Marine Mammal Evidence Review and Opportunities Analysis

A scoping review to assess the priorities for marine mammal evidence sought through the marine NCEA programme

Date: March 2023

Author: Samantha Parker, Natural England

Programme	Marine Natural Capital and Ecosystem Assessment (mNCEA)
Programme lead organisation	Department for Environment, Food and Rural Affairs
Project ID and title	NC36: Inshore Cetaceans Monitoring
Project lead organisation	Natural England
Project SRO	Tara Hooper, Natural England
Project start date	01/04/2022
Project end date	31/03/2023

This project was funded by the Department for the Environment, Food and Rural Affairs (Defra) as part of the marine arm of the Natural Capital and Ecosystem Assessment (NCEA) programme. Marine (m)NCEA is delivering evidence, tools, and guidance to integrate natural capital approaches into policy and decision making for marine and coastal environments.

Find out more at https://www.gov.uk/government/publications/natural-capital-and-ecosystem-assessment-programme.

Any enquiries regarding this publication should be sent to us at

marineNCEA@defra.gov.uk

Contents

Abbreviations 5

1. Executive summary 6

2. Introduction 7

Background to this study 7

What is natural capital? 7

The mNCEA programme 7

Purpose and scope 9

Aim 9

Policy needs 9

Scope 11

3. Review 12

Marine mammal ecosystem services 12

Provisioning ecosystem services 12

Regulation and maintenance ecosystem services 12

Cultural ecosystem services 13

Natural capital asset 16

Marine assets 16

Current cetacean asset knowledge gaps 16

Planned improvements to strategic cetacean monitoring 18

Current evidence projects 19

Marine mammal monitoring projects and programmes 19

Review findings 30

Further data sources 31

Potential future monitoring methods 31

Evidence accessibility 33

4. Knowledge gaps 34

Current monitoring of UK cetaceans 34

Uses of cetacean asset data 35
5. Recommendations 36
Enhance asset data on inshore cetaceans 36
Collect data in place on inshore cetaceans in readiness for natural capital assessment 36
Investigate innovative approaches to monitoring 36
Mobilise acoustic citizen science evidence 36
Review integration of wider marine mammal data 36
Long-term cetacean monitoring 37
Secured funding 37
Improve understanding of regulation and maintenance services 37
Improve understanding of cultural services 37
Conduct an economic evaluation of marine mammal cultural services 37
Empower citizen science projects to collect ecosystem services data alongside ecological data 38
Conduct natural capital assessments for marine mammals 38
6. References 39
7. Glossary 46
8. Appendices 47

Abbreviations

ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
BESS	British Energy Security Strategy
BMP	UK Bycatch Monitoring Programme
CATT	Cetacean Acoustic Trend Tracking
CICES	Common International Classification of Ecosystem Services
CMCCG	Cornwall Marine & Coastal Code Group
CMS	Convention on Migratory Species
CODA	Cetacean Offshore Distribution and Abundance in the European Atlantic
COMPASS	Collaborative Oceanography and Monitoring for Protected Areas and Species
CSIP	Cetacean Strandings Investigation Programme
DAERA	Department of Agriculture, Environment and Rural Affairs
DAS	Digital Aerial Survey
ECOMMAS	The East Coast Marine Mammal Acoustic Study
ECOPredS	Ecological Consequences of Orca Predation on Seals project
eDNA	Environmental DNA
EEZ	European Economic Zone
EPS	European Protected Species
EU Interreg	European Territorial Cooperation
FLOW	Floating Offshore Wind
HBDSEG	UK's Healthy and Biologically Diverse Seas Evidence Group
HD	High-definition photography
HPMA	Highly Protected Marine Areas
IAMMWG	Inter-Agency Marine Mammal Working Group
JCDP	Joint Cetacean Data Programme
JNCC	Joint Nature Conservation Committee
MarPAMM	Marine Protected Areas Management and Monitoring
MCAA	Marine and Coastal Access Act
mNCEA	Marine Natural Capital and Ecosystem Assessment programme
NGO	Non-Governmental Organisation
NRW	Natural Resource Wales
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
OWEAP	Offshore Wind Enabling Action Programme
OWEC	Offshore Wind Evidence and Change Programme
PAM	Passive Acoustic Monitoring
POSEIDON	Planning Offshore Wind Strategic Environmental Impact Decisions
QSR	Quality Status Reports
RADAR	Radio Detection and Ranging
SAC	Special Area of Conservation
SAMOSAS	Static Acoustic Monitoring of Scottish Atlantic Seas
SCANS	Small Cetaceans in European Atlantic waters and the North Sea
SCOS	Special Committee on Seals
SMRU	Sea Mammal Research Unit
UAS	Unoccupied Aerial Systems
UAV	Unmanned Aerial Vehicles
UKMMAS	UK Marine Monitoring and Assessment Strategy
WAMMS	Welsh Acoustics Marine Mammal Survey

1. Executive summary

This report aims to provide an understanding of the evidence requirements for marine mammals in English waters, with a focus on cetaceans. This is to inform the requirements of further studies to provide evidence for natural capital assessments.

A review of monitoring projects for marine mammals within UK and English waters has been conducted to obtain data relating to marine mammals as an ecosystem asset. The review encompasses both government-funded evidence projects as well as wider monitoring by non-governmental organisations (NGOs) and citizen science projects.

Government-funded cetacean monitoring within English waters is limited to broadscale visual summertime surveys every six to ten years (Small Cetaceans in European Atlantic waters and the North Sea, SCANS), and via bycatch and strandings monitoring. Monitoring by NGOs and citizen science projects is sporadic around the UK coast, with national programmes providing the most substantial evidence databases.

Monitoring methods were found to be predominantly visual, although emerging technology and methods, such as drone technology, acoustics onboard unmanned surface vehicles, and environmental DNA (eDNA), may be used in the future. There is currently no mechanism to support or incorporate *ad hoc* citizen science data into the evidence base, despite the large data volumes available, but scope to do so exists with an understanding of the limitations and standardisation.

There is no single solution for routine monitoring of cetaceans. However, there is a variety of techniques available that can be used effectively and in combination with one another, which will result in a more complete picture of the status and distribution of cetacean species.

As highlighted in previous reports, gaps in the understanding of cultural ecosystem services remain for marine mammals. These are considered in the context of this report. The cultural ecosystem services provided by marine mammals in the UK include wildlife watching, which has implications on the value of the benefits to people comprising of tourism economy, coastal economy, and wellbeing.

The gaps in our understanding of cetacean populations have led to incomplete assessments in our strategic reporting obligations. Gaining a higher-resolution understanding of inshore cetaceans, the ecosystem services they provide and the natural capital value they have, will provide a suite of evidence that will be central to our ability to make good evidence-based management decisions, and apply natural capital approaches.

Recommendations from this review have been grouped into: (1) enhancing the asset data available and (2) improving the understanding of cultural services. These two evidence bases, when combined, will allow the application of natural capital and ecosystems approaches for marine mammals, which will in turn provide a key building block to delivering the marine Natural Capital and Ecosystem Assessment (mNCEA) programme's vision for "a thriving marine environment where nature is at the heart of decision-making".

2. Introduction

Background to this study

What is natural capital?

Natural capital refers to “the elements of nature that directly or indirectly produce value to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions” (Natural Capital Committee). The idea behind natural capital is that it helps us define, quantify, and value these benefits in ways that help better represent them, and the natural environment that provides them. By taking a natural capital approach we can better value nature’s services, have an understanding of natural processes, and involve a human perspective (Figure 1). As such, natural capital helps us make decisions that benefit both people and nature (Rice *et al.,* 2021).

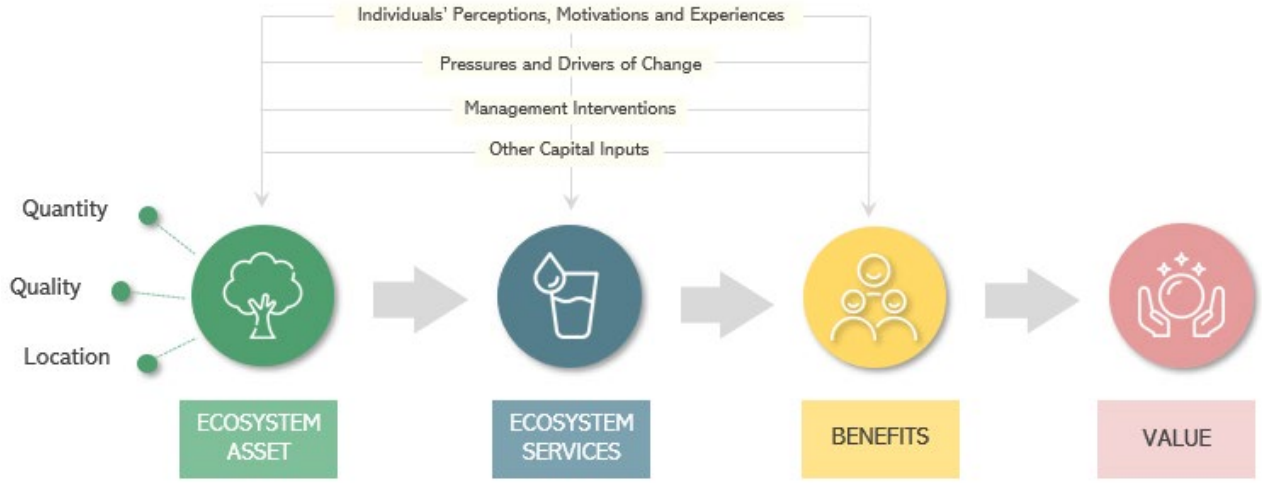

Figure 1: Natural England’s Natural Capital Logic Chain. Based on Potschin and Haynes-Young (2011) ecosystem services cascade. (Source: Wigley *et al*., 2020)

The mNCEA programme

One of Defra’s marine Natural Capital and Ecosystem Assessment (mNCEA) programme’s aims is to:

“Transform and innovate the way our evidence-base is captured, analysed and brought together to ensure science meets the needs of policy / decision makers to embed a natural capital approach, allowing us to leave our marine environment in a better state than we found it, achieving clean, productive, healthy and biologically diverse seas, and a sustainable blue economy.”

The mNCEA will provide a holistic, accurate and robust set of evidence and data for Defra to make informed policy decisions about the state of our natural capital assets in high profile policy areas (e.g. fisheries management, offshore wind etc.), and lead to better

outcomes for the environment. It will also identify innovative and transformative ways of collecting, analysing, and distributing natural capital data.

Better data and evidence are required so that government and society can:

- Understand our natural capital, and how and why it is changing.
- Tackle pressures on the environment and the drivers of change.
- Take biodiversity and natural capital into account in decision making.
- Target action where it will be most effective.
- Evaluate policies and interventions to improve their effectiveness.

Purpose and scope

Aim

The initial aim of this report was to provide an understanding of the evidence requirements for inshore cetaceans in English waters, to inform future evidence collection within the mNCEA programme.

We found that much of the information provided for cetaceans was relevant to all marine mammals (i.e. it includes pinnipeds). We therefore expanded the scope of the report to include other marine mammals.

This workstream will support Outcome 3 of the mNCEA programme: New ecological and socioeconomic monitoring, innovative methods, data science, decision support tools and best practise deliver transformational enhancements to our marine evidence base.

Policy needs

Through international and national legislation, the UK must protect cetaceans at both site-based and range-wide levels. The Habitats Directive, as translated into UK law, provides protection for European Protected Species (EPS) throughout their natural range, which includes all cetaceans. Of these protected cetacean species, three occur regularly in inshore English waters: harbour porpoise (*Phocoena Phocoena)*, bottlenose dolphin (*Tursiops truncates)*, and white-beaked dolphin (*Lagenorhynchus albriostris*). Annex II of the Habitats Directive details species that require special conservation measures and includes both harbour porpoise and bottlenose dolphin.

The gaps in our understanding of cetacean populations have led to incomplete assessments in our strategic reporting obligations. These include: the extent to which Good Environmental Status has been achieved for cetaceans, as set out in the UK Marine Strategy; Article 17 of the Habitats Directive; Management Units for cetaceans in UK waters; the Convention on Migratory Species; the OSPAR Convention, and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) (Table 1 and Appendix Table A). The drivers behind nature conservation requirements for marine biodiversity assessment and reporting obligations are detailed in Part 1 of the *Review of marine biodiversity assessment obligations in the UK* (Hinchen, 2014a).

Providing new evidence will have impacts on policy:

- 25 Year Environment Plan: baseline for *reversing the loss of marine biodiversity*, and *increasing the proportion of protected and well-managed seas, and better managing existing protected sites*

- Net Gain: informing planning and major infrastructure

- Marine and Coastal Access Act (MCAA): Highly Protected Marine Areas (HPMAs) baseline data and marine planning
- Environment Act: Halt the decline in species populations by 2030, and then increase populations by at least 10% to exceed current levels by 2042
- 10 Point Energy Plan: Floating offshore wind (FLOW) 5GW by 2030 (specific to evidence in the FLOW proposed locations)
- British Energy Security Strategy (BESS): Making environmental considerations at a more strategic level allowing us to speed up the process while improving the marine environment

In addition, English reporting following the Environment Act will include periodic reports by Natural England on the 'State of Natural Capital'.

