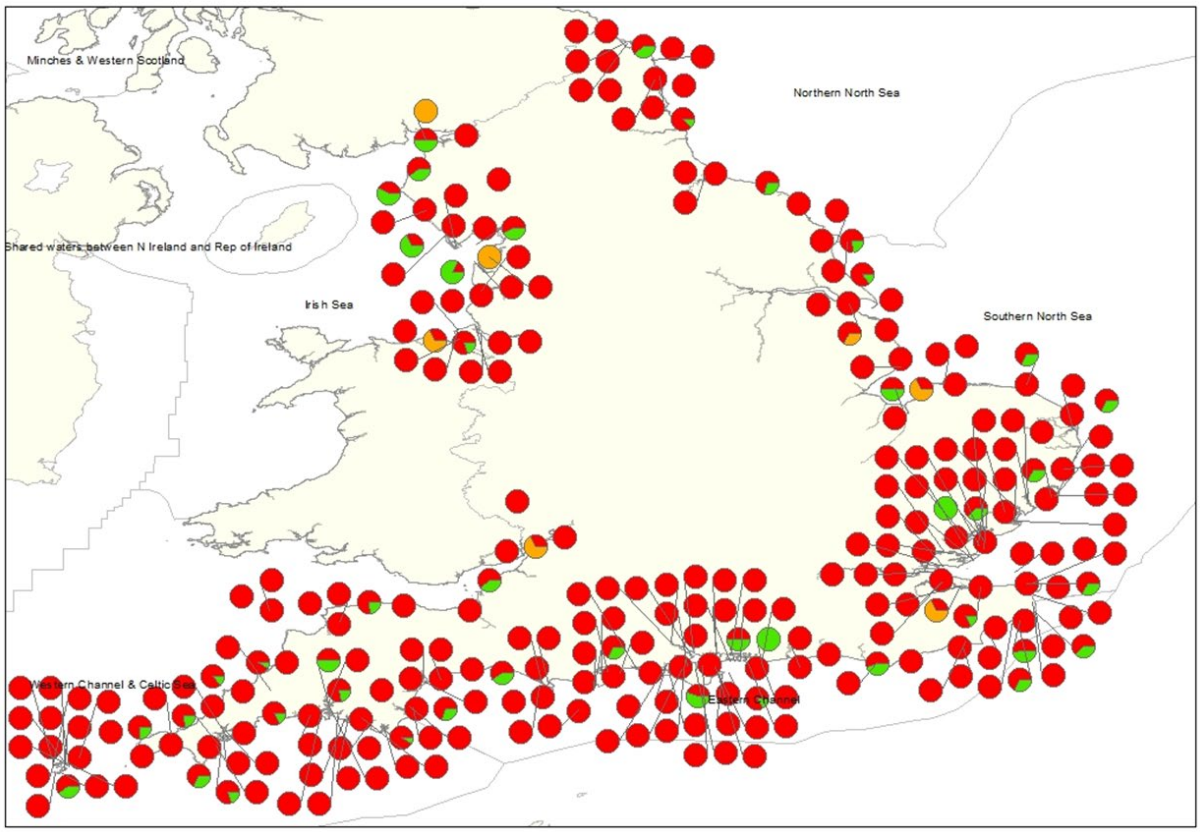

Figure 7. MPA site/habitat monitoring – Option 2 [figure created in 2017].

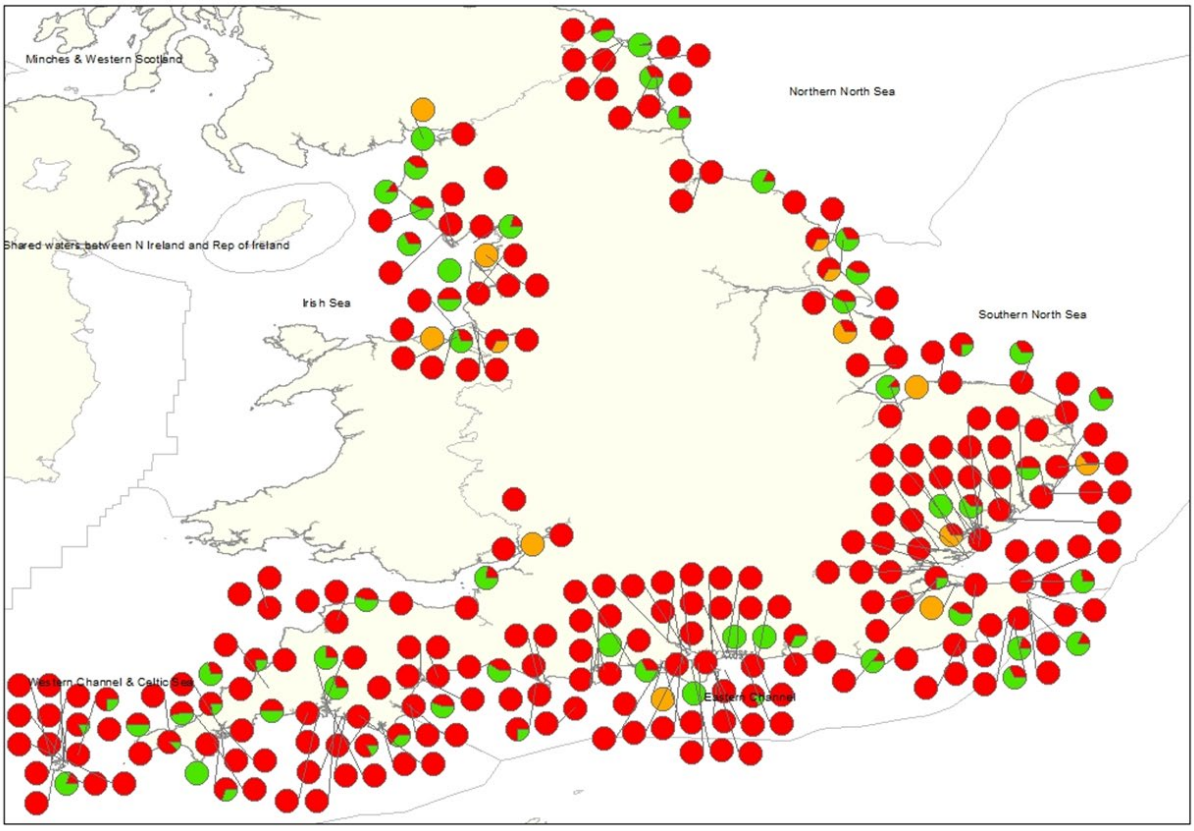

Figure 8. MPA site/habitat monitoring – Option 3 [figure created in 2017].

