Marine Natural Capital Assessment Guidance

Project Under Development
Content is incomplete, inaccurate and/or likely broken. Beware.

Purpose of the guidance

This guidance aims to provide an accessible and easily navigable resource for users wanting to carry out a comprehensive assessment of the environmental, social and economic characteristics of their local marine area. It is based on a natural capital approach framework.

The natural capital approach is a framework for decision-making that considers the importance of the natural environment for people and the economy. The approach recognises that nature underpins human wealth, health, wellbeing, and culture and that, therefore, the natural environment, society and the economy are complex systems that are inextricably linked. Natural capital approaches are used for a wide range of purposes (see **Natural Capital Overview** section).

The guidance allows you to **learn more** about the natural capital approach and **how to apply** it to marine and coastal environments. We have tried to simplify the guidance for non-expert users as far as possible and provide links to further examples and resources that provide further explanations but may be more technical.

The guidance:

- **Introduces** natural capital approaches
- **Describes** key components and steps* of a natural capital approach and how these build into a comprehensive assessment for a place
- **Signposts** to more detailed guidance, data, tools and examples to support users to develop their own projects to meet their needs

***Note:** Not all steps in the guidance are essential. The purpose of your assessment and

where you are starting from in terms of data, expertise and other resources will determine what parts of the guide and assessment steps you will be interested in.

Structure and content of the guidance

The guidance is based around **six themes** as shown in the diagram below (natural capital assessment themes). For each theme, the guidance provides:

- An **overview**,
- A summary **flowchart** identifying potential considerations and steps for an assessment
- Potential **methods to develop and apply tools and assessments**,
- **Examples and links** to external projects, guidance and data/evidence.
- **Data** The guidance links to a spatial data tool developed for this website and also provides links to national data portals that users are likely to require.
- **Case Studies (see navigation links):** The case studies, presented as standalone sections, and with elements incorporated into the guidance, provide worked marine examples of the basic approaches at regional and local scales. They demonstrate how available data can be utilised to support natural capital assessments.

Basic, Better and Best Approaches: what are they?

Your aassessment objectives and resources (time, expertise, budget and evidence) will determine your approach. For each element in the guidance sections, where possible we present options that range from basic, to 'better' and 'best' approaches:
Basic approaches: typically require a few days to apply and use readily available evidence or other resources
Better approaches: build on the basic approach but may require more extensive data gathering and more expertise. Typically may require a few weeks and supporting resources.
Best approaches: require more time and expertise but yield greater depth of information. They may focus on gathering primary (new) data rather than relying on secondary sources.

Note: Basic, Better and Best refer to the level of resource required not the quality of outputs. In many cases a basic approach will meet user needs, however the depth of knowledge gained about natural capital will generally increase with more resources. Projects may mix elements of each approach, for example a best approach to natural capital assets and a basic

approach to valuation.

Project team: This website was delivered by the Marine Biological Association of the United Kingdom, development of the guidance was led by ICF in collaboration with Plymouth Marine Laboratory (PML), AVS Developments and Mindfully Wired, The project concept was developed by Natural England, and funded by the Department for Environment, Food and Rural Affairs (Defra) through the Natural Capital and Ecosystem Assessment (NCEA) programme.

Acknowedgements: The guidance was shaped and supported by a wide range of experts and organisations via attendance at workshops, webinars and review of outputs. They are too numerous to thank individually and their input is gratefully acknowledged by the project team and Natural England.

To cite this data tool: Natural England. 2025. Marine Natural Capital Assessment Guidance. 2025. Available from: Archive for Marine Species and Habitats Data (DASSH). (InteractiveResource). https://doi

NCEA Natural Capital and Ecosystem Assessment

NATURAL ENGLAND

Natural Capital Overview

This section of the guidance introduces natural capital and the natural capital approach and its benefits. Natural capital approaches may be used for a variety of purposes and there is no standard approach or objective. Examples of different objectives are provided and the parts of the guidance that are most relevant are highlighted. Finally, some of the key limitations in the natural capital approach are identified with recommendations to address them.

Overview

This natural capital overview describes:

- **What is natural capital?**
- **What is the natural capital approach and what are its benefits?**
- **Natural capital assessment objectives and relevant parts of the guidance**
- **Limitations and recommendations in applying the natural capital approach**
- **Guidance documents: natural capital approaches (links to other resources)**

Components

What is natural capital?

Natural capital is a broad term that includes many different components of the living (biotic) and non-living (abiotic) natural environment that directly or indirectly produce value and benefits to people. The definition below is taken from the World Forum on Natural Capital.

"Natural Capital can be defined as the world's stocks of natural assets which include geology, soil, air, water and all living things. It is from this Natural Capital that humans derive a wide range of services, often called ecosystem services, which make human life possible. The most obvious ecosystem services include food, the water, plant materials used for fuel, building materials and medicines. There are also many less visible ecosystem services such as the climate regulation and natural flood defences provided by forests, the billions of tonnes of carbon stored by peatlands, or the pollination of crops by insects. Even less visible are cultural ecosystem services such as the inspiration taken from wildlife and the natural environment.

Poorly managed Natural Capital becomes not only an ecological liability, but a social and economic liability too. Working against nature by overexploiting Natural Capital can be catastrophic not just in terms of biodiversity loss, but also catastrophic for humans as ecosystem productivity and resilience decline over time and some regions become more prone to extreme events such as floods and droughts."

Example: Five capitals model

The Five Capitals Model provides a basis for understanding sustainability in terms of the economic concept of wealth creation or 'capital'. As shown in the figure below, there are different types of sustainable capital from where we derive the goods and services we need to improve the quality of our lives. All are stocks that have the capacity to produce flows of economically and socially desirable outputs. The maintenance of all five kinds of capital is essential for the sustainability of economic development. For further information see Forum for the Future.

Note: There are also other multi-capital approaches and classifications, the key point is that natural capital is not the only type of capital and realisation of the benefits of ecosystem services may require input from other capitals.

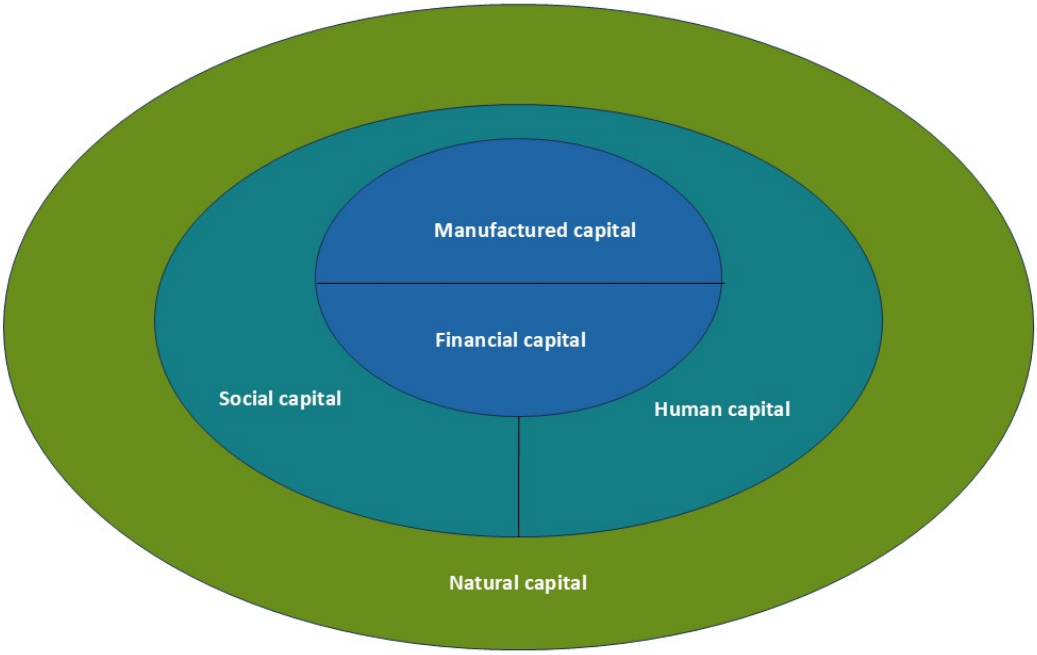

Figure 1. The Five Capitals model. Redrawn from the example at Forum for the Future.

Links for further information:

- Forum for the Future
- Natural Capital Coalition. 2016. Natural capital protocol

What is the natural capital approach and what are its benefits?

The natural capital approach is a way of making or supporting decisions that considers the Value

of the natural environment to the economy and people. It's based on the idea that nature is a key part of human wealth, health, and culture (Examples of the objectives of natural capital assessments are provided in the section below).

A natural capital approach can support decision-making and management. Whilst some assessments of natural capital may consider value in economic (monetary) terms, a natural capital approach will often consider the broader, non-monetary value of assets to citizens and society as a result of the ecosystem services they provide, such as appreciation of nature and cultural heritage. Value, in the natural capital approach, is therefore not limited to monetary values but may include ecological and socio-cultural values. Understanding nature as a set of assets that benefit people and society in all kinds of ways can support better decision-making and reduces the risk of the value of the natural environment being ignored in decision making.

The natural capital framework below (Figure 1) describes the link between the natural environment and the provision of ecosystem services and goods and benefits. The relationships between natural capital assets, the flows of ecosystem services and the benefits which society values are affected by pressures from human activities and other drivers (such as climate change) and how people manage the assets now and how they have historically been managed. (These diagrams are also referred to sometimes as natural capital logic chains, this term is used elsewhere in the guidance).

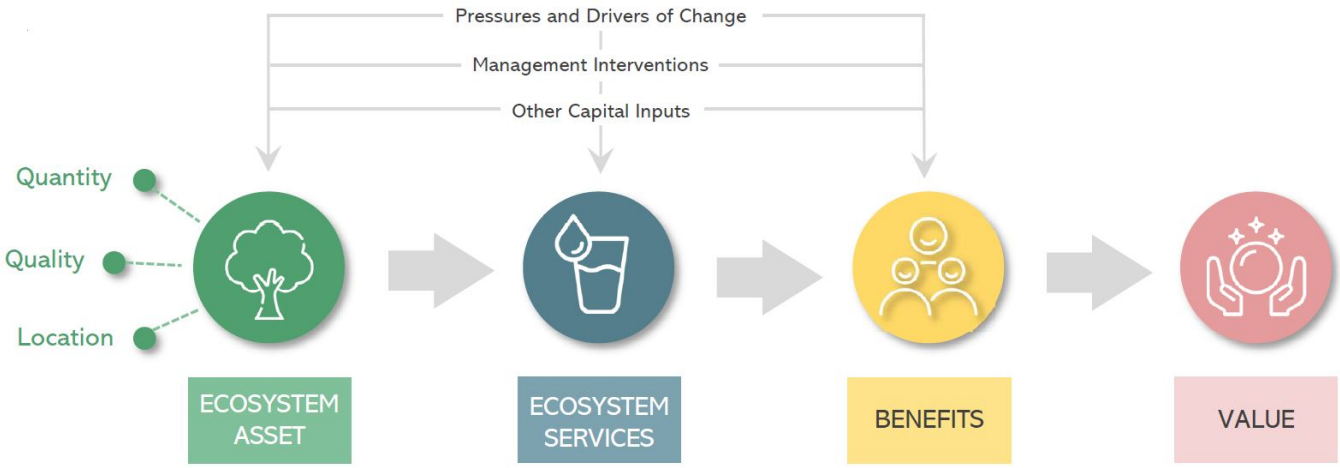

Figure 2: Natural capital logic chain describing the links between natural capital assets, ecosystem services and benefits. (Image taken from Natural England's Natural Capital Handbook.

Natural capital assessment objectives and relevant parts of the guidance

There is no single way to apply a natural capital approach, and the guidance presented within this website recognises that the aims of natural capital assessments differ. Typically, the core requirement is to **measure the presence and extent of natural capital assets** and the **ecosystem services and benefits** derived from them (Natural Capital Coalition, 2016; Natural Capital Committee, 2017). Approaches may also consider how changes in the condition (or quality) of habitats and species populations (stocks) affect their capacity to

deliver services and benefits. Such changes can then be used to demonstrate trade-offs that may result from, for example, **management initiatives** helping to define priorities, and **manage risks and opportunities**. This conceptual framework or logic chain has been used to organise the guidance into the six main themes.

Natural capital assessments may be carried out for a wide range of purposes. The table below provides examples of different natural capital assessment objectives and which of the six steps listed above need to be completed (indicating which parts of this guidance are relevant).

Table 1 Examples of natural capital approach objectives and relevant parts of this guidance. This table was adapted from Defra's Enabling a Natural Capital Approach (ENCA) Guidance

Assessment objective	Site Context	Natural Capital Assets	Ecosystem Services	Valuation and benefits	Condition	Management
Assessing baseline levels of natural capital to raise awareness, or inform targets	✔	✔	✔		✔	✔
Development of a natural capital plan to identify priorities and opportunities for habitat use and management	✔	✔	✔		✔	✔
Using nature to find ways to support management and policy objectives, whether or not they are environmental		✔	✔	✔	✔	✔
Assess the potential costs, benefits and risks of an intervention on a range of natural assets and their effects on benefits		✔	✔	✔		✔
Developing an understanding of the science and economic value of ecosystem services, which can inform accounting and appraisal exercises as well as strategic initiatives			✔	✔		
Informing a strategic objective, for example around concepts of net gain, growth of natural assets over time or applications to project-level decisions	✔	✔	✔			✔
Consideration of the spatial variation of natural assets or impacts on them, and how this affects their valuation		✔	✔	✔	✔	
Including natural capital as an integral part of development, regeneration and place-making, or as “green infrastructure”	✔	✔	✔		✔	✔
Identifying potential income streams from natural capital investment	✔	✔	✔	✔		✔

Limitations and recommendations in applying the natural capital approach

The review of marine natural capital assessments undertaken through this project highlights emerging best practice, but the reality is that expert judgement and opinion is required in all stages of a natural capital assessment. **Recommendation:** Users are encouraged to engage with expert support where available.

Natural capital assessments may aspire to value all the benefits arising from an area and link them back to services and to the asset state. However, the relationship between ecosystems, natural capital, delivery of benefits and how changes in condition affect these is a complex web of interactions and influences that are currently not fully understood. Thus, most assessments are limited to assessing a subset of assets, ecosystem services or benefits. This limitation can cause issues when using outputs which do not account for entire systems to make decisions. **Recommendation:** Where possible potential interactions should be identified or considered at least qualitatively, if not quantitively, when undertaking an assessment.

Data availability. Vast amounts of marine data exist, but much are inaccessible because it requires pre-processing prior to use, are hidden behind paywalls (e.g. at Local Records Centres), are dispersed across the multiple sources or requires specialist knowledge to enable interpretation. This project has therefore taken a “sign posting” approach. The data tool directs users to open access data which are typically national scale. The resolution of these data, however, limit the analyses that can be achieved. **Recommendation:** Where resources are available, users are likely to be able to build on basic approaches by sourcing additional local data or by engaging with expert stakeholders. **Note: This guidance is linked to a spatial data tool which can be searched and added to and you can also generate and then download the data sources it contains. See the guidance and background here.**

A wide variety of resources may be used when applying natural capital approaches, the quality, completeness and reliability of these may vary considerably. **Recommendation:** It is suggested that the outputs of natural capital assessments should be accompanied by confidence assessments where possible and, when guiding decision making, limitations should be made transparent and acknowledged.

Guidance Documents: Natural capital approaches

Further resources and guidance

A number of guides from other sources provide an overview of the planning and implementation of natural capital approaches, you may find these helpful for further information. Two comprehensive examples are:

Natural Capital Evidence Handbook

Intended to support place-based planning and decision-making, the handbook outlines how to come to shared strategic understanding about the natural environment, in a place, using a natural capital evidence base. It emphasizes the need to work collaboratively and in partnership to do more to enhance nature and human wellbeing. The report sets out an approach that will help users include natural capital evidence in strategic decision-making and identifies Natural England's evidence-based tools that can support this. The handbook includes additional guidance as annexes, including Natural Capital Accounts for National Nature Reserves, Microeconomic Evidence for the Benefits of the Investment in the Environment, and Managing Ecosystem Services Evidence Review. Natural Capital Evidence Handbook: to support place-based planning and decision-making - NERR092 (naturalengland.org.uk)

Natural Capital Committee (2017). How to do it: a natural capital workbook
Department for Environment Food and Rural Affairs (Defra). A practical guide aimed at anyone who wants to use natural capital approaches in making decisions about the natural environment. It provides a practical five step model intended to support decision makers, including planners, communities and landowners, in protecting and improving their local environment and natural capital. The aim of this guide is to provide a structured way of making informed choices

Sea the Value- Training materials including workshop materials for participatory mapping

Sea the Value is a NERC funded project led by PML that brings together a unique interdisciplinary team and international network of collaborators to address fundamental questions regarding the economics of biodiversity, specifically of blue carbon and marine water quality. The Sea the Value Project hosted a series of workshops aimed at members of the Coastal Partnerships Network (CPN) to build understanding of key concepts that the Sea the Value project aims to address. Across four workshops they discussed approaches to better understand, protect, and restore coastal habitats. The series provides valuable tools for participants from different backgrounds to collaborate in managing coasts and local environments and provides a starting point for those looking to run their own workshops with local community groups and networks. The project training materials in natural capital approaches are free to use for its intended purposes. "Marine Natural Capital Training material from the Sea The Value project."

Collar, M., Contento, C., Dickie, I., Watson, S.C.L., Broszeit, S., Preston, J., Van der Schatte, A., Watson, G., Anbleyth-Evans, J., Burdon, D., Potts, T., Chan, C., Chung, P., Tinch, R., Erskine, A., Watts, A., Beaumont N. (2025). Sea the Value Marine Natural Capital Training Materials. Plymouth, UK. 14pp.

Key tools for developing natural capital assessments (focused on economics and accounting) are
Enabling a Natural Capital Approach guidance (ENCA): The guidance is intended for those looking to learn about natural capital and how to apply it. It forms part of a suite of Defra resources. ENCA is recommended for use by HM Treasury's Green Book: appraisal and evaluation in central government (2020) and represents supplementary guidance to the

Green Book. It is aimed primarily at valuation and the development of Natural Capital Accounts. ENCA guidance includes coastal margins and marine habitats as broad habitat types.
ENCA guidance is a comprehensive document providing information and resources for Natural Capital. It covers:

- The natural capital framework
- Economic valuation of the environment
- How project or policy appraisal can incorporate natural capital
- Natural capital accounting principles and methods, benefits and challenges
- Applying natural capital at a local level
- Database (Excel spreadsheet) of case studies
- Asset databook identifying condition indicators from the 25 Year Environment Plan, selected bio-physical data sources, tools and evidence and selected valuation tools and evidence
- Service databook identifying a range of ecosystem services (not an exhaustive list) and valuation evidence and sources.

Natural capital assessment template (provided as Excel spreadsheet)
Environment Agency's Natural Capital Register and Account Tool (NCRAT)
The Environment Agency's Natural Capital Register and Account presents the value, quantity and quality of natural resources in a place. With the Environment Agency's natural capital register and account tool, users can now create an account for themselves within days and for free. This tool is the first of its kind to enable replicable, transferable and freely available natural capital accounting.

NCRAT is presented as an Excel workbook with three components

1. **Input** - using the tool requires the user to collect and input data about their place.
2. **Process** - the process calculations are automated.
3. **Output** - the output tables and graphics are largely self-generating.

The tool is available on request from: naturalcapital@environment-agency.gov.uk.

Site Context

Site context means understanding the key aspects of the site that inform a natural capital approach. This could be described as: “Understanding where you are setting out from” as defined in the Natural Capital Committee How to Handbook (Natural Capital Committee, 2017).

The purpose of this step is to ensure that **basic information relevant to natural capital** in the area being considered is gathered, documented, and synthesised. This data gathering stage will also be useful to identify evidence gaps and where additional searches for data may be required to address gaps in understanding. Gathering this detailed information will provide a basis for analysing what to do and to support later stages of assessment. Understanding the site context may highlight problems, and other plans and developments relevant to the area.

Overview

This section provides guidance on key aspects of the site that may influence natural capital and that users may wish to consider, including the environment, social and economic factors, boundaries, baselines, site users and stakeholders.

The site context guidance covers:

- Guidance flowchart: site context
- What type of information is needed to characterise the site?
- Planning data management: approach storage and expertise
- Scale of assessment and site boundaries: terrestrial, coastal and marine
- Developing an inventory of human activities and physical infrastructure that affect the site
- Site users and stakeholders: who are they?
- Environmental setting
- Historic environment, past decisions and legacy issues
- Site management and byelaws
- Identifying areas designated for conservation
- Data links for site characterisation

Depending on resources and objectives, the assessment may undertake a:

Basic approach: projects may conduct a desk-based assessment using existing data resources and tools. Coupled with this may be consultation with one or more local experts who will be able to provide key information about the site, especially where gap-filling is required. A basic approach would identify site boundaries, existing designations and characterisation of main uses of the site based on existing data

Better approach: As for “Basic” but with additional evidence where required to understand activities (intensity, frequency) and site uses. Projects may undertake more intensive local data sourcing and involve more stakeholders to address evidence gaps and increase site knowledge.

Best approach: As for “Better” but with more resource intensive data gathering to understand fully the site and uses, including changes over time. At the best level, where resources allow, projects may gather additional data through surveys and systematic engagement with stakeholders, perhaps through more formal and extensive processes. Some of these will link with later steps where the project focusses on developing a better understanding of specific aspects of natural capital. Stakeholders may have a more significant role through the creation of partnerships or shared platforms with a key role in co-developing or co-producing the assessment, which could include gathering data through stakeholder networks.

Components

Guidance flowchart: site context

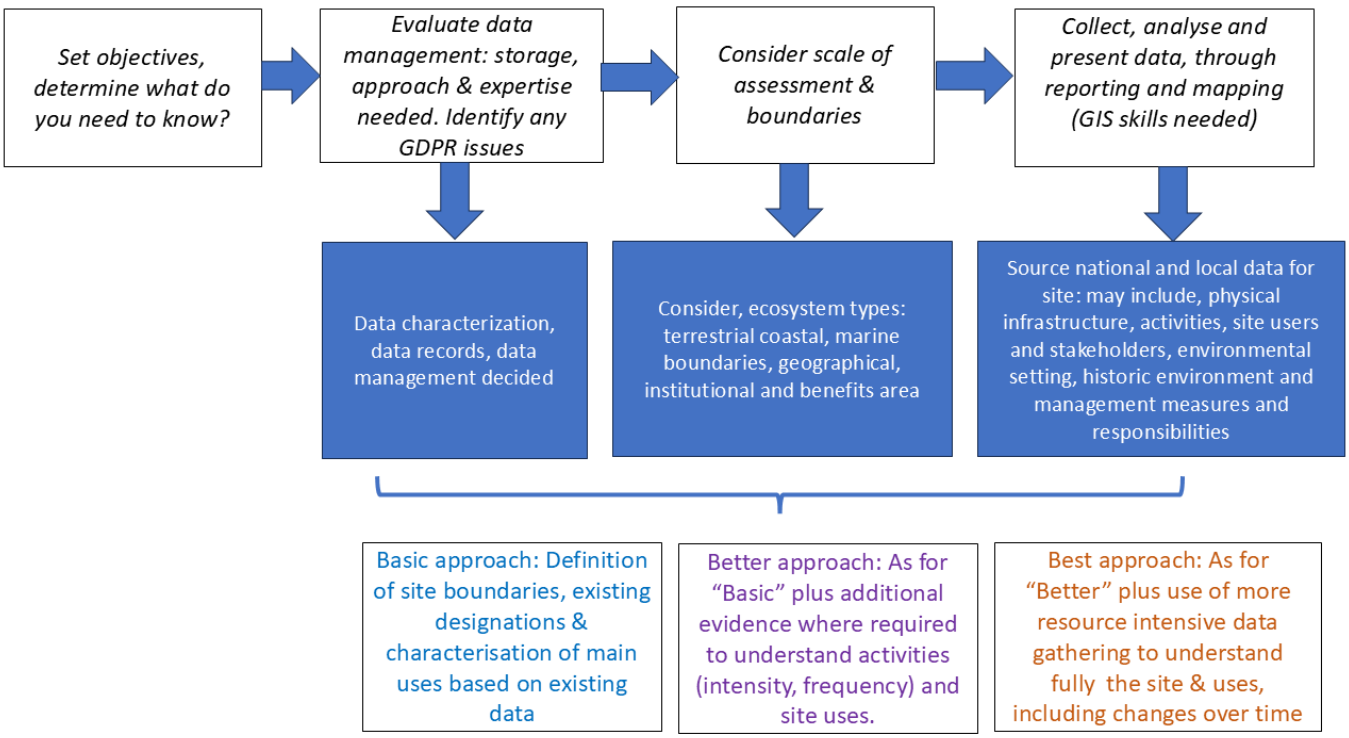

Figure 1: Suggested steps to follow to gather information on site context

What type of information is needed to characterise the site?

The objectives for the natural capital assessment will determine what information needs to be collected to understand the site but the following are typically required to understand the factors influencing the site. **Note: many of these sources will also be useful in later stages of a natural capital assessment and preliminary data may be added to as**

the project progresses.

In terms of site context, natural capital approaches are likely to consider:

- **Scale of the assessment and boundaries** of the site and any site divisions around management e.g. harbour areas, designated sites for conservation, areas that specific byelaws apply to.
- **Physical infrastructure and ownership** of infrastructure assets e.g. harbours, aquaculture facilities such as lines, trestles and pens, area of installed offshore wind capacity, and onshore embankments and footpaths, that are an important part of realising natural capital.
- **Stakeholders**, including groups and individuals with an interest in the site, site users, landowners and managers, beneficiaries etc.
- **Environmental setting**, which may include abiotic (non-living) natural capital assets (e.g. marine aggregates), geology, catchment area etc..
- **Baseline information** on the presence of the historic environment, past decisions, and issues from past activities such as contamination or habitat changes.
- **Activities taking place** in the area, e.g. fisheries, recreational activities and context, such as who is funding them and why. This is important to support financing and implementing decision making etc.
- **Management measures and responsibilities**, governance structures, policies and regulations.
- **Transboundary issues/ decisions** that are happening close by/ upstream that might impact the site, this may include migratory species or human activities that impact the condition of the site.

Note: To find data, the searchable data tool, developed by this project, provides links to key datasets. Users can also add data using the data profiling tool on the same site.

Planning data management: approach storage and expertise

Projects will need to establish the evidence base and plan how to source and store data and the expertise that is required.

Data storage and recording may be usefully defined by first setting-out what the project wants to know and identifying pre-existing data relevant to the objectives. This will help to identify gaps and highlight information that the project needs to collect.

The level of evidence required will depend on the assessment objectives and project resources.

Data may take many forms, including qualitative and quantitative, as well as text, verbal and figurative forms.

It is important to have some flexibility on what information can be used to inform decisions and make progress. For example, participatory mapping approaches (see the Deben Estuary

example below) can help provide information that can be used to bring decisions forward despite a lack of formal information.

Scale of assessment and site boundaries: terrestrial, coastal and marine

The scale of the assessment and selection of the location of landward and seaward boundaries is imprtant but may be challenging for users. The landward/seaward interface is important as:

- At the landward boundary, marine and terrestrial habitats are interconnected and links to/from terrestrial processes can be important. There may be shared influences (e.g. effects from air quality, and run-off) and links between activities (e.g. where cables from offshore wind farms reach land).
- When people visit the coast, they may spend their time in both marine and terrestrial habitats, for example snorkelling and camping in a field on a cliff above the beach.
- Estuaries are transitional ecosystems between the terrestrial environment, freshwater catchments and the coastal and marine. They are influenced by both changes in the marine environment such as sea level rise, and changes in the catchment such as land use changes.

Depending on objectives, natural capital assessments may need to include areas of terrestrial and freshwater habitats at the coastal fringe, estuaries, coastal habitats (above mean high water), intertidal habitats and fully marine (subtidal).

Defining the marine and/or coastal assessment boundary can be inherently difficult. The marine boundary tends to be defined using the **spring high tide mark** (the landward limit of the intertidal area), but some shoreline habitats such as saltmarsh, can be considered terrestrial in some contexts. For example, the sheep grazing provided by some saltmarshes is often considered to be a terrestrial ecosystem service, while flood defence, carbon removal, coastal recreation, and amenity services and benefits provided by saltmarsh are intrinsically tied to the sea and not included in other terrestrial natural capital accounts.

Different marine management and planning frameworks apply in the terrestrial, coastal and marine environments. This difference is reflected in the fact that many of the datasets, classification frameworks and assessments for habitats and ecosystem services may be either terrestriall or marine focussed.

The outer or sea boundary, may also require consideration and will be influenced by the objectives. Assessments of offshore areas may use the UK's Exclusive Economic Zone (EEZ) which represents the UK's fishing area reasonably well. However, minerals may be obtained from the whole continental shelf, so this wider boundary is sometimes used for assessments.

The Natural Capital Committee '[How to do it: a natural capital workbook]' (2017) provides guidance on decision making around scale and boundaries and connectivity:

- What is the **relevant geographic area**? What makes most sense as a decision-making

unit from a biophysical point of view? This could be a catchment, an ecosystem type, or a physical unit such as an island or an area that shares common natural capital features. If only a part of a geographic area is assessed, important interdependencies may be missed. For example, the quality of an estuary may well be dependent on actions further upstream.

- What is the **practical institutional area**? This addresses governance structures. This could be a county, a National Park, an estuary, a marine protected area (MPA) or an offshore marine area. An institutional area may have a number of groups with common interests and responsibilities, and effective influence over the whole area;
- What is the **relevant benefits area**? This is anywhere or anyone who is affected by the costs and benefits provided by the natural capital and ecosystem services under consideration. At one extreme the conservation of globally rare and endangered species might generate benefits internationally, even though the species themselves are confined to small geographic areas. Likewise, tourists from around the world travel to and value the UK's National Parks. However, other natural capital generates benefits which are almost entirely confined to a local area. For example, a coastal wetland might well reduce the flood risk to local properties in addition to the habitat created. Given the interconnectedness of benefit value chains, the suggestion is to use a proportionate approach. For example, in terms of flood protection a study may only focus on the direct beneficiaries of the site, but in other cases (e.g. valuation of carbon storge, which has global beneficiaries) a study may want to capture the value of benefits more broadly. These areas are unlikely to overlap completely, so it is important to consider what may be missing when choosing the focus for a plan.

Developing an inventory of human activities and physical infrastructure that affect the site

Human activities and physical infrastructure may affect the condition and extent of Natural capital assets and represent the realisation of some Ecosystem services. For example, fishing activity leads to pressures on the ecosystem such as removal of target species but also provides the realisation of ecosystem Benefits(food) and can be valued. Coastal paths provide access to nature, providing recreation benefits but they can also potentially lead to erosion and wildlife disturbance. Developing an inventory of activities and infrastructure within a site supports natural capital assessments, by identifying Pressure risks and ecosystem services and Benefits.

The **spatial data tool** linked to this guidance provides information on activities and management boundaries. You can also generate and then download the data sources it contains. See the guidance and background here.

Site users and stakeholders: who are they?

A variety of individuals, groups and organisations will be operating within any area, all of whom will benefit from and/or affect natural capital as well as spend money to enjoy those benefits. (Natural Capital Committee, 2017). Site users and stakeholders that are relevant

will depend on the assessment purposes but will typically include decision makers, those who provide supporting data and insights, those expected to benefit from a decision or intervention and those expected to be negatively affected as a result.

The North Devon marine pioneer project (Ashley et al., 2018) categorised stakeholders as:

- Direct stakeholders: individuals or organisations who directly exploit the natural capital assets and Natural capital stocks.
- Indirect stakeholders: individuals or organisations influencing the exploitation of natural capital by using products or services linked to natural capital (flows)
- Supporting stakeholders: services provided by various actors who never directly deal with natural capital but support the value chain.
- Governance stakeholders (regulatory frameworks, policies and infrastructures): people, organisations and institutions responsible for setting up and managing the regulatory framework for natural capital.
- Influence stakeholders: Groups or individuals who influence how natural capital is used and/or managed.

Within these categories, stakeholders include:

- Those who will benefit from the protection and improvement of the natural capital in relation to human health and wellbeing, such as local health care providers, community groups and NGOs with a wellbeing focus;
- Those who will bear the costs of the protection and improvement of natural capital: notably the local or national public and taxpayers;
- Local nature organisations (NGOs and community projects are playing an increasing role in restoring natural capital);
- Organisations representing those who use ecosystem services provided by natural capital (e.g. water companies, tourist boards, farmers, walking groups);
- Businesses: for example, developers or those with an interest in tourism, or flood risk reduction to land or buildings, or sales of products such as timber or fish;
- Those who have influence over how land is used and managed: for example, landowners and managers, organisations running nature reserves, farmers, and public bodies such as the local council, Environment Agency, Natural England;
- Those who may have an impact on natural capital as a consequence of their activities, some of whom may have a corresponding duty or interest to compensate, including major infrastructure bodies such as Highways England and Network Rail;
- Existing authorities and partnerships that may help to coordinate interests: for example, flood partnerships, Local Nature Partnerships, Local Enterprise Partnerships and National Parks; and
- Those who have expertise or information that may be helpful: accountants, economists, or subject specialists such as ecologists.

(Natural Capital Committee, 2017).
See the stakeholder engagement section for more information on how to identify and map stakeholders.

EXAMPLE Stakeholder engagement example: Linking natural capital, benefits and beneficiaries: The role of participatory mapping and logic chains for community engagement

This project uses a novel stakeholder driven approach to participatory mapping which enables engagement of communities in natural capital discussions across a series of face-to-face workshops. The approach was applied in the Deben Estuary, Suffolk (UK), and more recently in the Cromarty Firth and Solent; however, the methodological framework could be applied to any global ecosystem (terrestrial, freshwater, estuarine, marine, urban) and community setting.

The approach involves in-depth stakeholder engagement over three workshops to collect and define data relating to natural and man-made features, the benefits they deliver and trade-offs in benefit under future scenarios. Logic chains of the reliance and importance of ecosystem benefits to multiple beneficiaries are then produced. Through participation, the approach supports learning and research about the inter-connections between nature and well-being and helps to identify how communities can best manage their natural assets.

From a management perspective, the outcomes of this approach can help to identify which benefits, and therefore which beneficiaries, may be impacted by an intervention, and what direction that impact may take.

Burdon, D., Potts, T., Barnard, S., Boyes, S.J. and Lannin, A., 2022. Linking natural capital, benefits and beneficiaries: The role of participatory mapping and logic chains for community engagement. Environmental Science & Policy, 134, pp.85-99.

Environmental Setting

The environmental setting of a site consists of all elements that affect it. This includes inputs and condition of rivers in catchment. The relevant factors for assessments will be guided by objectives and the scale of the assessment. Note that species and habitat data is covered in the **Natural Capital Assets guidance**.

Heritage assets are not ‘natural’ capital, but they are important environmental inputs to the socio-ecological system (and generate ecosystem services in tandem with ecological assets) and so should be considered. Heritage assets include designated assets (as in the National Planning Policy Framework) but also locally significant buildings, monuments, sites, places areas or landscapes identified by Local Planning Authorities.

Historic environment, past decisions and legacy issues

The historic baseline for natural capital assets is discussed in that specific guidance. Information on the historic environment, past decisions, and issues from past activities such as contamination or habitat changes may need to be found for a site. The amount and type of data will be site-specific, with some areas more data-rich than others. Information may be

sourced from stakeholders, archives, record centres and others.

Site management and byelaws

Coastal governance is complex and covered by many different organisations including statutory and non-statutory bodies. The image below (Figure 2) is taken from the Solent Forum and summarises responsibilities from above the intertidal to areas beyond national jurisdiction (the high seas).

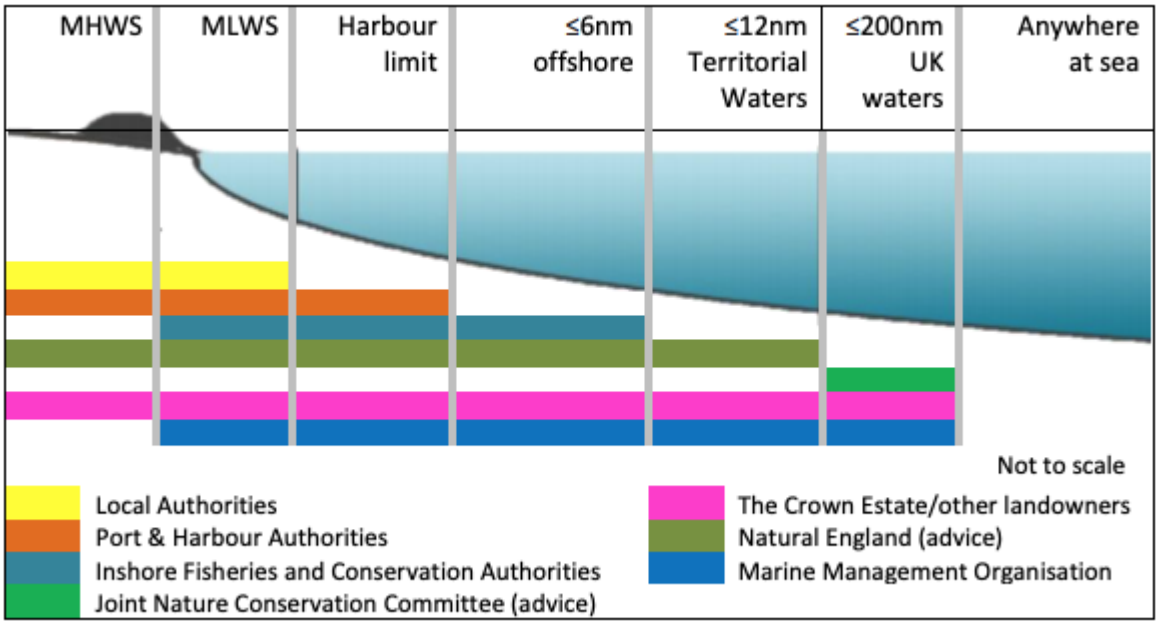

Figure 2. Summary of organisation responsibilities from the intertidal to offshore (copyright unknown, taken from the Solent Coast Forum website)

The **Marine Management Organisation** (MMO):

- Is responsible for licensing and regulating marine activities in the seas around England and Wales including commercial fishing, construction activities beyond the low tide mark including harbours, and coastal protection;
- Monitors fish quotas, licenses marine construction, and deals with marine pollution;
- Can make byelaws to control non licensable activities, and make emergency byelaws; and.
- Is responsible for preparing marine plans in England.

There are 11 English marine plan areas including inshore and offshore areas. Marine plans address the key issues for the area, setting a vision and objectives. Detailed policies set out how these will be achieved and how issues will be managed or mitigated. The policies inform decision-making for any activity or development which is in, or impacts a marine area.

Local government. Local authorities such as district and county councils have many responsibilities on the coast both as managers and regulators and in many cases also as the landowner. Responsibilities include planning; control of land use and development to low water mark, licensing of some activities and some local byelaws.

Port and Harbour authorities. Most harbour authorities in the UK are now constituted as private companies (or subsidiaries of such a company). Some are trust ports, originally established by private Act of Parliament and now operating under Harbour Revision Orders. Rights and responsibilities of port and harbour authorities derive from the legislation that created them, and they are governed by their own local legislation, which is tailored to meet their individual needs. Under these local acts and regulations, the authority is responsible for administering the ports and coastal waters within its jurisdiction and many have the power to create byelaws, mainly to ensure the navigation and safety of vessels.

The **Inshore Fisheries and Conservation Authorities** (IFCA) provide local regulation of commercial and recreational fishing activity, balancing the social and economic benefits from fisheries with the need to protect and restore the marine environment. They are responsible for the development, monitoring and enforcement of fishing regulations and protect MPAs using local byelaws.

