JNCC Report 765

Annex 1: 2018 options for monitoring UK cetaceans

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August 2024

ISSN 0963 8091

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This report should be cited as:
Macleod, K.[1] 2024. Options for Monitoring UK Cetaceans. *JNCC Report No. 765 (Annex 1: 2017 monitoring options for UK cetaceans)*, 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 Inter-Agency Marine Mammal Working Group (IAMMWG) and the Healthy and Biologically Diverse Seas Evidence Group (HBDSEG) Marine Mammal 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 the government funded UK cetacean 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. However, inflation has significantly increased the costs of marine monitoring and as a result there has been ongoing, yearly erosion of core monitoring.

Greater understanding of cetacean populations is required to provide evidence for tackling the biodiversity loss and climate crisis. Monitoring cetaceans 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.

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. 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 Background

JNCC and the country nature conservation bodies (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 address the UK's significant policy and statutory obligations.

The UK Marine Biodiversity Monitoring Programme (led by JNCC) has been tasked with developing recommendations for an integrated monitoring scheme for all marine biodiversity across all UK waters. Monitoring means to observe and check the progress or quality of something (e.g. population abundance) over a period to ensure conservation/ monitoring objectives are being met.

We are not currently [in 2017] fulfilling our nature conservation obligations (Table 1) for monitoring and assessment in a coordinated and cost effective manner, nor are we able to provide robust evidence for marine management purposes. A decision is now required on which option, or elements from each option, should be selected for monitoring UK cetaceans.

A workshop on 7 February 2017 discussed the proposed UK cetacean monitoring options with policy colleagues from the devolved administrations. It was not the purpose of the workshop to choose an option but to use criteria to discuss and score the risks and benefits of each. This activity helped understanding of the options during the workshop and provided a way of capturing views that can inform further considerations, that will eventually conclude on which option is preferred. There was no requirement for countries to agree on the same preferred monitoring options, but where possible, high priority assessment and reporting obligations should be met across the UK in a strategic manner. Determination of which monitoring option to implement will not be a purely scientific decision, as it will involve consideration of acceptable level of risk of damage to biodiversity 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.

2 Development of the UK Cetaceans monitoring options

The monitoring options are built around two types of monitoring: state and pressure. The 'what' and 'how' to monitor was identified by:

i) applying the principles set out in the UK Marine Biodiversity Monitoring Strategy,

ii) assessing performance of current [2017] monitoring activities against a suite of monitoring objectivities, and

iii) based on the outputs of stages i) and ii) develop options which build to an increasing inclusion of what needs to be monitored and regarding legal requirements and obligations.

In September 2015, Chief Scientist Group advised that there was a need for a workshop (subsequently held in October 2015) to discuss a 'reduced cost monitoring option'. Reduction in costs were identified in current [2017] monitoring programmes by stopping or modifying components of their work; although these changes could bring about cost savings they are not without risks. However, the reduced cost option was the foundation of the options presented at the February 2017 policy workshop (Macleod 2017). The option suite comprised:

Option 1: Reduced cost monitoring to meet prioritised legislative requirements.

Option 2: Option 1 plus additional effort to monitor status and pressures more effectively (less uncertainty) and for more species.

Option 3: Option 2 plus moving towards other measures of status and greater understanding of change.

The view of the February workshop participants on the three options can be summarised:

- All participants agreed that the cetacean options suffered from the lack of a 'most ambitious' option; this would help Ministers see the bounding scenarios and understand where the currently [2017] proposed options sit on the spectrum of possibility in terms of costs and benefits. The participants also felt that the development of a higher standard might allow 'spacing out' of the current [2017] options, allowing more real choice between the options in terms of activities, benefits, and costs.
- Since the options were originally drafted (primarily 2013–2014), further projects have come on-stream, especially using passive acoustics for monitoring cetacean seasonal distribution. These need to be captured in the options suite.
- Harbour porpoise candidate Special Areas of Conservation (SACs) have also recently been designated and development of monitoring for these also needs to be recognised within the option suite.

On that basis, the options have been revised to develop a suite of five options: Option 1 is a 'reduced cost' option; Option 2 is current [2017] monitoring; and Options 3 to 5 offer an increasing scope of monitoring activities (including target species, spatial scale and frequency of sampling) which consequently reduce risks arising from evidence gaps but also have increasing costs. The revised options have been developed with CNCB colleagues through the Inter-Agency Marine Mammal Working Group (IAMMWG).

3 The UK Cetacean Monitoring Options

3.1 Species to be monitored

There are 10 regularly occurring cetacean species in UK waters identified for monitoring. Some species occur predominantly on the continental shelf in water depths of 200 m or less, whilst others range more widely into offshore waters beyond the shelf edge (Table 2).

Existing monitoring programmes tend to focus on/are generally designed to sample the most common of the regularly occurring species (e.g. harbour porpoise, common dolphin, inshore bottlenose dolphin) to obtain valid sample sizes for meaningful analysis. However, the scope of species included in monitoring broadens from Option 1 through to 5, to build a comprehensive suite of monitoring activities of status and pressures for all regularly occurring species.

3.2 Definitions of trends in abundance

For the purposes of developing monitoring options, long-term trend was defined as a decline ≥ 30% over three generations. This is taken from the IUCN definition (IUCN Red List 2013) of how a species would be classified as *vulnerable*.

For short-term trends, the Habitats Directive asks that Member States report for a 12-year period and the reporting guidance (Evans & Marvella 2011) provides an 'indicative suggested threshold" for a large decline as 1% per year. The target for assessing trend for the OSPAR interim assessment is also 'short-term' and for wide-ranging cetacean species defines a negative trend (i.e. a decline) as 'a decreasing trend of ≥ 5% over 10 years'.

3.3 The options

3.3.1 Option 1: Reduced cost

Working under a reduced budget scenario, it was necessary to identify a priority legal driver for monitoring and focus on key parameters and species. This option focusses on monitoring the core indicators and targets identified through the work of OSPAR in the North East Atlantic. These parameters are part of OSPAR's Intermediate Assessment 2017 and will contribute to the delivery of the next OSPAR Quality Status Report as part of Contracting Parties commitment to delivering the OSPAR North-East Atlantic Environment Strategy. On this basis, indicators on abundance (and distribution) and population condition relating to bycatch are considered priority parameters. However, there is an overlap of these with requirements for the Habitats Directive; abundance is a key parameter in defining Conservation Status and Article 12 requires the impact of 'incidental capture' to be determined. EC Regulation 812/2004 requires cetacean bycatch to be monitored. There is also some overlap of Directive/Regulation requirements with those of Agreements, such as the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS).

Given the objective of this option is to reduce costs, the common species currently [2017] sampled would remain the focus as sampling less abundant species would require additional resources. The activities to be undertaken in this option are shown in Table 3 and maintain the UKs current [2017] monitoring programmes; Cetacean Stranding Investigation Programme (CSIP, including the Scottish Marine Animal Stranding Scheme, SMASS), Bycatch Monitoring Programme (BMP) and bottlenose dolphin SAC monitoring, but have reduced their costs compared to current (2016 to 2017), based on a number of potential identified changes to approach (Table 4). Potential cost savings were identified where components of existing monitoring programmes could be:

- reduced (e.g. less frequent sampling) and/or
- changed (e.g. alternative approaches to sampling or project management)

without affecting delivery of monitoring objectives. Changes to the approaches within current [2017] programmes that *might* bring about cost-savings include:

- CSIP: i) revising processes/approach for carcass collection and processing; ii) streamlining programme management/overview and iii) potentially reducing the number of post-mortems (PMs) carried out.
- BMP: i) reduce at-sea observations of pinger effectiveness ii) rely on non-dedicated observers to monitor low risk fisheries; and iii) delay seabird bycatch monitoring until an integrated approach has been assessed/identified.

The potential cost saving (Table 4) is an estimate only. If a reduced budget is the key driver, then an in-depth review of existing schemes would be needed to fully assess the magnitude of savings and the implications on the delivery of the schemes and monitoring objectives.

Activities which do not provide data to inform priority parameters are discontinued to 'reduce cost' (e.g. Northern Irelands land based monitoring). Similarly, activities which do not have

high “added value” (e.g. line transect surveys for Cardigan Bay SAC monitoring) and activities which cannot, without very significant resource demands, deliver precise parameter estimates (e.g. large-scale offshore surveys) are pared back in the achievement of a reduced cost option.

The evidence requirements delivered, and the risks/limitations are outlined in Table 7.

3.3.2 Option 2: Current [2017] monitoring

Monitoring of bottlenose dolphin SACs provides good power (Appendix 1) to assess abundance and population trends in abundance from annual photo-ID surveys currently [2017] undertaken. The funding structures for this work in Scotland and Wales differ. In the Moray Firth, funding currently [2017] comes from a framework with government, industry, and Aberdeen university such that Scottish Government funds surveys every three years. However, such a framework does not exist in Wales to support Cardigan Bay activities and it would be challenging to find additional funds to continue annual surveys and maintain the long-term dataset if the current [2017] Welsh Government funding was reduced. The annual surveys in Wales are crucial for the collection of survey data to support the population models used to generate abundance estimates.

Current [2017] monitoring at the national scale is limited and status and pressure parameters cannot be assessed confidently for many species. In summary, current [2017] monitoring activities (Table 3):

- Deliver precise population abundance estimates for the most common shelf species every ~10 years (SCANS surveys) which allow population level impacts of pressures, such as bycatch, to be assessed. Long-term trends (over decades; Appendix 1) in abundance can be detected for some species. However, decadal surveys do not enable short-term declines in abundance to be determined with good power for any species, which is needed for OSPAR targets or for Habitats Directive reporting (Appendix 1).
- Monitoring of coastal bottlenose dolphins using photo-ID methods, primarily associated with designated SACs is sufficient for monitoring abundance, trends in abundance and allows population demographics to be studied. Ad-hoc support for monitoring surveys of bottlenose dolphins in other coastal locations (e.g. southwest England).
- Regional visual projects assess relative abundance and distribution from shore-based watches (harbour porpoise, Northern Ireland; Risso’s dolphin, North Wales) or line-transect surveys (e.g. multi-species boat-based surveys west of Scotland; white beaked dolphins in Lyme Bay). Deliver fine scale distribution and relative abundance data, often from summer surveys only, that do not inform on species status in isolation.
- Regional acoustic projects off east Scotland (ECOMASS) and west Scotland and Northern Ireland (COMPASS) provide year-round data on the presence of cetaceans. The COMPASS project will provide some data in the Inner Hebrides and Minches SAC.
- From the 2012–2016 data, strandings and post-mortem examination (PME) programmes (CSIP and SMASS) are adequate for determining and detecting changes in the causes of death for harbour porpoise, common dolphin, and bottlenose dolphin only. It is inadequate for all other regular UK species (Appendix 2).
- Pressure monitoring through PME and ad-hoc analysis of samples is currently [2017] the only source of data on some of the pressures affecting UK cetaceans (e.g. pollutants).