Table 1: Summary of reporting obligations for UK marine mammals

Obligation	Latest report	Biological evidence required
ACSOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas)	2021 Annual National Report: United Kingdom link	Abundance & Distribution Conservation Status
OSPAR Convention (Convention for the Protection of the Marine Environment of the North-East Atlantic) **Biodiversity Strategy**	2023 Quality Status reports link	Distribution in the OSPAR Maritime Area Population (current/ trends/ future prospects) Condition (current/ trends/ future prospects)
Article 17 of the Habitats Directive	Article 17 Habitats Directive Report 2019: Species Conservation Status Assessments 2019 link	Range Population
UK Marine Strategy	2019 Marine Strategy Part One: UK updated assessment and Good Environmental Status link 2022 Marine Strategy Part Two: UK updated monitoring programmes link 2015 Marine Strategy Part Three: UK programme of measures link	Good Environmental Status Descriptor 1 (Biological Diversity) and Descriptor 4 (Food webs), for Cetaceans & Seals. Marine Strategy Framework Directive Criterion: 1.1: Species distribution 1.2: Population size 1.3: Population condition 4.1: Productivity (production per unit biomass) of key species or trophic groups (grey & harbour seals) 4.3: Abundance/distribution of key trophic groups/species
Management Units	IAMMWG Management Units for Cetaceans in UK Waters (January 2015, 2022, in draft) link	Boundaries based on Population Structure

Obligation	Latest report	Biological evidence required
CMS (Convention on Migratory Species)	United Kingdom CMS National Report 2019 link	Conservation Status of Migratory Species
Conservation of Seals Act	Scientific Advice on Matters Related to the Management of Seal Populations: 2021 link	Population size and trends Population health Threats

Scope

Cetaceans are iconic species, with a high value to the public, which generate direct economic benefits through tourism and recreation as well as providing other important ecosystem services as predators moderating fish populations, and as wider indicators of ecosystem health.

However, there are significant gaps in knowledge, especially the abundance and distribution of localised, inshore cetacean populations. Gaining a higher-resolution understanding of the distribution and abundance of inshore cetaceans, the ecosystem services they provide and the value they hold, will provide a suite of evidence that will be central to our ability to make evidence-based management decisions, and apply natural capital approaches.

There is a baseline level of knowledge of cetaceans at a UK-wide scale. In the last decade there have been efforts to collate databases of cetacean observations and infer species distribution at a UK-wide scale (Paxton *et al.,* 2016; Waggitt *et al.,* 2019). These studies have combined observation data with environmental datasets to predict relative abundance and distribution across UK waters. At a regional scale, absolute abundance (for summer only) has been provided through the three SCANS (Small Cetaceans in European Atlantic waters and the North Sea) surveys in 1994, 2005/07 and 2016, and reports will soon be released from the fourth SCANS survey which took place in 2022. Though these studies have advanced our knowledge at a UK-wide scale, there remains a significant gap in knowledge of the abundance and distribution of localised, inshore cetacean populations, particularly in English waters.

The primary focus of this review is on inshore cetacean ecosystem asset evidence, broadly defined by quantity, quality, and location (Figure 1). This report will not consider wider aspects of data deficiency such as pressure, risks and impacts, or effectiveness of management interventions.

This review was carried out as part of mNCEA project NC36 between April 2022 and March 2023. It therefore only includes evidence that was available at or before March 2023.

3. Review

Marine mammal ecosystem services

Little work has been completed with regards to applying a natural capital approach to marine mammal species. This section summarises the key findings of studies relating to marine mammal ecosystem services.

Following the Common International Classification of Ecosystem Services (CICES, Haines-Young and Potschin, 2018), ecosystem services are categorised as: regulation and maintenance; provisioning; and cultural values. Cook *et al.* (2020) state that whale ecosystem services fall into the following categories (Table 2), many of which are applicable to pinnipeds as much as cetaceans.

Table 2: Marine mammal ecosystem services. Information derived from Cook *et al.* 2020.

CICES category	Marine mammal ecosystem service
Provisioning	Food products (meat, blubber, skin, and intestines) Whale bones, teeth, and baleen Oil-based products derived from blubber
Regulation and Maintenance	Enhanced biodiversity and evolutionary potential Climate regulation (carbon sequestration)
Cultural	Tourism (whale watching) Whale music and arts (entertainment) Sacred and/or religious Educational Community cohesiveness and cultural identity Aesthetics (appreciation of the beauty of whales) Existence Bequest

Provisioning ecosystem services

In the UK, marine mammal legislation protects cetaceans and pinnipeds from being a supply of provisioning services.

Regulation and maintenance ecosystem services

Insights into cetacean regulation and maintenance ecosystem services have been provided by a recent report by Sheehy *et al.* (2022). The report focuses on the importance of climate change mitigation through regulation and maintenance, as cetaceans can store, transport, and influence stocks of carbon through climate regulation through carbon sequestration (living biomass and ‘whale-falls’), enhanced biodiversity and ecosystem potential, and enhanced primary productivity. Sheehy *et al.* (2022) utilised data from the Joint Cetacean Data Programme (JCDP) to highlight key areas for cetacean conservation

and additional protection within UK waters, which includes specific reference to the importance of the east coast of England for cetaceans.

Sousa *et al.* (2023) conducted an integrated socio-economic assessment which uses scenarios that projects potential climate impacts on the whale watching sector. The study demonstrates the importance of considering socio-economic, climate and ecological (species' thermal suitability responses) factors of whale watching when assessing the potential challenges posed by climate change. The paper provides a case study to help the whale watching sector develop climate action policies and strategies.

Cultural ecosystem services

Cultural service evidence gaps for marine mammals have been highlighted through two pilot projects within the mNCEA programme by Mulholland *et al.* (2021) '*Rapid review of marine natural capital asset classes and logic chains to identify priority information gaps'*, and Burton and Bayes (2022) '*A review of the cultural value of seabirds and marine mammals'.*

The Mulholland *et al.* report identifies key evidence and data gaps within marine natural capital assets and services (Appendix Table B). They concluded that cultural services are the area with the most significant data gaps for application of the natural capital approach to the marine environment, noting that "*there is very limited detailed understanding on the extent, nature and full set of benefits related to recreational activities, and limited understanding of the link between asset status and recreational service delivery"*. The report recommends that dedicated social science surveys should be conducted to develop fuller understanding of the benefits of cultural ecosystem services, and links to asset condition, at both a place-based scale (to determine impact/outcome of changes to asset status) and national level surveys to inform policy direction. In addition, the authors note the need for evidence on understanding extent, condition, quality, and quantity all of the assets.

Natural capital accounting places science and economic evidence at the forefront of decision making. Gaps in monitoring and evaluation will need to be addressed to enable policy to be more securely based on a sound understanding of the costs and benefits, including biophysical trade-offs, of different policy and development options (Thornton *et al.,* 2019).

The mNCEA natural capital account for the North Sea sandeel fishery used modelled data to produce biomass trends for sandeels, functional fish groups, sea birds and marine mammals (eftec, 2021). The sandeel natural capital account exposed a paucity of data relating to marine mammals which were highlighted by Burton and Bayes (2022), principally how marine mammal biomass data linked to the benefits of wildlife-based tourism and recreation through the enhanced visibility of wildlife.

This report supports the findings by Mulholland *et al.* (2021) that cultural services were most lacking in data across the logic chain (Figure 2). Evidence gaps across the logic chain are summarised as:

- Assets – *abundance and distribution*.

- Ecosystem services – *how an increase in the asset will influence the services associated with wildlife tourism*.

- Benefits – *discovery and awe experienced by those undertaking wildlife-based activities, and the existence and bequest benefits experienced by the general public*; and

- Values – *social and economic value (including non-monetary value) of wildlife-based activities.*

Burton and Bayes (2022) provide recommendations as to how further data collation and acquisition could lead to more robust recognition of the cultural values derived from an enhanced abundance and diversity of marine mammals:

- Obtain more data on the distribution and movements of seabirds and marine mammals, including cetaceans (porpoises, dolphins, and whales) and pinnipeds (seals) in the North Sea.

- Collect data on the use values (i.e. market price and travel costs) related to wildlife-based activities that are likely to be affected by increased abundance or diversity of seabirds or marine mammals in North Sea.

- Use stated preference valuation methodologies (i.e. choice modelling or contingent valuation) to determine the value placed on the likelihood of viewing marine mammals and birds by key user groups (e.g. birdwatchers, holiday makers, day trippers) visiting a number of locations on the East coast and the general public.

- Use stated preference methods to better assess visitor motivation, for example would the market price of nature reserve entry increase if there was a higher chance of seeing a rare species, or would wildlife watching boat trips become more popular if there was a guaranteed encounter with a whale, dolphin, or seal?

- Explore further the visitor motivations at locations where higher use values have been placed on wildlife watching to consider how management interventions could improve the cultural value placed on marine mammals and seabirds (e.g. improved awareness and facilities).

- Consider how improved stakeholder participation (including application of citizen science to seabird and cetacean monitoring) and other management interventions e.g. improved facilities could enhance the cultural ecosystem service values for marine charismatic species at locations where the chance of viewing marine mammals and seabirds is likely to be enhanced by the management of the sandeel fishery.

This information would provide marine mammal related evidence for use in other modelling for natural capital accounting, including enhancing the sandeel account.

Figure 2. Cultural ecosystem services natural capital logic chain for the enhanced abundance and diversity of seabirds and marine mammals. Figure from Burton and Bayes, 2022.

Cultural ecosystem services from wildlife-based activities such as bird, seal, dolphin, or whale watching not only contribute to human health, happiness, and wellbeing but they can also offer opportunities to support local economic growth (Zin *et al.,* 2019). A report commissioned by the Australian Government (Syneca Consulting, 2009) provides a summary of the socio-economic value of cetacean conservation and the non-consumptive use of cetaceans (cultural and existence) globally and reflects on policy implications.

Natural capital asset

Marine assets

Hooper *et al.* (2019) highlight that application of the natural capital approach has not been fully tested in the context of decision making for the marine environment, and that existing methodologies (developed for terrestrial systems) are not feasible in the marine context at the national scale. The report shows that data gaps in the marine environment are a "significant impediment to progress" and encourage the use of proxies, remote sensing, and interdisciplinary approaches.

For natural capital assets it is important to look at evidence on understanding quantity, quality, and location. As discussed in the introduction, these data feed directly into UK reporting obligations and feed understanding for various UK policies.

Across all species the Natural England summary of marine evidence (Natural England, 2015) states that there are significant gaps in knowledge of the distribution and extent of other marine habitats and species, especially outside of protected areas, and that habitat and species distributions is an area subject to active research. The report also highlights that, although there have been reports and evidence such as the National Ecosystem Assessment (http://uknea.unep-wcmc.org/), more research is needed to fully identify and quantify the 'worth' of marine biodiversity and healthy ecosystems.

In Scotland, a feasibility study of a marine natural capital asset index (Tillin *et al*., 2019) reviews the opportunity to utilise highly mobile species, such as marine mammals, as both an asset and as an indicator of ecosystem condition. By identifying key associations between pelagic habitat and highly mobile species, these species can be used as indicators to assess the likely condition of pelagic habitats, feeding grounds, nursery areas and other components such as prey species. The authors caveat this proposal with a limitation on the understanding of the links with trophic levels higher than plankton, and that these have not been evaluated and it may be that there are none. Again, the lack of highly mobile species data, and the variations in extent and effort in this data, also provide a key challenge for the use of marine mammal species as an asset itself, or as an indicator of condition for pelagic habitat.

Current cetacean asset knowledge gaps

For highly mobile species in the marine environment accurate asset data (quantity, quality, and location, i.e. health, abundance, and distribution) is notably challenging to obtain and monitor.

For many species of UK cetacean, we are lacking information to confidently understand their status. The implications of this include risks to the conservation of the species and limited information on which management decisions can be based.

Insufficient data on cetacean abundance and distribution was one of several key issues identified in relation to monitoring of cetaceans and pinnipeds (Defra, 2021).

The extent to which Good Environmental Status has been achieved for cetaceans remains uncertain (Defra, 2019). Uncertainty in the data means that conclusions cannot be drawn about any changes in cetacean abundance. Good Environmental Status is also unknown for harbour seals but is considered to have been achieved for grey seals.

The 2023 quality status reports (QSR, Geelhoed *et al.,* 2023) to OSPAR show that a lack of comparable abundance estimates does not allow robust trend assessments and advises a continued need for large-scale surveys to increase sample size and the power to detect trends for cetacean species. They note that there is a lack of seasonal abundance information due to summer only large-scale surveys.

Waggitt *et al*. (2019) has provided the most comprehensive study of cetacean distribution in recent years by collating and standardising diverse survey data for cetaceans in the North-East Atlantic. The study produced distribution maps for 12 species of cetacean in the months of January and July. The quantity and extent of survey data in the collation provides a good representation of distributional patterns in the study area. However, these data do not take account of inshore cetaceans, and purposefully exclude the inshore ecotype of bottlenose dolphins to not skew distribution data for the species.

The most recent cetacean Management Unit boundary review (IAMMWG, 2022 unpublished draft) has found that insufficient distribution evidence is preventing an understanding of the temporal and spatial extent of inshore bottlenose dolphins. However localised photo-identification efforts made off the south-west coast from citizen science projects have been taken into account by the Inter Agency Marine Mammal Working Group (IAMMWG), and work by Dudley (2017), Corr (2020) and Duncan (2021) has resulted in a boundary movement for the Coastal West Channel Management Unit for the species. Further localised efforts for inshore bottlenose dolphins have been reviewed in the context of the current extent of the Coastal East Scotland bottlenose dolphins. Local citizen scientist data report an increase in sightings of bottlenose dolphins along the coast off north-east England showing that members of the Central East Scotland population are present in English waters (Aynsley, 2017, Hackett in press, Citizen Fins, 2023). Current evidence is insufficient to draw conclusions on the temporal and spatial extent of these movement and so further research has been identified to understand how this population is shifting (Gutierrez-Munoz, 2021).