The Crown Estate owns virtually the entire seabed out to the 12 nautical mile (nm) territorial limit, including the rights to explore and use the natural resources of the UK continental shelf (excluding oil, gas and coal). The Energy Act 2004 vested rights to The Crown Estate to license the generation of renewable energy on the continental shelf within the Renewable Energy Zone out to 200nm. It also owns around 55% of the foreshore (the area between mean high and mean low water) and approximately half of the beds of estuaries and tidal rivers in the United Kingdom. It does not own the water column nor govern public rights such as navigation and marine fisheries. The Crown Estate lease the seabed for certain activities; however it is the MMO that issues licences for licensable activities such as aggregate extraction, (while it would be the Department for Energy Security and Net Zero /North Sea Transition Authority for oil and gas.

Other landowners may need to be considered. Landowners generally own the land down to the mean high water mark or mean low water mark; land below this and 50% of the foreshore is owned by the Crown Estate. Landowners can be either private individuals or companies, charitable bodies such as the National Trust or local and harbour authorities. Trinity House is the authority for lighthouse and deep-sea pilotage, and is responsible for the safety of shipping and the well-being of seafarers.

Identifying areas designated for conservation

A range of conservation designations that may apply within sites and could be associated with byelaws and other management approaches that should be considered within the natural capital approach. They may include areas where activities are excluded or where restoration potental is high. They may also provide cultural value thorugh conservation of biodiversity.

National Landscapes are designated areas where protection is afforded to protect and manage the areas for visitors and local residents.

There are several types of Marine Protected Area (MPA) in the UK, which in combination are intended to form an 'ecologically coherent and well-managed network' as a contribution to

the effective conservation and sustainable use of the UK's marine environment:

- **Special Areas of Conservation (SACs)** – designated to protect habitats and species of European importance.
- **Special Protection Areas (SPAs)** – designated to protect bird species of European importance and regularly occurring migratory birds.
- **Marine Conservation Zones (MCZs)** and Nature Conservation Marine Protected Areas – designated to protect nationally important species, habitats, ecological processes and features of geological/geomorphological importance.
- **English Highly Protected Marine Areas** – designated to protect the marine ecosystem of the area (including all marine flora and fauna, all marine habitats and all geological or geomorphological interests, including all abiotic (non-living) elements and supporting ecosystem functions and processes, in the seabed, water column and the sea surface).
- **Sites of Special Scientific Interest (SSSIs) / Areas of Special Scientific Interest (ASSIs)** – designated to protect any area of special interest for its flora, fauna, geological or physiographical features. These are coastal (and terrestrial) designations with some sites protecting marine features. ASSIs are designated in Northern Ireland, which are equivalent to SSSIs in England, Scotland and Wales.
- **Ramsar sites** – wetlands of international importance designated under the Ramsar Convention. These are coastal (and terrestrial) designations with some sites protecting marine features.

Example: Applying a natural capital approach to the Yorkshire coast – a feasibility report

This feasibility study for the Yorkshire coast, explored how marine and coastal ecosystem services should be incorporated into the natural capital approach, potential issues for a full assessment and approaches to overcome these. The report is a useful scoping and feasibility study with some of the issues around implementation (such as data gaps) applicable in other areas. The process for next steps and priority identification are likely to be of interest for users scoping out the application of a natural capital approach.
The three principal aims of this study were to:

1. Identify core evidence and/or resource gaps (relevant) to the implementation of a marine natural capital approach on the Yorkshire coast;
2. Work with key stakeholders to understand how a natural capital approach to marine environments could be applied to local and regional decision-making, and improve coordination across the marine, coastal and terrestrial ecosystems; and
3. Identify any potential challenges to the application of a natural capital approach, including 'artificial' boundaries (political, geographic and social) which may present barriers to progress in the coastal environment.

Barnard, S. and Atkins, J.P. (2022) Applying a natural capital approach to the Yorkshire coast – a feasibility report. Report for Yorkshire Marine Nature Partnership by Wolds Environmental Consulting Ltd

Data links for site characterisation

Note: This guidance is linked to a spatial data tool which can be searched and added to and you can also generate and then download the data sources it contains. See the guidance and background here.

Data Links to Boundary data	Source
Six nautical mile limit (GB)	Defra MAGIC map
12 nautical mile limit (GB)	Defra MAGIC Map
UK Continental shelf (GB)	Defra MAGIC Map

Data: Environmental setting	Source
National Network of Regional Coastal Monitoring Programmes. Consists of six Regional Monitoring Programme, each led by a local authority. Data varies by region but includes wave, tide and meteorology reports, map viewer and catalogue. Includes environmental data, habitat mapping and coastal defences.	https://coastalmonitoring.org/
Defra LIDAR analysis Digital Terrain Model. A set of Geo TIFF files for analysing low lying land susceptible to coastal flooding and coastal erosion.	https://environment.data.gov.uk/survey
Environment Agency Flood Risk Management Plans.	
Environment Agency Catchment Data Explorer. Provides information about the water environment used in River Basin Management Plans. Includes maps, summary information about catchments and condition, downloadable data and links to other useful sites.	https://environment.data.gov.uk/catchment-planning/
Environment Agency river catchment pollution. Data set of river catchment pollution events including pollution from agriculture, quarries, mines	https://environment.data.gov.uk/catchment-planning/England/rnags
Environment Agency flood risk assessment areas - note this link does not provide facility for download.	https://check-long-term-flood-risk.service.gov.uk/map
Bathing water monitoring locations. Identifies the locations of monitoring stations for assessment of bathing water quality.	https://www.data.gov.uk/dataset/dcb8bd46-c4cf-4749-bad0-7663da96845c/bathing-waters-monitoring-locations
The National Heritage List for England (NHLE) is the only official, up to date, register of all nationally protected historic buildings and sites in England - listed buildings, scheduled monuments, protected wrecks, registered parks and gardens, and battlefields.	https://opendata-historicengland.hub.arcgis.com/datasets/historicengland::national-heritage-list-for-england-nhle/explore?layer=9
Scheduled Monuments	Defra MAGIC Map
Registered Battlefields	Defra MAGIC Map
Registered Parks and gardens	Defra MAGIC Map
Protected wreck sites	https://historicengland.org.uk/listing/what-is-designation/protected-wreck-sites/ Defra MAGIC map
OS Open Rivers is a generalised open water dataset that is freely available, showing the flow and the locations of rivers, streams, lakes and canals across the whole of Great Britain.	https://www.ordnancesurvey.co.uk/products/os-open-rivers
Natural England Priority River Habitat Map. One of the two datasets that make up the Priority River Habitat Map. Consists of rivers and streams that exhibit a high degree of naturalness.	https://naturalengland-defra.opendata.arcgis.com/datasets/7e5dd3c72f424fd5bc6f013d18dd770c/explore
Geology Intertidal substrate foreshore (Ordnance Survey and British Geological Society	Defra MAGIC Map

Data type: Ownership, partnerships and responsibilities	Source
Foreshore and Coastline Ownership - The Crown Estate. A Web App by The Crown Estate for displaying Title and Ownership data for The Crown Estate Coastal Portfolio.	https://www.arcgis.com/apps/Viewer/index.html?appid=0aac22685d2f4d78a2a3b0a5aa1660db
Association of Inshore Fishing and Conservation Authorities. Map of regional boundaries, closure by fishing gear type and conservations areas. Not downloadable.	https://association-ifca.org.uk/map/
CABA catchment partnerships. The Catchment Based Approach (CaBA) is an inclusive, civil society-led initiative that works in partnership with Government, Local Authorities, Water Companies, businesses. CaBA partnerships are actively working in all 100+ river catchments across England and cross-border with Wales, directly supporting achievement of many of the targets under the Government's 25 Year Environment Plan.	https://catchmentbasedapproach.org/
Coastal Partnerships. Partnerships that are members of the Coastal Partnerships Network (CPN). The Partnerships, their networks, experience & expertise are available for integrating the delivery of statutorily required strategic plans	https://www.coastalpartnershipsnetwork.org.uk/
Local Nature Partnerships	Defra MAGIC Map

Data Recreation activities within marine sites	
England Coast Path Coastal margin. Line dataset showing all approved stretches of the England Coast Path Route. The England Coast Path Route is a new National Trail being created by Natural England under the Marine and Coastal Access Act 2009.	https://www.data.gov.uk/dataset/2cc04258-a5d4-4eea-823d-bf493aa31eef/england-coast-path-route
National Trails (England)	Defra MAGIC map
National Cycle Network The National Cycle Network is a UK-wide network of signed paths and routes for walking, wheeling, cycling and exploring outdoors. The interactive map is hosted by Ordnance Survey.	https://explore.osmaps.com/?lat=51.641136&lon=-2.923634&zoom=8.4445&style=Standard&type=2d&overlays=os-ncn-layer

Type of Data: Physical infrastructure and human activities	Source
MMO's website provides an overview of human activity including shipping, recreation, tourism, habitats, conservation areas, fishing areas (inc spawning grounds), culture and heritage. Note datasets have been gathered over different timescales and at different resolution. Local or more recent data should be used to augment this dataset where available.	https://explore-marine-plans.marineservices.org.uk/
Crown Estate manages the seabed and nationally owned sections of the coastline on behalf of the country. This includes the licensing of oil and gas, wind, tidal infrastructure including pipelines and cables as well as licensing of extraction and disposal. Dataset covers wind farms, cables, aggregate, tidal stream and carbon capture shapefiles	https://opendata-thecrownestate.opendata.arcgis.com/
Wave and Tidal energy research sites	The European Marine Energy Centre provides a database of wave and tidal projects https://www.emec.org.uk/marine-energy/wave-and-tidal-projects/
Fisheries data, effort	Vessel monitoring system data is not publicly available, contact the MMO for enquiries. Some aggregated and anonymised data may be available, for example, the 2020-2022 dataset
Spatial flood defenses. Environment Agency. The Environment Agency's (EA) Spatial Flood defences layer is the only comprehensive and up-to-date dataset in England that shows flood defences currently owned, managed or inspected by the EA. Flood defences can be structures, buildings or parts of buildings. Typically these are earth banks, stone and concrete walls, or sheet-piling that is used to prevent or control the extent of flooding.	https://www.data.gov.uk/dataset/cc76738e-fc17-49f9-a216-977c61858dda/aims-spatial-flood-defences-inc-standardised-attributes
UK Ports (coastal) Derived from the UK Ports (DfT) layer. This shapefile lists ports and harbours in the UK by status: company and private ports, trust ports, or municipal and other publicly operated ports. The list does not claim to be comprehensive. But all commercially significant ports are included, as well as a number of smaller ports and harbours around the UK coast. Note: The dataset is considered draft.	https://www.arcgis.com/home/item.html?id=eb85f4f485e34a1693b36d9c95786cfe
UK Harbour Masters' Association (UKHMA), website provides information for port and harbour users, marine professionals and members of the public. Many areas provide 'open information' which is free to access by all. The link provided in the data tool is for port locations.	https://www.ukhma.org/port-locations/
UKHO Ferry services datalayer: Ferry services Contains line information on transportation and route areas captured by the UKHO. It has been created by the UKHO as a "Electronic Navigational Chart" component product and is optimised for use in the enhancement of navigational safety. The layer files included are: Berth locations, deep water route, ferry route, recommended route and traffic separation scheme. (last updated 2015).	https://environment.data.gov.uk/dataset/723432c8-7f00-4559-9a0b-fb3b43c0c467
GIS layer showing the location of slipways and boat launches.	http://www.boatlaunch.co.uk/
Raw Environment agency information on sewage discharge events including duration. Requires some processing in order to generate shape layers.	https://www.data.gov.uk/dataset/19f6064d-7356-466f-844e-d20ea10ae9fd/event-duration-monitoring-storm-overflows-annual-returns
Monthly Fishing Statistics. Landings into UK ports by year and month. This provides an indication of the economic value of inshore fishing activity. However it does require filtering for ports of interest and UK boats.	https://www.gov.uk/government/publications/2023-uk-and-foreign-vessels-landings-by-uk-port-and-uk-vessel-landings-abroad-provisional-data https://www.gov.uk/government/collections/monthly-uk-sea-fisheries-statistics
A comprehensive list of charter boats on the English Coast	https://www.charterboats-uk.co.uk/england
A GIS Shapefile showing the extents of the Licenced Marine Disposal Sites for all of UK, including England, Wales, Scotland, Northern Ireland, Jersey, Guernsey and Isle of Man.	https://data.cefas.co.uk/view/407

Defra MAGIC MAP

Data type: Management and planning boundaries for human activities	Source
Districts and unitary authorities (England and Wales)	Defra MAGIC Map
IFCA Management boundaries	https://association-ifca.org.uk/map/
IFCA Byelaws	https://association-ifca.org.uk/map/
Marine Plan Areas (MMO)	
Marine Management Organisation Marine Nature Conservation Byelaws. The Marine Management Organisation (MMO) is responsible for making byelaws in English waters to protect habitats and species from activities that may harm them. MMO has the power to make byelaws within 0-200 nautical miles (nm). For the management of fishing activities, MMO leads on management between 6-200 nm, with the Inshore Fisheries and Conservation Authorities (IFCAs) leading in the 0-6 nm area. Byelaw information and spatial data download are available.	https://www.gov.uk/guidance/marine-conservation-byelaws
Countryside Rights of Way	http://www.openaccess.naturalengland.org.uk/wps/portal/oasys/maps/MapSearch/
Shoreline Management Plans. Assess the risks from coastal flooding and erosion and identify how to manage these risks over the short, medium and long term. Also currently being updated.	https://environment.data.gov.uk/shoreline-planning
Water Framework Directive coastal and transitional waterbodies	Defra MAGIC Map
Water Framework Directive Management Catchment	Defra MAGIC Map
Historic England Regions	Defra MAGIC map
Bathing Waters	Defra MAGIC map

Data type: Conservation Designations	Source
Natural England's Information on designated sites includes: • Local Nature Reserves, • National Nature Reserves, • Sites of Special Scientific Interest (including those that are proposed), • Ramsar, • Marine Conservation Zones, • Special Areas of Conservation and • Special Protection Areas. It can be searched by type of designation, by county or by combination of search terms. Provides maps, site information, background information and geography, site maps, feature condition, conservation objectives for the site and features and information on the sensitivity of features for the site to the pressures exerted by different activities. Note: some information links to Defra MAGIC map and other external websites.	https://designatedsites.naturalengland.org.uk/SiteSearch.aspx https://www.gov.uk/government/collections/conservation-advice-packages-for-marine-protected-areas
Marine Conservation Zones are areas that protect a range of nationally important, rare or threatened habitats and species. There are 91 MCZs in waters around England. These were designated in two phases after a process closely involving stakeholders.	https://naturalengland-defra.opendata.arcgis.com/datasets/marine-conservation-zones-england/explore Defra MAGIC Map

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Natural Capital Committee. 2017. How to do it: a natural capital workbook. Department for Environment Food and Rural Affairs. 30pp. https://assets.publishing.service.gov.uk/media/6017ebe2e90e07128a353a72/ncc-natural-capital-workbook.pdf

Natural Capital Assets

Natural capital assets are the living and non-living parts of ecosystems that provide value to society, they include species and habitats. Within a natural capital approach, identifying natural capital assets underpins the subsequent identification of Ecosystem services and the Goods and Benefits derived from these.

Overview

Natural capital approaches usually need to consider different aspects of natural capital assets., This section introduces natural capital asset identification and classification, focusing on coastal and marine habitats and mobile species (categorised under fish, birds, mammals). The guidance covers:

- What are natural capital assets and how to classify them
- Natural capital asset baselines and information limitations
- Natural capital asset registers/ asset inventory
- Natural capital logic chains
- Data to support natural capital asset mapping
- Approaches to collecting new data
- Best practice recommendations for evaluating natural capital assets within a natural capital approach

Depending on resources and objectives, the assessment may undertake:

- **Basic approach**: Use existing resources as part of a short desk-based assessment to compile a basic asset register, with evidence on asset quantity
- **Better approach**: Seek to identify more detailed data from a range of sources and consider quality (condition) of assets or spatial distribution (configuration)
- **Best approach**: Commission new data directly through survey work or with stakeholder input to collect new data or ground truth existing data to assess asset quantity, quality and spatial configuration

The approaches used will be influenced by the objectives of the assessment and the resources (time, expertise, budget, evidence) available.

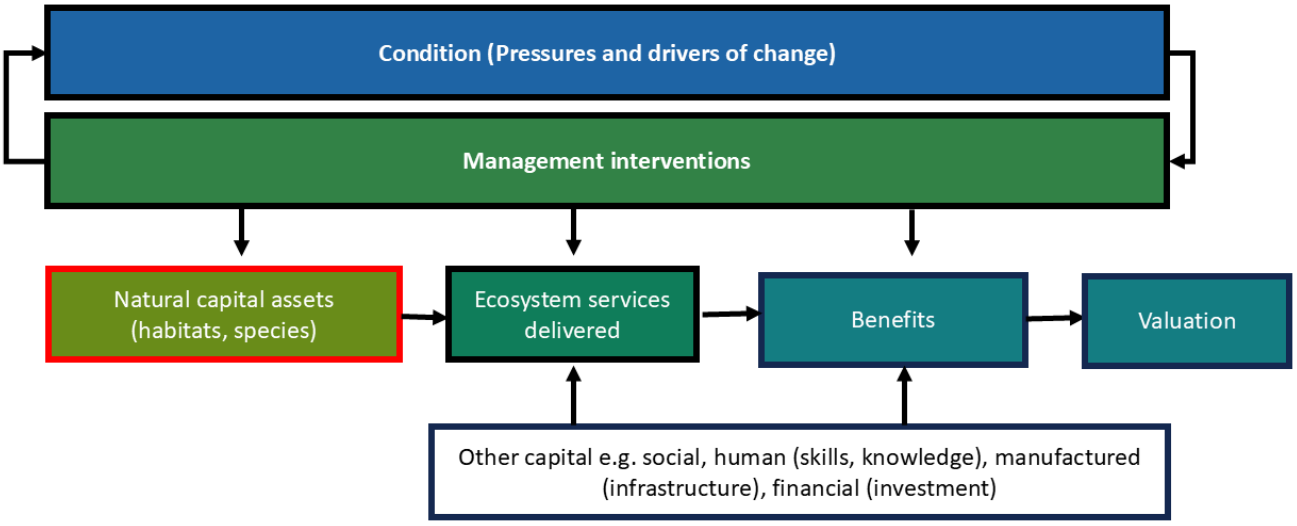

Figure 1: The natural capital logic chain shows that stocks of natural capital assets support the provision of ecosystem services

Components

Guidance flowchart: natural capital assets

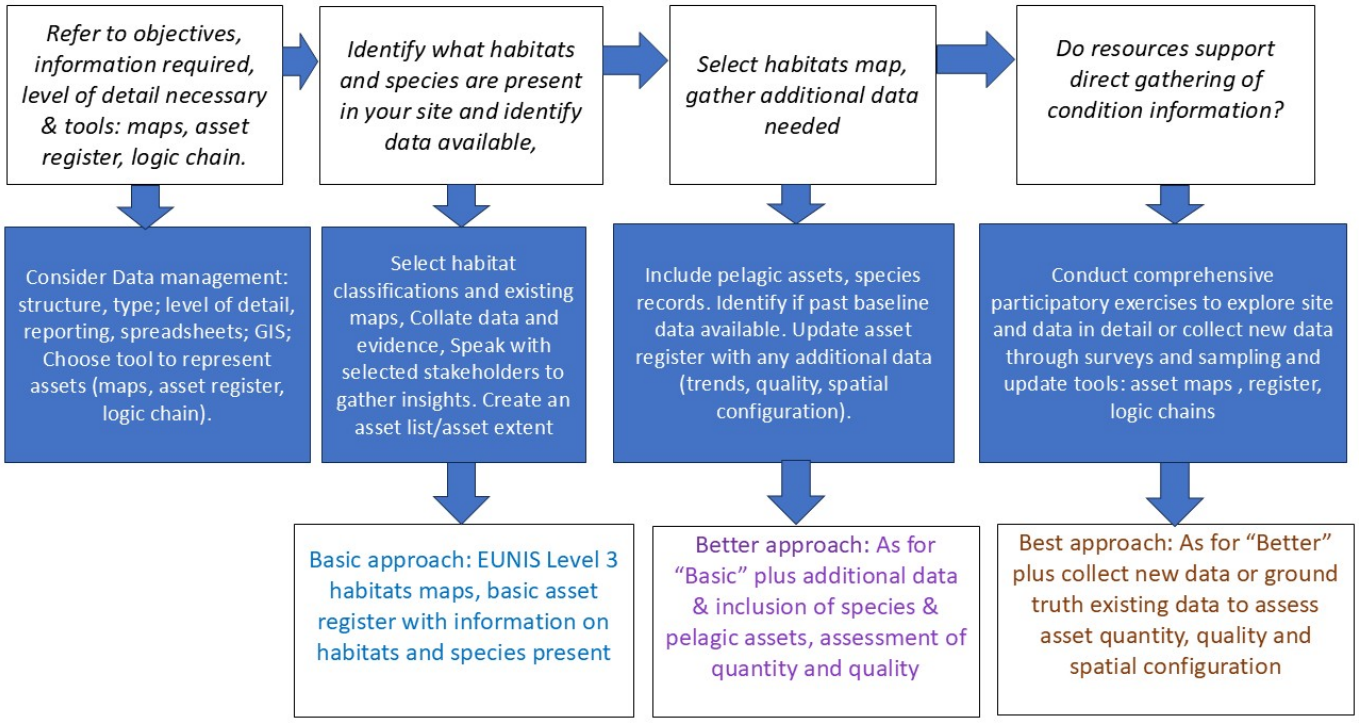

Figure 2: Steps to follow to support natural capital asset assessment for marine and coastal ecosystems

What are natural capital assets and how to classify them

Natural capital assets are the components of the environment, both living (biotic) and non-

living (abiotic), that typically provide ecosystem services through their functions and processes. Within this guidance, three main asset classes are considered,:

- Seabed (benthic habitats) that include both subtidal and intertidal
- Water column (pelagic assets)
- Mobile species (birds, fish and mammals)

Seabed (benthic) habitat assets

Seabed habitats considered in the guidance include intertidal and subtidal habitats. Seabed habitats are typically classified based on a range of factors that may include:

- Depth, e.g. intertidal, or based on light penetration which varies at depth, infralittoral (typically plant dominated) or circalittoral (typically animal domianted)
- Substratum type, e.g. rock, or sediments such as sand, mud and mixed sediments
- Wave and current energy, e.g. high energy, moderate enery, tide swept
- Species present, such as seagrass, kelp beds, saltmarsh

A wide range of habitat classifications for seabed habitats are available that are currently, or have previously been, used for UK habitat reporting and management. There is a limit to the number of distinct habitats that can be feasibly and cost-effectively considered within natural capital assessments and reporting, although this will vary with the scale and purpose of the assessment. The choice of which classification to use is likely to be a pragmatic choice balancing the objectives of the natural capital assessment and the data that are available. In some instances, a mix of habitat classifications may be used.

The two main classifications that are recommended, are interlinked and are described below. However, both were updated in 2022 and while previously they were strongly linked it is not clear how much they have diverged. The UK Marine Habitat Classification has had more limited changes but there are bigger revisions to the EUNIS classification. New correlation tables and crosswalks are expected to be published soon. Both approaches are still recommended and other tools to support natural capital assessment use the older classification (for example the MarLIN MarESA assessments that link the sensitivity of habitats and species to pressures are still linked to the older 2018 EUNIS codes).

The UK Marine Habitat Classification

The Marine Habitat Classification for Britain and Ireland (JNCC, 2022) is freely available. It is widely recognised and used by Government bodies, academic institutions, and the private and charity sectors as a system for the consistent description of habitat types. The classification lists all seafloor habitats currently known to occur in UK waters. These habitats are organised in a hierarchy whereby each level introduces more detail. For a natural capital study users may choose a broader or more detailed level on which to base the assessment depending on purpose. The site provides descriptions for each habitat and additional resources including maps. Users may also want to take a mixed approach, incorporating both broadscale habitats and those that are locally or regionally important or that deliver key

ecosystem services. JNCC provide guidance on how to use the habitat classification.

The European Nature Information System (EUNIS, European Environment Agency (2021)

The EUNIS habitat classification covers the terrestrial and marine habitat types of the European land mass and its surrounding seas. It is hierarchical in structure and includes a key with criteria for identification of habitats at the first three levels. The underlying database and interface via the EUNIS website include text descriptions and environmental parameters, and relationships to several other classifications and to legislative systems that draw upon this classification. The classification is freely available through the website portal.

Tool: JNCC Habitat correlation tables to compare classifications

The UK Maine Habitat Classification is closely aligned with the EUNIS habitat classification. Correlation tables provided by JNCC show the possible relationships between habitats in the Marine Habitat Classification for Britain and Ireland, the marine section of the EUNIS classification and those listed as being important for conservation under various legislative instruments (e.g. Annex I habitats, OSPAR habitats). The correlation tables are periodically revised as habitat definitions are refined. Two tools are available to investigate these correlations: the correlation spreadsheet and the correlation database. These two tools contain the same correlations presented in two different ways.

Note: The current correlation table and database do not include the new Marine Habitat Classification for Britain and Ireland version 22.04. The tables are currently under development following the changes in classification. The older 2018 version will still be useful for linking habitats to conservation designations and tools such as the MarLIN MarESA sensitivity assessments.

Other habitat classification systems that have been used for natural capital approaches

A range of other habitat classification systems are available and applied in the UK. These are described briefly. The habitat correlation table shows the inter-relationships between the UK National Ecosystem Assessment (UK NEA) and the European Union Mapping and Assessment of Ecosystem Services (MAES), the UK Land Cover Map (LCM) and the UK Marine Habitat Classification.

Habitat classification inter-relationships

Zone	Category	UKNEA		MAES		Land Class Map	UK Marine Habitat Classification
		Habitat	Habitat class	Habitat	Habitat class	Habitat	Broad habitat

Supra-littoral		Land cover	Sand dunes, Machair, Shingle, Sea cliffs				Supralittoral rock Supralittoral sediment	
Littoral		Pelagic	Coastal lagoons	Coastal margin	Low/reduced salinity water (of lagoons), variable salinity water (coastal wetlands, estuaries, other transitional waters), Marine salinity water (of other inlets). Coastal waters.	Marine inlets and transitional waters; coastal	Saltwater	
		Benthic	Saltmarsh, intertidal rock, intertidal sediments		Littoral rock & biogenic reef, littoral sediment		Saltmarsh, Littoral rock, Littoral sediment	A2.5 Saltmarsh A1. Littoral rock A2. Littoral sediment
Sub- littoral	Shallow	Pelagic		Marine	Coastal water			
		Benthic	Subtidal rock Shallow subtidal sediment		Shallow sublittoral rock & biogenic reef Shellow sublittoral sediment			A3. Infralittoral rock A.4 Circalittoral rock A.5 Sublittoral sediment
	Shelf	Pelagic			Shelf waters	Shelf		
		Benthic	Shelf subtidal sediment		Shallow sublittoral rock & biogenic reef Shelf sublittoral sediment			Infralittoral rock Circalittoral rock Sublittoral sediment
	Deep sea	Pelagic			Oceanic waters	Open ocean		

UK National Ecosystem Assessment (NEA)

The UK NEA classification is a hybrid of high intertidal (supralittoral, splash zone) and intertidal (littoral) habitats. However, it includes only two intertidal habitats (coastal lagoons and saltmarsh), while most intertidal habitats such as mudflats, other intertidal sediments and rocky shores are excluded.

UK Habitat Classification

UKHab has been designed to build on existing classifications. It is a fully translatable, hierarchical system that integrates with all major classifications in use in the UK and Europe. The system includes translation tables that allow legacy datasets to be translated into UKHab and for habitat data collected using other systems to be seamlessly integrated. For example, UKHab is designed to integrate with large-scale GIS-based habitat datasets, such as the Centre for Ecology and Hydrology (CEH) Land Cover Map. UKHab also links closely with the broad habitats from theUK National Ecosystem Assessment (2011) and Natural England's Natural Capital atlases. However, coverage of coastal and subtidal marine habitats is incomplete, and this classification is of limited use where subtidal habitats or more detailed habitat mapping is the approach focus.

EU MAES programme

The UK is no longer a collaborating partner to the European mapping and assessment of ecosystems and their services (MAES) programme. Nevertheless, users may find some outputs of this project- including the habitat classification- useful. The habitat classification selects broad habitat categories and includes biogenic reefs. Unlike the other classifications, MAES also considers pelagic habitats alongside benthic, with salinity levels differentiated, as well as different marine zones (e.g. coastal, shelf and oceanic).

Other coastal habitats

Other potential classifications for habitats above mean high water mark include the National Vegetation Classification, and Phase 1 and Phase 2 habitat classifications.

Key considerations when selecting a habitat classification

Habitat classification systems that have been applied in the UK are detailed below. When selecting which to use for a study the following will form the basis of selection.

1. **Ensure classification is fit for purpose and includes or differentiates between key habitat assets**
   A limitation of broad habitat classifications is that these either do not represent the biological assemblages that are present or do not differentiate between habitats that

may provide different levels of ecosystem services. For example, mud and sand habitats provide different levels of ecosystem services, and including these as a single 'intertidal sediment' will not capture these differences. Vegetated habitats (saltmarsh and seagrass habitats) and biogenic habitats such as oyster, worm or mussel reefs typically provide higher levels of ecosystem services (Potts et al., 2014) than sediment and rock habitats: therefore, for natural capital assessments it is likely to be important to capture these habitats, particularly at a local scale where detailed assessments may be required.

2. **Consider the data available and whether it can align with the chosen classification**
   A range of habitat datasets will be available at the national and local scale. The choice of which to use will balance pragmatism based on the purpose of the assessment, the resources available and any work planned to supplement these. For the purposes of a basic desk-based study, a broad habitat classification that is supported by existing studies may be adopted to provide a generic example whereas a more detailed, well-resourced study may decide to use the existing data and classifications and then build a more bespoke and detailed approach.

3. **Consider stakeholders and expertise available**
   The stakeholders or audience for the assessment will have different levels of knowledge and expertise. Broad habitat classifications or more distinct habitat types are more likely to be easily communicated to and understood by stakeholders. Many of the more detailed technical classifications based on biological communities included within the UK Marine Habitat Classification and EUNIS will be unfamiliar to most stakeholders. Classifying habitats to the biological assemblage level will also require more detailed sampling of species in most cases and data coverage is likely to be more limited for most areas. NOTE: Participatory mapping with stakeholders has a role here (mainly for intertidal habitats) as it can be used to turn local knowledge into maps which can be used to quantify the extent and location of marine habitats using satellite images or aerial photography. See the section on **stakeholder engagement** for more information.

Water column (pelagic) habitats

The **water column** overlying seabed habitats is also a natural capital asset (often referred to as the pelagic habitat). Large numbers of species (from plankton to whales) move through the water column. Some species may use different habitats (including seabed) and different areas within the water column for different phases of their lifecycle so that links to assets and services may be complex. For example, some fish lay their eggs on sediment, the young hatch and feed at surface layers or in nursery habitat sindhore, where the adults may spend more time offshore and in deeper habitats.

Habitat classifications for the pelagic ecosystem are less developed and detailed than

benthic habitat classifications. Defining pelagic habitats is complex as these do not have distinct boundaries. In most pelagic systems the prevailing conditions result from factors including:

- Bathymetry (depth and shape (topgraphy) of underwater terrain)
- Location
- Temperature
- Salinity
- Oxygen
- Circulation
- Carbon dioxide
- Light and turbidity

Aspects of pelagic habitats may be:

- **Permanent** such as depth and coastal features
- **Persistent**, based on the climate and hydrography any may vary seasonally, such as density current flows, frontal formation and stratification
- **Variable** such as changes in temperature, changes in salinity from rain, winds and tides

Progress has been made on developing **pelagic classification typologies** with:

Nine pelagic broad scale (Level 3) habitat classifications developed by EUNIS. The EUNIS classification text notes that because of the strong temporal variation in pelagic habitats, the classification of a water column in an area may change throughout the year.

MSFD Commission Staff Working Paper (2017) includes the category ‘water column habitats’ with divisions representing a simplified version of the EUNIS classification of pelagic water column (A7). The MSFD categorises pelagic habitats at four levels; variable salinity, coastal, shelf and oceanic/beyond shelf. These categories align with the MAES habitat typology.

Recent natural capital work and expert consultation (Cefas, 2021, MMO 2022) suggests that pelagic assets can be placed in one of two categories represented as:

- **Coastal pelagic assets**, which occur from the intertidal (MHWS) extending seaward up to one nautical mile. The Water Framework Directive’s (WFD) Transitional and Coastal boundary layer (Environment Agency, 2021) can be used to represent coastal pelagic assets.
- **Shelf pelagic assets,** which occur from one nm off the coast outwards to the edge of the Exclusive Economic Zone boundary line. The OSPAR Commission’s (OSPAR).

Ecohydrodynamic zones can be used to represent the shelf pelagic assets (Cefas, 2021).

The ecohydrodynamic zones have been constructed based on key water column features, which are important to plankton community (which should be considered an embedded part of pelagic habitats) structure and dynamics and are being used as the spatial basis of OSPAR reporting for plankton and oxygen indicators. There are six predominant types:

- Permanently mixed throughout the year
- Permanently stratified throughout the year
- Regions of freshwater influence (ROFIs)
- Seasonally stratified (for about half the year, including summer)
- Intermittently stratified and; indeterminate regions (inconsistently alternate between the above levels of stratification)

Maps for the UK are available from the Marine Online Assessment tool and in OSPAR assessment reports.Each of these pelagic assets should be considered as individual water masses that have a similar set of characteristics within that water mass- such as water temperature, nutrient load, turbidity and water current speeds- that differ to those water masses adjacent to them (MMO, 2022).

Coastal and marine species

Species are a natural capital asset that directly or indirectly support the provision of ecosystem services.

Micro-organisms, fungi, plants and algae and invertebrates, fish, birds and mammals all form part of the stock of coastal and marine natural capital assets.

It is not usually practical to assess all species present within a site, due to diversity, evidence and monitoring constraints. Natural capital asset assessments typically select a sub-set of species that meet the assessment objectives. These may include species of conservation interest, those that are of particular interest due to local significance or that support key ecosystem services. Examples include:

- Target fish for recreational fishers,
- Seals, dolphins and whales for nature watching
- Large burrowing worrms for waste remediation

Some species may already be monitored for conservation or other purposes providing useful data on presence and population trends that may act as both assessments of assets and stock and condition indicators (see guidance section on **condition)**. .

Less mobile species (invertebrates, plankton, micro-organisms and plants)

Less mobile benthic and plankton species may be considered as part of the benthic or pelagic habitat they are embedded within (Mulholland et al., 2021).

Very small organisms -such as micro-organisms, fungi and smaller invertebrates- are not included in habitat classifications (or monitored unless they are pathogens).

The ecohydrodynamic zone approach proposed for pelagic assets does embed plankton within the pelagic asset by considering the factors that are key to plankton communities.

Larger invertebrates such as oysters and mussels and species that form vegetated habitats (seagrass, saltmarsh and seaweeds) are recognised where these characterise habitats within the EUNIS and UK Marine Habitat Classification, e.g. seagrass beds and mussel beds. For each habitat the JNCC marine habitat classification identifies characterising species, and these characterising species are listed on the relevant JNCC webpages for each habitat and in spreadsheets for older versions of the classification (all available online).

Mobile species (fish, birds, mammals, cephalopods, reptiles)

Populations of mobile species are important natural capital assets.

Population data may be collected for some mobile species, such as:

- Long term monitoring of bird populations at nesting sites
- Commercial fish stocks because fisheries management includes the regular monitoring, mapping and modelling of mobile stocks.

However, other mobile species are less well understood.

Mobile species may be more difficult to link to specific areas due to their mobility or migratory nature. They may be linked to more than one habitat or area. Different habitats may also be important for different life stages. For example, juvenile fish may use one habitat as a fish nursery, but adult fish may live in a completely different habitat. Similarly, migratory (e.g. cetaceans, seals and birds) and anadromous species (e.g. salmon and trout) use numerous habitats over their lives.

Natural capital assessments at site level are likely to be interested in the **types of species** that are present and will need to source **additional data** on abundance, population demographics and locations of key habitats (e.g. breeding/nursery areas, feeding areas, resting areas such as seal haul-outs or roosting sites for birds). The case studies in this guidance provide examples and links are provided below to data.

Natural capital baseline, is information available?

The Natural Capital Committee's (NCC) 'How to do it: a natural capital workbook' explains that before making decisions, the baseline position of natural capital assets needs to be understood in order to set a starting point against which to measure changes. This baseline could be either the current situation or a historical baseline. In either case, setting the baseline will involve:

- Identifying previous habitat and species quantity (extent) and quality (condition)
- Including information on past human activities and pressures (see site context).

Identifying past data on **presence, extent and condition** of habitats and species is useful for later stages of a natural capital assessment to understand changes in **condition and for monitoring and management assessments**. For example, information on species and

habitat trends provide insight into changes in site condition and may be useful for identifying restoration opportunities.

Data for past conditions may be quite limited, especially for less accessible subtidal habitats and for mobile species that are not readily recorded (although there may be fishing records for fish stocks). The data catalogue contains a few examples of projects with national datasets for past locations for habitats that are of conservation and restoration interest (saltmarsh, seagrass and native oyster).

Baseline information availability is likely to be highly variable. Local datasets or other useful information may be held by local archives, record centres or similar. Local experts and stakeholders may be aware of these. Locations where there are or have been research stations are likely to have far more survey information available. Historic archives may contain information on fishing licences and permits (in Plymouth, for example, the city archive holds oyster fishery permits dating to the late 18th Century). With time and resources there may be the opportunity to undertake investigations using a range of sources. Project examples include the use of historic paintings to understand coastal change, photographs or other records.

Natural capital asset register/ asset inventory

A natural capital asset register is an inventory of the assets in an area and their condition. Developing an asset register supports a systematic approach to defining natural capital in the study area (at any scale). The development of an asset register and its usage in later stages of a natural capital assessment (if applicable) will be determined by the project's purposes.

An asset register typically defines assets according to their type, quantity (extent) and quality (condition) and will use maps and Geographical Information System (GIS) layers where possible (Natural Capital Committee, 2017).

The Natural Capital Committee (2017) provides guidance (although not a formal methodology) for developing an asset register and the type of information that should be included. A suggested format for an asset register is a summary table, which may be adequate for basic projects but for more complex work will be supported by documentation, evidence spreadsheets and mapping using GIS.

A simple asset register is shown below (Table 1) based on the habitat asset register developed for the Cornwall case study. The register is linked to the older 2018 EUNIS habitat classification (EUNIS levels 3 and more detailed Level 4 which identify the community present), as data were available in this form.

More detailed asset registers will provide additional information based on habitat extent and condition and spatial distribution configuration. A description of the information required and suggested options/examples of cell content is presented below (Table 2), based on guidance by Hooper & Austen (2020). This represents a better or best approach and for many assessments this data may not be available or only available for some habitats. If data is not available for the natural capital assets, the guidance on condition assessment identifies how

to generate some of this information using condition assessments based on exposure to human activities.

Table 1: Cornwall case study habitat asset register (selected habitats only) showing extent and proportion of assessed sea area.

