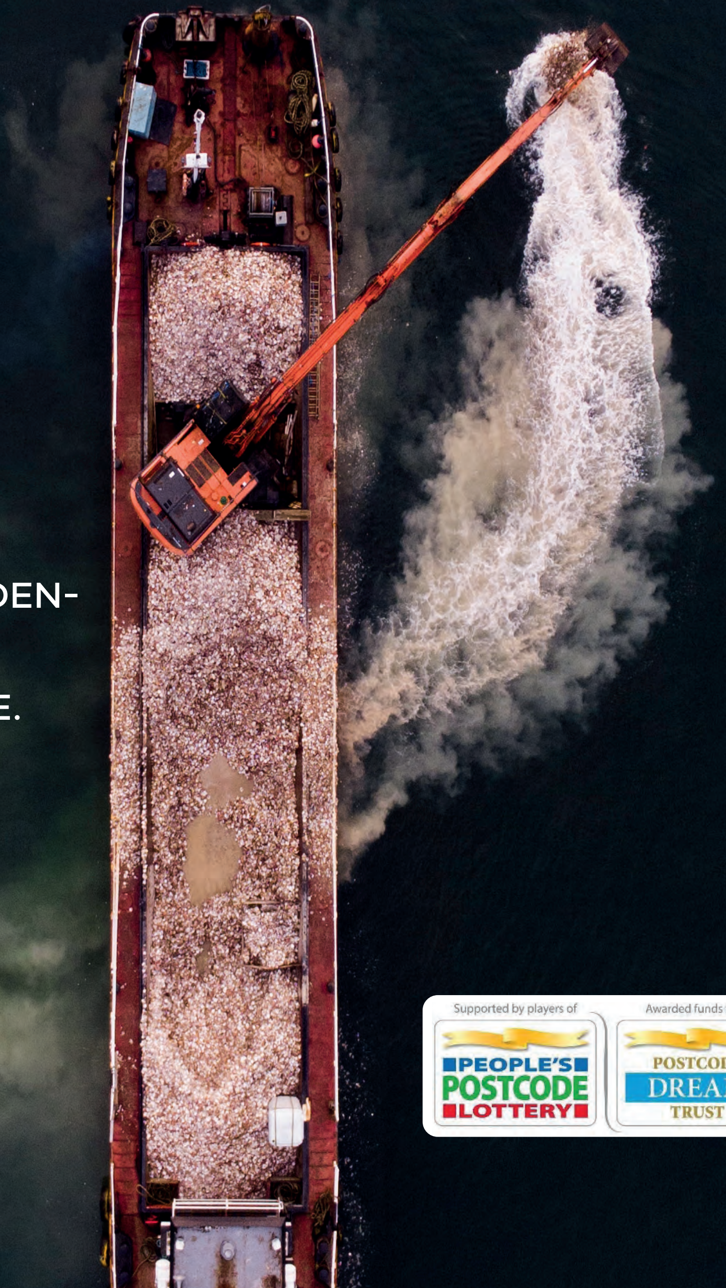
THE WILD OYSTERS PROJECT

NATIVE OYSTER HABITAT RESTORATION REPORT



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The Wild Oysters Project received £1.18m in funding that was raised by players of People's Postcode Lottery through the annual Dream Fund award. The Dream Fund receives player raised funds through Postcode Innovation Trust and exists to give organisations the opportunity to bring ambitious, innovative and collaborative projects to life.

ACKNOWLEDGEMENTS

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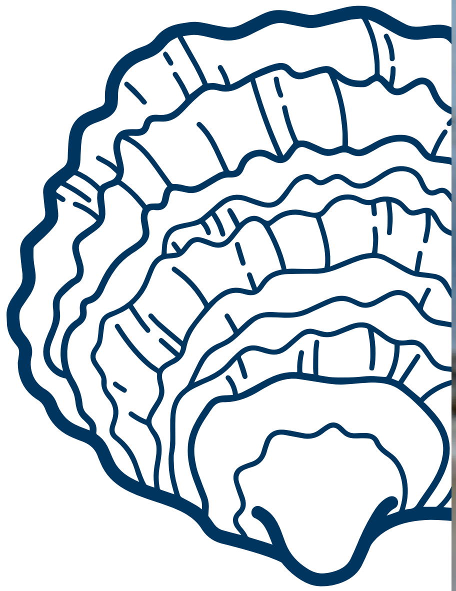
GROUNDWORK CHANGING PLACES CHANGING LIVES



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EXECUTIVE SUMMARY

This technical report provides an overview of the project development, methodology and logistical requirements of The Wild Oysters Project in restoring native oyster populations across two sites: Conwy Bay restoration hub in North Wales, and Tyne and Wear restoration hub in North East England.

The Wild Oysters Project completed detailed planning, extensive surveys, and collaborated with local representatives, with the aim of creating native oyster reefs covering a combined approximate $15,000m^2$ at the two restoration hubs.

The site selection process considered factors such as biogeographic and historic native oyster range, substrate types, proximity to the marinas, predicted larval dispersal, and deployment logistics. Through a review of existing habitat data and local consultation, an inshore area near Roker beach in the Tyne and Wear restoration hub, and an area within Conwy Bay near West Shore Beach were selected as the broadscale areas for restoration. Following this selection, a comprehensive habitat survey was completed at each site and detailed habitat mapping reports created to refine the exact area suitable for reef creation. The habitat and ground-truthing surveys served the dual purpose of informing site selection and establishing baselines for substrate types, habitat structures, and biodiversity at each site.

Deploying cultch and mature native oysters to create native oyster reef habitat was a substantial logistical undertaking. The first phase of deployment involved the transportation and deployment of hundreds of tonnes of materials, made up of limestone gravel and shell cultch to act as a suitable substrate for oyster settling. At the Tyne and Wear restoration hub, construction of a new native oyster reef was successful using a split-hopper barge, onboard excavator and a support vessel. Subsequently, 10,000 mature native oysters were deployed onto the reef site. At the Conwy Bay restoration hub, a method of cultch deployment was trialled, using tonne bags with discharge spouts to deploy the gravel. Challenges were encountered with the deployment technique which resulted in an uneven gravel distribution, bag blockages, and consequently the project timeline was impacted due to the licence requirement to level out the gravel cultch material. A new marine licence has been submitted to carry out levelling work on the gravel and finalise the reef construction. The trialling of the deployment method was a valuable lesson learnt, both for the project and the wider oyster restoration community, and emphasises the importance of the availability of suitable vessels for restoration works.

The restoration efforts in both the Tyne and Wear restoration hub and the Conwy Bay restoration hub have contributed towards native oyster restoration in these regions. In the Conwy Bay restoration hub, further work is due to take place to complete the habitat restoration. The lessons learned through The Wild Oysters Project provide valuable guidance for future large-scale restoration initiatives, emphasising the importance of thorough planning, community engagement, and adaptability in the face of unforeseen challenges.

The restoration efforts in both the Tyne and Wear restoration hub and the Conwy Bay restoration hub have contributed towards native oyster restoration in these regions

Photo: Mature native oysters for release onto the newly created reef © Lucie Machin

10,000 MATURE NATIVE OYSTERS WERE DEPLOYED ONTO THE REEF SITE AT TYNE AND WEAR

1. INTRODUCTION

1.1 Introduction to Native Oysters (*Ostrea edulis*)

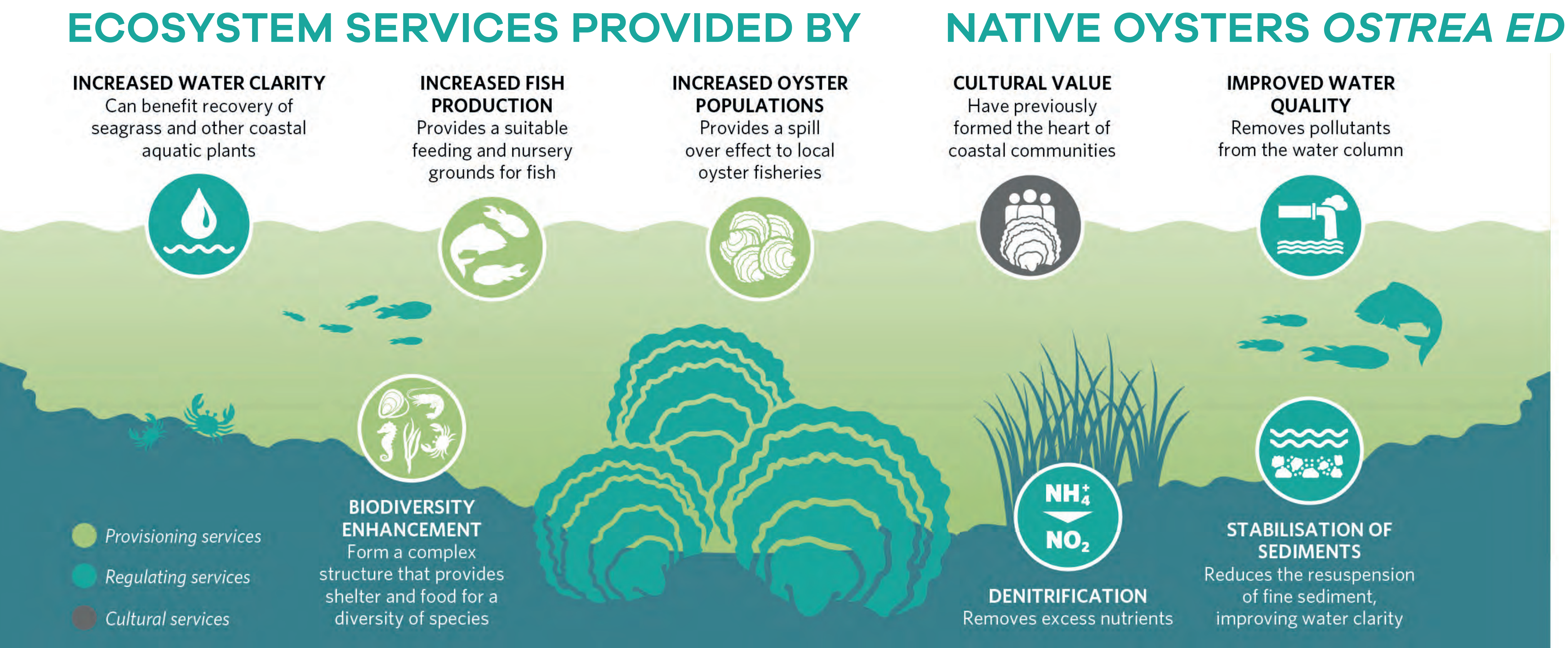
Across the UK, wild native oyster (*Ostrea edulis*) populations have declined by over 95 per cent since the 1800s, as a result of a combination of factors including habitat loss, over-harvesting, pollution and disease (Beck *et al*., 2011; Lown et al., 2021; Thurstan et al., 2024). With this decline, the many environmental and social benefits known as ecosystem services that native oysters provide (Figure 1) have also been lost. These benefits include improved water clarity and quality, increased biodiversity, shoreline protection through sediment stabilisation and denitrification (Lown *et al*., 2021; Fariñas-Franco *et al*., 2018; Helmer *et al*., 2019; Pogoda, 2019; Thomas *et al*., 2022). Both the presence of native oysters and the complex three-dimensional structure, which can be extremely beneficial to other marine life, as it provides vital nursery and feeding grounds. In addition, the water filtration capacity of native oysters is vast, with each adult oyster capable of filtering over 200 litres of water per day (Thomas *et al*., 2022).

The decline of native oyster populations is so significant that active human intervention is required for the recovery of this species from functional extinction. Efforts to restore native oysters around the UK and Europe continue to grow momentum with the Native Oyster Network – UK and Ireland (NON) and Native Oyster Restoration Alliance (NORA) bringing together restoration practitioners, scientists, industry, government and other representatives to share best practices and improve chances of success. This led to the publication of a series of restoration handbooks that enable other projects to progress through the experience gained by others (Preston *et al*., 2020A; zu Ermgassen *et al*., 2020; Hughes & zu Ermgassen, 2021; zu Ermgassen *et al*., 2021).

Conservation actions across Europe by restoration practitioners include protecting remaining populations, introducing broodstock oysters to repopulate denuded areas and actively restoring the species and the seabed habitat they create to areas from which they have been lost.