Likewise, data is scarce for another cetacean in inshore waters, the white-beaked dolphin. There are indications of an inshore population in Lyme Bay (IAMMWG, 2022 unpublished draft), however further data are required. Brereton *et al.* (2020) report that the waters off Northumberland support relatively high densities of white-beaked dolphins during the summer months compared to other regions in the North Sea. Brereton *et al.* (2016b) utilised photo-identification methods to determine abundance estimates in the south-west and north-east of England. Both Brereton *et al.* reports (2020, 2016a, 2016b) utilise data collected from citizen science methods.

The lack of systematic regional surveys in English inshore waters results in uncertain abundance estimates for inshore species.

Planned improvements to strategic cetacean monitoring

Natural England's approach to prioritizing marine species recovery (Hiscock *et al.,* 2011) details the lack of knowledge of population size and location of cetaceans, noting the recovery / conservation goal in the first instance is to raise levels of knowledge of these species to a suitable level to allow the creation of meaningful management goals. The insufficient data available results in the inability to assess cetacean species for decline in UK or English waters.

The UK Marine Monitoring and Assessment Strategy (UKMMAS) 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. As part of this, JNCC is leading development of an integrated UK Marine Biodiversity Monitoring Programme, including plans to implement an effective UK cetacean monitoring programme (utilising the UK Marine Biodiversity Monitoring Strategy; Kröger and Johnston, 2016) to ensure more complete understanding of conservation status of all UK cetaceans and to support management. To support the development of the monitoring programme, HBDSEG compiled a stabilisation review of UK biodiversity monitoring programmes. The review purpose was to enable changes such that each programme is suitably governed, funded, and functional. Successful implementation of a UK cetacean monitoring programme will ensure data collection is fit for purpose and analysis appropriate to deliver on the UK's national (e.g. the UK Marine Strategy) and international commitments (e.g. as Party to OSPAR) (Scottish Government, 2021).

Evans and Hammond (2004) and SMRU Ltd (2010) provide comprehensive reviews of monitoring methods available and how these can be used to determine an understanding of a population. Valid discussion on the pros and cons of each method including the resulting assumptions in the data are provided, and have been summarised in Appendix Tables C and D, with details on the outputs from various methodologies provided in Appendix Table E.

Current monitoring efforts of marine mammals are detailed in the following section.

Current evidence projects

Marine mammal monitoring projects and programmes

The lack of a systematic surveillance and monitoring scheme is the most significant gap the UK has in implementing its policy obligations (Pinn, 2010). Such a strategy is currently under development by JNCC in line with the UKMMAS (see above). This action will also identify and develop plans for any gaps in cetacean monitoring to ensure more complete understanding of conservation status of all UK cetaceans and to support management (Scottish Government, 2021).

To obtain data relating to marine mammals as an ecosystem asset a review of monitoring projects for marine mammals within UK and English waters has been conducted.

The review entailed two strands. For an understanding of the government-funded projects and programmes species specialists were consulted, and the UK Marine Strategy monitoring programmes examined (Defra, 2021). When gathering information on wider evidence gathering projects three approaches were taken:

1) An internal Natural England Staff survey was conducted to gather information from local area teams.

2) Information was gathered from the mNCEA Marine, Coast and Estarine Citizen Science Review (Tillin *et al.,* 2022; NC36).

3) An internet and social media search were conducted.

The UK Marine Strategy (Part Two: UK updated monitoring programmes; Defra, 2021) details the programmes listed in Table 3 as current provisions of data for the descriptors.

Table 3: UK monitoring programmes informing Defra. *Note that CSIP is now funded to additionally collect data on pinnipeds.

Cetaceans	Pinnipeds*
Abundance and distribution (i) Synoptic cetacean surveys including the Small Cetaceans in European Atlantic waters and the North Sea (SCANS) surveys (ii) Bottlenose dolphin inshore population monitoring (iii) Regional acoustic detection programmes **Mortality** (i) UK Bycatch Monitoring Programme (BMP) (ii) Cetacean Strandings Investigation Programme (CSIP) (England and Wales) (iii) Scottish Marine Animals Stranding Scheme (SMASS)	(i) Seal Population Monitoring (ii) UK Bycatch Monitoring Programme (BMP) (iii) Scottish Marine Animals Stranding Scheme (SMASS)

Monitoring programmes which feed into Natural England's evidence base are conducted by the following groups:

- UK government and devolved administrations.
- academia.
- sector-related (often relating to anthropogenic impacts).
- individual organisations and projects; and
- European collaborative projects (e.g. EU Interreg projects) (Natural England, 2015).

This review has been summarised in Tables 4 and 5, detailing projects across the UK funded by the UK government and devolved administrations, and a non-exhaustive list of projects in English waters by other groups, respectively. Research projects funded by UK government which have a wider remit but encompass elements of monitoring (for example monitoring the impacts of a pressure such as offshore wind) have not been included.

Table 4: Monitoring programmes funded by the UK government or devolved administrations.

Name	**Description** (incl. extracts from and updates to the *Marine strategy part two: UK updated marine monitoring programmes*, Defra 2021)	Cetaceans	Seals	Method	English waters?	Currently active?
Small Cetaceans in European Atlantic waters and the North Sea (SCANS) surveys	SCANS is a multilateral (ship and aerial) survey conducted once every six to ten years in Northern European waters to assess cetacean abundance. SCANS was initiated in 1994 and continued in 2005 and 2016 (SCANS-II & III) and 2007 Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA) project, with the most recent survey taking place in 2022 (SCANS-IV).	Y	N	Visual and acoustic	Y	Y
UK seal monitoring programme (Abundance and distribution of grey and harbour seals)	The UK seal monitoring programme is run by the Sea Mammal Research Unit (SMRU), University of St Andrews. It undertakes systematic monitoring of all major breeding colonies for grey seals and the entire coast of Scotland and selected English sites (not just haul-out sites) for harbour seals. This feeds directly into the Special Committee on Seals (SCOS) reporting to provide scientific advice to government on matters related to the management of seal populations. Monitoring of the smaller grey seal colonies in South West England, Wales, and some regions of Scotland such as Shetland is undertaken by a variety of groups, with information collated by SMRU. Harbour seal monitoring occurs on a rolling schedule with all areas surveyed at least once every five years (grey seal summer distribution is included). Haul-out sites in the Moray Firth, Tay estuary and the Wash are surveyed annually. Thermal imaging and GPS tracking are used by SMRU in monitoring these populations. The major grey seal breeding colonies are monitored once every two years. In Northern Ireland, Department of Agriculture, Environment and Rural Affairs (DAERA) monitors breeding populations of harbour and grey seal at sites for which they are a designated feature (by land and sea).	N	Y	Visual, tagging and thermal imaging	Y	Y
The Wash harbour seal aerial surveys (breeding)	Abundance and distribution data collected during breeding season annually. Conducted by SMRU on behalf of Natural England.	N	Y	Visual	Y	Y
Site Condition Monitoring of bottlenose dolphins in Moray Firth	Since 2004, SNH have funded the University of Aberdeen (in collaboration with the Sea Mammal Research Unit) to support photo-identification studies and use the data to report on the condition of the site.	Y	N	Visual and acoustic	N	Y

Name	Description (incl. extracts from and updates to the *Marine strategy part two: UK updated marine monitoring programmes*, Defra 2021)	Cetaceans	Seals	Method	English waters?	Currently active?
Site Condition Monitoring of bottlenose dolphins in Cardigan Bay	Natural Resource Wales (NRW) commission JNCC, Ceredigion County Council and SeaWatch Foundation to monitor the bottlenose dolphin population and estimate population status, both within the Cardigan Bay SAC (primary feature) and the wider Cardigan Bay area which includes the Pen Llŷn a'r Sarnau SAC (qualifying feature).	Y	N	Visual	N	Y
Skomer and Ramsay Islands seal monitoring	Grey seal colonies are currently monitored annually on Skomer and Ramsay Islands by Natural Resources Wales with partners: RSPB, Hilbre Bird Observatory.	N	Y	Visual	N	Y
ObSERVE	Aerial (2015-17) and Acoustic (2015-16) Surveys for Cetaceans Northern Ireland programme. Aerial surveys covered a significant portion of the EEZ across two summers and two winters.	Y	N	Visual and Acoustic	N	N
Northern Ireland Seal Monitoring	Various organisations on behalf of the Department of Agriculture, Environment and Rural Affairs DAERA. Seal Monitoring has been carried out carried out since 1993 to estimate population numbers and therefore fulfil the requirements of the EC Habitats Directive and national objectives.	N	Y	Visual	N	Y
Collaborative Oceanography and Monitoring for Protected Areas and Species (COMPASS)	The COMPASS project increases understanding of how cetaceans use an area of sea and how they may be impacted by or respond to pressure from human activities. This information is also used to inform marine protected area management. Through a network of oceanographic and acoustic moorings across the regional seas of the Republic of Ireland, Northern Ireland and West Scotland, COMPASS provides effective cross-border monitoring of monitoring and management of Marine Protected Areas (MPAs). This project runs 2017-2022.	Y	N	Acoustic	N	N
Marine Protected Areas Management and Monitoring (MarPAMM)	MarPAMM aims to deploy three marine mammal and underwater noise monitoring moorings at sites in Scottish waters, within the INTERREG VA "cross-border" region with Northern Ireland. Data are required to underpin the management of marine protected areas and protected species (marine mammals). The project completed in March 2022.	Y	N	Acoustic	N	N
The East Coast Marine Mammal Acoustic Study (ECOMMAS)	The East Coast Marine Mammal Acoustic Study monitors dolphin and harbour porpoise populations. Run by Marine Scotland since 2013, ECOMMAS uses echolocation click detectors at 30 sites on the East coast of Scotland, and broadband sound recorders at ten of these sites, to acoustically detect and monitor cetaceans.	Y	N	Acoustic	N	Y
SeaMonitor	The SeaMonitor project includes extending the existing network of buoys with acoustic receivers, delivered by a sister project, COMPASS, as well as marine telemetry. The project studied the seas around Ireland, Western Scotland, and Northern Ireland between 2019 and 2022.	Y	Y	Acoustic And tagging	N	N

Name	Description (incl. extracts from and updates to the *Marine strategy part two: UK updated marine monitoring programmes*, Defra 2021)	Cetaceans	Seals	Method	English waters?	Currently active?
Static Acoustic Monitoring of Scottish Atlantic Seas (SAMOSAS)	The SAMOSAS (2020-2021) project has collected year-round passive acoustic monitoring data in Scottish continental shelf waters addressing the data gaps for deep diving cetaceans SAMS in association with Marine Scotland and Uni of Plymouth. 2020-2021.	Y	N	Acoustic	N	N
Welsh Acoustics Marine Mammal Survey (WAMMS)	NRW acoustic programme commencing 2022. 3-year project collecting 18 months of data. Pilot to monitor HP north Anglesey SAC. Following completion of the pilot period a whole Wales monitoring approach will be evaluated.	Y	N	Acoustic	N	Y
UK Bycatch Monitoring Programme (BMP)	The UK BMP deploys dedicated protected species bycatch observers onboard commercial fishing vessels to monitor bycatch.	Y	Y	Visual	Y	Y
Clean Catch	Clean Catch is a collaborative group that has representatives from a wide range of stakeholders in the bycatch of non-target species. The group facilitate collaborations and further work to bring about improvements in monitoring and mitigation to reduce wildlife bycatch (including seals), with the UK Bycatch Mitigation Initiative underpinning the work. Studies include developing the use of Remote Electronic Monitoring (REM) to monitor wildlife bycatch, including marine mammals; and broadening bycatch monitoring via fisher self-reporting.	Y	Y	Various	Y	Y
Cetacean Strandings Investigation Programme (CSIP)	The CSIP records stranded cetaceans and pinnipeds and conducts post-mortems on a subset of strandings on the English and Welsh coastline. The results from the post-mortems help to identify the major causes of death, and can provide information on disease, contaminants, fisheries bycatch, reproductive patterns, and diet. A one-year funded seal post-mortem trial started in 2022 for England and Wales as part of CSIP.	Y	Y	Postmortem	Y	Y
Scottish Marine Animal Stranding Scheme (SMASS)	In Scotland, the SMASS, monitors seal strandings around the Scottish coast to determine cause of death.	N	Y	Postmortem	N	Y
Marine Mammals Stranding Investigations	In Northern Ireland, DAERA monitor strandings of both grey and harbour seals and, where appropriate, post-mortems are undertaken by the AFBI.	N	Y	Postmortem	N	Y
POSEIDON project (Planning Offshore Wind Strategic	Aims to establish a robust evidence base made accessible through new mapping tools, by collating and assessing existing data about seabirds, marine mammals, and filling data gaps in the North Sea and Celtic Sea with Digital Aerial Surveys (DAS).	Y	Y	Visual (DAS)	Y	Y

Environmental Impact Decisions)	The project is part of the Offshore Wind Evidence and Change Programme (OWEC), led by The Crown Estate, and will run 2023-24.					