- CSIP and SMASS undertake surveillance on the incidence of disease in stranded cetaceans to identify any substantial new threats to their conservation status.
- Targeted bycatch monitoring focuses on certain gears, areas and species with known bycatch or risk of bycatch, driven by the requirements set out in EC Regulation 812/2004 and Article 12 of the Habitats Directive.

Except for the Inner Hebrides and Minches SAC, current [2017] monitoring does not include activities for newly designated or proposed marine protected areas.

The evidence requirements delivered, and the risks/limitations are outlined in Table 7.

3.3.3 Option 3: Improvements to current [2017] monitoring to reduce uncertainty in monitoring parameters and ensuring MPA baseline condition monitoring in place

This option builds on current [2017] monitoring and expands activities to improve our ability to meet the core legislative requirements of European (e.g. OSPAR/MSFD) and UK legislation for a greater number of species. Status parameters are improved by increasing frequency of monitoring and pressure parameters by increasing effort for key species or expanding effort spatially.

Species abundance is estimated from large-scale SCANS-type surveys, but the survey interval is six-years rather than decadal; surveys could cover UK shelf only or, for additional resource (approximately double), both shelf and offshore waters. Robust abundance estimates generated from such surveys are required for assessing mortality from bycatch, for example, in a population context. Increasing survey frequency will potentially enable power to detect long-term trends (over decades) in 8 of the 10 species identified for monitoring; for white-sided dolphin, offshore bottlenose dolphins and Risso's dolphin the certainty to do this would be greater if precision (more effort) could be improved (Appendix 1). There are insufficient data on killer whales to generate population abundance within UK waters.

In the short-term (12 years), only large annual declines can be detected with six yearly large-scale surveys for any cetacean, which would result in population level changes of 30–90% for the various species within that timeframe. Trends are not detectable within this time frame for Risso's dolphin, Atlantic white sided dolphin, or sperm whales. Therefore, this option proposes that the use of existing monitoring data, collected by NGOs, industry, academia, be integrated with the large-scale monitoring data and collectively analysed to investigate power to detect short-term trends. This approach has been tested through analysis of monitoring data collated through the 'Joint Cetacean Protocol' (JCP). The JCP was a collaborative project aimed at collating disparate effort-related cetacean sightings datasets so that analyses could be applied to inform on distribution, abundance, and trends in UK waters. A new JCP would use available monitoring data, but investment would be required to better *coordinate* data collection using an identified standard, build a mechanism for data submission and storage and work towards a central, accessible database. Data can be used from a variety of platforms, including digital aerial surveys which are carried out (largely on behalf of industry) to survey cetaceans and seabirds. Good relationships with stakeholders need to be developed. In this respect, cetacean data may also be collected through schemes such as "Seabirds at Sea': although this scheme is currently [2017] not supported (agency specialists are not funded to join appropriate surveys), the seabird options developed as part of the UK Marine Biodiversity Monitoring R&D Programme include the development of a low-cost volunteer-based European Seabirds at Sea monitoring scheme. The methods employed during these surveys would enable cetacean data to be collected also. A large amount of data on cetaceans is already collected by volunteer

networks (through NGOs) using vessels of opportunity; additional surveys primarily developed for seabird sampling would augment these. Having an accessible database would enable a suite of questions relating to monitoring of cetaceans throughout the European shelf to be addressed; analyses could be conducted at intervals to coincide with reporting periods. The datasets and associated analyses would also be useful in identifying and managing MPAs.

This option ensures there is a basic level of condition monitoring in all designated and currently [2017] proposed cetacean MPAs. Inshore bottlenose dolphin abundance is best estimated through boat-based photo-identification. There is no change to current [2017] monitoring of bottlenose dolphins in this option because that associated with the SACs is sufficient for the purposes of assessing SAC condition. Current [2017] ad-hoc support for monitoring outside of SACs (e.g. in the southwest) is unchanged in this option as this work is not associated with an SAC.

Risso's dolphin are a potential MPA feature in Wales and a Nature Conservation MPA (NCMPA) proposal has been identified in Scotland. SCANS-III (Hammond *et al*. 2017) was the first large scale survey to have enabled an estimate of abundance for this species but its precision is poor. There are core areas where this species is distributed and targeted land-based visual surveys and photo-ID work in these areas could deliver more precise regional estimates. This species is also underrepresented in pressures monitoring (no power in the post-mortem data to detect changes in the relative causes of death, Appendix 2) and is a species whose status is poorly understood.

NCMPA proposals for minke whale could be surveyed through a combination of summer line transect and photo-ID studies.

For the large harbour porpoise SACs, sites are prioritised for monitoring based on risk from pressures and uncertainty surrounding evidence supporting their management. Sites that are at high risk from immediate pressures and/or have seasonal areas within the site that may influence management decisions, are proposed for monitoring in this option; namely Southern North Sea and West Wales cSACs. The proposed monitoring approach is year-round deployments of passive acoustic monitoring devices to monitor abundance. Depending on the device and design of the monitoring programme, such monitoring may also contribute to monitoring of noise and understanding of its impacts.

Seasonal abundance of other species will be achieved through expansion of the passive acoustic monitoring work currently [2017] on the east coast of Scotland that targets bottlenose dolphins. Deployments would also be placed in other areas used by bottlenose dolphin populations associated with an SAC, namely off west Wales.

Pressure-related monitoring for all cetacean species is achieved through the CSIP and BMP, but with increased effort/sampling to better sample areas/species. For example, monitoring effort undertaken through the BMP is expanded to provide wider spatial (e.g. North Sea) coverage to increase confidence in population level assessments of bycatch for key species. This programme should also include approaches to assess population level impacts from entanglements of minke whales. Networks of volunteers/reporting need to be strengthened in the CSIP to ensure species that are currently [2017] under sampled or infrequently retrieved for post-mortem (e.g. Risso's dolphin, white-sided) are improved. Analysis of samples from post-mortem work are also regularly supported (every 5 years) to derive demographic, life history and contaminant data.

The evidence requirements delivered, and the risks/limitations are outlined in Table 7.

3.3.4 Option 4: Option 3 plus moving towards other measures of status and greater understanding of change

This option includes all those activities identified in Option 3 but further reduces uncertainty in status and pressures parameters by expanding the spatial scope of monitoring activities (thus capturing more of the populations) and increasing sampling frequency. Some of the monitoring activities identified (Table 3) may fall within R&D initially rather than routine monitoring using tried and tested approaches.

The frequency of large-scale abundance surveys is triennial. This increase means that smaller declines in populations are detectable in the short term (12 years) but such changes remain large (greater than 30%) for all species other than harbour porpoise and common dolphin. Therefore, this option also proposes these large-scale survey data are contributed to a JCP so that monitoring of short-term trends in abundance for a wider range of species might be achievable through analyses. In this option, Governments/CNCBs would also support (e.g. match fund) small scale/regional cetacean surveys to fill evidence gaps at smaller spatial scales identified through the JCP.

Continuation of the annual photo-ID surveys in and around the bottlenose dolphin SACs provide information on abundance and short-term trends for this species. Work on bottlenose dolphin “SAC populations” is expanded to include other locations within this species range because only a proportion of the animals use the SAC at any one time. Population life-history parameters can also be studied through long-term photo-identification studies.

Monitoring of harbour porpoise within protected sites is expanded to other sites; namely the Bristol Channel and North Channel cSACs, both of which were designated for predicted elevated winter densities. Year-round passive acoustic monitoring would validate this and detect finer-scale seasonal and spatial use within the sites. The bottlenose dolphin acoustic monitoring work initiated on the east coast of Scotland is further expanded to cover more areas known to have resident inshore bottlenose dolphin groups/communities.

This option puts greater emphasis on other parameters, apart from abundance, to be monitored; for example, reproductive rate through the regular analyses of female reproductive organs from stranded animals, which is another potential approach to monitoring status, especially for species where precise abundance estimation is challenging (e.g. Atlantic white-sided dolphin). This could aid identification of underlying causes of population change (e.g. lowered reproductive rate has been linked to PCB concentration in cetaceans). Analysis of reproductive parameters may provide an option for detecting signs of population change in the shorter term and will complement or add confidence to JCP trend outputs and population abundance estimates. This benefit is, however, offset with the challenge of obtaining enough biological samples for analysis of these species within the UK. Combining data from the CSIP with data from other European stranding projects, would allow an assessment of reproduction rates on a regular basis for harbour porpoise and common dolphin. Other species which do not strand so frequently would require longer time scales to accumulate sufficient samples. Sample collection and storage in the tissue archive are already undertaken by the CSIP but there is a backlog to analyse. Teeth, for example, are routinely stored and analysis would allow an understanding of the age-structure of key species (harbour porpoise and common dolphins). The development of a biopsy programme associated with photo-ID boat based surveys for Risso’s, minke, and on an ad-hoc basis killer whales, would provide further samples for demographic, life history and contaminant analyses.

The CSIP and BMP continue to be the basis of pressure monitoring but further work, that brings in new technology to aid monitoring is invested in. Technology, in the form of Remote

Electronic Monitoring (REM), might facilitate the spatial/species expansion of the scheme; Development of an 'App' and volunteer network to record effort-related strandings data would greatly facilitate the interpretation of outputs from the strandings work. The Scottish Marine Animal Stranding Scheme (SMASS; partners in the CSIP) has already initiated a pilot project on this approach which will likely be trialled in Orkney.

This option increases the frequency of analysis of samples collected from monitoring activities of contaminants (PCBs and wider) in cetaceans. The impact that contaminants have on cetacean status is not clearly known. However, the effects of some contaminants (e.g. PCBs) have been well studied in recent years and potentially pose a serious threat to some species (e.g. bottlenose dolphin and killer whale). Ongoing assessment of contaminants as a component of a monitoring programme for key species would enable the impacts of this pressure to be better understood.

The evidence requirements delivered, and the risks/limitations are outlined in Table 7.

3.3.5 Option 5

This option includes all the activities of Option 4 but further increases spatial scope and frequency so that all species that should be monitored are and the precision of parameter estimates should be at its best given the extended data collection (Table 3).

