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Annex 6: 2018 options for monitoring UK deep sea benthic habitats

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Preface

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 the UK deep sea benthic habitat monitoring landscape in 2016 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 deep sea benthic ecosystems is required to provide evidence for tackling the biodiversity loss and climate crisis. Monitoring the deep sea 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. The deep sea plays a crucial role in carbon storage and regulation of climatic processes while highly diverse habitats and species profoundly influence the regeneration of nutrients for supporting surface productivity and fisheries.

It should be noted that some of the legislative drivers which have been referenced in this report have been updated or superseded since 2016. In addition, new legislation and obligations have been introduced since 2016. For clarity, '[2016]' 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 Background

A policy workshop attended by JNCC and representatives from Scottish Government, Marine Scotland Science, Scottish Natural Heritage, Defra, and Natural England was held on 7 October 2016 to discuss the selection of monitoring options for UK deep sea habitats. Discussions at this workshop led to an agreement to revise the options presented to reflect:

- The assumption that recent and proposed MPA and wider environment management measures will be established soon and that this will change the risk status of some MPAs and wider environment areas.
- The agreement that a less precautionary threshold of overlap between habitats and pressures should be applied to broadscale habitats to identify those habitats at risk at the UK scale.
- The agreement that there may be key monitoring objectives included in the more costly options which could be incorporated into the less costly options following the initial changes in the risk profile of the habitats and MPAs outlined in the above two points.

These changes and additional considerations have now been undertaken and a resulting suite of draft options were then discussed in detail with Marine Scotland Science [Marine Directorate of Scottish Government] in November 2016. This resulted in some further revisions and an explanation of this process, and the final revised options is given below. Updated cost information for Options 2 to 4 can be found in Appendix 1 below.

2 Option 1

This option remains as it was (i.e. no coordinated monitoring targeted at detecting change in the range, extent, or condition of deep sea benthic habitats). There would be no further investment from Governments to improve the coordination of sampling schemes that already take place in the deep sea (e.g. by Marine Scotland Science), including no repurposing of existing surveys.

This option does not include the monitoring survey that took place at the Geikie Slide and Hebridean Slope Nature Conservation MPA in 2015. This survey was designed as a test of implementing monitoring Option 2 or above, in the absence of any one monitoring option having been selected for implementation at that time.

3 Option 2

3.1 Summary of change

The original proposal for Option 2 was to only undertake Type 1 monitoring in high risk SACs and to undertake Type 2/3 monitoring for the most important pressure-state-management relationships within a selection of prioritised MPAs. It also included a commitment to undertake R&D work to investigate the utility of existing data collection schemes. It did not include any wider environment monitoring.

The revised proposal for Option 2 is to undertake Types 1, 2 and 3 monitoring in all high risk MPAs. This revision has come about as several SACs have been re-assessed as being at low risk due to established or impending fisheries management measures. These low risk SACs have therefore been removed from the Type 1 monitoring selection and other MPA types at high risk have been added in their place. One NCMPA has also been removed from

the Type 2/3 monitoring selection as it has been re-assessed as at low risk. The commitment to undertake R&D work remains as part of this option and all following options. Furthermore, Option 2 now takes a representative approach in using the monitoring of some sites to infer the condition of others, where this approach is ecologically sound.

3.2 Detail

Option 2 originally included Type 1 monitoring for high risk SACs only and Type 2/3 monitoring for those MPAs which had been prioritised for such studies (including MCZs and NCMPAs).

Following a fresh consideration of the risks to all deep sea MPAs, the following sites have been downgraded from high risk to low risk:

- **North West Rockall Bank SCI**: The majority of this site is closed to fishing activity and extra management measures have been proposed to align the boundary of the closure with the site boundary. However, some risk may remain in those areas which are not yet closed.
- **Anton Dohrn Seamount SCI**: There is a proposal for a full closure to demersal fishing gears in areas where the reef feature is present.
- **East Mingulay SCI**: There is no demersal trawling permitted within the boundary of the site and no demersal static gear permitted within a large portion of the site.
- **Rosemary Bank Seamount NCMPA**: There is a proposal for a full site closure to demersal fishing gears.
- **Hatton Rockall Basin NCMPA**: This site occurs at a water depth of around 1000 m and therefore will be covered by the agreed EU bottom fishing ban that will apply in waters below 800 m.