EUNIS Code	EUNIS Description	Habitat Area (ha)	Area as % of Sea Area
A3.1	A3.1: Atlantic and Mediterranean high energy infralittoral rock	16675.10	1.58
A4.1	A4.1: Atlantic and Mediterranean high energy circalittoral rock	69792.65	6.6
A4.12	A4.12: Sponge communities on deep circalittoral rock	850.04	0.08
A4.2	A4.2: Atlantic and Mediterranean moderate energy circalittoral rock	15242.41	1.44
A4.27	A4.27: Faunal communities on deep moderate energy circalittoral rock	28598.95	2.71
A4.3	A4.3: Atlantic and Mediterranean low energy circalittoral rock	1406.70	0.13
A4.33	A4.33: Faunal communities on deep low energy circalittoral rock	18345.19	1.74

Table 2: Asset register information categories for a more detailed register, description and options examples of options for cell contents (Hooper & Austen, 2020)

Column header	Description	Options/examples* for cell contents	Approach
Quantity	A quantified assessment of the area, volume or number of individuals (as appropriate).	e.g. 6.7km^2, 3,184 individuals	Basic
Quantity trend	Where time series data is available or can be estimated, the broad trend in the quantity of the asset should be noted, which can be represented visually,	e.g. as directional arrows. Improving; Stable; Declining	Better/best
Quality rating	Quality rating should be given on a categorical scale, which can be represented visually. (See condition section for additional information on assessing quality)	e.g. as a traffic light system. Poor; Moderate; Good	Better/best
Quality trend	Where time series data is available or can be estimated, the broad trend in the status of the asset should be noted, which can be represented visually,	e.g. as directional arrows. Improving; Stable; Declining	Better/best

Spatial configuration (habitats only)	The degree to which the asset is spatially coherent (i.e. occurs in patches of sufficient size to support effective ecological functioning, and has connections to other areas) and appropriately sited to provide ecosystem services. (See condition section for additional information on assessing spatial configuration)	Poor; Moderate; Good	Better/best
Spatial configuration trend (habitats only)	Where time series data is available or can be estimated, the broad trend in the spatial status of the asset should be noted, which can be represented visually, e.g. as directional arrows.	Improving; Stable; Declining	Better/best

Natural capital asset logic chains

Natural capital asset logic chains demonstrate the relationship between natural capital assets (the basis of the chain), the ecosystem services they provide, the benefits that can be or are realised from the services and (potentially) the value of these benefits. Natural capital logic chains have been developed and used by a number of UK projects (see Natural England's Natural Capital Indicators Project: Natural Capital Atlas (Natural England)).

How to develop a full chain is described throughout this guidance with further relevant information in the sections on **condition** (for assessments of quality), **ecosystem services** and **valuation**.

Natural England has developed a range of logic chains for coastal and marine habitats. The level of detail included will vary. A basic logic chain provides a simple overview of the concept that natural capital assets support delivery of ecosystem services and benefits (Figure 2). Further examples of natural capital logic chains range from basic and generic versions as shown in Figure 2 and 3, to a more detailed version for a specific asset and ecosystem service (Figure 4) that takes a documentary approach and identifies indicators, ecosystem service flows and benefits and value considerations.

Depending on project objectives, all of these may be developed at different points of an assessment or for different audiences, and all may be supported by evidence that is documented or recorded in spreadsheets that are updated as projects progress.

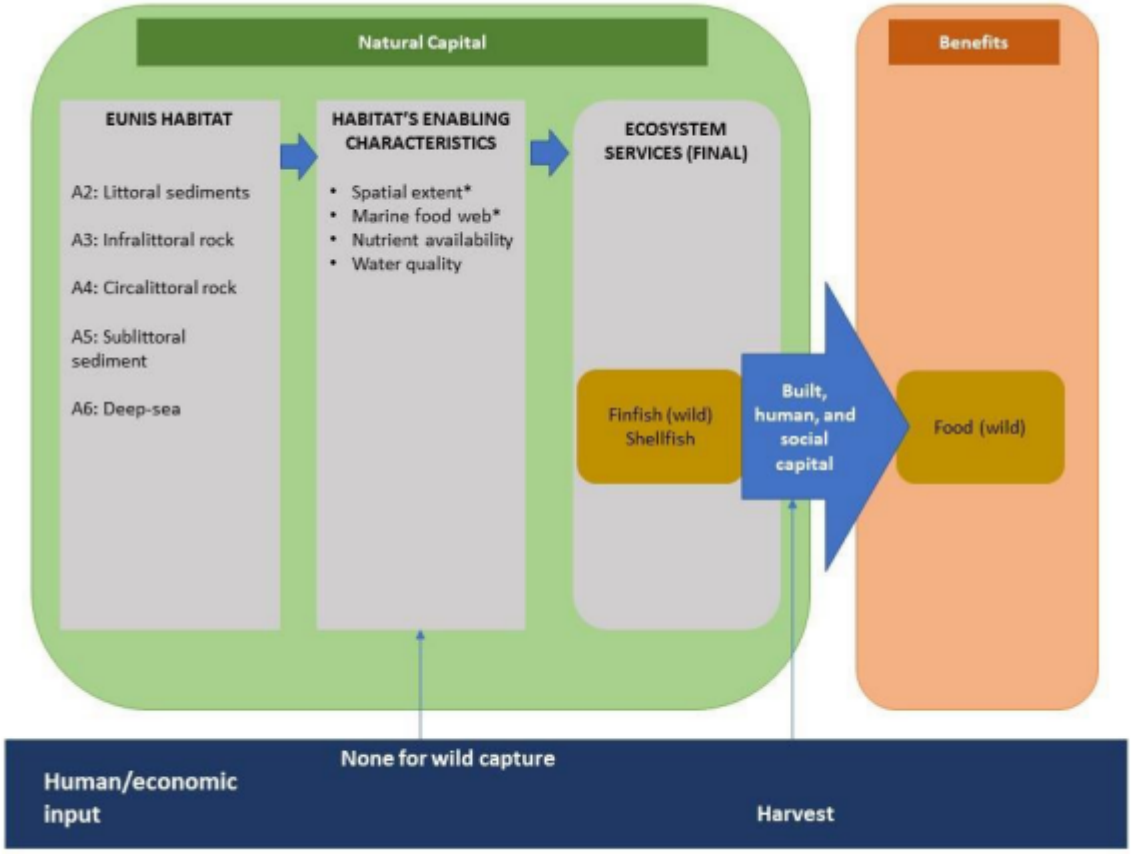

Figure 3: A simple logic chain that identifies natural capital assets, ecosystem services and benefits for wild seafood (from Mulholland et al. 2021)

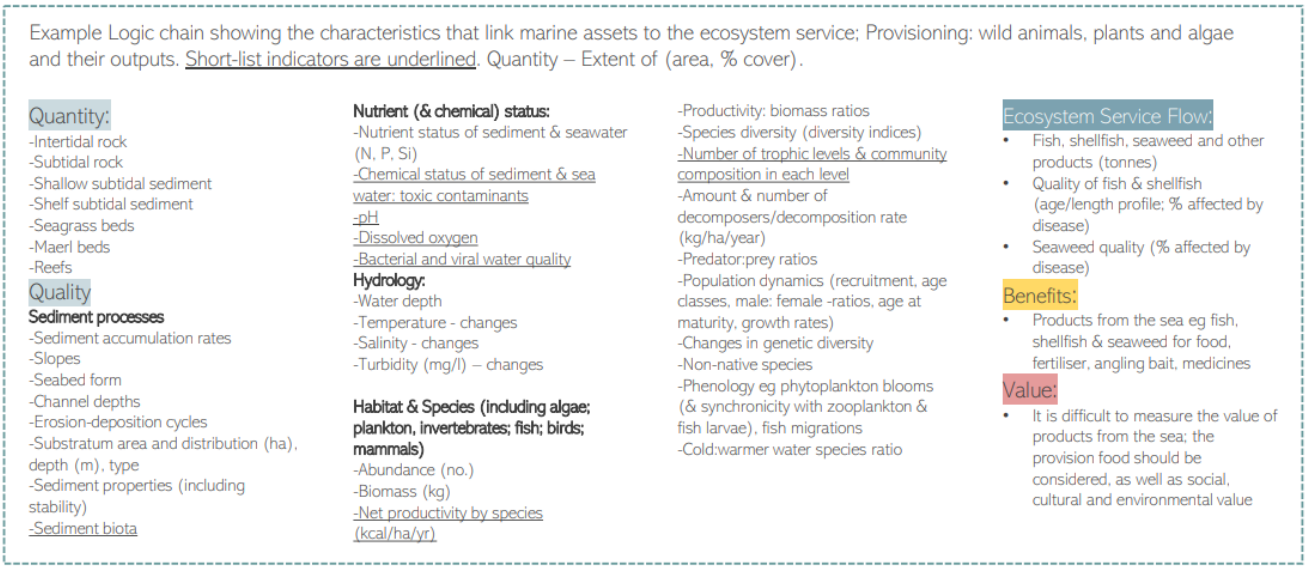

Figure 4: Example of a detailed logic chain developed by the Natural England Indicators project that links habitat asset extent and quality to ecosystem services, benefits and valuations

Resources: Natural Capital Logic Chains

1. **Natural England's Natural Capital Indicators Project: Natural Capital Atlas (Natural England))**
   Aims to identify key attributes for measuring change in natural capital assets in

England, at a range of scales. Natural capital assets were based on the eight broad habitat types as identified by the UK National Ecosystem Assessment (UKNEA) and natural capital logic chains were developed to show how ecosystem services and benefits flow from the natural capital assets. Indicators for quantity (extent), and quality (condition) are identified. The data package contains the shapefiles for the indicators mapped in these atlases. The data package is available for all of England, enabling users to explore the data layers in more detail. The accompanying GIS User Guide and ArcMap package (which runs in 10.2.2 or later) will help basic GIS users to download, open and explore the map data further. Coastal margin habitats are presented and marine habitats to 12nm.

2. **Nearshore water quality and pelagic asset status - ME4504 (Cefas)**
   Previous work evaluating marine natural capital has focussed on benthic habitats as the predominant descriptor of marine natural capital. However, the coastal, or 'nearshore', waters of England are a key part of the country's natural capital, providing a diverse range of benefits to society through provisioning, regulating and cultural services. This project was undertaken to develop the natural capital approach for management of nearshore water. To improve understanding of the link between nearshore water asset status and delivery of societal benefits across policy areas, logic chains were developed connecting attributes of nearshore water asset status with ecosystem service delivery. The project also undertook a monitoring and indicator assessment review to identify key information gaps that could be addressed by future data collection and evaluated the impacts of activities on water quality attributes.
   Le Quesne, W., Best, M, Capuzzo, E., Devlin, M., Greenwood, N. and Nelson, M. 2022. Nearshore Water logic chains and data & indicator review. Cefas Project Report for Defra, 52 pp.

Data to support natural capital asset mapping

Habitat data resources

A number of data resources are available that map coastal and marine habitats and species.

JNCC Habitat maps

JNCC compiles seafloor habitat maps of all types and classification systems from across the UK, from the shore to the deep sea. JNCC standardises maps by translating into a standard classification scheme – EUNIS. Metadata and confidence levels are provided. The maps are available at EMODnet.

JNCC provides links to a variety of maps including those of conservation interest. **UKSeaMap 2018** gives a broad-scale overview of the coverage of different physical seabed habitats in the UK. It is classified according to three schemes:

- Marine Habitat Classification for Britain and Ireland v15.03
- EUNIS marine habitat classification system, with additional deep-sea zones

- MSFD benthic broad habitat types

JNCC EUNIS Level 3 combined habitat map

The JNCC EUNIS Level 3 map provides complete coverage and consistent classification of the nearshore and offshore plan area. However, the layer does not cover the entire intertidal area and supralittoral zone.

Natural England Marine Habitats layer

The NE Marine Habitats supplies data into the JNCC EUNIS Level 3 combined habitat map. However, the NE Marine Habitats provides an advantage over JNCC EUNIS Level 3 combined habitat map by generally extending up to highest astronomical tide.

Regional Coastal Monitoring Programme (RCMP)

These Habitat Maps provide comprehensive maps of habitats (natural capital assets) relevant to shoreline management. The RCMP Habitat Maps are used for Biodiversity Action Plans, shoreline management plans and the development of flood and coastal defence schemes. The map classifies coastal and terrestrial habitats within the intertidal zone and coastal hinterland. They provide coverage of the intertidal and supralittoral zones, which are not covered in the JNCC EUNIS Level 3 combined habitat map.

Centre of Ecology and Hydrology Land Cover Map

The Centre of Ecology and Hydrology's (CEH) Land Cover Map dataset is created by classifying summer-winter composite satellite images to a resolution of 10 m2 providing an overall accuracy of 83% (CEH, 2011). The Land Cover Map (CEH, 2017) includes supralittoral and littoral rock, sediment and vegetated habitats. These are mapped and assessed in the same way as terrestrial habitats although as the snapshot is based on satellite images, the tidal state will influence the extent of mapped intertidal area. The latest UKCEH Land Cover Map is based on data from the year 2020, and it is intended that Land Cover Maps will begin to be released annually. The charges and licensing for obtaining the data depend on the type of intended use.

CORINE Land cover maps

CORINE Land Cover (CLC) data is open source and provides information on the extent of broad habitats. CORINE Land Cover Map datasets for the UK, Jersey and Guernsey provide consistent information on land cover and land cover changes across Europe. The inventory was initiated in 1985 (initial year 1990) and then established a time series of land cover information. Updates were made in 2000, 2006 and 2012, and most recently 2018. Coastal and marine relevant classes are: coastal lagoons; estuaries and open sea; saltmarshes; intertidal flats; beaches and dunes.

Difference between CEH Land cover map and CORINE Land cover map

CORINE data covers Europe. The smallest mappable data unit is 25 hectares. This dataset is available from the European Environment Agency and can be downloaded free of charge from their web site. The CEH maps cover the UK and are spatially more detailed, with the range of products including 10m, 20m, 25m and 1km raster data sets, as well as a vector product. The land cover classes (i.e. the habitat classification) used are also different to CORINE. Costs to access will vary depending on institution and use.

Species and habitat data resources

Marine Recorder

Marine Recorder Online is a UK data management system which supports the capture and storage of marine habitats and species data. Marine Recorder was originally built to funnel records from the Marine Nature Conservation Review programme (MNCR) to the National Biodiversity Network (NBN Atlas). The Marine Recorder database holds information on UK marine benthic data such as species, biotopes and physical attributes. Data extracted from a Marine Recorder database into a queryable format is known as a Marine Recorder Snapshot. This is an Access database (not mapped) and does not require installation of the Marine Recorder application. JNCC periodically compiles and combines all local Marine Recorder Snapshots into a single UK-wide version. A public version of this snapshot is available for download. Marine Recording is currently being updated to a cloud-based solution. Marine Recorder records are shared with the MEDIN Archive for Marine Species and Seabed Habitats Data (DASSH).

Local Environmental Records Centres (LERCs)

LERCs are not-for-profit organisations that collect, collate and manage information on the natural environment for a defined geographic area. LERCs each cover a defined geographical area, usually a county but in some cases several counties. Each LERC supports biological recording, provides a range of data products and services, and has knowledge and contacts in their area. Typically each LERC charges for access to data held in their systems.

DASSH The Archive for Marine Species and Habitats Data

Accredited through the MEDIN partnership, and core-funded by the Department for the Environment, Food and Rural Affairs (Defra) and the Scottish Government, and the UK node of OBIS, DASSH provides tools and services for the long-term curation, management, preservation and publication of marine species and habitats data, within the UK and internationally. DASSH data holdings can be accessed via the metadata catalogues, and the DASSH Data Mapper which allows users to identify the area of interest and the data available

for that area.

DASSH holds datasets provided by a variety of public and private bodies, and individual researchers. The data or imager provider will be stated in the associated metadata. Data providers retain copyright of the original data or imagery but have given DASSH their permission to hold a copy within the data archive. All data are freely available at the point of access.

The National Biodiversity Network (NBN) Atlas

The NBN Atlas collates records from various organisations and Local Environment Record Centres into a national picture. Data can be accessed through a free online web portal in which users can browse and download marine and terrestrial biodiversity data. The NBN combines multiple sources of information about species and habitats, with the ability to interrogate, aggregate and analyse these data in a single location. 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 their own use. The NBN is the UK node of the Global Biodiversity Information Facility and so it also provides a mechanism for disseminating species data internationally.

Habitats and species within sites designated for conservation

UK Protected Area Datasets for Download

JNCC holds datasets for all MPAs in UK offshore waters (outward of 12 nautical miles from the coast) and datasets for some types of MPA in all UK waters (inshore and offshore).

- **UK National Site Network (SAC and SPA): site summary details spreadsheet 2023**
  Downloadable spreadsheet contains the latest UK-wide data for all sites in the UK National Site Network. It includes habitat features with extent and cover information available for some habitats and information for species with records available for some. This data can only indicate presence rather than an accurate population census.
- **UK Offshore Marine Protected Areas**
  The downloadable shapefiles and spreadsheet contain boundary, site and feature information for designated UK offshore Marine Protected Areas (MPAs) (beyond 12 nautical miles from the coast). Offshore MPAs include Marine Conservation Zones (MCZs), Highly Protected Marine Areas (HPMAs), Special Areas of Conservation (SACs) with marine components and Special Protection Areas (SPAs) with marine components. The spreadsheet provides the same site attribute data as well as information on the sites' protected features (including feature names, feature codes and species population types) but not extent or abundance data.
- **Ramsar sites**

JNCC maintains datasets for all Ramsar sites in the UK. JNCC provides summary data for all UK Ramsar sites and their habitats and species features (spreadsheet format). The Ramsar site spreadsheet and Ramsar site shapefiles can be downloaded from the JNCC Resource Hub.

- **Natural England (DSS)**
  NE and their Conservation advice package status mapper links to all of the relevant materials on the DSS.

Mobile species data resources

Joint Cetacean Data Programme (JCDP)

JCDP is a collaborative international initiative which aims reduce the barriers to accessing cetacean (whale, dolphin and porpoise) data and support uptake of the growing evidence being collected via multiple means. The JCDP provides a platform and set of resources to support the collection and utilisation of standardised cetacean survey data. These resources include a Data Standard (developed with MEDIN), a Data Portal, and Metadata catalogue, along with this Information Hub, which provides guidance on the collection, collation and use of these data.

Seabird monitoring program

The Seabird Monitoring Programme (SMP) monitors breeding seabirds throughout the UK, the Isle of Man and the Channel Islands on an annual basis to provide data for the conservation of their populations. The locations sampled during the annual SMP provide some information on distribution and are accessible via the Seabird Monitoring Programme online database.

Habitat and species data: caveats and limitations

Habitat data

- Only a small area of the sea bed around the UK (typically inshore areas) has been sampled and mapped. Modelled data are used to fill many of the gaps. Modelled data that exist such as UKSeaMap are limited in accuracy.
- The nature of the marine environment makes data collection both difficult and expensive. Knowledge of the location and extent of habitats across most of the marine area is highly uncertain. A natural capital assessment that gathers its own data (from survey or stakeholders) on the extent and condition of marine benthic habitats has greater potential at smaller spatial scales, e.g. for an individual protected area.

Species data

- There tends to be more data on frequency and distribution of species, than on abundance as it is very difficult to record the latter for some species. For many groups only frequency data are available.
- There tends to be a spatial bias to recording. Some areas of the country are better recorded than others, possibly due to population density or the presence of experts in particular organisations.
- There is also a temporal bias as recording may have improved (or declined) in intensity over time.
- Microorganisms are poorly studied, especially at large spatial scales.
- For many species groups, the coverage of the data available are inconsistent in terms of taxonomic coverage (only a few species are monitored or recorded) and the spatial coverage of data is limited.

Approaches to collecting new data

To generate new data on natural capital assets, two approaches are available:

- to work with stakeholders to identify existing site knowledge
- to gather new field data.

A wide variety of options are available for conducting field surveys with chosen approaches depending on the target habitat and species. Such work is usually undertaken by specialist consultancies with relevant expertise, although the use of citizen scientists is becoming increasingly common with best practice emerging. Data gathering by professionals can be resource intensive, particularly for subtidal habitats where boats and dive teams or equipment such as drop down cameras or underwater robots (Remotely Operated Vehicles) are required. Costs will be highly variable depending on the approach selected.

A less resource intensive alternative is to **work with stakeholders** using methods such as participatory mapping to assess and update existing data (Burdon et al., 2022). In participatory mapping exercises, stakeholders with relevant knowledge are encouraged to amend and add detail to existing habitat and species maps or to create new maps from aerial or satellite images. These can then be digitised and captured in a GIS platform. Although this approach is likely to improve the level of accuracy of existing data, the resulting maps may still need to be validated and uncertainties may remain (Burdon & Potts, 2020). See **stakeholder engagement** section for more information.

Guidance documents: Field surveys- Chosen approaches for gathering field data vary according to the habitats and

species

A range of resources are available to provide guidance on different methods.

An accessible introduction and handbook that is aimed at supporting field survey by communities (citizen scientists) is provided by the Community-led Marine Biodiversity Monitoring Handbook. Although developed for Scotland much of the guidance is applicable to the entire UK. This handbook is split into six chapters and covers the information required to undertake marine biodiversity survey and monitoring. The handbook provides a guide to survey planning and getting started safely, a range of survey methods and specific operational guidance for survey equipment and techniques.

JNCC provides an introductory guide to Subtidal Data Collection: Survey Methods and Equipment.

The JNCC Marine Monitoring Method Finder provides a range of technical guidance that brings together a wide range of monitoring guidelines and procedures.

Citizen science approaches

Citizen science can broadly be defined as the involvement of volunteers in science. Most ecological and biological projects provide information on elements of natural capital assets (species, habitats) and may therefore directly or indirectly provide information on assets (stock) and/or condition by assessing some aspect of the stock (population size, demographics, changes in distribution etc.).

Guidance: participatory mapping

Burdon, D. and Potts, T. (2020) Participatory mapping of natural capital and benefits: method guidance document. Report produced for the MMO and Suffolk Marine Pioneer.

Best practice recommendation: Natural Capital Asset Register

To apply the natural capital approach it is recommended that users:

- Use well-defined and replicable classification systems for both natural capital assets and ecosystem services. Basing natural capital assessment on a classification that more closely follows a recognised hierarchy will provide a robust and systematic basis for the categorisation of assets.
- Develop an asset register/ inventory as a structured way of presenting information. The complexity and content of the asset register will depend on the project objectives and the data available;
- In developing an asset register, it is recommended that the UKHab classification is used

for terrestrial and freshwater habitats where required and that the UK Marine Habitat Classification linked to EUNIS is used for seabed habitats (although updates are still in the pipeline, following the 2022 revision of both classification systems).
- For coastal pelagic assets, from the intertidal to seaward (up to one nautical mile) use the Water Framework Directive's (WFD) Transitional and Coastal boundary layer (Environment Agency, 2021). For Shelf pelagic assets, which occur from one nm off the coast outwards to the edge of the Exclusive Economic Zone boundary line use the OSPAR Commission's (OSPAR) Ecohydrodynamic zones.
- Selected seabed habitat classifications should ensure vegetated habitats and biogenic reefs are adequately represented and separated from broader habitat classes.
- Natural capital classifications should consider the pelagic environment, the WFD coastal waterbody definitions should be used for inshore (out to 1 nm), beyond that the OSPAR ecohydrodynamic area units should be used.
- If studies apply a different definition of water pelagic assets, where possible, these should be able to nest directly on to the inshore and offshore assets defined

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Ecosystem services

Ecosystem services are functions and products from nature that can be turned into benefits with varying degrees of human input, such as fish caught from the sea, or waste remediation processes (Natural Capital Committee, 2017).

Overview

This section provides guidance on ecosystem services that are supported by marine natural capital assets, covering:

- Guidance flowchart: ecosystem services
- What are ecosystem services?
- Classifying ecosystem services
- Useful tools: asset-service and asset-benefit matrices
- Which to use, an asset service or asset-benefit matrix?
- Asset-service linkage caveats and limitations
- Gathering data on ecosystem services
- Links to ecosystem service data
- Best practice recommendations to apply ecosystem service classifications and frameworks

Depending on resources and objectives, the assessment may apply a:

- **Basic approach:** High level characterisation of natural capital asset to ecosystem service links based on generic frameworks
- **Better approach**: As for "Basic" plus incorporation of site knowledge to support asset linkages and level of ecosystem services, including temporal or spatial trends*
- **Best approach:** As for "Better" plus more engagement and data gathering to provide site level assessment.**

* As an example see Isles of Scilly asset and risk register developed using the ecological knowledge of fishers (Ashley et al., 2020)

** As an example see the North Devon asset and risk register, applying workshops to gather community weighting of natural capital, ecosystem service relationship and risk of losing the service, (Rees et al., 2019)

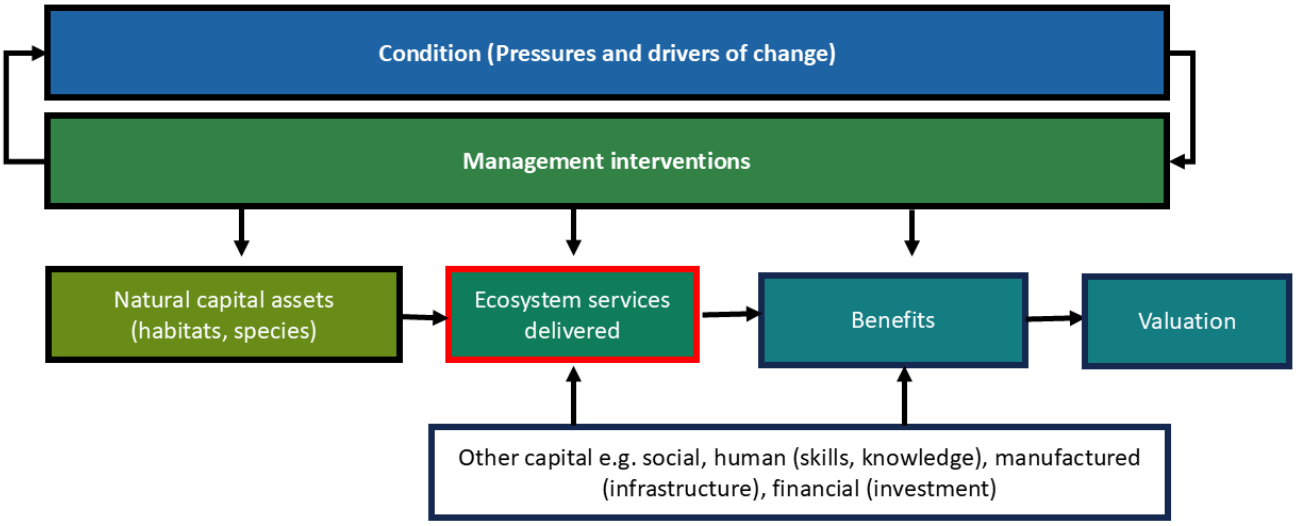

Figure 1: Natural Capital conceptual framework, the logic chain shows that ecosystem services are provided by the stocks of natural capital assets.

Components

Guidance flowchart: ecosystem services

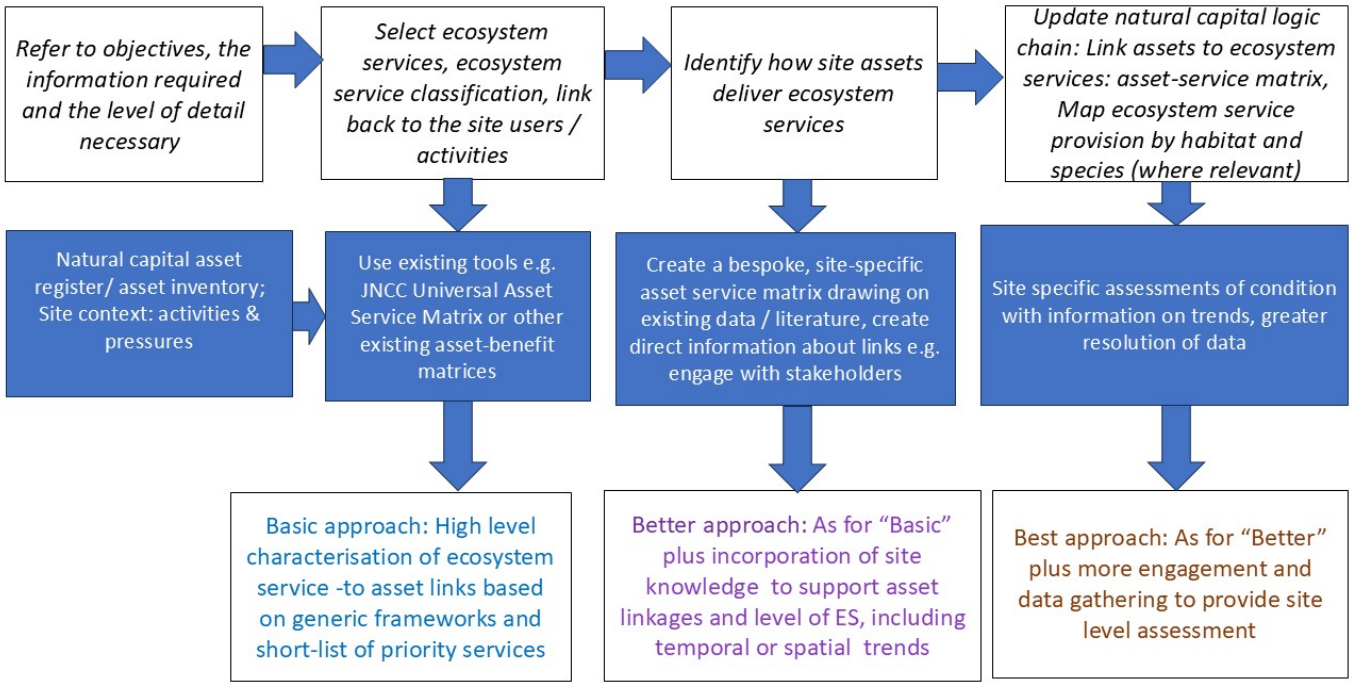

Figure 2: Steps to follow to support ecosystem service assessment for marine and coastal ecosystems

What are ecosystem services?

Ecosystem services are defined as functions and products from nature that can be turned into benefits with varying degrees of human input, such as fish caught from the sea, or improvements to water quality by biological processing or storage of wastes in sediment (Natural Capital Committee, 2017). The stocks of natural capital (assets) and the ecosystems within which they are embedded, provide flows of ecosystem services over time (see Figure 2).

Assessing the link between stocks and ecosystem services is a core component of natural capital assessments. Some services require human capital to realise benefits (e.g. fishing to get seafood) (Maes et al., 2013). Other services are free flowing, with benefits obtained passively without the need for human input (e.g. carbon sequestration), however, their use may depend on other factors influencing uptake. For example, there may be capacity held in benthic habitats to provide 'waste remediation' across large areas, but the supply of this ecosystem service is only prevalent where those habitats are most exposed to waste (for example in areas exposed to runoff from rivers).

Benefits are changes to human welfare that result from ecosystem services. The realisation of benefits from the flow of ecosystem services typically requires human inputs including **manufactured capital** (e.g. fishing vessels, port infrastructure), **human capital** (e.g. the time, knowledge and skills of fishers) and **social capital** (e.g. relationships within and between fisher communities, and their relationships with other communities). These capital inputs are not covered in this guidance, but information about beneficiaries and the value of services is covered in the **valuation** section.

Capacity to supply a service is held in the assets that have relevant features or functions, that are needed for that ecosystem service. For example, the capacity to supply the ecosystem service 'disturbance prevention' is supported by features that dissipate wave energy such as the presence of rock or vegetation (kelp, saltmarsh). Both living (biotic) assets and the non-living (abiotic) features of an area may be important in terms of determining capacity to supply a service.

Capacity will often depend on the state or condition of the asset but typically understanding this link is a current gap in knowledge. For some services, we know little about the link between where the assets supply the ecosystem service and where benefits arise, but for others we have more understanding. For example, for fishing there may be local benefits such as jobs and and income, but the broader benefits of nutrition and health from the seafood extracted could be felt much more widely, dependent on how far a particular output is distributed in the supply chain. For individual stocks of migratory species the area where the species is fished and/or landed, may be far away from important nursery and feeding grounds, creating uncertainty in the spatial link between the supporting natural capital assets and the ecosystem service.

When approaching the assessment of ecosystem services, it is important to note that:

- The concept of ecosystem services is highly anthropocentric. Ecosystem functions and / or processes (see guidance below) can only be considered services in the presence of humans to benefits from them. For example, marine habitats can provide coastal protection, but if there are no houses or businesses or other valuable pieces of land behind the coast benefiting from the coastal protection, the service of coastal protection should not be captured in a natural capital assessment.
- To avoid double counting in valuation or natural capital accounts, natural capital assessments should clearly differentiate between ecosystem services and benefits. For example, carbon sequestration is an ecosystem service and the net human benefit results from the climate control. Where possible, it is the final benefit that should be valued (although this can be challenging in practice).

Abiotic characteristics that influence ecosystem processes and functions

Abiotic characteristics influence ecosystem processes and functions either directly or indirectly through effects on natural capital assets and the processes and the functions they provide. Important characteristics include:

- Water temperature
- Water chemistry
- Sediment/substratum type
- Large-scale weather events
- Light attenuation
- Water movement (currents and waves)

Ecosystem processes and functions that underpin ecosystem services

Ecosystem functions are the processes and components associated with biota that support or provide ecosystem services (de Groot, 2002). Typical biotic components and processes, or their characteristics, that are regarded as ecological functions underpinning ecosystem services include:

- Primary production
- Secondary production/ nutrient cycling
- Larval and gamete supply
- Formation of species habitats

To support natural capital assessments and the valuation of benefits, considerable effort has been devoted to understanding how ecosystem services differ from natural capital assets (or components), ecosystem processes and functions, and benefits. The framework developed by the UK National Ecosystem Assessment (UK NEA) describes how marine ecosystem natural capital assets and processes support intermediate services (the ecological functioning of the

ecosystem) and how these deliver ecosystem services and goods and benefits to people. The ecosystem cascade captures the relationship between processes and functions to benefits (Figure 3).

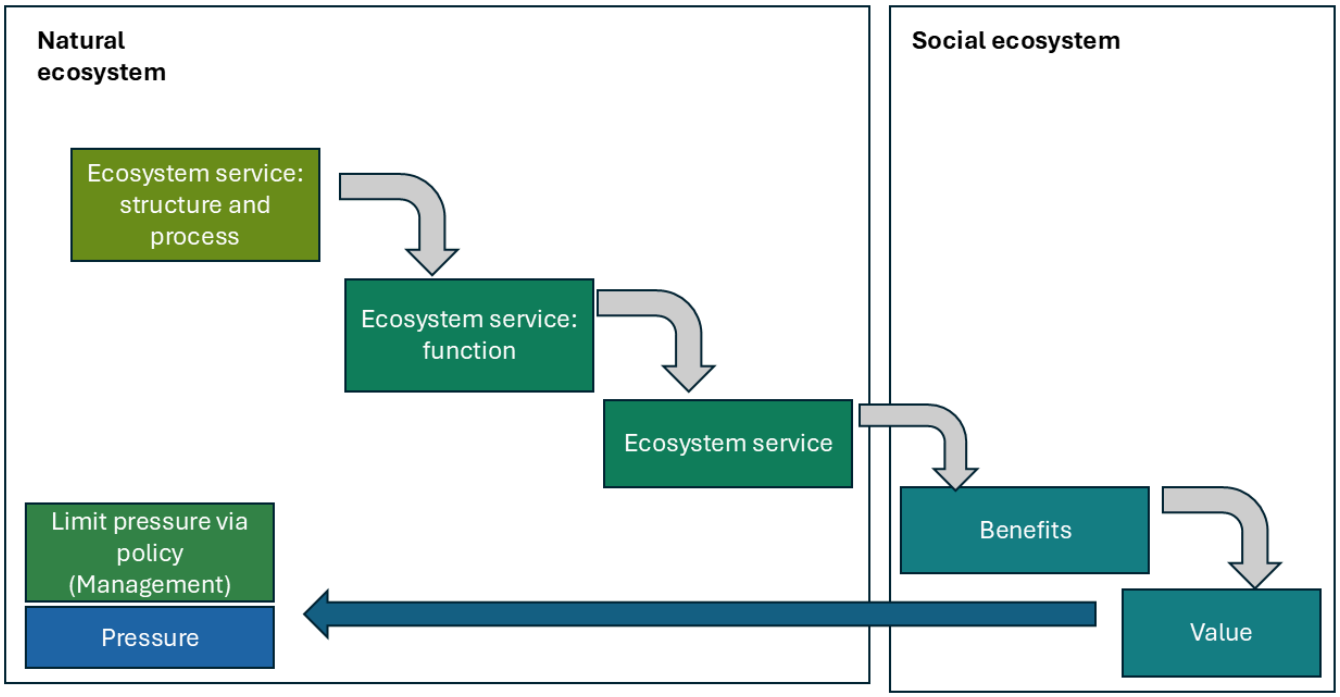

Figure 3 Ecosystem service cascade (figure redrawn following de Groot et al., 2002)

Species identity and abundance

The presence of specific species is found to be important for most services, including species-based recreation and the provision of fish, food and raw materials. Keystone species are those with a key role in maintaining particular ecosystem or ecosystem states and strongly influence the supply of ecosystem services from that particular habitat. Examples include vegetated habitats (kelp, seagrass, and saltmarsh) and biogenic habitats (bivalve reefs).

To support natural capital assessments and the valuation of benefits, considerable effort has been devoted to understanding how ecosystem services differ from natural capital assets (or components), ecosystem processes and functions, and benefits. The framework developed by the UK National Ecosystem Assessment (UK NEA) describes how marine ecosystem natural capital assets and processes support intermediate services (the ecological functioning of the ecosystem) and how these deliver ecosystem services and goods and benefits to people (Figure 3).

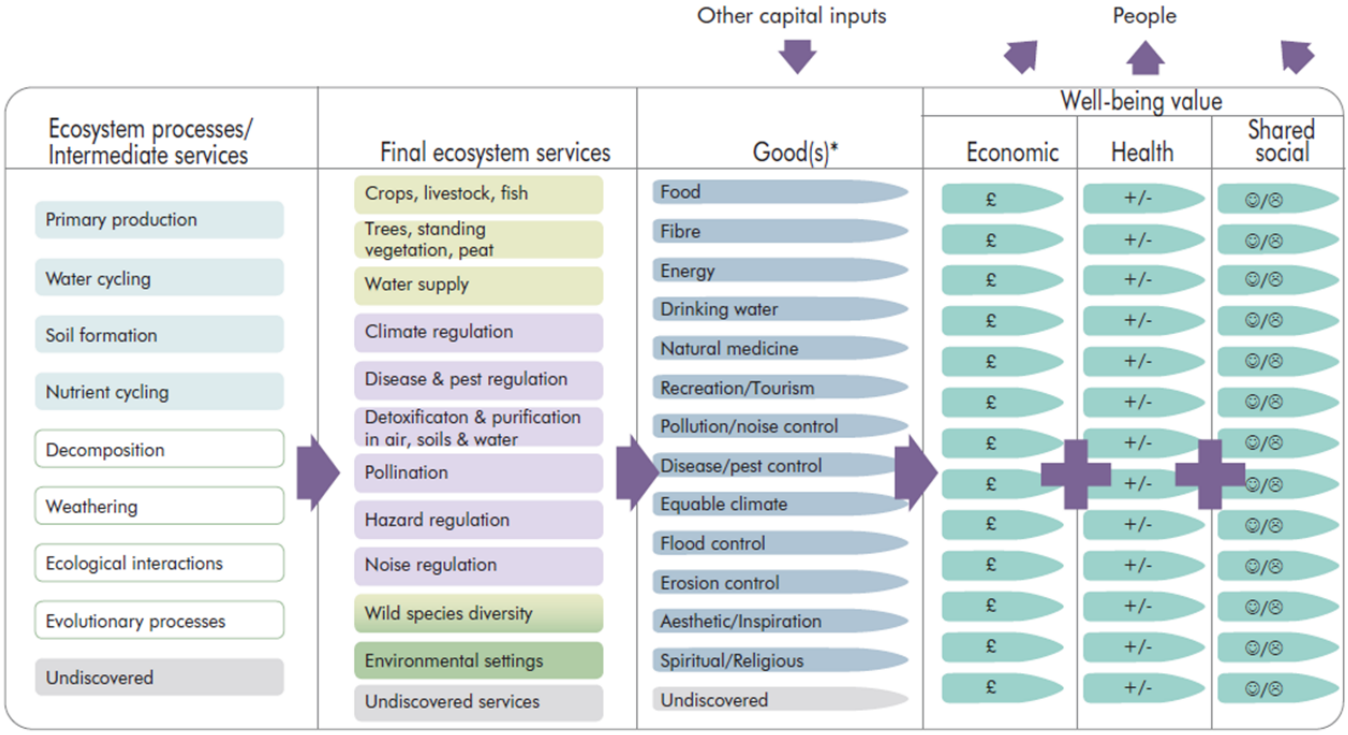

Figure 2.3 The full set of ecosystem processes, services, goods/benefits and values used in the UK NEA. Note that some ecosystem services can be both intermediate and final services. For simplicity, in this figure, services are shown only in the most final position that they occupy. Services such as pollination and climate regulation that also play important roles further back in the chain are not represented here. Cells with no colour are ecosystem processes/services that were not in the Millennium Ecosystem Assessment classification. *Note that the term good(s) includes all use and non-use, material and non-material outputs from ecosystems that have value for people. Source: adapted from Fisher *et al.* (2008).