Large-scale surveys of abundance are annual. As in previous options, these should take place in the summer months; attempting such surveys seasonally will not be cost effective because of the weather restriction on visual surveys. To increase understanding of seasonal abundance (of importance for assessments and management decisions), acoustic monitoring of bottlenose dolphins is extended to cover all areas where this inshore species is known to occur and throughout all the harbour porpoise SACs.

The annual surveys mean that relatively small changes in cetacean abundance can be detected in the short-term; they allow small annual declines (less than 1% as per Habitats Directive definition) to be detected for five of the 10 regular species (harbour porpoise, common dolphin, white-beaked dolphin, minke whale and pilot whale). Annual declines of 1–2% per annum could all be detected within 12 years for the other species, even for the 'rare' sperm whale. With regards the OSPAR short-term objective, the minimum decline in a 10-year period that could be detected from precise, annual abundance estimates is 5% for the harbour porpoise (i.e. the target could be measured and assessed). For all other species, the target is not measurable even with annual surveys.

All species within MPAs (including those that are currently [2017] proposals) are monitored seasonally using a variety of techniques; visual line transects, passive acoustic devices, photo-ID, and biopsy. Additional techniques (use of drones for example) may be trialled for monitoring of less studied pressures, such as the prevalence of starvation, by monitoring body condition in localised populations. The use of biopsy sampling is extended to killer whales, primarily around the northern Isles, where this species occurs annually; this sampling would provide further samples for demographics, life history and contaminant analyses.

Acoustic monitoring is expanded spatially and into the offshore area. However, depending on devices, acoustically monitoring the offshore waters would monitor seasonality in presence of a wide range of cetacean species, as well as ambient noise.

The bycatch monitoring programme would be a fully integrated programme, not just *targeting* cetaceans but effectively monitoring multi-species from a variety of taxa that are subject to bycatch (e.g. seabirds).

3.3.6 Monitoring abundance: other Member States approach

The abundance of cetaceans is one of the key parameters for monitoring the status of species. In the UK, robust estimates of population abundance for the most common species are achieved through contribution to the large-scale, pan-European SCANS surveys. Without this, the UK would not have population abundance estimates for most species. Because of the range of many 'UK' cetaceans (i.e. they are transboundary in nature), large scale surveys coordinated at the European scale are the recommended approach to achieve meaningful population abundances. Continued collaboration with European countries is important in ensuring meaningful population estimates are achieved. Interpretation of trends in UK abundance estimates, for the harbour porpoise for example, would be challenging without the wider context of abundance throughout its range.

Other European Member States have more frequent, systematic monitoring of the abundance of cetaceans in their waters. This is summarised in Table 5.

3.3.7 Costs of Monitoring Options

An average annual cost is estimated for each option over a ten-year period. This period was chosen to capture one decadal SCANS survey which is the greatest 'additional' expenditure (£600K over three-years [2017]) to the routine annual costs of running core programmes (CSIP/SMASS and BMP). All costs have been estimated based on existing or recent comparable work. The cost for 'reduced cost' monitoring (option 1) assumes that areas for cost savings within existing programmes can be realized; this has yet to be tested. Annual costs were increased through time by 1% to allow for some inflation. Uncertainty in costs increases with increasing options; inevitably option 5 includes some complex or more novel approaches that have not been well used in the UK and accurate costs will not be possible until all activities are properly designed. The cost of implementing each of the above options for UK cetaceans is given in Table 6.

4 Discussion

4.1 The options

The options rely on methods that have been applied and therefore are implementable. Where a choice of approach was available, the approach deemed more cost effective was chosen (for example, large-scale survey costs are based on a combination of shipboard and aerial surveys using observers rather than high-definition cameras). There has been an increasing interest in testing other approaches in recent years; high resolution digital cameras, gliders, and drones for example. Investment in these methodologies and further consideration of their capabilities may be worth further exploration through R&D projects.

These options do not implicitly consider monitoring related to monitoring noise (its impact on cetaceans) or collision risk (e.g. from wet renewables) primarily because the funding would not *necessarily* come from governments and has therefore not been considered. However, the Scottish Government are funding a demonstration project in partnership with industry to investigate interactions between tidal energy and marine mammals.

Some aspects of this work might be informed by monitoring approaches using passive acoustic devices but as the tidal industry is still small scale, what will be required in terms of monitoring is not clearly understood.

JNCC are working together with the CNCBs to develop monitoring options for other marine components (seabirds, benthic and deep-sea habitats). Integration of targeted monitoring for

mobile species, such as cetaceans, seals, and seabirds, at least, may improve efficiency by sharing methodologies suitable for surveying several mobile species components and from common survey platforms. Some such opportunities have already been identified in the options. However, whether similar integration could be achieved from benthic surveys has yet to be fully explored, and for mobile species such as cetaceans, the value in survey data collection from benthic surveys will depend primarily on the sampling design and survey area.

4.2 Country preferences regarding a monitoring option

The lead policy staff within the Devolved Administrations were given opportunity to review and comment on the revised option suite; the result of which is presented in this paper. They were also asked to consider which monitoring option or combination of activities across different options currently [2017] represents their position on future monitoring activities. A discussion was held via teleconference, on 21 September 2017, with representatives from JNCC, Defra, Welsh Government and Department of Agriculture, Environment and Rural Affairs. Marine Scotland communicated their preference via email.

The majority preference was for Option 2; maintain current [2017] monitoring. The primary reason for this was that commitments to increase funding for cetacean monitoring were currently [2017] not possible. Where additional funds were made available on an ad-hoc basis, there was ambition that this could be channelled into suitable projects, such as the Joint Cetacean Protocol. However, it was noted that this does not constitute a sustainable UK wide monitoring program given that a long-term commitment to funding such additional monitoring projects is not integral to the annual monitoring budget. Political will determines where additional funds are used and currently [2017], in England at least, this tends to align with stakeholder (e.g. NGO) priorities. This reflects the view that political risk was considered greater than legal risk from the EU or nationally. One DA opted for Option 3, recognising that this option effectively considers the needs for monitoring MPAs and maximises use of the resource in existing datasets (e.g. collected by NGOs on vessels of opportunity) through the Joint Cetacean Protocol. They considered that the further development of the JCP would bring about benefits to management decision making, allowing timelier, informed and therefore less precautionary decisions to be taken.

5 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. HBDSEG 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 HBDSEG advice

HBDSEG considered that the preferred option for cetaceans (current monitoring [2017]) was inadequate and posed considerable risk, both to conservation of cetacean species and our ability to meet legal monitoring obligations. HBDSEG also questioned whether 'current monitoring [2017]' costs truly reflected the long-term commitment, given that some projects were part funded (by the EU for example) and therefore, had a limited life span.

HBDSEG concluded that the current [2017] evidence base is deficient and advised on how current [2017] monitoring activities can be developed to provide a minimum level of evidence. This advice is outlined in the following paragraphs.

SCANS: having SCANS surveys every six years would ensure that there are up-to-date robust population abundance estimates for the regular cetacean species in UK waters. The SCANS project is an international effort, and the UK should support/encourage other participating countries to fulfil an increased project frequency. Failing that, UK only 'SCANS-type' surveys should be timed to coincide with surveys being carried out by other countries which would expand survey coverage.

Increasing survey frequency will also improve our ability to detect long-term trends. With current [2017] decadal surveys, we can only detect declines of 30% over three generations for some species, which equates to decades (22–84 years depending on species). The Habitats Directive defines 'long-term' trends as those occurring over a period of 24 years. If surveys were carried out every six years, then declines of 30% or less (14–29%) could be detected for the most common species within this period (Table A). Within this time frame, it would remain impossible to detect long-term trends for Risso's dolphin (shelf), Atlantic white-sided dolphin and sperm whale (both offshore species).

Table A: Magnitude of declines detectable with 6-yearly surveys in a 24-year ('long-term') period. Number of surveys is 5 and CVs are from the SCANS-III surveys of July 2016. Power is 80% and α = 0.05.

Species	CV	% Decline detectable over 24 years	Annual rate of decline detectable
Harbour porpoise	0.16	14	0.6
Common dolphin	0.27	24	1.15
White-beaked dolphin	0.29	26	1.25
Minke whale	0.33	29	1.4
Risso's dolphin	0.69	60	3.75
Atlantic white sided dolphin	0.83	72	5.2
Pilot whale	0.48	43	2.3
Sperm whale	1.08	94	11

New cetacean monitoring database: current [2017] monitoring of cetaceans is insufficient for detecting trends in populations at short time scales (i.e. timescales that are valuable to informing management decisions). Current [2017] monitoring has decadal summer surveys

and ad-hoc support for small scale regional surveys, often in summer. So, there is a lack of more frequent and seasonal information available.

Monitoring data are currently [2017] collected by many organisations in the UK, particularly NGOs. These data are an invaluable resource which, through collation into an accessible database and analysis, could be used to assess a wealth of monitoring (and management) objectives. Collation of disparate datasets means that collectively there would be better coverage, spatially and temporally, than analysing datasets in isolation. This could also improve power to detect trends in abundance for most species. The approach has already been trialled through the JCP and its analysis phases; there were many lessons learned from the JCP project on which a future project can correct and improve.

When established, analysis of the database could identify data-gaps and the need for additional targeted surveys could be realised. The variability of the datasets can be problematic for analysis, and so a new 'JCP' type project would also address data standards and work with those conducting surveys to collect data to a standard protocol.

SAC/SCI monitoring: currently [2017], only populations of bottlenose dolphin associated with the SACs in the Moray Firth, Cardigan Bay, and Pen Llŷn a'r Sarnau are monitored. There was recognition of the need to monitor the new harbour porpoise SCIs. In the cetacean monitoring options, there is a ramp up from Options 3 to 5 in harbour porpoise monitoring of SCIs, starting with just two of the six sites. The monitoring method envisioned was static Passive Acoustic Monitoring devices deployed for year-round monitoring of the sites to collect data on seasonal usage and changes, which may be anthropogenically driven. The exact approach to monitoring of the SCIs could only be established when commitment and outline budget is confirmed.

CSIP: there was also strong support for maximising the use of stranded cetaceans examined in the Cetacean Strandings and Investigation Programme (CSIP). The current [2017] focus for the scheme is on identifying cause of death, but with a small increase in resource, additional biological information on species could be gleaned; this type of information can identify drivers of biological change (e.g. relationships of reproductive rates with contaminant burdens) and could flag ecosystem changes also (e.g. diet shifts).