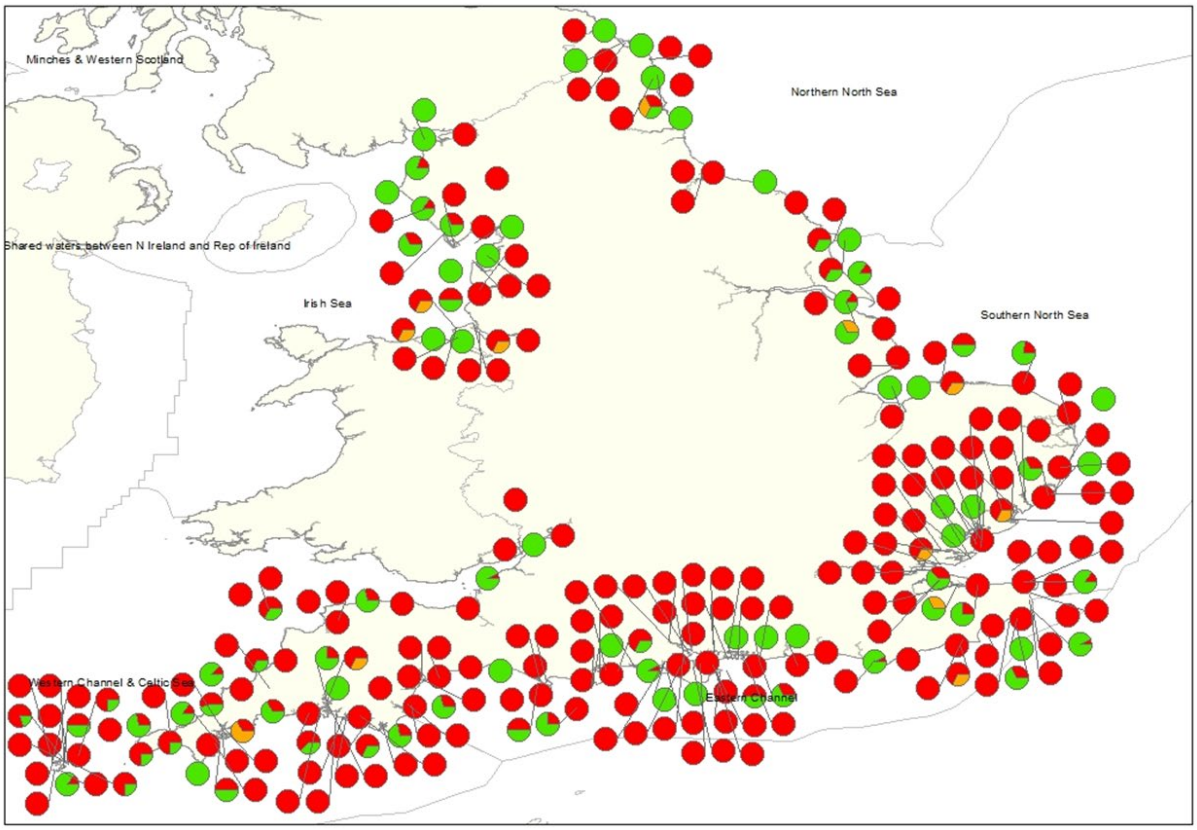

Figure 9. MPA site/habitat monitoring – Option 4 [figure created in 2017]

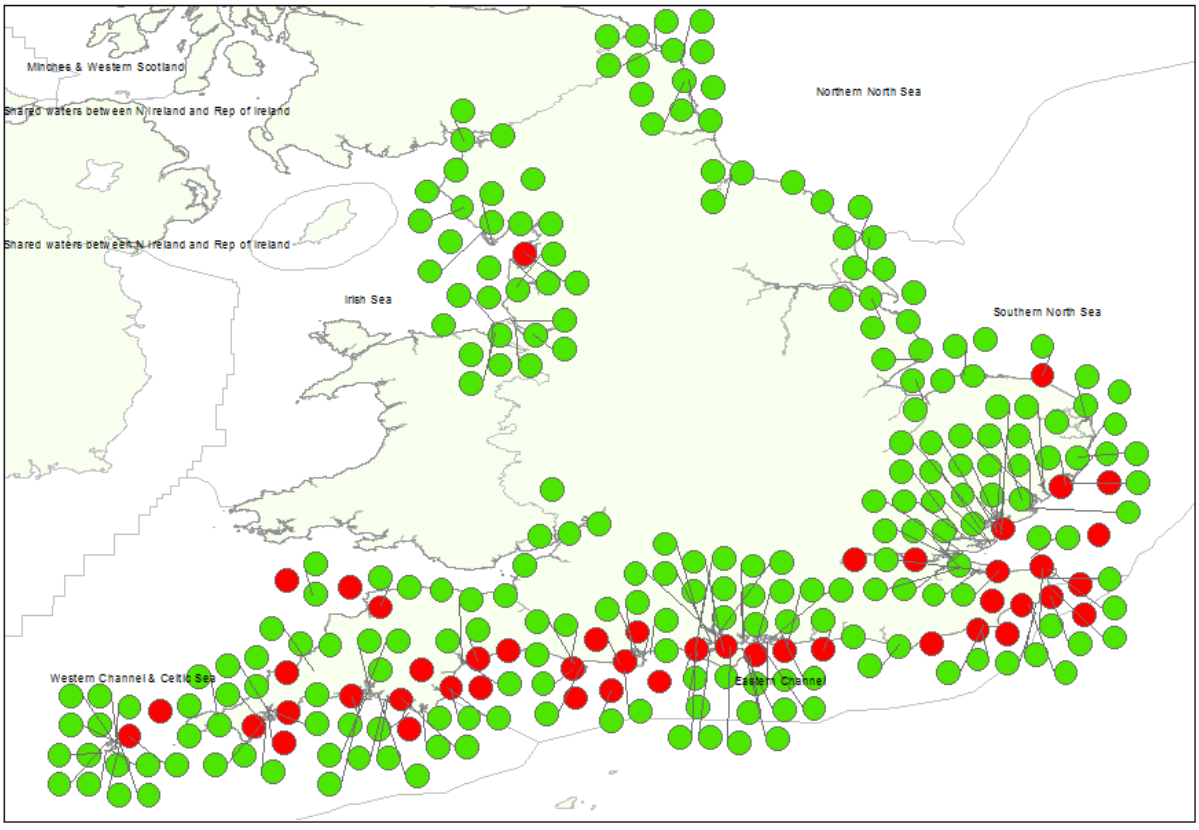

Figure 10. MPA site/habitat monitoring – Option 5. Note: sites still red are potential Type 3 MCZs [figure created in 2017].

3. Discussion

For Options 1 to 5 the evidence requirements delivered and associated risks/limitations are outlined in the Table 14. Note proportions do not include proposed Type 3 MCZs and their features.

Table 14. Evidence provision, risks, and limitations of each costed option [table created in 2017].

Option	Evidence requirements delivered	Risks and limitations
1	No/*de-minimus* evidence gathered for most inshore benthic habitats. Highly limited and ad-hoc evidence delivered at a variable scale and quality for approximately 30% of English Inshore Benthic Habitats (EIBH). Structured though incomplete evidence delivered for seagrass.	Spatial and temporal resolution of data required to assess and manage MPAs effectively is not provided, even for a sample of MPAs. Explicit and implicit monitoring requirements under the Habitats Directive 1992 (HC) would not be met, resulting in a risk of infraction by the European Commission. Explicit requirements to monitor marine habitats for Good Environmental Status (GES) under the Marine Strategy Framework Directive (2008) (MSFD) would not be met, resulting in a risk of infraction by the European Commission. Implicit monitoring requirements under the Marine and Coastal Access Act (2009) (MCAA) and the Wildlife and Countryside Act (1981 as amended (WCA) would not be met resulting in the continued lack of empirical information required to inform Secretary of States report to Parliament. Type 2 or 3 monitoring to understand pressure – state relationships and detect the effectiveness of management measures would not be delivered. Adaptive management ambitions would not be supported to any degree by this option. In conjunction with the paucity of pressure data (particularly for inshore fisheries), this option would require modelled assessments with low/ or very low confidence, declining further over time. Existing monitoring programmes will not provide the necessary coverage or statistical power to assess the condition of a large majority of inshore benthic habitats within and beyond MPAs. Inconsistencies in data collection and analysis techniques arising from ad-hoc monitoring approaches applied to a minority of inshore benthic habitats would result in data that would not support robust assessments of condition at larger spatial scales or inform specific management decisions.

Option	Evidence requirements delivered	Risks and limitations
2	Only High priority examples of high MES habitats will be monitored within the MPA network. 14% of EIBH examples would be directly monitored, and therefore could be assessed against their conservation objectives using direct monitoring data. 19% of English inshore MPAs would have some monitoring. At an England scale example of 72 % of EIBH types will be monitored. Type 1, 2 & 3 monitoring approaches will be undertaken at all locations to maximise evidence value for site based advice and wider interpolation and extrapolation. Long term time series focusing on, pressure-state relationship monitoring to inform management, indicator development and target setting plus Type 3 monitoring to inform management decisions and adaptive management cycles will be established for a sample of sites.	80% of English inshore MPAs will not have any direct monitoring. For high MES habitat examples in MPAs not monitored, habitat condition would need to be inferred from modelled data or the condition of the relevant representative MPA examples – if available. 18% of English inshore habitat types will not be monitored at all, condition would need to be modelled with result <=low confidence. Provided monitoring locations are located within SAC site boundaries, Explicit and implicit monitoring requirements under the Habitats Directive 1992 (HC) would be partially met, as there is incomplete coverage of habitat types and examples, there is still a risk of infraction by the European Commission. As all monitoring is restricted to the MPA network, the explicit requirements to monitor marine habitats for Good Environmental Status (GES) under the Marine Strategy Framework Directive (2008) (MSFD) would not be adequately met, resulting in a risk of infraction by the European Commission. Implicit monitoring requirements under the Marine and Coastal Access Act (2009) (MCAA) and the Wildlife and Countryside Act (1981 as amended (WCA) would be limited to designated SSSI features that spatially overlap with targeted SACs, therefore largely not be met. resulting in the continued lack of empirical information required to inform Secretary of States report to Parliament. The low level of monitoring replication in this option will prevent robust condition trend conclusions being drawn at a regional sea and will only support a national trend assessment for high MES habitats with moderate confidence. No wider sea benthic monitoring will be undertaken; therefore, the condition of the wider environment would need to be inferred from modelled data or proxy information on the location of pressures, etc. This would result in wider environment assessments of GES and FCS having associated low confidence. There will be no ability to assess whether the English inshore MPA network is delivering any biodiversity benefits due to the absence of wider sea environmental monitoring.

