Strategic Compensation Studies

Understanding the scale of opportunity for the removal of infrastructure as a potential strategic compensation measure

Offshore Wind Evidence + Change Programme | THE CROWN ESTATE

SCS Strategic Compensation Studies

OffshoreWind IndustryCouncil

Document Control

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About the OWEC Programme: This project forms part of the Offshore Wind Evidence and Change programme, led by The Crown Estate in partnership with the Department for Energy Security and Net Zero and Department for Environment, Food & Rural Affairs. The OWEC programme is an ambitious strategic research and data-led programme. Its aim is to facilitate the sustainable and coordinated expansion of offshore wind to help meet the UK's commitments to low carbon energy transition whilst supporting clean, healthy, productive, and biologically diverse seas.

About the OWEC SCS Project: The Strategic Compensation Studies (SCS) is a £3.5 million project running until the end of 2027 which forms part of the OWEC programme. Alongside OWEC funding, the SCS project is supported through financial and in-kind contributions from participating Offshore Wind Industry Council (OWIC) members. Further information can be found via the Strategic Compensation Studies webpage.

Purpose of this Report: This report forms part of the SCS Infrastructure Removal work package and aims to provide an initial investigation into the potential for removing defunct infrastructure in UK marine waters as a means of providing ecological compensation when Marine Protected Areas (MPAs) are adversely affected by residual impacts from offshore wind development.

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Acronyms

Acronym	Term
AEOI	Adverse Effect on Integrity
ANS	Artificial Nesting Structure
BTO	British Trust for Ornithology
DCO	Development Consent Order
DESNZ	Department for Energy Security and Net Zero
EEZ	Exclusive Economic Zone
HPMA	Highly Protected Marine Area
HRA	Habitats Regulations Assessment
INNS	Invasive Non-Native Species
JNCC	Joint Nature Conservation Committee
KCIMP	Kittiwake Compensation Implementation and Monitoring Plan
KCP	Kittiwake Compensation Plan
MCZ	Marine Conservation Zone
MMO	Marine Management Organisation
MPA	Marine Protected Area
NSN	National Site Network
OW	Offshore Wind
OWEC	Offshore Wind Evidence and Change
OWIC	Offshore Wind Industry Council
RSPB	Royal Society for the Protection of Birds
SNCB	Statutory Nature Conservation Body
SAC	Special Area of Conservation
SPA	Special Protection Area
TBC	The Biodiversity Consultancy

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Glossary

Term	Definition
Adaptive Management	A structured learning process which provides a framework for flexible and optimal decision-making in the face of ecological complexity. Adaptive management involves the implementation of evidence-based management decisions, the monitoring of the impact and evaluating of the outcome of those decisions, and the appropriate adjustment of management actions.
Additionality	Best practice principle relevant to (inter alia) compensation delivered in compliance with legislative requirements applicable to MPAs. A real increase in social value that would not have occurred in the absence of the intervention being appraised.
Biodiversity	Variability among living organisms from all ecosystems of which they are part, covering richness, rarity and uniqueness.
Ecosystem	A dynamic complex of living things (animals, plants and micro-organisms) and their physical environment interacting as a functional unit.
Ecosystem Resilience	The ability of a receptor to recover from disturbance or stress
Ecosystem Services	Ecosystem services are defined as services provided by the natural environment that benefit people.
Exclusive Economic Zone	The Exclusive Economic Zone (EEZ), the United Kingdom's Exclusive Economic Zone, extending up to 200 nautical miles from the coast, where the UK has rights to explore, exploit, and manage marine resources.
Habitat	A place where an organism or community of organisms normally live.
Habitat Creation	The process of establishing new habitats by closely matching the abiotic environment to desired ecological outcomes, considering factors such as geology, hydrology, vegetation structure, and regional climatic variations.
Innovation and Targeted Oil & Gas	A Crown Estate Scotland leasing round that enables offshore wind developers to apply for seabed rights for two types of projects—small-scale innovation projects testing new technologies, and targeted projects aimed at decarbonising existing oil and gas infrastructure in Scottish waters.

Term	Definition
Joint Nature Conservation Committee	JNCC is the public body that advises the UK Government and devolved administrations on UK-wide and international nature conservation.
Library Of Strategic Compensation Measures	A list of strategic compensation measures for offshore wind projects that have been approved by the Secretary of State for the Department for Environment, Food and Rural Affairs.
Like-For-Like	Also used as Ecological equivalence. In the context of biodiversity offsets, this term refers to areas with highly comparable biodiversity components. This similarity can be observed in terms of species diversity, functional diversity and composition, ecological integrity or condition, landscape context (e.g. connectivity, landscape position, adjacent land uses or condition, patch size, etc.), and ecosystem services (including people's use and cultural values). Source: BBOP (2012).
Marine Conservation Zone	MCZs are a type of marine protected area that can be designated in English, Welsh and Northern Irish territorial and offshore waters. MCZs protect a range of nationally important habitats and species such as cold-water coral reefs which thrive in the UK's deeper waters, sedimentary seabed habitats vital for a range of marine processes and other species, and the slow-growing ocean quahog identified as an OSPAR Threatened and/or Declining species.
Marine Net Gain	Net Gain is an approach to development that aims to leave the natural environment in a measurably better state than beforehand. This means protecting, restoring, or creating environmental features that are of greater ecological value to wildlife, habitats and people than any losses associated with the original project. MNG is therefore being developed from first principles to ensure it is appropriate for the marine environment. The aims of MNG relate primarily to nature recovery and biodiversity in the marine environment.
Marine Protected Area	MPAs are defined geographical areas of the UK marine environment established and managed to achieve long-term nature conservation and sustainable use. It is used as an umbrella term throughout this report to refer to designated marine protected areas including Special Areas of Conservation, Special Protection Areas, Marine Conservation Zones, Nature Conservation Marine Protection Areas, and Highly Protected Marine Areas.

Term	Definition
Marine Recovery Fund	The MRF is intended to facilitate the delivery of strategic compensatory measures to compensate for unavoidable damage to Marine Protected Areas (MPAs) from offshore wind developments.
Measures Of Equivalent Environmental Benefit	Used in the context of MCZs to refer to measures of equivalent environmental benefit to the damage which an act will or is likely to have in or on an MCZ.
Mitigation Hierarchy	Defines a sequential process that should be adopted to avoid, mitigate and compensate negative ecological impacts, with compensation very much interpreted as a measure of last resort.
Mitigation Measures	Measures taken to avoid, reduce and, if possible, offset the principal adverse effects of the licensed activity.
Net Zero	Refers to achieving a balance between emissions produced and emissions taken out of the atmosphere via such activities as carbon offsets. It allows the production of emissions as long as they are offset by reducing the greenhouse gases already in the atmosphere.
Remediation	Directed towards the achievement of specific nature conservation outcomes.
Restoration	The action of returning something to its previous condition. It can be applied to ecology as the attempts to return ecosystems that have been destroyed by human activity to their more natural, original state.
Special Area of Conservation	SACs are protected areas in the UK designated under: • the Conservation of Habitats and Species Regulations 2017 (as amended) in England and Wales (including the adjacent territorial sea) and to a limited extent in Scotland (reserved matters) and Northern Ireland (excepted matters), • the Conservation (Natural Habitats &c.) Regulations 1994 (as amended) in Scotland, • the Conservation (Natural Habitats, &c) Regulations (Northern Ireland) 1995 (as amended) in Northern Ireland, and • the Conservation of Offshore Marine Habitats and Species Regulations 2017 in the UK offshore area (JNCC 2025a).
Special Protection Area	SPAs are protected areas for birds in the UK classified under: • the Conservation of Habitats and Species Regulations 2017 (as amended) in England and Wales (including the adjacent

Term	Definition
	territorial sea) and to a limited extent in Scotland (reserved matters) and Northern Ireland (excepted matters). • The Conservation (Natural Habitats &c.) Regulations 1994 (as amended) in Scotland. • the Conservation (Natural Habitats &c.) (Northern Ireland) Regulations 1995 (as amended) in Northern Ireland. • the Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) in the UK offshore area (JNCC 2025b).

Executive Summary

The offshore wind (OW) sector is set to expand significantly to meet ambitious Government targets under Clean Power by 2030 and achieving net zero. It is recognised that the scale and location of future developments could mean that the derogation process[1] is increasingly likely to be triggered, hence there is a need for industry-scale consideration of how robust compensation will be delivered in the future. Strategic compensation has been identified as a potential solution for addressing some of these issues and could help streamline consenting timelines and deliver improved environmental outcomes at a seascape scale.

This project forms part of the Offshore Wind Evidence and Change (OWEC) programme, led by The Crown Estate in partnership with the Department for Energy Security and Net Zero (DESNZ) and Department for Environment, Food & Rural Affairs (DEFRA). The OWEC programme is an ambitious strategic research and data-led programme. Its aim is to facilitate the sustainable and coordinated expansion of offshore wind to help meet the UK's commitments to low carbon energy transition whilst supporting clean, healthy, productive, and biologically diverse seas.

The OWIC-led Strategic Compensation Studies (SCS) project aims to investigate the effectiveness of certain potential strategic compensation measures through desk-based studies and practical pilots to increase confidence in measures and provide strategic compensation options for OW plans and projects.

This report, written by The Biodiversity Consultancy (TBC) on behalf of the OWIC-led SCS project, forms part of the SCS infrastructure removal work package and aims to provide an initial investigation into the potential for removing defunct infrastructure in UK marine waters as a means of providing ecological compensation when Marine Protected Areas (MPAs) are adversely affected by residual impacts from OW development. Using publicly available data, the study maps the distribution and status (e.g. abandoned or not in

[1] Under the Conservation of Habitats and Species Regulations 2017 as amended (known as the Habitats Regulations) and the Marine and Coastal Access Act 2009 (MCAA).

use) of various infrastructure types, including pipelines, cables, coastal defences, and other marine installations, within and around the UK's MPAs, including Special Protection Areas (SPAs), Special Areas of Conservation (SACs), Marine Conservation Zones (MCZs), Highly Protected Marine Areas (HMPAs) and Nature Conservation Marine Protected Areas (NCMPAs).

A spatial analysis was conducted to quantify the length and/or count of these infrastructure features located within MPAs. To support exploration and decision-making, an interactive online mapping tool was developed. This tool visualises the infrastructure data alongside current and planned windfarm sites, the MPA network and ecologically important marine habitats. It is intended to provide users with a practical means of assessing whether the removal of specific infrastructure from MPAs could contribute meaningfully to marine conservation and restoration efforts via strategic compensation.

Initial analyses highlight that there is potential for infrastructure removal as a strategic compensation opportunity, particularly in English waters where MPAs, many in proximity to OW, overlap with ~3000 km of disused pipelines, ~3400 km of abandoned cables and ~3400 counts of various disused infrastructures. However, the potential of infrastructure removal as a strategic compensation measure must be considered in the context of existing policy drivers, notably OSPAR Decision 98/3, which may already mandate the removal of certain infrastructure types, as well as the potential environmental costs and benefits associated with any infrastructure removal. Other considerations include additionality, feasibility and cost of removal and the practicalities of implementing infrastructure removal on a strategic scale (due to the nature of some infrastructure this will need to be considered on a 'case-by-case' basis).

1 Scope of this report

The offshore wind (OW) sector is set to expand significantly to meet ambitious Government targets around net zero. It is recognised that the scale and location of future developments could mean that the derogation process is increasingly likely to be triggered, hence there is a need for industry-scale consideration of how robust compensation could be delivered. Strategic compensation has been identified as a potential solution for addressing some of these issues and could help streamline consenting timelines and deliver improved environmental outcomes at a seascape scale.

The term “compensation” as used within this report refers to both that required under the Habitats Regulations and measures of equivalent environmental benefit (MEEB) required under the Marine and Coastal Access Act (MCAA).

The OWIC-led Strategic Compensation Studies (SCS) project, funded by the Offshore Wind Evidence and Change (OWEC) programme, within which this piece of work is being delivered, aims to investigate the effectiveness of certain strategic compensation measures through desk-based studies and practical pilots to increase confidence in measures, and provide compensation options for OW plans and projects.

The SCS project will provide more confidence in different measures by carrying out practical trials and collating evidence to help fill data gaps, ensuring that OW projects can be consented/conditions discharged in a timely way and that the relevant frameworks and mechanisms are in place for strategic compensation delivery. The SCS project also aims, where possible, to promote additional measures for approval into the library of strategic compensation measures (LoSCM) to support the acceleration of OW delivery in the UK.

The SCS project includes six technical work packages, as follows:

- Work package 1 – artificial nesting structures;
- Work package 2 – predator reduction;
- Work package 3 – habitat creation;
- Work package 4 – infrastructure removal;
- Work package 5 – delivery mechanism and overarching actions; and
- Work package 6 – supporting measures.

This report forms part of the SCS infrastructure removal work package (WP4) and aims to understand the potential value of the removal of defunct infrastructure in delivering strategic compensation by mapping the types, and extent of this infrastructure in the UK.

Whilst a substantial volume of literature has been published on the impacts of infrastructure on the marine environment, to date very few of these have considered decommissioning (Lemasson *et al.* 2022). As much of this infrastructure reaches the end of its operational life, it is subject to ongoing debate in relation to decommissioning and removal (Fowler *et al.* 2020), a topic currently being explored as part of the INSITE (Influence of Man-Made Structures in the Ecosystem) programme. These debates arise as a consequence of, sometimes competing, policy objectives to restore and enhance the marine environment. For example, The Scottish Government draft marine and coastal restoration plan[2] and the UK Government 25 Year Environment Plan and Environmental Improvement Plan, which seek to implement Marine Net Gain (MNG) in England. At the same time, OSPAR Decision 98/3[3] introduces requirements to dispose of disused marine infrastructure. These policies may conflict with one another, for example, when infrastructure has supported the development of artificial reef communities but there is a policy requirement for it to be removed (Techera & Chandler 2015). There would therefore be a need to differentiate between infrastructure with the purpose of engineering and delivery only and that which could provide a nature recovery/enhancement.