7 Inclusion of HBDSEG advice in policy option preference

HBDSEG advised that to reach a minimum level of adequacy the monitoring programme should, in addition to all activities identified in 'current [2017] monitoring', include:

- An increase in the frequency of the Small Cetacean Abundance in the European Atlantic and North Sea (SCANS) surveys from the current [2017] ~ decadal interval to every six years.
- Development of a new cetacean monitoring database to collate and optimise use of existing datasets (akin to the discontinued Joint Cetacean Protocol).
- Monitoring within a sub-set of harbour porpoise Sites of Community Importance. Currently [2017], only populations of bottlenose dolphin associated with the SACs in the Moray Firth and Cardigan Bay are monitored.

A summary of the costs, benefits and risks associated with the policy option preference and HBDSEG amended policy option, are outlined in the Table B.

Table B: A comparison of the costs, benefits and risks associated with the policy option preference and HBDSEG amended policy option [table created in 2018].

Monitoring option	Key monitoring elements	Average annual Cost (£Mill)*	Benefits	Risks
Policy preference (Current [2017] monitoring)	• SCANS decadal aerial and shipboard survey. • Only 2 MPAS for bottlenose dolphins adequately monitored. • Some monitoring within 2 MPAs for harbour porpoise. • 5 ad hoc cetacean projects surveying with line transects & photo-ID and land-based methods. • Regional acoustic detection programmes (EcoMASS and COMPASS). • Protected species bycatch monitoring programme. Postmortem analysis to determine causes of death in stranded cetaceans.	1	Ability to detect long-term declines (over decades) in 5 regularly occurring species (harbour porpoise, pilot whales, minke whales, common dolphins, white beaked dolphins). Assess abundance and trends for 3 species within certain regional seas. Bottlenose dolphins very good data for populations associated with the SAC designation. Meets many of our ASCOBANS obligations.	Long-term trends (decades) possible for some species (e.g. harbour porpoise and inshore bottlenose dolphins). Unable to detect short-term trends in any species other than annually surveyed coastal bottlenose dolphin. Management decisions of activities causing key pressures (noise/bycatch/fishing/contaminants) occur in absence of detailed information on the relationship between pressure and potential impact. Unable to assess the effectiveness of existing measures outside of dolphin MPAs. Insufficient sampling to assess abundance and seasonal distribution of cetaceans for domestic policy goals and ambitions (e.g. OSPAR, UK Marine Strategy). Low engagement with environmental NGOs/citizen scientists and failure to utilise all existing data.

HBDSEG advised amendments to policy option	Changes to the policy preference: • SCANS aerial and shipboard survey every 6 years instead of 10. • Increased MPA coverage to include harbour porpoise SCI. Develop a cetacean monitoring database.	1.8	Robust population abundance estimates for the regular cetacean species in UK waters available at regular assessment/reporting intervals. Maximise potential in existing monitoring datasets. Analysis of the monitoring database may enable trends to be investigated for less abundant species. Datasets available to determine seasonal trends in distribution and abundance to inform management. Ability to conduct more robust assessments for cetaceans for MSFD, HD, OSPAR. Better able to assess the effectiveness of measures (e.g. MPAs). Full engagement with NGOS and citizen scientists to utilise existing data	SCANS is an international effort; greater benefit will be in ensuring it remains so and at the European scale. Access issues to stakeholder's data for the monitoring database.

Note: Average annual cost, this may vary between years depending on stage of activity.

References

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Appendix 1 – Tables

Table 1: National and international obligation for monitoring cetaceans [table created in 2017].

International & national obligations	Monitoring Requirement			Explanation
	Offshore	MPA	Wider environment	
Principal policy drivers				
EU Habitats Directive (HD 1992)	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. Bycatch (incidental capture and killing) monitoring is explicitly required under Article 12(4). 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). Post EU-exit, obligations will still be required through the Bern Convention.
National: Conservation (Natural Habitats, &c.) Regulations 1994; Conservation of Habitats and Species Regulations 2010; Conservation (Natural Habitats, &c) Regulations (Northern Ireland) 1995 (as amended); Offshore Marine Conservation (Natural Habitats & c.) Regulations 2007 (as amended)	Explicit	Implicit	Explicit	Several regulations transpose Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive) and Council Directive 2009/147/EC on the conservation of wild birds (Wild Birds Directive) into national law. Different regulations apply to the inshore (< 12 nm from the coast) and offshore marine area (waters beyond 12 nautical miles, within British Fishery Limits and the seabed within the UK Continental Shelf Designated Area). Regulation 48 of the Conservation of Habitats and Species Regulations 2010, relevant to inshore waters, states that *the appropriate authority must make arrangements in accordance with paragraphs (4) to (6) for the surveillance of the conservation status of natural habitat types of Community interest and species of Community interest, and in particular priority natural habitat types and priority species.* Section 44 of the Offshore Habitats Regulations states that *the Secretary of State must make arrangements for the surveillance of the conservation status of natural habitats of Community interest and species of wild flora and fauna of Community interest, and in particular priority natural habitat types and priority species.*

International & national obligations	Monitoring Requirement			Explanation
	Offshore	MPA	Wider environment	
EU Marine Strategy Framework Directive (MSFD 2008)	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.
National: Marine and Coastal Access Act (2009) Marine (Scotland) Act Marine Act (Northern Ireland)	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 country nature conservation agencies to carry out monitoring of MPAs designated under the Act (Section 124).
Additional requirements and commitments				
Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR 1998)	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. 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).

International & national obligations	Monitoring Requirement			Explanation
	Offshore	MPA	Wider environment	
Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)	Implicit	Implicit	Implicit	As a signatory state to ASCOBANS (daughter agreement of Bonn Convention/CMS), UK should work towards achieving the measures in the Conservation and Management Plan (CMP). This states that research "shall be conducted in order to (a) assess the status and seasonal movements of the populations and stocks concerned, (b) locate areas of special importance to their survival, and (c) identify present and potential threats to the different species." The CMP also states that "each party shall endeavour to establish an efficient system for reporting and retrieving bycatches and stranding specimens and to carry out … full autopsies in order to collect tissues for further studies and reveal possible causes of death and to document food composition". A number of resolutions have also been developed by Parties to ASCOBANS that request Parties to support further work to elucidate cetacean distribution, abundance and effects of chemical contaminants; to reduce bycatch below the threshold for unacceptable interactions (defined as a total anthropogenic removal above 1.7 % of the best available estimate of abundance [ASCOBANS 2000]); and to produce guidance to minimise risk and mitigate against the potential impacts of noise on cetaceans from offshore renewable energy activities.
Convention on Biological Diversity (CBD 1992)	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).
United Nations Convention on the Law of the Sea (UNCLOS 1994)	Explicit	Explicit	Explicit	As a signatory of UNCLOS, delivery of the work programmes agreed under the convention is mandatory for the UK. Part XI (Section 4, Subsection C, Article 165, 2h) together with Part XII (Section 4, Article 204), explicitly requires Contracting Parties to establish a monitoring programme to observe, measure, evaluate and analyse, on a regular basis, the risks, or effects of pollution on the marine environment, in particular undertaking surveillance of the effects of those activities which are permitted.

Table 2: Cetacean species identified for monitoring. Y = identified [table created in 2017].

Species	Shelf	Offshore
Harbour porpoise	Y	-
Inshore bottlenose dolphin	Y	-
Offshore bottlenose dolphin	Y	Y
Common dolphin	Y	Y
White beaked dolphin	Y	-
Risso's dolphin	Y	-
Killer whale	Y	Y
Atlantic white-sided dolphin	Y	Y
Minke whale	Y	Y
Pilot whale	-	Y
Sperm whale	-	Y

Table 3: Activities undertaken in current [2017] monitoring and within the five options. Each row represents a different activity (monitoring component) to monitor the parameter [table created in 2017].

Parameter	Option	1	2	3	4	5
	Need	**Reduced cost**	**Current [2017]**	**Improving abundance, trend, with existing programmes. MPAs prioritised. No R&D**	**Improving (reducing uncertainty) abundance, trend, pressures. MPAs & wider; R&D-type work and more species**	**Improving abundance, trend, pressures. R&D type work, more species. Minimised uncertainty**
Population abundance (wide ranging)	Status assessment; Impact assessment; management; MPA monitoring.	SCANS-type: shelf only; decadal.	SCANS-type: shelf + offshore; decadal.	a) SCANS-type: shelf every 6 years. b) & offshore every 6 years (doubles cost).	a) SCANS-type: shelf every 3 years. b) & offshore every 3 years (doubles cost).	SCANS-type: shelf annually. b) & offshore annually (doubles cost).
Population abundance (local/restricted populations)	Status assessment; MPA monitoring.	Bottlenose dolphin SACs: Scotland (photo-ID; Moray Firth (MF) only) (funded triennially by Govs).	Bottlenose dolphin SACs: Scotland (photo-ID; MF & Tay) (funded triennially).	As previous.	As previous & expand to St Andrews and Aberdeen) (funded triennially).	As previous & expand to cover east Scotland (Spey Bay in Forth and North coast of Moray Firth) (funded triennially).

Parameter	Option	1	2	3	4	5
	Need	**Reduced cost**	**Current [2017]**	**Improving abundance, trend, with existing programmes. MPAs prioritised. No R&D**	**Improving (reducing uncertainty) abundance, trend, pressures. MPAs & wider; R&D-type work and more species**	**Improving abundance, trend, pressures. R&D type work, more species. Minimised uncertainty**
Population abundance (local/restricted populations)	Status assessment; MPA monitoring.	Bottlenose dolphin SACs: Wales Cardigan Bay SAC (photo-ID only) (funded annually).	Bottlenose dolphin Welsh SACs: Wider Cardigan Bay, Cardigan Bay SAC and & Pen Llyn a'r Sarnau SAC (photo-ID+ line transect) (funded annually).	As previous.	As previous & Anglesey (photo-ID+ line transect) (funded annually).	As previous & North Wales coast (photo-ID+ line transect) (funded annually).
Population abundance (local/restricted populations)	Status assessment; MPA monitoring.	None.	Bottlenose dolphin South West MU: photo-ID analysis + line transect (funded occasionally).	As previous (no MPA or MPA proposal).	BND SW MU: photo-ID collection and analysis, dedicated line transect survey (*funded triennially*).	As previous but *funded annually.*

Parameter	Option	1	2	3	4	5
	Need	**Reduced cost**	**Current [2017]**	**Improving abundance, trend, with existing programmes. MPAs prioritised. No R&D**	**Improving (reducing uncertainty) abundance, trend, pressures. MPAs & wider; R&D-type work and more species**	**Improving abundance, trend, pressures. R&D type work, more species. Minimised uncertainty**
Population abundance (local/restricted populations)	Status assessment; MPA monitoring.	None.	Bottlenose dolphin West Scotland MU: Ad hoc line transects & photo ID & land based watches (funded occasionally).	As previous (no MPA or MPA proposal).	Targeted photo ID surveys of Sound of Barra and other known hotspots (Skye, Mull) (*funded annually).*	Coordinated photo ID surveys throughout Inner Hebrides (*funded annually).*
		None.	White beaked dolphin proposed Lyme Bay MCZ: 2 x summer photo-ID analysis & line transect (*funded every 5 years*).	White beaked dolphin proposed Lyme Bay MCZ: 2 x summer photo-ID & line transect surveys per year and analysis *(funded triennially).*	As previous but *funded biennially.*	As previous & 2 x winter photo-ID & analysis, dedicated line transect survey) *(funded annually).*
Long term trends in abundance	Status assessment.	Wide ranging - as 'population abundance wide ranging species'.	Wide ranging - as 'population abundance wide ranging species'.	Wide ranging - as 'population abundance wide ranging species'.	Wide ranging - as 'population abundance wide ranging species'.	Wide ranging - as 'population abundance wide ranging species'.