Figure 4: Ecosystem service cascade demonstrating the relationship between the natural and social ecosystem and links to pressure.

Table 11.3 Goods and benefits provided by final ecosystem services from Coastal Margin habitats. ◉ denotes high, and ⊙ denotes some importance of each good/benefit; superscript numbers indicate which goods/benefits are relevant to each habitat; * denotes locally important; † denotes historical use; P = Provisioning service, R = Regulating service, C = Cultural service, S = Supporting service.

Service Group	Final ecosystem service	Goods/Benefits	Sand Dunes †	Machair ¶	Saltmarsh	Shingle §	Sea Cliffs **	Coastal Lagoons
P	Crops, plants, livestock, fish, etc. (wild and domesticated)	Crops: vegetables, cereals, animal feed	-	⊙	-	-	-	-
		Meat: sheep/cattle[1], rabbits[2†], fish/shellfish[3]	◉ 1, 2 *	◉ 1	◉ 1 *	-	⊙ 1 *	⊙ 3 *
		Wild food: Mushrooms[4], Salicornia[5], other plants/berries[6], fish/shellfish[7], wildfowl[8]	⊙ 4, 6	⊙ 4, 6, 7	⊙ 5, 6, 8	⊙ 6	⊙ 6	⊙ 7
		Wool: sheep	⊙ *	◉ *	⊙ *	-	-	-
		Genetic resources of rare breeds[9], crops[10]	⊙ 9	⊙ 9, 10	⊙ 9	-	⊙ 9 *	-
P	Trees, standing vegetation & peat/other resources	Reed/grass for thatching†, mats & basket weaving†	⊙	⊙	-	-	-	⊙
		Timber for wood pulp, furniture	⊙ *	-	-	-	-	-
		Turf/peat cutting	-	⊙	⊙ *	-	-	-
		Seaweed gathering for fertiliser	-	⊙	-	-	-	-
		Extraction of sand[11], gravel[12]	⊙ 11	⊙ 11	-	⊙ 12	-	-
		Military use	⊙	⊙	⊙	-	⊙	-
		Industrial use: pipeline landfall/energy generation	⊙	⊙	⊙	-	-	-
R	Climate regulation	Carbon sequestration	⊙	⊙	⊙	⊙	⊙	⊙
P R	Water quantity	Water for irrigation, drinking	⊙ *	⊙ *	-	⊙ *	-	-
R	Hazard regulation—vegetation & other habitats	Sea defence	◉	◉	◉	◉	◉ Indirect	⊙
		Preventing soil erosion	-	-	-	-	⊙	-
R	Waste breakdown & detoxification	Immobilisation of pollutants	-	-	◉	-	-	⊙
P	Wild species diversity including microbes	High diversity, or rare/unique plants, animals and birds, insects	◉	◉	◉	◉	◉	⊙
		Ecosystem-specific protected areas	◉	⊙	◉	◉	◉	⊙
		Nursery grounds for fish	-	◉	◉	-	-	◉
R		Breeding, over-wintering, feeding grounds for birds	◉ *	◉	◉	◉	◉	⊙

Figure 5

When approaching the assessment of ecosystem services, it is important to note that:

- The concept of ecosystem services is highly anthropocentric. Ecosystem functions and / or processes can only be considered services in the presence of humans to benefits from them. For example, marine habitats can provide coastal protection, but if there are no houses or businesses or other valuable pieces of land behind the coast benefiting from the coastal protection, the service of coastal protection should not be captured in a natural capital assessment.
- To avoid double counting in valuation or natural capital accounts, natural capital assessments should clearly differentiate between intermediate (or supporting) services, final services and benefits. For example, carbon sequestration is an ecosystem service

and the net human benefit results from the climate control. Where possible, it is the final benefit that should be valued (although this can be challenging in practice).

Classifying Ecosystem Services

Following the Millennium Ecosystem Assessment (MA, 2005), ecosystem services are typically grouped into the following categories:

- **Provisioning services** – products obtained from ecosystems, including food, fuel, timber and medicines.
- **Regulating services** – obtained from the regulation of ecosystem processes, including climate regulation, waste remediation, coastal protection, air quality regulation and nursery habitats.
- **Cultural services** – result from cultural practices, interactions and relationships with environmental spaces. Unlike provisioning and regulating services, they are not the result of ecosystem functions and processes alone.

A number of ecosystem service classifications have been developed (e.g. through the Millennium Ecosystem Assessment, The Economics of Environment and Biodiversity and the UK NEA, among others).The following guidance section in the drop down provides more information about a widely adopted framework, the Common International Classification of Ecosystem Services (CICES).

Common International Classification of Ecosystem Services (CICES) (recommended approach)

The Common International Classification of Ecosystem Services (CICES) is the approach we recommend using as CICES is one of the most commonly used classification systems for natural capital assessments.

The CICES classification aims to support **natural capital accounting and valuation** and is designed to reduce double counting, by focussing only on final ecosystem services and excluding intermediate and supporting ones. The CICES classification defines ecosystem services as the contributions that ecosystems make to human well-being, with these being distinct from the goods and benefits that people subsequently derive from them (represented as the social ecosystem side of the ecosystem service cascade diagram presented above. The definition of each service identifies both the purposes or uses that people have for the different kinds of ecosystem service and the particular ecosystem attributes or behaviours that support them (Haines-Young and Potschin, 2018).

The framework includes a wide-range of ecosystem services but not all are applicable to the marine environment. Projects that have identified the marine relevant services are Culhane et al., 2019 (used CICES version 4.3) and Tillin et al. (2019, used CICES version 5.1). The Classification has now been updated and CICES v5.2. is now available (Tip: Search for CICES v5.2 to download the Excel spreadsheet).

Table 1 provides a list of CICES ecosystem services that are likely to be a high priority for basic natural capital approaches and that were considered in the case studies.

Table 1 Shortlisted ecosystem services from CICES v5.2 providing user friendly names as used in the asset-service matrices and valuation in the case studies.

Ecosystem Service Level 2	Ecosystem Service Level 3 (user friendly name)	Description/Examples
	Provisioning	
Food	Cultivated seafood	Aquaculture
	Game and wild fish	Capture fisheries
	Non-food products from non-living sources	Aggregates
Water	Water supply	Desalination
Energy	Energy from non-living sources	Wind, wave, tidal energy
Carrier	Commercial and other transport	Movement of goods via waterways, cables, military training exercises
	Regulation and maintenance	
Environmental quality	Water quality	Dilution, animals/plants that filter waste
Refuge habitats and nursery, breeding, and feeding grounds	Nursery populations and habitats or breeding grounds	Seagrass and kelp forests acting as a refuge for juvenile fish
	Refuge habitats	Ross worm reefs as a refuge for pink shrimp
	Feeding grounds	Intertidal cockle beds supporting wading birds
Hazard and nuisance reduction	Erosion control	Macroalgae and biogenic reef structures contributing to sediment stabilisation
	Flood protection	Macroalgae beds and biogenic reefs contributing to attenuation of wave energy and flood prevention
Climate regulation	Environmental regulation	Sequestration of carbon

Useful tools: asset-service and asset-benefit matrices

Asset Service Matrices (ASMs) catalogue and describe known linkages between natural capital assets (habitats and species) and their associated ecosystem services. They also provide a visual summary of these linkages which can help make the information easier to digest. Typically, asset-service matrices provide some indication of the level of service flowing from the asset (e.g. none, low, medium, high) and the confidence in the link. **(Tip:**

These matrices provide a useful starting point to understand how natural cpaital assets may be supporting ecosystem services, they can be used for the basic approach, or as a starting point for better and best approaches).

A wide range of previous studies have developed or reviewed ecosystem service typologies and classifications. Key studies are not reviewed in detail here but the examples provided below include descriptive studies identifying ecosystem services and linkages to ecosystem components that provide these:

- Alexander et al. (2016) identified components of marine ecosystems critical to ecosystem service generation;
- Beaumont et al. (2007 and 2008) linked marine biodiversity to ecosystem services;
- Culhane et al., (2018 and 2019) linked marine ecosystems and specific components with ES;
- Fletcher et al. (2012) linked ecosystem services provided by MPAs linked to broad-scale habitats and features of conservation importance;

Common approaches to link natural capital assets to ecosystem services, include the development of asset-service matrices. Examples of these include:

- Key UK breeding seabird species and their relative contribution to the delivery of intermediate ES and goods/benefits (Burdon et al., 2017);
- European Diadromous fish linked to CICES class types using a matrix from combined evidence review and expert elicitation (Ashley et al., 2023)
- The relative degree of ES provision from habitats and species within UK Marine Protected Areas (MPAs) (Potts et al., 2014);
- **JNCC Universal Asset Service matrix (uASm)** that links ecosystem services to the assets (habitats and species) that produce them (Cordingley et al. 2023). **This is a key resource, see information below!**
- UK NEA 2011 Asset to benefit matrices rather than asset service.

Ecosystem service matrices can be used to generate diagrams which graphically represent connectivity between the ecosystem and the services it supplies, as well as the strength of the connections. These may be simple, such as Figure 2 or more complex such as the linkage diagrams (Sankey diagrams) used to support the assessment of the impacts of gradual habitat degradation on the availability of corresponding ecosystem services by Armoškaite et al., 2020.

Note: The level of certainty associated with such asset-service and asset benefit linkages depends on the underlying information used to construct the links.

The JNCC Universal Asset Service Matrix

JNCC has developed a Universal Asset Service Matrix (uASM) tool. This aims to make evidence for natural capital assets and their ecosystem services more accessible and

available to a wider audience.

This tool stores data from existing ASMs and the wider literature in a standardised format. The standardisation within the uASM allows users to export data into any commonly used habitat or ES classification and enables the creation of bespoke ASMs for specific contexts.

The uASM currently contains over 4,000 documented asset-ecosystem service linkages and continues to grow, demonstrating the wide range of ES delivered by UK marine habitats and coastal saltmarsh. Users can filter by natural asset or by ES and can choose to what resolution they conduct this. Further filters include ES supply level (a relative score to gauge to what degree the ES is being supplied) and confidence scores (confidence in the link – ranked high, medium or low depending on data source). Each link comes with a reference and so can be easily traced back to the resource it was extracted from.

Table: Habitat asset-service matrix example showing some habitats from the Cornwall case study. The source for these assessments is the JNCC uASM

Habitat	Wild Seafood	Water quality	Erosion control	Coastal protection	Climate regulation (carbon sequestration)	Wildlife watching	Aesthetics
A3.1 - High energy infralittoral rock	High	Med		High	Med	High	Low
	High	Med		High	Med		Low
	High	Med	Med	High	Med		Low

Project examples

UK National Ecosystem Approach (UK NEA)

An alternative approach to the JNCC uASM draws on the outputs of the UK NEA. The NEA assessed a suite of ecosystem benefits and services. Simple matrices assess the importance of coastal and marine habitats to different ecosystem goods and benefits on a scale of no, some or high importance. It symbolically indicates whether the contribution is locally important or represents historical use.
The assessments represent six coastal margin habitats (Sand Dunes, Machair, Saltmarsh, Shingle, Sea Cliffs and Coastal Lagoons) and the marine environment as a whole. The key distinction between the NEA approach and the JNCC universal matrix is that the NEA

approach primarily links habitat assets to ecosystem benefits, rather than ecosystem services.

Table 11.3 Goods and benefits provided by final ecosystem services from Coastal Margin habitats. ◉ denotes high, and ⊙ denotes some importance of each good/benefit; superscript numbers indicate which goods/benefits are relevant to each habitat; * denotes locally important; † denotes historical use; P = Provisioning service, R = Regulating service, C = Cultural service, S = Supporting service.

Service Group	Final ecosystem service	Goods/Benefits	Sand Dunes †	Machair ¶	Saltmarsh	Shingle §	Sea Cliffs **	Coastal Lagoons
P	Crops, plants, livestock, fish, etc. (wild and domesticated)	Crops: vegetables, cereals, animal feed	-	⊙	-	-	-	-
		Meat: sheep/cattle[1], rabbits[2†], fish/shellfish[3]	◉ 1, 2 *	◉ 1	◉ 1 *	-	⊙ 1 *	⊙ 3 *
		Wild food: Mushrooms[4], Salicornia[5], other plants/berries[6], fish/shellfish[7], wildfowl[8]	⊙ 4, 6	⊙ 4, 6, 7	⊙ 5, 6, 8	⊙ 6	⊙ 6	⊙ 7
		Wool: sheep	⊙ *	◉ *	⊙ *	-	-	-
		Genetic resources of rare breeds[9], crops[10]	⊙ 9	⊙ 9, 10	⊙ 9	-	⊙ 9 *	-
P	Trees, standing vegetation & peat/other resources	Reed/grass for thatching†, mats & basket weaving†	⊙	⊙	-	-	-	⊙
		Timber for wood pulp, furniture	⊙ *	-	-	-	-	-
		Turf/peat cutting	-	⊙	⊙ *	-	-	-
		Seaweed gathering for fertiliser	-	⊙	-	-	-	-
		Extraction of sand[11], gravel[12]	⊙ 11	⊙ 11	-	⊙ 12	-	-
		Military use	⊙	⊙	⊙	-	⊙	-
		Industrial use: pipeline landfall/energy generation	⊙	⊙	⊙	-	-	-
R	Climate regulation	Carbon sequestration	⊙	⊙	⊙	⊙	⊙	⊙
P R	Water quantity	Water for irrigation, drinking	⊙ *	⊙ *	-	⊙ *	-	-
R	Hazard regulation—vegetation & other habitats	Sea defence	◉	◉	◉	◉	◉ Indirect	⊙
		Preventing soil erosion	-	-	-	-	⊙	-
R	Waste breakdown & detoxification	Immobilisation of pollutants	-	-	◉	-	-	⊙
P	Wild species diversity including microbes	High diversity, or rare/unique plants, animals and birds, insects	◉	◉	◉	◉	◉	⊙
		Ecosystem-specific protected areas	◉	⊙	◉	◉	◉	⊙
		Nursery grounds for fish	-	◉	◉	-	-	◉
R		Breeding, over-wintering, feeding grounds for birds	◉ *	◉	◉	◉	◉	⊙

Marine Protected Area features

A literature review by Fletcher et al. (2012) delivered a baseline understanding of the marine ecosystem services provided by the broad scale habitats and features of conservation importance that were likely to be protected by Marine Conservation Zones (MCZs). Each feature was reviewed to identify the beneficial ecosystem processes and ecosystem services using a systematic search method. This approach was extended and elaborated by Potts et al. (2014) to include features from other marine protected area (MPA) designations. They

used a five-point scale to assess contribution and assigned three confidence levels (Table 5). The marine matrix was developed by Potts et al. in (2014) and reapplied in several different marine settings in the UK alone or in combination with final services from CICES.

The Potts et al. (2014) classification identifies: supporting services, regulating services, final ES and goods and benefits as shown below in Table 1 and the example matrix.

Table 1 Ecosystem services assessed by Potts and others (2014)

Supporting services	Regulating services	Goods and benefits from provisioning services	Goods and Benefits from Regulating services	Goods and Benefits from Cultural services
Primary production Larval / Gamete supply Nutrient cycling Water cycling Formation of species habitat Formation of physical barriers Formation of seascape	Biological control Natural hazard regulation Regulation of water and sediment quality Carbon sequestration	Food Fish feed Fertiliser Ornaments (incl. aquaria) Medicine and blue biotechnology	Healthy climate Prevention of coastal erosion Sea defence Clean water and sediments Imobilisation of pollutants	Tourism / Nature watching Spiritual / Cultural wellbeing Aesthetic benefits Education

Which to use, an asset-service or asset-benefit matrix?

While deciding whether to use an asset-service or asset-benefit matrix may seem an academic discussion, it has implications for natural capital assessments.

Asset-benefit matrices have the advantage that they more readily facilitate valuation (because benefits are the focus of valuation). Many of the benefits identified by the NEA and used by Potts and colleagues have been valued and are captured in the ONS marine natural capital accounts. They also lend themselves to further, more refined valuation. For example, Burdon et al. (2024) have developed a model (the BEACH tool) to disaggregate national level economic values from marine natural capital accounts according to the relative importance of EUNIS habitats in providing those benefits which are valued. Nevertheless, asset-benefit matrices are disadvantaged by a lack of a comprehensive benefit classification, especially in relation to cultural benefits. What is captured in the matrix may be a limited representation of the full suite of benefits. Where studies can only access indicators for limited ES and benefits then assessment is best viewed as an **underestimate** of the full suite of benefits.

A **limitation** of matrix approaches are that these does not take into account the condition of habitats and therefore assumes that one habitat type (e.g. saltmarsh) provides the same amount of services or benefit as another patch of the same habitat type elsewhere in the UK. In many cases the condition/service relationship data doesn’t currently exist and research in this area is on-going.

In addition, given the level of uncertainty in the linkages between assets and services, and services and benefits, removing services from the logic chain is likely to increase the uncertainty in the overall natural capital assessment.

The link between asset condition and benefit is not well established. A change in benefits derived from natural capital assets may simply reflect a change in human preferences, rather than the result of ecosystem change.

Asset- service linkage caveats and limitations

Ecosystem service classifications provide a strong conceptual basis for assessing ecosystem services but are usually modified to suit specific project requirements. Modifications include focusing on a subset of services, grouping others and applying project specific definitions.

The certainty in asset-service links is highly variable. In some cases the links are clearly demonstrated, for example, stocks of commercially targeted fish supply food. In other instances, the links are less tangible or are more likely to be highly variable, for example the link between marine habitats and blue carbon sequestration or how natural capital assets contribute to cultural benefits such as education and research. Cultural services can be particularly challenging to assess as they are highly reliant on place and situation. Understanding from one location can be difficult to transfer to different places, or upscale and confidence in indicator data needs to be acknowledged at all times.

Users should be aware that the classifications based on habitats typically do not relate ecosystem service provision to the components of natural capital that directly support the service. For example, while saltmarsh or mudflats provide erosion prevention,this does not recognise that it is the plants, tubes of invertebrates and films of tiny algae and microorganisms that supply the service. Many assessments also rely on generic asset service linkages (with all examples of a given habitat being considered in the same way, irrespective of the condition or extent of the habitat).

For most users, using habitats as the units that provide ecosystem is likely to be adequate, but the limitations of this generic approach should be recognised. It has implications when trying to understand how the service is supplied, how the service may be altered by pressures from human activity, and how to protect or restore the service. How specific species support ecosystem service delivery is an active area of research with the evidence base being developed. However, most evidence for specific components will be scattered through the scientific literature and will not be readily accessible.

Gathering data on ecosystem services

Other forms of gathering information on ecosystem services flow are to adopt the approaches described in the **valuation** section that involve stakeholders. Examples of these approaches for the marine environment are participatory mapping approaches (Burdon et al., 2022) and the community voice method (Ranger et al., 2016) trialled in Orkney (as one example).

An example of a full review of all data sources identified for UK sites covered by Natural Capital Asset and Risk Registers (against MMO criteria for indicators robustness, scalability, transparency, etc) is the State of the Sound report (Rees et al., 2023). Local workshops are useful to make sure site specific data can be added to the list in the table. For the Plymouth based State of the Sound report, a workshop was held with local experts and interest groups including DEFRA family area teams (MMO, NE, EA) to identify relevant indicators and data sets

See the **stakeholder engagement section** or more information on how to identify and map stakeholders able to provide information on ecosystem services. Where there are opportunities to collect this information, gathering evidence for the natural capital logic chain would provide context for the natural capital assessment.

Note: This guidance is linked to a spatial data tool which can be searched and added to and you can also generate and then download the data sources it contains. See the guidance and background here.

Project Examples

Stakeholder engagement example: Linking natural capital, benefits and beneficiaries-The role of participatory mapping and logic chains for community engagement

The approach uses a novel stakeholder driven approach to participatory mapping which enables communities in natural capital discussions across a series of face-to-face workshops. The approach has been applied in Deben Estuary, Suffolk (UK), and more recently in the Cromarty Firth and Solent; however, the methodological framework could be applied to any global ecosystem (terrestrial, freshwater, estuarine, marine, urban) and community setting.

From a management perspective, the outcomes of this approach can help to identify which benefits, and therefore which beneficiaries, may be impacted by an intervention, and what direction that impact may take.

Burdon, D., Potts, T., Barnard, S., Boyes, S.J. and Lannin, A., 2022. Linking natural capital, benefits and beneficiaries: The role of participatory mapping and logic chains for community engagement. Environmental Science & Policy, 134, pp.85-99.

Scottish Wildlife Trust: Oceans of Value

The Trust's Oceans of Value project set out to compare two different approaches to identifying key values associated with the marine environment: a natural capital approach and the Community Voice Method. Work focused on the seas surrounding the Orkney Islands (out to 12 nautical miles from Orkney's coastline), which is one of the most well-studied marine environments in Scotland.

To capture the different values (derived from ecosystem services) members of Orkney's community place on the marine environment, a range of stakeholders were interviewed using Community Voice Method.

Further examples: The North Devon Marine Pioneer

The North Devon Marine Pioneer also approached firstly linking stakeholders/beneficiaries to natural capital assets, and secondly gathering local community perception of the importance of natural capital asset - benefit relationships and the risk (from existing pressures) to those relationships:

Report One linked stakeholders or beneficiaries to natural capital assets for 'wild food' benefits and for recreation and tourism benefits). (links between natural capital in North Devon and the stakeholders linked to fisheries) (stakeholders related to activities and businesses associated with watersports and coastal recreation) pp30-35

Ashley, M., Rees, S.E., Cameron, A. 2018. North Devon Marine Pioneer Part 1: State of the art report of the links between ecosystem and ecosystem services in the North Devon Marine Pioneer. A report to WWF-UK by research staff the Marine Institute at Plymouth University.

Report Two used a workshop setting to integrate a metric for Community Based Knowledge of the Risk developed though participation in a workshop of the members of the North Devon Marine Working Group (MWG). (Importance of the asset - benefit relationship was first scored low, moderate or high and risk to the asset - benefit relationship was assessed between low - medium - high).

Rees, S.E., Ashley, M., Cameron, A. 2019. North Devon Marine Pioneer 2: A Natural Capital Asset and Risk Register. A SWEEP/WWF-UK report by research staff the Marine Institute at the University of Plymouth

Links to ecosystem service data

In this section we give examples of the types of data that are available to try and understand the capacity to supply ecosystem services (ES) and the flow of ES. These are shown below in Table 4 and are taken from a range of sources (expert reviewers, Burdon, 2020; Hattam et al. 2015; Lear et al., 2021, Wigley et al., 2020).

Note: This guidance is linked to a spatial data tool which can be searched and added to and you can also generate and then download the data sources it contains. See the guidance and background here.

Table: Ecosystem service provision and capacity

Ecosystem service	Data type	Source

Provisioning: Wild seafood, fish and shellfish	ES flow: Fisheries landing statistics.	Internet search for up to date government and MMO fisheries statistics. The regional Inshore Fisheries and Conservation Authorities (IFCA) provide a wide range of assessments and data. Search for your regional IFCA. Each IFCA have their own reports on crab and lobster and many other species, eg mussel. Examples are provided below: UK Landings 2023: Monthly Sea Fishery Statistics MMO sea fishery statistics Declared catches report on salmon, sea trout, eels, smelt and lamprey International Council for the Exploration of the Sea provide assessments of stock spawning biomass and total allowable catch assessments for ICES areas as well as many other datasets and a wide range of information. Cefas provide a wide range of data including stock assessments, the data portal can be searched by species or data type species
Provisioning: Wild seafood, fish and shellfish	Capacity to supply ES: Presence/absence of desirable species; diversity of desirable species: Stock: area (m2) or biomass (tonnes km2) of seaweed. UK Capacity indicators: Reproductive capacity of commercially exploited stocks of UK interest.	Marine Online Assessment Tool for UK Indicators
Provisioning: Wild seafood, fish and shellfish	ES flow: Vessel Monitoring System (VMS) combined with UK commercial landings records (UK vessels >12m able to be evaluated at reasonably high spatial resolution). Supports mapping.	Vessel monitoring system data is not publicly available, contact the MMO for enquiries. Some aggregated and anonymised data may be available, for example, the 2020-2022 dataset
Provisioning: Reared animals for nutrition, materials or energy (Cultivated seafood)	Aquaculture	Local site maps, licensing applications, Cefas data portal contains maps and layers
Provisioning: Non-food products from non-living sources	ES flow: Aggregate production.	Crown Estate Licensing Aggregate site agreements
Provisioning: Non-food products from non-living sources	ES flow: Salt production.	Crown Estate Licensing.

Provisioning: Energy from non-living sources	Wind, wave and tidal energy.	The Crown Estate Open Data
Provisioning: Water supply	ES flow: Water abstraction.	Water available for abstraction (largely relevant to rivers and catchments)
Regulation: Water quality	ES capacity to supply:	Environment Agency Water Quality Data, Clean Seas Environmental Monitoring Programme; CEFAS Data hub; Blue Flag Beach Quality
Regulation: Water quality	ES capacity to supply: Presence of filter feeders. Presence of macroalgal beds.	Use habitat (asset maps), see Natural Capital Assets for data for kelp beds, mussel beds, oyster.
Regulation: Erosion control	ES capacity to supply: Sediment stabilisation/ spatial configuration. Width/area/location for dynamic movement & development of coastal habitats, e.g. saltmarsh and sand dune.	Environment Agency datalayers for: saltmarsh extent and zonation.
Regulation: Erosion control	ES capacity to supply: Extent (km^2) and health of seagrass/saltmarsh/oyster bed/biogenic reefs: density of living organisms, measures of growth and production, optimum ecophysiology.	Use habitat (asset maps), Centre of Ecology and Hydrology Land Cover Map: https://www.ceh.ac.uk/data/ukceh-land-cover-maps
Regulation: Flood protection	ES flow: Reduced inundation of terrestrial areas from marine flooding.	Environment Agency: Risk of Flooding from Rivers and Sea
Regulation: Flood protection	Reduced inundation of terrestrial areas from marine flooding.	AIMS Spatial Flood Defences. The Environment Agency's Spatial Flood defences layer is a national comprehensive layer which shows flood defences currently owned, managed and inspected by the EA.
Regulation: Flood protection	Reduced inundation of terrestrial areas from marine flooding.	National Coastal Erosion Risk Map Shoreline Management Plans

Regulation: Refuge habitats and nursery, breeding, and feeding grounds	Number and diversity of species using the area for nursery or reproduction (Hattam et al., 2015). Area of habitat or density of biogenic habitat creating species “used” or identified as important for nursery or reproduction (Hattam et al., 2015). Production and maintenance of complex structure providing suitable habitat including shelter from predators. Provision of food resources.	No national datasets identified, consider using complex biogenic habitats, seagrass, saltmarsh, kelp as proxies.
Regulation: Climate regulation (carbon sequestration)	Carbon sequestered and greenhouse gases fixed.	No base maps for carbon storage use habitat asset maps as a proxy. See also Wildlife Trust commissioned work and estimates
Cultural: aesthetics	Number and/or area of marine features of given stated appreciation; Length of Heritage Coast (km).	Office for National Statistics; Economic and Social Data Service (ESDS) (Burdon, 2020) Defra MAGIC MAP holds paths and routes
Cultural: recreation and tourism	Employees Working in Sector.	Dedicated social science surveys could be conducted to develop fuller understanding of the benefits of cultural services, and links to asset condition, at both a place-based scale and national level surveys.
Cultural: recreation and tourism	Seaspace available for recreation.	Number of km2 of sea with safe water quality available for recreational use (Hattam et al., 2015).
Cultural: recreation and tourism	Number and quality of beaches.	Number and quality of beaches.
Cultural: recreation and tourism	Number of visits, Duration of visits, Range of activities undertaken (number of people carrying out each activity, frequency, time spent).	Natural England's 'Monitor of Engagement with the Natural Environment' (MENE) survey data (NERR076). Now People and Nature survey Social media. A rang eof studies have used social media to assess cultural values. For example, back-end social media data was used to identify environmental and heritage areas of importance on St Helena, using a quick and easily transferable methodology

Cultural: recreation and tourism	Number of participants (number per year); Number of facilities (number visitors per facility/year); Amount of time spent participating (hours/days).	Office for National Statistics; UK Centre for Economic & Environmental Development (CEED); Great Britain Tourism Survey; OBIS SEAMAP; RSPB statistics; Royal Yachting Association (Burdon, 2020) National Cycle Network England Coast Path: Visit England tourism and leisure day visits https://gbdayvisitslightengland.kantar.com/ViewTable.aspx
Cultural heritage	The number of heritage assets (Burdon (2020).	Defra MAGIC Map
Carrier: supply	Ports and harbours, vessel movements.	Slipways & boat launches http://www.boatlaunch.co.uk/

Best practice recommendations to apply ecosystem service classifications and frameworks

- Clearly identify links between natural capital assets and ecosystem service provision – this should also factor in the impact of asset condition into ecosystem service provision where possible (see **Condition** section).
- Use well-defined and replicable classification systems for ecosystem services. For example, CICES v5.2 (recommended) or the UK NEA Follow on classification.
- For basic approaches, the JNCC Universal Asset Service matrix is likely to be adequate, or at least provide a useful starting point. Users can easily explore and export the data into their preferred habitat or ecosystem service classification systems and can create their own context specific, bespoke ASMs.

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Valuation

The benefits that flow from ecosystem services can be valued in monetary or non-monetary terms. This is crucial for natural capital assessments, as the value of natural capital is often poorly captured in decision-making processes. One key reason for this is the full value of ecosystem services are rarely reflected in market prices. Valuing both monetary and non-monetary benefits aids comparison with other policy options, making it an essential aspect of the natural capital assessment process. Value can be thought of in many different ways (e.g. social, cultural, health, economic, and ecological) and capturing these diverse values is likely to lead to greater policy integration and increasingly shared responsibility for decisions and actions.

Overview

This section provides an overview of Valuation methods including monetary methods and qualitative approaches. It also discusses methods for integrating qualitative and quantitative data in natural capital assessments and offers an overview of natural capital accounting to enable users to make informed decisions about the most appropriate valuation methods to employ. The guidance covers:

- Guidance flowchart: valuation
- Monetary valuation
- Monetary valuation caveats and limitations
- Non-monetary forms of valuation
- Non-monetaty valuation caveats and limitations
- How to integrate qualitative and quantitative data
- Approaches for drawing together existing data
- Methods for the collection and integration of qualitative value data
- Recommendations for integrating qualitative and quantitative data
- Natural Capital Accounting
- Useful tools and resources containing national monetary valuation evidence for selected ecosystem services

See the following resources for information on the topic of market and non-market valuation:

- The IPBES (the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) assessment report on diverse values and valuation of nature
- Defra's guidance on Enabling a Natural Capital Approach (ENCA)
- HM Treasury's Green Book (Chapter 6 and Appendix 1 on market and non-market valuation)
- Natural Capital Committee (2017) Economic valuation and its applications in natural capital management

- Natural Capital Committee (2020) The Green Book guidance: embedding natural capital into public policy appraisal

Depending on resources and objectives, the assessment may apply a:

- **Basic approach:** Valuation might include use of national datasets containing market value data that can be broken down to the regional (or potentially local) level for a limited set of natural capital assets, ecosystem services or wellbeing benefits, or it may include basic value transfer (i.e. the transfer of values estimated for one location to another, similar location).
- **Better approach:** Could include the above plus limited and newly collected data ("primary data") to support monetary or non-monetary valuation for a small number of natural capital assets, ecosystem services or wellbeing benefits. It could also involve more complex value transfer.
- **Best approach:** Will be the most comprehensive, including primary data collection for the monetary and non-monetary valuation of a wide range of natural capital assets, ecosystem services and wellbeing benefits.

The type of valuation undertaken as part of a natural capital assessment will vary according to the purpose of the assessment. The Natural Capital Committee highlight three general decision contexts in which valuation can be useful:

1. Determining priorities for investments in natural capital.
2. Determining actions affecting natural capital to (i) achieve target improvements; (ii) avoid deterioration; or (iii) compensate for losses (e.g. offsets).
3. Determining overall progress in objectives to protect and improve natural capital (including at the aggregate level).

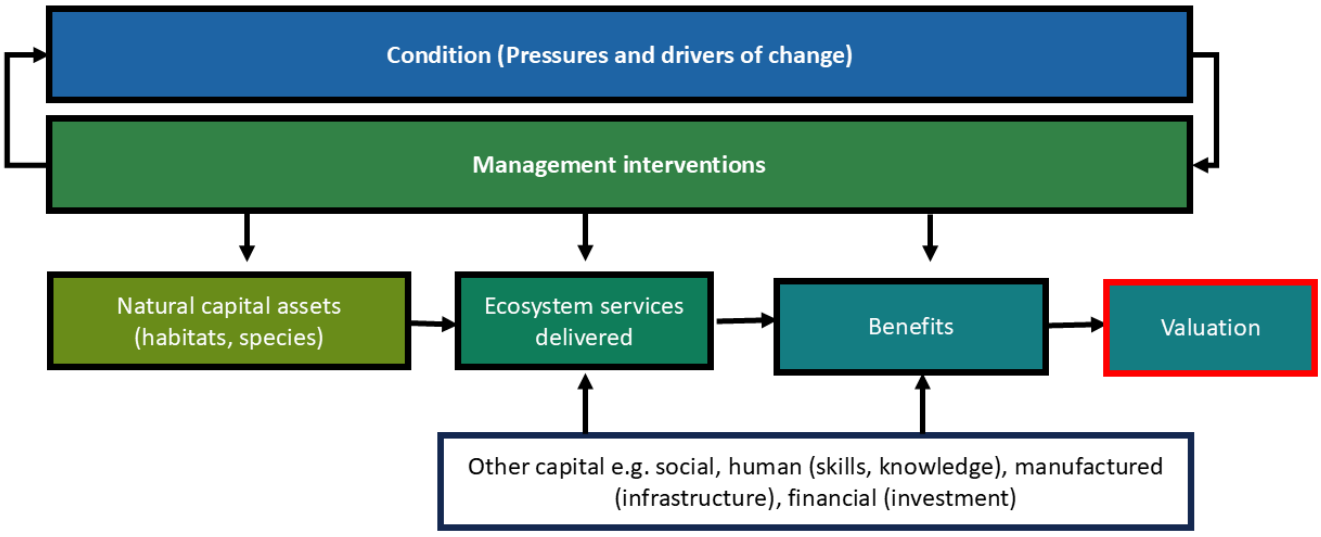

Figure 1: Steps to follow to support valuation of marine and coastal ecosystem services.

Components

Guidance flowchart: valuation

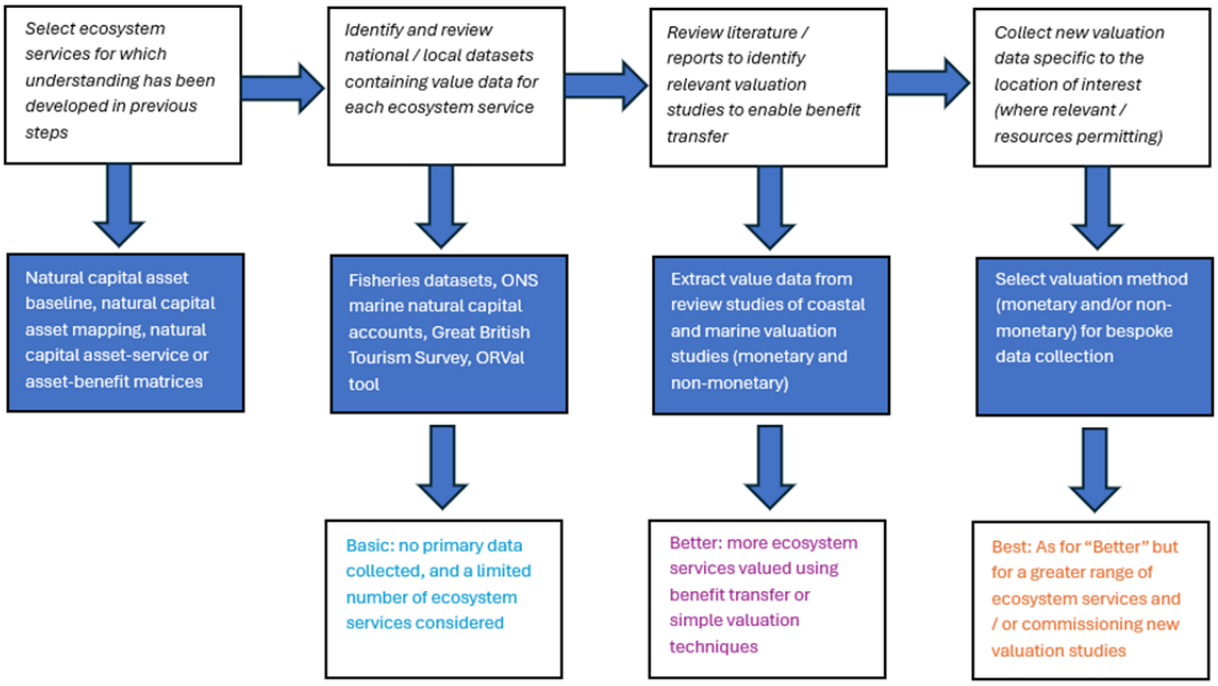

Figure 2: Flow chart.

Monetary valuation

Monetary valuation can be particularly useful to support decisions around investments or actions affecting natural capital. There are many different monetary valuation methods including:

- **Revealed preference methods:** Examine people's actual behaviour (e.g. the additional premium paid for living in a location with a sea view, the cost incurred when travelling to a higher quality coastal location, prices for goods traded through markets).
- **Stated preference methods:** Assess an individual's hypothetical willingness to pay for an improvement or to accept a loss in an environmental characteristic.
- **Production function approaches:** Explore the relationship between environmental characteristics and the level of production of marketable goods (e.g. the role of coastal wetlands in providing storm protection).

These methods all produce quantitative estimates of value in monetary terms that can be easily incorporated into other decision-making processes and decision support tools, such as cost benefit analysis. They are therefore well suited to policy analysis tools such as impact assessments. Application of these methods requires knowledge of economic theory as well as advanced statistical skills. All methods require access to relevant secondary data but stated preference methods (and some revealed preference methods) require the collection of

primary data through surveys.

Where resources are insufficient to apply the methods described above, an alternative is to undertake **value transfer** (also known as **benefit transfer**). This is a method for applying existing monetary valuation evidence in a new context. While value transfer is often quicker and can be undertaken at lower cost, it is not necessarily easy. Judgement is needed on when value transfer is appropriate, assumptions need to be made clear and sensitivity analysis is needed to address concerns of accuracy. When done well, it draws on a range of inputs from policy experts to scientists and other technical experts (e.g. statisticians).

The following guidance describes how to us value transfer methods.

Guidance documents: monetary valuation

Defra (2007) An introductory guide to valuing ecosystem services.