The Wild Oysters Project was an initiative providing active intervention to recover self-sustaining populations of native oysters at two restoration hubs – one in the North East of England (Tyne and Wear) and one in North Wales (Conwy Bay). The project was a partnership between the Zoological Society of London (ZSL), Blue Marine Foundation (Blue Marine), British Marine, and local project partners; the School of Ocean Sciences at Bangor University and Groundwork North East and Cumbria.

When considering native oyster restoration and locations for restoration efforts, the life cycle of native oysters must be considered. The life cycle of the native oyster is complex with many stages occurring in succession required for the next generation to



NATIVE OYSTER NETWORK UK & IRELAND

NORA

sea-changers

Figure 1. *Ecosystem services provided by Ostrea edulis. Source: Preston et al., 2020A.*

successfully establish (Figure 2). The process is reliant on a wide range of environmental and biological factors and is sporadic in nature.

Addressing each stage of the life cycle to improve chances of success is the approach being adopted for oyster restoration efforts. Native oysters spawn and release larvae into the water column. Native oysters are gregarious and oyster larvae prefer to settle where other oysters are present. The larvae require a hard substrate on which to settle, such as shell or stone. Successive settlement of juvenile oysters on living or dead oyster shells has the potential to form a complex three-dimensional, structured habitat, known as oyster reefs. Therefore, the area for restoration must be assessed and can typically be categorised as substrate and/or recruitment limited. Substrate limited refers to an area where there is a lack of suitable habitat for larvae to settle. Recruitment limited refers to an area that does not have enough broodstock to supply enough larvae to the area to enable settlement and further recruitment. Both limitations typically require human intervention to overcome.

To address recruitment limitation at the two Wild Oysters Project restoration hubs, The Wild Oysters Project, using lessons learned by Blue Marine, University of Portsmouth and partners in the Solent Oyster Restoration Project, installed a series of native oyster nurseries (Uttley *et al.,* 2023). This work was made possible by collaborating with local delivery partners and local marinas, and through the input of the Local Working Group (LWG) at each site.

The native oyster nurseries (see Uttley *et al.,* 2023) are complemented by the active seabed restoration work described in this report at the two restoration hubs. This work was based on the experience of Blue Marine, ZSL and partners through the establishment of reefs in The Essex Native Oyster Restoration Initiative (ENORI) and the Solent Oyster Restoration Project. Native oyster reef creation provides a suitable substrate for the native oyster larvae from the deposited broodstock to settle on and grow.

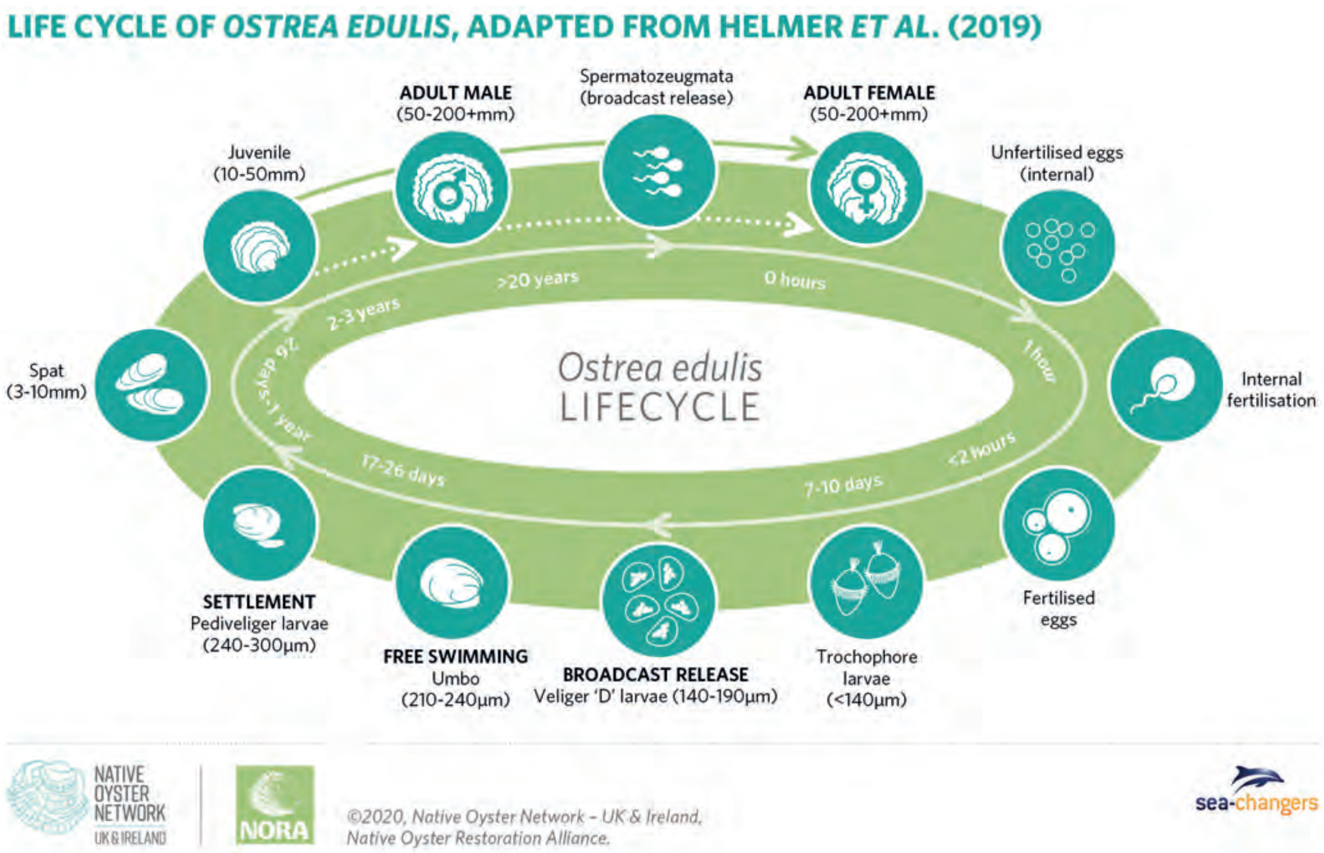


***Figure 2,** Lifecycle of the native oyster (Ostrea edulis). Source: Preston et al., (2020A), modified from Helmer et al., (2019).*

1.2 Considerations for Native Oyster Habitat Restoration

Native oyster habitat restoration is a complex undertaking with many considerations. A full summary of native oyster restoration and guide to navigate the considerations can be found in the native oyster restoration handbooks (Preston *et al.*, 2020A; zu Ermgassen *et al.*, 2020; Hughes & zu Ermgassen, 2021; zu Ermgassen *et al.*, 2021). This section of the report covers the key considerations that were assessed during the process of site selection and habitat restoration through The Wild Oysters Project. Site specific details of these considerations are covered in depth in sections 3 and 4 below.

1.2.1 Shell Availability

Determining shell availability is a key factor in determining how to progress with seabed restoration. Shell availability is the amount of shell, or alternative suitable settlement substrate, that is naturally occurring in an area and is available for settlement of oyster larvae. As well as an important factor for site selection, shell availability is an important metric to record as the reef develops and gives an indication of available substrate for future recruitment. The areas that were considered for seabed restoration through The Wild Oysters Project were surveyed for shell availability, substrate type and existing habitat type as part of the site selection process.

Sites containing a large amount of subtidal mixed sediment, including live oysters or old shells, may not require a large deposit of additional cultch (stone and shell) material to make the area suitable for future larval settlement, or to make the area suitable to deploy additional mature oysters.

The Wild Oysters Project seabed sites were assessed for shell availability and despite containing rocky, hard ground, it was deemed that additional cultch deployments were required to create the ideal settlement environment for the oyster larvae and provide a suitable base layer for the deployment of mature native oysters.

As well as an important factor for site selection, shell availability is an important metric to record as the reef develops and gives an indication of available substrate for future recruitment.

1.2.2 Cultch Types

Shell Cultch

In areas of particularly low cultch availability, additional material is required to provide enough suitable substrate to allow for larval settlement. This material is called cultch and is made up of hard materials, generally bivalve shells and gravel. The type of shell used in oyster restoration is generally dictated by shell availability as all shell types will receive spat settlement. Old oyster shell is generally recognised as the most suitable type of shell for oyster larval settlement, but restoration projects elsewhere in the UK have successfully trialled scallop, cockle, mussel and slipper limpet shells (The Essex Native Oyster Restoration Initiative, The Solent Oyster Restoration Project, The Dornoch Environmental Enhancement Project (DEEP), Native Oyster Aquaculture Research (NOAR) Bangor University). Anecdotal evidence from ENORI suggested that greatest settlement rates were seen on oyster and scallop shell, followed by mussel shell and lower rates seen on cockle and slipper limpet shells.

Oyster shells are not commonly available in large quantities as oysters tend to be served on the shell and so the shell is then classified as food waste and is accordingly disposed of. Therefore, both of The Wild Oysters restoration hubs secured large quantities of scallop shell, supplemented with significant amounts of gravel to form the new oyster reefs. Scallop shell was sourced from shellfish processing companies, whereby the scallop shell was pre-ordered before it became a waste product, repurposing it for restoration. The project pre-ordered and weathered 97 tonnes of scallop shell and 50 tonnes of cockle shell at the Conwy Bay restoration hub, and 185 tonnes of scallop shell at the Tyne and Wear restoration hub.

Stone Cultch

Stone cultch was used to form the first layer of cultch material for the reef creation at both The Wild Oysters Project sites. When deciding a source of gravel for reef deployment in The Wild Oysters Project sites, stones that were locally sourced and in keeping with the type and size of those found in the reef site and surrounding areas were used. This ensured best practice for conservation, with minimal change to existing habitat types or features. The stone used was from a local, land-based source, which removed the risk of disease and Invasive Non-Native Species (INNS) transfer that would be present if marine aggregates were to be used. Marine sources of gravel have been explored by other projects and wider discussions about the beneficial use of dredged sediments in oyster restoration are continuing (Manning *et al.*, 2021).

Biosecurity of Cultch

The deployment of cultch has the potential to pose a biosecurity risk; however, it is possible for these to be mitigated through best practice. Cultch will need to be bio-secure prior to deployment. A full Biosecurity Measures Plan was followed throughout the project (Appendix 1). Cultch that had been sourced from the marine environment (all marine based shells) had to be treated prior to use to ensure that it was clean from any biological material that may pose a biosecurity risk. Shells that were cooked as part of food processing were deemed safe for use (as per standard best practice recommendations (zu Ermgassen *et al.*, 2020)). Uncooked shell was stored outside subject to the elements and weathered for a minimum of twelve months in the Tyne and Wear restoration hub and a minimum of six months in the Conwy Bay restoration hub, as per local regulator advice. During this time cultch was turned to ensure that all cultch was exposed and allow all biological material to degrade. Before deployment, sub-samples of cultch were taken and analysed to ensure all cultch was free from live biological material. Twenty shells were randomly selected, and both sides of the shell inspected and photographed. Any sign of remaining biological tissue or fouling on the shells was noted. In addition to the selected shells, an overall inspection of visible shells in the storage facility was undertaken for any signs of biological material.

Land-based sources of cultch, such as gravels, could be safely used without the need for weathering as they do not pose a biosecurity risk. However, gravel types were carefully selected to ensure that they were locally sourced and in keeping with those occurring naturally in the marine environment.

1.2.3 Oysters Supply and Biosecurity

Oyster supply is a limiting factor in many oyster restoration projects. Sourcing native oysters from outside the local area can present significant biosecurity risks such as the transfer of disease or INNS. The use of wild stocks to supply the demand from restoration projects has the potential to further damage the remaining populations, therefore The Wild Oysters Project sourced the mature broodstock oysters from a *Bonamia ostreae* free area from Loch Ryan in Scotland. To ensure there was minimal risk of the spread of disease or INNS, a stringent Biosecurity Measures Plan (Appendix 1) was followed and a thorough cleaning of oysters took place to remove all associated epibiota prior to deployment.

Additionally, there are several criteria that the donor site (where oysters are being translocated from) must fulfil and a number of checks that need to be made prior to translocation:

- All donor sites must be of equal or higher health status (with regards to notifiable shellfish diseases) than receiving sites.
- Donor sites must not have high-risk invasive species present that are not present at the receiving site.
- Where possible, donor populations will come from within the same body of water as the restoration site.
- All donor sites to be agreed with the Fish Health Inspectorate prior to deployment.