Before the challenges, costs and benefits of infrastructure removal as a strategic compensation option can be considered, there is a need to understand the scale of opportunity. Therefore, this work has focused on gathering publicly available data on the location and status of this infrastructure to aid in the investigation of whether or not removal could provide strategic compensation opportunities, through mapping out their location and status.

To support the strategic assessment of infrastructure removal as a compensation measure, this report includes high-level maps showing the

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[2] https://www.gov.scot/publications/draft-marine-coastal-restoration-plan-consultation/pages/2/

[3] https://www.ospar.org/documents?v=57705

distribution and status of infrastructure across multiple regions of the UK. These visual summaries provide an overview of the scale and spread of opportunity for removal. Complementing and aiding the interpretation of these maps, an interactive online tool has been developed, enabling users to explore infrastructure types and locations in greater detail. This tool is designed not only to aid decision-making around removal feasibility, but also to serve as a repository for infrastructure records (namely type and location) which risk being lost over time due to asset handovers or once infrastructure is abandoned and no longer linked to a financially viable entity. This approach draws on lessons from the Offshore Energies UK "Designing for Decommissioning" paper, which highlighted the long-term value of retaining such data (OEUK 2024).

Upon completion of this work, the SCS project will review the information collated and consider whether any further work will be undertaken to progress infrastructure removal as a potential strategic compensation measure. These decisions will be informed through wider discussions and engagement with relevant stakeholders, such as through the Collaboration on Offshore Wind Strategic Compensation (COWSC).

2 The derogation process and need for strategic compensation

When bringing forward OW projects, developers must assess the environmental impacts of developments on MPAs under both the Habitats Regulations (in the form of Habitats Regulations Assessments (HRAs) for SACs and SPAs (and as a matter of policy, Ramsar sites) and under the MCAA (in the form of MCZ assessments).

Projects must show they have followed the mitigation hierarchy in a sequential manner to avoid, reduce and mitigate any environmental impacts. If, after exhausting these options, a project cannot either rule out an Adverse Effect on Integrity (AEOI) of a SAC or SPA, or that it will hinder (or has the potential to hinder) the achievement of the conservation objectives of a MCZ, the responsible authority cannot consent to it. However, derogations from these regulations can be applied for in order to gain consent for the development.

In the case of an SPA or SAC, this means satisfying the decision-making authority that there are no alternative solutions and the project is necessary due to Imperative Reasons of Overriding Public Interest (IROPI), despite the likely AEOI on a SAC or SPA. In such cases, the decision-making authority must secure that any necessary compensation measures are implemented to ensure the overall coherence of the national site network.

In the case of an MCZ, the developer must demonstrate that there is no other means of proceeding with the act which would create a substantially lower risk of hindering the achievement of an MCZ's conservations objectives; that the benefit to the public of proceeding with the act clearly outweighs the risk of damage to the environment that will be created by proceeding with it; and that the person seeking the authorisation will undertake, or make arrangements for the undertaking, of MEEB to the damage which the act will or is likely to have in or on the MCZ.

These requirements are particularly relevant to Annex I habitats which may occur in locations in which offshore wind farms are planned, such as 'sandbanks covered by seawater all the time'. Where projects, or their associated infrastructure pass through MPAs for which these habitats are designated features, it is not always possible to rule out AEOI or risk of hindering the achievement of an MCZ's conservations objectives, meaning compensation and/or MEEB must be provided for any residual impacts.

2.1 Project-led approaches to benthic compensation

The Appropriate Assessment completed as part of the HRA for Hornsea Three could not rule out AEOI on the Annex I habitats 'sandbanks which are slightly covered by sea water all of the time' and biogenic 'reefs' features of the North Norfolk Sandbanks and Saturn Reefs (NNSSR) SAC, and therefore a derogation case was required to achieve consent. An AEOI could also not be ruled out for the 'sandbanks which are slightly covered by sea water all of the time' of the Wash and North Norfolk Coast (WNNC) SAC. The compensation measures required for Hornsea Three on Annex I benthic features included marine litter removal within a specified area within the WNNC and NNSSR SACs and a marine debris reduction and awareness campaign measures. Subsequent advice has however been received from Natural England stating that the proposed marine debris removal campaign and marine debris awareness campaign would not provide sufficient compensation for the long-lasting loss of designated sandbank habitat resulting from the placement of external cable protection within both NNSSR SAC and WNNC SAC.

The Norfolk Boreas and Norfolk Vanguard Appropriate Assessment could not rule out an AEOI on sandbanks which are slightly covered by sea water all of the time, as well as *Sabellaria spinulosa* reefs of the Haisborough, Hammond and Winterton (HHW) SAC. The Development Consent Orders (DCOs) granted for these projects stipulated the following compensation measures: marine debris removal from within the HHW SAC, and marine debris reduction and awareness campaign measures in relation to the HHW SAC.

2.2 Strategic approach to benthic compensation

Currently the only approved strategic compensation measure for benthic features is MPA designation and/or extensions of MPAs (in England and Wales). The UK Government has commenced a programme of work to identify possible modifications to the existing MPA network to provide compensation for unavoidable damage to benthic habitats for eligible offshore wind projects. It is expected that projects that may use MPA designation and/or extensions as a strategic compensation measure may include:

- Projects that received a seabed lease from The Crown Estate under Leasing Rounds 3 or 4, and the 2017 extensions round;
- Celtic Sea Leasing Round 5 projects;
- Associated transmission infrastructure projects;
- Consented projects that are unable to discharge their consent; conditions or where adaptive management may now be required as the agreed compensation measures have not had the impact expected when consent was granted; and
- Operational projects delivered in Leasing Round 2 which may be required to compensate for essential maintenance activities carried out once the wind farm is operational and/or for unforeseen impacts.

In light of the limited number, regional extent and scale of benthic compensation measures currently available for OW development, there is merit in progressing investigation into other potential options which, if deemed to be ecologically effective, strategic and feasible, could be added to the LoSCM.

3 Infrastructure removal as a strategic compensation option

A wide range of man-made infrastructure has been placed within the UK marine environment, on or below the seabed, and in coastal areas (EMODnet 2025). This includes oil and gas infrastructure such as wellheads, production platforms, rigs, and pipelines, as well as submarine power and telecommunications cables, flood defences, and historic dumped munitions.

Removing infrastructure that has been abandoned or come to the end of its operational life could positively impact marine habitats and biodiversity in UK marine waters and thus could be progressed as a potential strategic compensation option for OW. The impact of this removal is likely to be context specific. For example, pipelines, cables, and other hard surfaces often introduce a hard substrate in soft sediment environments such as sandbanks, creating an artificial reef system where invertebrates, corals and fish aggregate (Fowler *et al.* 2020). However, this infrastructure may also result in negative impacts, principally the ongoing loss of seabed habitat due to the presence of hard infrastructure on the seabed and subsequent alteration / and removal the ecosystems services provided by that soft sediment habitat (Fowler *et al.* 2020). Other impacts include abandoned oil and gas infrastructure, such as wellheads, leaking oil and methane into surrounding waters (Kang *et al.* 2016). The structures themselves may also disrupt natural ecosystems by favouring opportunistic species, facilitating the spread of invasive species, and altering ecological community structures (Fowler *et al.* 2020; Lemasson *et al.* 2022).

The various infrastructure types, and potential impacts during installation and operation are discussed in more detail below in section 3.1 to 3.10. The potential impacts of removal of redundant infrastructure are discussed further in section 7.2 and 7.3. However, it is important to note that advice from Natural England, for example in relation to Five Estuaries OW Farm, is that the removal of this infrastructure would only constitute compensation where it is having an impact on the relevant features of the protected site[4].

3.1 Surface laid pipelines for the oil and gas industry

Pipelines transport oil and gas from offshore wells to land and can range from 4 to 48 inches (100–1200mm) in diameter and are typically made of steel, sometimes with added concrete protection layers known as mattressing (see section 3.3). Smaller pipelines are often buried using trenching and backfilling, while larger ones are usually laid directly on the seabed. If not carefully managed, this construction activity can lead to negative environmental impacts, for example due to disturbance and loss of seabed habitat (de Groot, 1982; Schmitt *et al.* 2023). Once in place, smaller lines in particular are vulnerable to damage from fishing activity, for example trawling, which could result in severe environmental consequences should damage cause a leak to occur (FLTCS, 2015a).

A previous study conducted by DESNZ Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) in 2022 concluded that very few of pipelines are surface laid within UK MPAs. The removal of buried pipelines would result in increased disturbance (and has been previously discouraged by SNCBs). In addition, the comparative assessments undertaken for oil and gas decommissioning often find that it's technologically very difficult, if not impossible to remove these buried pipelines.

3.2 Wellheads

Subsea wellheads are robust steel structures installed on the seabed to serve as the upper termination point of oil or gas wells. They provide a connection between the well and the infrastructure that transports hydrocarbons to production facilities, such as pipelines or risers leading to platforms or shore. A single wellhead can be 3-4 metres square and up to 5 metres high. When several are grouped together they become very large structures on the seabed (FLTCS 2015b). After initial drilling, a well may be temporarily

[4] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010115/EN010115-000546-EN010115%20Revised%20VE%20Natural%20England%20Relevant%20Represantations%20Appendix%20F%20-%20Benthic%20Compensation.pdf

suspended if an operator intends to carry out further operations at a later date – these are referred to as suspended wellheads in the FishSAFE datasets (see FLTCS 2015b).

3.3 Debris and redundant surface laid protection

In the context of subsea pipelines, "protections" refer to the various physical measures used to safeguard pipelines from damage and reduce the risk they pose to marine activities, particularly fishing, and the risk of spillages into the environment should they be damaged (FLTCS 2015a).

These protections typically include methods such as rock dumping or concrete mattresses, which are placed over exposed sections to shield them from impacts, anchor strikes, or gear snagging. Debris, as defined in the FishSAFE dataset, encompasses abandoned/seriously degraded protections such as large rocks or mattrasses that impede fishing activity and are no longer associated with pipelines. It should be noted that there would likely be significant barriers relating to removal of debris such as rock dump, as this type of infrastructure would likely be very difficult to locate and logistically difficult to remove at scale. Debris and redundant surface laid protection has however been included for completeness to assess the potential scale of opportunity.

3.4 Coastal flood defences

A defence in this context is any asset that provides flood defence or coastal protection functions. This includes both man-made and natural defences. Natural defences may include man-made elements to make them more effective or protect them from erosion. Normally a number of assets will be used together to manage the risk in a particular area (Environment Agency 2024). Examples of man-made flood defences along the coast are embankments, seawalls, breakwaters, ripraps and piling, whilst natural defences include cliffs and beaches.

Hard, man-made coastal defence structures support lower levels of biodiversity than natural habitats (Martins *et al.* 2016), and their cumulative impacts on ecosystems such as reducing sediment supply and habitat, and altering habitat types, which may have been over-looked by decision makers (Cooper *et al.* 2020).

3.5 Telecommunications cables

Submarine communications cables are vital infrastructure used to transmit data across oceans using fibre optic technology. At their core are ultra-thin strands of glass that carry data as pulses of light, enabling high-speed, long-distance communication with minimal signal loss. Cables are often protected by concrete mattresses or rock dump, which are placed over exposed sections to shield them from impacts, anchor strikes, or gear snagging.

There is evidence of entanglement of marine mammals with early underwater telecommunications cables (Wood & Carter 2008). However, changes to the design and laying of telecommunications cables mean that there have been no reports of this since 1959 (Wood & Carter 2008). Modern telecommunications cables are typically around 60mm in diameter and contain multiple fibre optic strands. Surrounding the fibres are layers including waterproof insulation, a copper core for powering signal boosters, and steel armour for protection (European Subseas Cable Association 2025).

The installation of marine cables and associated mattress protections can disturb the seabed and increase sediment suspension, impacting water clarity. However, these impacts tend to be temporary occurring only during the installation phase, after which their environmental impact is minimal (UNEP WCMC & ICPC 2025). Operational impacts, and which last until removal, is the replacement of soft-sediment seabed habitat with hard structures, often intended as protection, a key impact relevant to all subsea infrastructures mentioned in this report. It should be noted that the nature and extent impacts of telecommunications cables on the seabed are likely to depend on factors such as size/diameter and be highly site specific.

3.6 Power cables

Submarine power cables transmit electricity across bodies of water, with early examples dating back to 1811 and the first commercial high-voltage direct current cable installed in 1954. These cables, which can carry either direct or alternating current, are used to connect power grids, supply energy to offshore facilities and islands, and transmit electricity from marine renewable energy sources like OW farms. Power cables are often protected by concrete mattresses, amongst other types of protection.

Technological advances have extended the length, capacity, and applications of submarine power cables including cables that span the water column for floating energy platforms. While the cables enable critical energy infrastructure, they also introduce environmental changes – mostly during the installation phase, but also during the operational phase. As for telecommunication cables above, the introduction of hard substrates into a soft sediment environment being the key issue. There have also been concerns over changes in electromagnetic fields, heat emission, the risk of entanglement, chemical pollution, disturbance during cable repair and maintenance, and creation of artificial reef and reserve effects from cables and their hard protections (as outlined in section 3.5)(Taormina *et al.* 2018).

3.7 Dumped munitions

Dumped munitions refers to the conventional and chemical weapons that were disposed of in marine environments, primarily after the two World Wars. These include bombs, shells, mines, torpedoes, and containers of chemical agents, often scuttled at sea as a means of disposal.

A major concern in the marine environment is the presence of discarded munitions containing harmful substances such as organo-arsenic agents, mustard gases, and organo-phosphorus compounds. Arsenic-based chemicals tend to accumulate in seabed sediments and can be toxic to certain marine species (OSPAR 2025).

Explosions (whether accidental or intentional) during disposal can produce intense underwater noise and pressure, leading to hearing damage in marine mammals and physical harm or death in other marine life.

3.8 Outflows/ Discharge points

Discharge points are designated locations in the sea where liquid waste such as treated or untreated sewage, industrial effluents, and runoff are released into the marine environment. These outflows often originate from urban infrastructure, industrial facilities, or ships and can carry a range of substances including nutrients, chemicals, and organic material.