Defra (2023) Enabling a Natural Capital Approach guidance Annex 3 contains a useful introduction to common economic valuation methods.

HM Treasury (2022) The Green Book – Annex 1 contains detail relevant to valuation methods for natural capital assessments.

Valuing Nature Programme (2016) Demystifying Economic Valuation. Valuing Nature Paper. Provides a non-technical introduction to monetary valuation.

Johnston, R.J., Boyle, K.J., Adamowicz, W., Bennett, J., Brouwer, R., Cameron, T.A., Hanemann, W.M., Hanley, N., Ryan, M., Scarpa, R. and Tourangeau, R., 2017. Johnston et al. (2017) Contemporary Guidance for State Preference Studies. Journal of the Association of Environmental and Resource Economists, 4(2), pp.319-405. Provides in-depth detail on how to conduct stated preference studies.

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Monetary valuation caveats and limitations

Monetary valuation methods have improved considerably in recent years, but it is important to:

- Recognise that examples of poor practice remain, which means that available valuation studies need to be critically reviewed, especially if using the results to support value transfer.

- Understand the limitations of the methods (e.g. not all benefits can be robustly valued and their valuation may not be straightforward – simplification may mean that values elicited cannot be readily mapped on to ecological change).
- Recognise that values derived from different valuation methods cannot be summed as each approach assesses different aspects of value.
- Ensure that a critical eye is used to sense-check the outputs of the analysis.
- Include a confidence score alongside any monetary value estimates (or an assessment to highlight potential uncertainty in the estimates).

In cases where robust valuation is not possible, alternative approaches can be used that do not provide a monetary value.

Example

Very few marine natural capital assessments include monetary valuation. One exception is the NI-MANACA study (An Assessment of Northern Ireland's Marine Natural Capital). This uses a simplified benefit transfer approach, using values from the ONS marine accounts to provide an initial valuation of Northern Ireland's marine natural capital. It is important to note that this study does not take into consideration the condition of the marine environment, thereby introducing uncertainty into the values estimated.

Burdon, D., Barnard, S., Strong, J.A., & Atkins, J.P., 2023. An Assessment of Northern Ireland's Marine Natural Capital (NI-MANACA). Report to AFBI by Daryl Burdon Ltd., Willerby, UK (Report No. DB Ltd. 017/2020.

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Non-monetary forms of valuation

Other forms of valuation that explore social and cultural values, including wider benefits to wellbeing, are also important for determining priorities for natural capital investments (general decision context 1, above) or determining actions affecting natural capital (general decision context 2, above). Despite the potential difficulties of integrating different types of value data, relevant social data should be considered in natural capital assessments in order to develop a more comprehensive view of the value of natural capital. As with monetary valuation methods, social and cultural values and wellbeing benefits can be assessed in many ways. Exemplar methods include:

- **Exploratory approaches based on interviews, focus groups and workshops:** These data collection tools can be designed to explore with stakeholders what they perceive to be of importance or of value about a particular location or environment.
- **Deliberative methods** (e.g. citizen juries and group deliberation approaches): These are a suite of participatory methods including stakeholder interviews and facilitated discussions. They may aim to build consensus about the importance and/or wider value

of aspects of natural capital.
- **Visual methods** (e.g. photovoice and community voice): These methods have similarities to deliberative approaches, but in addition to stakeholder interviews and discussions include film making, photography and/or other creative methods (e.g. model making).
- **Participatory mapping** involving interviews or group discussions in which stakeholders are invited to indicate on maps locations that are of importance to them (for ecological, economic and/or social reasons). These hand annotated maps are then digitised to create layers in a GIS.

These methods are often qualitative in nature, meaning that the outputs are usually based on interpretation or description. They provide a rich and deep understanding of why or how certain behaviours occurred, as opposed to how many or how much and how often. Strengths of these methods include:

- The ability to capture a full range of benefits, not only those that can be measured quantitatively (e.g. the importance of natural capital to an individual's or place's identity or to creating a sense of place).
- They are transparent and enable sharing of information between stakeholders. They can therefore support co-creation of visions, plans and activities and create shared ownership of the data generated.
- They enable exploration of the connections between ecological features and values, and how change in those features may affect values.
- They can be used to capture and understand different stakeholders' views and values, which can help different stakeholder groups understand each other's perspective.

Example

The Marine Conservation Society has produced a number of examples of the Community Voice Method

Non-monetary valuation caveats and limitations

As with all valuation methods, non-monetary valuation methods also have their limitations:

- The application of methods may be highly localised, meaning that outputs are not easily scalable or generalisable across locations.
- As the number of people it is possible to engage with using these methods is often restricted (due to study purpose or time and resources), the representativeness of the outputs can be limited, meaning that findings cannot be assumed to reflect the views of all people in a location.
- Depending on method design, repeated interactions may be needed with stakeholders, which can lead to "stakeholder fatigue" and stakeholder reluctance to engage. This issue means it is important to consider whether a participatory valuation method is most appropriate and if the assessment being undertaken sufficiently impacts stakeholders to necessitate this approach.

- Qualitative outputs can be challenging to represent spatially, although participatory mapping can help to overcome this.

Guidance documents

Kenter et al. (2014) Shared, Plural and Cultural Values: A Handbook for Decision Makers. UK National Ecosystem Assessment follow-on phase. Cambridge, UNEP-WCMC.

Ochieng NT, Wilson K, Derrick CJ, Mukherjee N. The use of focus group discussion methodology: Insights from two decades of application in conservation. Methods Ecol Evol. 2018; 9: 20–32. https://doi.org/10.1111/2041-210X.12860

Burdon, D. and Potts, T. (2020) Participatory mapping of natural capital and benefits: method guidance document. Report produced for the MMO and Suffolk Marine Pioneer.

Acott, T. G., Willis, C., Ranger, S., Cumming, G., Richardson, P., O'Neill, R., & Ford, A. (2023). Coastal transformations and connections: Revealing values through the community voice method. People and Nature, 5, 403–414. https://doi.org/10.1002/pan3.10371

Photovoice method - https://www.betterevaluation.org/methods-approaches/methods/photovoice

How to integrate qualitative and quantitative data

When trying to assess the social and cultural values of natural capital, ecosystem services and the benefits that they deliver, there is often a need to draw on multiple sources of data. This information can arise in multiple formats, including numerical, text, images, video and audio. This presents challenges in terms of how to bring these diverse sources together and represent them on an equal footing.

Despite its challenges, integrating different types of data in natural capital assessments can be particularly beneficial for decision-makers. Different data types are useful for representing a diverse range of different values, such as social, cultural, economic and ecological. When varying data types are effectively integrated, this can provide decision-makers with the opportunity to compare different values, aiding in more comprehensive decision-making which can garner greater levels of local support.

The aim of this section then is to provide an overview for methods for integrating both quantitative and qualitative data types and to guide decision-makers on how they might do this depending on their decision-making context. Depending on resources and objectives, the assessment may apply a:

- **Basic approach:** Quantitative and qualitative data are presented alongside one another with attempts made to discuss the two data types and how they relate to one another.

- **Better approach:** Quantitative and qualitative data are integrated following the data collection stage. This is done by either transforming quantitative data into qualitative data (or vice versa) or through narrative and presentational techniques. This can make comparison easier and help to mitigate against some of the risks of one data type being favoured over the other.
- **Best approach:** Integration is considered throughout the project from data collection to analysis and presentation. Methodology and data complementarity and commensurability is also considered throughout and leads to multiple dimensions of value being represented through the integration of multiple types of evidence. This approach would minimise the loss of detail that often occurs when quantitative and qualitative data are mixed, or one type of data is transformed into another.

Challenges of integrating qualitative and quantitative data

Comparing or integrating quantitative and qualitative data often presents a challenge as they may not be compatible. The range of qualitative data types can make it difficult to summarise and present this information. For instance, open-ended interview responses and geo-located social media photos can both bring useful insight to natural capital assessments but are difficult to present together or combine into a single integrated result.

Approaches to integrating quantitative and qualitative data

There are different approaches to including and integrating quantitative and qualitative data. Which you chose will depend on the decision-making context, the available resources and your desired outcomes. The following sections of the guidance discuss a variety of different approaches to integrating the two data types.

When reviewing these approaches and considering how to integrate qualitative and quantitative data, key questions to consider include:

1. Are the quantitative and qualitative data collected sequentially or simultaneously?
2. Which has priority – quantitative or qualitative?
3. What is the function of integration – e.g. to compare, explain or explore?

Approaches to drawing together existing data

When conducting marine natural capital assessments, it is useful to first consider how to integrate and present existing data. The use of secondary data can offer a less resource and skill intensive avenue for integrating qualitative and quantitative data. Approaches to the integration of quantitative and qualitative data at this stage include:

1. **Narrative integration:** Involves describing qualitative and quantitative findings in a report or series of reports. Two broad approaches are typically used: (i) a contiguous approach, when findings are presented in a single report but in separate sections for qualitative and quantitative results; and (ii) the ‘weaving approach’ which involves

writing both qualitative and quantitative findings together on a theme-by-theme or concept-by-concept basis.

2. **Integration through data transformation:** Involves one type of data being converted into another type of data (qualitative into quantitative, or vice versa). An example is quantitative analysis of unstructured data, such as responses to open questions. Data can be coded into themes and then the frequency of themes counted, a process sometimes referred to as **content analysis**. This type of data transformation represents an avenue for making the results of semi-structured interviews, focus groups and other deliberative approaches more comparable, accessible, and presentable alongside quantitative data.
3. **Joint displays:** These integrate data by drawing them together through visual means such as tables, matrixes, graphs, interactive diagrams or selected images. This shared visual presentation can help to generate new insights beyond what is understood from the respective quantitative and qualitative evidence

Considerations: Different types of data may be conflicting and highlight different relationships between natural capital, its associated values and various drivers of change. Practitioners should take care when drawing conclusions from these data types and ensure that they make decision-makers aware of the nuances present in the data. Integration or synthesis of information can also obscure potential biases between data sources if this process is not conducted visibly and rigorously.

Examples

Data transformation to show demand for recreation between seasons (Vierikko & Yli-Pelkonen, 2019)

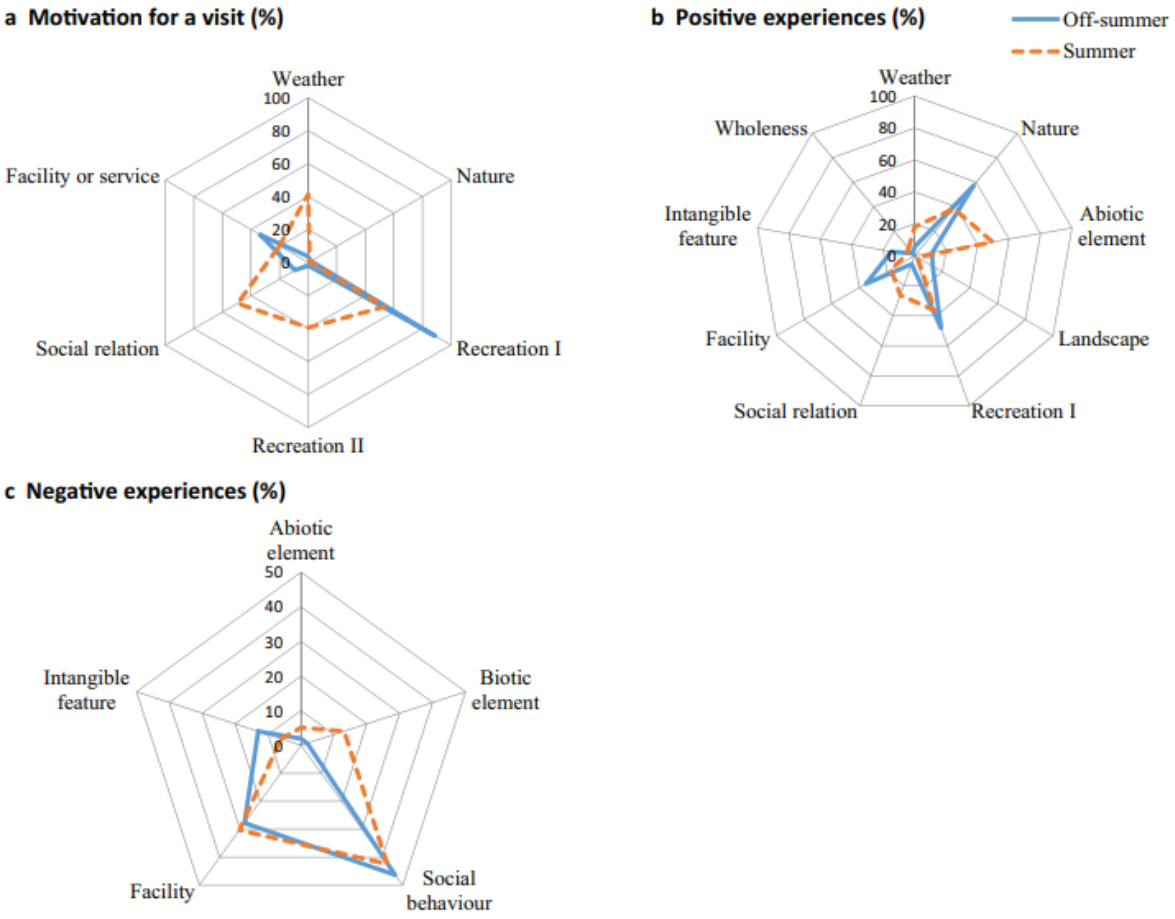

Fig. 3 (**a**) Six categories of motivations for a visit, (**b**) nine categories of positive experiences and (**c**) five categories of negative experiences that were grouped from answers of off-summer (solid line) and summer season (dot line) visitors to the questions i) reason for visit, ii) things they enjoyed and (iii) disturbing things. The figure shows the proportion (%) of the interviewees who mentioned at least one activity or thing under the value type. The interviewees could mention several reasons or things they experienced

In this example, responses to open-ended questions were coded as a binomial variable (1= interviewee mentioned an issue, 0 = they didn't) so that frequency values for each variable could be measured. Variables were then grouped and classified into thematic categories for (a) visitor motivations and (b) their experiences at a site, in order to better understand the socio-cultural values of visitors to this site in question. These quantified results were displayed graphically in spider plots, allowing for a clear and more comparable visual representation of the trends emerging from qualitative interview responses.

A joint display of quantiative and qualitative evidence for socio-cultural values (Gould et al, 2014)

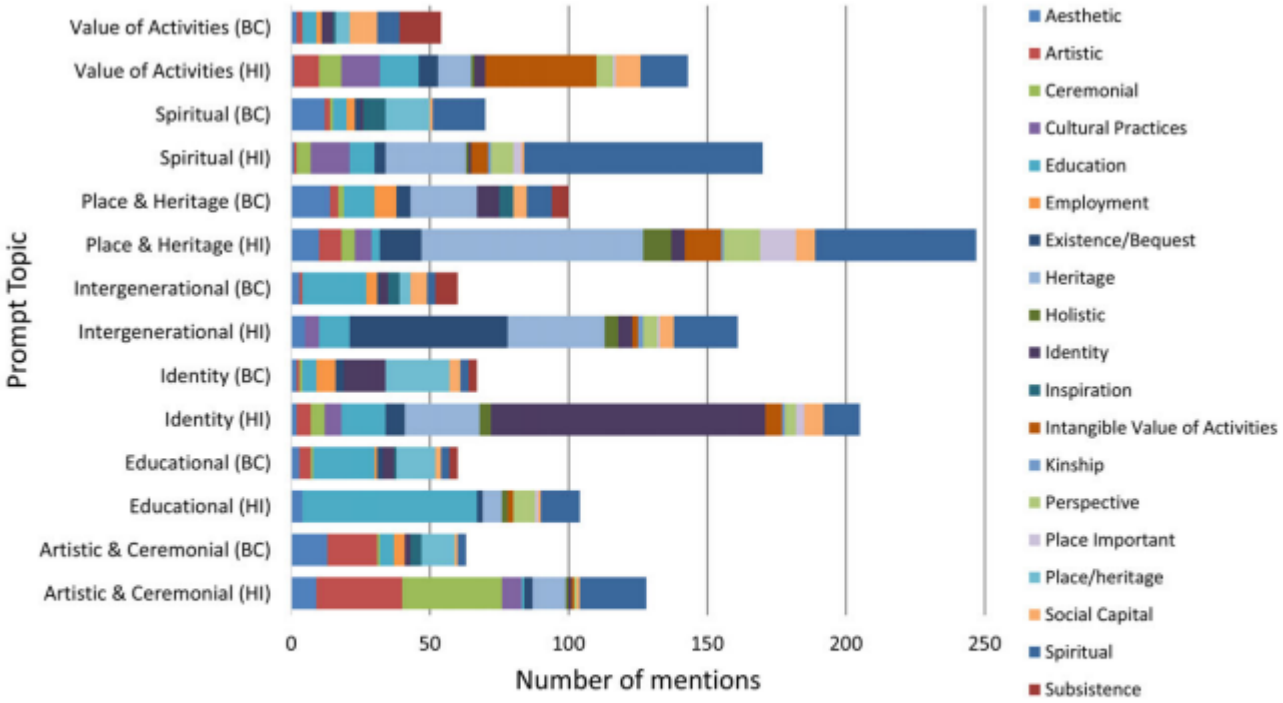

Figure 2. Responses to interview prompts categorized by the benefits and values mentioned in discussion following each prompt (bars, number of times various benefits and values were mentioned in response to the prompt topic; BC, British Columbia; HI, Hawaii).

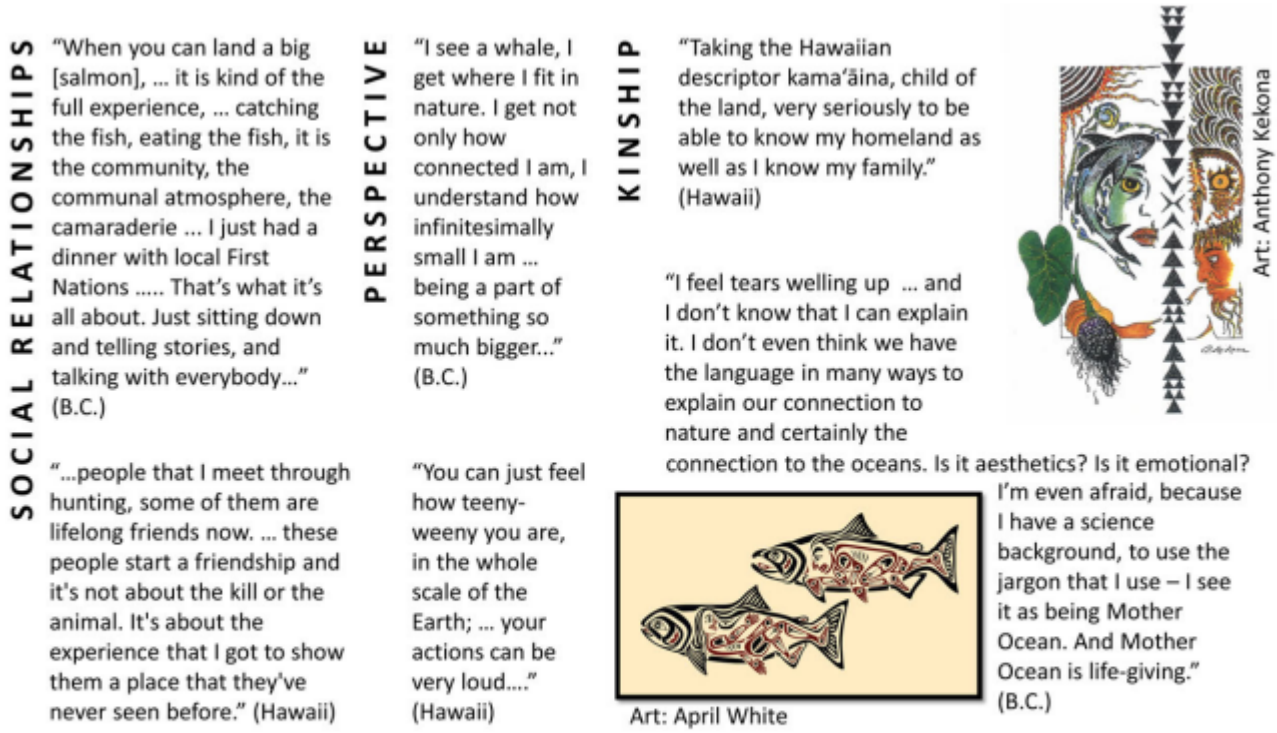

Figure 3. Examples of respondents' unsolicited comments about kinship, perspective, and social relationships in British Columbia (B.C.) and Hawaii. We offer one example of each theme from each site. The kinship quotes express sentiments also found in the place-based art shown (credit displayed on figure).

The coding and analysis of semi-structured interview responses led to the production of a bar chart representing how often socio-cultural values were mentioned in response to different interview prompts. This is placed alongside qualitative evidence in the form of illustrative interviewee quotes and select place-based art. This joint visual presentation of qualitative and quantitative socio-cultural value data can enrich understanding and better contextualise

these different forms of evidence. This also highlights how the same qualitative data can be interpreted and analysed both qualitatively and quantitatively.

The Cultural Value of Dublin Bay

This StoryMap, developed as part of The Cultural Value of Coastlines project funded by the Irish Research Council, highlights how cultural representations of places can be used as expressive indicators of natural areas' significance and the non-monetary social and cultural values associated with them. Collating and analysing various forms of art and literature is, therefore, an avenue for capturing cultural ecosystem services and their benefits such as scenic appreciation, inspiration, sense of place, emotional and symbolic values.

This particular approach combines the in-depth nuance of qualitative evidence with interactive mapping, allowing for this range of evidence to be brought together in a consistent and spatially explicit manner. Through geo-referencing and locating cultural representations onto a map, these forms of evidence are more clearly linked to natural capital and more easily compared to quantitative evidence.

Care for the environment can be enhanced using this approach to art, literature, and storytelling, especially in showing how specific places have inspired artists and writers or encouraging people to tell their own stories or show their own images of the places they are engaged by. This project's Toolkit for Assessing Cultural Ecosystem Services is designed to help users such as local authorities identify cultural ecosystem service benefits and ensure that communities can articulate and include a wide range of values in this process.

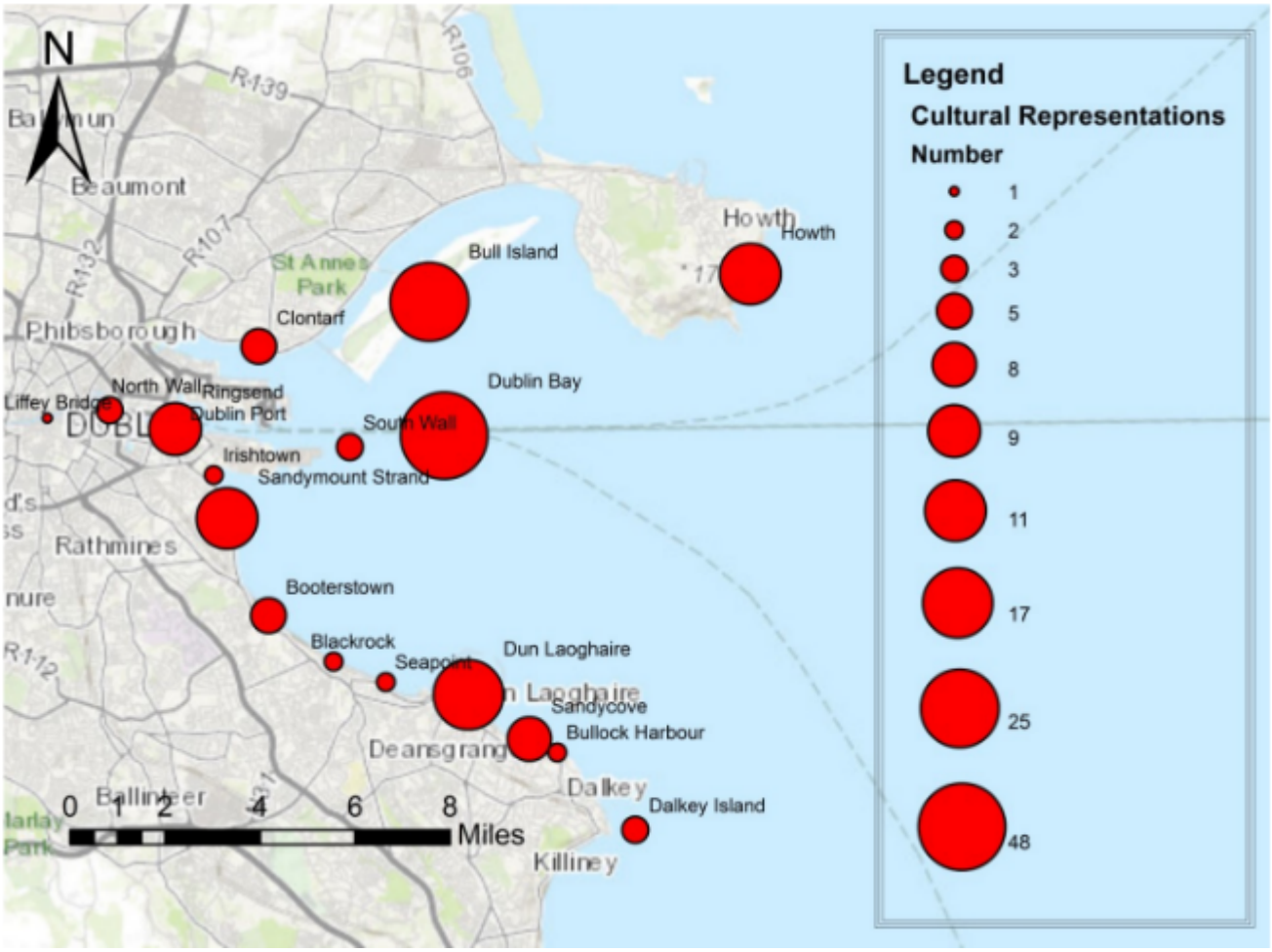

Figure 4

Figure 4 is a map generated from a count of the number of paintings and literary works that have been set in each location indicates which areas have been valued most consistently by artists and writers.

Figure 5

Figure 5 is an example of how cultural representations, as a form of evidence for socio-cultural values, can be included in online interactive maps.

Methods for the collection and integration of qualitative value data

Practitioners can use various approaches at the data collection stage to collect and integrate different types of value data into natural capital assessments. These approaches will often require more resource and a wider range of methodological expertise. Below is an overview of a variety of methods which allow for this type of integration:

- **Deliberative methods** (e.g. citizen juries and group deliberation approaches) accept that values are plural and often incommensurable, and so allow for quantitative and qualitative evidence of monetary and non-monetary values to be brought together.
- **Participatory mapping** is a common approach to integrating socio-cultural values into quantified spatial maps, allowing for these often intangible values to be presented in a similar manner to biophysical and monetary data.
- **Visual methods** (e.g. photovoice and community voice) are often similar to deliberative approaches but include film making, photo elicitation and other creative methods to encourage deliberation of shared values, both monetary and non-monetary.
- **The Q-method** combines qualitative and quantitative techniques into a more structured approach to studying people's subjective values, opinions and beliefs related to natural capital.
- **Multi-Criteria Decision Analysis (MCDA)** can help address intangible values and integrate monetary and sociocultural values into natural capital assessments, as it can take explicit account of multiple criteria which are not easily compared.
- **Narrative approaches** (e.g. storytelling and scenario development) are one of the most practically important ways of eliciting and including different types of values associated with natural capital, as they can be used to bring together qualitative and quantitative evidence collected at a range of spatial and temporal scales.

Table 1 offers a review of the above methods according to criteria or features that appear to have been important for method selection. These criteria can be used to ensure the methodology selected is best suited to the specificities of each natural capital assessment.

Table 1

Criteria	Photo elicitation	Narrative analysis	Scenario development	Deliberative processes	MCDA	Participatory mapping
Addresses multiple ecosystem services	X	X	X	*	X	X
Enables trade-offs to be explored	X	X	X	*	X	X

Facilitates social learning	*	X	X	X	X	X
Stakeholder participation	X	X	X	X	X	X
Incorporates local knowledge	X	X	X	X	X	X
Easy to communicate	X	X	X	X	X	X
Easy to understand	X	X	X	X	X	X
Spatially explicit		*		*	*	X
Temporally explicit			X		*	*
Mainly quantitative data	*				*	*
Mainly qualitative data	*	X	X	X	*	X
Requires time series data					*	
Data intensive	*	X			X	
High level of expertise needed		*			X	
Large amount of resources needed	*	*	X	*	X	*

Table 1: Key criteria for non-monetary valuation methods. Key: X = key feature/very important criteria for method selection; * = possible feature/some importance for method selection. (Barton et al, 2017, p31)

Guidance

For reviews of methodologies and their requirements:

OPENNESS Integrated assessment and valuation of ecosystem services: Guidelines and experiences - Use the Method Factsheets for a review of methods in terms of their advantages, constraints, types of value elicited, and resource requirements (data, expertise, time, money and others).

Chapter 3 of IPBES's assessment of the diverse values and valuation of nature - See Table 3.10 for a comparison of valuation methods with regards to their relevance, robustness and resource requirements

Guidance Documents

Brown G, Fagerholm N. Empirical PPGIS/PGIS mapping of ecosystem services: A review and evaluation. Ecosystem Services. 2015;13:119-133. https://doi.org/10.1016/j.ecoser.2014.10.007

Saarikoski, H., Barton, D.N., Mustajoki, J., Keune, H., Gomez-Baggethun, E. and Langemeyer, J., 2016. Multi-criteria decision analysis (MCDA) in ecosystem service valuation. In OpenNESS ecosystem services reference book (pp. 1-6).

Chapter 3 of IPBES's assessment of the diverse values and valuation of nature

OPENNESS Integrated assessment and valuation of ecosystem services: Guidelines and experiences (see the socio-cultural methods factsheets in the Annex for further guidance and resources)

Irish Research Council Toolkit for Assessing Cultural Ecosystem Services

Recommendations for integrating qualitative and quantitative data

There is no one-size-fits-all approach to natural capital and ecosystem service assessments. This guidance encourages practitioners to critically consider their project aims and context alongside the guidance and criteria provided here so that they can select the most appropriate approaches to meet their specific requirements.

Below are high-level recommendations for practitioners looking to integrate qualitative and quantitative data in the valuation of natural capital and ecosystem services:

- **Plan to engage with partners with a wide range of expertise, skills and local knowledge.** For example, interdisciplinary collaboration with local experts in social sciences or the arts can help to ensure access to qualitative data and expertise in its analysis.
- **Community and local stakeholder engagement**, through qualitative techniques such as interviews and workshops, can help to ensure recognition of a wide range of relevant ecosystem services and values in the natural capital assessment process and related decision-making.
- **Consider establishing advisory or steering groups** featuring local experts and representatives from a range of sectors and backgrounds. This can help in the process of identifying qualitative data sources relevant to the area of interest and ensure continued buy-in.
- **Use a variety of methods and data types** to capture the diverse range of values that your site provides. However, more is not always better, so make sure that you can still address your key aims and research questions within your resource constraints.
- **Consider data commensurability, comparability and integration** from the outset. Integration need not be complex but considering how and if data will fit together in a

final report can help to refine data collection and analysis earlier in the process.
- **Adopt a flexible approach to collecting, analysing, and integrating data.** The range of methods, data sources, and approaches to integration covered should emphasise the importance of creativity in tailoring your approach to your specific context (both geographically and in terms of resource constraints).

The summary below reiterates some of the different ways to integrate qualitative evidence into natural capital assessments:

- **Input-output transfers of qualitative and quantitative data between methods:** In which data outputs from one method act as the input to another. For example, the results of a participatory mapping exercise can be inputted into integrated modelling programmes.
- **Transfer of ideas, concepts and learning:** As well as data, broader learning of concepts and ideas may be transferred between methods. For example, stakeholder workshops can expose participants to key ideas (e.g. cultural ecosystem services) which are then relied upon in subsequent participation mapping exercises.
- **Triangulation of evidence for cross-checking and validation:** It is common for place-based studies to address the same issue through complementary yet different data in order to understand an issue from multiple dimensions and ensure validity of results. This can enhance credibility by overcoming the limitations and potential biases of a single type of evidence.
- **Combination of methods into hybrid methods:** Combining methodologies can help overcome weaknesses in individual methods and customise approaches to the particularities of a location.

Guidance documents

IPBES Preliminary guide on diverse conceptualisation of multiple values of nature and its benefits

IPBES Diverse Values and Valuation Guidelines – Methodological guidance based on the IPBES preliminary guide on diverse conceptualisation of multiple values of nature and its benefits. Features a six-step approach to valuation, including a section on 'Integration, bridging and up-scaling'

Community-based participatory research: A guide to ethical principles and practice

Natural Capital Accounting

When exploring progress over time towards overarching policy goals and targets (general decision context 3), a different approach to valuation is needed. Rigorous accounting approaches are particularly useful for this as they operate at a higher, more aggregate level.

Natural Capital Accounts (NCAs) are a way of organising information about natural capital and how it changes over time. They are an extension to traditional accounts as they include

the values for economic benefits that are not provided through markets.

The accounting element of the natural capital approach has been the focus of significant effort in response to national and international policy drivers. The accounting framework includes assessment of both stocks and flows of natural capital assets, in monetary and non-monetary (physical) terms. Physical accounts consider the extent and quality of stocks, and quantities (rather than values) of ecosystem services. They therefore overlap with concepts of a natural capital asset registers and condition assessment. Changes to the physical and monetary accounts are recorded over time, usually annually.

The Office for National Statistics (ONS) has been developing a set of NCAs for the UK and the nations within it. These include accounts for marine and coastal margin habitats including 14 different ecosystem services. The aim of the accounts is to reveal broad trends. Any declines at national level or in individual asset classes will signal a need for action. The valuation methods outlined earlier can be used to identify the best way to deliver action.

Asset values are calculated using the **net present value (NPV) approach**. This uses the annual service flow as a basis for projecting flows across the life of an asset. For renewable assets (e.g. salt marshes) a 100-year life is assumed, compared to a 25-year life for non-renewable assets (e.g. unsustainably fished fish stocks). Because people are assumed to prefer receiving benefits from assets now rather than in the future, when the overall asset value is calculated, a discount rate of 3.5% is applied.

Guidance documents

ONS (2017) Principles of Natural Capital Accounting

ONS (2020) UK natural capital accounts methodology guide: 2020

Environment Agency (2023) The natural capital register and account tool version 1.2 – user guide

Examples

Marine examples of natural capital accounts are growing and, in addition to the ONS Marine accounts, natural capital, UK: 2021 include:

- 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. This report creates monetary accounts for fish and shellfish, waste (nutrient) remediation, natural hazard protection, climate regulation (carbon sequestration and storage), places and seascapes for nature watching and recreation, renewable energy from offshore wind farms and marine aggregates.
- Eftec and ABPmer (2022) A Natural Capital Account for the Industrial Sandeel Fishery. This report provides a baseline natural capital account and two accounts for different

fisheries management scenarios (no sandeel fishing and reduced sandeel fishing effort).

Useful tools and resources containing national monetary valuation evidence for selected ecosystem services

All resources listed below are national data sets:

- The summary tables for ONS marine natural capital accounts UK 2021 can be used to extract valuation data for the UK nations. The experimental methods used can support the valuation of the services captured in the accounts in other locations.

Wild food

- Fisheries: Monthly UK sea fisheries statistics containing details of landings (volume and value) since 2014 https://www.gov.uk/government/collections/monthly-uk-sea-fisheries-statistics
- Fisheries: UK sea fisheries annual statistics containing details of landings (volume and value) for major ports only: https://www.gov.uk/government/collections/uk-sea-fisheries-annual-statistics

Case study example: fish landings in Cornwall

The MMO collates and publishes monthly and annual UK sea fisheries statistics. These data include details of ports, volume of landings and the value of landings by UK and non-UK vessels. The value of landings does not account for the costs associated with fishing (e.g. wages, boat running costs etc.) and so is an overestimate of the value of the wild food provisioning; although the value does not account for fish caught through recreational angling.

Some stock assessments are available through ICES, but these are only available for EcoRegions (e.g. Celtic Seas, Greater North Sea) and do not cover all species. Cefas contributes to these international stock assessments, and also produces shellfish stock assessments for the UK, although many of these are not recent.

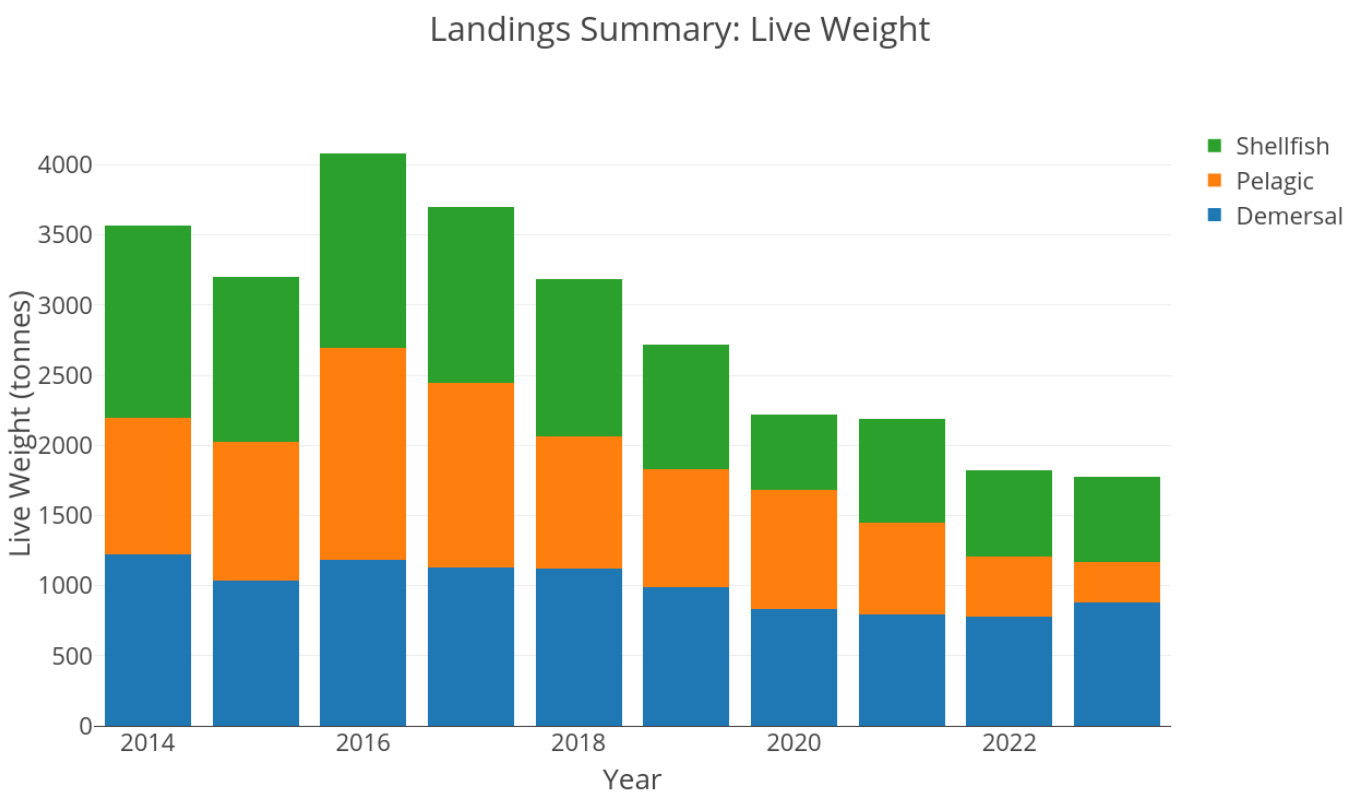

Figure 1 Fish (pelagic and demersal) and shellfish landings live weight in Cornwall from vessels under 10m.