Option	Evidence requirements delivered	Risks and limitations
2		The limited MPA coverage in conjunction with the lack of wider sea monitoring would reduce our ability to determine whether changes detected at the MPA habitat scale are part of larger scale processes/changes, such as climate change. Where knowledge of the relationship between pressure and habitat state is limited, the lack of information on wider scale trends may result in overly precautionary management measures at the MPA scale because of erroneous conclusions regarding the cause of observed local changes, based on best available but limited information. Emergent wider scale issues may be missed, or their detection substantially delayed due to lack of wider environment monitoring, resulting in potentially irreversible damage to biodiversity and ecosystem services.
3	Builds upon Option 2 Replication level for high MES habitats within MPAs is increased. 32% of EIBH examples would be directly monitored, and therefore could be assessed against their conservation objectives using direct monitoring data. 28 % of English inshore MPAs would have some monitoring. Additionally, examples of Moderate and Low MES habitats are monitored within the MPA network, therefore, all EIBH types are monitored at a regional seas level. Type 2 & 3 monitoring is applied to high MES habitats	72% of MPAs and 68% of EIBH examples will not be monitored, habitat condition would need to be inferred from modelled data or the condition of the relevant representative MPA examples – if available. With the increased level of replication and monitoring all habitat types, coupled with an increased confidence associated with interpolation and extrapolation, the explicit and implicit monitoring requirements under the Habitats Directive 1992 (HC) would be either partially or substantively met. However, with only 1/3 of habitat examples monitored, there may still be a significant risk of infraction by the European Commission. With enhanced monitoring within the MPA network, and some limited monitoring outside the MPA network, the explicit requirements to monitor marine habitats for Good Environmental Status (GES) under the Marine Strategy Framework Directive (2008) (MSFD) would be either partially or substantively met, resulting in an overall reduction in the risk of infraction by the European Commission, though the residual risk may still be significant. Implicit monitoring requirements under the Marine and Coastal Access Act (2009) (MCAA) would be met in part as monitoring will encompass a small subset of MCZs. Condition for 68% of habitat examples across 72% of MPAS would need to be modelled. Implicit monitoring requirements under the Wildlife and Countryside Act (1981 as amended (WCA) would be limited to designated SSSI features that spatially overlap with targeted SACs, therefore still largely not be met. resulting in the continued lack of empirical information required to inform Secretary of States report to Parliament.

Option	Evidence requirements delivered	Risks and limitations
3	within the MPA network only. Limited [type 1] monitoring is undertaken in the wider sea – limited to high and mod MES habitat types.	Monitoring replication level supports a statistically valid assessment of condition trends for high MES habitats within the MPA network, at both a regional and National scale, which should result in the ability to draw conclusions with low and mod-high confidence respectively. For moderate and low value MES habitats statistically valid assessments of condition trend at a regional level are not possible but can be undertaken at a national level with moderate and low confidence respectively. Wider sea monitoring is limited to high and moderate MES habitat types with by low levels of replication. At best, there will be a low likelihood of picking up national trends outside of MPAs, and if picked up any assessments would have a low confidence. Therefore, the condition of the wider environment would need to be augmented by modelled data and proxy information on the location of pressures and habitat vulnerability, etc. This would result in wider environment assessments of GES and FCS having associated low- moderate confidence. Wider sea monitoring effort would be insufficient to support a robust assessment of whether the MPA network is delivering biodiversity benefits. Limited wider environment monitoring effort would affect our ability to determine whether changes detected at the MPA scale are part of larger scale processes/changes, such as climate change. Where knowledge of the relationship between pressure and habitat state is limited, the lack of information on wider scale trends may result in overly precautionary management measures at the MPA scale because of erroneous conclusions regarding the cause of observed local changes. Emergent wider scale issues may still be missed or substantially delayed due to low level of wider environment monitoring, resulting in potentially irreversible damage to biodiversity and ecosystem services.
4	Builds upon Option 3. Replication levels for all habitats both within and out with the MPA network is enhanced. All habitat types are monitored in all regions both within and outside the MPA network.	64% of MPAs and 58% of EIBH examples will not be monitored, habitat condition would need to be inferred from modelled data or the condition of the relevant representative MPA examples – if available. A sample of SPA and Ramsar supporting features will be monitored at a replication level that will support a national assessment of, for example food resource availability with high confidence. This will provide empirical evidence with which to interpret population trend based data collected under the bird's biodiversity component.

Option	Evidence requirements delivered	Risks and limitations
4	42% of EIBH examples would be directly monitored, and therefore could be assessed against their conservation objectives using direct monitoring data. 36% of English inshore MPAs would have some monitoring. Type 2 & 3 monitoring is now applied to some moderate MES habitats within the MPA network, and to high MES in the wider sea. Targeted monitoring of a subset of SPA and Ramsar supporting habitat features is undertaken, with 25% of SPA sub features in 40% of sites monitored.	With the increased level of replication and monitoring of all habitat types, coupled with an increased confidence associated with interpolation and extrapolation, the explicit and implicit monitoring requirements under the Habitats Directive 1992 (HC) would be substantively met. Although < 50% of habitat examples are directly monitored, increased replication levels allow higher confidence interpolation and extrapolation, therefore the risk of infraction by the European Commission would be low-negligible. With enhanced monitoring within the MPA network, and some limited monitoring outside the MPA network, the explicit requirements to monitor marine habitats for Good Environmental Status (GES) under the Marine Strategy Framework Directive (2008) (MSFD) would be substantively met, resulting in a lower residual risk of infraction by the European Commission. Implicit monitoring requirements under the Marine and Coastal Access Act (2009) (MCAA) would be met in part, as monitoring will encompass a subset of MCZs. Condition for 58% of habitat examples across 62% of MPAS would need to be modelled. Implicit monitoring requirements under the Wildlife and Countryside Act (1981 as amended (WCA) would be limited to designated SSSI features that spatially overlap with targeted SACs. Though more MPAs are targeted under this option, there will be a lack of empirical evidence for a significant majority of SSSI MPA features, resulting in the continued lack of empirical information required to inform Secretary of States report to Parliament. For high MES habitats within the MPA network high confidence statistically valid assessment of condition trends can be made at both a regional and national scale. In the wider sea, statistically robust assessments can be made at the regional and national scale with low and high confidence respectively. For moderate and low MES habitats within the MPA network statistically robust analysis can be undertaken at a regional and national level with low and high confidence respectively. For moderate and low MES habitats in the wider sea statistically robust assessment of condition trends can only be made at a national level with moderate confidence.