3.9 Marine Instruments

Coastal monitoring instruments such as tide gauges, wave buoys, and weather stations, are used for tracking sea-level changes, wave dynamics, and coastal hazards. There is little information available on the environmental impacts of their operational lives separate from the general disturbances to marine habitats during installation and maintenance. Additionally, little information is available about the expected longevity of these instruments, whether decommissioning or removal is formally required, and which authorities or entities are responsible for overseeing these processes once the instruments are no longer in active use.

3.10 Ports and harbours

Ports and harbours were initially considered for inclusion during the scoping phase of this work. However, ports and harbour associated infrastructure was ultimately excluded due to the continued relevance and necessity in delivering future environmental enhancements for the ports and harbours themselves. As critical infrastructure supporting long-term marine planning and restoration objectives, removal could conflict with broader strategic goals. Therefore, while this infrastructure may present physical footprints within the marine environment, it is not currently viewed as a candidate for strategic compensation through infrastructure removal.

4 Approach

4.1 Data sources

In order to better understand the scale of opportunity for infrastructure removal as a potential strategic compensation measure, it was necessary to collate datasets describing:

- The appropriate marine spatial boundaries for screening;
- MPAs;
- Infrastructure types and status[5]; and
- Marine habitats of interest.

Initial data collation was based on discussions between TBC and the OWIC SCS team. Following these discussions, a limited number of stakeholders most likely to have access to relevant, previously unidentified datasets, were identified with a view to identifying and securing additional data. The following organisations were contacted:

- Scottish Government Marine Directorate Licensing and Operations Team;
- Marine Management Organisation;
- The Crown Estate;
- NatureScot;
- The Environment Agency; and
- OPRED.

Follow up discussions were held with The Crown Estate, NatureScot and OPRED. Following this, the identified datasets were screened for inclusion in the subsequent mapping and analysis. The datasets selected and the justifications for their inclusion or, in some cases, exclusion are set out in Table 4.1.

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[5] Only infrastructure that is abandoned, not in use, or otherwise considered redundant is displayed on the online mapping tool or considered during the analysis interpretation. However, active infrastructure has been included in the raw analysis outputs contained in Appendix 2.

4.2 Limitations and assumptions during analysis

This analysis is based on publicly available datasets, each with its own update schedule, structure, and level of detail. During project scoping, the decision was made to only utilise freely available datasets due to budgetary considerations and the strategic decision to prioritise mapping the entire UK over acquiring more detailed, paid datasets. This approach also supported the development of the online tool by enabling direct links to the original data sources, thereby maximising usability for a broad range of stakeholders.

While every effort was made to ensure consistency between datasets (such as standardising formats, removing duplicates, and visually checking for overlap) the outputs are ultimately dependent on the accuracy and completeness of the source data. Some datasets are updated regularly, while others may be out of date or lack clear metadata on infrastructure status or ownership.

Where multiple datasets covered similar infrastructure types (e.g. pipelines), they were cleaned and merged to avoid duplication. In some cases, assumptions were necessary e.g. where infrastructure status was unclear or where metadata was missing. Infrastructure located beneath the seabed (such as drill lines) was excluded from the analysis, as it falls outside the scope of physical removal.

The spatial extent of the analysis covers the UK Exclusive Economic Zone (EEZ), including Northern Ireland's waters. However, due to the absence of a clearly defined marine boundary for Northern Ireland, these waters were not treated as a separate jurisdiction. The outputs should therefore be considered indicative rather than definitive, and users of the online tool are encouraged to refer to the original datasets where more detailed or up-to-date information is required, or to the master spreadsheet of outputs in Appendix 2 which contains the raw outputs of the analysis.

Table 4.1: Data used for the Project analyses and for visualisation of the distribution and types of various marine infrastructure within UK and adjacent waters.

Dataset/Source	Description	Justification for inclusion/exclusion
Infrastructure type		
Pipelines		
Pipelines - FishSAFE	Polylines of oil and gas pipelines, including information on status (3 categories), ownership, material transported, and installation date.	Combined, these three datasets provided a comprehensive overview of redundant oil and gas pipelines in UK waters. Each dataset was processed to ensure consistency—involving the standardisation of names and operational status information, correction of formatting inconsistencies, and removal any incomplete or duplicate entries—to ensure they were compatible for analysis. The datasets were then aggregated, as each contained different pipelines, and a visual check was carried out to confirm there was no overlapping or duplicated spatial data.
Pipelines – EMODnet Human Activities	Created in 2017 and updated yearly, this dataset contains polylines of oil and gas pipelines in European waters, including information on status, operator, and start/end facilities.	
Linear pipelines – North Sea Transition Authority	Updated biannually, this data reported to and collated by the NSTA contains polylines of oil and gas pipelines in UK marine waters. These pipelines are duplicates of the FishSAFE dataset mentioned above, however they have been split into six categories rather than FishSAFE's three, offering more nuance.	

Dataset/Source	Description	Justification for inclusion/exclusion
Submarine cables		
Subsea cables - KIS-ORCA	Updated regularly, the KIS-ORCA dataset provides geospatial information on subsea infrastructure across UK waters, including submarine cables and offshore renewable energy installations. It is designed to support safe marine operations, particularly for the fishing industry.	Some of the data contained by the KIS-ORCA dataset overlaps with other datasets such as EMODnet and FishSAFE. Unfortunately access to the raw data set is restricted, thus TBC were unable to incorporate the KIS-ORCA data to the online map, instead relying on the duplicated data from FishSAFE and EMODnet.
Cables - FishSAFE	Contains polylines on anchor, power, seismic, and telecom cables in UK marine waters. Contains information on status, owner, and start/ end dates.	Excluded from analysis due to data being a duplicate of the below EMODnet datasets.
Telecommunication cables – EMODnet Human Activities	Created in 2014 and updated yearly, this is an aggregation of datasets provided by several EU and non-EU sources. The datasets relevant to this project are from the UK, Netherlands, France, and Germany, as these have cables either starting, ending, or passing through UK marine waters. They all contain information on status, however unfortunately the French dataset uses codes from 1 – 4 to represent status, and TBC have been unable to confirm what these codes refer to.	The UK data is very limited in scope and entries, but any entries that exist have been included in the analysis.

Dataset/Source	Description	Justification for inclusion/exclusion
Power cables - EMODnet Human Activities	As above, created in 2014 and updated yearly, this is an aggregation of datasets provided by several EU and non-EU sources. The datasets relevant to this project are those from France, Germany, Netherlands, and Norway. Unfortunately, there is no UK dataset included. Information on status is used for all once more, however the French status codes remain unknown.	No UK specific data, but some of the cables owned by the neighbouring countries pass through, originate, or end in UK marine waters. These have thus been included in the project analysis.
Global Submarine Cable Map - TeleGeography	The Submarine Cable Map dataset contains polylines of the world's active and planned submarine telecommunications cables. It includes details such as cable names, landing points, lengths, and owners. It does not include information on cable status.	Excluded from analysis due to not having information on cable status.
Other oil and gas infrastructure		
Suspended Wellheads - FishSAFE	This dataset from FishSAFE contains locations of all suspended wellheads in the UK marine waters. Suspended wellheads may be only temporarily suspended, with the possibility of being revived in the future, or they may remain unused forever.	Excluded from analysis due to the below subsea dataset containing duplicate data, but we will include this data on the online tool for visual exploration.
Offshore activities – North Sea Transition Authority	This interactive dataset, developed by the North Sea Transition Authority (NSTA), provides spatial information on offshore oil and gas infrastructure across the UK Continental Shelf. It includes data on	Of the datasets provided by the NSTA, only the pipelines dataset was included for analysis and

Dataset/Source	Description	Justification for inclusion/exclusion
	platforms, pipelines, and other associated assets, compiled from publicly available sources under the Energy Act 2016. The map is designed to support transparency and planning around offshore activities, including decommissioning.	display in the online tool (see pipeline infrastructure section above). The other datasets were excluded for two main reasons: the wellheads dataset is duplicated data already included from other sources (in this case, the FishSAFE dataset); and secondly, the drill lines of wells beneath the seabed represent subsurface infrastructure that is not physically removable and therefore not relevant to the scope of this project, which focuses on above-seabed infrastructure with potential for strategic removal.
Subsea Structures | FishSAFE	This dataset includes location information on pipeline spans, subsea points (which refers to all subsea wellheads, including active or suspended, overlapping with the above suspended wellheads points at times), and pipeline points.	Included in the analysis as contains information on infrastructure status, including a more granular version of the Suspended wellheads dataset mentioned above.
Surface Structures | FishSAFE	This dataset includes locations of oil rig platforms, floating production, storage, and offloading facilities (FPSOs), and Buoys (which mark subsea infrastructure for fishing vessels to steer clear of). This includes information on their status.	These two datasets were included in the analysis due to having status information, with a visual check

Dataset/Source	Description	Justification for inclusion/exclusion
Oil and Gas Wells – EMODnet Human activities	Created 2014 and updated yearly, this dataset contains subsea well locations with information on status, operator, country, and installation date.	done to ensure no duplicates/overlaps between data.
Offshore Installations – EMODnet Human Activities	Created in 2015, this dataset contains information from an aggregation of European countries on offshore oil and gas infrastructure locations, including the UK (data is from the Oil and Gas Authority). Information on status, category and function of the installation, and sub-structure and topside weights (tonnes) is included.	Included as contains information on status.
Coastal defences		
AIMS Spatial Flood Defences - Environment Agency	Updated daily, the Environment Agency's (EA) Spatial Flood defences layer shows flood defences currently owned, managed or inspected by the EA, and is limited to their jurisdiction in England. 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.	These three coastal defence datasets were included as there is a possibility of identifying defences suitable for removal, however as there is no information available from the datasets on status of the defences, limited inference can be formed on the suitability for removal. No suitable comparable datasets for Northern Irish coastal defences were identified, limiting the extent of coverage of the datasets to England, Wales, and Scotland.

Dataset/Source	Description	Justification for inclusion/exclusion
DynamicCoast Artificial Coastal Defences – Nature Scot	Last updated late 2023, this dataset provided by Nature Scot describes the location, type, and extent in km of artificial coastal defences in Scotland. Defences include ripraps, embankments, seawalls, demountable defences, and engineered high grounds.	
The National Flood Asset Database – NRW	The National Flood Asset Database managed by Natural Resources Wales (NRW) and updated regularly records flood infrastructure in Wales, including coastal defences. It includes embankments, walls, flood gates, culverts, and inlet screens (which catch debris), but not all flood infrastructure maintained or owned by these parties.	
A detailed list of all Northern Ireland flood defences - DFI	Posted by the Department for Infrastructure, Northern Ireland, this is a detailed list (in .csv format) of all Northern Ireland flood defences, including: individual id, point locations, last recorded condition, target condition, and most recent inspection date.	This dataset was not included in the analysis because its format as point location data with limited georeferences could not be integrated with the line data used in the Welsh, Scottish, and English datasets. As no suitable alternatives were found, Northern Ireland was excluded from the analysis.

Dataset/Source	Description	Justification for inclusion/exclusion
Miscellaneous – Other Infrastructure		
National Wave Tide Met Instrumentation – National Coastal Monitoring	Point locations of various instruments used to monitor coastal conditions, such as wave buoys, tide gauges, and meteorological stations along the UK coastline. These instruments collect data on wave heights, tidal levels, and weather conditions. This dataset contains information on status of the instrumentation.	Included as contains information on status of instrumentation.
Dumped Munitions – EMODnet Human Activities	Created in 2018, this dataset contains points and/or (where available) polygons representing dumped munitions sites in the European sea basins. It includes information on the type of munition (chemical or conventional) and date last updated.	Included in analysis due to the discarded nature of dumped munitions making them suitable for removal where feasible.
Discharge points -EMODnet Human Activities	This dataset contains information on the location of discharge points, link to specific treatment plant, type of receiving area into which the effluent/wastewater is discharged, related waterbody/river basin on individual points of discharge from wastewater treatment plants along the coast.	These have been included in the dataset to investigate how many outflows are in MPAs.