Table 5: Marine mammal monitoring in English waters by non-government funded or government-funded partnership projects, including citizen science

Name	Description	Cetaceans	Seals	Method	Coverage
CMCCG Disturbance Register	Individuals can report disturbance events via a 24-hour hotline which is linked to the disturbance register. Cornwall Marine & Coastal Code Group (CMCCG) compile reports from this data.	X	X	Visual	Cornwall
[Sightings database]	Cornwall Seal Group Research Trust (CSGRT) hold database of public records of seal sightings. Land and boat-based surveys, ad hoc, at five main areas: North Devon, Lundy (Managed by Lundy Company), Cornwall, Isles of Scilly and South Devon		X	Visual	Cornwall
Marine Strandings Network	Cornwall Wildlife Trust database of strandings The network is the licensed recorder for all marine strandings in Cornwall This feeds into CSIP.	X	X	Visual	Cornwall
SW Bottlenose Dolphin project	Cornwall Wildlife Trust / ERCCIS database of sightings	X		Visual	Cornwall & Isles of Scilly
Seal Photo Identification Project (PIP)	Dedicated photo id surveys undertaken from boats. Marine Life and Human Activity surveys also records human activity and records lost fishing gear at sea. Cornwall Seal Group Research Trust (CSGRT)		X	Visual	Cornwall
People Protecting Precious Places (PPPP) surveys	Dedicated PPPP surveys to monitor disturbance at sites. Cornwall Seal Group Research Trust (CSGRT)		X	Visual	Cornwall
Seaquest Southwest	Seaquest has been running now for 10 years and collects sightings data on the abundance and distribution of marine megafauna around the Cornish coast. Cornwall Wildlife Trust.	X	X	Visual	Cornwall
[Survey]	Cumbria Wildlife Trust and Sea Watch organised surveys.	X		Visual	Cumbria
[Survey]	Cumbria Wildlife Trust and Walney Bird Observatory. Land and drone counts of South Walney seals.		X	Visual	Cumbria
Seal Spotter app	University of Plymouth and The Seal Project. Public can report seal sightings, logging individual's location, appearance, behaviour, and condition. Aim is to map the health of the local population.		X	Visual	Devon
Dorset seal photo-ID catalogue	Dorset Wildlife Trust		X	Visual	Dorset
[Survey]	Lincolnshire Wildlife Trust: ground count, annual, at Donna Nook.		X	Visual	East Coast
[Survey]	National Trust: ground count, annual, at Farnes Islands and Blakeney Point.		X	Visual	East Coast
Epicollect5 App	Societe Jersiaise marine sightings App. Public can report sightings of dolphins, seals to the app.	X	X	Visual	Jersey
[Sightings database]	Hampshire and Isle of Wight Wildlife trust Request for sightings of seals to be submitted. Informed the Solent Seal Project		X	Visual	Hampshire and Isle of Wight
Lyme Bay Project (SW)	Trained surveyors submit into database from surveys Includes PhotoID of BND and white beaked dolphins	X	X	Visual	Lyme Bay

Name	Description	Cetaceans	Seals	Method	Coverage
[Sightings database]	Visual monitoring of Lundy MPA priority species common dolphin and harbour porpoise. Managed by The Landmark Trust. Sightings from January 2012.	X		Visual And acoustic	Lundy Island
[Sightings database]	MARINElife database. Public can submit sightings of cetaceans and seabird. Trained surveyors submit into database from ferry surveys on Lundy Ferry, Seatruck Ferries and DFDS ferry routes Includes PhotoID of BND and white beaked dolphins	X	X	Visual	National, North Sea, English Channel, Lundy
OceanWatchers App	The ORCA: Organisation Cetacea Ocean Watchers online training course, along with a bespoke app will enable everyone to collect effort-based data about whales, dolphins, and porpoises.	X		Visual	National
[Survey]	ORCA: Organisation Cetacea Marine Mammal Surveyors onboard Ferry routes	X	X	Visual	National
[Sightings database]	ORCA: Organisation Cetacea				
National Whale and Dolphin Watch	Sea Watch Foundation Once a year dedicated survey nationally	X		Visual	National
Sea Watcher App	Sea Watch Foundation Observer App	X	X	Visual	National
[Sightings database]	Sea Watch Foundation database collating records from public and trained surveys from ferry routes.	X	X	Visual	National
SealPred	SMRU project. Individuals who have observed signs of grey seal predation report their observation using an online form. To understand number of grey seals that are MM predators		X	Visual	National
ECOPredS project	SMRU project looking for sighting reports and image/footage of killer whale foraging behaviour	X		Visual	National
Bycatch Evidence Evaluation Protocol (BEEP)	University of Exeter and Cornwall Wildlife Trust project to develop and test a diagnosis tool for detecting bycatch in stranded cetaceans using external features, such as encircling marks and other wounds. This was funded by Defra via CSIP.	X		Visual	National
[Sightings database]	Norfolk Cetaceans. Official cetacean recorder for Norfolk. Collates sightings. Sightings relayed to SeaWatch Foundation and The Norfolk Biodiversity Information Service.	X		Visual	Norfolk
[Survey]	Weekly counts of grey seals (adults and pups) hauled out in the breeding season by Friends of Horsey Seals. The data collected is sent to the SMRU at St Andrews University.		X	Visual	Norfolk
Photo ID at Horsey seal colony	Project run by Natural England in liaison with SMRU. Count numbers of individuals on beach, take photos of breeding mothers (ones with a pup in association) for photo ID purposes. Data shared with SMRU at St Andrews University.		X	Visual	Norfolk
North East Cetacean Project (NECP)	MARINELife NECP with support from Natural England, Northumberland IFCA and Northumberland Wildlife Trust. Marinelife started this project in collaboration with Northern Experience Wildlife Tours and Natural England in late 2009 with the aim of generating up-to-date information on the status of cetaceans off the Northumberland coastline. The project has now expanded to include the North Sea from the Humber to the Scottish Boarder.	X		Visual	North East

Name	Description	Cetaceans	Seals	Method	Coverage
	Includes PhotoID of Bottlenose dolphins and white beaked dolphins.				
White-beaked dolphin population monitoring	Dr. Ben Burville in Partnership with Newcastle University. Documenting offshore white-beaked dolphin populations with use of video footage on tourist vessels.	X		Visual	North East
CitizenFins	Led by SMRU. This project combines research and citizen science photo-identification data of bottlenose dolphins, to help understand how the pattern of movements of bottlenose dolphins along the east coast of Scotland and into NE England is changing.	X		Visual	North East
Secrets of the Solent	Members of the public collect ad hoc sightings data for the Wildlife Trust.	X	X	Visual	Solent
[Survey]	Langstone Harbour Board and Chichester Harbour Conservancy: annual land/boat-based surveys since 2015 in the Solent		X	Visual	Solent
The Solent Seal project	A partnership project, led by the Wildlife Trusts South East Marine Programme in partnership with Chichester Harbour Conservancy, Sea Mammal Research Unit, and Natural England. This project ran 2008-2010. The aim was to learn more about the Solent seal population with a view to improving its conservation. The project utilised various techniques to survey and monitor the seal populations, including visual counts at haul-outs, a public sightings scheme, photo-identification and telemetry.		X	Tagging	Solent
Somerset Marine Mammal Survey	One of a series of two-hour surveys for porpoises, dolphins and other marine life being carried out along the Somerset and North Somerset Coast throughout the year. Run in conjunction with Somerset Wildlife Trust's Somerset Wilder Coast Project and the SeaWatch Foundation.	X		Visual	Somerset
Somerset Synchronised Marine Mammal Survey	Synchronised Sea Watch surveys coordinated by the Somerset Wildlife Trust. Surveyors at every significant headland on the Somerset coastline for a single day. Data collated by the Sea Watch Foundation.	X	X	Visual	Somerset
Cetacean Acoustic Trend Tracking (CATT)	Commencing in 2022, CATT is a long-term passive acoustic monitoring project using Chelonia F-POD acoustic loggers run by Research Development UK. F-PODs are currently deployed along the southwest and south England coast, including Lundy Island. Partnering with the FishIntel project at several locations.	X		Acoustic	South coast
Sussex (Brighton) Dolphin Project	Launched in 2018, as a project of the World Cetacean Alliance (WCA), Sussex Dolphin Project is committed to protecting dolphins through Research, Awareness & Education. Data collected on all marine mammal species.	X	X	Visual	Sussex
Teesside Seal Monitoring Programme (TSMP)	Industry Nature Conservation Association (INCA) have been monitoring seals since 1989.		X	Visual	Tees Estuary
Tidal Thames monitoring:	In 2018, ZSL conducted the first harbour seal breeding survey in the Thames since the 2011 survey by the Sea Mammal Research Unit (University of St Andrews). Harbour seal		X	Visual	Thames Estuary

Name	Description	Cetaceans	Seals	Method	Coverage
harbour seal breeding survey	breeding surveys take place in early July using the same aerial, boat and land based transects as for the population surveys. This survey will provide an estimate of the number of harbour seal pups born in 2018 and their distribution across the Thames coastline and sandbanks.				
Tidal Thames monitoring: seal population surveys	Started annual seal population surveys in 2013. The surveys are completed in August using aerial, boat and land based transects. This coincides with the harbour seal moult period, when harbour seals spend a greater proportion of their time hauled out on sand banks, allowing us to estimate the population size of this species and of grey seals in the Thames.		X	Visual	Thames Estuary
Tidal Thames monitoring: harbour seal tagging	ZSL project in 2012, ZSL tagged ten harbour seals in the Thames Estuary to gather information on harbour seal movements and map haul out sites and foraging areas in the Thames Estuary.		X	Tagging	Thames Estuary
Thames Marine Mammal Sightings Survey (TMMSS)	Since 2004, ZSL has encouraged members of the public to submit their sightings of marine mammals from the Thames and its tributaries in order to help us better understand their distribution.	X	X	Visual	Thames Estuary
Thames porpoise survey	Marine Conservation Research and ZSL undertake an acoustic and visual survey for harbour porpoises of the Thames Estuary. Surveys in 2015 and 2022.	X		Visual and Acoustic	Thames Estuary
[Sightings database]	Yorkshire Seals Group manage a network of citizen scientists record a variety of variables including population density, site fidelity, mortality rates and tagged seals. Also photo ID and coastal visitor demographics. Also provide education sessions to schools.		X	Visual	Yorkshire

Review findings

There is a wide geographical spread of projects utilising visual, acoustic (cetaceans only) and tagging (seals only) methodologies.

For government-funded projects (Table 4) within English waters, monitoring of cetaceans is limited to broadscale visual summertime surveys every six to ten years (SCANS), digital aerial survey via the POSEIDON Programme (2023-24 only), and via bycatch and strandings monitoring (ongoing via the UK Bycatch Monitoring Programme and the UK Cetacean Strandings Investigation Programme (CSIP)).

The use of strandings data provides a source of evidence for asset 'quality' (i.e. health) when regarding health of populations and changes of pressures temporally (Gkotsis *et al.,* 2022; Bojko and Arrow, 2023; Williams *et al.*, 2023) and can be supplemented by local photo-ID data which gives insights into fecundity (Fearnbach, 2012; Arso Civil *et al.,* 2017). However, stranding data are not effort related and do not easily lend themselves to a quantitative analysis of population trends (SMRU Ltd, 2010).

For non-governmental organisations (NGOs) and citizen science projects (Table 5) in English waters, monitoring is sporadic around the UK coast, with national programmes (such as Sea Watch Foundation, ORCA and MARINElife) providing the most substantial evidence databases. A previous review of NGO survey effort in the waters around the British Isles and Ireland (Anderwald *et al.,* 2007) has shown coverage was greatest in the southern Irish Sea, followed by the waters off West Scotland and then parts of eastern Scotland. It has been poorest offshore in the North Sea.

All but four NGO and citizen science projects recorded in Table 5 were visual sightings based. Those that were not visual were: Cetacean Acoustic Trend Tracking (CATT) (static), SCANS-II (towed) and Thames porpoise (towed) passive acoustic monitoring (PAM) projects, and the Solent Seal project was a tagging project.

Visual techniques include sightings only and capture-recapture Photo-ID techniques, and platforms include aerial digital (High-definition photography) and observer observations, and land-based and boat-based observations. These vary from casual watching by inexperienced observers to dedicated watching by trained and experienced observers. Anderwald *et al.* (2007) found that observations were concentrated between the months of April to September.

It is worth noting that only one of the projects recorded explicitly states the collection of social data. The Yorkshire Seal Group gathers the asset (biological) data but also collates information on other aspects relevant for a natural capital approach: social (visitor demographics) and pressures. The Cornwall Marine and Coastal Code Group (CMCCG) explicitly collects data on disturbance records for its disturbance register.

Further data sources

It is important to acknowledge that marine industries and academics also conduct monitoring activities of marine mammals, however these have not been included in this review.

In addition to the data outlined in review Tables 4 and 5 above, sightings data is also collected by offshore industries (such as oil and gas, construction, and offshore wind) when conducting monitoring for their activity or development.