Figure 2 shows the sales value at the point of first sale for the same categories of fish into Cornish ports by UK registered boats. While landings have decreased, total sales values have fluctuated.

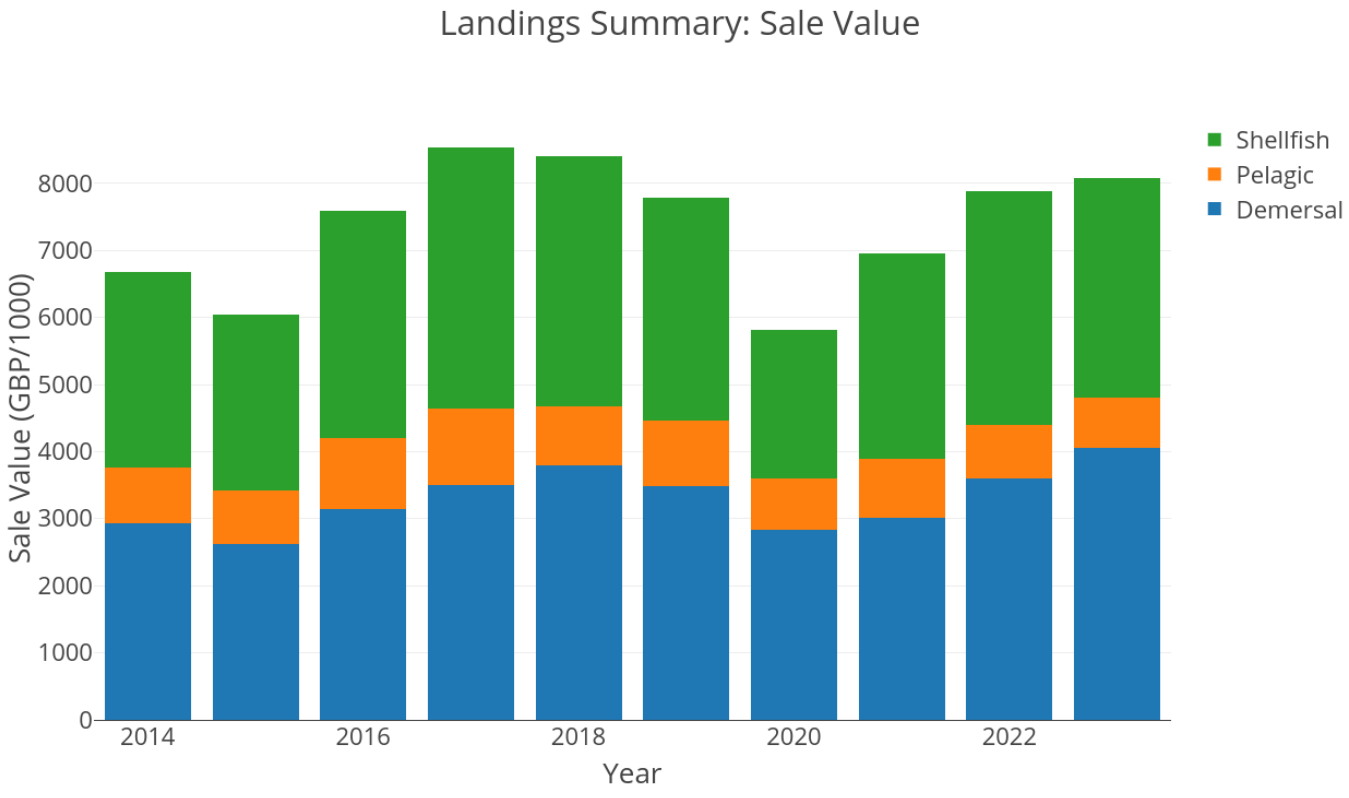

Figure 2: Fish (pelagic and demersal) and shellfish landings sale value in Cornwall

Despite this, the economic price per tonne of fish and shellfish has increased over the same time period (Figure 8).

Figure 3: Price per tonne of fish (pelagic and demersal) and shellfish

These three graphs illustrate that the value of fresh fish has increased significantly since 2020. This is co-incident with the impacts of Brexit, the Covid-19 pandemic and the war in Ukraine. These had significant impacts on market demand, the regulatory environment and input costs (especially diesel). **Without stock assessments, however, it is not possible to conclude whether changes in landings volume and value are reflected in the status of the natural capital asset**.

Some stock assessments are available through ICES, but these are only available for EcoRegions (e.g. Celtic Seas, Greater North Sea) and do not cover all species. Cefas contributes to these international stock assessments but also produces shellfish stock assessments for the UK, many of these, however, are not recent.

Climate regulation

- HM Treasury (2023) Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal, especially Data table 3, which contains carbon values for use in appraisals.
- There is no agreement on sequestrations rate in different habitats. Values can be extracted from the ONS marine natural capital accounts UK 2021, but other sources include Burrows M.T., Kamenos N.A., Hughes D.J., Stahl H., Howe J.A. & Tett P. 2014. Assessment of carbon budgets and potential blue carbon stores in Scotland's coastal and marine environment. Scottish Natural Heritage Commissioned Report No. 761. UK

Parliament (2021) Blue Carbon POSTENOTE 651 contains values for carbon sequestration across a range of UK marine habitats, plus links to the original studies.

Case study example: climate regulation in Cornwall

Rough estimates can be given to the value of carbon sequestration across saltmarsh, subsea sands and muds drawing on the approach taken by the ONS marine natural capital accounts.

For example, the Cornish marine area contains the following areas of saltmarsh, subsea sands and muds (saltmarsh area obtained from Natural England's Priority Habitats Inventory, extent of sand and mud extracted from UK Seamap):

- 392 ha of saltmarsh
- 424,252 ha of sands
- 1,672 ha of muds

Taking a conservative approach and using low sequestration rates (taken from the ONS marine natural capital accounts) of:

- 3.15 tnC/ha/yr-1 for salt marsh
- 0.29 tnC/ha/yr-1 for sand
- 0.44 tnC/ha/yr-1 for mud

And a non-traded carbon value of £130/tCO2e (2022 prices) (using carbon values from data table 3 of the Treasury Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas (GHG) emissions).

The following values for climate regulation are obtained (area x sequestration rate x non-traded carbon value):

- 392 ha of saltmarsh sequesters 1235 tonnes C annually, valued at £160,524 (in 2022).
- 424,252 ha of sand sequesters 123,033 tonnes C annually, valued at £16 million (in 2022).
- 1,672 ha of mud sequesters 735 tonnes C annually, valued at £95,638 (in 2022).

Tourism and recreation

- The Great British Tourism Survey provides data on tourism visits and day visits. The summary report and pivot tables allows users to explore data by UK region and by seaside and other coastal visits. Data can also be extracted for the county and Local Authority level, but these data cannot be disaggregated by seaside and other coastal visits. Historical data for England (tourism and day visits) are available at the regional level.
- Tourism and recreation statistics will soon become available through the Department for Culture, Media and Sport participation survey. The Survey for 2023/24 is being boosted to enable the disaggregation of data at the Local Authority level.

- University of Exeter's Outdoor Recreation Valuation Tool (ORVal) https://leep.exeter.ac.uk/orval/ - can be used to extract estimated welfare values and visitor numbers to outdoor spaces along the coast including national trails and beaches.

Case study: Tourism and Recreation

Recreation along the Yorkshire Coast

1. **Using the Great Britain Tourism Survey**: The Great Britain Tourism Survey estimated that on average between April 2021 and March 2023, 29 million leisure visits lasting more than 3 hours were taken in the Scarborough and East Riding of Yorkshire areas (coastal Local Authorities in Yorkshire). These equated to £849 million total spend per year.

   There are no data to indicate the location of these leisure visits, but data on tourism visits (with overnight stays) could be used as a proxy. The Great Britain Tourism Survey 2022 estimated that 45% of tourism visits to Yorkshire and Humberside took place at the seaside or other coastal locations worth 78% of the value of all tourism visits. Although this introduces uncertainty, in the absence of other data we can use these proportions to provide a rough estimate for leisure visits. It can therefore be assumed that approximately 13.1 million leisure visits lasting more than 3 hours were taken per year to the Scarborough and East Riding of Yorkshire seaside or other coastal locations, worth approximately £662.22 million annually.
2. **Using the University of Exeter's ORVal tool version 2.0 (Outdoor Recreation Valuation Tool)**: The ORVal tool can be used to explore the potential welfare value associated with access to greenspace in England and Wales. This includes national walking trails, access points to the coast and beaches. The Cleveland Way walking trail runs 80.3 km along the North Yorkshire coast from Saltburn-by-the-Sea to Filey. ORVal estimates that this portion of the national trail attracts 1.3 million visitors, with a welfare value of £4.1million. There is no national trail south of this along the Holderness coast, however there are a number of access points to beaches at Bridlington, Hornsea and Withensea. ORVal estimates that these access points attract 2.4 million visitors annually, worth approximately £13.0 million per year.

Tourism in Cornwall (using the Great Britain Tourism Survey)

The Great Britain Tourism Survey estimated that on average, between April 21 and March 2023, 4 million overnight trips were taken to Cornwall. These equated to £1,528 million total spend per year and 19.1 million nights per year. There are no data to indicate the proportion of these trips that were spent at the seaside or other coastal locations in Cornwall. The best evidence comes from the Great Britain Tourism Survey 2022, which estimated that in the South West, 15.16% of nights were passed at seaside or other coastal locations, worth 15% of the value of all South West tourism visits. Using these proportions as a rough estimate, it

can be assumed that on average, approximately 2.9 million nights were spent annually in Cornish seaside or other coastal locations, with a value of approximately £229.2 million per year. This may be an underestimate given the number of coastal locations in the county.

While the value of tourism can be approximated using the Great Britain Tourism Survey at county level or Local Authority level, these data are not disaggregated further. For smaller scales and unitary authorities such as Cornwall, these data cannot be disaggregated further.

Social and cultural values

Social and cultural values are location specific, and databases of such values do not yet exist. However, there is a growing body of publicly available data which illustrate the importance of capturing socio-cultural values and offer an insight into how and why people value natural capital and ecosystem services.

These data sources can be categorised into three overlapping domains, set out below.

Data on people's access to and interaction with nature

- The People and Nature Surveys for England
- The Department for Culture, Media and Sport's Participation Survey
- Social media data (e.g. Flickr or Instagram)

These types of data sources can provide information on visitor frequency, duration, activities, and the benefits and motivations for engaging with the natural environment.

Data on land characterisation and designations

- Marine Conservation Zones (MCZs)
- Sites of Special Scientific Interest (SSSIs)

The designation of natural areas is often the result of a series of consultations and discussions with stakeholders at a range of scales. Examining these designations and their associated documents can provide valuable qualitative insight into the types of values linked with particular places.

Data on interventions and projects

- The Marine Conservation Society's beach clean and survey volunteers

Investigating local nature-related programmes and interventions is another way to understand the social and cultural values associated with natural capital and ecosystem services, as these initiatives draw attention to the range of benefits associated with nature engagement.

Examples

Crowdsourcing social values data

Geotagged photos posted to image-based social media platforms, such as Flickr, offer a potentially rich source of cost efficient and high-volume data with high levels of detail over space and time. These publicly available photos can represent the actual use of ecosystem services, and the content analysis of such photos and their captions can highlight the benefits and values linked to this use. Including this form of qualitative evidence in natural capital assessments can generate important insights, as images and their captions can be analysed to consider what species and landscape features are particularly valued by users and what emotional responses these may generate. However, these data will be affected by accessibility, demographic biases in social media use, and a tendency to overrepresent values that are easily photographed and interpreted.

The People and Nature Surveys for England

This survey offers accredited official statistics about how children and adults interact with and benefit from the natural environment. Although it does not provide a high level of granularity, it does offer nationally representative statistics based on adult survey samples of up to 25,000 and children survey samples of up to 4,000 in England.

Provides nationally representative statistics and regional breakdowns for:

1. The frequency of visits to green and blue natural spaces.
2. The types of natural places people visit.
3. Access to local natural spaces.
4. Travel options to natural space.
5. Reasons for visiting or not visiting natural space.
6. Benefits of visiting green and natural spaces, including physical health, mental health, happiness, feeling part of nature, nature connectedness.

Use the interactive data viewer to set your own parameters (including regional breakdowns) to access data that is relevant to your needs and interests.

Natural capital accounts

The following resources pertain to the provisional ONS marine and coastal natural capital accounts and the data used to prepare them.

- ONS (2023) UK natural capital accounts: 2023
- ONS (2021) Marine accounts, natural capital, UK: 2021 summary tables
- The Environment Agency’s Natural Capital Register and Account Tool NCRAT version 1.2

and accompanying natural capital scorecard for valuing and assessing the quantity and quality of natural resources in a place.

Condition

Natural capital assessments are likely to need to consider the condition of natural capital assets and whether and how this impacts their capacity to provide ecosystem services that ultimately support human wellbeing. Natural and human driven processes and pressures cause landscapes and ecosystems to change and therefore alter condition. They can be direct (e.g. land management interventions, urban development) and/or indirect (e.g. population change, policy change) and be historic, recent or current. Climate change is an important driver that can have both direct and indirect effects on natural capital.

Overview

This section provides guidance on how to measure and monitor condition of natural capital assets, link human activities to pressures to assess the risk to ecosystem services posed by human activities using existing tools, and develop a natural capital **asset-risk register** and natural capital **asset check**. Note that risk-based approaches can be both quantitative and qualitative and include a level of expert judgement.

This guidance covers:

- Links between natural capital asset condition and ecosystem service capacity and supply.
- Development of an asset risk register based on direct condition information, indicators or exposure to human activities.
- Natural capital asset condition assessments: basic, better and best approach.
- Developing an asset risk register or service risk register.
- Caveats and limitations.
- Useful data and resources for condition assessments.

Depending on resources and objectives, the assessment may apply a:

- **Basic approach:** Basic risk register of condition based on generic data resources using habitat exposure to activities and pressures and MarLIN MarESA sensitivity assessments. (Note: although this is considered to be a basic approach in terms of the output, it may require significant time and investment as well as expert input to bring together the assessments and mapping required for the approach.)
- **Better approach:** Evidence-based assessment of condition using condition indicators for the site.
- **Best approach:** Direct measure of condition through survey and comparison with historical condition baselines.

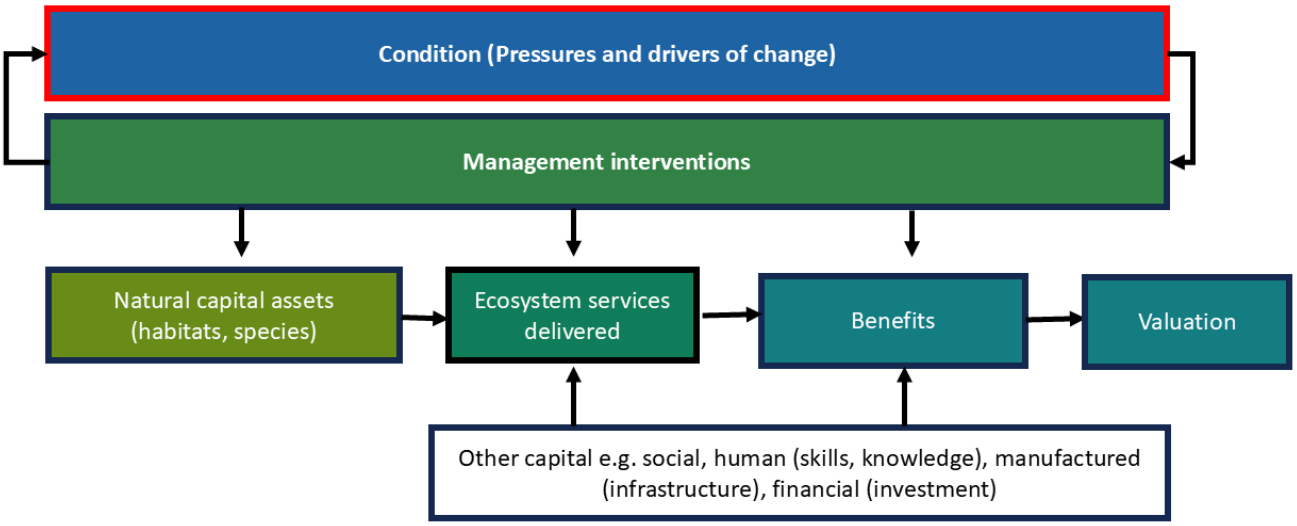

Figure 1: Natural capital logic chain: management of pressures supports condition of natural capital assets

Components

Guidance flowchart: condition

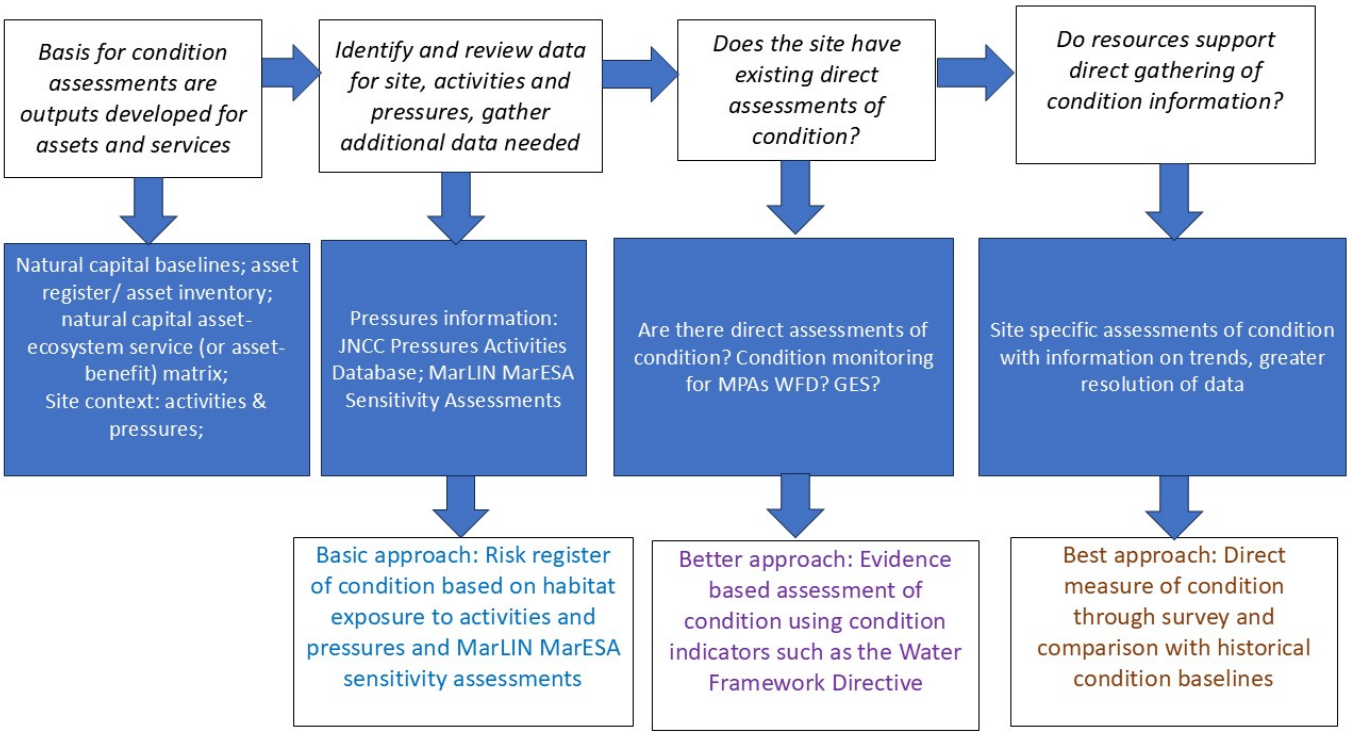

Figure 2: Steps to follow to support condition assessment for marine and coastal ecosystems

Links between natural capital asset condition and ecosystem service capacity and supply

The relationship is not always straightforward between the state or condition of natural

capital assets that support ecosystem services and the flow of ecosystem services. Understanding the condition of assets is an active research area in ecology and it is recognised that condition is not always easy to define and measure. In some instances, the ecosystem state/service supply relationship may be clear and strongly linked to condition (e.g. the abundance of a fish population that is fished) but in other cases:

- There may be no relationship or only weak relationships between the condition of an asset and its capacity to supply ecosystem services.
- The relationship between ecosystem services and the state of assets that have capacity to supply the service may be poorly understood.
- There may be a lack of data to assess the link between condition and capacity.

General considerations

Provisioning services:

The capacity to extract **non-living** (abiotic) materials like salt and aggregates is largely independent of the condition of the living (biotic) natural capital assets; whereas for **living** components such as seafood, there is a relationship between condition of the natural capital assets and the capacity to supply particular types of seafood. This relationship may be well known for key commercial species, but unknown for other less well studied species. Where there is a strong link indicators such as the catch of commercially targeted species can be considered to indicate the quality of the habitat.

Relationships between the condition of an asset and the supply of different ecosystem services may vary. For example, when it comes to wild seafood ecosystem services, a ‘healthy’ benthic habitat (in ‘good’ status) may improve the supply of some commercial fish species while having a negative impact on fish species which prefer slightly disturbed conditions (MMO, 2022).

Cultural services:

The capacity to supply some cultural services, such as recreational and leisure opportunities, may not require all aspects of the ecosystem to be in pristine state to still have strong capacity for service supply. For some activities, human capital inputs such as pathways and carparks may be more important (MMO, 2022). However, water quality will be important to swimmers and surfers, with condition measured through bathing water quality.

Regulating and maintenance services:

Regulation and maintenance of the environment (e.g. waste remediation, provision of nursery habitats) are ecosystem services that humans passively use. If the ecosystem is functioning as needed to supply these ecosystem services, no human capital is needed to support the flow of the ecosystem service. However, where condition or structure of the relevant natural capital assets is degraded, management interventions to remove pressures or restore assets may be needed to improve supply (e.g., managment of activities such as anchoring in sensitive habitats and re-seeding of seagrass beds).

Understanding how assets support services is important. For example, the quality of sedimentary habitats, and the sediment underlying seagrass and saltmarsh, has an important role in how well these biotic assets provide regulatory services, e.g. flood protection, water quality and climate regulation. Environmental pressures that can alter the quality of biotic assets, e.g. water quality, need to be managed to maintain and enhance these services. Adaptation to climate change associated pressures is also critical, e.g. managed realignment to create mudflat and saltmarsh to offset habitat squeezed out with sea level rising against sea walls.

Development of an asset risk register

The Natural Capital Committee (2013) suggests that the assets at greatest risk from unsustainable use and poor management should be identified to prioritise natural capital management and investment decisions.

A regularly updated **risk register** that systematically documents the threats to assets and benefits is proposed as an important tool for this process.

A risk register should document the **likelihood of changes in the delivery of benefits and the scale of impact of such changes** (Natural Capital Committee, 2017).

The following sections detail how to assess condition using a basic, better and best approach. These can be used to develop risk registers as described in the later sections with examples provided. Projects may however, have other objectives for determining condition and these aproaches can also be adopted and adapted to meet user requirements.

Natural capital asset condition assessments based on sensitivity and exposure to activities (basic approach)

An alternative approach to direct monitoring or use of indicators, is to use proxy measures to assess condition based on exposure to pressures to create a **vulnerability assessment.** These combine evidence for exposure to pressures with an assessment of the sensitivity or impact on receptors and are also referred to as **risk assessments.**

The advantage of this approach is that typically:

- It can include a wider range of pressures/activities thaat don't all have associated condition indicators.
- Human activity data for assessments are also more likely to be frequently updated than direct condition assessments.
- Existing pressure frameworks and sensitivity assessments can be used to link human activities to the condition of ecosystem components.

Examples of this approach are **risk registers** based on an understanding of the likely exposure of the co-occurring pressures from activities with assets, and the severity of an interaction where there is exposure (impact). An outline methodology for this work is shown

below in Figure 3.

Examples of projects that have taken this approach are:

- The North Devon Marine Pioneer: A Natural Capital Asset and Risk Register. (Rees et al., 2019)
- Feasibility study for amarine natural capital asset index for Scotland provides worked example using abrasion from fishing(Tillin et al., 2019)
- Oceand of Value natural capital assessment for Orkney (Behrendt et al. 2021).
- MPA condition assessments available on Natural England's Designated Sites View are largely based on vulnerability assessments.

The tools and approach are described in more detail in the next few sections, briefly it requires:

- Information on human activities and the pressures these cause
- The sensitivity and degree of exposure of habitats and species to these
- GIS expertise to intersect data layers if a more detailed approach is required.

The basic approach would identify potential risk from known co-occurrence of habitats and activities. The approach is developed using:

- Activity and pressure mapping (see site context);
- Natural capital asset mapping (see natural capital assets guidance);
- Existing evidence for pressures resulting from human activities; and
- Existing sensitivity assessments for habitats and species presence.

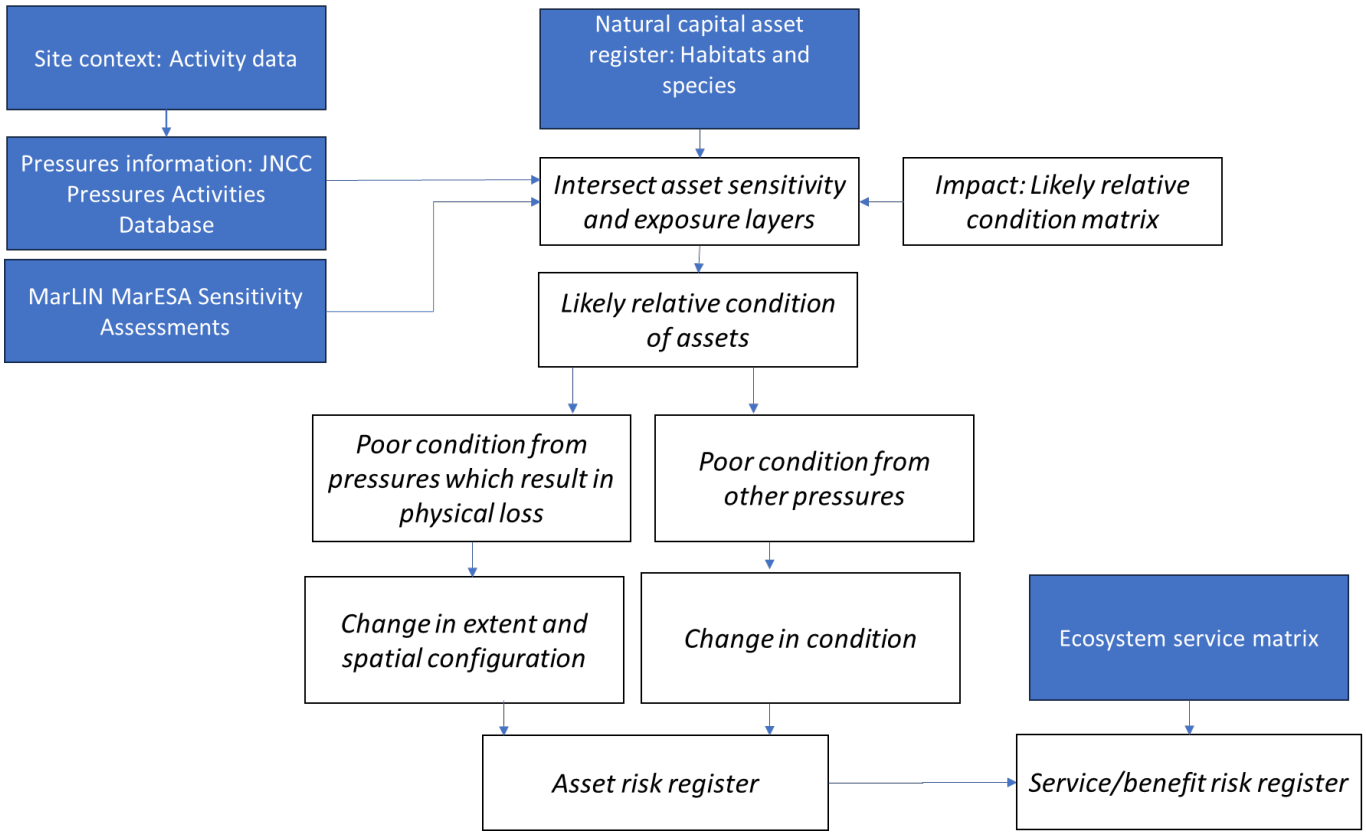

Figure 3: Developing a risk register methodology, outline workflow

Site context: activity data - linking activities within the site to pressures

Coastal and marine ecosystems are exposed to pressures associated with a variety of marine activities and developments. Activities identified as occurring within the site can be linked to the pressures that they cause, using existing tools such as the MarLIN MarESA assessments.

For the **basic approach**, an assessment of asset risk based on presence or exposure to activities to which they are sensitive would provide an indication of risk.

Better and best approaches will build on mapping and data collation and create condition assessments to assess the proportion of habitats impacted and the indicative effect on ecosystem service potential.

JNCC Pressures and Activities Database

The JNCC Pressures-Activities Database (PAD) compiles the evidence base for the relationships between a standard list of 112 marine-based human activities and their associated pressures for inshore and offshore waters UK-wide. It is a starting point to identify which pressures may be caused by which activities and gives an indication of the general risk the pressures pose to the environment under normal conditions.

Only pressures that can be linked to asset condition and ecosystem service delivery are valid candidates for this approach. Pressures that are linked to benthic species and ecosystem processes and service delivery, and are likely candidates, include: physical loss; physical change; removal of substratum; siltation rate changes; organic enrichment; subsurface penetration and/or disturbance of the substratum; and removal of target and non-target species.

For highly mobile species, the following pressures are likely to affect the stock and delivery of ecosystem services: removal of target and non-target species; underwater noise changes; visual disturbance; death or injury by collision; and barriers to species movement.

The table below provides a snapshot of pressure information from the JNCC PAD. The text captures the evidence and the risk pressure profile (i.e. the level of risk from the pressure) for two activities, aggregate dredging and agriculture grazing, and the phase of the activity in which the pressures occur.

Activity	Above water noise	Abrasion/ disturbance (surface of the seabed)	Barrier to species movement	Changes in suspended solids (water clarity)
Aggregate dredging	**Operation. RPP Low Noise** can arise from many activities in the marine environment. The use of machinery, vessels, explosives, people will result in an increase of above water noise. Some examples of sources of airborne noise are drilling rigs and support [3111],[3149], vessels used to service aquaculture facilities [2834],[3151], vessels used in coastal developments and flood defences [2817],[3085],[2838],[3136],[3153],[3154],[3132], military activities, aggregate extraction [3152], cabling operations [3158],[3164], piling [1329],[3082], etc. However, the magnitude of pressure would depend on the scale, intensity and duration of the activity.	**Operation. RPP Medium-high** Aggregate extraction removes the surface layers of sediment from the seabed. The method of dredging determines magnitude and depth of the structural damage. Trailer hopper suction dredging creates shallow furrows that may extend for several kilometres in length. The depressions are generally 2-3 m wide and initially only around 0.5 m deep. Static dredging tends to create deep (5-10 m) depressions in the seabed. On occasion this might result in the damage of seabed features or biologically important structures [3081],[3102],[3080].	**Operation. RPP Low** The pressure refers to obstructions to species movement caused by physical barrier or prolonged exposure to noise, light, visual disturbance or changes in water quality. The scale of the impact will depend on scale of activity and the location and will need to be considered on case-by-case basis to determine relevance to given feature/site. Noise generated during sonar operations have been linked with behavioural changes even stranding in marine mammals [5077]. A variety of activities have the potential of being a barrier to species movement through increase noise (e.g. construction, shipping, acoustic deterrents), lighting, presence of structures, changes to water quality and suspended sediments [2817],[3085],[3096],[3106],[3195],[2763],[3111],[3149],[2834],[3151]. The noise and turbidity arising from dredging operations may pose a barrier to migration when occurring on or in proximity of specific migratory routes [3152],[3080],[2757].	**Operation. RPP Medium-high** Marine aggregate extraction increases suspended solids in the water column. This occurs at the draghead, via the spill ways or by screening. Plumes generated by the draghead tend to be of small magnitude. The sediment overspilled or screened is dispersed laterally and vertically by waves and tides and forms a turbid plume. Particles generally settle within 250 - 500 m but can travel up to 5 km where currents are strong [3080],[3102],[4336].
Agriculture grazing		**Operation: RPP Low** Grazing animals can disturb the substrate of the coast by compacting saltmarshes and coastal soils [JNCC0370]. Trampling through walking may cause disturbance to the surface and shallow sub-surface of the foreshore [5185]. The amount of physical disturbance will be dependent on the intensity of the activity, in most cases the extent of the 'footprint' will be relatively localised. This impact will generally be intertidal or very shallow sub tidal and heavier animals such as horses and cows will have more impacts than smaller grazers [JNCC0371].	**Operation: RPP Low** The pressure relates to obstructions to species movement caused by habitat fragmentation from land claim or agricultural improvement and alteration of seed dispersal processes [JNCC0311]. The scale of the impact will depend on scale of activity and location and will need to be considered on a case-by-case basis to determine relevance to a given feature/site.	**Operation:** Activities that change the use of land, such as agricultural grazing, may change the amount of drainage and soil run off and therefore change the amount of suspended sediment in adjacent coastal areas [JNCC0246; JNCC0312].

It should be noted that different human activities may result in similar pressures. Development of an activity pressure matrix for an assessment may lead to pressure maps rather than activity maps providing the basis for exposure mapping to support vulnerability assessment. Figure 4 illustrates this, based on a small number of activities and pressures taken from the JNCC PAD Database.

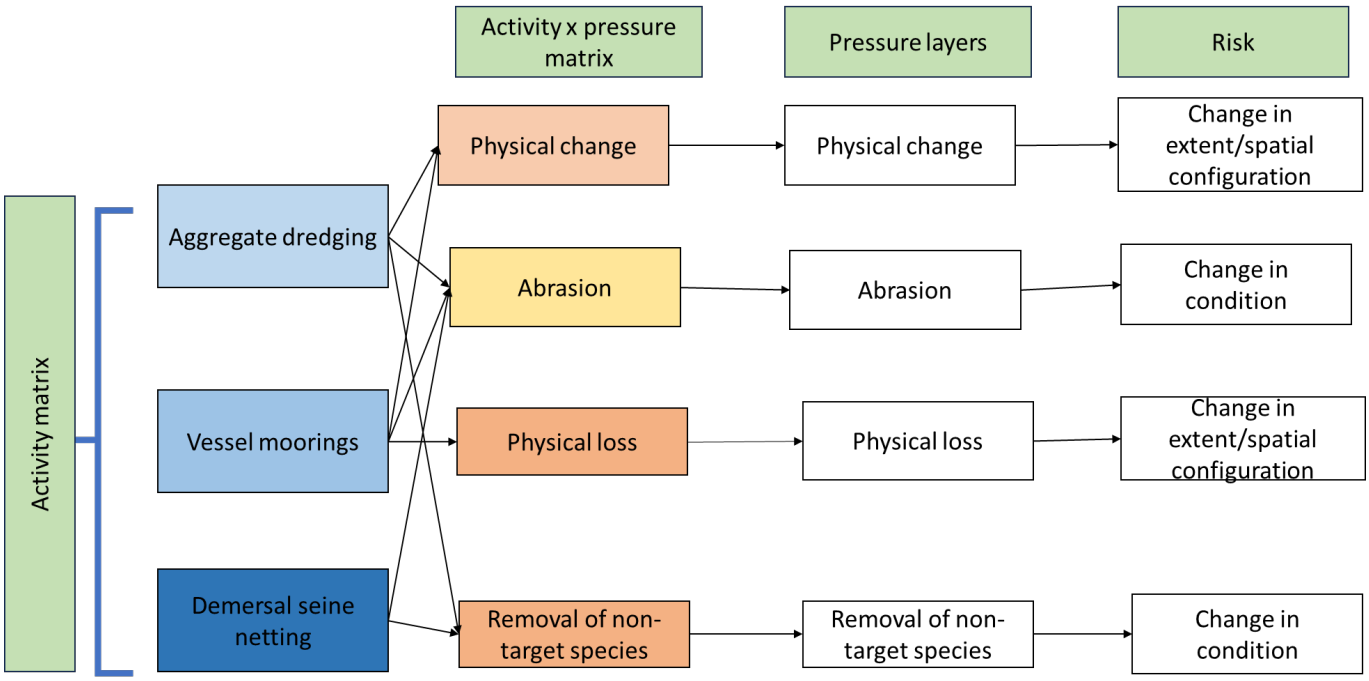

Figure 4 Example of links between activities, pressures and risks, based on information in the JNCC PAD database

Marine sensitivity assessments

Sensitivity is defined as the likelihood of change when a pressure (which could be chemical, physical, hydrological or biological) is applied to a species or habitat. It is a function of the ability of the habitat or species to tolerate or resist change (resistance or tolerance) and the rate (or time taken) for it to recover from impact (resilience or recovery) (Tillin & Tyler-Walters, 2014). Two main tools provide these sensitivity assessments for a range of UK marine habitats and species:

MarESA sensitivity assessments, undertaken through the Marine Life Information Network (MarLIN)

The MarLIN website provides sensitivity assessments for a range of EUNIS and Britain and Ireland habitat classification (v15.03) biotopes, UK-wide, alongside their detailed evidence bases.

Assessments are undertaken mainly at EUNIS Level 5 and 6 of the classifications (e.g. the biological assemblage level). The assessments are based on a detailed review of available evidence on the effects of pressures on biotopes, and a subsequent scoring of sensitivity against a standard list of pressures, and their benchmark levels of effect. The full MarESA method is detailed in the MarESA guide available on the MarLIN website. Key drawbacks are that coastal and pelagic habitats are not included, and the assessments are typically based at the biotope level rather than the broadscale habitat that many natural capital assessments are likely to adopt as the basis of the assessment. Assessments for mobile species are limited.

Evidence for the sensitivity assessments and a full bibliography are available to view within MarLIN and download. The table below shows an asset (habitat)- sensitivity matrix constructed from a MarLIN MarESA download, following the steps laid out for development of a uASM asset service matrix also on that site. The habitats were matched to the EUNIS classification and for EUNIS Level 3 habitats the worst-case (highest score) sensitivity was used from the underlying habitats.

	Abrasion/disturbance of the substrate on the surface of the seabed	Changes in suspended solids (water clarity)	Deoxygenation	Emergence regime changes, including tidal level change considerations
Coastal brackish/saline lagoons	Low	NS	NS	NR
Marine beds (Seagrass)	Med	High	NS	Med
Native Oyster (*Ostrea edulis*)	High	NS	NS	NS
Sand / shingle shores (including dune systems	Low	Low	NS	Low
Sand / shingle shores (including dune systems	Med	Low	NR	Med
Sublittoral sediment (Watson et al., 2022)	High	NR	NR	NR

Table 2: Example of a habitat- pressure sensitivity matrix based on MarLIN MarESA sensitivity assessments.

Feature, Activity, Sensitivity Tool (FeAST)

The FeAST online tool uses a Marine Protected Area ‘feature’ approach (e.g. habitat or species) and provides sensitivity assessments for Scotland’s Priority Marine Features (including benthic habitats and species, seabirds, fish and mammals). Assessments have been made tailored for Scottish waters.

Evidence for the sensitivity assessments and a full bibliography are available to view within FeAST.

Likely relative condition of assets

To use pressure as a proxy for condition of seabed habitats, and thus assess likely condition, an understanding is needed of how different levels of pressure affect the condition of seabed habitats.

The two examples provided both use MarLIN MarESA sensitivity assessments, but the exposure and condition categories are based on expert judgement and opinion. The first approach developed by Tillin et al. (2019) uses habitat resistance assessment (part of the MarESA sensitivity assessment scoring and available for download to Excel) and information on abrasion frequency based on the area swept by a fishing gear. Condition (the cell entries) is ranked into classes where A is the best and E is the worst. The % habitat in each abrasion class was calculated, and from this, the percentage of habitat in each condition was calculated.