This re-assessment of the level of risk to deep sea MPAs has resulted in four MPAs being removed from the Option 2 set (Rosemary Bank Seamount NCMPA was not included originally as it is not a high risk SAC; Hatton-Rockall Basin NCMPA was originally included for Type 2/3 studies only). Additionally, the Barra Fan portion of the Barra Fan and Hebrides Terrace Seamount NCMPA has been removed from the Option 2 set as the condition of this part of the feature (Burrowed mud, offshore deep sea mud and offshore subtidal sands and gravels) could sensibly be inferred from monitoring the Geikie Slide and Hebridean Slope NCMPA, which remains included in this option. The Hebrides Terrace Seamount is also fully closed to fishing activity and is therefore assessed as being at low risk.

The removal of these MPAs from the Option 2 set allows Type 1 monitoring for the remaining MPAs, which are at high risk, to be added to this option. This would deliver evidence for reporting against the Conservation Objectives of high risk sites across the MPA network and not just for reef features within SACs, as previously proposed. Type 2/3 studies can also be undertaken in those high risk MPAs which are suitable for such monitoring, as was included in Option 2 originally, providing evidence for adaptive fisheries management and developing understanding of pressure-state relationships. This would also include some monitoring outside of MPAs as part of a Type 3 monitoring BACI design, for example.

Therefore, monitoring Option 2 now includes the following high risk MPAs and monitoring types:

Table 1: Option 2 MPA surveys and applicable monitoring types [developed in 2016].

Survey	MPA to be surveyed	Monitoring types
1	The Canyons MCZ	High effort Type 1 + Types 2/3 to investigate pressure gradients and management measures
2	Faroe-Shetland Sponge Belt NCMPA **or** North-East Faroe Shetland Channel NCMPA	
	Wyville Thomson Ridge SCI	
3	Geikie Slide and Hebridean Slope **and/or** Barra Fan NCMPA	
	East Rockall Bank SCI	

3.3 Costs

The associated average yearly cost for this monitoring option (assuming Type 1 monitoring would only take place *once* per six year reporting cycle) would be **£0.84 million**. It should be noted that the cost of this option has been averaged over a six year period and actual costs are likely to differ each year depending on whether a survey is taking place. Costs could be more evenly distributed by processing samples in a subsequent year, etc.

4 Option 3

4.1 Summary of change

The original proposal for Option 3 was to undertake Type 1 monitoring in high risk MPAs and high risk areas of the wider environment and to undertake Type 2/3 monitoring for the most important pressure-state-management relationships within a selection of prioritised MPAs and wider environment areas. It also included a commitment to undertake R&D work to investigate the utility of existing data collection schemes.

The revised proposal for Option 3 is to carry through those changes presented for Option 2 and to reduce the selection of high risk habitats and areas in the wider environment that would be prioritised for monitoring effort. This revision has come about by applying a 20% overlap threshold of habitat and pressure to identify risk to habitats at the UK scale, as opposed to the original 5% overlap threshold.

This 20% threshold is an arbitrary choice which is intended to be sufficiently different from the original 5% choice to allow a comparison in terms of evidence provision. By using different % thresholds to identify what is ‘at risk’ from a biodiversity point of view, one can understand how the risks and benefits of monitoring can be varied using this approach, according to policy risk appetite.

4.2 Detail

Option 3 originally included Type 1 monitoring in high risk MPAs and high risk areas of the wider environment plus Type 2/3 monitoring in those high risk MPAs and areas of the wider environment which are suitable for such studies. Risk in the wider environment was assigned based on applying a 5% overlap threshold of habitats and pressures to which they are sensitive.

The updated consideration of risk at the MPA scale that was undertaken for Option 2 has been carried through into Option 3, such that the MPAs identified as being at high risk for Option 3 are also those listed in Table 1.

In line with what was agreed at the policy workshop, a revised % overlap threshold of habitats and pressures was applied to deep sea broadscale habitats to identify risk at the UK scale. Therefore, a 20% threshold of overlap with physical abrasion pressure was used to identify when a broadscale habitat becomes at risk at the UK scale. This re-assessment of the UK scale risk has resulted in the following habitats being downgraded from high to low risk at the UK scale:

- Atlantic upper bathyal mud, rock / sediment mosaic and rock
- Atlantic mid bathyal mud, sand, coarse and mixed sediments, rock / sediment mosaic and rock
- Atlanto-Arctic upper bathyal mud, sand, coarse and mixed sediments, and rock / sediment mosaic