During offshore operations certain activities require the use of trained Marine Mammal Observers. In UK waters, JNCC-accredited Marine Mammal Observers conduct watches prior to pile driving, geophysical surveys and explosive use. Data from Marine Mammal Observers can create a valuable resource and have been reviewed in the past for general species distribution trends as well as effects on behaviour from operations (e.g. Stone, 2015; Stone *et al.,* 2017). This monitoring collects a large volume of sightings data across large marine areas where data collection via dedicated survey means would be prohibitively costly. For example, 190,728 hours of effort (95% visual monitoring and 5% acoustic monitoring) resulted in 9,073 sightings of 124,024 individuals from seismic Marine Mammal Observer data between 1996-2010 (Stone *et al.,* 2017). It is important to note that any trends in distribution need to be treated with caution due to platform bias influencing observed distribution and abundance (i.e. data is restricted to geophysical survey location and may be impacted by noisy activities).

A review by SMRU Ltd (2010) outlined a range of options and evaluated costs for meeting the requirements of baseline monitoring of marine mammals for the offshore wind industry. The authors detail high definition (HD) photography from aerial platforms as an alternative technology. HD photography is a developing field, and this method has now been used for obtaining data on seabirds and marine mammals for the offshore wind industry for several years.

Potential future monitoring methods

Having reviewed the monitoring currently conducted for marine mammals we have found that, of the current programmes and projects, the vast majority were visual observation studies. For estimating absolute abundance, visual surveys remain one of the best and most statistically robust choices (SMRU Ltd, 2010).

As mentioned in the previous section, the use of HD photography from aerial platforms is a developing field, however for marine mammals some important factors remain unresolved. For example, there continues to be difficulty in identification of marine mammals to species level, particularly for dolphin species, often due to the flight heights required for the avian survey methodology, and difficulties calculating correction factors associated with availability bias (animals not at the surface) and perception bias (probability of detection on the transect line). Nevertheless, such effort-related digital aerial data have been included in wide-scale collation of marine mammal data e.g. through the JCDP, and by

Waggitt *et al.* (2019), thereby contributing to broader understanding of marine mammal distribution.

Static passive acoustics / autonomous acoustic monitoring, such as those identified on the CATT project, have been common use in monitoring of marine mammals for some time (e.g. Bailey *et al*., 2010) and offer an alternative to the costly aerial and boat-based visual surveys. Two towed passive acoustic surveys were also identified in the review but incur vessel costs and are for discrete temporal periods, whereas static monitoring offers continuous data collection.

Telemetry projects have been conducted under licence for tagging of seals in UK waters. Cetacean tagging projects are uncommon in the UK due to the legislation constraints (Animals (Scientific Procedures) Act 1982), practical difficulties (attachment of device and data recovery) and costs involved (SMRU Ltd, 2010).

With regards to monitoring projects listed in Tables 4 and 5, Cumbria Wildlife Trust was the only group identified utilising visual surveys via drone technology (unmanned aerial vehicles, UAVs; SCOS, 2021; Pirotta *et al.*, 2022), although a UK citizen science project outside of English waters have also been seen to use this technology (Ecological Consequences of Orca Predation on Seals project (ECOPredS), Scotland). Additionally, the UK seal monitoring conducted by the Sea Mammal Research Unit (SMRU) was found to be the only infrared imaging project, again technology used in Scottish waters (Verfuss *et al.,* 2018; Smith *et al.,* 2020),

None of the projects listed in Tables 4 and 5 were using acoustics onboard unmanned surface vehicles (USVs) (Pierpoint *et al.,* 2016; Cauchy *et al*., 2023), RADAR (Verfuss *et al*., 2018), satellite imagery (Clark, 2023), active acoustics (Gillespie *et al*., 2022), unoccupied aerial systems (UAS) (Rodofili *et al*., 2022) or environmental DNA (eDNA) techniques (Suarez-Bregua *et al*., 2022), all of which are emerging technologies for the surveillance of marine mammals.

Despite these technologies not being found within this review it is known that industry and academia are exploring these. For example, in assessing impacts of an energy project active acoustics are used for monitoring of marine mammals' interaction with tidal turbine devices (Royal Haskoning, 2011; Staines *et al*., 2020; Gillespie *et al*., 2022). eDNA methods have been used at the Blyth Offshore Demonstrator project (Elliott *et al*., 2022), and eDNA has also been investigated in the Moray Firth by academics (Boyse, 2022).

It is worthwhile noting that the new UK Earth Observation Marine and Climate Mission Development Programme will be investigating the development of various technologies with regards to the collection of marine mammal and bird distribution data.

These techniques may offer alternative options for future monitoring of marine mammals, depending on the monitoring requirement to fill the obligation, i.e. not all obligations require the same type of monitoring (Kröger and Johnston, 2016).

Evidence accessibility

Some data collected in the monitoring projects and programmes described may be utilised in UK reporting of indicators (Table 1), however not all projects create data sources which can be utilised for this purpose. No projects have been created specifically for indicator reporting. The JNCC recently compiled data flow maps (Rush *et al.,* 2022a and 2022b) describing the use of data for the UK Marine Strategy indicators which highlights key areas where data flow can be streamlined, improved, or created.

Key issues highlighted in the Rush (2022a and 2022b) reports are:

- data discoverability.
- data upload to UK databases.
- inconsistent data sharing.
- duplication of effort across databases.
- underutilisation of available resources; and
- sampling effort inconsistent with the data requirements.

Suggestions of improvements include data standards and guidelines, and alignment of monitoring effort.

The JCDP has been created to collate cetacean survey data from across the North-East Atlantic to maximise value and accessibility, and to promote and facilitate data standardisation. Standardised data (JCDP, 2022) collected from a variety of organisations are pooled together in the JCDP Data Portal to significantly increase understanding of cetacean abundance and distribution.

Additional existing public databases or portals which do (or may do in the future) receive cetacean and seal data from key sector organisations are detailed in Appendix Table F.

4. Knowledge gaps

This review has provided an understanding of the evidence requirements for marine mammals in English waters, and current monitoring for obtaining asset evidence.

Current monitoring of UK cetaceans

The review has found that there are several mechanisms to determine asset evidence of UK cetaceans, but rarely are they adequate for the evidence required. Specifically monitoring of English waters for inshore cetaceans is sporadic and *ad hoc* and not part of any strategic programme.

There is no systematic and appropriate monitoring in place to monitor the effectiveness of designations in UK waters, specifically within English waters, such as the harbour porpoise Southern North Sea Special Area of Conservation (SAC).

There is currently no mechanism to support or incorporate *ad hoc* citizen science data into the evidence base despite the large data volumes available, but scope to do so exists with an understanding of the limitations and standardisation. The uses of these data include:

- general trends in distribution.
- temporal trends for commonly sighted species.
- local abundance estimates (from Photo-ID efforts).
- cetacean biodiversity and recording of rare species; and
- Habitat use (Bruce *et al.*, 2014; Ellwood *et al.,* 2017; Pirotta *et al.*, 2020; Cranswick *et al.,* 2022; Pirotta *et al.*, 2022; Velandia, 2022).

The examples of bottlenose dolphins and white-beaked dolphins (Section 3: Current cetacean asset knowledge gaps) shows the value of citizen science data to the evidence base on the abundance and distribution of inshore cetaceans, particularly given that there is no regular strategic monitoring of inshore cetaceans in English waters. It must be noted that the efforts of the JCDP have allowed incorporation of offshore citizen science data (where standards have been met).

There is no single solution for routine monitoring of cetaceans. However, there is a variety of techniques available that can be used effectively at relatively low cost for surveillance of cetacean populations at various spatial and temporal scales (Anderwald *et al* 2013). Methods by which to collect cetacean data in current monitoring efforts are predominantly visual observation. There is scope to incorporate large volumes of visual data into the evidence base, noting limitations and biases. However, the landscape of monitoring methodologies is continually advancing with technology and many options are worthy of further investigation. For example, for inshore cetaceans, expanding the use of acoustic

techniques, and investigating the use of eDNA techniques further may provide valuable evidence for understanding cetacean distributions.

Uses of cetacean asset data

The uses of ecological data for marine mammals are extensive:

- for monitoring population trends and health (Williams *et al.*, 2023).
- for monitoring of species recovery efforts (Hiscock, 2011).
- for generating the data required to monitor the effectiveness of conservation and management measures (Kröger and Johnston, 2016; Wade *et al.,* 2021).
- as sentinels for informing climate change policy (Hamilton and Evans, 2018; Williamson *et al*., 2021) and for ocean ecosystem health (Bossart, 2010; Moore and Kuletz, 2019); and
- as indicator species in the monitoring of HPMAs.

It is important to note the limitation of the majority of methods for monitoring of marine mammals as, although monitoring will begin to address gaps in abundance and distribution evidence, additional tailored research is required to address the lack of information about fecundity, mortality rates, and prey and habitat preference (Scottish Government, 2021).

Given the power and range of use for these data, it is vital that the proposed UK cetacean monitoring programme (part of the JNCC-led UK Marine Biodiversity Monitoring Programme) is implemented as soon as possible. However, in order to conduct natural capital assessments, recommendations have been made for monitoring inshore cetaceans, alongside gathering data on cultural services.

Gaps in monitoring and evaluation need to be addressed to enable policy to be more securely based on a sound understanding of the costs and benefits, including biophysical trade-offs, of different policy and development options (Thornton *et al*., 2019).

It would be pertinent to consider that combining methodological approaches which complement one another will result in a more complete picture of the status and distribution of cetacean species.

5. Recommendations

As stated by Burton and Bayes (2022) and Mulholland *et al*., (2021), there are a number of evidence gaps across the natural capital logic chain (see Section 3). These evidence gaps prevent appropriate and accurate natural capital assessments regarding marine mammals. The following recommendations are given to address these within the mNCEA programme, as well as beyond the programme lifetime.

Enhance asset data on inshore cetaceans

Collect data in place on inshore cetaceans in readiness for natural capital assessment

Utilising the cost-effective proven technology of bioacoustic monitoring to improve the coverage, scale and quality of evidence and allow a greater understanding of inshore cetacean trends. The location is recommended within a Natural England identified sentinel zone. Further work can be done to enhance this data including the discrimination between *delphinids* from F-POD data.

Investigate innovative approaches to monitoring

In order to evaluate new, cost-effective, monitoring solutions it is recommended to gain an understanding of the effectiveness of eDNA for marine mammals as an emerging technology. Work areas proposed for year 2 of the mNCEA programme include investigation of primers, validating eDNA efficiency against acoustic data, refining the sampling methodology for marine mammal eDNA collection, and reviewing the potential of using citizen science approaches to collect eDNA. In addition, it is recommended further consideration be given to satellite earth observation data.

Mobilise acoustic citizen science evidence

Acoustic data gained from the citizen science initiatives would be valuable evidence for understanding the distribution of inshore cetaceans. Therefore, it is recommended that citizen science acoustic data should be mobilised into the evidence base. Owing to the complexities of data storage for acoustic data the primary task will be to prepare data management systems for this data type, prior to incorporation of new data.

Review integration of wider marine mammal data

Investigate the value of integration of wider sightings data of marine mammals into the evidence base, reviewing issues around standardised data collection and accessibility. This data includes potential sources such as land-based citizen science data, military survey data (UK Navy), strategic research data (such as from projects like POSEIDON), data from industry baseline characterisation surveys (such as HD aerial photography and

acoustics), and Marine Mammal Observer data from offshore operations. In addition, periodic reviews of this data should be undertaken to obtain general trends in species distribution, ensuring mitigation of potential biases and being mindful of limitations.

Long-term cetacean monitoring

The proposed UK cetacean monitoring programme, part of the JNCC-led UK Marine Biodiversity Monitoring Programme, will provide a strategic monitoring programme for cetaceans in the UK. This programme is not yet in place but will provide stability in asset evidence for these species. Periodic reviews of the data within the JDCP are recommended.

Secured funding

A key recommendation in all monitoring strategies is the security of funding. To assure the longevity of monitoring programmes, and therefore asset evidence, stable and continuous financial support is required. It is recommended that this is funding is aligned with the requirements of the proposed UK cetacean monitoring programme, but worth noting this is a shared challenge with the voluntary sector (Anderwald *et al* 2013).

Funding is also a precursor to developing and maintaining the skills and expertise necessary and to support processing, analysis, and interpretation of data.

Improve understanding of regulation and maintenance services

Following the recent Sheehy *et al.* (2022) study it is recommended that levels of uncertainty can be improved by further study on carbon stocks in cetacean living biomass and cetacean-driven nutrient cycling enhancing primary productivity. Additional research regarding regulation services in the context of climate change are also needed.

Improve understanding of cultural services

Conduct an economic evaluation of marine mammal cultural services

Natural capital approaches cannot be fully implemented without the associated understanding of the benefits that arise from biological assets, and the value of these. Burton and Bayes (2022) outlined clear monetary valuation techniques for determining cultural values for marine mammals. It is recommended that a study be conducted to understanding the linkages between marine mammals and economic activities such as wildlife watching.

Empower citizen science projects to collect ecosystem services data alongside ecological data

To enable the flow of ecosystem service data in place, it is recommended that a set of guidance be designed to educate current citizen projects, whose primary objective is to gather ecological data, on how to add value to their project by monitoring ecosystem services. Cultural service data such as visitor motivation, stakeholder participation, and the value determined by likelihood of observations (Burton and Bayes, 2022), could be collected by these avenues. It is also recommended that this guidance help groups monitor the societal impact of their initiative.