Dataset/Source	Description	Justification for inclusion/exclusion
Context data: MPAs, UK waters extent, and offshore wind leases		
UK country and Crown Dependency water boundaries - JNCC	This dataset includes boundaries for the UK Exclusive Economic Zone (EEZ), the territorial sea limits, and the Crown Dependency Waters, provided by the Joint Nature Conservation Committee (JNCC). Combined these are spatial representation of the maritime area over which the United Kingdom has special rights regarding the exploration and use of marine resources, including energy production from water and wind.	TBC and OWIC agreed that, for the purposes of this project, the UK EEZ is an appropriate representation of the maximum spatial extent over which the UK can assert jurisdiction. To add further granularity, the analysis could be disaggregated by Crown Dependency waters, allowing for clearer identification of which infrastructure falls within the jurisdiction of each respective territory.
UK SPAs with marine components - JNCC	The SPAs with Marine Components dataset, provided by JNCC identifies areas designated under the UK Birds Directive that include marine habitats such as intertidal zones and offshore waters, which are crucial for seabirds and waterfowl. These sites are areas where bird species rely on marine habitats for activities like feeding, moulting, or overwintering.	OWIC has selected these types of MPAs for investigation as potential sites for infrastructure removal, based on their potential to deliver the greatest positive impact on biodiversity.
UK SACs with Marine components - JNCC	The SACs with Marine Components dataset, published by JNCC, contains information on sites across the UK, such as reef systems, sandbanks, sea caves, and habitats used by marine species like harbour porpoises and seals. These sites are designated SACs	

Dataset/Source	Description	Justification for inclusion/exclusion
	to protect biodiversity in accordance with the Habitats Directive.	
UK MCZs- JNCC	The MCZs dataset, published by JNCC, identifies areas in UK waters designated to protect nationally important marine wildlife, habitats, geology, and geomorphology. These zones include a wide range of features such as seagrass beds, mud habitats, and species like spiny lobsters and native oysters. MCZs are designated under the Marine and Coastal Access Act 2009 and contribute to the UK's wider network of MPAs.	
Scottish NCMPAs - JNCC	The Nature Conservation Marine Protected Areas (NCMPA) dataset, published by JNCC, contains information on NCMPAs which protect a range of nationally important habitats and species such as sand eels, sedimentary seabed habitats vital for a range of marine processes and other species, and deep-sea sponge aggregations identified as an OSPAR Threatened and/or Declining habitat.	
English HPMAs - JNCC	Highly Protected Marine Areas (HPMAs) are designated zones by JNCC in English waters based on ecological criteria such as biodiversity, naturalness, and ecosystem services, alongside social and	

Dataset/Source	Description	Justification for inclusion/exclusion
	economic considerations to minimise impact on sea users and coastal communities. They are jointly designated as MCZs.	
Northern Ireland ASSIs - DAERA	Areas of Special Scientific Interest (ASSIs) are protected areas designated under The Environment (Northern Ireland) Order 2002 for their species, habitat and/or geological features. Coastal ASSIs that have marine features contribute towards the MPA network. Some ASSIs are also subject to other designations - for example they can be designated as a SAC or SPA.	
Sandbanks – JNCC	This annex dataset, published by JNCC, maps the distribution of shallow subtidal sandbanks across UK marine waters. These sandbanks are considered a priority marine habitat under the EU Habitats Directive and are often included as protected features within SACs. They support high biodiversity and play a vital role in ecosystem functioning.	These two habitat datasets, JNCC's Sandbanks and EU Seamap, were not included in the infrastructure analysis but have been uploaded to the online tool to provide visual context on the surrounding habitats in proximity to relevant infrastructure and windfarms. Furthermore, whilst compensatory measures should prioritise the impact at the location concerned, this is not always feasible. In such circumstances, measures supporting similar or equivalent ecological functions elsewhere can be considered. These habitat datasets can help to identify locations where comparable ecological functions are present.
EU Seamap 2023 - EMODnet	The EMODnet Seabed Habitats dataset is a pan-European resource that provides detailed spatial information on the distribution of seabed habitats across European marine waters. A 2025 update is available; however, it has not yet been released in a	

Dataset/Source	Description	Justification for inclusion/exclusion
	format suitable for inclusion in the online map, therefore the 2023 version has been kept.	
Energy, Windfarms - EMODnet Human Activities	This dataset provides information on OW farms in European marine waters. It includes both point data for individual wind turbines and polygon data outlining the boundaries of wind farm areas.	The EMODnet Wind Farms dataset have been uploaded to the online tool to visualise the proximity between infrastructure and wind farm areas, using only the polygon data. It was chosen as the sole wind energy dataset for display due to its greater completeness and coverage, which either matches or fully encompasses the alternative Crown Estate offshore wind datasets.
INTOG Application Areas - Crown Estate Scotland	This dataset maps the application areas submitted under the Innovation and Targeted Oil & Gas (INTOG) leasing round, launched by Crown Estate Scotland. INTOG allows developers to apply for seabed rights for two specific types of offshore wind projects: • Innovation projects (smaller scale, aiming to test new technologies) • Targeted Oil & Gas decarbonisation projects (wind farms designed to support the decarbonisation of existing oil and gas infrastructure)	The INTOG Application Areas will be uploaded to the online tool, to visualise potential areas of new development for windfarms in the UK marine waters.

Dataset/Source	Description	Justification for inclusion/exclusion
	The dataset outlines the geographic boundaries of each application area proposed by developers during the leasing round.	
Celtic Sea Project Development Areas (PDAs)	The PDAs identified under The Crown Estate's Offshore Wind Leasing Round 5. These areas are in the Celtic Sea, off the coasts of South Wales and Southwest England, and are designated for the development of floating offshore wind farms.	The Celtic Sea PDAs have been included in the online tool to help enable a proactive approach/forward look ahead to potential compensation opportunities associated with future leasing areas.

4.3 Mapping

The analysis was conducted across the spatial extent of the UK EEZ subdivided into Crown Dependency waters for England, Scotland, and Wales. Northern Ireland's waters and associated MPAs were included; however, due to the absence of a clearly defined marine boundary, they were not treated as a separate jurisdiction.

Within this area, infrastructure was assessed specifically within the boundaries of UK-designated SPAs, SACs, MCZs, HPMAs, and NCMPAs. To support further exploration, an online mapping tool was developed to visualise infrastructure types, planned and operational wind farm areas and a variety of seabed habitats (see section 5). This enables users to visually assess which MPAs may yield the greatest biodiversity benefits from infrastructure removal, particularly where similar habitat types are affected by nearby wind farm activity, and where the greatest concentrations of likely redundant infrastructure are located.

4.4 Quantification of infrastructure in different marine regions

To understand the scale of opportunity for infrastructure removal in each marine region, the total extent of infrastructure within each individual MPA was estimated. However, the overlap between some MPAs means that simply summing this across all MPAs would lead to an overestimation of the scale of opportunity due to double counting. For example, Figure 4.1 highlights the overlap between the Greater Wash SPA and the Inner Dowsing, Race Bank and North Ridge SAC. Two pipelines pass through these MPAs. In this instance, summing the total length of pipeline within each MPA would lead to the portion of the pipeline that passes through the area of overlap being counted twice.

To avoid double counting infrastructure located within overlapping MPAs, the main analysis has been split to provide two outputs (attached in Appendix). The first output breaks down infrastructure and its status by individual MPA. The second output lists each asset per marine region. This approach allows for accurate interpretation: the MPA output enables site-specific insights, while the summary output provides a clear view of the total unique infrastructure present, eliminating the risk of overestimation caused by overlapping MPAs as seen in Figure 4.1.

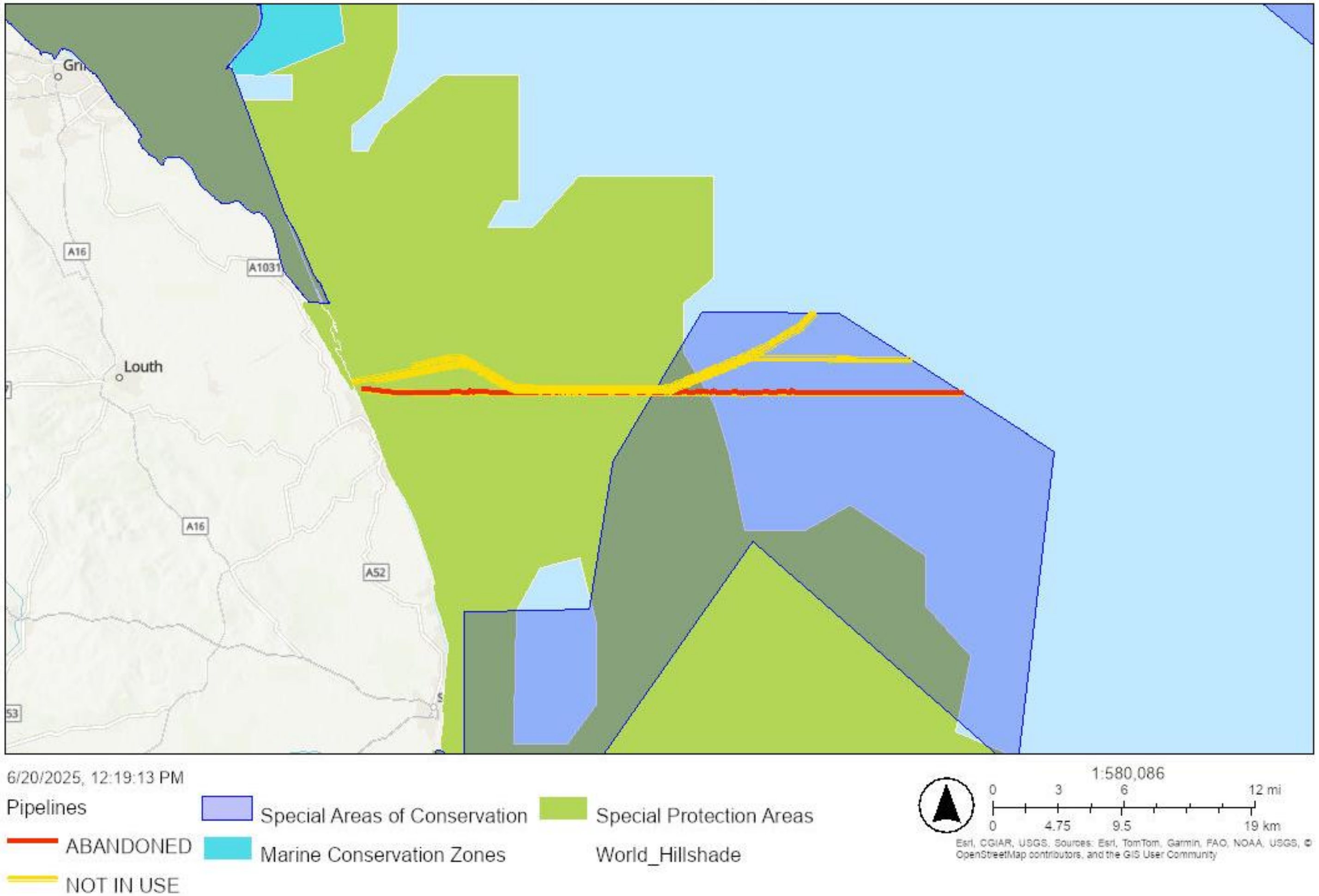

Figure 4.1: Pipeline infrastructure that passes through both the Greater Wash SPA and the Inner Dowsing, Race Bank and North Ridge SAC (noting that this is provided as an example for where infrastructure may pass through two MPAs)

5 Online mapping tool

This document provides an initial summary of the scale of opportunity for redundant infrastructure removal within MPAs. The maps included in this report offer a high-level overview of the presence and distribution of redundant infrastructure. Alongside this report, and the maps contained within, an online mapping tool has been developed. This tool incorporates the datasets described above, displaying only redundant or disused infrastructure, and enables users to explore these data in greater detail and at a finer resolution as well as to investigate additional context surrounding the MPAs, such as proximity to windfarms and marine habitat types. The tool has the ability to be updated as new datasets become available. Subsequent maps included within this report have been produced using the online tool as an example of some of its capabilities.

6 Results

This section presents the findings of the spatial analysis conducted to assess the scale and distribution of disused marine infrastructure within UK MPAs, with a view to identifying opportunities for strategic compensation through infrastructure removal.

The results are structured to:

- Provide a high-level overview of infrastructure types and their status across UK marine regions.
- Highlight regional differences in infrastructure density and type.
- Visually identify overlaps between disused infrastructure and MPAs using the online mapping tool.
- Use the online mapping tool to explore proximity to OW developments to support strategic compensation planning.

The analysis focuses on infrastructure classified as abandoned, not in use, not applicable (n/a) (in the case of infrastructure where a status is implied, namely dumped munitions and discharge points)) or unknown, and includes:

- Pipelines (oil and gas);
- Submarine cables (telecoms and power);
- Coastal defences (excluding Northern Ireland); and

- Other seabed infrastructure (e.g. wellheads, dumped munitions, discharge points).

To support interpretation, the results are presented through:

- Regional maps according to the JNCC UK country waters (Table 4.1) showing infrastructure distribution within MPAs.
- Summary tables of infrastructure length or count by region and status.

These outputs are complemented by the interactive online mapping tool, which allows users to explore the data in greater detail, including infrastructure proximity to OW farms, MPAs and benthic habitats. This tool is intended to support decision-making around the feasibility and ecological value of infrastructure removal as a strategic compensation measure and provide a basis for further work in this space.

It should be noted that the results presented within this report are based on publicly available datasets and have been developed to provide a high-level analysis of the likely scale of the opportunity. There may be some variation from other work carried out to date, such as OPRED's 2022 assessment of surface laid pipelines within UK MPAs, due to the granularity of information within the datasets used for the analyses. Further work, including engagement with other industries to better understand any such differences, is a recommended next step but is beyond the scope of this report. Limitations related to data completeness, regional coverage (e.g. lack of Northern Ireland equivalent datasets for coastal defences), and status classification are discussed in 4.2 and data groupings are documented in Appendix 1.