Parameter	Option	1	2	3	4	5
	Need	**Reduced cost**	**Current [2017]**	**Improving abundance, trend, with existing programmes. MPAs prioritised. No R&D**	**Improving (reducing uncertainty) abundance, trend, pressures. MPAs & wider; R&D-type work and more species**	**Improving abundance, trend, pressures. R&D type work, more species. Minimised uncertainty**
		As 'population abundance (local/restricted populations)'.	As 'population abundance (local/restricted populations)'.	As population abundance (local/restricted populations)'.	As 'population abundance (local/restricted populations)'.	As 'population abundance (local/restricted populations)'.
Short term trends in abundance	Status assessment; management; MPAs including HP SACs.	None.	None.	Develop JCP to collate monitoring data from NGO/industry/existing surveyor network.	As previous + targeted monitoring smaller scale surveys to fill gaps spatially. 1 x non-summer survey every 3rd year.	As previous + targeted monitoring smaller scale surveys to fill gaps seasonally. 3 x non summer surveys every 3rd year.
		None.	None.	None.	None.	As population abundance (wide ranging).
Seasonal distribution & relative abundance	Management; MPAs (including HP SACs).	None.	None.	From JCP development (see short term trends in abundance).	From JCP development (see short term trends in abundance).	From JCP development (see short term trends in abundance).

Parameter	Option	1	2	3	4	5
	Need	**Reduced cost**	**Current [2017]**	**Improving abundance, trend, with existing programmes. MPAs prioritised. No R&D**	**Improving (reducing uncertainty) abundance, trend, pressures. MPAs & wider; R&D-type work and more species**	**Improving abundance, trend, pressures. R&D type work, more species. Minimised uncertainty**
Seasonal distribution & relative abundance	Management; MPAs (including HP SACs).	None.	Regional land based surveys (NI) - 1 watch per month, 100 minutes, five headlands.	Regional land based surveys (NI) - 4 watches per month, 45 minutes.	Regional land based surveys (NI) - 4 watches per month, 45 minutes, 8 headlands.	Regional land based surveys (NI) - 7 watches per month, 45 minutes, 8 headlands.
		None.	Risso's dolphin Wales: Combined land-based surveys with photo-ID surveys (annual/summer) from Bardsey Island.	As previous + sea-based photo-ID taken during option 2 for bottlenose dolphin Welsh SACs. Risso's dolphin is a potential MPA feature.	Risso's dolphin Wales: Combined land-based surveys with photo-ID surveys (annual/summer) from Bardsey Island & 4 other sites (sea-based photo-ID taken during option 3 for bottlenose dolphin Welsh SACs).	As previous + dedicated sea-based photo-ID for Risso's dolphin.

Parameter	Option	1	2	3	4	5
	Need	**Reduced cost**	**Current [2017]**	**Improving abundance, trend, with existing programmes. MPAs prioritised. No R&D**	**Improving (reducing uncertainty) abundance, trend, pressures. MPAs & wider; R&D-type work and more species**	**Improving abundance, trend, pressures. R&D type work, more species. Minimised uncertainty**
Seasonal distribution & relative abundance	Management; MPAs (including HP SACs).	None.	Risso's dolphin West Scotland: Ad hoc funding of line transects and Photo ID.	Risso's dolphin West Scotland: line transects and Photo ID in NE Lewis pNCMPA - 2 x summer survey *(funded triennially*).	Risso's dolphin West Scotland: develop line transects and Photo ID in NE Lewis pNCMPA - 2 x summer, 2 x winter (*funded biennially*).	Risso's dolphin West Scotland: develop line transects and Photo ID in NE Lewis pNCMPA - seasonal surveys and wider Hebridean coverage (*annual).*
		None	Minke whale west Scotland – ad hoc support of boat-based surveys through HWDT and CRRU.	Line transect summer surveys (1 summer for minke whale NCMPAs (Sea of Hebrides & southern trench) (*funded triennially).*	Line transect 2 x summer surveys with photo-ID for minke whale NCMPAs *(funded biennially).*	Wider area line transect surveys annually to establish summer distribution in relation to MPAs. (*funded annually).*

Parameter	Option	1	2	3	4	5
	Need	**Reduced cost**	**Current [2017]**	**Improving abundance, trend, with existing programmes. MPAs prioritised. No R&D**	**Improving (reducing uncertainty) abundance, trend, pressures. MPAs & wider; R&D-type work and more species**	**Improving abundance, trend, pressures. R&D type work, more species. Minimised uncertainty**
Seasonal distribution & relative abundance	Management; MPAs (including HP SACs).	None.	East Scotland: ECoMASS, 10 stations, north Moray Firth - St Abbs.	Previous + West Wales & North Angelsey (Cardigan Bay & Llyn Sarnau population), 9 stations each with a deployment.	Previous + South coast England, 8 stations & coastal west Outer Hebrides (Barra 'pop'), 4 stations.	Entire coast (including North coast & Northern Isles; 18 stations).
		None.	West Coast Scotland: COMPASS project: cross border monitoring of MPA network including acoustic stations within HP cSAC.	Southern North Sea cSAC; 59 stations (25km grid) & West Wales cSAC 12 stations (seasonal sites).	Previous + Bristol Channel & North Channel (winter sites); 9 & 3 stations.	Previous + North Anglesey Marine cSAC (summer site); 5 stations.
		None.	None.	None.	None.	Offshore increase (only 1 in COMPASS); add 5 on shelf edge and offshore.

Parameter	Option	1	2	3	4	5
	Need	**Reduced cost**	**Current [2017]**	**Improving abundance, trend, with existing programmes. MPAs prioritised. No R&D**	**Improving (reducing uncertainty) abundance, trend, pressures. MPAs & wider; R&D-type work and more species**	**Improving abundance, trend, pressures. R&D type work, more species. Minimised uncertainty**
Demographics (repro.rate/age structure/mortality, population structure)	Status.	None.	Ad hoc when money available to use PM samples (age structure & reproductive parameters).	Analyses of historical samples (age structure & reproductive parameters) from CSIP/SMASS for HP and CD. Ongoing collection & routine analyses (every 5 years).	As previous + every 10 years white beaked dolphin, Atlantic white-sided dolphin, and long-finned pilot whale.	As previous + routine analyses of samples from CSIP/SMASS for other species, but needs EU collaboration for less common species.
		Analysis of the BND SAC photo-ID monitoring; some from ad hoc Risso's, killer whale, and white-beaked dolphin photo-ID.	See 'abundance (local/restricted)' and photo-ID work within Seasonal distribution & relative abundance.	See 'abundance (local/restricted)' and photo-ID work within Seasonal distribution & relative abundance.	See 'abundance (local/restricted)' and photo-ID work within Seasonal distribution & relative abundance.	See 'abundance (local/restricted)' and photo-ID work within Seasonal distribution & relative abundance.

Parameter	Option	1	2	3	4	5
	Need	**Reduced cost**	**Current [2017]**	**Improving abundance, trend, with existing programmes. MPAs prioritised. No R&D**	**Improving (reducing uncertainty) abundance, trend, pressures. MPAs & wider; R&D-type work and more species**	**Improving abundance, trend, pressures. R&D type work, more species. Minimised uncertainty**
Demographics (repro.rate/age structure/mortality, population structure)	Status.	None.	None.	None.	Biopsy in bottlenose SACs & R&D biopsy programme for Risso's proposed MPA; minke whale proposed MPAs; white beaked dolphin proposed MCZ.	R&D As previous plus biopsy programme for killer whale - likely Northern Isles & wider Scotland.
Causes of mortality	Pressure.	REVIEW & IDENTIFY SAVINGS: Cetacean Strandings and investigation Programme + Scottish Marine Animal Strandings Scheme.	Cetacean Strandings and investigation Programme + Scottish Marine Animal Strandings Scheme.	As previous + increase effort/set up systems to increase retrieval and post-mortem of under-represented species (bottlenose and Risso's).	As previous + R&D development of citizen science network for effort related monitoring.	As previous but longer R&D to working system + dedicated monitoring approach with representative, designed coverage.

Parameter	Option	1	2	3	4	5
	Need	**Reduced cost**	**Current [2017]**	**Improving abundance, trend, with existing programmes. MPAs prioritised. No R&D**	**Improving (reducing uncertainty) abundance, trend, pressures. MPAs & wider; R&D-type work and more species**	**Improving abundance, trend, pressures. R&D type work, more species. Minimised uncertainty**
Mortality due to bycatch	Pressure.	REVIEW & IDENTIFY SAVINGS: UK bycatch monitoring scheme.	UK Bycatch Monitoring Programme.	As previous + expand bycatch observer scheme sampling spatially (North Sea, including SNS SAC) in fisheries of high apparent risk.	As previous + R&D Remote Electronic Monitoring Trials - in high risk, poorly sampled metiers. 3 vessels.	Fully integrated (across taxa) vulnerable species bycatch monitoring programme - observers & REM to provide cost effective approach.
Mortality due to bycatch	Pressure.	None.	None.	Establish effective monitoring of large whale entanglement (primarily minke whales) utilising fishers.	As previous.	As previous.