Conduct natural capital assessments for marine mammals

In order to apply a natural capital approach, once the relevant evidence gaps have been filled, the following natural capital assessments are recommended:

- How changes in inshore cetaceans affected by local pressures (e.g. wildlife watching disturbance / recreational pressures) are affecting changes in the local economy (a place-based study).
- How changes in the local economy (such as Celtic Seas Floating Offshore Wind) affect pressures on marine mammals (e.g. underwater noise, increase in inshore vessel traffic) (a place-based study).
- At national scale, conduct an assessment to review the implications of policy such as BESS resulting in an exponential increase in offshore developments, and the biophysical trade-off effect on marine mammals from this. Note this specific example is planned within the POSEIDON research programme and will align with the work of the Offshore Wind Enabling Action Programme (OWEAP).

6. References

Anderwald, P., Ansamann, I., Baines, M., Baulch, S., Evans, P.G.H., Nuuttila, H., & Pesante, G. 2007. Cetacean monitoring effort carried out by voluntary NGOs in UK waters up to 2007. JNCC Report No 480

Arso Civil, M., B. Cheney, N. J. Quick, P. M. Thompson, and P. S. Hammond. 2017. A new approach to estimate fecundity rate from inter-birth intervals. Ecosphere 8(4) DOI: e01796. 10.1002/ecs2.1796

Aynsley, C. 2017. Bottlenose dolphins (*Tursiops truncatus*) in north-east England: A preliminary investigation into a population beyond the southern extreme of its range. Unpublished master's Thesis. Newcastle University.

Bailey, H., Clay, G., Coates, E.A., Lusseau, D., Senior, B. and Thompson, P.M. 2010. Using T-PODs to assess variations in the occurrence of coastal bottlenose dolphins and harbour porpoises. Aquatic Conserv: Mar. Freshw. Ecosyst., 20: 150-158. doi: 10.1002/aqc.1060

Bojko, J., Arrow, N. 2023. Interim report- 'mouth rot' investigation. Unpublished report by Teeside University and BDMLR for the UK Cetacean Strandings Investigation Programme Project Steering Committee.

Brereton, T., Jones, D., Leeves, K., Davies, R., McNie, F & Russell, T. 2016a. Population Structure, Mobility and Conservation of Bottlenose Dolphins in Southwest England from Photo-identification studies 2007 - 2013 Commissioned Report to Natural England (NERP 01679)

Brereton, T., Kitching, M. Davies, R., McNie, F and Walker, R. 2016b. Photo-identification Analysis of White-beaked Dolphins off Southwest and North east England 2007-2014 Commissioned Report to Natural England (NERP 03082)

Brereton, T., Davies, R., Babey, L., Kitching, M. and Walker, R. 2020. Temporal and spatial analysis of Marinelife and Orca white-beaked dolphin data from Northumberland and adjacent sea areas. Commissioned Report to Natural England (NECR 289) ISBN: 978-1-78354-591-9.

Bossart, G.D. 2010. Marine Mammals as Sentinel Species for Oceans and Human Health Veterinary Pathology 48 (3). doi: 10.1177/0300985810388525

Boyse, E., Robinson, K., Beger, M., Goodman, S. 2022. Tracking Cetaceans and their prey in the Moray Firth with environmental DNA. [poster presentation]. Marine Forum 26th November 2022.

Burton, S., & Bayes, J. 2022. A review of the cultural value of seabirds and marine mammals. Unpublished mNCEA report for Defra.

Bruce, E., Albright, L., Sheehan, S., Blewitt, M. 2014. Distribution patterns of migrating humpback whales (*Megaptera novaeangliae*) in Jervis Bay, Australia: A spatial analysis

using geographical citizen science data. Applied Geography. Volume 54: pp 83-95. DOI: 10.1016/j.apgeog.2014.06.014.

Cauchy P., Heywood K. J., Merchant N. D., Risch D., Queste B. Y., Testor P. 2023. Gliders for passive acoustic monitoring of the oceanic environment. Frontiers in Remote Sensing. Vol 4. doi: 10.3389/frsen.2023.1106533

Citizen Fins, 2023. https://citizenfins.wp.st-andrews.ac.uk/

Clark, P (2023,19th January) Stranding and satellite imagery project [verbal presentation]. CSIP Project Steering Group.

Cook, D., Malinauskaite, L., Daví.sdóttir, B., Ogmundardóttir, H., and Roman, J. 2020. Reflections on the Ecosystem Services of Whales and Valuing Their Contribution to Human Well-Being. Ocean. Coast. Manage. 186, 105100. doi: 10.1016/j.ocecoaman.2020.105100

Corr, S., 2020. Using citizen science data to assess the vulnerability of bottlenose dolphins (*Tursiops truncatus*) along England's south coast. Unpublished Master's Thesis. University of Plymouth.

Cranswick, A.S., Constantine, R., Hendriks, H., Carroll, E.L. 2022. Social media and citizen science records are important for the management of rarely sighted whales. Ocean & Coastal Management. Vol 226, pp.106271. DOI: 10.1016/j.ocecoaman.2022.106271.

Defra. 2019. Marine Strategy Part One: UK updated assessment and Good Environmental Status

Defra. 2021. Marine Strategy Part Two: UK updated monitoring programmes.

Dudley, R.H., 2017. Using citizen science data to assess the social structure, residency, and distribution of bottlenose dolphins (*Tursiops truncatus*) in southwest England. Unpublished Master's Thesis. University of Plymouth.

Duncan, S., 2021. Is conservation management fit for purpose: a case study using a small coastal resident bottlenose dolphin (*Tursiops truncatus*) population. Unpublished Master's Thesis. University of Plymouth.

Eftec. 2021. A Natural Capital Account for the Industrial Sandeel Fishery. Eftec report for Defra mNCEA project NC01.

Elliott, M., Dickens, S., Stanton, S., Wort, E. 2022. Trial to Validate Environmental DNA (eDNA) as a Survey Method for Fish Ecology Assessment around Offshore Wind Farms. Paper for MASTS: Annual Science Meeting (8-10 November 2022).

Ellwood, E.R., Crimmins, T.M. and Miller-Rushing, A.J 2017. Citizen science and conservation: recommendations for a rapidly moving field. Biological Conservation. 208, pp. 1-4.

Evans, P.G.H., and Hammond, P.S. 2004 Monitoring cetaceans in European waters. Mammal Rev. 34 (1). pp 131–156.

European Court of Auditors. 2019. Special Report NO 16/2019: European Environmental Economic Accounts: usefulness for policymakers can be improved

Fearnbach, H. 2012. Individual- based population assessment for cetaceans: Using photographs to infer abundance, demography, and individual quality. Unpublished PhD Thesis. University of Aberdeen.

Geelhoed, S.C.V., Authier, M., Pigeault, R., Gilles, A. 2022. Abundance and Distribution of Cetaceans. In: OSPAR, 2023: The 2023 Quality Status Report for the Northeast Atlantic. OSPAR Commission, London. Available at: https://oap.ospar.org/en/ospar-assessments/quality-status-reports/qsr-2023/indicator-assessments/abundance-distribution-cetaceans/

Gillespie, D., Oswald, M., Hastie, G., Sparling, C. 2022. Marine Mammal HiCUP: A High Current Underwater Platform for the Long-Term Monitoring of Fine-Scale Marine Mammal Behavior Around Tidal Turbines. Frontiers in Marine Science. Vol 9. Doi: 10.3389/fmars.2022.850446

Gkotsis, G., Nika, M-C., Nikolopoulou, V., Alygizakis, N., Bizani, E., Aalizadeh, R., Badry, A., Chadwick, E., Cincinelli, A., Claßen, D., Danielsson, S., Dekker, R., Duke, G., Drost, W., Glowacka, N., Göckener, B., Jansman, H.A.H., Juergens, M., Knopf, B., Koschorreck, J., Krone, O., Martellini, T., Movalli, P., Persson, S., Potter, E.D., Rohner, S., Roos, A., O' Rourke, E., Siebert, U., Treu, G., van den Brink, N.W., Walker, L.A., Williams, R., Slobodnik, J., Thomaidis, N.S. 2022. Assessment of contaminants of emerging concern in European apex predators and their prey by LC-QToF MS wide-scope target analysis. Environment International. Vol 170, pp 107623. DOI: 10.1016/j.envint.2022.107623.

Gutiérrez-Muñoz, P., Walters, A.E., Dolman, S.J. and Pierce, G.J., 2021. Patterns and Trends in Cetacean Occurrence Revealed by Shorewatch, a Land-Based Citizen Science Program in Scotland (United Kingdom). Frontiers in Marine Science, 8.

Hackett K. (in press) Movement and ecology of bottlenose dolphins (*Tursiops truncatus*) along the North-East coast of the UK. MSc dissertation, University of Bangor. For submission to the Journal of Marine Mammal Science (Submitted in September 2022).

Haines-Young, R. and Potschin, M.B. 2018: Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. Available from www.cices.eu

Hamilton, V., Evans, K., 2018. Establishing growth chronologies from marine mammal teeth: A method applicable across species. Journal of Experimental Marine Biology and Ecology. Vol 505, pp 24-34. doi: 10.1016/j.jembe.2018.04.006.

Hinchen, H. 2014a. Review of marine biodiversity assessment obligations in the UK. Part I: A summary of the marine biodiversity assessment obligations stipulated within national

and international legislative and policy instruments, JNCC Report 497, JNCC, Peterborough

Hinchen, H. 2014b. Review of marine biodiversity assessment obligations in the UK. Part II: Identifying similarities and differences between marine biodiversity assessment obligations. JNCC Report No. 497 (Part II), JNCC, Peterborough.

Hiscock, K., Bayley, D., Pade, N., Cox, E. & Lacey, C. 2011. A recovery / conservation programme for marine species of conservation importance. Natural England Commissioned Reports, Number 065.

Hooper, T., Ashley, M., Börger, T., Langmead, O., Marcone, O., Rees, S., Rendon, O., Beaumont, N., Attrill, M. and Austen, M. 2019. Application of the natural capital approach to the marine environment to aid decision-making. Phase 1 Final Report. Report prepared for the Department for Environment Food and Rural Affairs

IAMMWG (2022 unpublished draft) Review of Management Units for marine mammals in UK waters

JCDP (Joint Cetacean Data Programme). 2022. JCDP Data Standard: Core Data Fields and Vocabulary Guidance (version 1.2). JNCC, Peterborough.

Kröger, K., & Johnston, C. 2016. The UK Marine Biodiversity Monitoring Strategy. JNCC, Peterborough.

Moore, S.E., Kuletz, K.J. 2019. Marine birds and mammals as ecosystem sentinels in and near Distributed Biological Observatory regions: An abbreviated review of published accounts and recommendations for integration to ocean observatories, Deep Sea Research Part II: Topical Studies in Oceanography. Volume 162: pp 211-217. DOI: 10.1016/j.dsr2.2018.09.004.

Mulholland, R., Le Quesne, W, and Mynott, F. 2021. Rapid review of marine natural capital asset classes and logic chains to identify priority information gaps. Cefas report for Defra mNCEA project NC09.

National Ecosystem Assessment http://uknea.unep-wcmc.org/

Natural Capital Committee 2017. How to do it: a natural capital workbook. Version 1.

Natural England. 2015. Natural England Access to Evidence Information Note EIN010: Summary of evidence: Marine 2015

Paxton, C.G.M., Scott-Hayward, L., Mackenzie, M., Rexstad, E. & Thomas, L. 2016. Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resource, JNCC Report No. 517, JNCC, Peterborough, ISSN 0963-8091.

Rice, P., Lusardi, J., Lord, A., Sunderland, T. 2021. Natural Capital Evidence Handbook: to support place-based planning and decision-making. Natural England Research Report, Number 092.

Pierpoint C., Sidorovskaia N., Heath B., Marks K., Scala L., Morrison B., Rutter D., Royston J., Fuselier J. 2016. Passive Acoustic Monitoring of Marine Mammals Using Autonomous Surface Vehicles. Poster presentation at Gulf of Mexico Oil Spill and Ecosystem Science Conference- Tampa, 2016.

Pinn, E. H. 2010. Healthy and Biologically Diverse Seas Evidence Group Technical Report.

Pirotta, V., Hocking, D.P., Iggleden, J., Harcourt, R. 2022. Drone Observations of Marine Life and Human–Wildlife Interactions off Sydney, Australia. Drones (6) 3: 75. DOI: 10.3390/drones6030075

Pirotta, V., Reynolds, W., Ross, G., Jonsen, I., Grech, A., Slip, D., et al. 2020. A citizen science approach to long-term monitoring of humpback whales (*Megaptera novaeangliae*) off Sydney, Australia. Marine Mammal Science. 36(2), pp. 472-485. DOI: 10.1111/mms.12651

Rodofili EN, Lecours V, LaRue M. 2022. Remote sensing techniques for automated marine mammals detection: a review of methods and current challenges. PeerJ. 2022 Jun 20;10:e13540. doi: 10.7717/peerj.13540.

Royal Haskoning. 2011. SeaGen Environmental Monitoring Programme Final Report. Report for Marine Current Turbines. Report Reference 9S8562/R/303719/Edin.

Rush, S., Griffiths, Y., Webb, K. & Manca, E. 2022a. Mapping the flow of data from monitoring programmes into UK Marine Strategy indicators for cetaceans. Technical notes: Dataflow descriptions & recommendations. JNCC Report No. 713A, JNCC, Peterborough, ISSN 0963- 8091.