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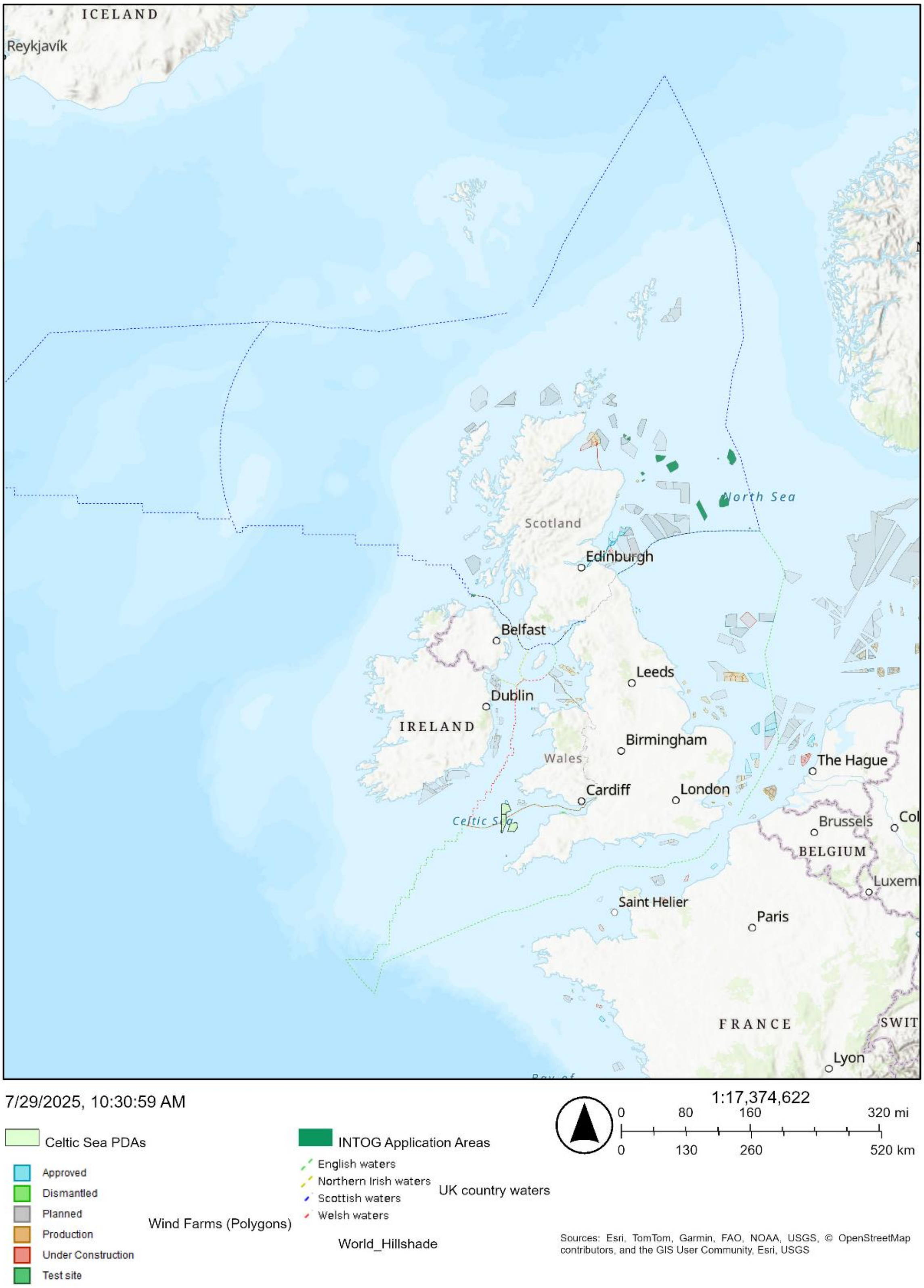

Figure 6.1: Map showing the extent of the analysis, which has been carried out in line with JNCC MPAs within the UK Crown Country waters.

For the purposes of this report, regional maps have been created for east and southwest English waters (Figure 6.2 and Figure 6.3), Wales (Figure 6.4), Northern Ireland and northwest England (Figure 6.5), and Scotland (Figure 6.6) to aid visual interpretation of the results.

Overall, English coastal waters, especially along the East coast (Figure 6.2), contain the longest stretches of abandoned or inactive cables and pipelines within their MPAs, with Scotland having the next largest overlap. Only English MPAs contain cables.

Amongst the miscellaneous other infrastructure examined – which includes dumped munitions, oil and gas protections such as mattresses, and other subsea/surface structures - the majority is found in English and Scottish waters (Table 6.1 and Table 6.4). More generally, oil and gas abandoned/ not in use (which includes suspended where infrastructure is left on the seabed to facilitate re-entry if required, see Table 4.1. Wellheads are one of the most abundant types of defunct infrastructure found within the MPAs, alongside dumped munitions. There is therefore potential for the removal of wellheads to deliver strategic compensation, especially considering their strong negative environmental impacts when abandoned (Section 3.2). Whilst many Discharge points were identified in the analysis, these are not counted as abandoned and presented to illustrate the potential for relocating them outside of UK MPAs.

The status of coastal defences is not reported in the publicly available datasets, making it difficult to gauge the opportunities available for removal. However, they are widespread throughout England, Wales and Scotland (Table 6.1, Table 6.2 and Table 6.4) and some may be at the end of their lifespan and viable for removal, warranting further investigation. For the purposes of this report, data for England has been obtained from the Environment Agency (EA) AIMS dataset, from Natural Resource Wales for Wales, and from NatureScot for Scotland. It was not possible to identify an equivalent dataset for Northern Ireland. When assessing coastal defences removal as potential strategic compensation, however, the importance of coastal protection means that the scope for removal may be limited in terms of scalability and would need to the be considered on a case-by-case basis. In Wales, coastal defences are also being mapped and may be utilised as part of the National Habitat Creation Programme to combat coastal squeeze and flooding. This may also impact their potential to be available as a strategic compensation measure.

6.1 Extent of infrastructure in different regions

The following sections (section 6.1.1 to 6.1.4) provide a summary of the extent of infrastructure in the different regions of UK waters considered. Appendix 3 contains the full raw outputs of the spatial analysis and aggregates infrastructure data by marine region, removing duplication caused by overlapping MPAs. This may be used to estimate the total scale of opportunity for strategic compensation across broader geographies.

6.1.1 English waters

Analysis of infrastructure within MPAs located in English waters indicates a substantial concentration of disused assets, particularly along the East and Southwest coasts. Over 3,400 km of abandoned cables and approximately 3,000 km of disused pipelines (Table 6.1) were identified, representing the highest recorded total of infrastructure overlap with MPAs across the UK. In addition, English waters contain a notable number of abandoned/not in use oil and gas wells (2,191), dumped munitions (900), discharge points (174), and ~ 107 km of manmade coastal defences.

Table 6.1. Infrastructure by status, length and/or count within MPAs located in English waters.

Infrastructure type	Status	Length (km) or count present in MPAs
Pipelines	Abandoned	1081 km
	Not in use	1885 km
Cables	Abandoned	3442 km
	Unknown	2172 km
Coastal defences – Bridge abutments	-	0.08 km
Coastal defences – demountable defences	-	0.22 km
Coastal defences – Embankments	-	53.5 km

Infrastructure type	Status	Length (km) or count present in MPAs
Coastal defences – Engineered high ground	-	35.9 km
Coastal defences – Flood gates	-	0.5 km
Coastal defences – Promenades	-	0.9 km
Coastal defences – Quays	-	1.3 km
Coastal defences – Walls	-	21.4 km
Buoys	Abandoned	2
Debris	Abandoned	11
Discharge points	-	174
Dumped munitions	-	900
Oil and Gas protections	Abandoned	52
Oil and Gas wells	Abandoned	1329
	Not in use (including suspended where infrastructure is left on the seabed to facilitate re-entry if required, see Table 4.1)	862
Other structures (Subsea)	Abandoned	8
Other structures (Surface)	Abandoned	39

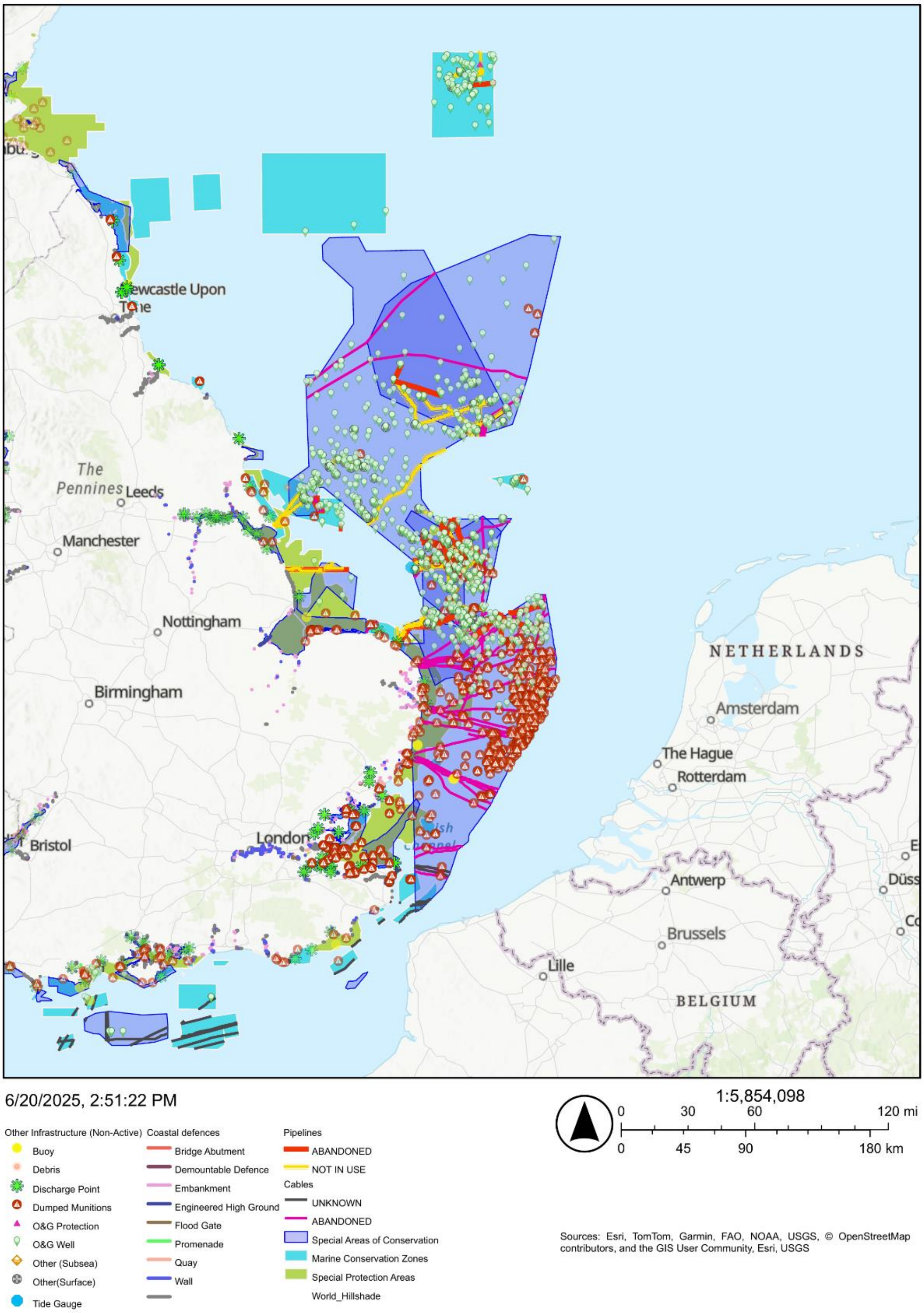

Figure 6.2: Map of redundant infrastructure within East England MPAs.

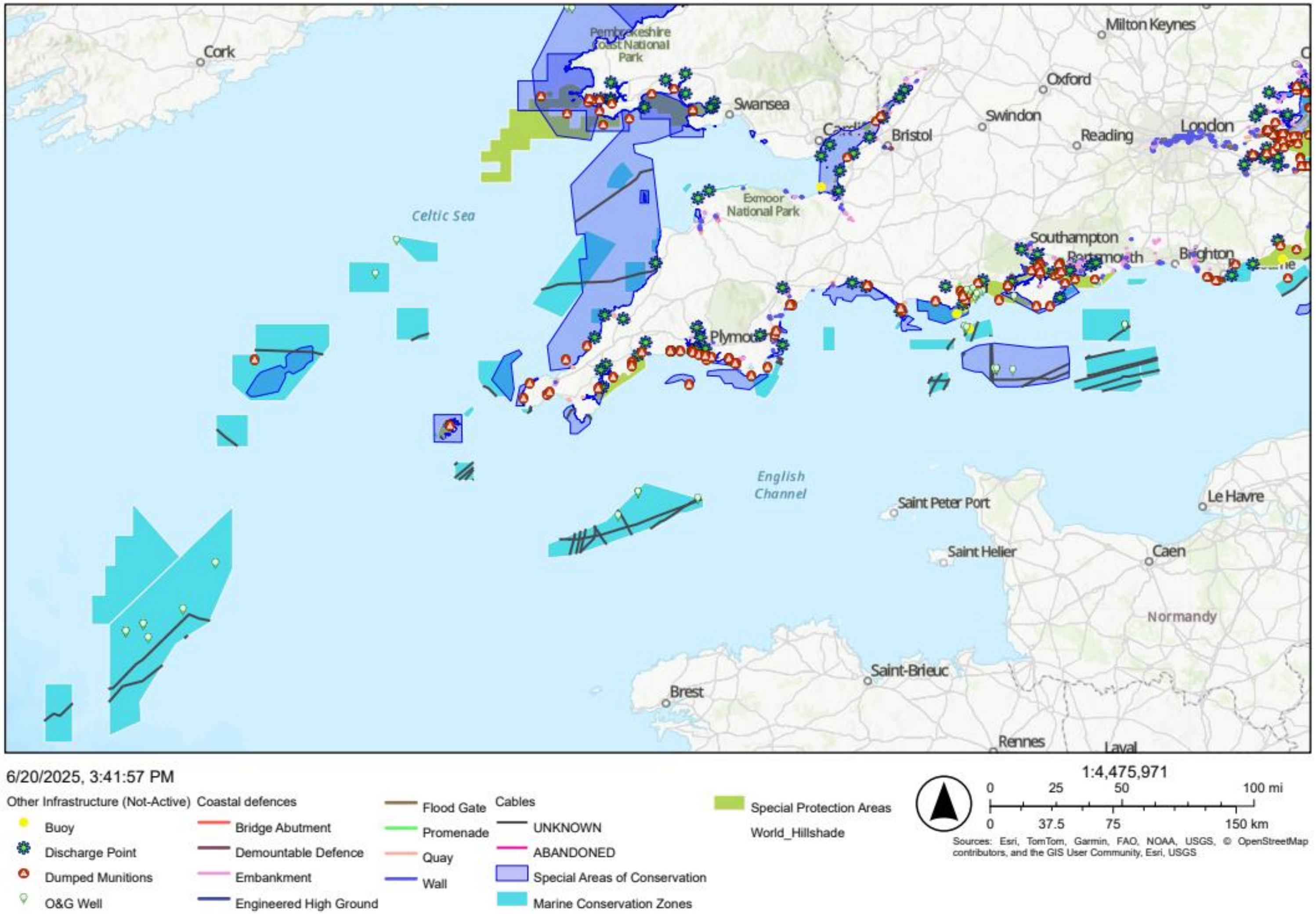

Figure 6.3: Map of redundant infrastructure within Southwest England MPAs.