Therefore, at a 20% spatial overlap threshold of habitat extent and physical abrasion pressure, only the following broadscale habitats remain at risk at the UK scale:

- Atlantic upper bathyal sand
- Atlantic upper bathyal coarse and mixed sediments

A further consideration of the habitats that were excluded from targeted monitoring effort using this threshold resulted in Altantic upper and mid bathyal mud habitats being re-examined. Several of the ecological groups found in these habitats are highly sensitive to surface and sub-surface physical abrasion (Serpetti *et al*. 2014). Therefore, the risk to these habitats from physical abrasion pressure is potentially very great and would benefit from targeted monitoring effort. These habitats have been added back into the option 3 selection on this basis. The final list of UK scale at risk habitats is therefore:

- Atlantic upper bathyal sand
- Atlantic upper bathyal coarse and mixed sediments
- Atlantic upper bathyal mud
- Atlantic mid bathyal mud

The regions prioritised for the monitoring of these habitats are the Hebridean Slope (for upper bathyal sand and upper and mid bathyal mud), West Shetland Slope (for upper bathyal coarse and mixed sediments) and South West Approaches (for upper bathyal coarse and mixed sediments) and the applicable monitoring types are high effort Type 1 with a nested Type 2 design to investigate pressure – state relationships, if appropriate.

It should be noted that the removal of Atlantic and Atlanto-Arctic upper and mid bathyal rock / sediment mosaic from the Option 3 selection of ‘at risk’ habitats means that these habitats would not be targeted for high effort Type 1 or Type 2 studies. Evidence would therefore not be collected to provide a better understanding of the relationship between pressures caused by demersal fishing gear and the communities associated with deep sea rock / sediment mosaic habitats. This has been identified as a current [2016] data gap in providing robust fisheries management advice and could therefore be problematic. It is important to note that

the % overlap thresholds employed to identify risk at the UK scale can be re-examined if needed, according to risk appetite and evidence requirements.

Therefore, monitoring Option 3 now includes the MPAs, wider environment regions and monitoring types as listed in Table 2:

Table 2: Option 3 MPA and wider environment surveys and applicable monitoring types. Italics indicate regions added to the survey effort compared to Option 2 [developed in 2016].

Survey	MPA / region to be surveyed	Monitoring types
1	The Canyons MCZ	Types 1, 2 & 3
	South-west Approaches region	*High effort Type 1*
2	Faroe-Shetland Sponge Belt NCMPA or North-East Faroe Shetland Channel NCMPA	Types 1, 2 & 3
	Wyville Thomson Ridge SCI	Types 1, 2 & 3
3	Geikie Slide and Hebridean Slope and/or Barra Fan NCMPA	Types 1, 2 & 3
	East Rockall Bank SCI	Types 1, 2 & 3
4	*Hebridean Slope region*	*High effort Type 1 & 2*
	West Shetland Slope region	*High effort Type 1 & 2*

4.3 Costs

The associated average yearly cost for this monitoring option (assuming Type 1 monitoring would only take place *once* per six year reporting cycle) would be **£1.97 million**. It should be noted that the cost of this option has been averaged over a six year period and actual costs are likely to differ each year depending on whether a survey is taking place. Costs could be more evenly distributed by processing samples in a subsequent year, etc.

5 Option 4

5.1 Summary of change

The original proposal for Option 4 was to undertake Type 1 monitoring in all MPAs (both high and low risk) and high risk areas of the wider environment and to undertake Type 2/3 monitoring for the most important pressure-state-management relationships within a selection of prioritised MPAs and wider environment areas. It also included a commitment to undertake R&D work to investigate the utility of existing data collection schemes.

The revised proposal for Option 4 is to carry through those changes presented for Options 2 and 3 and to add Type 1 monitoring for all deep sea habitat MPAs to the survey effort, as was originally proposed.

5.2 Detail

Option 4 originally included Type 1 monitoring for all MPAs (low and high risk) and high risk areas of the wider environment plus Type 2/3 monitoring in those high risk MPAs and areas of the wider environment which are suitable for such studies. As with the previous option, risk in the wider environment was originally assigned because of applying a 5% overlap threshold of habitats and pressures to which they are sensitive.

The updated consideration of risk at the UK scale that was undertaken for Option 3 has been carried through into Option 4. As per with the original Option 4, all MPAs would be covered by Type 1 monitoring in this option, regardless of their risk level.