Option	Evidence requirements delivered	Risks and limitations
4		With the enhanced monitoring package, there will be a mod-high likelihood of picking up national trends, with moderate to high confidence. This would result in wider environment assessments of GES and FCS having associated moderate confidence. Wider sea monitoring effort would be largely sufficient to support a robust assessment of whether the MPA network is delivering biodiversity benefits – with low - moderate confidence. It is still possible that some emergent wider scale issues may still be missed due to a relatively low level of wider environment monitoring, potentially resulting in irreversible damage to biodiversity and ecosystem services, though the probability of this would be substantially reduced
5	Largely comprehensive monitoring package, building on Option 4. All EIBH examples monitored in all locations. Equal monitor effort applied to EIBH examples lying out with the MPA network. Type 2 or 3 monitoring approach applied in all suitable locations	With comprehensive monitoring all habitat types, the explicit and implicit monitoring requirements under the Habitats Directive 1992 (HC) would be entirely met. No risk of infraction by European Commission. Similarly, the explicit requirements to monitor marine habitats for Good Environmental Status (GES) under the Marine Strategy Framework Directive (2008) (MSFD) would be met, resulting in no risk of infraction by the European Commission. Implicit monitoring requirements under the Marine and Coastal Access Act (2009) (MCAA) and the Wildlife and Countryside Act (1981 as amended (WCA) would be met in full. Comprehensive SPA supporting habitat data would be available to combine with bird population trend & dynamics data collected under the marine ornithological data. Statistically valid assessments of condition trends can be made for all EIBHs both inside and outside the MPA network. With the further enhanced monitoring package, there will be a high likelihood of picking up national trends, with high confidence. This would result in wider environment assessments of GES and FCS having associated high confidence. Wider sea monitoring effort would support a robust assessment of whether the MPA network is delivering biodiversity benefits, with high confidence. It is still possible that some emergent wider scale issues may still be missed due to a relatively low level of wider environment monitoring, potentially resulting in irreversible damage to biodiversity and ecosystem services, though the probability of this would now be relatively low.

Option	Evidence requirements delivered	Risks and limitations
5		Whilst essentially comprehensive, the reality is that there are 101 activities and 39 pressures occurring across the English inshore waters that are potentially biologically damaging. Type 2 or 3 monitoring costs have been set on one pressure or management stratification in any one habitat location, whereas there may be up to 16 overlapping pressures in any one location. Therefore, this funding scenario will not deliver a full picture of pressure-state interacts in all locations.

4. Summary and Next Steps

Within this paper, Natural England have presented five costed options for English Inshore benthic habitat monitoring, and described how each of these options is constructed. Options 1 and 5 represent the 'no direct monitoring' and the 'fully comprehensive' options respectively. Option 2 represents a modelled scenario based on the 2017–2018 funding package (in the absence of an indicative 2018–2019 package), and how this might best be deployed to deliver some effective monitoring across as much as possible of the entire Inshore MPA network into the future.

As the options progress from 1 to 5, they become increasingly comprehensive in terms of:

- network coverage;
- more detailed monitoring of pressure-state relationships;
- monitoring and the efficacy of management measures;
- monitoring a wider range of MPA designation types;
- monitoring of habitats in the wider sea.

As these elements are progressively introduced and resourced, thus the types of questions that the monitoring data can answer progress sequentially from simple location-specific condition assessments to the understanding of condition trends at national and regional scales, the understanding of pressure-state relationships, the efficacy of management interventions, and answering the big questions, such as 'is the MPA network' delivering biodiversity benefits.

Defra policy colleagues will be invited to discuss the options and their constituent elements in appropriate detail and then to consider the options against the evaluation criteria at a workshop hosted by NE on 8 March.

Once an initial option preference is selected, this can be reviewed alongside adjacent offshore options outputs, (as well as those for other ecosystem components) to ensure the required level of consistency and representativity for those habitats which occur both inshore and offshore. This will be initiated at the HBDSEG workshop planned for March.

Once an option is eventually selected, the next step in the process consists of more detailed planning of the monitoring activities (e.g. decisions on areas, gear types, choice of sampling platform, and staff). It is at this stage where practical integration of the monitoring activities through collaboration with other agencies (sharing of vessel time, gear, and staff), other

monitoring activities and potentially with marine industries and NGOs (including citizen science initiatives) can be addressed in more detail. It is expected that this process will result in some additional cost savings, though the costed options presented above, were predicated on best value partnership working examples.

5. Policy Workshop Outcomes

There was a clear recognition that, in real terms, the funds available to support the monitoring of inshore MPAs (per unit area) have seen dramatic declines over recent years.

Generally, an Option 3 approach was favoured, with investigation into the feasibility of seeking potential savings / efficiencies in regional sea areas that span more than one UK Country. There was also a recognition, that the monitoring of SPA and Ramsar supporting habitats (which is introduced in Option 4), would provide useful habitat and food resource data to underpin seabird options, and would be the only habitat based data set with which to interpret SPA and Ramsar bird species trend results, and is relatively cost effective. Scoring sheets are appended in annex.

It was noted and acknowledged that under Option 3, whilst all habitat types are monitored in all regions, approximately 72% of designated MPAs would NOT have any direct monitoring, and that for 68% of monitoring habitat examples, no direct evidence would be collected. However, there was consensus that with the level of monitoring replication afforded by this option, that inferences could be made in a few key areas which would also reduce existing risk of challenge. Appendix D lists the MPAs that would NOT be monitored if Option 3 was adopted in full.

Natural England was tasked with investigating the potential for efficiencies in the Northern North Sea and the Irish where these regional sea zones include areas in Scotland and both Wales and Scotland respectively. Natural England was also tasked with clarifying the costs of the discreet SPA supporting habitat component for further consideration (see Table 15).

Table 15. Estimated costs associated with reducing replication in overlapping regional sea zones, and with basic SPA/Ramsar targeted supporting sub-feature monitoring [table created in 2017].

Proposed Modification	Assumption	Cost implication	Result
Reduction in monitoring replicates in regional seas with overlaps	33–50% reduction in English Replicates in Northern North Sea & Irish Sea.	Reduction by ~£0.3 to 0.5 million	Loss of power to detect trends in condition and use inference. England scale.
Inclusion of low level SPA sub-feature monitoring	Four replicates of SPA sub-feature monitoring per regional sea	Increase by -£0.17 million	Ability to gather key prey availability and other underpinning data to interpret bird trends

Natural England undertook some simple further analysis, into provide a justification for the reduction in effort for overlapping regional sea zones.

Firstly, the number of MPAs in each CP2 region was investigated. It would seem like a reduction in replicate effort in CP2 regions 1 (Northern North Sea) and 5 (Irish Sea), may be appropriate, as the MPA count in these regional seas areas is the lowest (see Figure 11). However, when the area of designated MPA was investigated (Figure 12), the proposed reduction is less well supported as the area of MPAs in these regions is greater than some

others. The key consideration to take forward is that of monitoring 'representivity', and the importance which is attached to this especially in terms of monitoring effort per unit area of MPAs.

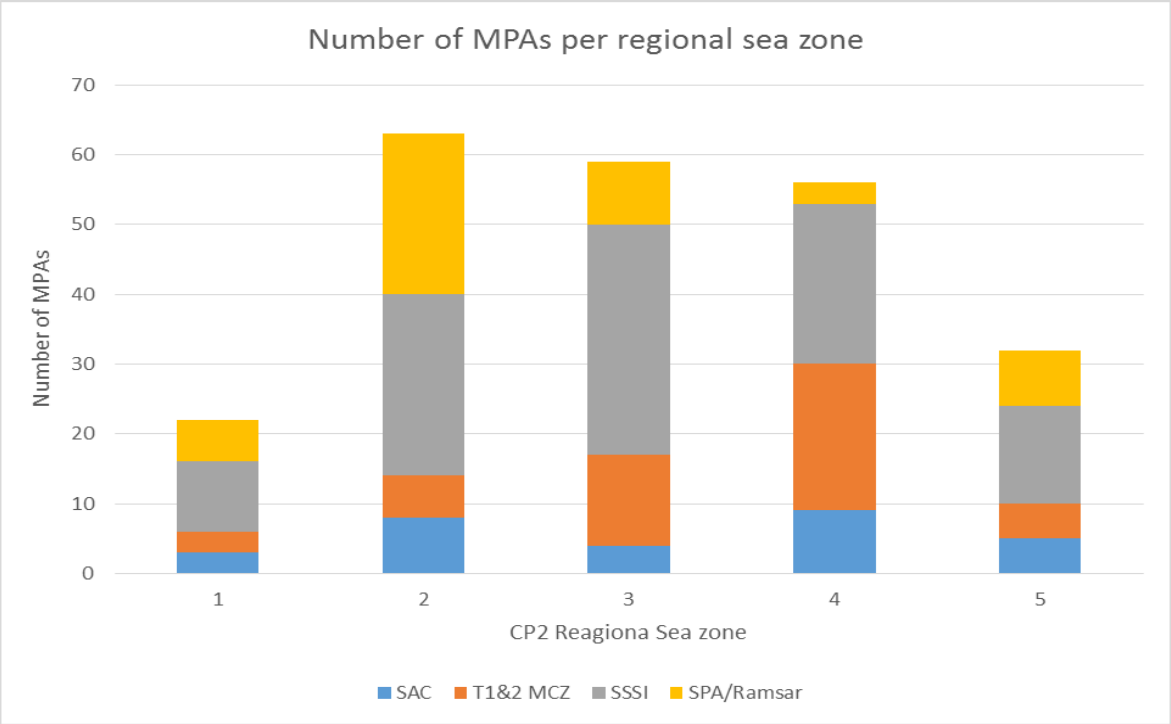

Figure 11. MPA numbers by designation type across regional sea zones [figure created in 2017]. Key. 1= Northern North Sea, 2 = Southern North Sea, 3 = Eastern Channel, 4 = Western Channel and Celtic Sea, 5 = Irish Sea.