The Wild Oysters Project sourced the mature broodstock oysters from a *Bonamia ostreae* free area from Loch Ryan in Scotland

Photo: Mature Native Oysters

2. SELECTION OF WILD OYSTERS PROJECT RESTORATION HUBS

Native oysters once formed extensive reef habitat around the coast of the UK, English Channel and the North Sea. The Piscatorial Atlas, created in 1883, portrays the distribution of native oyster habitat around Northern Europe and the United Kingdom (UK) coastline (Figure 3). The complete biogeographic range of the native oyster is greater still and extends across the entirety of northern Europe and the Mediterranean (Figure 4).

Figure 3. *Olsen's Piscatorial Atlas of the North Sea, 1883, showing the distribution of native oyster beds around the UK and across the North Sea (Olsen, 1883).*

Site selection can have a significant impact on the success rate of a native oyster reef. The area chosen must be biologically suitable for native oysters but also not significantly impact or be impacted by human activities. The first consideration of site selection for the restoration hub locations was the biogeographic range, local historic presence (including fisheries) and natural distribution of native oysters around the UK. Furthermore, native oyster restoration potential model outputs from Natural Resources Wales (for Conwy Bay) and the Environment Agency (for the Tyne and Wear) were used to further refine areas deemed suitable for restoration. The Wild Oysters Project selected sites in North East England and North Wales which fell within the biogeographic, historic and natural distribution of native oysters, and where there was a presence of suitable partners and local marine knowledge required to ensure the project's success. Upon the formalisation of collaboration with partners locally, a broadscale and detailed site selection process was undertaken.

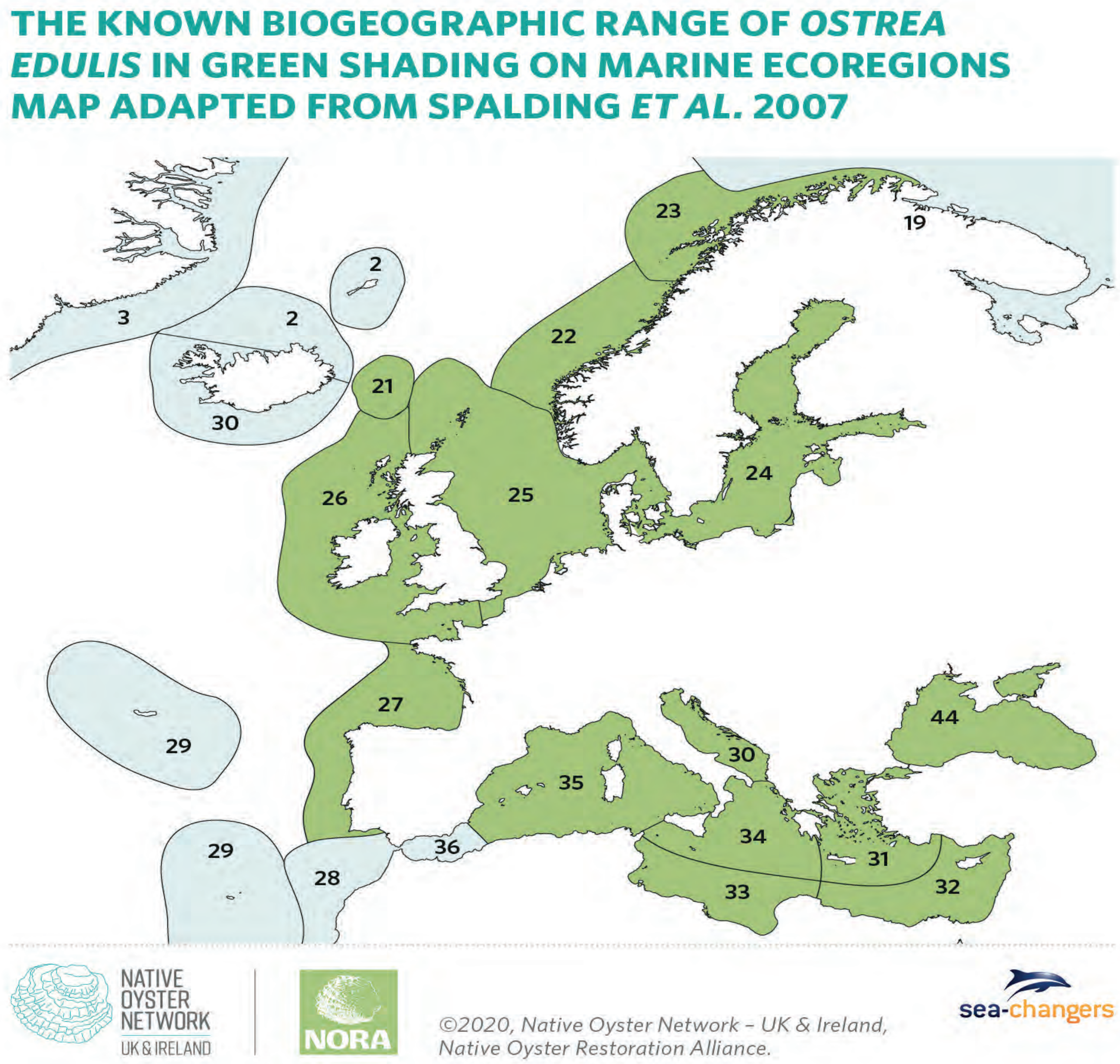


Figure 4. *The known biogeographic range of Ostrea edulis. (Preston et al., 2020)*

3. Native Oyster Habitat Restoration in Conwy Bay

3.1 Conwy Bay Restoration Hub

Wales once had a prolific fishery for native oysters. There are early records of the oyster trade in Wales, with a consignment of 20,000 oysters traded from Milford in 1592. In 1860, Welsh oyster boats in North Wales reported each landing on average 3,000-4,000 oysters daily, up to 8,000 oysters (Hayden-Hughes *et al.*, 2023). Conwy Bay is situated in north-west Wales where there were productive native oyster beds during the 18th and 19th centuries in the Menai Strait near Caernarfon and Bangor, around Anglesey in Rhoscolyn, Llanddwyn Island and Puffin Island. However, native oysters were being consumed locally long before then with remnants of native oyster shell discovered in Upper Kendrick's Cave on the Great Orme near Llandudno dating back to Neolithic and Bronze Age (10,000–4,500 BC). Vital shellfish research was carried out at the Ministry of Agriculture and Fisheries (MAFF) (now known as Centre for Environment, Fisheries and Aquaculture Science (CEFAS)) Fisheries Experimental Station in Conwy from 1919, when the station was created to support declining fisheries, until its closure in 1999. The living memory of the native oyster fishery within the local community has almost been lost after the decline of the native oyster fisheries due to overexploitation and disease in the early 1900's (Hayden-Hughes *et al.*, 2023). Conwy Bay is still an important area for shellfish fisheries and has a low impact, self-sustaining mussel fishery which uses traditional handheld rakes, passing on their knowledge and skills for generations.

The Wild Oysters Project established a native oyster restoration hub in Conwy Bay in 2020. This chapter of the report provides a summary of the process of site selection, licence application, survey work and habitat restoration work undertaken by The Wild Oysters Project (Figure 5).

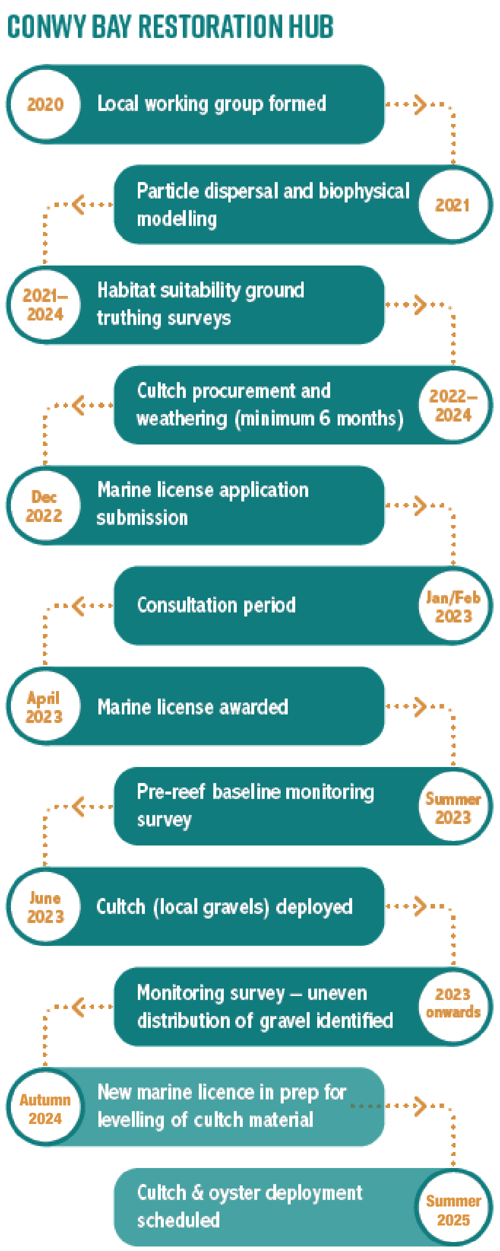


Figure 5. *The habitat restoration timeline in the Conwy Bay restoration hub (sourced from The Wild Oysters Project evaluation report, 2024). Note- At the time of writing, the final two timeline milestones are scheduled in the future, so may be subject to change in date.*

3.2 Broadscale Site Selection

In 2021, Natural Resources Wales (NRW) commissioned a study identifying spatial opportunities and the benefits of restoring marine and coastal habitats in Wales (Armstrong *et al.*, 2021). A dedicated data layer was produced in relation to native oyster beds, and provides a national, high level, indication of where native oyster reefs could potentially be restored in Wales. The map produced (Figure 6) shows where native oyster beds could potentially be established in Welsh subtidal areas. The data layer was derived from seabed sediment, depth and current speed data (Armstrong *et al.*, 2021). The NRW restoration potential map identified restoration potential within Conwy Bay, but further scoping work by The Wild Oysters Project was then required to identify the broadscale areas in which seabed restoration was feasible and specific areas which were to be submitted to NRW for a marine licence to carry out the restoration works.

> The map produced shows where native oyster beds could potentially be established in Welsh subtidal areas.

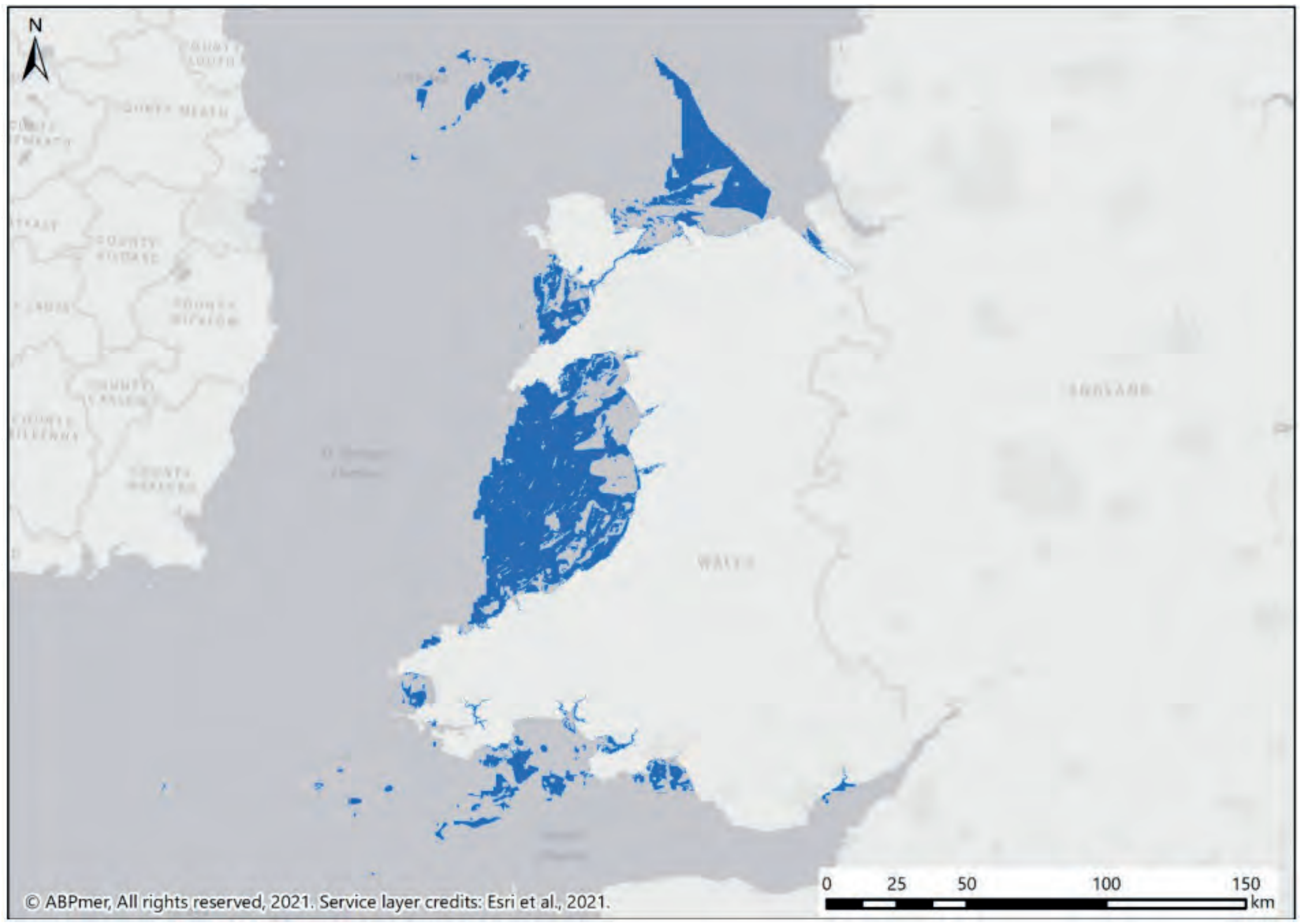


Figure 6. *Native oyster restoration potential map, produced by Natural Resources Wales (Armstrong et al., 2021).*