Therefore, monitoring Option 4 now includes the following MPAs, wider environment regions and monitoring types as listed in Table 3.

Table 3: Option 4 MPA and wider environment surveys and applicable monitoring types. Italic cells indicate MPAs added compared to Option 3 [developed in 2016].

Survey	MPA / region to be surveyed	Monitoring types
1	The Canyons MCZ	Types 1, 2 & 3
	South-west Approaches region	High effort Type 1
2	Faroe-Shetland Sponge Belt NCMPA or North-East Faroe Shetland Channel NCMPA	Types 1, 2 & 3
	Wyville Thomson Ridge SCI	Types 1, 2 & 3
	Darwin Mounds SCI	*Low effort Type 1*
3	Geikie Slide and Hebridean Slope and/or Barra Fan NCMPA	Types 1, 2 & 3
	Rosemary Bank Seamount NCMPA	*Low effort Type 1*
4	East Rockall Bank SCI	Types 1, 2 & 3
	Anton Dohrn Seamount SCI	*Low effort Type 1*
	East Mingulay SCI	*Low effort Type 1*
5	*Hatton-Rockall Basin NCMPA*	*Low effort Type 1*
	Hatton Bank SAC	*Low effort Type 1*
	North west Rockall Bank SCI	*Low effort Type 1*
6	Hebridean Slope region	High effort Type 1 & 2
	West Shetland Slope region	High effort Type 1 & 2

5.3 Costs

The associated average yearly cost for this monitoring option (assuming Type 1 monitoring would only take place *once* per six year reporting cycle) would be **£2.33 million**. It should be noted that the cost of this option has been averaged over a six year period and actual costs are likely to differ each year depending on whether a survey is taking place. Costs could be more evenly distributed by processing samples in a subsequent year, etc.

6 Option 5

This option remains the same as it was originally (i.e. all high and low risk MPAs, and all high and low risk regions of the wider environment would be covered by Type 1 monitoring (high or low effort) and all pressure – state – management relationships would be monitored with relevant Type 2/3 studies within MPAs and priority areas of the wider environment).

The associated yearly cost for this monitoring option (assuming Type 1 monitoring would only take place once per six year reporting cycle) would be at least **£3.70 million**.

7 Selecting monitoring objectives from Options 4/5 that would be valuable in Options 2/3

In re-examining the risk to MPAs in Option 2, this removed the need to carry out Type 1, 2 and 3 monitoring in several SACs and NCMPAs, as described above. In applying a less precautionary threshold of habitat-pressure overlap to habitats at the UK scale in option 3, this removed the need to carry out Type 1 and 2 monitoring in several habitats in the wider environment, as described above. These revisions meant that some monitoring objectives included in the costliest options could be incorporated into the lower options without significantly altering the original cost whilst adding significant evidence benefits for a broader range of habitats and MPAs.

The key monitoring objectives taken from Options 4 and 5 into Options 2 and 3 are:

1. High effort Type 1 monitoring in high risk MPAs (The Canyons MCZ; Faroe-Shetland Sponge Belt NCMPA; North-East Faroe Shetland Channel NCMPA and Geikie Slide and Hebridean Slope NCMPA) is now included in Option 2.
2. High effort Type 1 monitoring in the Hebridean Slope and West Shetland Slope regions of the wider environment for upper bathyal sand, coarse and mixed sediments is now included in Option 3.

8 Summary table of revised options [2016]

Option	Summary	Yearly cost
1	No routine coordinated monitoring of deep sea benthic habitats in UK waters. No further Government investment in building a coordinated monitoring programme for UK deep sea habitats	£0.35 m
2	Type 1, 2 and 3 monitoring of high risk, representative MPAs	£0.84 m
3	Type 1, 2 and 3 monitoring of high risk, representative MPAs plus high risk areas of the wider environment (using 20% threshold + sense check of resulting habitats and consideration of sensitivity)	£1.97 m
4	Type 1, 2 and 3 monitoring of all MPAs plus high risk areas of the wider environment (using 20% threshold + sense check of resulting habitats and consideration of sensitivity)	£2.33 m
5	Type 1, 2 and 3 monitoring of all MPAs and wider environment regions covering all habitats and all pressure – state – management relationships	At least £3.70 m

Based on discussions at the October 2016 policy workshop and subsequent discussions with Marine Scotland Science (on revising the risk level of MPAs and adding vital aspects of more ambitious original options to the revised package), a preliminary option preference of Option 3 (revised version) has been identified.