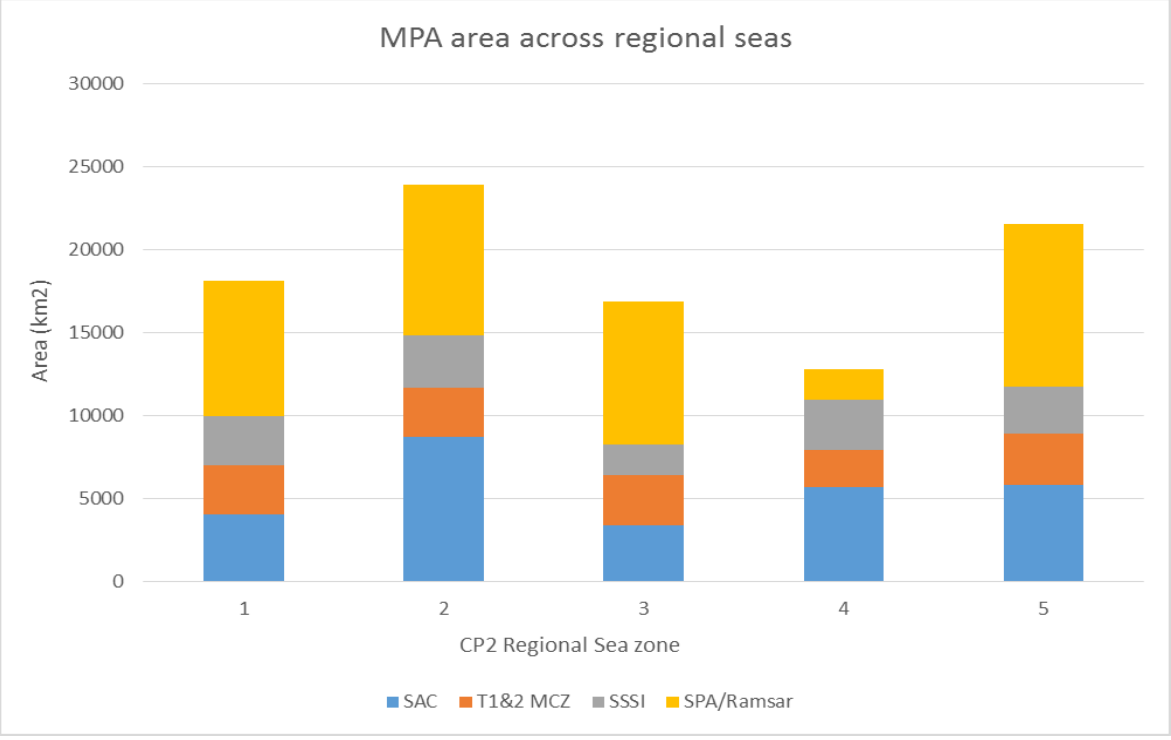

Figure 12. MPA areas by designation type across the regional sea zones [figure created in 2017]. Same key as Figure 11.

6. HBDSEG review of policy preferred option

The preferred option selected by policy was reviewed by HBDSEG, alongside the remaining biodiversity components, at a two-day workshop, 27 to 28 March 2018. Participants provided advice on whether an adequate level of evidence would be achieved by the policy option preferences and, if inadequate, what it would take to bring the option to a level of adequacy that would fulfil the following monitoring objectives:

- understanding the natural variability of the biodiversity component and its role within ecosystem processes and functions;
- understanding pressure-state relationships and facilitating the development of pressure-based monitoring to enable the sustainable management of human activities;
- undertake robust assessments of conservation status and site condition at required scales and temporal frequencies to fulfil national and international reporting obligations.

HBDSEG developed advice on how best to address the key inadequacies identified within the policy preference and made recommendations on the minimum acceptable level of monitoring.

6.1. HBDSEG advice

HBDSEG recognised the complexities of the English inshore environment and the challenges which these represent for monitoring in terms of the volume of MPAs, the extensive array of benthic habitats and the broad range of activities and pressures operating. In general, HBDSEG were supportive of the approach taken to focus monitoring within a sub-sample of benthic habitats and MPAs in each region. However, HBDSEG considered the evidence base provided by the policy option preference would not be able to adequately fulfil all our monitoring and assessment commitments. HBDSEG were specifically concerned about the limited ability of the policy option preference to provide an overall level of understanding of the health and status of inshore benthic habitats and crucially, inform future management of human activities.

The key concerns expressed by HBDSEG were:

- low replication levels – particularly for moderate and low MES habitats;
- limited wider seas monitoring effort (20%);
- monitoring within SPA supporting habitats not included.

HBDSEG strongly advised that the increased spatial spread and replication associated with monitoring Option 4 (with minor modifications) would provide the evidence base required to adequately fulfil our monitoring and assessment commitments and fundamentally improve our ability to answer a wider range of policy questions. HBDSEG emphasised the improved evidence base would provide the following benefits:

- all monitoring habitats monitored at National and Regional level;
- dramatic increase in the conservation and policy questions that could be robustly answered by statistically valid analyses due to the increased replication levels for high and moderate MES habitats (see Tables 6 and 7 for comparison of Option 3 and 4, respectively);

- robust assessment and reporting to the majority of drivers at the national and regional level;
- ability to more confidently extrapolate and interpolate feature condition trends in non-monitored locations, due to increased habitat specific replication levels across the network;
- vastly improved ability to inform management of human activities due to the improved evidence provided by targeted studies into pressure-state interaction and effectiveness of management;
- ability to confidently understand the effectiveness of the MPA network in the context of wider environment trends due to increased wider environment monitoring (67% versus 33% effort).

HBDSEG also recognised that whilst adequate, a package aligned with Option 4, would still provide problems for NE in providing site specific advice on the impact of operations or the effectiveness of management in most locations. The intent is that monitoring a sub-set of locations will provide robust evidence from which interpolation and extrapolation can be undertaken. However, it was recognised that this would take time, and that in the interim the evidence base (be it site specific or proxy) would be problematic for non-monitored locations.

HBDSEG considered the following modifications to Option 4 to improve cost efficiency:

1. For low MES habitat, replication rates should be kept low as in Option 3.
    - *Though not precisely calculated, this is only likely to result in a <= 5% reduction in Option 4 costs.*
2. For regional seas that overlap multiple UK Country jurisdictions, there may be the possibility of reducing replication levels within England.
    - *Subsequent analysis of MPA area in the five English regional sea area, has suggested that this may have limited/negligible scope in the two overlapping regional seas (see figure 12 above).*
3. For monitoring habitats that occur both in the inshore and offshore benthic zones, there may be opportunities for replicate reduction.
    - *This would apply to six monitoring habitat types and would result in a limited saving estimated of <=4%.*

Table 16. Comparison of cost profiles and evidence provision associated with English inshore and UK offshore benthic habitat monitoring options [table created in 2017].

Parameter	EIBH Option 3 (policy preferred option)	EIBH Option 4 (HBDSEG recommendation)	UK offshore BH Option 2.5 (policy preferred option)
~Cost (million per annum)	£3.34	£4.78	£2.36
% MPA visited	28	36	59
No' MPA visited	75	96	19
% MPA feature examples monitored	32	43	54
No MPA feature examples visited	~331	~445	~80
Saving (per unit benthic area) relative to 2011–2012	55%	37–40%	n/a

Note: Though a significant increase above current [2017] funding levels, Option 4, when expressed as a value per unit area of benthic habitat monitored offers a net reduction of ~ 40% since 2011–2012.