3.3 Selection of Licence Areas

To ensure the best chance of success for The Wild Oysters Project native oyster habitat restoration work, the areas that were to be included within the marine licence applications for restoration sites were carefully selected following a process of modelling potential larval dispersal from the marina sites and analysing existing substrate and habitat data for Conwy Bay. The broadscale site selection was made in discussion with the Conwy Local Working Group (LWG) and NRW. The initial broadscale site selection process also considered abiotic factors (section 3.3.4) within a site that would impact native oysters, and several logistical and social factors (section 3.3.5), such as existing designations, fisheries activities and industrial activities.

The broadscale licence areas selected then underwent ground-truthing with seabed surveys (section 3.3.7) to select areas to be submitted within marine licence applications (section 3.5). The data collected from habitat surveys was used to identify the most suitable restoration site for seabed restoration and creation of a native oyster reef. This decision was made in consultation with the Technical Working Group (TWG) and local regulators to come to a consensus on the most appropriate restoration site.

3.3.1 Biophysical Modelling

The Wild Oysters Project installed oyster nurseries into Conwy Marina and Deganwy Marina in the Conwy Bay restoration hub. These nursery sites hold up to 1,400 adult breeding oysters, capable of producing up to 180 million larvae each year (Uttley *et al*., 2023).

> Any future settlement on the newly restored areas of oyster reefs would have to come from the nursery sites or from mature oysters deployed directly onto the reef post construction.

The Conwy Bay restoration hub has no known wild native oyster populations in the immediate vicinity. Therefore, any future settlement on the newly restored areas of oyster reefs would have to come from the nursery sites or from mature oysters deployed directly onto the reef post construction. Understanding the hydrodynamics and larval distribution from the nursery sites was therefore an important part of the site selection process to ensuring successful settlement and recruitment of native oysters to seabed restoration sites. Larval dispersal models were commissioned and undertaken by The Shellfish Centre at Bangor University. The model predicted larval dispersal from the nursery marinas, both singularly and as combined dispersal on various states of the tide during the oyster summer spawning period. Figure 7 shows the predicted larval dispersal between 7-10 days from release overlayed with designated sites in the Conwy Bay restoration hub. This larval dispersal model plots the particle density as a percentage of total larvae released from Conwy Marina and Deganwy Marina. When considering the next stages of site selection, areas within the modelled larval plume were considered suitable.

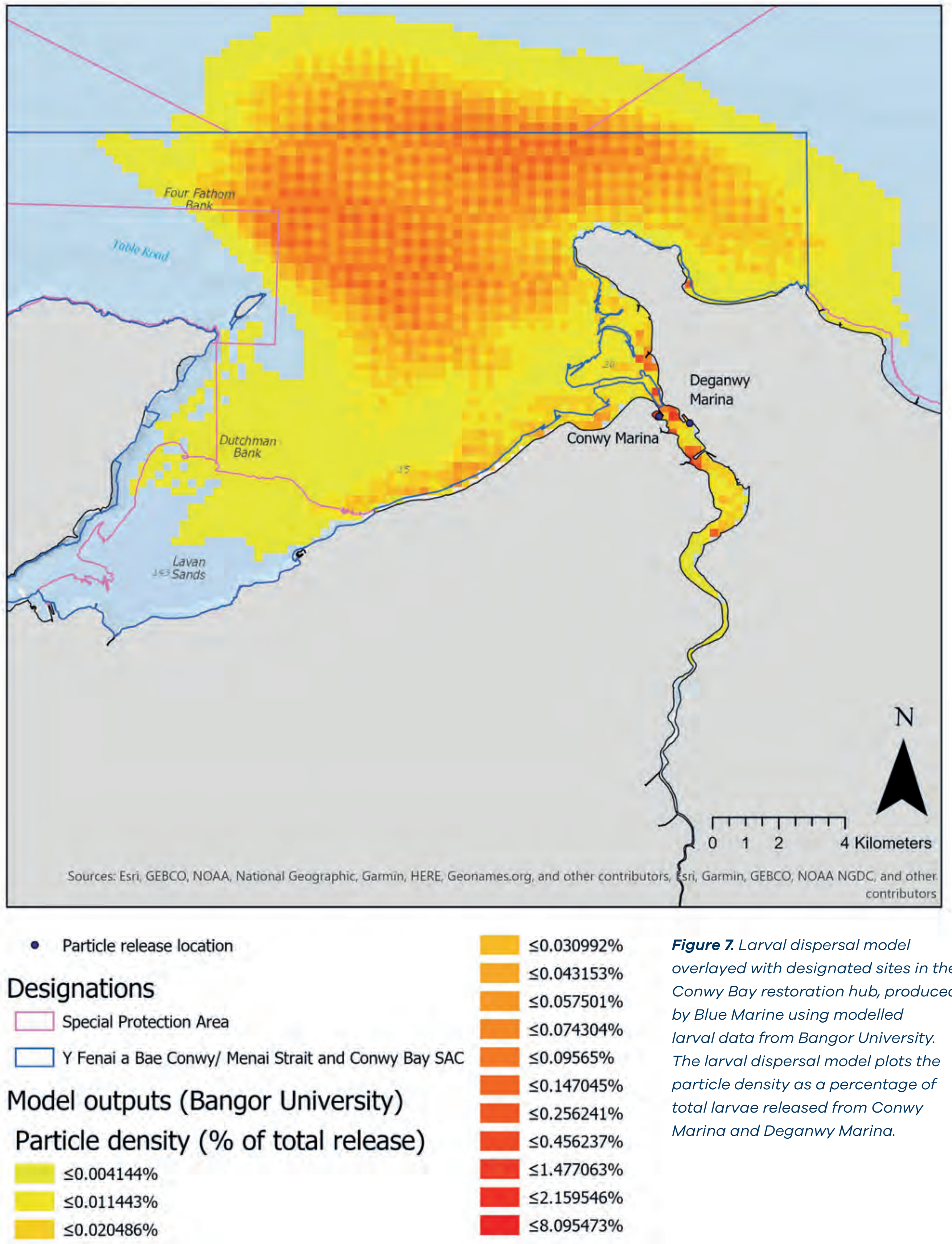


Figure 7. *Larval dispersal model overlayed with designated sites in the Conwy Bay restoration hub, produced by Blue Marine using modelled larval data from Bangor University. The larval dispersal model plots the particle density as a percentage of total larvae released from Conwy Marina and Deganwy Marina.*

Not for navigation. Created by the BLUE MARINE FOUNDATION 2021. All rights reserved. British National Grid. Data sources: Modelled larval data from Bangor University. Other shapefiles from Lle Wales Accessed: 09/11/2021

3.3.2 Interaction with Marine Protected Areas

When selecting a restoration site, it was essential to consider marine designations that may be impacted. Feature based designation (Solandt *et al.*, 2020) ensures that activities that take place within or near protected sites do not significantly impact the conservation status of protected features. Restoration of the seabed for native oysters is an active intervention that involves the addition of a significant quantity of stone and shell onto the seabed. This active intervention has the potential to impact certain important protected features and habitats, such as Annex I stony reef. Designations do not rule out restoration, but careful consideration must be taken of potential impacts.

In undertaking site selection for broad-scale scoping survey site, areas that contained designated features that may potentially be damaged or altered by restorative activities were ruled out. As a first indication of suitable sites, designated areas were overlaid onto the larval projection models to highlight areas that were within the larval plume but outside of designations (Figure 7). A full Habitats Regulations Assessment (HRA) was then undertaken for each site to assess potential impact on features if working in or near a designated area. The HRA screened for any Likely Significant Effect (LSE) of restoration work on any designated feature in all protected areas within a 50km buffer zone of the project. If LSE was determined, then the sites were taken forward to a second stage, Appropriate Assessment. Areas where it was deemed that there was no risk of damage or alteration by restoration activities passed through to the next phase of site selection.

At the Conwy Bay restoration hub, any restoration sites scoped were situated within the Y Fenai a Bae Conwy/Menai Strait and Conwy Bay Special Area of Conservation (SAC) (UK0030202). This SAC covers 265 km2 and encompasses marine areas, sea inlets, tidal rivers, estuaries, mud flats, sand flats, lagoons, salt marshes, salt pastures, salt steppes, shingle, sea cliffs, and islets. The SAC was designated primarily to protect Annex I habitats comprising sandbanks which are slightly covered by seawater all the time, mudflats and sandflats not covered by seawater at low tide, reefs, large shallow inlets and bays and submerged or partially submerged sea caves.

The HRA for the Conwy Bay restoration hub indicated that none of the Y Fenai a Bae Conwy/Menai Strait and Conwy Bay SAC protected features or other designated sites were likely to be subject to significant effects due to the reef deployment work on any of the nearby SACs.

The suggested restoration sites were also within 50 km of three further SACs with marine components:

- Dee Estuary / Aber Dyfrdwy SAC (UK0030131);
- Bae Cemlyn / Cemlyn Bay SAC (UK0030114);
- North Anglesey Marine / Gogledd Môn Forol SAC (UK0030398);
- Anglesey Coast: Saltmarsh / Glannau Mon: Cors heli SAC (UK0020025);
- Lleyn Peninsula and the Sarnau / Pen Llyn a r Sarnau SAC (UK0013117).

Other designations in proximity to the Conwy Bay restoration hub were:

- Liverpool Bay / Bae Lerpwl Special Protection Area (UK9020294);
- Traeth Lafan / Lavan Sands, Conway Bay Special Protection Area (UK9013031);
- Anglesey Terns / Morwenoliaid Ynys Môn Special Protection Area (UK9013061);
- Ynys Seiriol / Puffin Island Special Protection Area and Ramsar Site (UK9020285);
- The Dee Estuary Special Protection Area and Ramsar Site (UK9013011);
- Mersey Narrows and North Wirral Foreshore Special Protection Area and Ramsar Site (UK9020287).

3.3.3 Habitat and Substrate

The output maps of the larval dispersal models and designated areas were then overlaid with publicly available habitat and substrate maps (Figure 8) in order to select potential areas with suitable habitat for improvement (existing hard ground or mixed sediment) which were likely to receive a larval input. These publicly available substrate maps were used as a guide for potential areas of suitable substrate and subsequent, detailed substrate mapping surveys were undertaken to ground truth this data (section 3.3.7).

Areas that were within the predicted larval receival zone, passed the HRA screening process and possessed potential areas of suitable settlement substrate such as hard, rocky or mixed substrate ground (Preston *et al.*, 2020B), were then put forward for further consideration for broad-scale scoping seabed surveys. Areas that were predominantly mud or sand on the habitat and substrate maps were avoided. These areas would not be suitable to deploy oysters on as they could be smothered or buried. In addition, deploying cultch material onto sandy or muddy substrates would significantly change the habitat characteristics. It is preferable to deploy reef material onto mixed substrate or hard ground to avoid significant changes to habitat morphology. The local working group and technical working group were consulted on these potential survey areas.