6.1.2 Welsh waters

The analysis identified limited infrastructure within Welsh MPAs. No disused pipelines or cables were recorded, and no abandoned buoys, debris, or other structures were identified (Table 6.2). However, 31 discharge points and 43 dumped munitions were mapped, alongside a small number of oil and gas wells (16 abandoned and 5 not in use), and ~41 km of coastal defences was found to be present within MPAs from the Natural Resources Wales dataset.

While the overall scale of opportunity appears low compared to other regions, the presence of discharge points, legacy munitions, and the ~41 km of coastal defences would still warrant further investigation, particularly where they overlap with sensitive benthic features or conflict with the conservation objectives of designated sites. Figure 6.4 provides a spatial overview of infrastructure distribution within Welsh MPAs. Using the online tool, users can investigate proximity of MPA's with important marine seabed habitats.

Table 6.2 Infrastructure by status, length and/or count within MPAs located in Welsh waters

Infrastructure type	Status	Length (km) or count present in MPAs
Pipelines	Abandoned	0 km
	Not in use	0 km
Cables	Abandoned	0 km
	Unknown	0 km
Coastal defences – bridge abutment	-	0.01 km
Coastal defences – Embankments	-	40.7 km
Coastal defences – Engineered high ground	-	0.2 km
Coastal defences – Promenades	-	1.8 km
Coastal defences – Quays	-	0.03 km

Infrastructure type	Status	Length (km) or count present in MPAs
Coastal defences – Walls	-	10.2 km
Buoys	Abandoned	0
Debris	Abandoned	0
Discharge points	-	31
Dumped munitions	-	43
Oil and Gas protections	Abandoned	0
Oil and Gas wells	Abandoned	16
	Not in use (including suspended where infrastructure is left on the seabed to facilitate re-entry if required, see Table 4.1)	5
Other structures (Subsea)	Abandoned	0
Other structures (Surface)	Abandoned	0

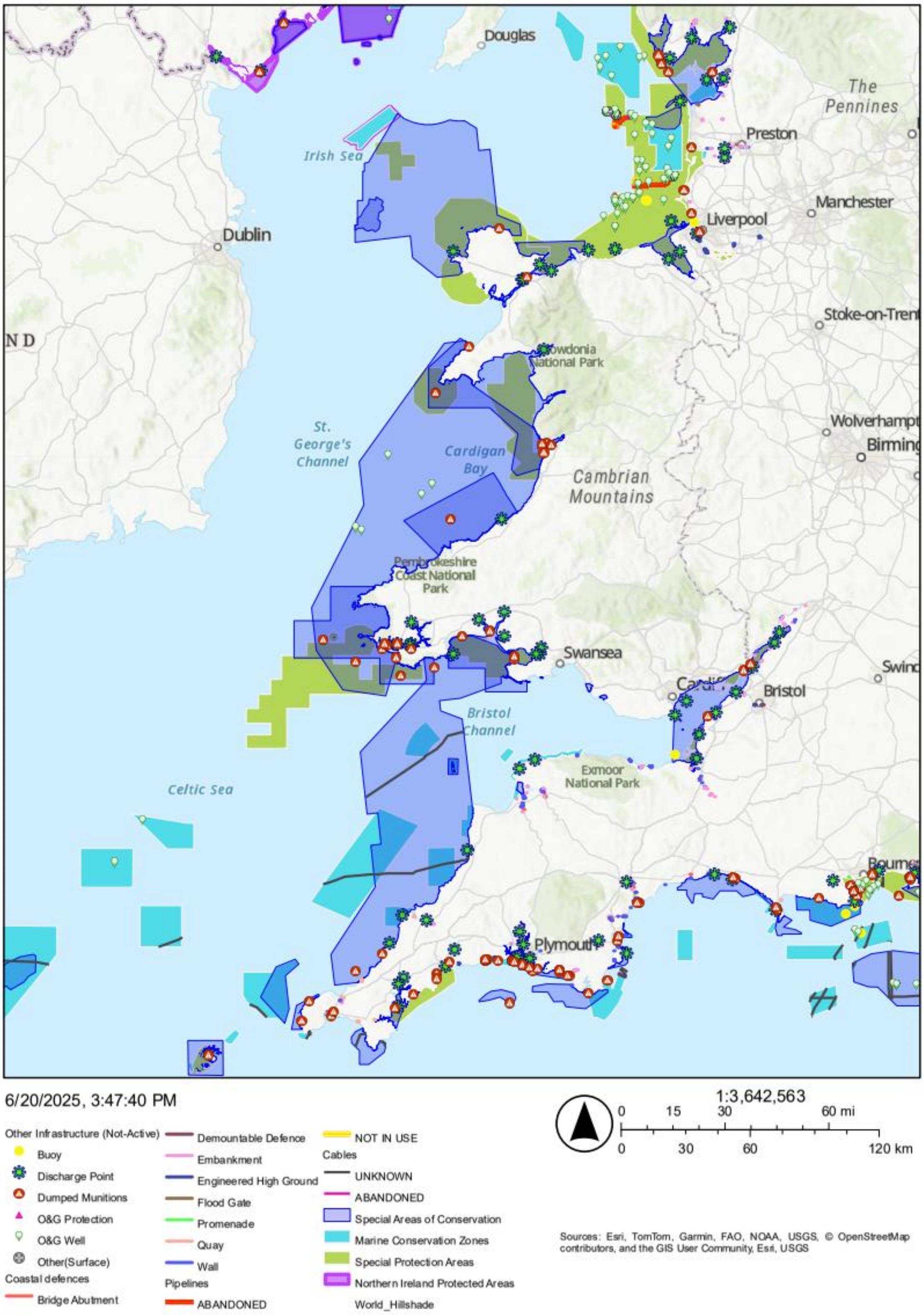

Figure 6.4: Map of redundant infrastructure within Welsh MPAs.

6.1.3 Northern Ireland waters

Northern Ireland's MPAs also show limited overlap with disused infrastructure. No disused pipelines or cables were recorded, and only four abandoned oil and gas wells were identified (Table 6.3). 30 discharge points and 18 dumped munitions were mapped, along with 20 abandoned buoys. Coastal defences were not assessed due to a lack of suitable public data.

While the overall scale of opportunity is modest, the presence of legacy munitions and discharge infrastructure may offer potential strategic compensation similar to that described for Wales, by focusing on hard infrastructures which overlap with designated features or conservation priorities. Figure 6.5 illustrates the spatial distribution of infrastructure within Northern Ireland and adjacent northwest English MPAs. Using the online tool, users can investigate proximity of MPA's with important marine seabed habitats.

Table 6.3. Infrastructure by status, length and/or count within MPAs located in Northern Ireland's waters.

Infrastructure type	Status	Length (km) or count present in MPAs
Pipelines	Abandoned	0 km
	Not in use	0 km
Cables	Abandoned	0 km
	Unknown	0 km
Buoys	Abandoned	20
Debris	Abandoned	0
Discharge points	-	30
Dumped munitions	-	18
Oil and Gas protections	Abandoned	0
Oil and Gas wells	Abandoned	4

Infrastructure type	Status	Length (km) or count present in MPAs
	Not in use (including suspended where infrastructure is left on the seabed to facilitate re-entry if required, Table 4.1)	0
Other structures (Subsea)	Abandoned	0
Other structures (Surface)	Abandoned	0

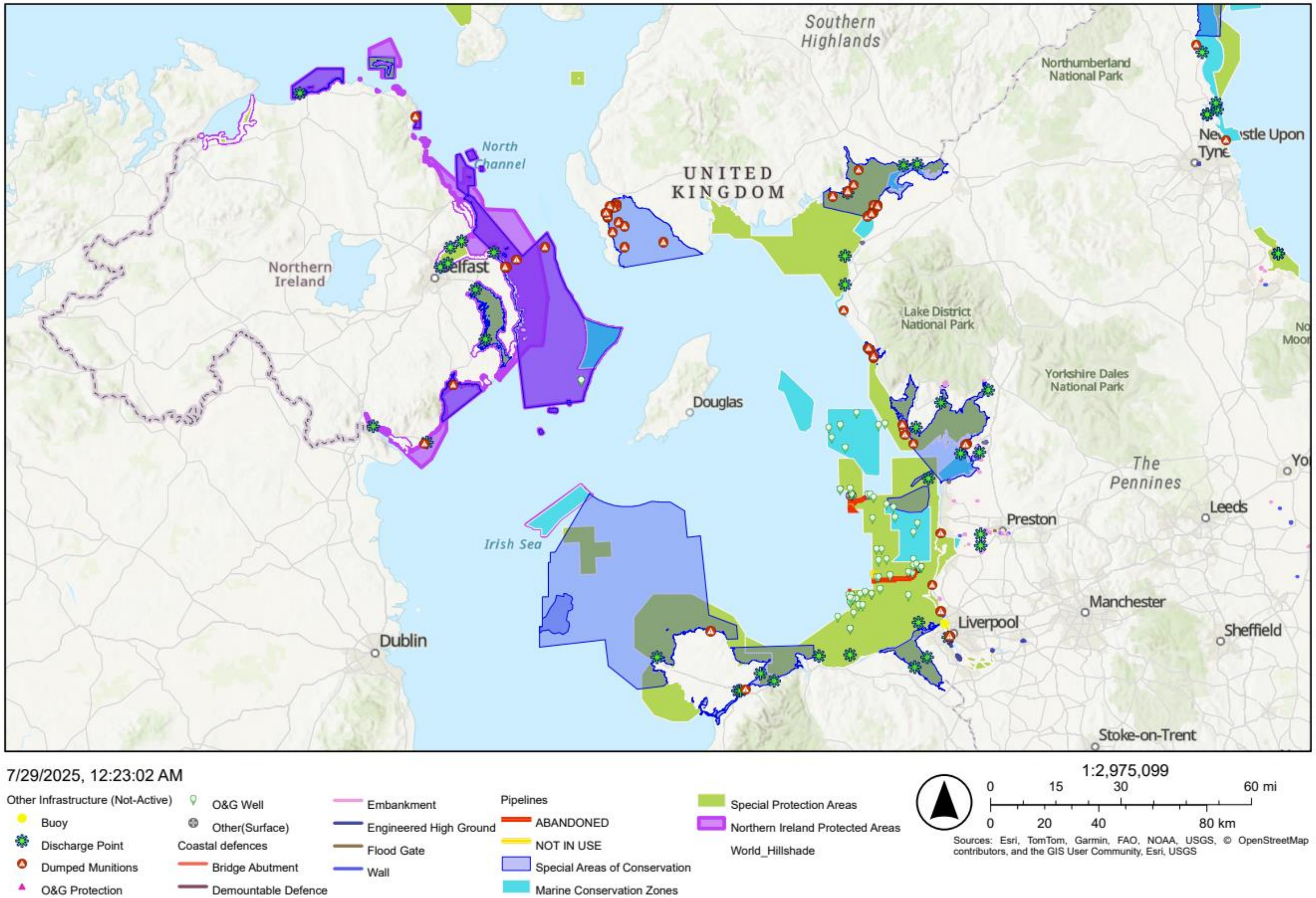

Figure 6.5: Map of redundant infrastructure within Northern Ireland and Northwest England MPAs.

6.1.4 Scottish waters

Scottish MPAs contain the second highest quantity of disused oil and gas infrastructure, with 360 km and 57 km of pipelines recorded as not in use and abandoned, respectively, and 490 abandoned or not in use (including suspended where infrastructure is left on the seabed to facilitate re-entry if required, see Table 4.1) oil and gas wells, amongst other infrastructures (Table 6.4). There is also overlap with ~44 km of manmade coastal defences, according to the Nature Scot dataset. One singular length of cable was found in the Moray Firth SAC, measuring 1.8 km and of unknown status.

provides a visual summary of infrastructure within Scottish MPAs. Given Scotland's historic in oil and gas extraction, the high concentration of NCMPAs and other MPAs in Scottish waters, and the significant presence of offshore windfarms in the North Sea, this region presents significant opportunities for strategic compensation efforts to offset cumulative impacts from the wind energy industry.

Table 6.4. Infrastructure by status, length and/or count within MPAs located in Scottish waters.