9 Research questions in support of monitoring and management

Monitoring in such relatively unknown habitats brings with it challenges. The monitoring described above will yield a huge amount of information to inform our understanding of deep sea habitats. Three areas of ongoing research are needed in support of this monitoring:

a. Research to investigate the possibility of using data for purposes other than those for which they were collected, to inform further understanding of deep sea ecosystems.

b. Research directed at improving monitoring techniques (e.g. method testing, indicator selection using Conceptual Ecological Models (CEMs) and sample design testing, etc.).

c. Research targeted at answering questions to improve our understanding of the ecology of deep sea ecosystems of interest.

These research areas will work together with the monitoring to improve its power and efficiency in detecting and attributing change to natural or anthropogenic causes.

10 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 preference 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 for this biodiversity component.

HBDSEG advice:

HBDSEG did not wish to fundamentally alter the preferences put forward by policy colleagues for the deep sea (and offshore) UK benthic environments. Their advice was to strengthen the underpinning of the preferences so that the evidence base could be considered as adequate for assessment, reporting and management purposes.

HBDSEG emphasised the importance of the frequency of monitoring being ecologically relevant, linking to the natural variability of the features and any impacts from pressures. It was also highlighted that appropriate (new and existing) environmental data are required to allow accurate interpretation of biological data and to improve our ability to confidently attribute causes of change (e.g. to climate change).

It was noted that our ability to extrapolate findings from directly monitored areas to unmonitored areas has a heavy reliance on access to pressures data at the correct spatial and temporal resolutions, both for current [2016] and emerging pressures on the marine environment. The group highlighted that there is little to no evidence that using a selection of MPAs as proxies for others in terms of condition and effectiveness of management measures is scientifically valid.

It was also recognised that a strong role for industry should be highlighted, in terms of providing access to data and carrying out monitoring (e.g. Types 2/3) of new impacts through licencing agreements. There is currently [2016] a risk that the licensing process is not as robust and effective as is assumed. Industry monitoring input would also necessitate some shared protocols for monitoring data collection, so that data from multiple sources can be integrated successfully. This approach could help to calibrate and ground-truth indicator models, if monitoring targeted different levels of pressure e.g. physical disturbance.

HBDSEG advised that the Type 1 monitoring network for benthic habitats should be as wide (spatially and temporally) as possible to allow impacts of large scale pressures such as climate change to be detected and to ensure that emerging pressures e.g. from fishing displacement, are not missed. Without this network, there is a risk that we do not understand the impacts of MPA management on the wider seas and that important emerging, large scale pressures are missed. HBDSEG emphasised the importance of the frequency of monitoring being ecologically relevant (e.g. linked to the natural variability of the features and any impacts from pressures).

Finally, it was acknowledged that significant efficiencies might be possible by considering all the benthic habitat option preferences together at the UK scale, when the outputs are all available.

These suggested HBDSEG amendments would ensure that the policy preference could be implemented with some confidence in the outputs in terms of informing decision making. A strong evidence base of pressures and environmental data is a pre-requisite to ensuring robust data analysis and would bring value for money in terms of allowing expensive biological data collection to be interpreted correctly. Delivery of some of these data through industry monitoring represents integration that could yield benefits to both conservation organisations, regulators, and developers. More robust, targeted, and standardised data collection on marine habitat impacts would allow advice and consents to be given from a stronger evidence base, which may allow conservation advisors to be less precautionary. A Type 1 monitoring network that operates at the relevant spatial and temporal scales and at a suitable frequency of data collection, would ensure that risks around emerging pressures and climate change were minimised.

Inclusion of HBDSEG advice in policy option preference:

Amendments have been made to the cost profiles for the policy option preference (Option 3), to reflect the additional resource required to coordinate industry data flows. These roles (one Senior Executive Officer and one Higher Executive Officer) will encompass both the offshore and deep sea benthic habitat environments and will improve access and optimisation of industry data, facilitate join-up in monitoring protocols and assist understanding of the single and cumulative impacts of human activities and associated pressures. This will improve ability to effectively advise on licensing agreements and monitoring protocols to ensure impacts of current [2016] and new licensed activities are understood and mitigated as far as possible.