Rush, S., Griffiths, Y., Webb, K. & Manca, E. 2022b. Mapping the flow of data from monitoring programmes into UK Marine Strategy indicators for seals. Technical notes: Dataflow descriptions & recommendations. JNCC Report No. 714A, JNCC, Peterborough, ISSN 0963- 8091.

SCOS (Natural Environment Research Council Special Committee on Seals). 2021. Scientific Advice on Matters Related to the Management of Seal Populations: 2021

Scottish Government. 2021. UK Dolphin and Porpoise Conservation Strategy: Action Plan

Sheehy JM, Taylor NL, Zwerschke N, Collar M, Morgan V and Merayo E. 2022. Review of Evaluation and Valuation Methods for Cetacean Regulation and Maintenance Ecosystem Services with the Joint Cetacean Protocol Data. Front. Mar. Sci. 9:872679. doi: 10.3389/fmars.2022.872679

Smith H.R., Zitterbart D.P., Norris T.F., Flau M., Ferguson E.L, Jones C.G., Boebel O., Moulton V.D., 2020. A field comparison of marine mammal detections via visual, acoustic, and infrared (IR) imaging methods offshore Atlantic Canada, Marine Pollution Bulletin, Vol 154, p 111026. ISSN 0025-326X. doi: 10.1016/j.marpolbul.2020.111026.

SMRU Ltd. 2010. Approaches to marine mammal monitoring at marine renewable energy developments. Report Reference MERA 0309 TCE

Sousa, A., Coelho, R.E., Costa, H., Lourenço, T.C., Azevedo, J.M.N, Santos, C.F. 2023. Integrated climate, ecological and socioeconomic scenarios for the whale watching sector, Science of The Total Environment 857 (3), doi: 10.1016/j.scitotenv.2022.159589.

Staines, G., Zydlewski, G.B., Viehman, H.A., Kocik, R. 2020. Applying Two Active Acoustic Technologies to Document Presence of Large Marine Animal Targets at a Marine Renewable Energy Site. J. Mar. Sci. Eng. 2020, 8, 704; doi:10.3390/jmse8090704

Stone, C. J. 2015. Marine mammal observations during seismic surveys from 1994-2010. JNCC Report No 463a. ISSN 0963 8901

Stone, C. J. Hall, K., Mendes, S. & Tasker, M.L. 2017. The effects of seismic airguns on cetaceans in UK waters: analysis of Marine Mammal Observer data. Journal of Cetacean Research and Management. 16:71-85.

Suarez-Bregua P, A´lvarez-Gonza´ lez M, Parsons KM, Rotllant J, Pierce GJ and Saavedra C. 2022. Environmental DNA (eDNA) for monitoring marine mammals: Challenges and opportunities. Front. Mar. Sci. 9:987774. doi: 10.3389/fmars.2022.987774

Syneca Consulting Pty Ltd. 2009. Socio-economic value of cetacean conservation. Report to Department of the Environment, Water, Heritage and the Arts, Australia Government.

Tillin, H.M., Langmead, O., Hodgson, B., Luff, A, Rees, S., Hooper, T. & Frost, M. 2019. Feasibility study for a Marine Natural Capital Asset Index for Scotland. Scottish Natural Heritage Research Report No. 1071.

Tillin, H.M., Lubelski, A., Mieszkowska, N., Watson, A. 2022. Marine, Coast and Estuarine Citizen Science Review: Informing Marine Natural Capital in English waters. Natural England Report for Defra mNCEA project NC36.

Thornton, A., Luisetti, T., Grilli, G., Donovan, D., Phillips, R. and Hawker, J., 2019. Initial natural capital accounts for the UK marine and coastal environment. Final Report. Report prepared for the Department for Environment Food and Rural Affairs

Velandia, N. 2022. Spatiotemporal Trends of Cetaceans Inferred from Citizen Science Data. Unpublished Master's Thesis. University of Exeter.

Verfuss, UK, Gillespie, D, Gordon, J, Marques, TA, Miller, B, Plunkett, R, Theriault, JA, Tollit, DJ, Zitterbart, DP, Hubert, P & Thomas, L. 2018. Comparing methods suitable for monitoring marine mammals in low visibility conditions during seismic surveys. Marine Pollution Bulletin, vol. 126, pp. 1-18. doi: 10.1016/j.marpolbul.2017.10.034

Wade, P.R., Long, K.J., Francis, T.B., Punt, A.E., Hammond, P.S., Heinemann, D., Moore, J.E., Reeves, R.R., Sepúlveda, M., Sullaway, G. and Sigurðsson, G.M. 2021. Best practices for assessing and managing bycatch of marine mammals. Frontiers in Marine Science, p.1566.

Waggitt, James & Evans, Peter & Andrade, Joana & Banks, Alex & Boisseau, Oliver & Bolton, Mark & Bradbury, Gareth & Brereton, Tom & Camphuysen, Cornelis & Durinck, Jan & Felce, Tom & Fijn, Ruben & García-Barón, Isabel & Garthe, Stefan & Geelhoed, Steve & Gilles, Anita & Goodall, Martin & Haelters, Jan & Hamilton, Sally & Hiddink, Jan. 2019. Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology. 57. 253-269. doi: 10.1111/1365-2664.13525.

Wigley, S. Paling, N. Rice, P. Lord, A. & Lusardi, J. 2020. National Natural Capital Atlas. Natural England Commissioned Report Number 285.

Williams, R.S., Brownlow, A., Baillie, A., Barber, J.L., Barnett, J., Davison, N.J., Deaville, R., ten Doeschate, M., Penrose, R., Perkins, M., Williams, R., Jepson, P.D., Lyashevska, O., Murphy, S. 2023. Evaluation of a marine mammal status and trends contaminants indicator for European waters. Science of The Total Environment. Vol 866, pp. 161301. DOI:10.1016/j.scitotenv.2022.161301.

Williamson, M.J., ten Doeschate, M.T.I, Deaville, R., Brownlow, A.C., Taylor, N.L. 2021. Cetaceans as sentinels for informing climate change policy in UK waters. Marine Policy 131. doi: 10.1016/j.marpol.2021.104634

Zin, W.S., Suzuki, A., Peh, K, S-H. and Gasparatos, A. 2019. Economic Value of Cultural Ecosystem Services from Recreation in Popa Mountain National Park, Myanmar: A Comparison of Two Rapid Valuation Techniques. Land, 8, 194. Available at: land_08_00194_v3.pdf (soton.ac.uk)

7. Glossary

Bequest value: Preservation for future generations (e.g. the protection of nature for the sake of future generations)

Cetacean: Whales, dolphin, and porpoises.

Cultural ecosystem services: the non-material benefits people obtain from nature. They include recreation, aesthetic enjoyment, physical and mental health benefits, and spiritual experiences. They contribute to a sense of place, foster social cohesion and are essential for human health and well-being.

Ecosystem services: the components of nature that are directly and indirectly enjoyed, consumed, or used to maintain or enhance human well-being.

English inshore waters: The area of sea within the limits of territorial waters (12 nautical miles) adjacent to the English coastline.

Existence value: the value that individuals place on the knowledge that a resource continues to exist, whether or not they use that resource themselves.

Highly mobile species: Species that range over large distances and include fish, birds, marine mammals, and turtles. Individuals are often part of widespread international populations and may only be present in local areas on a seasonal basis or for part of their life cycle.

Monitoring: Observe and check the progress or quality of something (e.g. population abundance) over a period of time to ensure conservation/monitoring objectives are being met (Scottish Government, 2021).

Management Unit (MU): Refers to a geographical area in which the animals of a particular species are found to which management of human activities is applied.

Natural capital: The Natural Capital Committee defines natural capital as “the elements of nature that directly or indirectly produce value to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions” (Natural Capital Committee, 2017)

Natural capital approach: the natural environment as a stock of assets from which there is a flow of ecosystem services to people who benefit from them.

Natural capital accounting: A tool to measure the changes in the stock of natural capital at a variety of scales and to integrate the value of ecosystem services into accounting and reporting systems (European Commission definition, European Court of Auditors, 2019).

8. Appendices

Table A. Listed marine mammal species listed under legal instruments. Adapted from Hinchen (2014b).

Species (Common Name)	OSPAR Convention	Habitats Directive Annex II	Habitats Directive Annex IV	Habitats Directive Annex V	MSFD Listed Species	PMF for SMPA	UK BAP	Marine & Coastal Access Act FOCI	Convention on Migratory Species: Appendix 1	Convention on Migratory Species: Appendix 2	Convention on Migratory Species: ASCOBANS	Conservation of Seals Act	Wildlife & Countryside Act: Section 9.1 (taking and killing/injuring), Section 9.2, 9.4a	Wildlife & Countryside Act: Section 9.4A	Wildlife & Countryside Act: Section 9.4b	Wildlife & Countryside Act: Section 9.4c	Wildlife & Countryside Act: Section 9.5a	Wildlife & Countryside Act: Section 9.5b
Common minke whale			x		x	x	x	x						x			x	x
Sei whale			x				x	x						x			x	x
Blue whale	x		x				x	x	x					x			x	x
Bowhead whale								x										
Fin whale			x		x	x	x	x						x			x	x
Hooded seal				x														
White whale			x					x		x				x			x	x
Common dolphin			x		x	x	x	x		x	x			x			x	x
Bearded seal				x														
Northern Right whale	x		x				x	x	x					x			x	x
Long-finned pilot whale			x		x	x	x	x		x	x			x			x	x
Risso's dolphin			x			x	x	x		x	x			x			x	x
Grey seal		x		x	x	x				x		x						
Northern bottlenose whale			x			x	x	x		x	x			x			x	x
Pygmy sperm whale			x		x			x						x			x	x
Fraser's dolphin			x															
Atlantic white-sided dolphin			x		x	x	x	x		x	x			x			x	x
White-beaked dolphin			x		x	x	x	x		x	x			x			x	x
Humpback whale			x		x		x	x	x					x			x	x
Sowerby's beaked whale			x			x	x	x						x			x	x
Blainville's beaked whale			x															
Gervais' beaked whale			x					x						x			x	x
True's Beaked whale			x				x	x						x			x	x
Narwhal			x					x		x				x			x	x
Walrus								x					x		x	x	x	x
Killer whale			x		x	x	x	x		x	x			x			x	x
Melon-headed whale			x															
Harp seal				x														
Ringed seal		x		x														
Harbour seal		x		x	x	x	x	x		x		x						
Harbour porpoise	x	x	x		x	x	x	x		x	x						x	x
Sperm whale			x			x	x	x						x			x	x
False killer whale			x											x			x	x
Striped dolphin			x				x	x		x	x			x			x	x
Common bottlenose dolphin		x	x		x	x	x	x		x	x			x			x	x
Cuvier's Beaked whale			x				x	x			x			x			x	x

Table B. Marine Mammals Priority Information Gaps. Table adapted from 'Rapid review of marine natural capital asset classes and logic chains to identify priority information gaps' (Mulholland *et al*., 2021; Appendix 3 gap analysis spreadsheet).

Service	Species asset	Key evidence gap(s)	Options to address evidence gap(s)
Provisioning	Cetaceans	1. Underwater noise mitigation technology effectiveness for reducing noise impacts on cetaceans from construction activities (offshore wind, O&G) 2. Collision risk with tidal and wave energy devices	1. Additional /advanced testing of mitigation technologies 2. More monitoring data required from test sites/deployed devices
	Seals	1. Noise impacts and collision risk in relation to renewable energy activities	1. Additional/ advanced testing of mitigation technologies; More monitoring data required from test sites/deployed devices
Regulating	Cetaceans	1. Role of cetaceans in nutrient cycling and carbon sequestration	1. Review of literature; scope for more research
	Seals	[None listed]	
Cultural	Cetaceans	1. Understanding of distribution, numbers, and activities of cetaceans at sea 2. Social and economic value (inc. non-monetary) of whale watching trips 3. Lack of data and modelling approaches to link food web status (e.g., fish abundance) to cetacean (to predict impacts of climate change and anthropogenic pressures on cetaceans). Population status (charismatic megafauna) 4. Underwater noise mitigation technology effectiveness for reducing noise impacts on cetaceans from construction activities (offshore wind, O&G) 5. Collision risk with tidal and wave energy devices 6. Linking changes to assets with changes to the services associated with wildlife tourism. Is there a threshold where it is noticeable? E.g., if there are 10% more cetaceans will watcher numbers increase or do numbers need to increase by 50%? 7. Location-linked survey data on recreational visit motivations: relatively straightforward in the case of species	1. Existing citizen science scheme (ORCA Oceanwatcher - volunteer recording from ferries) could be expanded/supported to restore the survey post-pandemic. Continue R&D (follow on from small pilot last FY) to use EO for monitoring cetaceans 2. Collate evidence from whale watching industry to understand value. 3. Development of validated ecosystem models to evaluate management impacts on food webs and sea birds. 4. Field studies on noise mitigation technologies 5. Field observations of collision risks 6. Need to collect empirical data on this. 7. Marine engagement survey or integration with existing survey e.g. People and Nature
	Seals	1. Social and economic value (inc. non-monetary) of seal watching trips 2. Lack of data and modelling approaches to link food web status (e.g., fish abundance) to seal productivity (to predict impacts of climate change and anthropogenic pressures on seals). 3. Estimate of seals (and other animals) affected by marine litter (?)	1. Collate evidence from seal watching industry to understand value. 2.? 3. Citizen science? 4. Need to collect empirical data on this. 5. Marine engagement survey or integration with existing survey e.g. People and Nature

Service	Species asset	Key evidence gap(s)	Options to address evidence gap(s)
		4. Linking changes to assets with changes to the services associated with wildlife tourism. Is there a threshold where it is noticeable? E.g., if there are 10% more seals will watcher numbers increase or do numbers need to increase by 50%? 5. Location-linked survey data on recreational visit motivations: relatively straightforward in the case of species	
Other considerations	Cetaceans	1. Cumulative impacts of multiple activities e.g., large number of offshore wind developments within a region (applies to multiple services and assets)	1. Standardised/agreed process for undertaking CEA; more field studies/monitoring of impacts to inform future modelling for CEA
	Seals	[None listed]	

Table C. Summary of advantages and potential disadvantages of different approaches to cetacean monitoring. Table taken from Evans and Hammond (2004).