Parameter	Option	1	2	3	4	5
	Need	**Reduced cost**	**Current [2017]**	**Improving abundance, trend, with existing programmes. MPAs prioritised. No R&D**	**Improving (reducing uncertainty) abundance, trend, pressures. MPAs & wider; R&D-type work and more species**	**Improving abundance, trend, pressures. R&D type work, more species. Minimised uncertainty**
Changes in distributional pattern in relation to noise	Pressure; MPA measures.	None.	None.	See acoustic monitoring components. Impact survey designs yet to be considered but partnerships between Govs & industry to deliver should be developed.	See acoustic monitoring components. Impact survey designs yet to be considered but partnerships between Govs & industry to deliver should be developed.	See acoustic monitoring components. Impact survey designs yet to be considered but partnerships between Govs & industry to deliver should be developed.
Contaminants	Pressure.	None.	Ad hoc sampling as money becomes available.	As previous.	Routine analyses of samples from CSIP/SMASS for contaminants for representative species every 3 years (HP, CD).	As previous but annual, longer term and EU collaboration for less common species to acquire adequate sample sizes.
		None.	None.	See biopsy sampling in ‘Demographics’.	See biopsy sampling in ‘Demographics’.	See biopsy sampling in ‘Demographics’.

Parameter	Option	1	2	3	4	5
	Need	**Reduced cost**	**Current [2017]**	**Improving abundance, trend, with existing programmes. MPAs prioritised. No R&D**	**Improving (reducing uncertainty) abundance, trend, pressures. MPAs & wider; R&D-type work and more species**	**Improving abundance, trend, pressures. R&D type work, more species. Minimised uncertainty**
Incidence of starvation	Pressure.	None.	As a cause of death, routinely monitored through CSI/SMASS PMs. Ad-hoc analyses of prey items to species.	As previous + but regular analysis of stomach contents to identify prey for HP, CD.	As previous + all species (builds understanding of competition with fisheries for example).	As previous (R&D perhaps - monitoring using drones).
Incidence of collision	Pressure.	None.	As a cause of death, routinely monitored through CSI/SMASS PMs. Industry led in relation to wet renewables - but future potential threat. Shipping low risk.	As previous.	As previous.	As previous.

Table 4: Potential approaches to making cost savings in the current [2017] monitoring programmes of UK cetaceans [table created in 2017].

Parameter	Programme	Potential approach	Pros	Cons	Dependencies	Potential cost saving per annum compared to current (£'000)	Assumptions
Bycatch	Protected Species Bycatch Monitoring Programme.	Reduced at-sea observations for pinger mitigation.	* Only source of data to estimate levels of bycatch cetaceans * Identifies low-risk area of work where more cost-effective approaches may suffice.	* Open to challenge of not fully meeting Reg812/2004 * Loss of data for determining long-term effects of pinger use. Level and distribution of bycatch observations is further limited.	* Ongoing good relationship with relevant fisheries through contractor.	12	Reducing from 70 to 50 days (~5% reduction in programme costs).
		Non-dedicated observers for at-sea observations of pelagic trawls.	* Identifies low-risk portion of the fleet and monitors them using non-dedicated/other cost effective means * lowers the use of costlier independent observers.	* Not fully meeting Reg812/2004 because not using 'independent on-board observers' in sector of fleet where monitoring is mandatory * Quality of data likely reduced.	* Ongoing good relationship with relevant fisheries through contractor.	10	Assume 45-day dedicated monitoring effort is reduced by 50%.

Parameter	Programme	Potential approach	Pros	Cons	Dependencies	Potential cost saving per annum compared to current (£'000)	Assumptions
Bycatch	Protected Species Bycatch Monitoring Programme.	Delay seabird bycatch targeted monitoring, at least in the short term.	* Immediate reduction in costs until such time a proper assessment of integration (across species) has been completed.	* Loss of data on seabird bycatch * Not effectively assessing impact of bycatch as required under Article 12 of the Habitats Directive. * Delay in data collection needed to progress the MSFD seabird indicator.		21	

Parameter	Programme	Potential approach	Pros	Cons	Dependencies	Potential cost saving per annum compared to current (£'000)	Assumptions
Causes of mortality	CSIP & SMASS.	revising processes/ approach for carcass collection and processing.	* Continue to deliver the same parameter information and functions as "early warning' system * but potential to reduce costs by evaluating (and implementing) carcass triage, translocation, and more effective use of volunteers.		* Feasibility of this needs further consideration; translocation costs may sometimes be cheaper than in-situ post-mortem (in remote areas for example).	10	Potential to save in translocation cost - assume that 20% less collected (.51K currently in translocation costs).

Parameter	Programme	Potential approach	Pros	Cons	Dependencies	Potential cost saving per annum compared to current (£'000)	Assumptions
Causes of mortality	CSIP & SMASS.	Streamlining management/ overview.	* More efficient management and delivery of UK strandings scheme *Clearly identified roles of partners to deliver efficient programme.			15	UK overview of strandings and strandings coordination (IoZ + subcontractors) is 34% of the CSIP budget. Reduce this by at least 10% should be feasible.

Causes of mortality	CSIP & SMASS.	Reduce number of PMs.	* Continue to deliver the same parameter information and functions as "early warning' system * delivers a cost-saving and does not jeopardise understanding of causes of mortality * still meets obligations under ASCOBANS.	* public perception of government doing less * pressure from NGO * May require expansion of volunteer network outside Scotland.	* A re-analysis of the minimum number of PMs required should be conducted on more recent data (2012-2016) before a decision to reduce is made. A re-analysis on the 2012-2016 data in Appendix II shows that ~60 harbour porpoise and 20 common dolphins are needed making a reduction in PME less feasible based on more recent data if trends in the causes of death are required for these species.	20	60 PMEs instead of 100.

Parameter	Programme	Potential approach	Pros	Cons	Dependencies	Potential cost saving per annum compared to current (£'000)	Assumptions
SAC condition monitoring	Cardigan Bay.	Stop or reduce frequency (Triennial line transect surveys).	* Estimates of abundance for the West Wales group * Platform to achieve unbiased spatial coverage in photoID surveys.	Photo-ID data prone to spatial bias where dolphins are regularly surveyed.	* Value of having annual estimates of abundance using this method AND photo-ID questionable. Frequency of surveys reduced at least, and survey data can be input to JCP, if it is operational.	4	

Table 5: Summary of large-scale visual survey monitoring activity in EU Member States [table created in 2017].

Country	Area	Frequency	Year initiated	Funder
GE	EEZ	summer every 3 years	2002	Ministry for the Environment; Federal Agency for Nature Conservation
GE	N2000	2 x per year	2002	Federal Agency for Nature Conservation
NL	EEZ	every year	2008	Ministry of Economic Affairs
NL	N2000	2 x per year	2008	Ministry of Economic Affairs
BE	EEZ	4 x per year	2008	OWF monitoring
DK	N2000	yearly in summer	2011	The Nature Agency under the Danish Ministry of Environment

Table 6: Summary of [2017] estimated monitoring costs, where the averages are annual and calculated over a 10-year period. Demog. = demographics, Contam. = contaminants.

Parameter / Option	Average annual cost over 10 years (£K)*									Annual Average	Lowest year cost	Highest year cost
	Population abundance (wide ranging) & long-term trends	Population abundance (local/restricted populations)	Short term trends	Seasonal distribution & relative abundance	Demog	Causes of mortality	Mortality due to bycatch	Contam	Incidence of starvation			
1	30	73	0	0	0	403	204	0	0	719	660	809
2	60	91	0	132	2	450	252	2	0.1	1,006	871	1,530
3	60 (shelf) + 60 (offshore)	111	26	849	59	469	345	21	2	2,029	1,659	3,392
4	100 (shelf) + 100 (offshore)	175	52	1,032	127	507	391	25	2	2,570	2,108	4,039
5	300 (shelf) + 300 (offshore)	251	96	1,416	149	507	557	48	12	3,753	3,260	5,665

*Staff costs are uncertain. Where there are additional programmes, project costs including staff have been estimated from comparable existing costs. Additional costs to JNCC staff to administer projects has been captured but SNCB resource has not.

Table 7: Evidence requirements, risks, and limitations of each option. CSIP = Cetacean Strandings and Investigation Programme; SMASS = Scottish Marine Animal Strandings Scheme; BMP = Bycatch Monitoring Programme; HD = Habitats Directive; MSFD = Marine Strategy Framework Directive [table created in 2017].

Option	Evidence requirements delivered	Limitations	Risks
Option 1 (reduced cost)	Lower cost option arising from prioritising monitoring parameters and species identified through OSPAR core indicator work and through efficiencies in current [2017] programmes. Abundance estimates and summer distribution available every 10 years for most common species throughout EU shelf and offshore; Abundance estimates provide context for impact of pressures; Long-term trends possible for some species; short term trends not possible. Existing CSIP and SMASS monitor sources of mortality in all species but trends in causes of death only possible for porpoise & common dolphin. UK BMP programme provides annual estimates of harbour porpoise bycatch and satisfies Council Regulation 812/2004. Ad-hoc and infrequent smaller scale surveys provide information on distribution and relative abundance and seasonality. High powered monitoring of bottlenose in SACs. Some evidence for SEA, EIA and HRA.	Reporting species status is reliant on incomplete and often uncertain evidence. No offshore abundance estimates. Unable to report on long term trends for some species. Unable to report short term trends for any species, except inshore bottlenose dolphin, at UK scale: therefore, robust assessments for OSPAR, MSFD and Habitats Directive would not be possible for most species. No monitoring of any MPAs other than that already established for bottlenose dolphin SACs. Finer scale temporal and spatial data not available which often needed to underpin management: Management decisions would carry considerable risk or be highly precautionary.	Legal challenge due to insufficient monitoring on which to report status for the 10 commonly occurring UK cetaceans at least; inadequate enough survey effort or mechanism to detect trends. Ability to assess trends underpin assessments in OSPAR, MSFD and Habitats Directive. Legal challenge to lack of adequate monitoring in MPAs. High risks associated with no evidence of short-term changes in status that may require management/intervention. EU case law states decadal scale is insufficient to meet needs of Habitats Directive. Savings in ‘reduced cost’ programmes may not be realised; savings may short-term if lack of data leads to challenge. Risk of challenge from NGOs with regard some approaches to cost savings (e.g. reduction in number of post-mortem examinations). Conservation risk: species declines undetected, or new and emerging threats are undetected.

Option	Evidence requirements delivered	Limitations	Risks
Option 1 (reduced cost)			Risk of legal challenge with regard some potential approaches to cost savings which may reduce compliance with Reg812/2004. Uncertainty around bycatch estimates continues to hinder assessments about the population impact (OSPAR/MSFD) (a greater issue for other MS). Reputational risk of having insufficient data to provide scientifically robust assessments.