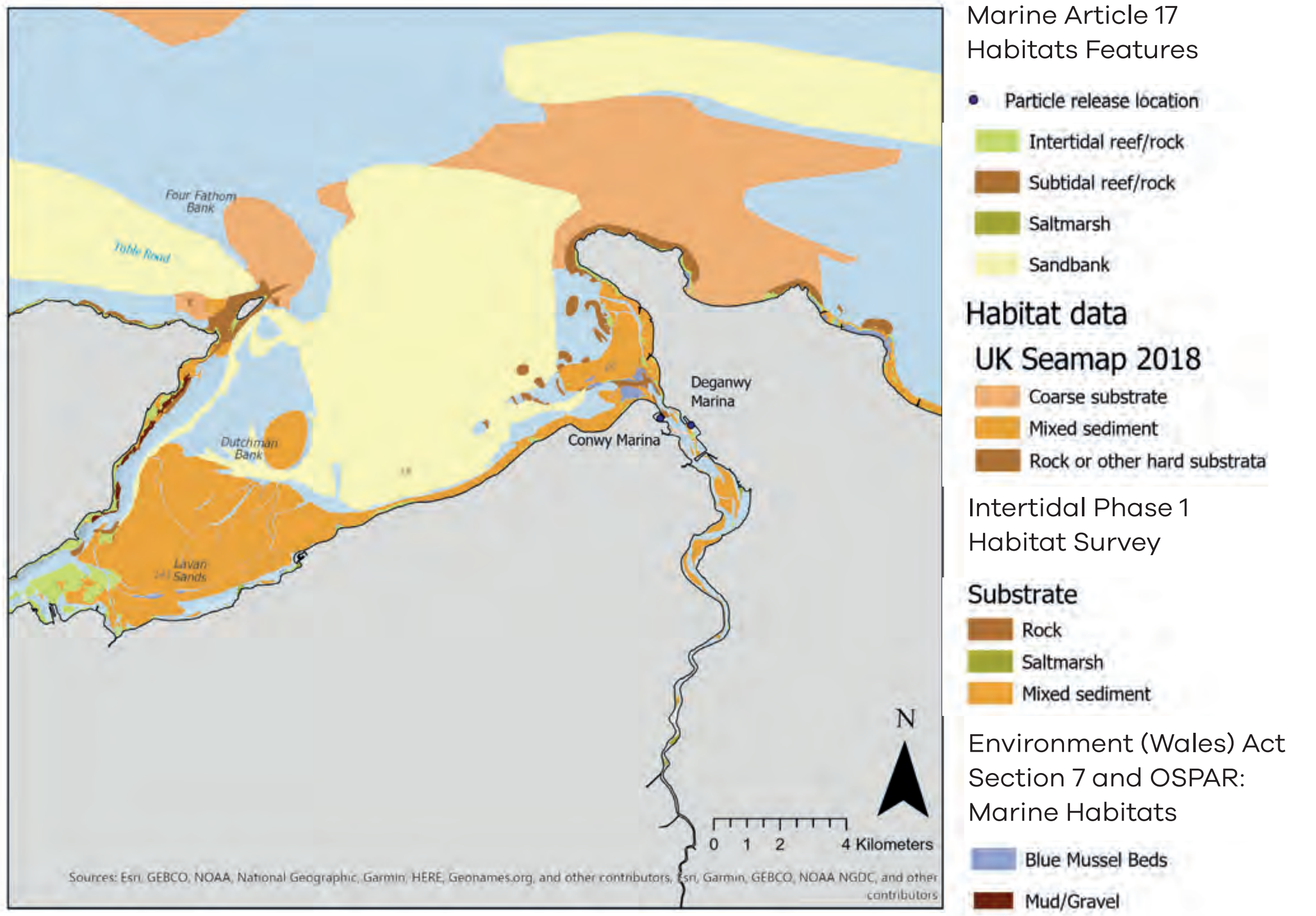


***Figure 8.** Publicly available data on habitat and substrate types in Conwy Bay. Produced by Blue Marine and shapefiles from Lle Wales (accessed 09/11/2021).*

3.3.4 Abiotic Factors

Abiotic factors considered were those that would limit or inhibit oyster survival or reproduction potential at the site. The high oyster survival and reproduction rates in the nearby native oyster nurseries (Uttley *et al.*, 2023) was a good indication that the restoration sites in close proximity were likely to be suitable. Publicly available data was examined for each key factor in comparison to the known tolerance of native oysters. The key abiotic factors and reasons for consideration are given in Table 1.

Table 1. *Abiotic factors that were considered in the broadscale site selection criteria and assessed if data was available.*

Abiotic factors	Consideration
Seawater temperature	Average annual temperatures remain within species known tolerance
Salinity	Salinity range is within the species known tolerance
% gravel of seabed	Higher percentage of gravels and shells may be more desirable
% mud of seabed	High percentage mud may be less desirable
Depth of water	Deeper water provides a more stable temperature but may make surveying work harder, known range is from intertidal to 80m.
Turbidity	High suspended sediment can impede growth and feeding

3.3.5 Logistic and Social Considerations

The logistic and social considerations of where to situate a restoration site are of huge importance. There are many logistics to consider in creating an oyster reef, for example, considerable volumes of cultch material are required. The deployment of cultch requires access for large transport vehicles and work boats. Local port access for these large vehicles and vessels is essential to deployment. It is possible to load cultch onto a vessel at a port further afield, but this would have considerable time and cost implications.

For the restoration effects to have long term success, local buy-in is essential and therefore the restoration site must not unreasonably impact on existing social or commercial activities. The site must also not be in an area that existing activities are likely to have a significant detrimental impact on the reef. For example, bottom towed fishing and aggregate dredging in the restoration site would severely damage the reef. Therefore, protection of the reef from extraction or damage, was a key consideration for selecting a seabed site for restoration. The project made no provision for oysters in seabed sites to be harvested in the future.

Extensive consultation took place with the local working group and relevant authorities for areas with lower fishing pressure and areas permanently closed to dredge fishing, in addition to local engagement with other water users and local fishing communities. In the absence of fishing closures, seabed features that created natural protection by preventing fishing activity was considered e.g., rocky ground or the presence of nearby wrecks.

The initial local working group in Conwy Bay included representatives of the following groups (in addition to Wild Oyster partner organisations):

- **North Wales Wildlife Trusts**
- **Conwy Mussels Company**
- **Conwy Harbour Office**
- **Porth y Felin School**
- **Conwy Council Education Services**
- **Deganwy Marina**
- **Conwy Marina**
- **Bangor University**
- **Natural Resources Wales**

Photo: Conwy Bay restoration site, © Maria Hayden-Hughes

Despite best efforts to include all local interested groups within the LWG, it later came to light that additional fishing groups were keen to feed into the development of the project, so were invited to the group. These included local charter fishers and the Chair of the Welsh Fishermen's Association - Cymdeithas Pysgotwyr Cymru (WFA-CPC).

Low impact fishing (e.g. potting or charter fishing) could continue in the reef site without detriment to the reef. Additionally, despite a short-term disturbance to fishing during and immediately after deployment, the reef would likely provide long term benefits for these low impact fishing types. The complex three-dimension structure of the reef could provide feeding and nursery grounds for many commercial species, which could result in an increase in diversity and abundance of commercial species over time.

Other social and commercial activities were also considered and discussed with the local working group to ensure no risk of conflict or project impact. The key logistical and social factors and reasons for consideration given in Table 2.

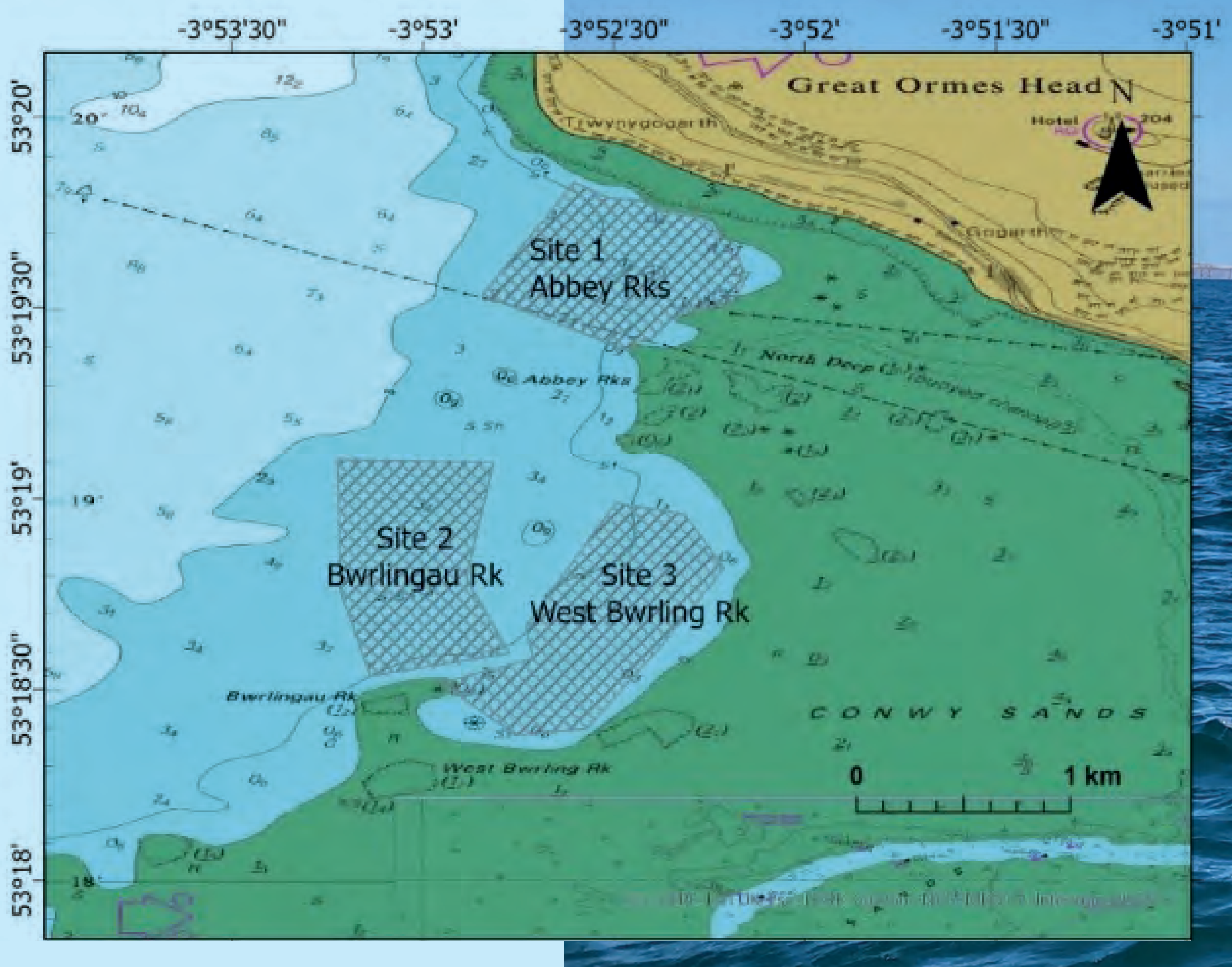
Table 2. *Logistical and social factors that were considered in the broadscale site selection criteria and assessed if data was available.*

Logistical and social factors	Consideration
Level of protection from damaging fishing	Higher levels of protection are more desirable, be they natural, legal or voluntary.
Access for work boats	Barges and surveying boats will need access to restore seabed.
Poaching risk	Hard to quantify but lower risk more desirable if known.
Local dredge activity	Regular dredge activity nearby e.g., capital or maintenance dredging may increase sedimentation and is not desirable.
Local anchoring	Free anchoring on restoration sites may cause abrasion to the seabed.

3.3.6 Broadscale Site Selection

Following the site selection process highlighted in sections 3.2 and 3.3 and communication with the LWG, three potential sites were put forward to the LWG for consideration to take forward for broadscale seabed survey areas to inform the marine license application process (Figure 9). All three sites were in close proximity to the two marina sites and situated just outside the mouth of the estuary in Conwy Bay (Figure 9). These sites were suitable based on modelled substrate type, larval input, existing designations and considering all other factors set out in Tables 1 and 2. Through the LWG meetings, and discussions with NRW who flagged potential areas that could act as an oyster larval sink because of hydrodynamics and geomorphology of the bay, the three areas were further refined and finalised (Figure 10).