Category	Advantages	Potential disadvantages
Survey techniques		
Visual	*For estimation of absolute abundance* Data collection and analysis methods that take potential problems into account are well established	Need to take account of animals missed on the transect line and any responsive movement Labour intensive and expensive Limited temporal coverage Need sufficient data to estimate detection function
Visual	*For estimation of relative abundance* Not labour intensive and relatively cheap Wide spatial and temporal coverage possible Minimum equipment requirements Suitable for platforms of opportunity	Need to account for sighting efficiency varying with distance from vessel, observer abilities, group size, sea conditions, platform type Estimation of group size Responsive movement of animals For platforms of opportunity – little or no control over survey design
Acoustic	Not labour intensive Less affected by sea conditions 24-hour coverage possible Easier to standardize and automate data collection Suitable for platforms of opportunity	Relies upon animals being vocal Methods to relate sounds to abundance of animals are not well developed Requires specialist data collection equipment Ideally requires quiet vessels For platforms of opportunity – little or no control over survey design
Photo-ID	Not labour intensive and relatively cheap Abundance estimation through mark-recapture methods Additional information on life history (birth and death rates, movements)	Only applicable for species with long-lasting identifiable natural marks Natural marks must be unique, recognizable, and not change Definition of population being estimated not always clear Heterogeneity of capture probability
Survey platforms		
Headland/ installation	Non-intrusive Usually inexpensive Not labour intensive	Limited to small detection area Information that requires close proximity to animals is hard to collect
Vessel	Ocean going vessels can cover wide areas over long periods Ancillary information (environmental and biological) can be collected	Large vessels are expensive and may be labour intensive to operate Small vessels are limited to coastal areas
Aircraft	Can cover large areas quickly Can make efficient use of windows of good weather Not labour intensive	Collection of ancillary information limited Logistical limitations Expensive to charter but little flying time may be required

Table D. Summary of advantages and potential disadvantages of different approaches to cetacean monitoring. Table adapted from SMRU Ltd (2010).

Category	Advantages	Potential disadvantages
Line-transect surveys	Data allow for estimation of absolute or relative density & abundance Can provide information on distribution Can be long-term Can cover entire range of population	Often expensive Restricted by weather conditions and to daylight hours Variability often high – can be difficult to detect trends Provide "snapshots" over relatively short time periods
Boat-based surveys Cetaceans	Offshore and near-shore Additional data can be collected Well established and robust methods for assumption violations, especially for large vessels Near-shore only Small boats can take advantage of good weather in some circumstances	Offshore and near-shore Large vessels expensive Responsive movement Near-shore only Small boats range-restricted Small boats reduced effective strip width and survey team size/effectiveness for line-transects Small bots highly constrained by weather
Boat-based surveys Pinnipeds	May be cheaper than air surveys Data allow for estimation of local relative abundance (or absolute abundance is association with telemetry data) May be more flexible to local weather conditions	Range-restricted (limited elevation) Quality of counts may be poor Responsive movement May cause disturbance to site
Aerial surveys Cetaceans	Fewer issues with responsive movement Can cover large areas quickly Can take advantage more readily of good weather windows May already be taking place to carry out bird surveys	Logistical limitations Responsive movement may be a problem for some aircraft types or some species Height limitations around wind farms
Aerial surveys Pinnipeds	Data allow for estimation of relative abundance (or absolute abundance in association with telemetry data) Can provide information on distribution (on land) Should have limited disturbance to haul out site Can be long-term Can cover entire range of population Photographic or video records can be kept for verification after surveys	Often expensive Restricted by weather conditions and to daylight hours Variability often high – can be difficult to detect trends Time consuming and labour intensive Land based information only Health and safety Responsive movement
Land based surveys Pinnipeds	May cause disturbance to site Data allow for estimation of local relative abundance (or absolute abundance is association with telemetry data) May be more flexible to local weather conditions Could be combined with other fine scale or individual based studies	Logistical limitations – sites may not be accessible or only partly visible Quality of counts may be poor
Platforms of opportunity	Cheap way of collecting data Can provide good temporal coverage	Generally not possible to estimate absolute abundance Not good for pinnipeds

Category	Advantages	Potential disadvantages
	Data can be used to investigate relative abundance and habitat preference May be possible to generate density surface maps	Effort is generally restricted spatially Un-calibrated responsive movement No control over the area/region surveyed
Towed hydrophone array	Data are independent of daylight and most weather conditions Can provide high spatial resolution data	Methods to estimate abundance are only developed for harbour porpoises and sperm whales; species identification is currently difficult for other species Performance is dependent on the noise level of the vessel High frequency vocalisations have a limited detection range of approximately 200m
Autonomous data loggers	Stationary click detectors provide high temporal resolution Data collection can be relatively inexpensive Long-term data sets can be collected Data can be used to monitor relative abundance if click rates are assumed to be constant over time	Methods to estimate abundance are not well developed High frequency vocalisations have a limited detection range of approximately 200m Devices require retrieval to obtain the data No background noise compensation Limited ability for most designs to provide detection range
Fixed-point surveys	Inexpensive (compared to boat based or aerial methods) Observers not influencing behaviour of animals Can provide spatial and temporal data on usage and distribution Can collected data for pinnipeds, cetaceans and sea birds using the same approach Established analysis frameworks Can be extended to assess long-term trends	Generally not possible to estimate abundance Experienced observes are required Weather restricted Need to find a suitable site/vantage point Often confined to coastal strips or channels
Telemetry	Can provide information on movements, migration, and range of individuals Can provide information on behaviour Can provide information on habitat preferences and areas of special importance Detailed information on animals without human disturbance (after release)	Many individuals need to be tagged to make general conclusions Invasive - potential animal welfare issues from tagging process Equipment is relatively expensive

Table E. Outputs from marine mammal survey methods. Table taken from SMRU Ltd, 2010.

Table 2: Outputs from field techniques commonly used for studying marine mammals. Please refer to text above for description of abundance. Habitat use is related to distribution, describing where animals are found, but also for what purpose (e.g. feeding, breeding, etc). Life history may relate to survival rates, reproductive data (age at first reproduction, calving interval etc), maximum age etc. Behaviour encompasses physical (feeding) and acoustic (vocalisation) types.

	Pinnipeds (P) and/or Cetaceans (C)	Presence/ absence	Relative abundance	Absolute abundance	Habitat Use	Movement/ migration	Life History	Behaviour	Ancillary data[2]
Strandings	PC	•					•		
Incidental sightings	PC	•						•	
Autonomous acoustic monitoring	C(P)	•						• (P)	•
Fixed-point surveys	PC	•	•		•	•		•	
Platform of opportunity at-sea survey	C	•	•		•	•		•	•
Dedicated at-sea or coastal* **and** aerial sightings surveys	P*C	•	•	•(not P)	•	•		•	•
Towed hydrophone surveys	C	•	•	•[3]	•			•	•
Photo-identification	PC	•		•	•	•	•	•	
Telemetry	PC	•			•	•		•	•

[2] Refers to data collected on other species sighted and/or the environment at the same time as the main survey was conducted.

[3] Only for sperm whales.

Table F. Public Databases that do or may handle marine mammal and seal data. Amended from (Rush, 2022a and 2022b). Description of existing public database or portal that may in the future or already does receive cetacean and seal data from key sector (public, charity, industry, and academia) organisations and individual data recorders in the UK data landscape. Note: That this table utilises information from Rush *et al.* (2022a and 2022b), which does not list the Marine Data Exchange (MDE) which holds data from a variety of industries and also data from research and evidence projects.

Scottish / UK database or portal	Description of system purpose and niche	Sector contribution
ICES Bycatch and Fisheries Database	**Purpose:** The ICES bycatch database houses bycatch data related to the ICES regions for protected species. **How it differs from other systems:** The database provides the ability to submit and retrieve data using a programming interface for monitoring and assessment purposes.	Marine species
NBN Atlas **Scotland Portal**	**Purpose:** The NBN Atlas Scotland collates records from various organisations and LERCs into a national picture on a free online web portal for users to browse and download. The NBN combines multiple sources of information about species and habitats, with the ability to interrogate, combine, and analyse these data in a single location. **How it differs from other systems:** provides a Scottish picture of both marine and terrestrial species data together. It is not a data management system, but rather a discovery point for users to find datasets; it allows users to view species records together with other environmental information such as habitat information and geographical boundaries and to download and export maps and reports or summaries for your own use. The NBN is a node of GBIF and so it also provides a mechanism for disseminating species data internationally.	All sectors
UK Sea Watch Foundation Database	**Purpose:** The aim of the Sea Watch Foundation database is to provide a central archive of cetacean sightings and associated seabirds from all around the UK. Data includes sightings, species, effort, observer, geographical and platform information. The data is managed by the Sea Watch Foundation so that the data can be made available to answer questions on ecology and cetacean occurrence. **How it differs from other systems:** This archive is internal only, there is no external portal for viewing or accessing data. Sightings are recorded in the field and are sent to Sea Watch on paper forms or electronically.	Cetaceans and associated seabirds
The Joint Cetacean Data Programme (JCDP) **The JCDP Data Portal**	**Purpose:** The purpose of the JCDP is to promote and facilitate cetacean data standardisation and maximise value through collation and universal access. The JCDP Data Portal provides a dashboard and the tools necessary to search, filter and downloaded third-party cetacean effort-related survey datasets from the North East Atlantic. ICES have been contracted by JNCC on behalf of Defra to build and host this platform within the ICES Datacentre. The programme will also develop a data standard to guide data collection and storage to ensure high-quality data collation and facilitating access to collated datasets for bespoke analyses. Regularly updated open access data products will be made available to strengthen cetacean science and decision making.	Cetaceans

Scottish / UK database or portal	Description of system purpose and niche	Sector contribution
	How it differs from other systems: Historically there has been no mechanism to facilitate access to all existing effort-related cetacean monitoring datasets in the North East Atlantic from vessel or aerial platforms. This platform will be the first to streamline this process of accessing and utilising these data and collating them into a single resource.	
DASSH (Archive for marine species and habitats data) **UK Data Archive Centre**	**Purpose:** DASSH operates as the archive for marine biodiversity data. It provides tools and services for the long-term curation, management and publication of marine species and habitats data, within the UK and internationally (e.g. EurOBIS, EMODNet). DASSH are a key provider of marine data to the NBN. **How it differs from other systems:** DASSH has well established links between UK and International marine data systems, which other UK databases and portals, such as NBN, do not have. DASSH archives fully attributed data, while only summary data is available through the NBN. DASSH supports both marine species and habitats data. DASSH, as a DAC, has a very flexible database structure and is able to receive data from many different sources and in multiple formats, whereas Marine Recorder has a strict database structure and can only accept data in that format. DASSH fulfils the niche well as a data archive and data disseminator, Marine Recorder fulfils the niche as a data management system.	All sectors
ICES **Global Portal**	**Purpose:** The ICES data portal is separated into several thematic portals focused on the marine environment including benthic and pelagic biota as well as oceanographic and pressure data. Data in the ICES data portal are collected for the purpose of aiding assessments of expert groups and regional sea conventions. The ICES data portal has a web-based user-interface which provides a suite of tools which help visualise and calculate data products. Data held in ICES data portal contributes to OSPAR CEMP, ICES stock assessments and AMAP contamination assessments. **How it differs from other systems:** The ICES data portal focuses on the ICES regions and providing data for specific assessments	All sectors
OSPAR Biodiversity Portal (Seals) (Housed within the ICES Global Portal)	**Purpose:** The Biodiversity Portal for seals sits within the ICES data portal. The database hosts seabird and seals abundance and distribution records. The portal assembles data supplied by contracted parties to OSPAR and the ICES area. The ICES data portal has a web-based user-interface which provides a suite of tools which help visualise and calculate data products. The database is covered by the ICES data policy. **How it differs from other systems:** It is specifically purposed to supporting OSPAR and providing the information needed to feed into biodiversity regional assessments.	Seals and seabirds

Scottish / UK database or portal	Description of system purpose and niche	Sector contribution
OSPAR ODIMS **Global Portal**	**Purpose:** The OSPAR Data and Information System (ODIMS) is an online tool providing a single point of access to all the data and information gathered through OSPAR's Joint Assessment and Monitoring Programme across the different thematic work areas of the Convention. It will help ensure that data is readily accessible for OSPAR assessments, but also help a broad range of users to find data held by OSPAR, to facilitate access to it and make use of it. **How it differs from other systems:** ODIMS is focused on the OSPAR regions and includes data from different aspects related to Ocean health which include information on benthic species but also on offshore industry, hazardous Substances, environmental impact of human activity etc. It is specifically designed to hold data for OSPAR assessments	All Sectors