The condition classes were combined with mapped habitats and mapped abrasion to create two proxy condition indicators:

- % of each habitat in “good” (condition categories A and B)
- % of each habitat in “poor” condition (condition categories D and E)

Table Condition classes (cell entries) based on habitat resistance to abrasion and exposure to abrasion categories, used for condition assessments by Tillin et al.

(2019).

Habitat resistance	Abrasion category							
	Complete - high freq	Complete - mid freq	Complete - low freq	Complete	High	Moderate	Low	V low
None	**E (0)**	**E (0)**	**E (0)**	**E (0)**	**D (0.25)**	**C (0.5)**	B (0.75)	A (1)
Low	**E (0)**	**E (0)**	**D (0.25)**	**D (0.25)**	**C (0.5)**	B (0.75)	B (0.75)	A (1)
Medium	**E (0)**	**D (0.25)**	**C (0.5)**	B (0.75)	B (0.75	B (0.75)	B (0.75)	A (1)
High	A (1)	A (1)	A (1)	A (1)	A (1)	A (1)	A (1)	A (1)

The second approach (Rees et al., 2019) develops an assessment of 'Likely Relative Condition' (LRC) of the seabed habitat, using MarLIN MarESA sensitivity and an assessment of exposure. Sensitivity and exposure are combined to provide a matrix of impacts or vulnerability (Table 3). These are then translated to likely relative condition scores (Table 4), where 1 indicates poor LRC (the habitat has been exposed to a pressure to which it is sensitive) and 5 indicates a good LRC (no exposure to pressure or pressure thresholds are within the tolerances of the defined sensitivity of the habitat).

Table Matrix for impacts or vulnerability based on marLIN MarESA sensitivity and exposure to fishing abrasion (from Rees et al (2019).

Sensitivity	**Exposure**			
	None	Low	Moderate	High
Not sensitive	None	None	None	None
Low	None	Low	Low	Mod.
Medium	None	Low	Mod.	High
High	None	Mod.	High	Very High

Table Matrix for impacts translated to Likely Relative Condition (scored from 1-5) (from Rees et al (2019).

Sensitivity	**Exposure**			
	None	Low	Moderate	High
Not sensitive	5. Good	5. Good	5. Good	5. Good
Low	5. Good	4.	4.	3.
Medium	5. Good	4	3.	2.
High	5. Good	3.	2.	Very High

Changes in likely relative condition combined with asset service matrices can be used to construct an asset-service risk register. The example shown below is developed using a slightly different approach by Rees et al. (2019). Information on risk however could be used to identify changes in extent and spatial configuration, where habitats are exposed to physical loss pressures and changes in condition for other pressures.

Natural capital asset condition assessments based on condition indicators (better approach)

Indicators are proxies for complex phenomena (Hattam et al., 2015). For excosystem services they can be used to evaluate the provision of a service and how it is changing over time. Indicators, where measureable, are useful for supporting management activities as well as contributing to studies aiming to model and value changes in ecosystem service provision

Key indicator resources for seabed and pelagic habitats are identified in work by Natural England (marine and coastal habitats) and Cefas (pelagic habitats). For seagrass, saltmarsh, kelp and mudflat, matrices of natural capital indicators , identified through literature reviews, have been created by the Environment Agency for their Natural Capital Ecosystem Assessment (NCEA) Land Sea Interface project (LINK) . These indicators reflect how pressures (including pressures arising from land based activities and climate change) effect the condition of these habitats and in turn how these changes in condition could effect ecosystem services delivery. The matrices could be used to help prioritise data collection depending on the environmental pressures and ecosystem services of interest at a site.

Guidance: Resources for identifying condition indicators

Natural England’s Natural Capital Indicators Project: Natural Capital Atlas (Natural England)

The Natural Capital Atlas aims to identify key attributes for measuring change in natural capital in England, at a range of scales. Indicators are identified for measuring change in natural capital, using a logic chain approach, enabling natural capital assets to be clearly linked to ecosystem services and benefits. Where possible, corresponding data sets have been found and linked to each indicator and a resulting list of data gaps detailed. Key indicators have been identified for the quantity, quality and location of ecosystems. Coastal and marine are included but there are numerous gaps. Natural capital assets were based on the eight broad habitat types as identified by the UK National Ecosystem Assessment (UKNEA). Indicators were identified for key biotic and abiotic provisioning, regulating and cultural ecosystem services, as well as services from geodiversity.

The Natural Capital Atlases follow on from indicators work and map out indicators showing asset quality, quantity and location. Indicators for some flows of ecosystem services are also mapped. These atlases provide an “off the shelf” natural capital evidence base for each county or city region. They can be added to and built on. The data package contains the shapefiles for the indicators mapped in these atlases. The data package is available for all of

England, enabling users to explore the data layers in more detail. The accompanying GIS User Guide and ArcMap package (which runs in 10.2.2 or later) will help basic GIS users to download, open and explore the map data further. The Map Presentation Resources can be used to create maps which match those in the atlases.

Nearshore water quality and pelagic asset status - ME4504 (Cefas)

Previous evaluation of marine natural capital has focussed on benthic habitats as the predominant descriptor of marine natural capital. However, the coastal or 'nearshore' waters of England provide a diverse range of benefits to society through provisioning, regulating and cultural services. This project was undertaken to develop the natural capital approach for management of nearshore water. To improve understanding of the link between nearshore water asset status and delivery of societal benefits across policy areas, logic chains were developed connecting attributes of nearshore water asset status with ecosystem service delivery. The project also undertook a monitoring and indicator assessment review to identify key information gaps that could be addressed by future data collection and evaluated the impacts of activities on water quality attributes.

Le Quesne, W., Best, M, Capuzzo, E., Devlin, M., Greenwood, N. and Nelson, M. (2022). Nearshore Water logic chains and data & indicator review. Cefas Project Report for Defra, 52 pp.

Natural capital asset condition assessments: direct assessment (best approach)

For a site, **direct assessments of condition** may be available, especially for sites managed for conservation where direct assessments may be available through statutory monitoring.

Direct assessments of condition can be based on

- Biological parameters, ,such as assessments of population characteristic
- Chemical parameters, such as the presence of contaminants or measures of variables such as oxygen and salinity
- Physical parameters, such as sediment and substratum condition

Surveys that may provide information vary in scope from citizen science projects such as SeaSearch (carried out by volunteer divers), to expert studies undertaken to support development proposals and academic research. Projects may also be able to directly commission surveys to assess condition.

Information on condition is likely to be limited in the marine environment. For benthic habitats there may be data on extent, and for Marine Protected Areas (MPAs) there may be baseline surveys, but annual data on condition are rare. Condition monitoring of many MPAs is on cycle of six years or more and is moving to a site-specific risk-based approach. MPA

condition assessments available on Natural England's Designated Sites View are a useful resource but largely based on vulnerability assessments.

Developing an asset risk register or service risk register

Intersecting asset maps with activity or pressure maps can be used to identify the area of asset exposed to the pressure. Sensitivity and exposure can be linked to condition as described above to identify the area of habitat in each condition class. Where there is past data for activities, trends in condition can be determined. Table 6 provides an asset risk register developed by Rees et al. (2019). A similar risk register could be developed using changes in likely relative condition. Figure 4 outlines how different pressures may alter different aspects of the asset condition (extent, condition and spatial configuration).

Table: Asset- risk register showing selected assets from Rees et al. (2019)

		Assets								
	Risk category policy	**Saltmarsh**			**Sublittoral mud**			**Fish (migratory species salmon & trout)**		
		Ex.	Con.	Sp.	Ex.	Con.	Sp.	Ex.	Con.	Sp.
Ecosystem services/benefits	Food (Wildfood -fish and shellfish)			*			*	*		*
	Healthy climate (Carbon sequestration			*						
	Sea defence (natural hazard regulation /flood prevention)			*						
	Recreation and tourism			*				*		*
	Clean water and sediments			*			*			

Key: For each ecosystem service risk was assessed in relation to policy targets. The colour of the cell shows the risk rating for the asset status extent (Ex), condition (Con) and spatial configuration (Sp). Red = highrisk, amber = medium risk (*amber cells with an asterisk, indicate asset status is below target and the trend in status is declining, suggesting risk rating is close to moving to the high risk category), green = low risk. Lighter shaded, red, amber or green cells = less confidence (greater uncertainty), due to limited evidence and/or limited agreement between evidence sources (e.g. modelled habitat data). Grey cells = asset–benefit relationships which were assessed to provide a low potential of benefit (and therefore not considered a priority for assessment); white cells indicate relationships where there was no evidence or too limited information to make an assessment

Examples

Asset-risk registers at national scales

A methodology for developing a risk register, and a preliminary high-level assessment for the UK, was developed by Mace et al. (2015). This was part of the Natural Capital Committee's work to highlight those natural capital assets whose current condition put at risk a sustainable flow of ecosystem services into the future. The register used eight Broad Habitat types (as adopted in the UK National Ecosystem Assessment and Follow On, 2011, 2014) including coastal margins and marine and ten major benefits: food, fibre, energy, aesthetics, freshwater, recreation, clean air, wildlife, hazard protection and equable climates. For each habitat-benefit relationship, Mace et al. (2015) explored the influence and modification of quantity, quality or spatial configuration of habitat on the identified benefit (i.e. the provision of a usable service or good to human populations).

Quantity was defined as "the amount of an asset, its area, volume or mass",

Quality as "a range of more specific conditions of the natural asset [that] will be critical where the nature of habitat management or the presence of certain components or processes affects benefits"

Spatial configuration referred "to the location of the asset and/or its spatial patterning and fragmentation" (Mace et al., 2015).

The assessed relationships were then placed in an institutional context and evaluated against existing societal targets, regulatory limits and policy commitments to derive scores of high, medium or low risk.

Mace, G.M., Hails, R.S., Cryle, P., Harlow, J. and Clarke, S.J., 2015. Towards a risk register for natural capital. Journal of Applied Ecology, 52(3), pp.641-653.

Asset-risk registers at local scales

North Devon Marine Pioneer

The North Devon Marine Pioneer project developed (see Ashley et al., 2018) and applied (see Rees, et al., 2019) a framework to assess marine natural capital. This included mapping habitat extent of the accounting boundary, establishing links between natural capital assets and ecosystem service/benefit provision and identifying indicators to measure ecosystem service flows. The risk register built on Mace et al. (2015) to consider not only the asset benefit relationship but also the severity of risks to the provision of ecosystem services. The risk register approach developed by the North Devon Marine Pioneer is the basis of the risk assessment methodology presented in this guidance.

A user friendly overview is provided and more detailed reporting is also available.

Other examples buidling on this approach now provide asset registers for large portions of English marine and coastal regions:

Plymouth:
Ashley, M., Rees, S., Mullier, T., 2021 Natural Capital Asset and Risk Register to Inform Marine Site Management Plans and Implementation of Plymouth National Marine Park. Part Two: Baseline Asset and Risk Register. A report by research staff at the University of Plymouth
Rees, S.E., Ashley, M., Beaumont, K., Mullier, T. 2023. State of the Sound, Final Report - Using Natural Capital and Ecosystem Service Indicators to demonstrate the quality and quantity of natural assets in Plymouth Sound National Marine Park and the social and economic benefits provided to society. A report to Plymouth City Council by research staff at the University of Plymouth. Pp 41

Isles of Scilly (providing evidence to support decision making for IFCA byelaws and licensing)
Ashley, M., Rees, S., Mullier, T., Reed, B., Cartwright, A., Holmes, L., Sheehan, E., 2020. Isles of Scilly Natural Capital Asset and Risk Register to Inform Management of Isles of Scilly Fisheries Resources. A report by research staff the Marine Institute at the University of Plymouth

Sussex (Providing evidence for IFCA no trawling byelaw / kelp recovery):
Williams, C., Rees, S., Sheehan, E., Ashley, M., & Davies, W. (2022) 'Rewilding the Sea? A Rapid, Low Cost Model for Valuing the Ecosystem Service Benefits of Kelp Forest Recovery Based on Existing Valuations and Benefit Transfers', Frontiers in Ecology and Evolution, 10. Available at: https://doi.org/10.3389/ fevo.2022.642775

North East England
Ashley, M., Mullier, T., Bibaud, R., Agosti, H., Rees, S., 2024 Stronger Shores: A Natural Capital Asset and Risk Register for the Northeast UK Coastline Part Two: Baseline Natural Capital Asset and Risk Register. A report by research staff at the University of Plymouth

A Natural Capital Asset Check and Risk Register for the Anglian Water Combined Services Area

Lovett et al. (2018) broadly replicated the approach taken by Mace et al. (2015) in developing a risk register for the Anglian Water Combined Services Area, again reporting only for the same broad-scale, aggregated coastal and marine habitats. The construction of the register for the risk register used the same habitat type, habitat modification and benefit categories as Mace et al. (2015). The assessment provides a starting point for identifying the most important natural capital assets and where they occur. It also suggests that there are certain parts of the region where the pressures on natural capital assets are likely to be particularly acute and therefore these may need to be a focus of future investments or other management initiatives.

Lovett, A., Turner, K., Sünnenberg, G., Ferrini, S., Stephanou, E. and Greaves, S., 2018.A natural capital asset check and risk register for the Anglian Water combined services area. Report to Anglian Water Services Ltd.

Caveats and limitations

The specific relationship between marine habitats and their condition (structure and functioning) and the ecosystem services has not been assessed in most instances. This is an emerging area of research.

Ideally, condition indicators would relate to the capacity of habitats to deliver ecosystem services, so that changes in the indicator reflect changes in service delivery. However, indicator selection is constrained by the availability of data and there are gaps within indicators that mean for some habitats and ecosystem services there may not be an indicator.

Research effort on pressure impacts is typically focussed on widespread activities that are likely to be of concern and that are commercially important. Hence, fishing and associated physical damage pressures are better understood than other activities that are more limited in extent and intensity. The impacts of physical damage are also more predictable. It is clear that fragile features that rise above the seabed are more likely to be removed by physical abrasion than deeply buried features and that a complex habitat created by living organisms will be more sensitive to abrasion than bare rock.

The pathways by which other pressures, e.g. water quality and sediment supply, impact species and habitats are less predictable and thus it is harder to identify what the impacts may be. The cumulative effects of different pressures also need to be considered but eparating these and finidng data are likely to be issues.

Useful data and resources for condition assessments

Note: This guidance is linked to a spatial data tool which can be searched and added to and you can also generate and then download the data sources it contains. See the guidance and background here.

Key tools are the:

JNCC Marine Pressures-Activities (PAD) Database: links activitiy to pressures

MarLIN MarESA Assessments: llink pressures to sensitivity of habitats and species

Data type	Source

Natural England Conservation advice packages for marine protected areas. Advice packages are listed by marine area. The interactive maps attached to each marine area page explore the designated sites and the status of their advice packages. The packages include: • Site information • Supplementary advice on designated features • Advice on operations Some packages are still in draft and being consulted on and may be subject to change.	https://www.gov.uk/government/collections/conservation-advice-packages-for-marine-protected-areas
Bathing water catchments. Surface water catchments influencing water quality at designated bathing waters in England.	Defra MAGIC
Bathing water monitoring locations. Identifies the locations of monitoring stations for assessment of bathing water quality.	https://www.data.gov.uk/dataset/dcb8bd46-c4cf-4749-bad0-7663da96845c/bathing-waters-monitoring-locations
WFD Shellfish Water Protected Areas England	Defra MAGIC
Bathing Waters (Condition)	Defra MAGIC

Environment Agency Catchment Data Explorer. Provides information about the water environment used in River Basin Management Plans. Includes maps, summary information about catchments and condition, downloadable data and links to other useful sites.	https://environment.data.gov.uk/catchment-planning/
Environment Agency river catchment pollution. Data set of river catchment pollution events including pollution from agriculture, quarries, mines.	https://environment.data.gov.uk/catchment-planning/England/rnags
Sewage discharge information. Event Duration Monitoring (EDM) dataset relates to the performance of storm overflows in England. Data are provided by Water and Sewerage Companies (WaSCs) to the Environment Agency each year as part of their regulatory Annual Return, to fulfil their permitted conditions to discharge from these storm overflows under the Environmental Permitting Regulations.	https://www.data.gov.uk/dataset/19f6064d-7356-466f-844e-d20ea10ae9fd/event-duration-monitoring-storm-overflows-annual-returns
Marine Online Assessment Tool	https://moat.cefas.co.uk/

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Pioneer. A report to WWF-UK by research staff the Marine Institute at Plymouth University.

Behrendt, K., Tillin, H., Langmead, O., Taylor, F., Parker, P., Bradshaw, K., Harding, N., Want, A., Mieszkowska, N., Lewis-Reddy, L., Taylor, P., Bendell, A. and McFarland, T. (2021) Natural Capital Assessment of the Orkney Marine Region Area. Report for Scottish Wildlife Trust.

Erhard, M., Teller, A., Maes, J., Meiner, A., Berry, P., Smith, A. et al. (2016). Mapping and assessment of ecosystems and their services. mapping and assessing the condition of Europe's ecosystems: Progress and challenges. Luxembourg: Publications office of the European Union.

Lovett, A., Turner, K., Sünnenberg, G., Ferrini, S., Stephanou, E. and Greaves, S., 2018. A natural capital asset check and risk register for the Anglian Water combined services area. Report to Anglian Water Services Ltd.

Mace, G.M., Hails, R.S., Cryle, P., Harlow, J. and Clarke, S.J., 2015. Towards a risk register for natural capital. Journal of Applied Ecology, 52(3), pp.641-653.

MMO 2022. Embedding a natural capital approach into marine plan development: a pilot study, MMO Project No: 1288

Natural Capital Committee. 2017. How to do it: a natural capital workbook. Department for Environment Food and Rural Affairs. 30pp

Rees, S.E., Ashley, M., Cameron, A. 2018. Executive Summary: North Devon Marine Pioneer, links between the ecosystem and ecosystem services in the North Devon Marine Pioneer. A report to WWF-UK by research staff the Marine Institute at University of Plymouth

Rees, S.E., Ashley, M., Cameron, A. 2019. North Devon Marine Pioneer 2: A Natural Capital Asset and Risk Register. A SWEEP/WWF-UK report by research staff the Marine Institute at the University of Plymouth .

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. and Tyler-Walters, H., 2014. Assessing the sensitivity of subtidal sedimentary habitats to pressures associated with marine activities. Phase 1 Report: Rationale and proposed ecological groupings for Level 5 biotopes against which sensitivity assessments would be best undertaken.

Management

Environmental management is a vast subject. This guidance refers only to management in the context of the natural capital approach. It focusses on management of natural capital assets with regard to ecosystem services and their benefits, i.e. the management of natural capital assets to provide, restore or enhance ecosystem services and associated benefits.

Management interventions may **assist** habitat restoration (e.g. restoration of seagrass and saltmarsh by planting) or support assets indirectly via **pressure removal** approaches that remove or reduce the pressures that are negatively impacting natural capital assets, to allow them to recover.

Earlier steps in the natural capital approach are key to identifying where and what management interventions are required. The **site context** and **condition** guidance sections describe how influences on the site such as past and present activities and the condition of natural capital assets may be evaluated. These assessments, when combined with an understanding of **natural capital assets** and associated **ecosystem services** and **benefits**, will begin to identify where management of natural capital assets may be required.

Overview

This section provides guidance on how natural capital approaches and tools such as **asset mapping** and **risk registers** may be used to identify and guide decision-making around management interventions. Options are identified for supporting recovery and restoration, and tools and evidence to identify potential suitable sites. Information collected around **site context** and **condition** are useful to inform management decisions and the respective guidance sections for these should be referred to.

This guidance covers:

- Guidance flowxhart: management
- How to identify where management options may be required
- Management options for habitats and species
- Timescales for recovery following pressure removal
- Pressure removal challenges
- Active habitat restoration and recovery approaches to support natural capital
- Active approaches: caveats, limitations and feasibility
- What resources are available to identify restoration or creation opportunities?
- Useful data and resources

Depending on resources and objectives, the assessment may apply a:

- **Basic approach:** Analysis of existing modelled data as available (e.g. seagrass bed

restoration potential).

- **Better approach:** Supplementing more generic tools, with site-based understanding of restoration potential, informed by a greater understanding of restoration approaches available and their applicability to the site.
- **Best approach:** Analysis or participatory mapping, use of historical references and full feasibility assessment to guide and implement management interventions.

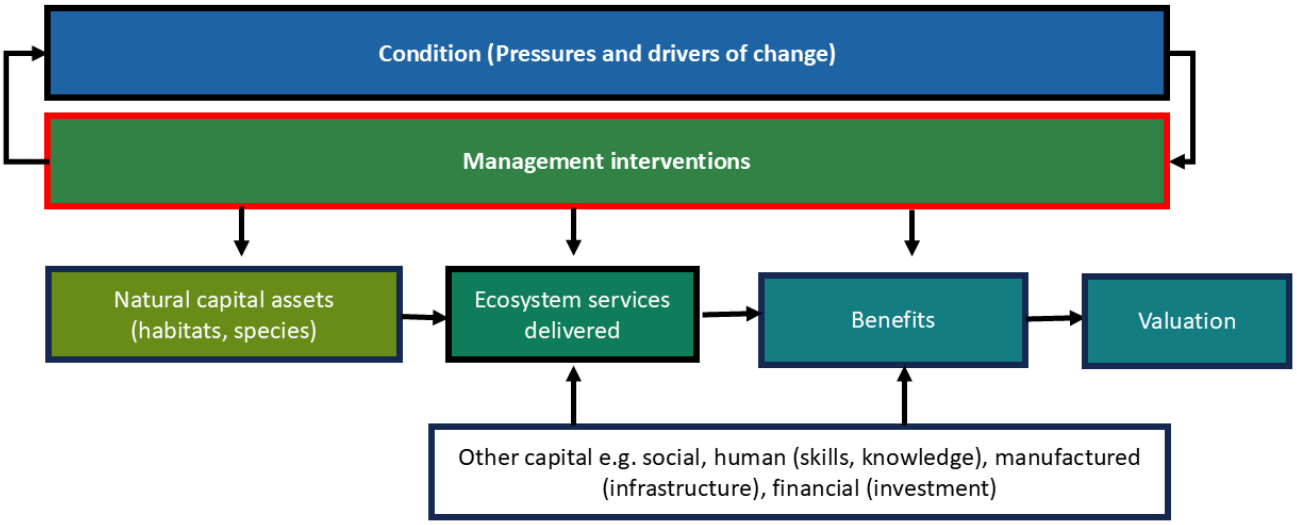

Figure 1: Natural capital logic chain: By managing pressures and drivers of change, management interventions influence natural capital assets, ecosystem services and benefits.

Components

Guidance flowchart: management

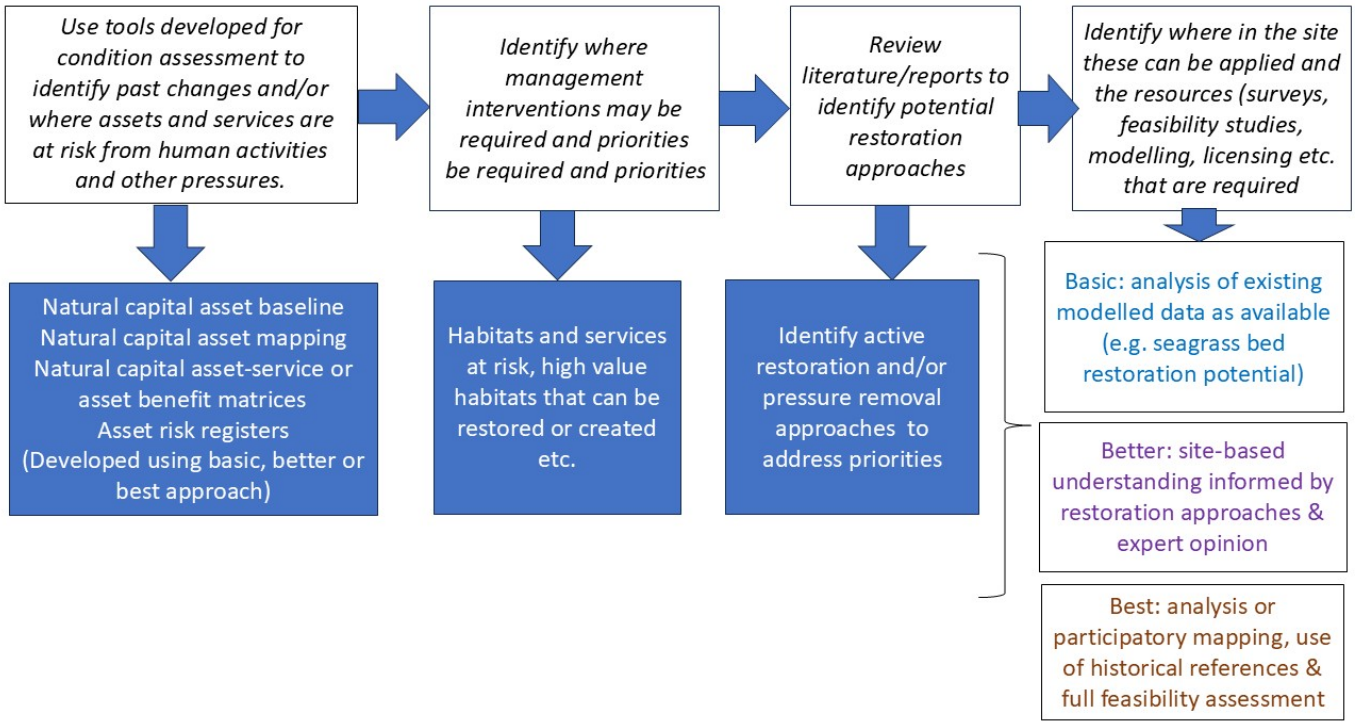

Figure 2: Management: outline of potential workflow and approach options

How to identify where management options may be required

As described in the **site context** and **condition** sections, coastal and marine sites are subject to a wide range of direct and indirect influences.

Some of these, such as climate change, site geology, water and air quality, or the catching of migratory fish species are outside local control and cannot be managed.

Within sites, however, there may be opportunities to manage natural capital assets to improve ecosystem service capacity and benefits. To **identify** these opportunities, you are likely to need to understand:

- The natural capital assets the site supports or could support.
- The associated ecosystem services and benefits, and how these are impacted by human activities or other factors.
- How to support recovery or restoration and enhancement.

To evaluate where management interventions may be required, the key tools developed through the natural capital logic chain (Figure 1) include:

- **Natural capital asset baselines** identify how habitats and species may have changed and been lost and why, and where there may be opportunities to restore these if site suitability has not changed (see site context guidance and natural capital assets guidance).
- **Natural capital asset mapping** (the extent and condition of stocks) identifies the location of natural capital assets (natural capital assets guidance).
- **Natural capital asset-service or asset-benefit matrices** identify how the stocks may deliver or support ecosystem services (ecosystem services guidance).
- **Asset-risk registers** identify the condition of assets, and where assets and services are at risk from human activities and pressures (condition guidance).

In combination, these tools can be applied to start to identify **where, how and why management** could be effective and should be targeted. The tools may be used to identify priorities and opportunities for management of natural capital assets and hence the associated ecosystem services and benefits. The tools may identify which **stocks** (habitats and species) could be **introduced** (through stock or habitat introduction or creation), **enhanced** (by increasing extent or population or improving condition) and **supported** (by managing exposure to risks).

Note: Management of sites is complex and may involve multiple stakeholders. The tools, especially those generated with stakeholder engagement (e.g. through participatory mapping or focused workshops), may be used to constructively communicate why management is needed, discuss options and reach agreement.

Examples

A Natural Capital Account for the Industrial Sandeel Fishery - ME4501

The report demonstrates the use of a natural capital tool and ecosystem-based approach to improve fisheries management decisions. A natural capital assessment framework was developed and used to explore the potential impact of different management scenarios for the North Sea industrial sandeel fishery in ICES Area IV. This demonstrated how natural capital approaches can inform fisheries management to deliver sustainable environmental and socioeconomic benefits.

Case studies on the natural capital approach in marine decision making: The development of fisheries management byelaws

The report presents three short case studies from fisheries and marine protected area management, in- and offshore. It shows how a natural capital approach is beginning to be used to support specific management strategies. Asset registers (based on the approach developed in the North Devon Marine Pioneer) were used for two examples to support the development of inshore fishery byelaws.

Hooper, T . 2021. Case studies on the natural capital approach in marine decision making: The development of fisheries management byelaws. JNCC Report No. 685 (Research & Review Report), JNCC, Peterborough, ISSN 0963-8091.
*(*https://hub.jncc.gov.uk/assets/dea8a2dd-810b-4fa4-a67e-c09f1dcd92ae)

Management options for habitats and species

This guidance classifies approaches to managing marine habitats and species as either:

- **Active or assisted approaches** that directly manage natural capital assets by introducing species, creating habitats or actively restoring and enhancing habitats.
- **Pressure removal or reduction approaches** that manage natural capital assets by removing pressures that impact them (Note: Pressures are considered to be the pathways by which human activities or other factors affect assets).

Pressure removal and reduction management options

Pressure removal or reduction approaches

- Are the most widespread approach to managing the marine environment.

- Effective where the habitat or species is able to recover
- Widely implemented in the UK.

Examples for habitats include:

- Pressure removal or reduction through marine spatial planning, noise abatement etc.
- Use of byelaws or other enforcement measures to ensure activities avoid sensitive areas
- Designation of areas for conservation, for example Marine Protected Areas, Highly Protected Marine Areas to protect species and habitats of conservation interest
- Improvements in water quality through reduction in contaminants and nutrients

Examples for species include:

- Reduction of quotas/exploitation of prey: sand eels for birds and mammals.
- Direct pressure removal, for example, removal of predators such as rats that harm nesting colonies of seabirds and litter collection.
- Reduce human disturbance: wardening of seabird and seal colonies to reduce human disturbance in breeding season.
- Fisheries management: Reduce by-catch/entanglement; escape grids in nets, acoustic deterrent on fishing gear, seals; dolphin escape and exclusion devices; increasing the visual and acoustic detectability of fishing gear to marine mammals.

Timescales for recovery following pressure removal

Most evidence for recovery from disturbances is based on fishing activities, dredging and aggregate extraction. These activities mainly affect soft-sediment habitats and there is, therefore, less direct recovery evidence for rock habitats – particularly animal-dominated circalittoral rock habitats.

Habitat processes and characteristics are a key factor determining recovery rates. For habitats that tend to be physically disturbed such as sand and coarse sediment habitats in areas of high wave action or water currents, habitat recovery is typically relatively rapid (days to a few months); whereas in more sheltered muddy sand and mixed habitats, habitat restoration is much longer, taking months or more than a year (Dernie et al., 2003). For habitats in stable conditions that are characterised by long-lived habitat forming species, recovery may require longer timescales. For particularly sensitive features, recovery may not occur without active restoration. Deep-sea corals and sponges grow more slowly and recovery times from trawling disturbance or oil spills may range from 30 years to more than a century (Duarte et al., 2020).

Borja and others (2010) reviewed 51 long-term case studies where recovery was monitored after cessation of pressures. They found that while in some cases, recovery can take <5 years, especially for the short-lived and high-turnover biological components, full recovery of coastal marine and estuarine ecosystems from over a century of degradation can take a minimum of 15–25 years to attain the original biotic composition and diversity may take longer. The time span of recovery after removal of the pressure was highly variable,

extending from several months (in the case of meiofauna) to more than 22 years (in hard-bottom macroalgae and some seagrass species).

Natural recovery may be prevented by persistent pressures that cannot be removed such as climate change, the presence of invasive non-native species or legacy contamination from sediments. Changes in environmental conditions may mean that areas become unsuitable for habitats and species that were previously present.

MarLIN recovery assessments: A tool to assess potential recovery timescale

An indication of recovery timescale from pressures is provided by the MarESA sensitivity assessments developed by MarLIN (www.marlin.ac.uk) which provide separate assessments of resistance to impacts and time to recovery. This information can be downloaded as an Excel spreadsheet.

Pressure removal challenges

Implementation of pressure removal may be challenging. To implement measures may require a **range of resources** through the process, from identifying what approaches may be needed to assessing their feasibility and likely success to implementation.

Stakeholders with different values and political or other sensitivities may need to be involved, with lengthy consultation, discussion and agreement required. Legal and management frameworks may be specific to activities and pressures. Many pressure reduction or removal approaches at broader scales may need to be delivered by government, depending on the approach required. Communication may be key to ensure that relevant site users or stakeholders are aware of or understand the need for measures, especially where these are voluntary.

Monitoring or enforcing compliance with measures may be challenging.

Pressure removal is more difficult for pressures which are long-lived. Examples include persistent contamination, habitat change and the introduction of invasive non-native species. Pressures that have caused changes in habitat conditions such as changes in sediment or other factors such as wave action and current flow may prevent recovery of the habitat to its original state.

Baseline information for habitats and species which indicates where these were historically present may be used to guide restoration or recovery efforts, however, this data may not have been collected or be available.

Example

Sussex IFCA: Assessment and implementation of a nearshore trawling byelaw to support kelp recovery

As part of an existing byelaw that prohibited seasonal nearshore trawling, it was proposed (following informal public consultation in June 2018 and statutory public consultation in September and October 2019) to extend the existing restrictions, which covered 58km2 of the district, to a year-round trawling exclusion in an area of more than 300km2 (Sussex IFCA, 2020). In developing the evidence base for the new proposal, the IFCA (Sussex IFCA, 2020) considered:

- The type and extent of natural capital assets within the district, their sensitivity, diversity, and associated ecosystem goods, services and value.
- An indication of current natural capital assets condition and risks to these.
- The empirical assessment also incorporated explicit natural capital methods and concepts, including:
    - Adoption of the principles from the asset register developed by Rees et al. (2019) as part of Defra's Marine Pioneer programme to determine extent and condition of habitats and species.
    - A matrix of ecosystem service provision by the main habitat types (to EUNIS Level 3) on scale of zero (very low) to five (very high).
    - A multicriteria analysis to attribute "environmental value" (on a four-point scale) to the different habitats, which was also used as a proxy indicator of potential risks to the flow of services and benefits.
- Commissioning a valuation of the ecosystem service benefits that could arise from the recovery of kelp beds off the coast of West Sussex.

Sussex IFCA. 2020. Sussex IFCA District Nearshore Trawling Byelaw 2019 Impact Assessment (IA No: SXIFCA007).

Active or assisted management options

Active enhancement options for the marine environment can be classified as either:

- **Approaches that improve the environment** (including sediments, water quality and quantity); or
- **Directly manipulate species populations** through replanting or restocking species (Elliott et al., 2007).

In practice, both approaches may be required for recovery. Examples include restocking filter-feeding bivalves to improve water quality, an approach that has been used in small, enclosed dock habitats (Hawkins et al., 2020).

Active approaches are effective for habitats that have undergone historic declines in extent and distribution and that will not recover, or are unlikely to recover, without management.

Examples of habitats that may recover only with active intervention are **boulder reefs** that

have been removed in their entirety, and **oysters and seagrass beds** which have suffered extensive, historical declines and suffer from low natural recruitment due to multiple factors.

Examples of active approaches to habitat enhancement and creation include:

- Managed realignment of coastline.
- Regulated tidal exchange.
- Beneficial reuse of sediments.
- Sediment recovery through shell-seeding, gravel seeding, dredging unwanted material from the seabed, bed levelling and recontouring, filling of excavation pits.
- Targeted sediment placement (sediment capping).
- Boulder field restoration - repositioning boulders to restore boulder reefs.
- Sediment harrowing to resurface buried shells to improve larval settlement of target species (typically oysters).
- Creating reefs by adding reef blocks or artificial hard substratum.

Examples of active approaches to species enhancement and restoration include:

- Restocking: Transplanting or introducing juveniles (oysters, other bivalves, lobster) or spat (oyster, mussel) and fish such as shad and sturgeon from hatcheries or donor populations, or seeds, seedlings, spores, rhizomes (saltmarsh, kelp, seagrass).
- Artificial or natural substratum restoration/ enhancement: Adding cultch (bivalve shell or gravel) to provide suitable settlement cues and substratum for scallop and oyster; coir for mussel spat.
- Provision or improvement of nesting sites for seabirds, through:
    - Clearance of vegetation.
    - Floating rafts (terns and gulls).
    - Artificial nesting towers (kittiwake and potentially auks).
    - Nest boxes.
    - Artificial nesting burrows (petrels, auks, puffin).
- Habitat enhancement for specific species, including provision of shelters and features such as lagoons created for fish within intertidal habitat restoration or creation.

Restoration guidance

For many active and assisted approaches, guidance is limited. An exception and key resource for the UK are the saltmash, seagrass and native oyster and restoring estuarine and coastal habitats with dredged sediment handbooks

The handbooks provide practical guidance on restoring and creating estuarine and coastal habitats, bringing together advice on planning and implementing such schemes with case studies and lessons from previous examples. They are intended to be a tool to support local authorities, community partnerships and environmental organisations on restoring blue carbon habitats – habitats that can absorb carbon dioxide, help achieve net zero and tackle climate change.

The three detailed handbooks have been written by academics, industry specialists and

environmental organisations that are experts in the field:

- Saltmarsh, led by the Environment Agency
- Seagrass, led by Zoological Society of London, University of Portsmouth and the Environment Agency
- Restoration of Estuarine and Coastal Habitats with Dredged Sediment, led by Centre for Environment, Fisheries and Aquaculture Science, Environment Agency and marine consultancy and survey company ABPMer

The creation of these habitats will provide flood defence, fisheries, water quality, biodiversity, social and wellbeing benefits, as well as mitigating against climate change.

The coastal restoration handbooks are hosted on the website of the Catchment Based Approach (CaBA), a partnership of local authorities, water companies, environmental organisations and businesses working together to maximise the natural value of the environment.

Assisted approach challenges

Although the body of evidence and projects to support understanding is rapidly growing, feasible approaches for most habitats and species are not available or well-established. Active approaches over larger areas to improve ecology have not been applied in the UK previously (with the exception of managed realignment and tidal exchange) and many approaches should be considered as largely experimental and subject only to small-scale trials.

In general, successful habitat creation, restoration and enhancement has been most successful for intertidal habitats through managed realignment, tidal exchange and beneficial re-use of sediments. Natural and artificial subtidal reefs have been created for several purposes and have been colonised by typical reef assemblages. At smaller scales, projects to enhance habitats for species have been demonstrated for nature inclusive designs that provide habitats for species on artificial infrastructure. For vegetated (seagrass and kelp) and biogenic reefs (oyster, horse mussel, blue mussel) approaches to restore these are largely at the trial or pilot stage, with oyster and seagrass projects subject to high losses/failure rates but with a growing body of techniques to overcome these limitations.

As knowledge and experience of overcoming limiting factors and experience increases, habitat enhancement and restoration outcomes are likely to improve.

What resources are available to identify restoration or creation opportunities?

Several resources are available to identify potential approaches and the benefits and challenges of these, and to identify site suitability at a high level as outlined below. Application of these provides a basic approach. More in-depth assessments of potential to implement restoration and recovery include environmental feasibility and management

feasibility.

Guidance

What are the benefits of assisted versus natural recovery?

(NECR475): This project assessed natural recovery potential (including timescale) and assisted recovery options for active restoration and the costs, benefits (in terms of ecosystem services) and challenges of these for marine habitats.

Tillin, H.M., Lubelski, A., Watson, A., Tyler-Walters, H. 2022. What are the benefits of assisted versus natural recovery? NECR0475. Natural England

Online Marine Registry (OMReg) Information about restoration, creation and enhancement schemes

A freely accessible resource managed by ABPmer, OMReg is a database of completed habitat creation projects that helps widely share knowledge about coastal adaptation initiatives. The OMReg website includes enhanced search tools which allow users to better understand and study a range of completed coastal habitat creation schemes and adaptation projects, and inform best practice for future schemes.