Figure 9. *The three broadscale seabed survey areas in Conwy Bay. Data collected was used to inform the selection of license areas suitable for native oyster restoration that were taken forward to the marine license application process. © British Crown and OceanWise, 2021. All rights reserved. Licence No. EK001-20180802. Not to be used for Navigation.*



To identify areas of suitable substrate and potential restoration sites, a three-stage process was implemented:

1. Survey areas were identified using available habitat and substrate datasets to ensure that surveys focused on suitable substrate types (sections 3.3.3 and 3.3.7).
2. Bathymetric and multibeam or side scan surveys were carried out to identify and ground-truth the publicly available datasets.
3. Grab and video surveys were undertaken to definitively ground truth bathymetric data and identify specific habitat mosaic of survey areas to EUNIS level 3. Sites that were of suitable substrate types were then considered for the next phase of site selection.

Photo: Bangor University's small inshore survey vessel, *Macoma.* *© Maria Hayden-Hughes.*

3.3.7 Broadscale Seabed Survey

At the Conwy Bay restoration hub, acoustic seabed data was collected by Bangor University including Multibeam Echosounder (MBES) (Figure 11) and backscatter (Figure 12), along with drop down video (DDV) imagery and grab samples collected at 29 stations across the three scoping areas. Ocean Ecology were commissioned to process this data; record all Annex I habitats present across the three sites; identify sediment types present across the three sites; and map Broad-Scale Habitats (BSH) (EUNIS Level 3) present across the three sites (full methodology can be found in the Ocean Ecology Habitat Assessment Report).

Particle Size Distribution (PDS) analysis was undertaken by Ocean Ecology and the sediment classified based on the Wentworth Classification System (Wentworth, 1922). All seabed video imagery analysis was undertaken using the Bio-Image Indexing and Graphical Labelling Environment (BIIGLE) annotation platform to provide Broad-Scale Habitat type and EUNIS habitat classification as well as highlighting the presence of any Annex 1 Reef habitat (designated as low, medium or high resemblance stony reef based on standard characteristics of stony reef (composition, elevation, extent and biota (Irving, 2009)).

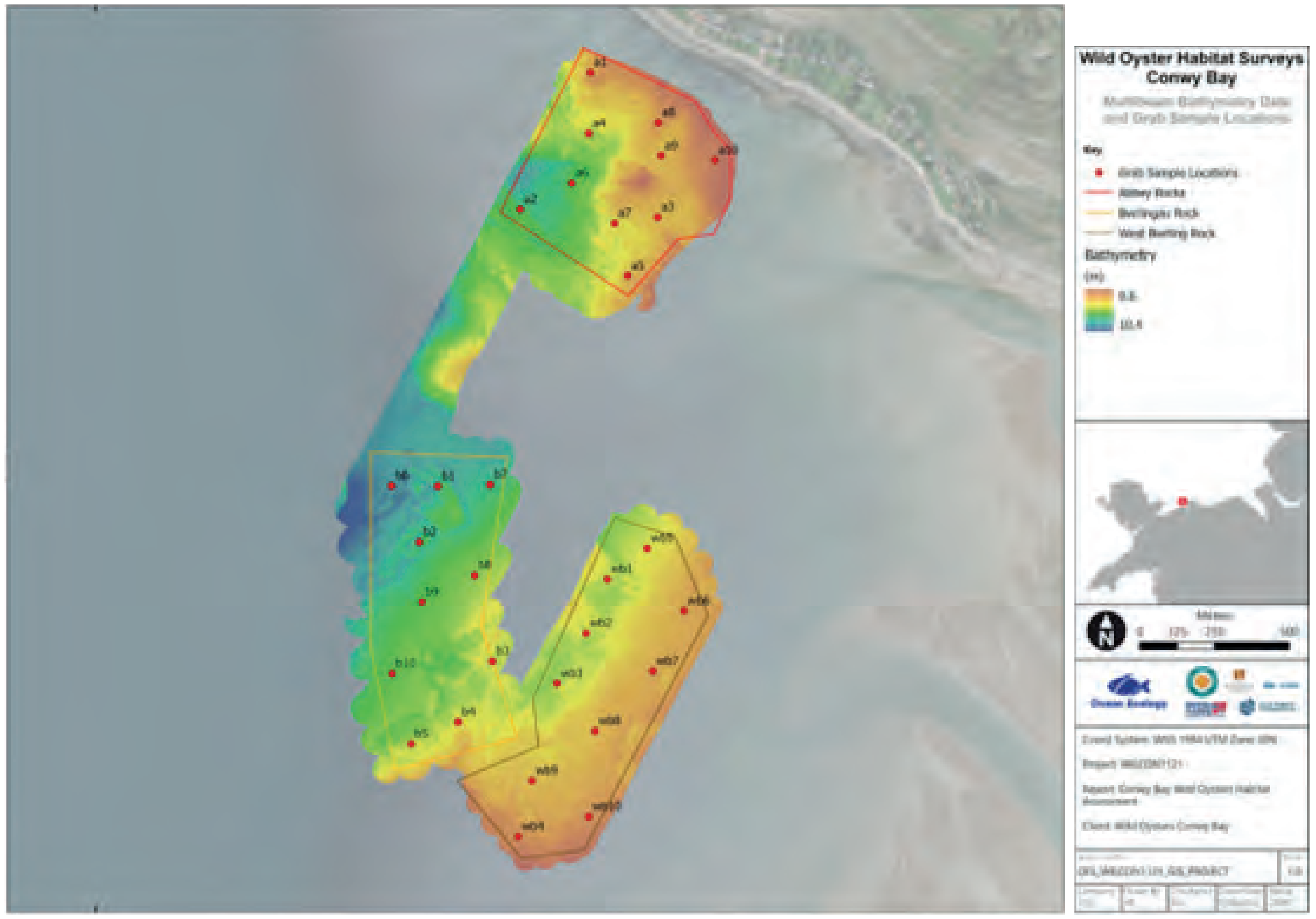


Figure 10. *Overview of the Conwy Bay survey areas displaying the MBES and DDV/grab sampling locations. The bathymetry data in this figure shows the depth across the three sites, with hotter red colours depicting shallower areas and cooler blue colours the deeper areas.*

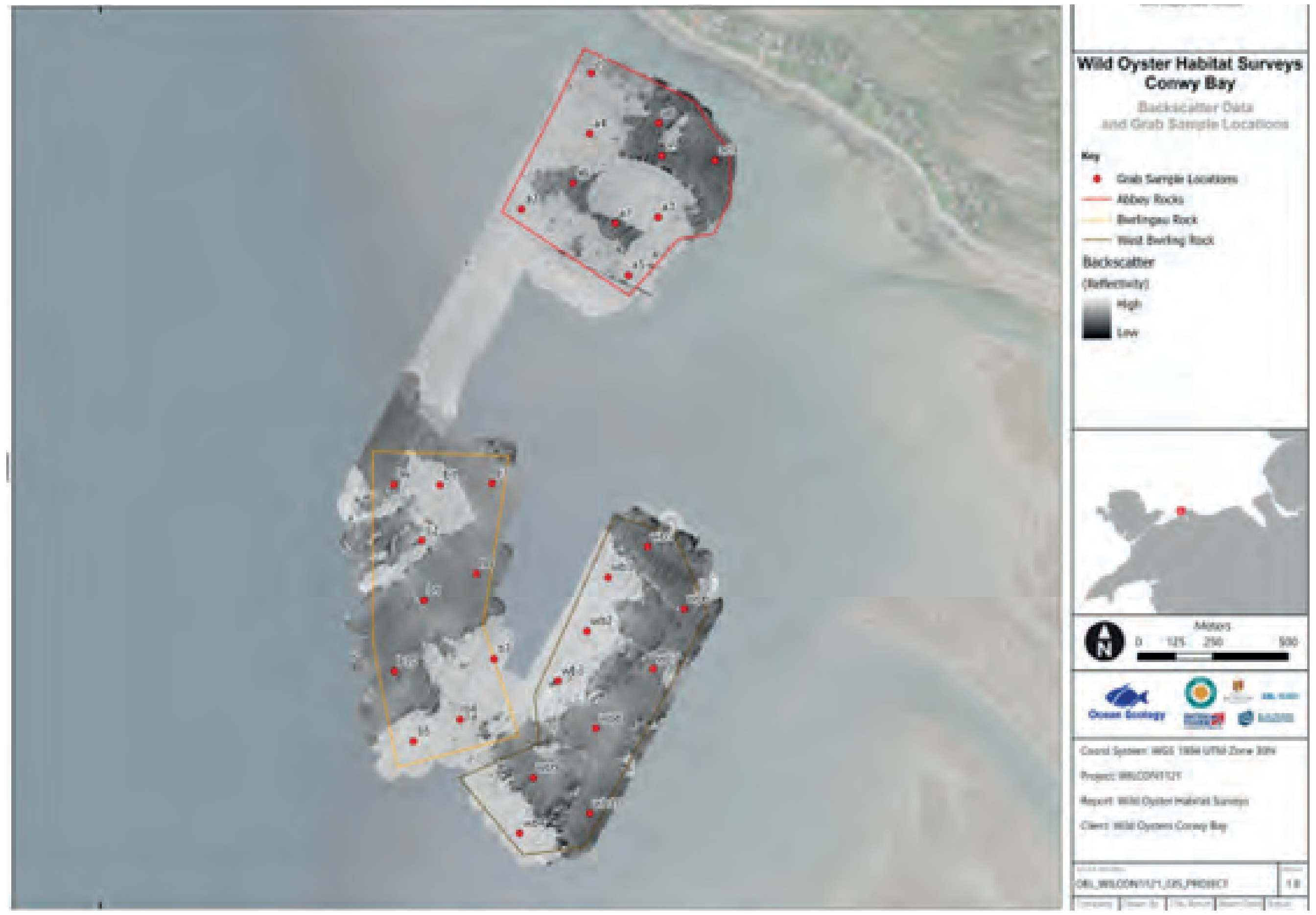


Figure 11. *Overview of the Conwy Bay survey areas displaying the Backscatter and DDV/grab sampling locations. The backscatter data in this figure shows the substrate hardness across the three sites, with darker areas depicting softer ground and lighter areas the harder ground type.*

Seabed data was collected to record habitat types across the survey areas

The habitat assessment report presented the following BSH EUNIS habitats: Moderate energy infralittoral rock A3.2, Moderate energy circalittoral rock A4.2, Subtidal Sand A5.2, Subtidal Mud A5.3, Subtidal Mixed Sediments A5.4 and Subtidal Macrophyte Dominated Sediment A5.5 (Figure 13). Subtidal sand (A5.2) was the most frequently occurring BSH, followed by subtidal mixed sediment. The majority of the hard substrate (rock) segments contained a high percentage cover of elevated boulders and cobbles and contained taxa characteristic of both mixed sediment and rock-based biotopes. These areas were better described as mixed substrata and as such were considered as mosaic habitat (a combination of A5.4/A3.2, A5.4/A4.2). In addition, potential Annex I stony reef was identified at 13 of the sampling stations, with 10 stations meeting criteria for low resemblance stony reef and three stations meeting criteria for medium resemblance stony reef.

Using this information, Figure 12 was created to show the habitat types overlayed with areas of potential stony reef. The PSD data was then combined with the EUNIS habitat data to sediment percentage contribution from grab samples across the survey area (Figure 13).

***Figure 12.** EUNIS Level 3 habitat map based on geophysical and imagery data and locations based on imagery analysis.*

Photo: Spat collector being deployed in the Conwy Bay Restoration Hub. © Maria Hayden-Hughes'

***Figure 13.** EUNIS Level 3 broadscale habitats based on geophysical and imagery data and sediment percentage contribution from grab samples across the survey area.*

Restoration efforts and reef creation are ideally focused in areas of subtidal mixed sediments. Native oysters are a recognised biotope of subtidal mixed sediments (EUNIS code A5.435) and it is deemed as a preferential habitat type for oysters. However, other hard substrates were considered in the absence of subtidal mixed sediment or if other overriding factors made the subtidal mixed sediment present unsuitable for deployment. In addition, areas of potential Annex I stony reef were highlighted in the seabed surveys. Following consultation with NRW it was agreed that any areas of potential medium resemblance stony reef should be avoided but that the locations of potential low resemblance stony reef were permitted for reef deployment. The information gathered was used to inform the selection of the licence areas in the Conwy Bay restoration hub.

Native oysters are a recognised biotope of subtidal mixed sediments, and it is deemed as a preferential habitat type for oysters.

3.4 Selection of the License Areas and Reef Location

Section 3.3 describes selection of the site selection scoping survey areas. The information gathered was used to inform the selection of the licence areas in the Conwy Bay restoration hub.