Infrastructure type	Status	Length (km) or count present in MPAs
Pipelines	Abandoned	57 km
	Not in use	360 km
Cables	Abandoned	0 km
	Unknown	1.8 km
Coastal defences – Embankments	-	1 km
Coastal defences – Ripraps	-	12.7 km
Coastal defences - Walls	-	5.7 km
Coastal defences – Unknown	-	24.8 km
Anchor	Abandoned	6

Infrastructure type	Status	Length (km) or count present in MPAs
Buoys	Abandoned	2
Debris	Abandoned	14
Discharge points	-	38
Dumped munitions	-	92
Oil and Gas protections	Abandoned	4
Oil and Gas wells	Abandoned	229
	Not in use (including suspended where infrastructure is left on the seabed to facilitate re-entry if required, see Table 4.1)	261
Other structures (Subsea)	Abandoned	0
Other structures (Surface)	Abandoned	0

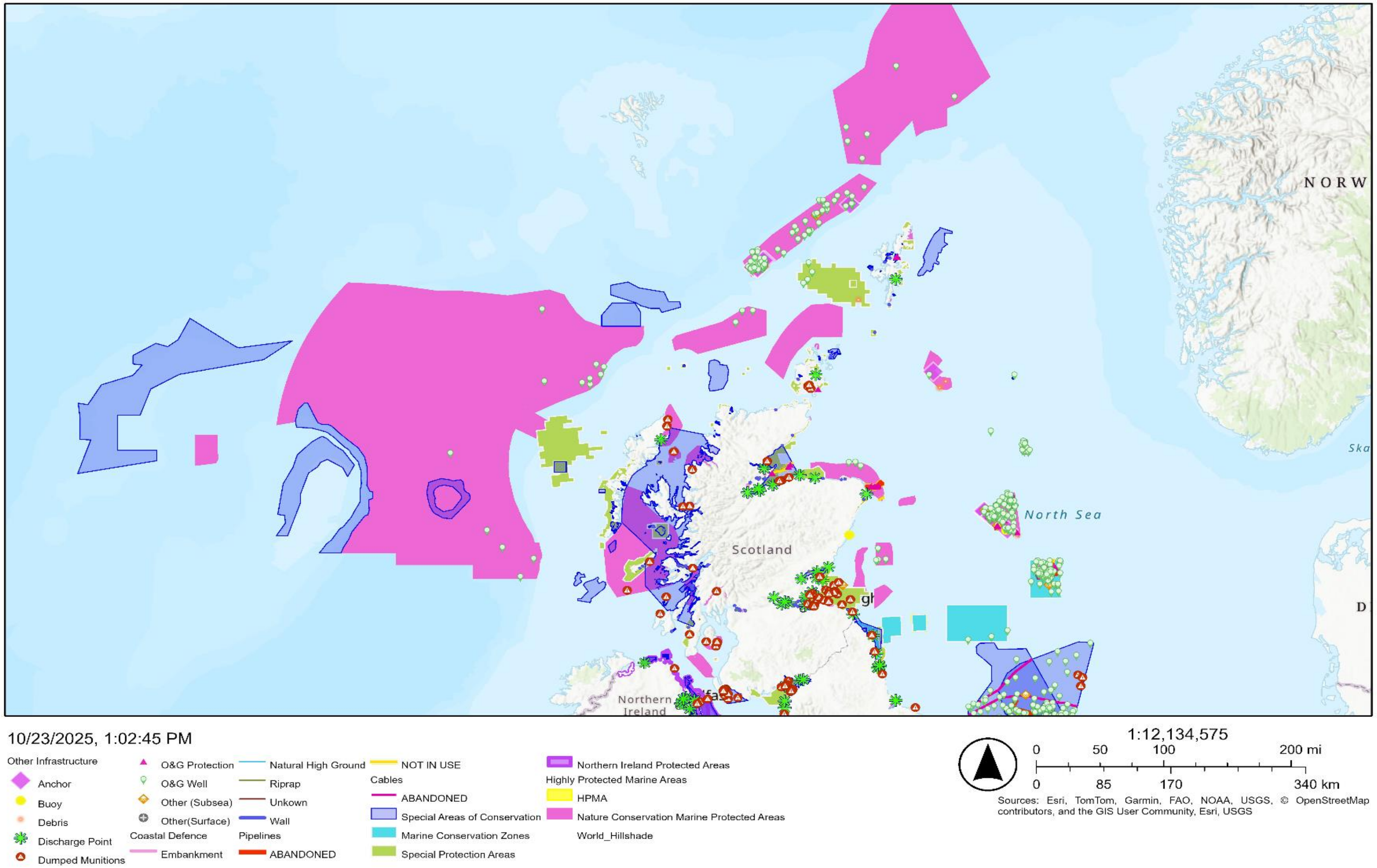

Figure 6.6. Map of redundant infrastructure within Scottish MPAs.

6.2 Proximity and overlap of infrastructure with offshore wind farms and MPAs

The online tool integrates wind farm polygons from EMODnet's wind farm mapping and Crown Estate Scotland's INTOG application areas to visualise the proximity of MPAs to existing and proposed OW developments. The core aim of this exercise is to explore opportunities to compensate for the in-combination and direct impacts of OW on features of MPAs, and in particular Annex I benthic habitats. By layering these data with spatial information on disused infrastructure, the tool visualises MPAs containing redundant infrastructure that are nearest to wind farms (with the assumption being that due to their proximity these MPAs are most impacted by these windfarms) These areas could then be prioritised for infrastructure removal as a measure to compensate for the pressures from OW expansion. The tool is intended as a live document that can be updated as new information becomes available, and additional assets reach the end of their operational lives. MPA breakdown. Appendix 3 lists infrastructure type, status, and either length (km) or count for each individual MPA in UK waters. This supporting spreadsheet can be used to identify site-specific opportunities for infrastructure removal.

7 Discussion

7.1 Areas where infrastructure removal is likely to have the greatest benefit

The results of this analysis indicate that English and Scottish waters, particularly along the East coast, contain the highest density and diversity of disused infrastructure within MPAs (Figure 7.1 and Figure 7.2). This includes the greatest recorded lengths of abandoned and not in use pipelines and cables, as well as the highest counts of oil and gas wells, dumped munitions, and discharge points. In contrast, infrastructure within Welsh and Northern Irish MPAs was more limited, though this may in part reflect differences in data availability and coverage.

Oil and gas infrastructure, particularly wellheads, is the most widespread asset type across all regions. Other features such as dumped munitions and discharge points were also common, although their potential for removal as a strategic compensation may be more constrained. Manmade coastal defences were assessed throughout the UK, except Northern Ireland due to limited data; their removal potential will be highly site-specific and require stakeholder engagement to investigate individual defence lifespans and uses.

While the density of disused infrastructure in Welsh and Northern Irish MPAs is lower than those in English and Scottish waters, the presence of even limited redundant assets in proximity to existing or planned OW development areas may still offer strategic compensation opportunities. This is particularly relevant for Welsh waters, where the Round 5 Celtic Sea leasing areas for offshore wind are found, as this region contains a notable volume of redundant infrastructure and may offer future opportunities for compensation linked to floating offshore wind development.

It is important to note that these findings are based on publicly available datasets and do not incorporate certain industry data such as KIS-ORCA due to lack of public access. As such, the results should be interpreted as indicative rather than comprehensive, and further work would be required to refine these estimates and assess feasibility on a case-by-case basis.

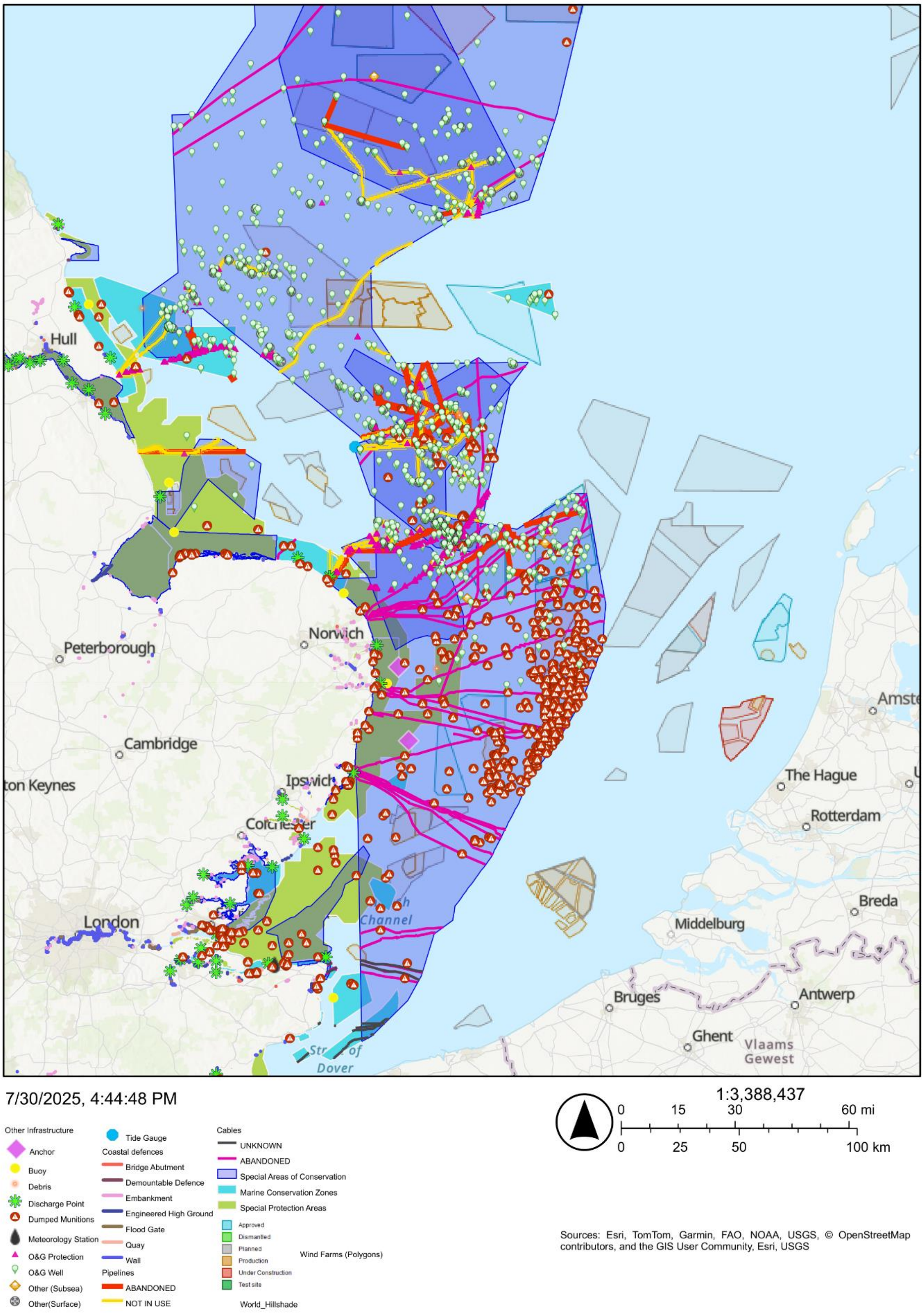

Figure 7.1. Map of the East Coast of England showing MPAs, the related redundant infrastructure and proximity to planned and operational offshore wind farms.

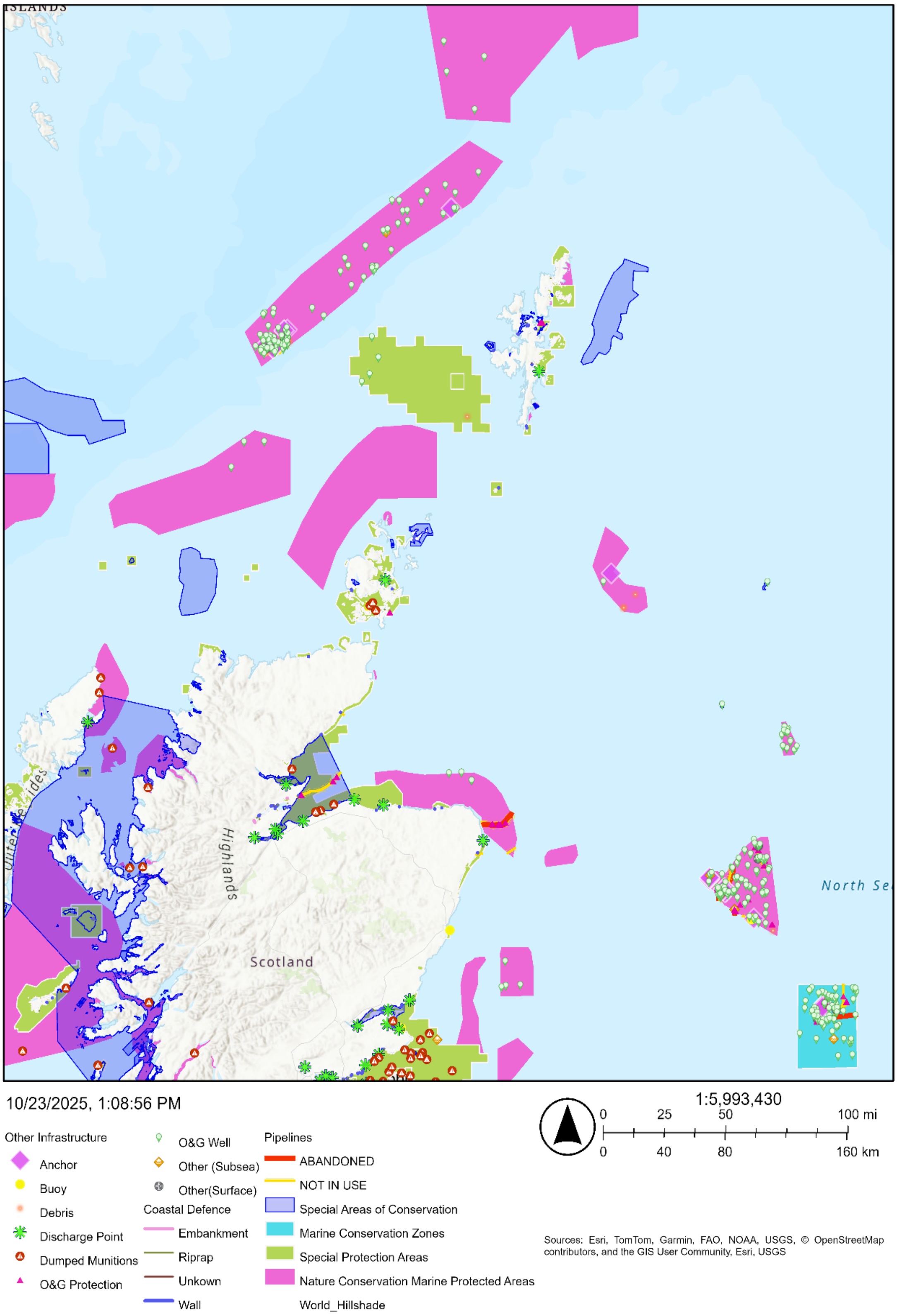

Figure 7.2: Map of the East and Northern coast of Scotland showing MPAs, the related redundant infrastructure and proximity to the INTOG application areas.

7.2 Potential benefits of infrastructure removal

Infrastructure removal can present significant opportunities for environmental benefit and a return to pre-construction environmental baseline conditions. Targeting the most impactful types of infrastructure, particularly oil and gas wellheads and pipelines (and associated protection), offers the greatest opportunity. Oil and gas wellheads are known sources of pollution, often leaching hydrocarbons, heavy metals, plastics and other contaminants into surrounding ecosystems (Kang *et al.* 2016; Sommer *et al.* 2019; Marappan *et al.* 2022). The risk of damage to this infrastructure is forecast in increase in coming years in response to increased wind and wave conditions likely to be associated with climate change (Brooks *et al.* 2020). Consequently, the removal of this infrastructure as it reaches the end of its operational life may reduce the risk of the release of these pollutants both now, and in the future, supporting the recovery of, and preventing further damage to, marine habitats.