Option	Evidence requirements delivered	Limitations	Risks
Option 2 (Current)	Meets some of the needs of Habitats Directive and OSPAR/MSFD reporting but only for most common species: Abundance estimates and summer distribution available every 10 years for most common species throughout EU shelf and offshore; Abundance estimates provide context for impact of pressures. Long-term trends possible for some species but short term trends not possible. Existing CSIP and SMASS monitor sources of mortality in all species but trends in causes of death only possible for porpoise & common dolphin. Ad-hoc funding of sample analysis from this scheme for contaminants. UK BMP programme provides annual estimates of harbour porpoise bycatch and satisfies Council Regulation 812/2004. Increased effort to assess seasonal distribution relative abundance through ad-hoc visual surveys and passive acoustic arrays. High powered monitoring of bottlenose in SACs; limited support to monitor proposed white beaked dolphin MCZ. Some evidence for SEA, EIA and HRA. Meets many of our obligations to ASCOBANS.	Reporting species status is reliant on incomplete and often uncertain evidence. Abundance estimates not possible/imprecise for less common and/or species with a spatially limited distribution. Insufficient sampling frequency to detect long term trends in abundance for all species and short term trends cannot be detected for any species, except inshore bottlenose dolphin associated with SACs, therefore, robust OSPAR, MSFD and Habitats Directive not possible for most species. CSIP and SMASS monitor changes in causes of death with enough power only for harbour porpoise and common dolphin. Small scale surveys are hard to interpret in isolation and no repository for small-scale survey data from which distribution and abundance could be generated at appropriate/useful scales. Timely advice for management decisions is not possible and value of data to HRA, EIA, etc. decreases with time after each survey. Pressures for most species only monitored through strandings and population level impacts unknown. No harbour porpoise SACs are monitored.	Legal challenge due to insufficient monitoring on which to report status for the 10 commonly occurring UK cetaceans at least; not enough survey effort or mechanism to detect trends. Trends underpin assessments in OSPAR, MSFD and Habitats Directive. Legal challenge due to lack of adequate monitoring in MPAs. High risks associated with no evidence of short-term changes in status that may require management/intervention. Uncertainty around bycatch estimates continues to hinder assessments about the population impact (OSPAR/MSFD) (a greater issue for other MS). Pressure monitoring very limited and reliant of CSIP that only reliably informs for harbour porpoise and common dolphin. EU case law states decadal scale is insufficient to meet needs of Habitats Directive.
Option 2 (Current)			Conservation risk: species declines undetected, or new and emerging threats are undetected.

Option	Evidence requirements delivered	Limitations	Risks
		Management decisions would carry considerable risk or be highly precautionary.	Management over precautionary because of lack of evidence. Reputational risk of having insufficient data to provide scientifically robust assessments.

Option	Evidence requirements delivered	Limitations	Risks
Option 3	Six yearly surveys on/off shelf or both (cost decision) ensure long-term (decades) trends can be detected for all species, if abundance estimates have good precision. Only large scale changes in abundance can be detected in the short-term, other than in bottlenose dolphin SACs. This option collates the large-scale survey data with existing monitoring data from NGOs, industry, etc (i.e. as the JCP) and proposed its analyses be the mechanism for deriving short-term trends. Effort is increased to improve spatial coverage of BMP, thereby improving UK estimates. Effort increased in CSIP to target underrepresented species. Analyses of samples from CSIP is regular (every 5 years) to provide evidence to contribute to status assessments (e.g. reproductive rates) and pressures (e.g. contaminants). Improved evidence available for EIA, SEA and HRA (understanding seasonal distribution/relative abundance through wider use of acoustic networks). Sufficient monitoring of bottlenose dolphin SACs abundance and focus on establishing baseline monitoring in all MPA cetacean networks (e.g. Risso's dolphin), providing evidence for MPAs	Insufficient sampling frequency to detect small, short term trends in abundance for any species, except inshore bottlenose dolphin associated with SACs, at UK scale: therefore, robust OSPAR, MSFD and Habitats Directive not possible for most species. CSIP and SMASS monitor changes more species, but still only a sub-set of regular shelf species. Not all harbour porpoise SACs are monitored but risk-based approach applied.	Increased survey frequency may counter challenge based on EU case law states decadal scale is insufficient to meet needs of HD. Legal challenge may remain if offshore waters not surveyed and also because short-term trends not possible from survey data, although other approaches (analysis of JCP) may counter this. Legal challenge due to only partial monitoring of harbour porpoise SAC network; but all other MPAs have 'baseline' monitoring. Conservation risk: species declines undetected, or new and emerging threats are undetected – but risk is less than previous options. Less risk from NGO challenge to pressure monitoring through CSIP and BMP because of extended effort. But analyses of sample archive (e.g. for contaminants) remains ad hoc.

Option	Evidence requirements delivered	Limitations	Risks
Option 3	being considered under the Marine (Scotland) Act 2010. Monitoring established in only 2 harbour porpoise SACs based on assessment of risk/evidence needs. ASCOBANS obligations met.		

Option	Evidence requirements delivered	Limitations	Risks
Option 4	Increased large-scale survey sampling to every 3 years. Includes all other activities identified in option 3 but with increased resource on improving monitoring of pressures; introduction of R&D type work to improve bycatch sampling (e.g Remote electronic monitoring) and enhance strandings reporting (and consequently PME of relevant species) (citizen science & App). Uncertainty around bycatch estimates will reduce and give greater confidence in assessments of population impact (As per Article 12, HD). Evidence for status reporting MPAs & wider much improved. Ability to detect short-trends more likely to be feasible through JCP. Archive material analysed & ongoing analyses to look at demographics for more species to inform on status and understand change. Ad-hoc support for survey data collection to augment stakeholder data collection and fill smaller scale evidence needs. Improves ability to report to OSPAR/MSFD and Habitats Directive. Improves evidence available for EIA, SEA and HRA in terms of temporal and spatial knowledge of distribution, abundance and trends for more species, more visual and acoustic survey coverage. More useful basis for management decisions. Porpoise SAC monitoring expanded and other MPAs	In the short-term, detectable changes in abundance remain relatively large (> 20%). Not all harbour porpoise SACs are monitored but a risk-based approach applied.	Increased survey frequency should counter challenge based on EU case law which states decadal scale is insufficient to meet needs of HD. Legal challenge may remain if offshore waters are not surveyed and because short-term trends, as per OSPAR and HD, are not detectable from survey data, although other approaches (analysis of JCP) may counter this. Trials of new monitoring activities may not deliver as planned, so investment lost. Conservation risk: species declines may not be detected quickly enough to make effective decisions on management but significantly lower risk than previous options. Legal challenge due to only partial monitoring of harbour porpoise SAC network; but all other MPAs have improved ‘baseline’ monitoring. Need for increased staff resource to process higher levels and frequency of data.

Option	Evidence requirements delivered	Limitations	Risks
Option 4	received increased monitoring effort, variety approaches. Evidence to interpret demographic data increased as is monitoring of pressures such as contaminants. ASCOBANS obligations met.		
Option 5	Annual large-scale surveys that and increased resource for monitoring pressures (bycatch, contaminants), for all regular species; all MPAs have basic monitoring of abundance; annual survey frequency means that even short-term trends may be determined for some regular species as per HD definition. JCP may fulfil short-term trend analysis for others. Frequent analyses of demographic data compliment survey data in understanding drivers of changes; Ability to report on status for OSPAR/MSFD and Habitats Directive is very high. High quality evidence available for EIA, SEA and HRA in terms of temporal and spatial knowledge of distribution, abundance, and trends for more species. Management decisions can be made confidently. Sufficient monitoring of all MPAs.	Sample sizes for some infrequently stranded species may, at UK level, be too small and will require collaboration with other MS.	Opportunity cost of investing in monitoring. Need for increased staff resource to plan and process higher levels and frequency of data. Challenges regarding appropriate use of funds – political risk. However, excellent standard of monitoring to allow robust assessments and appropriate/efficient use of mitigation and management resources.

Appendix 2 – Power analyses of abundance data

Calculating power

Power in abundance estimates to detect long and short-term trends was calculated using and solving the general inequality equation of Gerrodette (1987).

$$r^2n^3 > 12CV^2 (Z_{\alpha/2} + Z_{\beta})^2$$

Where r = rate of change over the time period in question, n = the number of surveys during the time period, CV = coefficient of variation of abundance, $Z_{\alpha/2}$ = the value of a standardised random normal variable for the probability of making a Type I error, α (set to 0.05), Z_{β} is the value of a standardised random normal variable for the probability of making a Type II error, β, and power is (1-β). The CVs are those from the SCANS-III surveys in summer 2016 (Hammond *et al.* 2017).

Power to detect long-term trends in abundance from large spatial scale surveys

For the purposes of developing monitoring options, long-term trend was defined as a decline ≥ 30% over three generations. The generation times of cetaceans used in this work are given in Table 8. For the more common species of UK cetacean, there are only two estimates of abundance for their UK population and the power in these data to detect long term trends is extremely poor for all species (30% or less) (Table 2). However, a series of decadal surveys is sufficient for common dolphin, white beaked dolphin, minke whale and the offshore pilot whale (4 of the 11 regularly occurring species) to detect long term trend in UK abundance (~ 40–80 years). For the harbour porpoise, being able to detect the trend over three generations is more challenging because of their much shorter generation time (22 years); however, providing abundance estimates from surveys are precise (as SCANS-III, CV ≤ 0.16), then 80% power could be achieved.

Table 8: Generation times for cetaceans (*WGMME 2017).

Species	Generation time (years)	3 x Generations (years)
Harbour porpoise*	7.5	22.5
White beaked dolphin*	18	54
Minke whale*	22	66
Short-beaked common dolphin*	14	44
Other shelf & shelf/offshore (Risso's, killer whale)	19.6	59
Bottlenose dolphin (offshore)*	21	63
Other offshore (pilot whale, sperm whale)	28	84

SCANS-III (Hammond *et al.* 2017) provided the first estimate of abundance for Risso's dolphin at the UK scale. However, within the UK survey blocks, the best CV achieved was 0.69 which, based on continued decadal surveys over the next 59 years would only have ~ 45% power to detect trends in abundance for this species. For Risso's dolphin, either survey effort needs to be increased to improve the precision of abundance estimates for this species, or the frequency of SCANS-type surveys needs to be increased to a minimum of

every 7 years (Table 2). For the white-sided dolphin, offshore bottlenose dolphin and sperm whale, surveys have to date generated abundance estimates with very poor precision in UK waters (CV greater than 0.6), and consequently even decadal surveys over long time periods (59–84 years) cannot detect trends for these species. For these offshore dolphins, surveys at least every ~ 6 years should enable long-term trends to be detected.