Using the depth, habitat, sediment percentage and Annex I presence data, a site selection matrix was then created (Appendix 3). Each of the sample stations was listed and given a grading for each of the key factors. On the advice of NRW, any stations that consisted of medium resemblance stony reef were disregarded. The highest-ranking stations were calculated, these areas highlighted and presented to the TWG. Three most suitable locations were suggested (Figure 14) and included in the marine license application.

Once the licence application had been made (section 3.5), the focus was on selection of specific reef and control sites within the larger licenced area and identify specific sites where active deployment of cultch materials and the creation of a reef could occur.

The most appropriate reef sites were selected through a process of elimination, considering logistical, biological and environmental constraints. Precise reef and control sites were prioritised through a score-based site selection matrix to determine the most optimal seabed site. Following consultation with the TWG, the area was selected as the most suitable location for deployment. Despite this area containing a high proportion of hard ground types, it was decided by the TWG that the use of cultch was still appropriate to raise the profile of the reef and provide a suitable bed for the deployment of broodstock adult oysters, and to add shell material to increase the settlement substrate available for oyster larvae.

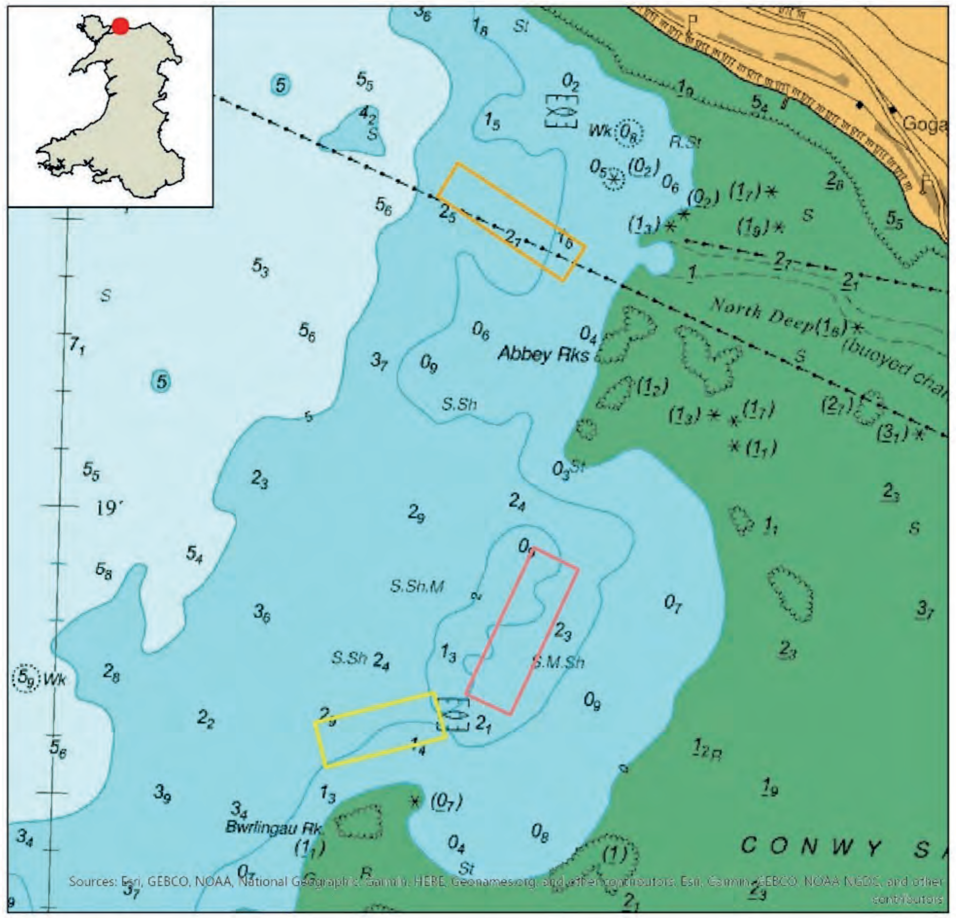


__Figure 14.__ The three final sites agreed after local consultation that were submitted within the marine licence application at the Conwy Bay restoration hub.

3.5 Marine Licensing and Permissions

To complete the deployment of cultch material, and to conduct pre- and post-reef monitoring, a marine licence was required at both restoration hubs. Under Section 58 of the Marine and Coastal Access Act 2009, a marine licence is required for carrying out a licensable marine activity, summarised as:

- Deposit any substance or object, in the sea or on or under the seabed;
- Construct, alter or improve any works either in or over the sea or on or under the seabed;
- Use a vehicle, vessel, aircraft, marine structure or floating container to remove any substance or object from the seabed; and
- Carry out any form of dredging, whether or not involving the removal of any material from the sea or seabed.

The marine licensing authority at the Conwy Bay restoration hub is Natural Resources Wales Marine Licensing. A seabed lease was also required from The Crown Estate in order to undertake the cultch and oyster deployment activities. The Wild Oysters Project contracted MarineSpace Ltd., a marine planning and environmental services consultancy, to identify all necessary licensing, consultation consenting requirements, and drafting of marine licence applications and associated required documents including environmental assessments, see Table 3. The Wild Oysters Project team provided MarineSpace Ltd with survey data, and selected license areas, and reviewed and provided feedback on the drafted documentation.

__Table 3,__ below, sets out the required documentation, timelines and costs associated with the licence application process in the Conwy Bay Restoration hub.

Site	Documents Required	Date Submitted	Consultation	Regulator Costs	Consultancy Costs	Date Granted
Conwy Bay (Original licence only)	The Crown Estate Licence to Install and Use Works Particulars; NRW Marine Licence Application form; Habitats Regulations Assessment; Environmental Impact Summary; Water Framework Directive Assessment; and Site Information Document.	13th December 2022	Notice published in a local paper Cost: £1,012	£1,920 (NRW) £50 per annum (The Crown Es-tate)	£11,979.17 (plus, combined project manage-ment costs of £3,118.77)	6th April 2023 (3 months, 3 weeks)

Figure 15. A spat collector ready for deployment in the Conwy Bay Restoration Hub. © Maria Hayden-Hughes

3.6 Monitoring and Surveys

Throughout the duration of the project, site selection surveys and reef monitoring surveys were undertaken, a full breakdown of surveys undertaken at the Conwy Bay restoration hub is given in Table 4.

Broadscale site selection surveys (sections 3.2 and 3.3) were integral to ensuring that the reef was deployed in a suitable location. However, the surveys also provided valuable baseline data on substrate and habitat type. This information will be monitored post-reef deployment to track changes over time.

After the final reef and control sites were selected and agreed upon, pre-reef deployment surveys were completed to gather a baseline data to monitor associated biodiversity changes. As with the substrate and habitat baselines, changes in associated biodiversity will be monitored over time to track the impact of the restoration work. The project aims to continue to complete annual reef monitoring surveys detailed in Table 4, to assess the long-term impact of the restoration activities, subject to continuing to successfully gain project funding.

An additional monitoring tool that was utilised was spat collectors. This system is commonly used in French aquaculture and has been used successfully to monitor settlement in restoration areas in Essex by the ENORI project. Spat collectors are plastic discs that are coated in lime and set upon a metal frame (Figure 15). The spat collector is deployed into the reef and control area to monitor the number of oyster spat that settle on the discs. The spat collectors were not used as a site selection tool but rather as an indication of how many spat could be reaching the restoration site. Spat collectors are easy to remove from the water and monitor without the need to grab and disturb the seabed or newly created reef. Spat collectors were deployed at the reef and control site in 2022 and 2023. Native oyster spat settlement was not observed in 2022 and no data was retrieved for the 2023 because the equipment was damaged by severe weather. Methodologies are being reviewed for future spat settlement assessment at the reef and control sites.

Table 4. *Summary of all monitoring and survey work undertaken at the Conwy Bay restoration hub.*

Site	Survey Type	Collection Method	Purpose	Replicate	Date completed
3 wider scoping areas	Site Selection / Baseline	Multibeam Echosounder (MBES)	Substrate type and rugosity	na	March 2022
3 wider scoping areas	Site Selection /Base-line	Grabs	Ground-truthing substrate and habi-tat types	30	April 2022
3 wider scoping areas	Site Selection /Base-line	Drop Down Video	Ground-truthing substrate and habi-tat types	29	June 2022
2 frames within licence proximity	Spat collection	Two spat collector frames	Monitor for any spat settlement	2	June 2022
Reef Site and Control	Pre-reef Deployment	Drop down video	Shell cover Oysterdensity Biodiversity:Invasive Non-Native Species, epifaunalsessile invertebratesand macrophytes	7 transects per site	May 2023
Reef Site and Control	Pre-reef Deployment	Grabs	Biodiversity: Infaunal inverts, epifaunal sessile invertebrates and macrophytes	10 per site	May 2023
Reef Site and Control	Pre-reef Deployment	Baited re-mote under-water video (BRUV)	Biodiversity: Small resident fish and mobile invertebrates, transient fish and crustaceans	3 per site (60-minute recording)	June 2023
2 frames within licence proximity	Spat collection	Two spat collector frames	Monitor for any spat settlement	2	August 2023 (delayed because of rearranging reef activities)
Reef Site	Post-reef deployment	Multibeam Echosounder (MBES)	Project footprint and height	na	July 2023
Reef Site	Post-reef deployment	Multibeam Echosounder (MBES)	Project footprint and height (assess nat-ural redistribution of limestone aggre-gate)	na	November 2023; May 2024
Reef Site and Control	Annual monitoring	Multibeam Echosounder (MBES)	Project footprint and height	na	August 2024
Reef Site and Control	Annual monitoring	Drop Down imagery	Shell cover Oyster density Biodiversity: Invasive Non-Native Species, epifaunal sessile invertebrates and macrophytes	5 transects per site	August 2024
Reef Site and Control	Annual monitoring	BRUVs	Biodiversity: Small resident fish and mobile invertebrates, transient fish and crustaceans	3 per site (60-minute recording)	October 2024
Reef Site and Control	Post-reef deployment	Multibeam Echosounder (MBES)	Project footprint and height	na	Not yet completed
Reef Site and Control	Post-reef Deployment	Grabs	Biodiversity: Infaunal inverts, epifaunal sessile invertebrates and macrophytes	10 per site	Not yet completed
Reef Site and Control	Post-reef Deployment	Drop Down Video	Shell cover Oyster density Biodiversity: Invasive Non-Native Species, epifaunal sessile invertebrates and macrophytes	7 transects per site	Not yet completed
Reef Site and Control	Post-reef Deployment	BRUVs	Biodiversity: Small resident fish and mobile invertebrates, transient fish and crustaceans	3 per site (60-minute recording)	Not yet completed

3.7 Reef Deployment

The deployment of cultch material and oysters, to form a native oyster reef, is logistically complicated. The transportation of several hundred tonnes of gravel and weathered scallop shell to a port, onto a barge, followed by deployment at sea is a large operation. At each restoration site, the deployment methods differed based on the available local vessels and infrastructure.

It is common practice for oyster restoration projects to deploy both gravel and shell cultch when creating a new oyster reef, with gravel deployed first creating a lifted, uniform bed for the shells and adult oysters to be deployed on. For both Wild Oyster Project restoration hubs, a local source of limestone gravel and weathered shells were utilised following the criteria set out in Sections 1.2.1 and 1.2.2.

The size of the planned reef at the Conwy Bay restoration hub was agreed through the TWG to be 75m by 100m in Conwy Bay. This size is comfortably within the much larger licenced areas and is small enough to be very low impact on surrounding habitats, yet large enough to provide a substantial area for oyster settlement and to deploy up to 10,000 mature native oysters on. The volumes of gravel required for the reef was calculated based on the available volume of weathered shell cultch and an appropriate ratio of gravel to cover the reef to an average height of 10cm (Table 5).

The cultch types used in deployment were carefully considered. In Conwy Bay, the local geological features were assessed as part of the designation of the Menai Strait and Conwy Bay Special Area of Conservation. These studies suggest that the geology within the site is complex and varied. Limestone is a common rock type in Conwy Bay with exposures of softer carboniferous limestone around the Great Orme and surrounding areas. Limestone reef and the associated assemblages of marine plants and animals are noted as of conservation importance within the SAC designation. Many rocky areas within the site are composed of boulders, cobbles and pebbles rather than bedrock, making the deployment of gravel in keeping with the natural composition of the seabed. In addition, the use of limestone is in keeping with other marine works locally as limestone rock from inland quarry sources has been used in North Wales for beach nourishment and flood and coastal erosion risk management, at the following locations Pwlldu Bay, Gower, Llanfairfechan, Morfa Conwy (Pye and Blott, 2018).