A broad additional cost has been estimated for two extra large-scale deep sea monitoring surveys per six-year reporting cycle, increasing the number of surveys from four to six. This

will increase the frequency of monitoring (MPA and wider environment) from once every five years to once every four years (on average). Monitoring at a higher frequency will improve our ability to understand the natural variability of deep sea habitats and ensure monitoring is conducted at an ecologically relevant frequency, while enabling earlier detection of human impacts. Improved understanding of the natural variability of each deep sea habitat type will allow us to move towards monitoring at an ecologically relevant frequency.

A broad additional cost has been estimated for the collection, processing, and analysis of additional environmental parameters (i.e. physico-chemical properties of sediment and water column), to ensure the correct interpretation of causes of change in biological communities and habitat structure and to improve our ability to attribute variation to large-scale drivers such as climatic changes. This will also require the incorporation of existing large-scale environmental datasets (e.g. those collected by remote sensing) to interpret changes in the context of regional, national, or global trends. It should be noted that the specific parameters to be monitored for each habitat type/site/region need to be considered in detail at the implementation stage of this monitoring option and therefore only coarse associated costs have been provided.

HBDSEG highlighted the reliance of this option on having access to pressures data at the correct spatial and temporal resolutions. This is an assumption of the current [2016] option preference but should be considered explicitly in terms of whether the data are readily available and what the cost would be. There is a role here for the UKMMAS pressures steering group and the Productive Seas Evidence Group (PSEG). A cost has not been estimated for this element as the governance and structure already exists, but the requirement for alignment of products which can improve our ability to infer potential impacts of human activities is acknowledged and emphasised.

A summary of the costs, benefits and risks associated with the policy option and HBDSEG amended policy option, are provided in Table 4.

Table 4: Comparison of costs, benefits and risks associated with policy option and HBDSEG amended policy option [table created in 2018].

Monitoring option	Key monitoring elements	Average annual Cost (£Mill)	Benefits	Risk
Policy preference (Option 3)	• Monitoring within 5 representative high priority MPAs (~35% of deep sea MPAs) once per 6-year cycle. • Monitoring of high priority deep sea habitats in the wider (outside of MPA) environment.	1.97	• Ability to directly assess conservation status of high priority* habitats within ~35% of MPAs. • Wider environment monitoring will provide some data for regional assessments (e.g. MSFD), detection of emergent issues and context for MPA-scale change. • Monitoring within a range of pressure intensities (inside and outside of MPAs) will improve indicator models for assessing and inferring habitat condition.	• No direct monitoring to determine habitat condition for any habitats within 65% of MPAs; this is likely to result in ineffective management and / or unnecessary harm to protected habitats, and / or stakeholder livelihoods. • Limited understanding of the individual and combined impacts of human pressures on deeps sea habitats and pressure maps of insufficient resolution limit's ability to effectively manage human activities in those areas not directly monitored. • Lack of understanding of the composition and function of many deep sea habitats and how they naturally vary over time means monitoring only once every 6 years will limit ability to assess effectiveness of management. • Limited ability to detect large scale changes associated with climate change due to limited spatial extent and temporal frequency of monitoring in the wider environment.

Monitoring option	Key monitoring elements	Average annual Cost (£Mill)	Benefits	Risk
Policy preference (Option 3)				• Impact of licensed activities on deep sea habitats may be greater than anticipated especially for new activities, due to lack of join-up with industry monitoring protocols and limited access to industry data.
HBDSEG advised amendments to policy option	• Monitoring within 5 representative high priority MPAs and wider environment habitats at a greater frequency to improve understanding of natural variability. • Two additional roles (S and H grade) for coordinating the industry data flow to improve access and optimisation of industry data, facilitate join-up in monitoring protocols and enable better understanding of the impact of human activities.	3.04 Policy option plus: • Increased frequency of monitoring (+£1M for 2 extra large-scale surveys per 6-year cycle) • Industry data flow coordinator (+£50K) • Collection/processing/analysis of environmental data (+~£20K)*.	• Ability to directly assess trends in conservation status of high priority* habitats within ~35% of MPAs. • More frequent monitoring will improve understanding of natural temporal variability, allow earlier detection of emergent issues and higher confidence in detecting impacts from human impacts and evaluating effectiveness of management. • Improved ability to effectively advise on licensing agreements and monitoring protocols to ensure impact of current and new licensed activities are understood and mitigated as far as possible.	• No direct monitoring to determine habitat condition for any habitats within 65% of MPAs; this is likely to result in ineffective management and / or unnecessary harm to protected habitats, and / or stakeholder livelihoods. • Limited ability to detect large scale changes associated with climate change due to limited spatial extent of monitoring in the wider environment.