HBDSEG strongly emphasised that the full effectiveness of the Option 4 approach to monitoring could only be realised in alignment with improved human activity and pressures data. HBDSEG acknowledged that the currently [2017] available inshore human activity and pressure data are very limited and impede ability to infer condition of habitats/features in non-monitored locations.

HBDSEG highlighted the following residual risks and requirements:

- current [2017] lack of inshore fishing pressure data (paramount to address); IVMS (positional); Logbook (gear-type) and landings data all need to be collected and collated;
- need for enhanced and standardised collection of recreational activity data, with the setting up of a UK DAC;
- there are still significant risks at the site level in relation to NE's ability to deliver credible site/feature based, evidenced advice for those sites / features which would not be monitored. Clearly the value of any extrapolated conclusions are highly dependent on adequate pressure data;
- there would still be no targeted monitoring of inshore species features – outstanding gap;
- there is a clear lack of supporting process data (O_2, Acidity, temp, turbidity, chlorophyll A, etc.), at an appropriate scale required to inform the interpretation of biological data.

Note: a review of the element is the subject of a current [2017] joint NE/JNCC R&D bid to Defra.

6.2. Inclusion of HBDSEG advice in policy option preference

HBDSEG identified a preferred monitoring option (based on Option 4) which would address the key deficiencies identified with the initial policy preference. As well as increasing the proportion of MPA feature examples monitored up to 43%; thus, providing more empirical information to inform site level management. The key benefits of this option are the ability to understand condition trends and address management questions much better at regional scales; and especially have much improved confidence in status for habitats outside of designated sites. The additional improvements suggested by HBDSEG would add a further £1.4M to the delivery of English inshore benthic habitat monitoring.

A summary of the costs, benefits and risks associated with the policy option and HBDSEG advised option, are provided in Table 17.

Table 17. Summary of the costs, benefits and risks associated with the policy option and HBDSEG advised option [table created in 2017].

Policy	Key monitoring elements	Cost (£Mill)	Benefits	Risk
Policy Preference	• 28% of English inshore MPAs with some monitoring. • 32% of MPA feature locations monitored. • All habitat types within the MPA network will receive some monitoring; effort will be focused on habitat types where change will more likely be detected. • 80% of monitoring effort will be focused within MPA network, with 20% directed towards wider sea.	3.34	• Condition trend determination to directly inform management of MPAs for 32% of feature examples. • Overall condition trend determination within MPAs at a national level for most habitat types. • Possible condition trend determination at a national level for most habitat types in the wider seas. • Potential to develop a regional understanding of condition trends and pressure state relationships within example MPAs for majority of habitat types. • An understanding of some key pressure-state interactions and or management efficacy at locations, providing some basis to inform management more generally by applying learning in apparently similar situations	• No empirical information to determine habitat condition for any habitats within 72% of MPAs; this is likely to result in ineffective management and/or unnecessary harm to protected habitats, and/or stakeholder livelihoods. • Absence of appropriate information to assess the distribution of pressures inside and outside MPAs makes determining management based on better understood situations very difficult. • Apparent National trends in MPA condition are not regarded as robust due to relatively small proportion of MPA feature locations with monitoring. • Cannot be confident in determining the condition of a substantial proportion of habitats in the wider seas at a regional or national level, resulting in gaps or low confidence in data for reporting and management.

Policy	Key monitoring elements	Cost (£Mill)	Benefits	Risk
HBDSEG Advice	• 37% of MPAs with some monitoring. • 43% of MPA feature locations monitored. • All habitat types (both within and outside the MPA network) will receive some monitoring. • 67% monitoring effort will be focused within MPA network with 33% directed towards wider sea. • Enhanced habitat monitoring where there are spatial overlaps with SPA supporting habitats (~35% SPA supporting features). • Provision of higher resolution pressure data (not costed). • Provision of enhanced physio-chemical data (not costed).	4.78	• Condition trend determination to directly inform management for 43% of feature examples. • Overall condition trend determination within MPAs at a National level for examples of **all** habitat types. • A statistically robust comparison between feature condition within and outside the MPA network nationally for all habitats. • Robust regional scale assessment of trends for most habitat types within MPAs and potentially outside, supporting regional comparisons. • A reasonable understanding of pressure-state interactions at a regional level for most habitats. • Monitoring the condition of SPA supporting habitats at four SPAs per region, which can inform assessment of national trends.	• No empirical information to determine habitat condition for any habitats within 63% of MPAs; this is likely to result in ineffective management and/or unnecessary harm to protected habitats, and/or stakeholder livelihoods. • Cannot be confident in determining regional trends for a minority of habitat types in the wider seas.

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Webb, K., Griffiths, Y. & Proudfoot, R. 2024. The U.K. Marine Biodiversity Monitoring Programme: Development of advice on future monitoring (2019). *JNCC Report 765*, JNCC, Peterborough, ISSN 0963-8091.
https://hub.jncc.gov.uk/assets/5db2e26e-b98d-4a49-9293-76a62a25d6f7

Appendix 1: Monitoring Efficacy Value bands for the benthic monitoring habitats [as advised in 2017]

Monitoring Efficacy value and ideal monitoring frequency were both determined by expert judgement. Six Natural England marine monitoring staff were involved in discussions, considering such things as:

- natural variability;
- practicality of monitoring feature;
- power to detect change.

Monitoring Habitat	Monitoring Efficacy Value (MEV)	Ideal Monitoring Frequency	
		Range	Average
High energy intertidal rock	Low	(3–4)	4
Intertidal coarse sediment	Low	(2–6)	3
High energy infralittoral rock	Low	(3–6)	6
Low energy infralittoral rock	Low	(2–6)	3
Estuarine rocky habitats	Low	(2–6)	3
Submerged or partially submerged sea caves	Low	(6–12)	12
Intertidal sand	Moderate	(2–4)	3
Subtidal coarse sediment	Moderate	(2–4)	3
Low energy intertidal rock	Moderate	(2–4)	3
Intertidal rock (including rock pools)	Moderate	(3–4)	3
Intertidal under boulder communities	Moderate	(3–4)	1
Infralittoral rock	Moderate	(2–6)	3
Subtidal sand	Moderate	(2–4)	3
Moderate energy intertidal rock	High	(2–3)	3
Intertidal biogenic reefs	High	(1–3)	2
Intertidal blue mussel (*Mytilus edulis*) beds	High	(1–3)	2
Honeycomb worm (*Sabellaria alveolata*) reefs	High	(1–10)	2
Intertidal stony reef	High	(2–3)	3
Littoral chalk communities	High	(3–4)	3
Intertidal mixed sediments	High	(2–3)	3
Intertidal mud	High	(2–3)	2
Intertidal seagrass beds	High	(1–6)	1
Moderate energy infralittoral rock	High	(3–6)	5

Monitoring Habitat	Monitoring Efficacy Value (MEV)	Ideal Monitoring Frequency	
		Range	Average
Fragile sponge & anthozoan communities on subtidal rock	High	(1–3)	2
Circalittoral rock	High	(3–6)	3
High energy circalittoral rock	High	(3–6)	4
Moderate energy circalittoral rock	High	(3–6)	4
Low energy circalittoral rock	High	(3–6)	4
Subtidal chalk	High	(2–6)	3
Subtidal stony reef	High	(2–4)	3
Native oyster beds (*Ostrea edulis*)	High	(2–6)	3
Subtidal biogenic reefs	High	(2–3)	2
Subtidal blue mussel (*Mytilus edulis*) beds	High	(2–3)	2
Ross worm reefs (*Sabellaria spinulosa*)	High	(2–3)	2
Subtidal mixed sediments	High	(2–3)	2
Subtidal mud	High	(2–3)	2
Sea pens and burrowing megafauna	High	(2–3)	2
Sheltered muddy gravels	High	(2–4)	3
Maerl beds	High	(1–3)	2
Subtidal macrophyte-dominated sediment	High	(1–3)	2
Subtidal seagrass beds	High	(1–3)	1
Seagrass beds	High	(1–6)	1
Peat and clay exposures	High	(3–6)	6
Blue mussel (*Mytilus edulis*) beds	High	(1–3)	2

Appendix 2: Generic survey costings used to build costed options [as estimated in 2017]

Survey grouping	Core survey cost £k	Cost per additional feature £k
Intertidal rock	18	5
Intertidal sediment	20	7
Infralittoral rock	25	7
Circalittoral rock	25	7
Subtidal sediment	25	7
Diving	25	20
Intertidal seagrass	3	-
Other	20	7

Appendix 3 – NE Marine monitoring strategy – summary [as of 2017]

NE has developed a marine monitoring strategy that will, if set up effectively and implemented, enable NE to:

- undertake sub-feature and feature condition trend assessment;
- understand Natural Variability;
- pick up lower effect size responses with a higher confidence, which will in turn:
    - allow NE to build up a detailed understanding of pressure-state interaction in key locations;
    - allow NE to pick up early signs of habitat deterioration;
    - allow NE to evaluate the effectiveness of management regimes in key locations.
- collect data from the wider sea - to address such broad questions as 'do MPAS work?'
- provide data from which NE can assess habitat condition in the wider marine environment.