One of the most significant ecological benefits of removing hard infrastructure is the potential to restore soft sediment habitats that were previously lost or fragmented due to installation. Many MPAs in UK waters are designated for features such as subtidal sandbanks and mud habitats, which provide critical ecosystem services including nutrient cycling, carbon storage, and habitat for benthic species (Natural England 2025). The presence of surface-laid pipelines, pipeline and cable protections, and other hard structures displaces these habitats, altering sediment dynamics and reducing ecological function. Removal of redundant infrastructure would allow these areas to recover, contributing to the restoration of habitat extent, structure, and function. This may also support the achievement of conservation objectives within designated sites, including the recovery of qualifying features and the supporting processes on which they rely.

The removal of hard structures in the marine environment may also help minimise the spread of INNS (Invasive Non-native Species), particularly those with pelagic larvae (such as barnacles, gastropods and algae). Adams *et al.* (2014) highlight how marine infrastructure may offer stepping stones on which pelagic larvae can settle, enabling future generations to disperse more widely. This is a particular risk close to ports, and other areas where ships may discharge ballast (Castro *et al.* 2022).

“Ghost fishing” caused by abandoned fishing gear such as nets, traps, and lines, occurs when this abandoned gear continues to catch and kill fish and other marine life when discarded. This can be further exacerbated by gear catching on marine debris and other gear, further tangling together, increasing in size and posing a greater risk (NOAA 2023). Abandoned infrastructure on the seabed would be a prime candidate for fostering this phenomenon, and removing the infrastructure could have positive biodiversity effects by providing fewer opportunities for fishing gear to snag and accumulate, reducing the risk to marine species through secondary entanglement. Whilst infrastructure removal would not address the wider issue of ghost gear, it would reduce the potential for this secondary entanglement.

Hard coastal defences are known to disrupt ecosystem services and replace coastal habitats important for birds and other marine species. The removal of defunct or redundant defences may pose an opportunity for localised habitat restoration and biodiversity benefits. Additionally, key types of habitat creation/restoration through the removal of hard defences could deliver biodiversity benefits farther afield, such as through the establishment of saltmarshes for bird communities (Atkinson *et al.* 2004).

In addition to biodiversity benefits, infrastructure removal also presents opportunities to support circular economy principles. Materials recovered from decommissioned infrastructure such as steel, copper, and plastics can be recycled and reintroduced into the supply chain, reducing the need for extraction of new raw materials and lowering associated carbon emissions. For example, sections of out-of-service submarine cables have been successfully repurposed for new installations, demonstrating the potential for reuse and resource efficiency in marine infrastructure decommissioning efforts (UNEP WCMC & ICPC 2025). These benefits should be considered against any potential environmental impacts and carbon emissions related to the removal of infrastructure.

7.3 Potential negative impacts of infrastructure removal

According to (Fowler *et al.* 2020), removing offshore infrastructure can lead to the loss of biologically rich, artificial reef habitats that have developed on these structures over decades (Redford *et al.* 2021). These artificial reefs, which form around a range of structures including the concrete mattresses and rock dump used to protect pipelines, can support high local biodiversity, and have been known to host species of conservation significance, specifically the habitat-forming coral *Desmophyllum pertusum* (IUCN Red List Status Vulnerable) and marine worm *Sabellaria spinulosa* (IUCN Red List not evaluated, though Sabellaria reefs are listed as a UK habitat of conservation concern and a JNCC Annex I reef feature and protected under the Natural Environment and Rural Communities Act). Complete removal may eliminate or degrade these habitats, displacing or destroying the associated communities and potentially reducing local and regional biodiversity. Although it is not fully understood whether these habitats colonising the infrastructure are functioning in the same way as they would be on natural substrates.

The loss of these habitats may also have impacts further afield by disrupting ecological connectivity between populations, particularly for species that rely on offshore structures as "stepping stones" for dispersal across the otherwise soft sediment dominated North Sea. Though it should be noted that the loss of these stepping stones may also be beneficial if they facilitate the movement and settling of pelagic larvae from potentially invasive non-native species (Adams *et al.* 2014). The consequences of this are likely to be highly context specific. This area of research is being actively explored through the INSITE Programme, which investigates the ecological role of offshore infrastructure in the North Sea, including how these structures function as artificial reefs and influence biodiversity and connectivity.

In addition to the creation of habitat below water, some types of infrastructure may support species close to, or above the sea surface. Grey seals *Halichoerus grypus* have been shown to be attracted to the feeding opportunities associated with offshore wind farm support structures (Russell *et al.* 2014). Similarly, seabirds are regularly recorded roosting on artificial structures in the marine environment including buoys (e.g. Owen *et al.* 2019) and wind turbines (e.g. Stienen *et al.* 2024). They are also regularly recorded breeding on artificial platforms such as oil and gas platforms (e.g. Christensen-Dalsgaard *et al.*

2020). Consequently, removal of these structures may negatively impact the species associated with them, and limit other opportunities for the provision of compensation, for example in relation to the potential repurposing of existing offshore infrastructure artificial nesting structures.

In some instances, the removal of infrastructure may be as disruptive as its initial installation. In addition to the disturbance caused by removal operations, seabed excavation may lead to the resuspension of sediments (e.g. from drill cuttings) and risk releasing pollutants, degrading surrounding habitats, and the risk of debris being left behind as marine litter (Sommer *et al.* 2019; Schläppy *et al.* 2021).

An additional unintended consequence of removal may be that it could reopen areas to bottom trawling, reversing any de facto protection these exclusion zones provided and reintroducing pressures on benthic ecosystems (Fowler *et al.* 2020). Consequently, for infrastructure such as telecommunication cables, particularly where these are buried, and environmental impacts once installed are minimal (UNEP WCMC & ICPC 2025), careful consideration should be given as to whether removal will cause greater disturbance than if the structures were left in place.

7.4 Challenges to infrastructure removal as a strategic compensation measure

There are a number of technical challenges associated with the installation and removal of marine infrastructure due to the highly dynamic nature of the environment and the often deep water in which that infrastructure is deployed. These technical aspects are not fully considered within this report and further work with regards the feasibility of implementation would need to be carried out to progress the measure. However, a brief overview of the legal, regulatory and safety challenges in relation to infrastructure removal as a compensation measure are provided in the below sections.

A key consideration relates to additionality requirements for compensatory measures. A recent consultation led by DEFRA (2024) highlighted that proposed measures do not meet requirements for additionality if they are:

- reasonably accepted as part of normal protected site management
- normal steps to avoid deterioration or disturbance (or both) or address threats and pressures to MPAs.

Under OSPAR Decision 98/3 there is an existing requirement to remove infrastructure associated with the oil and gas industry (including external pipeline protections), where it is technically feasible. Despite this, some structures remain in place due to safety risks, high costs, and technical challenges associated with dismantling large steel or concrete installations (Evidence on The future of the oil and gas industry 2018). However, it should be noted that unlike platforms, pipelines are not covered by the OSPAR 98/3 ban on the disposal of installations at sea. Decommissioning of pipelines is considered on a case-by-case basis, by comparative assessment of the options. The operator is required to demonstrate that the proposed approach meets international obligations to ensure the safety of navigation and fishing, and protection of the marine environment.

Similar to OSPAR Decision 98/3, removal at end of life is generally a licensing requirement for both power and telecommunications cables within 12 nautical miles of the coast (e.g. ABPmer 2020). In these instances, removal of cables is likely to constitute a normal step to address threats and pressures to MPAs. Whilst this would suggest that these measures could not be considered additional, and therefore, would not normally be considered compensation, DEFRA (2024) suggests that if proposals would speed up delivery of removal, this may constitute compensation. However, in light of other government policies, plans to introduce MNG and requirements of other industries, such as ports, to deliver compensatory measures (where needed), any redundant infrastructure may already have been identified for removal to support these drivers, rather than to the benefit of the OW industry.

Additionally, in some cases redundant oil and gas infrastructure may be ear-marked for other purposes such as Carbon Capture Storage (CCS). Similarly, as seabirds have been regularly recorded breeding on artificial platforms such as oil and gas platforms, the potential repurposing of existing offshore infrastructure artificial nesting structures as a strategic compensation measure is also currently being explored. There is therefore a potential conflict where despite the removal of redundant infrastructure benefitting benthic features of a MPA, there could potentially be additional benefit in the infrastructure remaining in place in some instances, for example in relation to nesting sites for birds. Further consideration of what the removal of infrastructure could achieve in relation to potential strategic compensation. Questions around how and if the removal of infrastructure will positively contribute to the cohesion of the designated site network and how this would work could be aligned with potential repurposing of the infrastructure as strategic compensation or CCS.

Safety considerations, such as the risk to divers, the complexity of removing large or degraded structures, and the potential for disturbance to surrounding habitats should explosives or large machinery be used for removal, are a key reason why redundant infrastructure has often been left in place. These risks must be carefully weighed against the potential ecological benefits of removal, particularly in sedimentary habitats where restoration may be possible.

8 Conclusions

This initial review has highlighted that there is a substantial quantity of infrastructure in the UK EEZ which may be suitable for removal as part of strategic compensation for offshore wind farms (Figure 6.2 to Figure 6.6). The area with the greatest opportunity appears to be the East Coast of England, followed by the East coast of Scotland. However, as a strategic compensation option, infrastructure removal must be considered in the context of existing requirements and regulations, and the potential environmental costs and benefits of any action to marine habitats.

In light of the limited options for strategic compensation at present, there is merit in further consideration of opportunities for infrastructure removal and I's addition as a measure into the LoSCM. To aid this consideration, the following steps would be recommended:

1. Updating the online tool to incorporate new and additional datasets, such as the one being developed by the Marine Management Organisation in relation to hard protection, as they become available.
2. Mapping existing regulatory demands and requirements around infrastructure removal for different industries to understand the extent to which this may reflect an additional action.
3. Reviewing the risks associated with leaving defunct infrastructure in situ, and assessing these in the context of any disturbance and disruption associated with its removal.
4. Assessing the extent to which the benefits of infrastructure removal may vary spatially, including the extent to which the surface footprint of the infrastructure may be contributing to habitat loss. Consideration also where there could be greater value associated with removing hard structures further offshore, where they may act as stepping stones for colonisation by INNS, which could form part of a wider measure in the future.
5. Assessing the potential costs of the removal of infrastructure identified in this report relative to the benefits that removal of this infrastructure would deliver for biodiversity.
6. Drawing from the above information to develop a decision support tool to highlight locations and types of infrastructure that may be appropriate for removal as a form of strategic compensation.

7. Further engagement with other industries to better understand the feasibility of, and support for, infrastructure removal as a form of compensation.

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Appendix 1 Changes and groupings in infrastructure dataset to simplify the reporting on infrastructure statistics on the online tool.

Original Category	Grouped Category
Mattress	O&G protection
Protection	O&G protection
Valve	O&G protection
Tree	O&G protection
Pipe junction	O&G protection
Anode assembly (subsea)	O&G protection
Manifold	O&G protection
Anchor	Anchor
Anchor pile	Anchor
Other (subsea)	Other (subsea)
Other (pipeline)	Other (subsea)
Other surface	Other (surface)
Platform	Other (surface)
Well	O&G well
Wellhead	O&G well
Obstruction (subsea)	Debris
Obstruction (pipeline)	Debris
Obstruction	Debris
Debris	Debris
Dumped munitions	Dumped munition
Wells	O&G well

Original Category	Grouped Category
Discharge point	Discharge point
Buoy	Buoy

Appendix 2 List of changes made to the raw datasets for their final inclusion in the online tool.

#	Field(s) touched	Original value(s) / pattern	New value(s) / rule applied	Reason
1	Status	Active, active, operational, under construction	Active	Consolidate all live assets
2	Status	Abandoned, closed down, disused, decommissioned in 2013/2016	Abandoned	Consolidate all retired assets
3	Status	Suspended → not in use <null> → na	Align with pipeline status vocabulary	
4	Column names	Marine area, data source	Marine_area, data_source	Remove spaces (r-friendly & arcgis popup-safe)
5	Marine_area	"\marine plan areas (england)" → england "\marine plan areas (wales)" → wales "\marine regions and areas (scotland)" → scotland digitized → northern ireland	Strip path prefixes & harmonise regions	
6	Source	Marine_Conservation_Zones → MCZN_Ireland_PAs → Northern Ireland MPA	Short, human-readable source tags	
7	Category (where <Null>)	Data_Source = *EMODnet_DumpedMunitions* → DUMPED MUNITION *EMODnet_Wells* → WELL *EMODnet_Discharge_Points* → DISCHARGE POINT	Impute missing categories from source	

#	Field(s) touched	Original value(s) / pattern	New value(s) / rule applied	Reason
8	Category (typo fixes)	Waves → buoy tides → tide gauge met → met station tee piece → tree	Standardise sensor / object labels	
9	Category (whitespace)	Leading/trailing spaces	Trimmed	Remove hidden duplicates
10	Category (final consolidation)	Mattress, protection, valve, tree, pipe junction, anode assembly (subsea), manifold → o&g protection• anchor, anchor pile → anchor• other (subsea), other (pipeline) → other (subsea)• other surface, platform → other (surface)• well, wellhead → o&g well• obstruction (subsea), obstruction (pipeline), obstruction, debris → debris	Create tidy, analysis-ready groupings	
11	Grouping & pivot (region)	—	Group_by (marine_area, category, status) → counts	Region-level summary
12	Grouping & pivot (site)	—	group_by (SITE_NAME, Source, Category, STATUS) → counts	PA-level popup table→ infrastructure (final exported sheet)

Appendix 3 Full analyses and outputs

Appendix 3 can be used to explore the full raw outputs of the spatial analysis. This appendix is split into two key datasets:

- MPA breakdown. This output lists infrastructure type, status, and either length (km) or count for each individual MPA. This can be used to identify site-specific opportunities for infrastructure removal.
- Regional summary. This version aggregates infrastructure data by marine region, removing duplication caused by overlapping MPAs. This can be referred to when estimating the total scale of opportunity for strategic compensation across broader geographies.

REN_UK_Analyses_20250530.xlsx