Monitoring option	Key monitoring elements	Average annual Cost (£Mill)	Benefits	Risk
HBDSEG advised amendments to policy option	• Provision of environmental data including collection of new data and use of existing large-scale datasets (broad costs reflect sample collection/processing) • Provision of more practicable pressures products and sensitivity information and improved alignment with PSEG.			

Footnote: * Cost includes one additional survey day per year (split across surveys), processing and analysis.
** Cost includes one SEO- and one HEO-grade role split between offshore and deep sea benthic habitats.

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Appendix 1 – New cost information for Options 2-4

Table A1: Costing information for Options 2 to 4. Cost information for Options 1 and 5 remain as before [table created in 2016].

Option	Number of surveys required to implement option	Survey	Areas to be surveyed	Monitoring type(s) - where multiple types are required, it is assumed that designs would be nested to avoid duplication of samples	Total number of survey days per survey campaign	Total costs per survey	Total cost per year (survey costs / 6)
Option 2	Five surveys within the first six years	1	The Canyons MCZ.	Type 2 & 3	-	-	£0.84m
				High effort Type 1	36	1,486,483	
		2	Faroe-Shetland Sponge Belt NCMPA - would do one of FS sponge belt or NE FSC. For cost purposes, assumed the most expensive of the two (NE FSC) but FS sponge belt may be selected for survey due to baseline data.	Type 2 & 3	-	-	
				High effort Type 1	-	-	
			North-East Faroe Shetland Channel NCMPA.	Type 2 & 3	-	-	
				High effort Type 1	-	-	
			Wyville Thomson Ridge SCI.	High effort Type 1 + 2 & 3	43	1,704,975	
		3	Geikie Slide and Hebridean Slope NCMPA and/or Barra Fan (assumed cost for Geikie only).	Type 2 & 3	-	-	
				High effort Type 1	-	-	
			East Rockall Bank SCI.	High effort Type 1 + 2 & 3	46	1,860,525	
Option 3		1	The Canyons MCZ.	Type 2 & 3	-	-	£1.97m

Option	Number of surveys required to implement option	Survey	Areas to be surveyed	Monitoring type(s) - where multiple types are required, it is assumed that designs would be nested to avoid duplication of samples	Total number of survey days per survey campaign	Total costs per survey	Total cost per year (survey costs / 6)
	Five surveys within the first six years			High effort Type 1	-	-	
			South-west approaches - UB coarse & mixed sediments.	High effort Type 1	70	3,045,150	
		2	Faroe-Shetland Sponge Belt NCMPA - would do one of FSC sponge belt or NE FSC. Assumed most expensive of the two.	Type 2 & 3	-	-	
				High effort Type 1	-	-	
			North-East Faroe Shetland Channel NCMPA.	Type 2 & 3	-	-	
				High effort Type 1	-	-	
			Wyville Thomson Ridge SCI.	High effort Type 1 + 2 & 3	43	1,704,975	
		3	Geikie Slide and Hebridean Slope NCMPA and/or Barra Fan (assumed cost for Geikie only).	Type 2 & 3	-	-	
				High effort Type 1	-	-	
			East Rockall Bank SCI.	High effort Type 1 + 2 & 3	46	1,860,525	
		4	Hebridean Slope - UB sand & UB/MB mud.	Type 1 & 2	-	-	
			West Shetland Slope - UB coarse & mixed sediments.	Type 1 & 2	126.50	5,231,900	
Option 4		1	Hatton Bank.	Low effort Type 1	-	-	**£2.33m**

Option	Number of surveys required to implement option	Survey	Areas to be surveyed	Monitoring type(s) - where multiple types are required, it is assumed that designs would be nested to avoid duplication of samples	Total number of survey days per survey campaign	Total costs per survey	Total cost per year (survey costs / 6)
	One extra survey		Hatton Rockall Basin.	Low effort Type 1	-	-	
			NW Rockall Bank.	Low effort Type 1	39.00	1,448,600	
		Survey add-ons	Darwin Mounds.	Low effort Type 1	6	199,250	
			Rosemary Bank.	Low effort Type 1	5	161,400	
			East Mingulay.	Low effort Type 1	-	-	
			Anton Dohrn.	Low effort Type 1	10	319,000	