Identifying sites suitable for marine habitat restoration or creation

MMO1135: The project reviewed the status, ecology and environmental conditions and techniques to restore selected marine habitats. The study developed six Geographical Information System (GIS) datalayers which could be used/uploaded onto the MMO's Marine Information System (MIS) to identify potential creations sites for mudflats and saltmarshes, biogenic reefs (honecomb worm and European flat oyster) and seagrass.

- Mudflats and saltmarshes
    - Potential habitat creation sites within the current floodplain (applying the techniques known as 'managed realignment' or 'regulated tidal exchange').
    - Potential beneficial use (mud) – stretches which may benefit.
    - Potential beneficial use (mud) – dredge disposal sites could be a potential material source.
- Biogenic reefs:
    - Potential honeycomb worm (Sabellaria alveolata) restoration – historic and current sites.
    - Potential European flat oyster (Ostrea edulis) restoration – historic and current sites.
- Seagrass beds:
    - Potential seagrass creation / restoration – historic sites.

These datalayers can be used to aid searches for potential restoration or creation sites. They would generally be most useful during the initial stages of a search for potential sites, and further investigations and consultation of local knowledge would always be required to confirm if a site is actually suitable for the restoration or creation of a given habitat.

Marine Restoration Potential MaRePo (JP054) Natural England- Mapping

The Marine Restoration Potential (MaRePo) project is a proof-of-concept study which explores the habitat restoration potential of some key threatened and declining (subtidal) marine habitats as defined by the OSPAR convention: kelp, maerl, native oysters, horse mussels, and sea pen and burrowing megafauna communities. These habitats were chosen as they occurred within English waters and were known to have some possibility for active or passive restoration interventions. This project uses a spatial analysis approach to investigate the current, historic, and potential future distribution of these habitats in English waters (out to 200 nautical miles (nm) from the shore). Note: MaRePo+ is in progress (due March 2025) and will include similar outputs for species (mammals, birds, fish)

Johnson, C.L.E. Axelsson, M., Brown, L., Carrigan, K.H.O. Cordingley, A. Elliot, A.L. A., Downie, A., Gannon, L. Green, B., Jones, J., Marsh, M.K., McNie, F., Mills, S.R.A., NWallace, N.M., H.J. Woods, H.J., (2023) Marine Restoration Potential (MaRePo). Natural England Research Report JP054

Restoring Meadow, Marsh and Reef (ReMeMaRe)- Guidance and restoration potential maps

Restoring Meadow, Marsh and Reef (ReMeMaRe) aims to address baseline shift and reverse centuries of decline of three priority estuarine and coastal habitats: seagrass meadows, saltmarshes and European native oyster (Ostrea edulis) reefs. To support the aims of ReMeMaRe, a suite of “how to” practical habitat restoration handbooks for seagrass, saltmarsh and native oyster restoration have been produced. These are supported by a handbook for restoring estuarine and coastal habitats with dredged sediment.

A set of “where to” restoration potential maps have been produced for the three priority habitats. Based on factors such as biogeographic ranges, these maps provide a high level, national scale overview of sites where successful restoration may be possible. One of the next steps of ReMeMaRe will involve the refinement of these maps at a more regional or local level, to better support place-based delivery in the future.

Tools to support management approaches

Environmental Benefits from Nature Tool (Natural England)

The Environmental Benefits from Nature tool aims to enable wider benefits for people and nature from biodiversity net gain, by employing a habitat-based approach to provide a common and consistent means of considering the direct impact of land use change across 18 ecosystem service services. It includes only coastal and intertidal habitats: coastal rock, biogenic reefs, coastal saltmarsh, coastal lagoons, seagrass beds, vegetated dunes and shingle, beach and bare sands and other littoral sediment. It is targeted at developers, planners and other interested parties.

Natural England Biodiversity Metric

The Biodiversity Metric published by Natural England provides a way of measuring and accounting for biodiversity losses and gains resulting from built development or a change in the way land is managed. It is designed for use in England. A Biodiversity Metric 3.0 was released in July 2021. It is supplemented by a Small Sites metric, which is currently available as a 'beta' test version. The Small Sites Metric is intended for use according to specific criteria for the size of the development, and where there is no priority habitat present.

Outdoor Recreation Valuation Tool (ORVal)

ORVal is a freely accessible web-based tool that predicts the number of visits to existing and new greenspaces in England and estimates the welfare value of those visits in monetary terms. Users can examine the recreational value of existing green space and test how the number of visits and the value of these visits might change if the land cover was changed, or if new green spaces were created. Results can be grouped by local authority area or catchment, and can be split by socio-economic group. The user can zoom into a map of England and Wales showing existing publicly-accessible green spaces (parks, countryside paths, woods, beaches, allotments, cemeteries, nature areas etc.). The maps also show information on the habitat types (woodland, agriculture, natural grass, managed grass etc.), designations (SSSI, nature reserve, etc.) and points of interest (historic site, archaeology, scenic feature, viewpoint, playground) at those sites. Estimates of visits to each site and the value generated from those visits is estimated via an econometric model of recreation trip choice (specifically a random utility travel cost model) based on seven years of data from the weekly MENE (monitor of engagement with the natural environment) survey (2009 to 2016). Trip and value estimates control for the socio-economic characteristics of local populations as well as the location, size, land covers and features of a site and, importantly, of substitute sites.

Integrated Valuation of Ecosystem Services and Trade-offs (INVEST)

InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) is a suite of open-source software models for mapping and valuing the ecosystem services provided by land and

seascapes. It uses data about the environment to explore how changes in ecosystems are likely to affect the flow of benefits to people. It is designed to inform decisions about natural resource management. All InVEST models are available as stand-alone software. Models can be run through a graphical user interface or directly in Python, for users with coding skills. Mapping software such as QGIS or ArcGIS are required to prepare certain inputs and to perform any further analysis (e.g. overlays).

InVEST is designed to inform decisions about natural resource management in terrestrial, freshwater and marine ecosystems. The models use input data (map/GIS data and information in tables) to explore how changes in ecosystems are likely to affect the flow of benefits provided to people. It consists of 22 software models for mapping and valuing ecosystem services, plus several supporting tools to help with preparing, processing and visualising data. Models can be applied at multiple scales. Most models use a 'production function' approach, meaning that the ecosystem service output (map) is derived using information about environmental condition and processes. The final map result is expressed in either biophysical terms (i.e. a quantity) or economic terms. InVEST is suitable for users who wish to look at multiple services or have multiple objectives for their area of interest.

Useful data sources to identify restoration potential

Note: This guidance is linked to a spatial data tool which can be searched and added to and you can also generate and then download the data sources it contains. See the guidance and background here.

Data	Source
Identifying sites suitable for marine habitat restoration or creation (MMO1135)	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/798829/20190430_MMO1135_Identifying_sites_for_habitat_creation_datalayers_Report_a.pdf
Seagrass Historic locations (MMO) Potential seagrass restoration/creation sites in England. Point data based on a spreadsheet provided by AER (Aquatic Environmental Research), showing English sites where seagrasses are either no longer present, or highly degraded, and where restoration may be beneficial. Dataset created as part of the project: Identifying sites suitable for marine habitat restoration or creation (MMO1135)	https://www.gov.uk/government/publications/identifying-sites-suitable-for-marine-habitat-restoration-or-creation-mmo1135
Historic oyster habitat and fisheries in English Coastal Waters. Dataset collates primary and secondary written sources from government, scientific, maritime and popular media accounts that mention the use and presence of the native oyster, Ostrea edulis, across England, Channel Islands and the Isle of Man. From these sources locations of oyster habitat and fishery exploitation were identified, and – where available – descriptions of the extent of habitat and timings of decline.	https://environment.data.gov.uk/dataset/c3c60843-e831-43ba-8bef-054437e60f7c
Natural England Seagrass Potential. Provides a national 'high level' indication of where intertidal and subtidal seagrass could potentially be restored based on some key physical attributes. It should be considered as an initial aid to identifying sites	https://www.data.gov.uk/dataset/5b943c08-288f-4d47-a924-a51adda6d288/seagrass-potential
Native-oyster-bed-potential	https://www.data.gov.uk/dataset/31530300-0f98-42ac-9b68-b6c980f5383c/native-oyster-bed-potential

Data	Source
Restoring Meadow, Marsh and Reef (ReMeMaRe)	https://ecsa.international/reach/tools-and-guidance
Marine Restoration Potential MaRePo (JP054) Natural England	https://publications.naturalengland.org.uk/publication/6296202682040320

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Case Studies

Overview

This section includes case studies that demonstrate the practical applications of the marine natural capital guidance and showcases the broader work of the marine Natural Capital Ecosystem Assessment Programme (mNCEA).

Two case studies have been produced illustrating tangible outputs achievable through the application of this guidance. The first case study is at the regional-scale, covering Cornwall to the Isles of Scilly. The second focuses on a nested, local-scale assessment, covering the marine protected area stretching from Falmouth Bay to St. Austell Bay.

These case studies are presented in both long and short form versions. The long form report provides a detailed overview of the natural resources within the area, including data sources, making it suitable for an informed reader seeking an in-depth understanding.

The short form summary is concise and visually engaging; it is designed for decision-makers with limited time who need a quick understanding of the natural resources in the area, and other interested parties who want an accessible summary of the results. This format was developed following a stakeholder workshop where participants discussed the most effective ways to share the results of a natural capital assessment.

Additionally, we present two more summary infographics to highlight the broader efforts of Natural England’s work under the mNCEA, one focused on Morecambe Bay and the other on Northumberland. These examples showcase the diverse and impactful work being undertaken in using interdisciplinary and natural capital approaches to enhance our understanding and management of marine areas.

Components

Cornwall to the Isles of Scilly

The outputs from the larger scale Cornwall to the Isles of Scilly case study can be found below:

- Cornwall to the Isles of Scilly visual summary
- Cornwall to the Isles of Scilly full report

Falmouth Bay to St. Austell Bay Special Protection Area (SPA)

The outputs from the local-scale Falmouth Bay to St. Austell Bay Special Protection Area (SPA) case study can be found below:

- Falmouth Bay to St. Austell Bay SPA visual summary
- Falmouth Bay to St. Austell Bay SPA full report

Morecambe Bay: A new approach for fisheries management

This infographic presents the work Natural England have been undertaking to explore how a natural capital approach can help develop equitable management of the cockle fishery in Morecambe Bay.

Northumberland: From dune to sea

This infographic demonstrates how marine natural capital approaches have been used to support decision-making processes along the Northumberland coast.

Stakeholder Engagement and Participation in Natural Capital Assessments

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Overview

Stakeholders are groups or individuals who can affect, or are affected by, an individual's or organisation's decisions and actions. Stakeholders will therefore have an interest in these decisions and may hold knowledge that can help improve decision-making and the implementation of actions. Similarly, how stakeholders behave may influence the result of a decision or success of an action.

As natural capital assessments aim to support decision-making, it will be important to engage with stakeholders and to use that engagement to shape the assessment. Natural England's Natural Capital Evidence Handbook (Natural England 2021) recommends that stakeholder engagement should ideally occur throughout the natural capital assessment process. For example, engagement can be used to:

- **Scope a natural capital assessment**, its vision and objectives: to determine the purpose of the assessment and identify its boundaries, baseline year and timescales.
- **Communicate the project approach** and **identify** which of the material assets, services, benefits and beneficiaries are included and which are not, justifying the reasons for their exclusions and identifying the implications for the results.
- **Identify activities** (past and present) in the study area: to understand the scale, frequency, intensity, and location of activities that are taking place.
- **Understand who are the beneficiaries:** of ecosystem services, and how benefits are distributed across different groups in society (e.g. socio-economic, ethnic, generational).
- **Assess values** that beneficiaries place on natural capital and the benefits that flow from the ecosystem services they provide.
- Investigate distributional impacts of management options.

Access to time and resources, however, will constrain the level of engagement possible. At its simplest, engagement may focus primarily on determining the vision and objectives for the assessment. At its most complete, it may include the collection and validation of data used in all steps of the assessment, and participation in the discussion and assessment of possible management actions.

Components

Identifying your stakeholders

If stakeholders are not well known, or your knowledge of them is incomplete, scoping and stakeholder mapping should be undertaken to identify which stakeholders to engage. Coastal partnerships may be a useful resourse to help identify and/or provide stakeholder lists and support engagement. A recommended first step is to contact local coastal/nature partnerships to see if stakeholders have already been identified for the site or to ask who to contact in the first instance. Coastal partnerships will also be aware of the issues of "stakeholder fatigue"- this requires knowing what other project are ongoing in the area and therefore who may also be trying to engage the same stakeholders.

Regulatory stakeholders as well as local users should all be considered for inclusion in the assessment cycle (Makowska et al., 2022). See the section on site context for more details.Considerations for stakeholder engagement should also consider ensuring representation of groups that may be harder to reach and to ensure a diversity of stakeholders.

A **stakeholder map** is a visual representation of relevant stakeholders that can be used to aid identification of key stakeholders, understand their influence, and develop a strategy for their engagement and management. Stakeholder mapping should consider potential beneficiaries. and stakeholders who need to understand impacts and dependencies, and those that can provide data.

Guidance from the academic literature that may be useful includes work by Newton and Elliott (2016). A typology of stakeholders and guidelines for engagement in transdisciplinary, participatory processes.

Guidance document: stakeholder mapping

The Government's Communication Service (2021) Ensuring effective stakeholder engagement provides useful guidance on how to identify and map stakeholders. It recommends first brainstorming to identify stakeholders and then use of the Boston Matrix. The Boston Matrix is a tool for categorising stakeholders according to their level of interest and influence. Those with high influence and interest should be fully engaged. Those with high influence but low interest should be kept aware and satisfied. Those with low influence but high interest should be consulted with, and those with low influence and low interest should just be kept informed.

Why engage with stakeholders?

There are many reasons for, and benefits associated with, stakeholder engagement. In a review for Natural England, Hafferty (2022) identified the following benefits:

- Greater representation of diverse voices that bring different knowledge and experiences.
- Empowering stakeholders to better participate in similar processes and use the outputs generated.
- Increasing the likelihood that decisions are sustainable, holistic, representative and fair.
- Promoting social learning (i.e. stakeholders learn from each other and better understand each other's points of view).
- Producing more robust research or decision-making outcomes based on higher quality information as different types of knowledge and information are captured.
- Increasing the likelihood that local needs and priorities will be met as a result of the decision-making process.
- Creating a sense of ownership among stakeholders over the process stakeholders are engaged in and its outcomes, increasing support for, and trust in, the decision-making organisation.
- Increasing wider public trust in decisions if they are viewed to have been taken in an open and transparent manner.

What makes good stakeholder engagement?

It is important to think carefully about how to implement stakeholder engagement activities, as poorly designed engagement can erode trust and result in disillusionment and even conflict. To ensure successful engagement, Reed at al. (2018) highlight the importance of:

- Understanding the context (social, economic, cultural, political and institutional) in which engagement takes place;
- Careful design of engagement activities (which may vary across contexts);
- Management of power dynamics to ensure all voices are heard; and
- Consideration of the relevant scale at which engagement takes place (e.g. local, regional, national).

HM Government Communication Service (2021) provides some useful guidance on how to ensure effective stakeholder engagement. The guidance encourages you to think about:

- What you want to achieve?
- Which stakeholders are critical to your success?
- How are you going to engage with these stakeholders?
- Examples of best practice
- Implementation
- Review of whether you achieved what you wanted to achieve

Guidance documents

Hafferty, C., 2022. Embedding an evidence-led, best-practice culture of engagement: learning from the evidence. Natural England Commissioned Report NECR448

HM Government Communication Service (2021) Ensuring effective stakeholder engagement

Reed, M.S., Vella, S., Challies, E., de Vente, J., Frewer, L., Hohenwallner-Ries, D., Huber, T., Neumann, R.K., Oughton, E.A., Sidoli del Ceno, J. and van Delden, H. (2018) A theory of participation: what makes stakeholder and public engagement in environmental management work? Restoration Ecology, 26: S7-S17

Royal Institute of Chartered Surveyors (RICS) and Association of Project Management (APM) 10 key principles of stakeholder engagement

Stakeholder engagement methods

Stakeholder engagement and participation can take many different forms and the most appropriate method will depend on the purpose of the engagement, as well as the time and resources available. For example:

- To set out the vision and objectives for a natural capital assessment, exploratory, information gathering approaches (e.g. focus groups and workshops) may be most suitable.
- To validate or gather new ecological knowledge and data, visual and narrative approaches could be employed, although more simple focus groups and workshops could also be used.
- To support discussions around management and policy options, deliberative and consensus methods could be used, although where resources are limited simpler exploratory approaches may also be effective.

Many of these methods can also be used to capture (primarily) qualitative information about how stakeholders value aspects of the marine environment and marine natural capital.

Guidance documents: stakeholder engagement methods

Sea the Value- Training materials including workshop materials for participatory mapping

Sea the Value is a NERC funded project led by PML that brings together a unique interdisciplinary team and international network of collaborators to address fundamental questions regarding the economics of biodiversity, specifically of blue carbon and marine water quality. The Sea the Value Project hosted a series of workshops aimed at members of the Coastal Partnerships Network (CPN) to build understanding of key concepts that the Sea the Value project aims to address. Across four workshops they discussed approaches to better understand, protect, and restore coastal habitats. The series provides valuable tools for participants from different backgrounds to collaborate in managing coasts and local environments and provides a starting point for those looking to run their own workshops with local community groups and networks. The project training materials in natural capital approaches are free to use for its intended purposes. "Marine Natural Capital Training material from the Sea The Value project."

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Presenting Marine Natural Capital Outputs for Use in Decision-Making

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Overview

The outputs from marine natural capital assessments can be complex and highly technical. This makes conveying results to target audiences and providing clear advice to decision-makers a challenge.

Decision-makers to whom the outputs of natural capital assessments will be highly relevant include statutory bodies, parliamentarians, local government, and IFCAs. Other target audiences include those affected by the decisions made, for example community groups, fishing organisations, and the broader public. While no single output will resonate with all audiences, and the approach and messaging should always be tailored to the needs of each target audience, the commonalities that exist across audience groups mean that best practices can be applied to producing materials from natural capital assessment outputs. For example, a best-case output may look like a graphic heavy, lightly interactive navigable report, or a slide deck that can be easily amended and repurposed for different contexts and audiences.

Components

Making outputs easy to understand

Technical terms should always be used with care, as they can mean different things to different people.

While such terms may need to be used when explaining and discussing the subject matter at hand, the following approaches can aid understanding and mitigate the risk of confusion:

- Consider the key audience(s) you are aiming the output at, and their specific needs. For example, an output aimed at both the general public and researchers will need to use “plainer” language than one aimed only at researchers (e.g. instead of "taxa", you could use "kind/type of animal"; for "eutrophication", you could use "when sewage, and fertiliser from farms, pollutes waterways").
- Avoid using the term at the outset of a communications product, save in specific circumstances (e.g. if the term will have particular resonance for a policy audience,

given its relevance to strategic policy objectives); instead, include the term once the wider context for the work has been articulated.
- Provide real-life examples to make technical terms less abstract (e.g. "Natural capital assets can provide a range of ecosystem services. For example, frequent sightings of bottlenose dolphins – the "asset" – make the bay a popular place for wildlife watching trips – with this form of tourism being the "ecosystem service").
- Include a glossary and/or "acronym buster" (if the length of the output allows for this).
- "Value" in particular is a concept that is fundamental to natural capital approaches, yet is likely to be understood differently by different audiences and individuals. Its use in different natural capital assessments may also differ; one project may focus only on monetary value, while another may apply it in ecological and cultural terms too. As such, always clarify what “value” means for the natural capital assessment in question.

Even within groups of people working in the same field, preferences around terminology can differ, and names for similar concepts may change over time. For example, there have long been efforts to develop systems and approaches that highlight the importance of nature to society and the economy, try to secure a balance between human and environmental needs, and recognise the wide range of people and information that should be included in decision-making processes. These have included the "ecosystem-based approach", "natural capital", and now a transition towards using "systems thinking". To avoid confusion and to ensure that communications materials have a lasting legacy, consider when such technical terms are actually necessary. For example, "assets" can be useful to frame the concept that the environment is important and valuable in the same way that someone’s house and other such material assets are, but the use of “asset” to describe a species or habitat is much less likely to resonate.

If you do need to use a technical term, unpack it by:

- Providing a definition.
- Additionally providing alternative terms which refer to the same concept.

Beyond technical terminology, all outputs will benefit from language that is as plain, direct, and active as possible. Key ways to achieve this include:

- **Using shorter words rather than longer ones** (e.g. "need" rather than "requirement").
- **Avoiding nominalisation of verbs** - this is when a verb is turned into a noun, resulting in a word that ends in one of the following: -ment, -ion, -ence, -ance, -ity, -ent, -ant, or -anc. Noting the point above, an example would be "It is a requirement that stakeholders are involved" versus the plainer and more direct "stakeholders need to be involved".
- **Avoiding negative construction** (e.g. use "at least" instead of "no fewer than"; or "be direct" instead of "do not be indirect") – this is because negative construction requires more "processing power" of the reader.
- **Using active voice rather than passive voice whenever possible** - this is where the "agent" is placed before the "action" (e.g. "the project team consulted stakeholders" is better than "stakeholders were consulted by the project team"; a

counter-example would be where stakeholders have been consulted by multiple agents at different times, in which it would be better to use the passive construction).
- **Using metaphors and analogies where appropriate** - these can spark images and emotions in readers that will aid their understanding and retention of key information.

Making outputs easy to digest

Where possible, present information visually, as an infographic or similar. Such materials should also be adaptable to a range of formats (e.g. presentations, social media content) so that they can be efficiently and effectively reused and repurposed in different contexts. Infographics and other visual materials can be created using apps in the Microsoft Office suite (subscribed to by many organisations) or free online tools like Canva and AdobeExpress. Paid-for tools like Canva Pro and Adobe InDesign come with greater functionality, but often need more training to use. Simple design tactics to make outputs shine include:

- Creating a set of branding guidelines (e.g. colour palette, font(s), and font size(s)) and sticking to this.
- Left-aligning any blocks of text, to better guide the eyes.
- Adding bold formatting to text you want to emphasise (but don't overdo it!).
- Using different block colours to help separate different sections.
- Using plenty of whitespace to balance visual elements and avoid overcrowding.
- Using high-resolution (300+ dpi) for any imagery.
- Select suitable font sizes relative to final dimensions of the output (e.g. if you are creating a design for an A3 poster).
- Using CMYK colour mode for outputs to be printed (RGB can lead to colour discrepancies).
- Proofing print outputs by:
    - Viewing the design at 100% size to ensure all details are clear.
    - Printing a small test version (if possible) to check layout and readability (printing or viewing in PDF is recommended for proofing purely text-based outputs too!).
    - Checking colours on a calibrated screen to ensure accurate reproduction in print (see this handy quick guide from Microsoft).

Outputs drawing on a lot of data may benefit from including charts (e.g. bar chart, scatter plot, treemap, etc.), which can draw a viewer's/reader's attention to insights that might otherwise be hard to pick out from a table. Datylon's chart library gives a helpful overview of common chart types and the data they are especially suitable for visualising.

Outputs should always be as concise and short as possible. However, where longer - and likely more technical - reports or complex tools are needed to provide sufficient detail on a subject, apply the following tactics to text and more visual elements:

- Layer the information, with a high-level summary first, followed by increasing levels of detail.
- Use clear and logical headings and subheadings.
- Keep both sentences and paragraphs as short as possible (optimal paragraph length is three to eight sentences, containing no more than 150 words; and paragraphs should

ideally not exceed 250 words).
- Include cross-links, so the user can skip straight to the information they need and rapidly navigate the output.
- Whether the output is high-level only, or one that goes into greater detail, it should always signpost the user to where they can find more information. This could include links to further data, resources, or supporting material.

Making outputs accessible

Visual/graphical materials in particular should be designed bearing in mind accessibility needs. All users will benefit from clear and uncluttered layouts, and any colour schemes should be developed with reference to "colourblind-safe" schemes. Find examples of these and tips on how to incorporate them into graphs and other graphics in this Datylon blog post; and find a colour-blind simulator at Colblindor.

Online tools or platforms should additionally undergo accessibility checks as part of their development. These days, a lot of software comes with accessibility checkers (e.g. the Microsoft Office suite), and many accessibility checkers are freely available online. It is also important to consider the potential need for online tools or platforms to be updated in future as new information becomes available, and whether stakeholders could be enabled to make such updates.

Summary of recommendations

Summary of what to include and what to avoid in presenting natural capital assessment outputs:

What to include	What to avoid
• Short and succinct messaging. • Plain and direct language. • Accessible terminology. • Elements and imagery that are both visually engaging and accessible. • The decision-making context (detail on how decisions are made and why). • Site context and relevant maps. • Links to further information (relevant data, further work). • Where appropriate and available: a note on data quality (confidence, data gaps, etc.); and evidence of collaboration and knowledge sharing.	• Outputs which are heavily technical or contain technical information inappropriate to the user's experience. • Using technical terms without providing clear explanations and context for these (such terms should only be included when fundamental to the subject matter; jargon for the sake of jargon should be avoided entirely). • Unduly long reports. • Outputs which are difficult to amend or update. • Materials that cannot be downloaded or used effectively offline. • Extensive interactive tools, when not appropriate to the target audience – these can be time consuming to develop and navigate.

Glossary

Abiotic assets	The non-living components of the natural environment that provide services to humans, such as fossil fuels
Asset register	Also known as a natural Capital asset register. Defined as “an inventory of the natural assets in an area and their condition”, for which assets could be defined according to their type, area and quality, using maps and Geographical Information System (GIS) layers where possible (Natural Capital Committee, 2017).
Asset-service Matrix	An asset-service matrix provides the links between natural capital assets, including habitats and species, and the ecosystem services that they provide. Typically links are scored and a confidence level may be provided.
Assets	A distinctive component of natural capital as determined by the functions it performs, for example, soils, freshwater and species (Natural Capital Committee, 2017).
Bathymetry	Measurement of ocean or lake depth and the study of floor topography
Benefits	In the natural capital approach benefits are changes in human welfare (or well-being) that result from the use or consumption of goods, such as food, coastal protection or recreation opportunities or from the knowledge that something exists (for example, from knowing that a rare or charismatic species exists even though an individual may never see it). Note that benefits can be both positive and negative (dis-benefits) (Natural Capital Committee, 2017).
Benthos	The term benthic refers to anything associated with or occurring on the bottom of a body of water and includes the seabed sediment. The animals and plants that live on or in the bottom are known as the benthos (NOAA)
Bioblitz	A communal citizen-science effort to record as many species within a designated location and time period as possible. Find out more
BODC	British Oceanographic Data Centre. MEDIN Oceanography DAC that looks after and distributes data concerning the marine environment. Find out more
capital	Capital refers to resources used to generate wealth or income. Categories in use vary and include financial, human, intellectual, social, and natural capital.
CC-BY	Creative Commons license where credit must be given to the creator. Find out more
CC-BY-NC	Creative Commons license where credit must be given to the creator and only non-commercial uses are permitted. Find out more
CC-BY-SA	Creative Commons license where credit must be given to the creator and adaptations must be shared under the same terms. Find out more

Cefas	Centre for Environment, Fisheries and Aquaculture Science. UK government's marine and freshwater science experts that provide data and advice to government and overseas partners, and MEDIN fisheries DAC. Find out more
DAC	Data Archive Centre. A collection of data archive centres work with different data themes as part of the Marine Environmental Data and Information Network. Find out more
DASSH	The Archive for Marine Species and Habitats Data, based at the Marine Biological Association in the UK. Find out more
DOI	Digital Object Identifier. A digital identifier of an object - physical, digital, or abstract. Find out more
Drivers of change	Natural and human driven processes that cause landscapes and ecosystems to change. They can be direct (e.g. land management interventions, urban development) and indirect (eg population change, policy change). Climate change is an important driver that can have both direct and indirect effects on natural capital.
Ecological communities	A group of actually or potentially, interacting species living in the same place. Groups of interacting species form distinctive assemblages interacting with their physical environment (Maskell et al., 2014).
Ecosystem service	Ecosystem services are functions and products from nature that can be turned into benefits with varying degrees of human input, such as fish caught from the sea, or waste remediation processes (Natural Capital Committee, 2017).
Ecosystem service flows	The current flow of ecosystem services provided by natural capital stocks and the systems within which they are embedded. These yield the welfare-bearing goods and services which provide actual or potential benefits to humans. Flows can be split between ecosystem and abiotic services (Natural Capital Committee Terminology, 2019).
EDMO	European Directory of Marine Organisations. Contains up-to-date addresses and activity profiles of research institutes, data holding centres, monitoring agencies, governmental and private organisations, that are in one way or another engaged in oceanographic and marine research activities, data & information management and/or data acquisition activities. Find out more
EMODnet	European Marine Observation and Data Network. A network of organisations supported by the EU's integrated maritime policy that work together to observe the sea, process the data according to international standards and make that information freely available as interoperale data layers and data products. Find out more
EUNIS	The European Nature Information System. Contains a controlled vocabulary to describe habitat types. Find out more

EurOBIS	European Ocean Biodiversity Information System. Publishes data on marine species, collected within European marine waters or collected by European researchers outside European marine waters. Find out more
FAIR	Findable Accessible Interoperable Reusable. The guiding principles for scientific data management and stewardship. Find out more
GBIF	Global Biodiversity Information Facility Find out more
GDPR	General Data Protection Regulation. Find out more
GIS	Geographic Information Systems
GUID	Globally Unique Identifier
HES	Historic Environment Scotland. Scottish data archive centre and MEDIN historic environment DAC. Find out more
ICES	International Council for the Exploration of the Seas. Marine science organisation that provides evidence on the state and sustainable use of the seas and oceans. Find out more
iNaturalist	A global community for nature lovers where you can record your own nature observations and get help identifying them. iNaturalistUK is a member of the iNaturalist network and is co-ordinated in the UK by the National Biodiversity Network Trust (NBN Trust) with the support of the Marine Biological Association (MBA) and the Biological Records Centre (BRC). Find out more
INSPIRE	Infrastructure for Spatial Information in the European Community. It places legal obligations on public bodies to publish particular datasets that are geo-spatial, in any of the 34 INSPIRE themes and should be existing data. Find out more
IPT	Integrated Publishing Toolkit. A free open-source software developed by GBIF and used by organisations around the world to create and manage repositories for sharing biodiversity datasets. Find out more
iRecord	Recording platform for UK wildlife Find out more
JCDP	The Joint Cetacean Data Programme promotes and facilitates cetacean data standardisation and maximises value thorugh collation and the enabling of universal access to these data. Find out more
JNCC	Joint Nature Conservation Committee. Statuatory nature advisor to the four countries in the UK. They provide scientific evidence and advice to aid decision makers with turning science into action for nature. Find out more

LifeWatch ERIC	A European Research Infrastructure Consortium providing e-Science research facilities to scientists investigating biodiversity and ecosystem functions and services in order to support society in addressing key planetary challenges. Find out more
Maestro	Software for creating MEDIN-compliant metadata records. Find out more
Marine Recorder	A benthic survey data management system used widely within the UK's statutory nature conservation bodies to store and query benthic sample data across the UK's offshore and inshore waters. The system is able to store species occurrence data (with associated measurements), biotope information in the Marine Habitat Classification for Britain & Ireland and physical attribute data. The system maintains consistency and relationships between sample information, measurements and surveys allowing for accessible querying of the database. Find out more
Marine Scotland	Marine Scotland is part of the Scottish government, and a MEDIN fisheries DAC, responsible for managing Scotland's marine and freshwater environment. Find out more
MarLIN	The Marine Life Information Network. Provides information on the biology of speices and the ecology of habitats found around the coasts and seas of the British Isles. Find out more
Materiality	Impact or dependency on natural capital is material if consideration of its value (irrespective of whether or not that value can be quantified or monetized), as part of the set of information used for decision making, has the potential to alter that decision (BS 8632, from Makowska et al., 2022).
MBA	The Marine Biological Association of the United Kingdom. A learned society with a scientific laboratory that undertakes research in marine biology. Find out more
MEDIN	Marine Environmental Data and Information Network. An open partnership representing government departments, research institutions and private companies in the UK that promote the sharing of, and access to, marine environmental data. Find out more
Met Office	Meteorological Office Find out more
MMO	Marine Management Organisation, an executive non-departmental public body, sponsored by the Department for Environment, Food and Rural Affairs. Find out more Find out more
mNCEA	Marine Natural Capital and Ecosystem Assessment Programme. A research and development program funded by Defra. Find out more

MSBIAS	Marine Species of the British Isles and Adjacent Seas. Register of marine species, which is a subset of WoRMS containing species found in the British Isles and Adjascent Seas. Find out more
Natural capital	Natural capital can be defined as the world's stocks of natural assets which include geology, soil, air, water and all living things. It is from this natural capital that humans derive a wide range of services, often called ecosystem services, which make human life possible. (Natural Capital Forum).
Natural Capital Accounts (NCA)	NCAs are a series of interconnected accounts that provide a structured set of information relating to the stocks of natural capital and flows of services supplied by them. They form part of the environmental satellite accounts. The UK's NCAs are comprised of: 1) extent accounts, measuring the area of each habitat 2) condition accounts, tracking the ecological health of those habitats 3) physical accounts, presenting the annual service flow 4) monetary accounts, assigning a monetary valuation to selected services on an annual basis and recording an overall valuation of the natural asset's ability to generate future flows of services. (Principles of UK natural capital accounting, 2023) Find out more
Natural capital approach	A natural capital approach integrates the concept of natural capital into decision-making. Thinking in 'capital' terms enables comparison of many changes and decisions at the same time. The natural capital approach uses information from, and provides input to, many existing environmental management and analytical approaches (Capitals Coalition, 2019).
Natural capital asset	A natural capital asset is a distinctive component or grouping of natural capital components, including soils, seawater and species. Natural capital assets are not mutually exclusive - there is overlap between categories (for example, soils include species, minerals and water), illustrating the complexity of natural capital. Natural capital assets typically come in systems, rather than discrete atomised components, limiting the scope for conventional economic analysis. Natural capital assets provide ecosystem services (flows) such as pollination and water purification, which support the production of goods and services, and generate benefits (Natural Capital Committee, 2019). Find out more
Natural capital asset quality	Refers to the underlying condition of natural capital assets and their ability to maintain flows of services (Natural Capital Committee Terminology, 2019), see also Natural Capital Condition
Natural capital assets	A distinctive component of natural capital as determined by the functions it performs, for example, soils, freshwater and species (Natural Capital Committee, 2017).

Natural capital baselines	Provide a starting measurement point of natural capital assets. Changes relative to the baseline over time provide a measure of progress or decline (Natural Capital Committee Terminology, 2019). A natural capital asset baseline is essential for any proper, robust evaluation of national and corporate environmental performance.
Natural capital benefits	The value of natural ecosystems or habitats in terms of their benefits to the economy, or to society, or to nature itself (may also be referred to as ecosystem benefits)
Natural capital condition	Quality of natural capital assets measured in terms of their biotic and abiotic characteristics and their ability to maintain flows of benefits (Makowska et al., 2022).
Natural capital extent	The quantity, volume, or amount of a natural capital asset (from Makowska et al., 2022).
Natural capital stocks	The extent and condition of the natural assets. For example, the total number of cod that can be harvested would be a measure of extent; and a measure of condition could be the size of adult fish (which acts as a proxy for longevity and breeding potential).
NBN	National Biodiversity Network in the UK Find out more
NBN Atlas	NBN data repository Find out more
NCEA	Natural Capital and Ecosystem Assessment. A science innovation and transformation programme, which spans across land and water environments. It has been set up to collect data on the extent, condition and change over time of England's ecosystems and natural capital, and the benefits to society. Find out more
NERC	Natural Environment Research Council. Find out more
NMBAQC	The NE Atlantic Marine Biological Analytical Quality Control Scheme provides a source of external Quality Assurance (QA) for laboratories engaged in the production of marine biological data. Find out more
OBIS	Ocean Biodiversity Information System. A global open-access data and information clearing-house on marine biodiversity for science, conservation and sustainable development. Find out more
OGL	Open Government License for public sector information. Find out more
ORCA	Marine conservation charity dedicated to the long-term study and protection of whales, dolphins and porpoises and their habitats around the world. Find out more
Pressure	A pressure is defined as 'the mechanism through which an activity has an effect on any part of the ecosystem' (Robinson et al., 2008). Pressures can be physical (e.g., sub-surface abrasion), chemical (e.g., organic enrichment) or biological (e.g., introduction of non-native species).

QGIS	Quantum Geographic Information System. An open-source software used to visualise, manage, edit, analyse data and compose printable maps. Find out more
R package	A free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. Find out more
RCAHMW	Royal Commission on the Ancient and Historical Monuments of Wales. MEDIN Historic Environment DAC which has a role in developing and promoting understanding of the archaeological, built and maritime heritage of Wales, as the originator, curator and supplier of authoritative information for individual, corporate and governmental decision makers, researchers, and the general public. Find out more
Repository	Data repositories are a centralised place to hold data, share data publicly, and organise data in a logical manner
Risk register	Risk means in this context the probability of changes in the delivery of benefits. The risk register needs to consider both the likelihood of such a change and the scale of its impact (Natural Capital Committee, 2017a)
Schematron	Tool for validating MEDIN metadata records. Find out more
SeaDataNet	Pan-European Infrastructure for Ocean and Marine Data Management. SeaDataNet has federated open digital repositories to manage, access and share data, information, products and knowledge originating from oceanographic fleets, new automatic observation systems and space sensors. Find out more
SeaSearch	A project for recreational divers and snorkellers who want to collect information about habitats, plants and anumals they see underwater. Find out more
Service Providing Unit	The term Service Providing Unit (SPU) was coined, initially, to describe the group of individuals that provides one or more ecosystem services, while recognising that the definition of any SPU would vary according to context, particularly in terms of spatial and temporal scales (Luck et al. 2003). This guidance uses the term asset instead of SPU.
Spatial configuration	Refers to the location of the asset and/or its spatial patterning and fragmentation, both of which have been shown to have substantial effects on benefits (Natural Capital Committee Terminology, 2019).
Species assets	All living organisms including plants, animals, fungi and micro-organisms. The product of ongoing evolutionary processes (Maskell et al., 2014).
The Rock Pool Project	A not-for-profit community interest company, passionate about connecting people of all ages and backgrounds to the incredible wildlife found around the UK coastline. Find out more

Trade-off	A natural capital trade-off refers to the situation where utilizing one natural resource or ecosystem service for a specific purpose results in the depletion or reduction of another natural resource or service, meaning that choosing one benefit often comes at the cost of another, requiring decision-makers to weigh the various benefits and potential negative impacts when managing natural capital.
UK GEMINI	UK geographic metadata standard that provides guidance on how to publish geographic metadata in a way that conforms to UK government guidelines and the relevant ISO standards. Find out more
UK National Site Network:	Formerly Natura 2000 sites these refer to Special Areas of Conservation (for habitats) and Special Protection Areas (for birds).
UKDMOS	The United Kingdom Directory of Marine Observing Systems. An internet-based searchable database of marine monitoring conducted by UK organisations, managed by MEDIN. Find out more
UKHO	UK Hydrographic Office. A UK executive agency and MEDIN data archive centre for hydrography, specialising in marine geospatial data. Find out more
Valuation	Assignment of values to a particular good or service in a certain context (such as decision making) in monetary or other terms
Value	A measure of the change in human wellbeing that results from the consumption of goods. This may be expressed in monetary terms though this is not always possible (Natural Capital Committee, 2017a).
Verification	A step to verify the accuracy, consistency and truth of the data, often involving experts confirming the accuracy of records.
WoRMS	World Register of Marine Species. The aim of a World Register of Marine Species (WoRMS) is to provide an authoritative and comprehensive list of names of marine organisms, including information on synonymy. While the highest priority goes to valid names, other names in use are included so that this register can serve as a guide to interpret taxonomic literature. Find out more