Table 9: Power of the decadal (Options 1 and 2) SCANS surveys to detect long-term trends in UK cetacean populations. Long-term trend is ≥30% decline in three generations. For some species, decadal is sufficient given the stated precision (CV) for long-term trends. For others, only more frequent surveys will achieve the desired power to detect long-term trends [table created in 2017].

Scenario/ option	Distribution category	Species	Period for trend detection	Survey interval (years)	Number surveys	CV	Power to detect trend
Existing data	Shelf	Harbour porpoise	-	-	2	0.21 (2005)	20%
						0.16	30%
1 and 2			22	10	3	0.21	55%
					3	0.16	80%
Existing data	Shelf	White-beaked dolphin	-	-	2	0.29	10%
1 and 2			54	10	6		>80%
Existing data	Shelf	Risso's dolphin	-	10	1†	0.44	-
1 and 2			59	10	6	0.69	45%
Minimum survey frequency				7	8		>80%
Existing data	Shelf/offshore	Common dolphin	-	-	2	0.27	10%
1	Shelf/offshore*		0	0	0	0	0
2	Shelf/offshore		44	10	5	0.26	>80%
Existing data	Shelf/offshore	Minke whale			2	0.33	10%
1	Shelf/offshore*		66	0	0		-
2	Shelf/offshore			10	6		>80%
Existing data	Shelf/offshore		-	-	2	0.826	-

Scenario/ option	Distribution category	Species	Period for trend detection	Survey interval (years)	Number surveys	CV	Power to detect trend
1	Shelf/offshore*	Atlantic white-sided dolphin	0	0	0		-
2	-		59	10	6		~30%
Minimum survey frequency				6.5	9		>80%
Existing data	Offshore	Bottlenose dolphin	-	-	2	0.64	-
1	Offshore*		0	0	0		-
2	Offshore		64	10	7		-
Existing data	Offshore	Pilot whale	-	-	2	0.35	10%
1	Offshore*		0	0	0		-
2	Offshore		84	10	9		>80%
Existing data	Offshore	Sperm whale	-	-	2	1.08	-
1	Offshore*		0	0	0	-	-
2	Offshore		84	10	9	-	-

†There is currently [2017] only a single estimate of abundance in UK waters for this species from the SCANS-III survey.

*Under Option 1, there would be no surveys of offshore waters.

Power to detect shorter term trends

For reporting under the Habitats Directive, short and long-term trends in species abundance are to be assessed. Short and long-term are defined as 12 and 24 year periods. The reporting guidance (Evans & Marvella 2011) also provides an 'indicative suggested threshold" for a large decline as 1% per year.

For the OSPAR interim assessment, a negative trend (i.e. a decline) was defined as 'a decreasing trend of ≥ 5% over 10 years'.

Table 10 explores the frequency of surveys required to be able to confidently (80% power) report trends as defined by the Habitats Directive.

Table 10: The effect of survey frequency on the rate of decline per year (r_{year}) and total decline for the period (r_{period}) that can be detected with 80% power in the short term (12 years). Survey frequency is increased according to the options. Green means that small annual declines (≤ 1%) can be detected. Yellow is annual declines of 1–2% [table created on 2017].

Species	Declines	Survey frequency in 12-year period		
		Option 3	Option 4	Option 5
		Every 6 years (n=3)	Every 3 years (n=4)	Annually (n=12)
Harbour porpoise	r year	2.9	1.8	0.3
	rperiod	29.9	19.4	3.8
White-beaked dolphin	r year	6.3	3.6	0.5
	rperiod	54	36	6.9
Risso's dolphin	r year	-	14.1	1.47
	rperiod	-	84	16.3
Common dolphin	r year	5.7	3.2	0.55
	rperiod	50.6	32.8	6.4
Minke whale	r year	7.6	4.2	0.66
	rperiod	61.2	40.2	7.6
White-sided dolphin	r year	-	-	1.7
	rp	-	-	19.3
Offshore Bottlenose dolphin	r year	-	11.4	1.3
	rp	-	76.6	14.7
Pilot whale	r year	17.8	7.1	1.0
	rp	90.5	58.7	11.4
Sperm whale	r year	-	-	1.9
	rp	-	-	25.3

If large-scale, SCANS-type surveys were conducted every 6 or 3 years, only large changes (greater than 1% per annum) could be detected. For example, for the most abundant species, the harbour porpoise, precise estimates of abundance are generated but with surveys every 6 and 3 years, respectively, the population would have declined by 20–30% before it could be detected within 12 years. If surveys were annual, small changes (less than 1%) should be detectable for a wide range of species, except for Risso's and white-sided dolphins and sperm whales where annual changes of greater than 1–2% could be detectable.

For the OSPAR IA objective, a decline of 5% over 10 years could only be detected with 80% power from annual, precise abundance estimates for the harbour porpoises. For all other

species, the total change in the population would be between 8-30% before it could be detected with annual surveys in 10 years.

Table 11: Minimum total decline that can be detected in a 10-year period with annual surveys as per option 5 [table created in 2017].

Species	Minimum total decline (%)
Harbour porpoise	5
White-beaked dolphin	9
Risso's dolphin	21.2
Common dolphin	8.3
Minke whale	10.1
White-sided dolphin	25.4
Offshore bottlenose dolphin	19.4
Pilot whale	14.9
Sperm whale	33.3

The detection of small changes in short time frames is challenging. Given the levels of change that can be detected for a given frequency of survey, policy specialists need to decide what level of change is acceptable given the definitions of acceptable change in the relevant Directives but also understanding risks.

Trends in abundance from photo-ID of localised populations

The OSPAR indicator for inshore bottlenose dolphin populations states that:

> *'For each assessment unit, maintain inshore bottlenose dolphin population sizes at or above baseline levels, with no decrease of ≥30% over any ten-year period.'*

Current [2017] annual surveys have excellent power to detect such a change in a ten-year period. If only trends in abundance are of concern (and not demographics), then precise abundance (CV ≤ 0.16) estimates from triennial surveys would also enable trend to be detected with greater than 80% power.

Other species, Risso's dolphin and killer whale, are also subject to photo-ID. A single estimate of abundance for Risso's dolphin is available from photo-identification data at a local scale, off Bardsey Island, North Wales (de Boer *et al*. 2013). Surveys (mainly opportunistic in nature) have been carried out since 1997 and these have been annual for 1999–2007. Abundance estimation was only possible by pooling data over 10 years. Other photo-identification data have been collected off the Isle of Lewis, Outer Hebrides (Atkinson *et al*. 1998) but have not been analysed to generate abundance estimates. Similarly, for killer whales, photo- identification data has been collected around the Northern Isles but not analysed for abundance (e.g. Foote *et al*. 2010).

Table 12: Power of existing bottlenose dolphin photo-identification monitoring to detect a 30% decline in abundance 10 years. Italic (green) cells indicate the objective is being met [table created in 2017].

Area	Species	CV of estimate of abundance	Estimate frequency (option 2)	Power (%) to detect trends in abundance
Moray Firth	Bottlenose dolphin (inshore)	0.15	Annual	*> 80%*
Cardigan Bay	Bottlenose dolphin (inshore)	0.095	Annual	*> 80%*

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Appendix 3 – Power analyses of post-mortem data

Calculating power

The standard output from post-mortem examination (PME) is the cause of death of all individuals sampled. These were used in a power analysis to test whether the levels of PME currently [2017] conducted by the CSIP were sufficient for detecting significant changes in the causes of mortality. The power analysis was conducted using a χ^2 Goodness-of-fit approach to provide an a priori assessment of the number of PME required to detect changes with a significance level, α, of 0.05, power $(1-\beta)$ of 80% and the population size effect to be detected. The latter was calculated from the PME data for 2012 through 2016.

Power to detect changes in relative causes of mortality in the current (option 2) monitoring activity [developed in 2017]

Over the last decade, the power to detect changes in the causes of death of cetaceans has remained good (i.e can detect changes with 80% power) from the post-mortem examination of harbour porpoise and common dolphin. However, the power in the PME data has varied for some species and this is driven by the number of categories of 'cause of death' and the number of events in each. For example, the recent data for white-beaked dolphin (2012–2016) has shown that the live strandings category has dominated and few data in other categories; this makes it harder to detect changes without having a larger sample. The number of PME of white-sided dolphin was extremely low in the last five years and we're insufficient for sampling: this may be the result of lack of strandings events or inaccessible strandings events or animals were too decomposed for PME. These results are summarised in Table 12.

Table 1. Summary of the mean number of post-mortem examinations required per year over five-year periods to be able to detect changes in the causes of death of stranded cetaceans [table created in 2017].

Species	Causes of death established by PME	2007-2011		2012-2016	
		Mean PME required per year	Annual mean PME	Mean PME required per year	Annual mean PME
Harbour porpoise	Bycatch, starvation, infectious disease, bottlenose dolphin/grey seal attack, live stranding, physical trauma, other, not established	47	60.6 ± 7.8	57	75 ± 18.2
Common dolphin	Bycatch, starvation, bottlenose dolphin attack, live stranding, physical trauma, other, not established	7	22.8 ± 13.9	21	22.6 ± 8.4
White-beaked dolphin	Bycatch, starvation, infectious disease, live stranding, other, not established	3	4.0 ± 1.9	13.2	6.6 ± 3.0

Species	Causes of death established by PME	2007-2011		2012-2016	
		Mean PME required per year	Annual mean PME	Mean PME required per year	Annual mean PME
White sided dolphin	starvation, infectious disease, live stranding, other	5	4.8 ± 3.3	NA	0.6 ± 0.89
Risso's dolphin	Live stranding, bycatch, physical trauma, starvation, infectious disease, gas embolism, other, not established	NA	1.4 ± 2.1	NA	2.0± 2.0
Bottlenose dolphin	Bycatch, starvation, infectious disease, physical trauma, live stranding, other, not established	5	3.4 ± 1.5	2.2	2.8 ± 3.0
Minke whale	Entanglement, starvation, live stranding, physical trauma, infectious disease, not established	2	2.2 ± 1.6	NA	3.4 ± 1.8

*NA = Not assessed due to insufficient data.