The components of the strategy are:

I Sentinel MPA component

The sentinel (core) MPA component will consist of a subset of sub-feature locations within MPAs which are chosen to be representative of the sub-feature. This equate with the high MES habitat location in the costed options process.

II Wider MPA component

The wider MPA, or 'validation' component will consist of a concurrent, though much lower level, programme of MPA monitoring consisting of one off monitoring events targeted at sub-feature/ MPA locations not in the core programme. This equates to additional habitat replicates that come in from Option 3 upwards, and we allow NE to understand whether sentinel location are representative of the wider MPA network.

III Wider seas component

The wider seas or 'contextual' component will consist of a relatively small suite of sub-feature locations out with the MPA network – where feasible. The purpose of gathering data at theses location would be to help ascertain whether the MPA network is delivering ecological benefits. Directly equates to wider sea element of costed options.

IV High frequency component

The high frequency component will consist of a relatively small number of 'fixed – point' sub-feature locations (tailored at a specific subset of sub-features that will be monitored very regularly to pick up short term variability information. This is not directly covered in the costed options but would be targeted at habitats where we are unsure about natural variability.

V The Additional component

This would cover no benthic habitat monitoring and in not therefore covered by the costed options process.

Appendix 4 - Sites NOT monitored under Option 3 [as advised in 2017]

Note: Indicative list - actual sites to be monitored/ not to be monitored is likely to alter. No potential Type 3 sites will be monitored.

Site Name	Designation
Adur Estuary	SSSI
Alde-Ore Estuary	SSSI
Alnmouth Saltmarsh and Dunes	SSSI
Benfleet and Southend Marshes	Ramsar
Benfleet and Southend Marshes	SPA
Benfleet and Southend Marshes	SSSI
Blackwater Estuary	SSSI
Boscastle to Widemouth	SSSI
Brading Marshes to St. Helen's Ledges	SSSI
Breydon Water	Ramsar
Breydon Water	SPA
Breydon Water	SSSI
Bridgwater Bay	SSSI
Chesil and The Fleet	SSSI
Chesil Beach and The Fleet	Ramsar
Chesil Beach and The Fleet	SPA
Chichester and Langstone Harbours	Ramsar
Chichester and Langstone Harbours	SPA
Chichester Harbour	SSSI
Christchurch Harbour	SSSI
Colne Estuary	Ramsar
Colne Estuary	SSSI
Colne Estuary (Mid-Essex Coast Phase 2)	SPA
Coquet Island	SPA
Cowpen Marsh	SSSI
Crouch and Roach Estuaries	Ramsar
Crouch and Roach Estuaries	SSSI
Crouch and Roach Estuaries (Mid-Essex Coast Phase 3)	SPA
Dawlish Warren	SSSI
Deben Estuary	Ramsar
Deben Estuary	SPA

Site Name	Designation
Deben Estuary	SSSI
Dee Estuary	SSSI
Dengie	Ramsar
Dengie	SSSI
Dengie (Mid-Essex Coast Phase 1)	SPA
Drigg Coast	SSSI
Duddon Estuary	Ramsar
Duddon Estuary	SPA
Duddon Estuary	SSSI
Dungeness, Romney Marsh and Rye Bay	SPA
Dungeness, Romney Marsh and Rye Bay	SSSI
Eling and Bury Marshes	SSSI
Erme Estuary	SSSI
Exe Estuary	Ramsar
Exe Estuary	SPA
Exe Estuary	SSSI
Falmouth Bay to St Austell Bay	SPA
Farne Islands	SPA
Flamborough Head	SSSI
Folkestone Warren	SSSI
Foulness	Ramsar
Foulness	SSSI
Foulness (Mid-Essex Coast Phase 5)	SPA
Gibraltar Point	Ramsar
Gibraltar Point	SPA
Gibraltar Point	SSSI
Great Yarmouth North Denes	SPA
Hamford Water	Ramsar
Hamford Water	SPA
Hamford Water	SSSI
Hayle Estuary and Carrack Gladden	SSSI
Humber Estuary	SSSI
Hurst Castle and Lymington River Estuary	SSSI
Hythe to Calshot Marshes	SSSI
Isles of Scilly	Ramsar
Isles of Scilly: Gilstone to Gorregan	MCZ

Site Name	Designation
Isles of Scilly: Hanjague to Deep Ledge	MCZ
Isles of Scilly: Higher Town	MCZ
Isles of Scilly: Lower Ridge to Innisvouls	MCZ
Isles of Scilly: Men a Vaur to White Island	MCZ
Isles of Scilly: Plympton to Spanish Ledge	MCZ
Isles of Scilly: Smith Sound Tide Swept Channel	MCZ
Isles of Scilly: Tean	MCZ
King's Quay Shore	SSSI
Langstone Harbour	SSSI
Lincegrove and Hackett's Marshes	SSSI
Lindisfarne	Ramsar
Lindisfarne	SPA
Lindisfarne	SSSI
Liverpool Bay / Bae Lerpwl	SPA
Lower Fal and Helford Intertidal	SSSI
Lower Test Valley	SSSI
Lundy	SAC
Lundy	SSSI
Lune Estuary	SSSI
Lynher Estuary	SSSI
Margate and Long Sands	SAC
Medina Estuary	SSSI
Medway Estuary and Marshes	Ramsar
Medway Estuary and Marshes	SPA
Medway Estuary and Marshes	SSSI
Mersey Estuary	SSSI
Mersey Narrows	SSSI
Mersey Narrows and North Wirral Foreshore	SPA
Minsmere - Walberswick	Ramsar
Minsmere-Walberswick	SPA
Minsmere-Walberswick Heaths and Marshes	SSSI
Morecambe Bay	SSSI
New Ferry	SSSI
Newton Links	SSSI
Newtown Harbour	SSSI
Norrard Rocks	SSSI

Site Name	Designation
North Norfolk Coast	Ramsar
North Norfolk Coast	SPA
North Norfolk Coast	SSSI
North Solent	SSSI
North Wirral Foreshore	SSSI
Northumberland Marine	SPA
Northumbria Coast	Ramsar
Northumbria Coast	SPA
Orwell Estuary	SSSI
Otter Estuary	SSSI
Outer Thames Estuary	SPA
Pagham Harbour	Ramsar
Pagham Harbour	SPA
Pagham Harbour	SSSI
Pakefield to Easton Bavents	SSSI
Pevensey Levels	Ramsar
Plymouth Sound Shores and Cliffs	SSSI
Poole Harbour	Ramsar
Poole Harbour	SPA
Poole Harbour	SSSI
Poole Rocks	MCZ
Porlock Ridge and Saltmarsh	SSSI
Portland Harbour Shore	SSSI
Portsmouth Harbour	Ramsar
Portsmouth Harbour	SPA
Portsmouth Harbour	SSSI
Ribble and Alt Estuaries	Ramsar
Ribble and Alt Estuaries	SPA
Ribble Estuary	SSSI
River Camel Valley and Tributaries	SSSI
River Coquet and Coquet Valley Woodlands	SSSI
River Eden and Tributaries	SSSI
River Wye	SSSI
Robin Hood's Bay: Maw Wyke to Beast Cliff	SSSI
Rosemullion	SSSI
Runnel Stone	MCZ

Site Name	Designation
Ryde Sands and Wootton Creek	SSSI
Salcombe to Kingsbridge Estuary	SSSI
Saltern Cove	SSSI
Saltfleetby - Theddlethorpe Dunes	SSSI
Sandwich Bay to Hacklinge Marshes	SSSI
Seaford to Beachy Head	SSSI
Seaton Dunes and Common	SSSI
Severn Estuary	SSSI
Sinah Common	SSSI
South Dorset	MCZ
South Thames Estuary and Marshes	SSSI
South Walney and Piel Channel Flats	SSSI
St. Martin's Sedimentary Shore	SSSI
Stour and Orwell Estuaries	Ramsar
Stour and Orwell Estuaries	SPA
Stour Estuary	SSSI
Tamar - Tavy Estuary	SSSI
Tamar Estuaries Complex	SPA
Taw-Torridge Estuary	SSSI
Teesmouth and Cleveland Coast	Ramsar
Teesmouth and Cleveland Coast	SPA
Thames Estuary and Marshes	Ramsar
Thames Estuary and Marshes	SPA
Thanet Coast	SSSI
Thanet Coast and Sandwich Bay	Ramsar
Thanet Coast and Sandwich Bay	SPA
The Lagoons	SSSI
The Mersey Narrows and North Wirral Foreshore	Ramsar
The Swale	SSSI
The Wash	SSSI
Thorness Bay	SSSI
Tweed Catchment Rivers - England: Till Catchment	SSSI
Tweed Catchment Rivers - England: Lower Tweed and Whiteadder	SSSI
Upper Fal Estuary and Woods	SSSI
Upper Hamble Estuary and Woods	SSSI

Site Name	Designation
Upper Severn Estuary	SSSI
Upper Solway Flats and Marshes	SSSI
Wembury Point	SSSI
Western Rocks	SSSI
Whitecliff Bay and Bembridge Ledges	SSSI
Whitsand and Looe Bay	MCZ
Wyre Estuary	SSSI
Yar Estuary	SSSI
Yealm Estuary	SSSI

Appendix 5 – MPA area and number breakdown across regional seas [as of 2017]

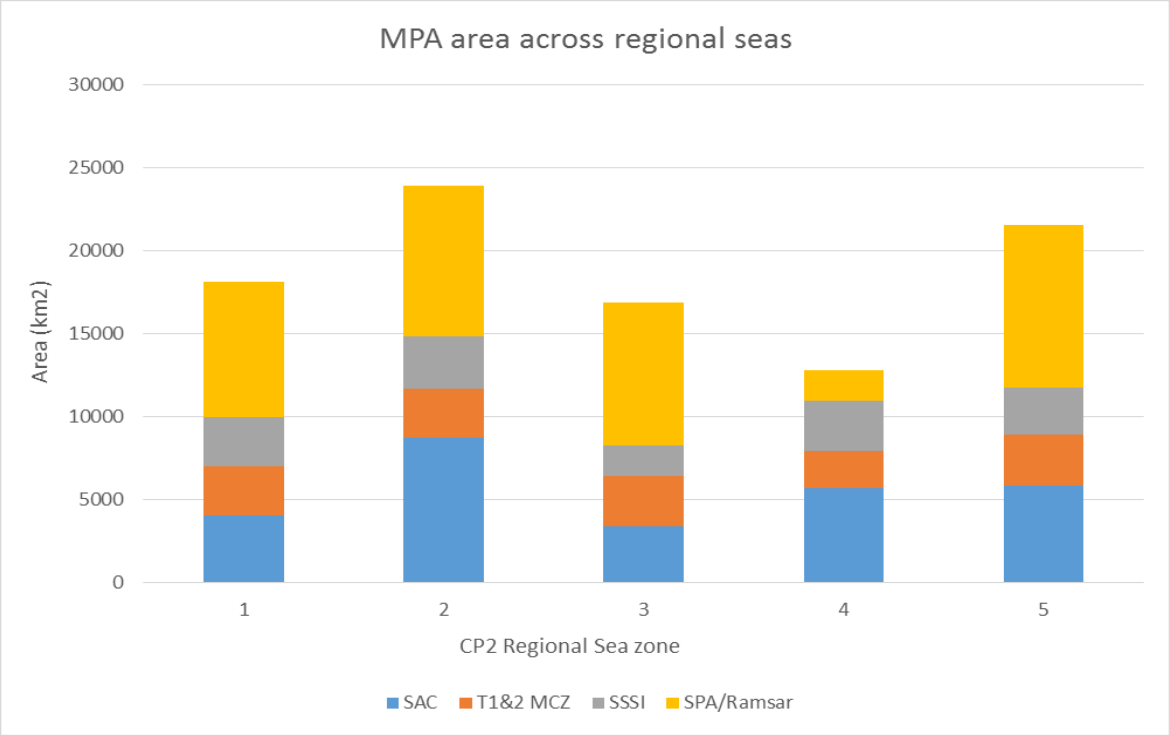

Figure 5.1. MPA areas by designation type across the regional sea zones [figure created in 2017]. Key. 1= Northern North Sea, 2 = Southern North Sea, 3 = Eastern Channel, 4 = Western Channel and Celtic Sea, 5 = Irish Sea.

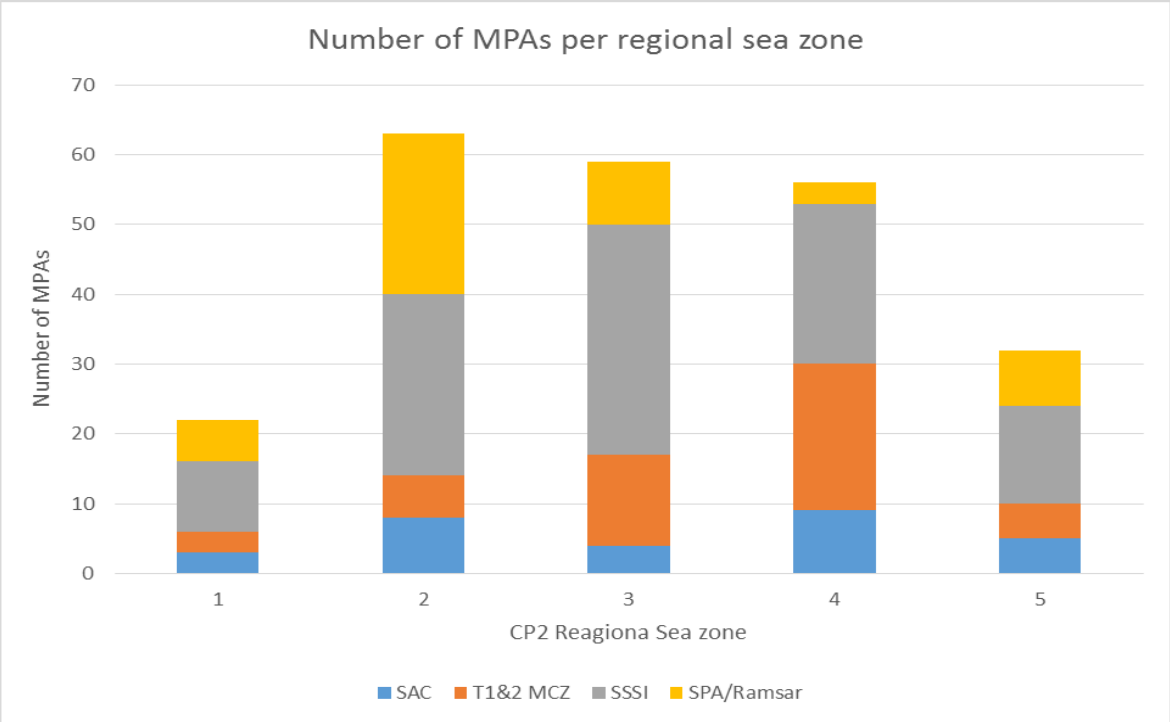

Figure 5.2. MPA numbers by designation type across regional sea zones [figure created in 2017]. Key. 1= Northern North Sea, 2 = Southern North Sea, 3 = Eastern Channel, 4 = Western Channel and Celtic Sea, 5 = Irish Sea.