Both native oyster shells and limestone contain calcium carbonate, the use of calcium carbonate lime for oyster settlement is well documented and common practice in European oyster aquaculture (Colsoul *et al.*, 2020). Therefore, limestone aggregate was deemed the best natural fit for the base layer of the reef, as it was in keeping with the natural conditions and is suitable for oyster settlement. At the Conwy Bay restoration hub 630 tonnes of limestone ranging from 32-100mm was deployed during reef construction.

> It is common practice for oyster restoration projects to deploy both gravel and shell cultch when creating a new oyster reef

Table 5. *Summary table of the Conwy Bay restoration hub reef deployment*

Location	Conwy Bay restoration hub	Reef located in Conwy Bay NE of the mouth of the River Conwy, approximately 2000m from shore.
Reef Size	75m X 100m (7500m²)	631 tonnes limestone gravel **deployed** 147 tonnes of shell cultch (97 tonnes scallop; 50 tonnes cooked cockle) still **to be deployed**
Oysters Deployed	10,000	Oysters **to be deployed** following completion of the reef deployment.

3.7.1 Reef Deployment Method

At the Conwy Bay restoration hub, a variety of different methods were explored for deployment of cultch. The ideal method would be to load cultch directly onto the deployment barge at a quay and then to deploy the cultch within the elected site with an excavator on board the barge. However, this requires a suitable vessel and a suitably large loading quay. Unfortunately, it was not possible to locate such a vessel that was within a reasonable distance of the project site or that was within the project budget. Therefore, an alternative method of cultch deployment was developed. The gravel cultch was delivered to a hardstanding in Beacons Car Park (north of Conwy Marina). The cultch was then loaded into handled tonne bags with discharge spout by the Conwy Harbour Authority using tractors and a hopper. The bags of gravel were then loaded directly onto a multipurpose landing craft via the slipway at Beacons Jetty.

Main Photo: Loading of gravel cultch for the Conwy Bay reef. © Lucie Machin. **Above:** Limestone gravel cultch used to create the Conwy Bay reef. © Lucie Machin

The Conwy Harbour Authority placed temporary marker buoys in the four corners of the reef deployment area to act as a visual guide during the deployment process. In addition to the marker buoys, the deployment barge plotted the precise coordinates of the reef area onto their onboard navigational system to ensure that all materials were deployed within the allocated area. There was also a wide margin of error for this deployment area with regards to the marine licence, as the actual reef location was well within the boundaries of the wider licenced box.

When the vessel was in position within the designated reef area, two of the bags were connected to a crane and lifted over the side of the vessel. The discharge spout on the bottom of each bag was then untied and the gravel steadily unloaded as the vessel moved forward (Figure 16). Unfortunately, there were some challenges experienced when carrying out this deployment method. Firstly, some pieces of gravel were too large to easily pass through the discharge chute in high volumes and caused blockages. Although the grade size of limestone was adjusted to ease deployment, conversely, because there was limited control over the gravel deployment speed once the bags were untied, the bags sometimes emptied quickly, and this could be a cause of the uneven distribution of gravel. A further multibeam survey was conducted in August 2024 as part of annual monitoring of the reef and control sites. Drop-down imagery and baited remote underwater video (BRUV) was also collected (Table 4).

The pre-planned multibeam survey was carried out by Bangor University and confirmed the presence of peaks and provided accurate heights and locations. Since the original HRA submitted as part of the marine license application did not assess a cultch height greater than 0.5m in the marine licence application, all further deployments of shell and oysters were put on hold until relevant assessments were made, or the reef height reduced. The relevant regulators were informed and a Local Notice to Mariners issued. The local Harbour Authority confirmed that there was no risk to navigation and methods of flattening the peaks were investigated.

Photo: Conwy Castle, © Maria Hayden-Hughes

Figure 16. *Deployment of gravel cultch using the bag with discharge spout method during the Conwy Bay reef construction. © Lucie Machin*

The action of flattening the peaks would use bottom contacting equipment and would be considered dredging of a substance on the seabed using a vessel, which constitutes a marine licensable activity. Dredging was not included on the original licence, therefore, a new marine licence is required. At the time of writing this report, The Wild Oysters Project is working with MarineSpace to complete all necessary impact assessments and consulting, to submit a new marine licence application to permit the peaks to be levelled. The proposed levelling plan is for a small tug based out of Holyhead (Saint David), to be chartered. This vessel will tow a plough over the seabed targeting the peaked areas identified from the bathymetric survey, aiming to achieve a uniform reef with a maximum height of 0.5 m, as stipulated within the original marine licence application. The methods planned would not result in the removal of any materials and should cause minimum disturbance to the wider seabed, only focusing the activity on the high peaks of deployed cultch. The vessel has the capability to monitor the changes in height in real-time to ensure that the works are completed to the required standards and in as timely manner as possible.

Additional multibeam surveys were also conducted in November 2023 and May 2024, as part of post-deployment monitoring. The limestone gravel remained within the project footprint and wider licence area, and a natural redistribution of the limestone gravel was indicated, as maximum peak height had reduced. In some areas the reef height still exceeds 0.5 m.

A further multibeam survey is planned in August 2024 (weather permitting) as part of post-deployment monitoring. Seabed maps will be updated with these data, prior to the proposed re-levelling works. When the levelling works are complete, the shell cultch and oysters will be deployed to conclude construction of the native oyster reef.

4. NATIVE OYSTER HABITAT RESTORATION IN THE TYNE AND WEAR

4.1 Tyne and Wear Restoration Hub

Tyne and Wear is a county in North East England surrounding the mouth of the River Tyne and the River Wear. It is difficult to know the true presence of wild native oysters unless there is an active fishery in the wider region. However, some information on local presence was available, as was information on the historic importance of native oysters in the Tyne and Wear region. The Piscatorial Atlas by Olsen (1883) (Figure 3) is used by many restoration practitioners as a baseline for the historical distribution of native oysters around the coast of the UK and North Sea. This indicates that native oysters were found in the North East of England in the late 1800s. Historical records from Royal Conchological Society surveys in the early 1900's show that native oysters were present south of Middlesbrough (NBN Atlas, 2020), but there are limited other records for seas around the Tyne and Wear. In the North East area, no evidence was found of an active fishery or of recent incidental landings of native oysters. Pacific oyster culture occurs in the intertidal areas of Holy Island (Lindisfarne) adjacent a mussel bed, which historically bore native oysters – the 'Oyster Scap'. Two recent records of live native oysters, both in 2009, were confirmed in the waters around the Farne Islands (NBN Atlas 2009A & 2009B). These records were collected by Seasearch divers. These two records of individuals were in separate locations and no records of native oyster biogenic habitat were found. It should be noted that the two records of native oysters at the Farne Islands were in close proximity to the historically cultivated oyster beds at Holy Island.

There is some evidence that oysters were an important part of the local culture. For example, a street in Newcastle upon Tyne is called Oystershell Road, named after a house nearby called Oystershell Hall, which was demolished in the 1850's. Oystershell Hall was described by a local resident as: "the whole of the building, except the roof, but including the chimneys, was covered with oyster shells, the concave side, or inside outwards. When the sun shone on them, the effect was brilliant." (Stokoe, 1890). Recently when panelling was lifted off the front of a barber shop in South Shields, it revealed a historic sign underneath for the West End Fish Mart, which primarily sold oysters (Metal & Dust, 2020). Finally, there is a building and control record from 1865 for an Oyster Saloon on Bedford Street in Tynemouth, owned by a Mr Sutherland, suggesting oysters were popular in the area at this time (Tyne & Wear Archives, 2020). There is a clear historic association with native oysters, with a limited known presence of native oyster habitat in the region.

The Wild Oysters Project established a native oyster restoration hub in the Tyne and Wear region in 2020. This chapter provides a summary of the process of site selection, licence application, survey work and habitat restoration work undertaken by The Wild Oysters Project (Figure 17).

> The Wild Oysters Project established a native oyster restoration hub in the Tyne and Wear region in 2020.

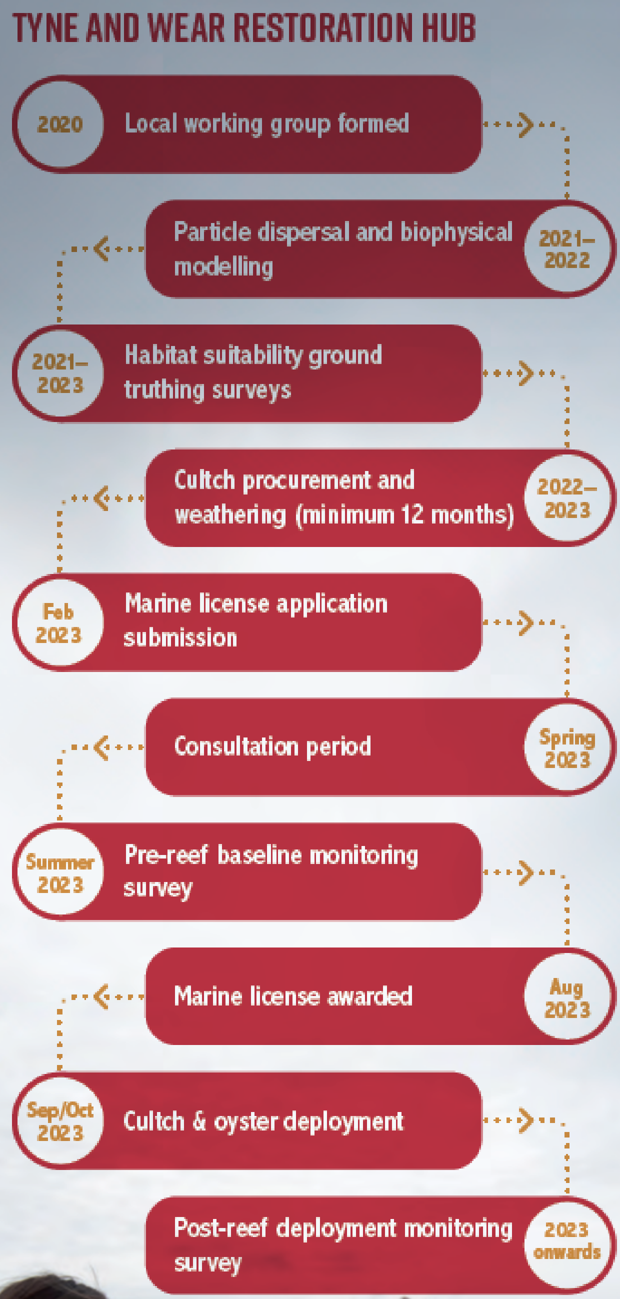


Figure 17. Habitat restoration timeline in the Tyne and Wear restoration hub (sourced from The Wild Oysters Project evaluation report, 2024).

Photo: Creation of the Tyne and Wear restoration hub native oyster reef © Lucie Machin

4.2 Broadscale Site Selection

The Environment Agency desktop study of suitable native oyster restoration sites from 2020 was consulted (Environment Agency, 2020) (Figure 18). This study modelled potential subtidal oyster restoration areas based on current speed, substrate type and depth. The model suggested that there were suitable areas for native oyster restoration north of Newcastle, near Newbiggin by the Sea, Blyth and Old Hartley, and further south with a large area near Whitburn, between Newcastle and Sunderland.

This suitability modelling formed the basis of investigation into site selection within the Tyne and Wear area, but other factors were also considered that were not included in the Environment Agency modelling. A comprehensive literature review was completed for the Tyne and Wear site which addressed; subtidal habitats, marine protected areas, invasive species, hydrology, water quality, Water Framework Directive Status, current and historic oyster distribution, local fishing activity, shipwrecks and local marine policy. Locations of local marinas that were suitable for the installation of native oyster nurseries, part of the restoration process as a larval dispersal mechanism were also considered.

The Tyne and Wear region was also an area of interest to explore native oyster restoration, as there are several other marine habitat restoration projects along coastline of North East England, and East coast of Scotland. The projects based locally to The Wild Oysters Project Tyne and Wear site, and present in the North Sea, are summarised in the Table 6 below. There is therefore potential connectivity between these restoration projects with the creation of habitat and larval dispersal aiding long-term natural regeneration across the region.

> The Tyne and Wear region was also an area of interest to explore native oyster restoration, as there are several other marine habitat restoration projects along coastline of North East England, and East coast of Scotland.

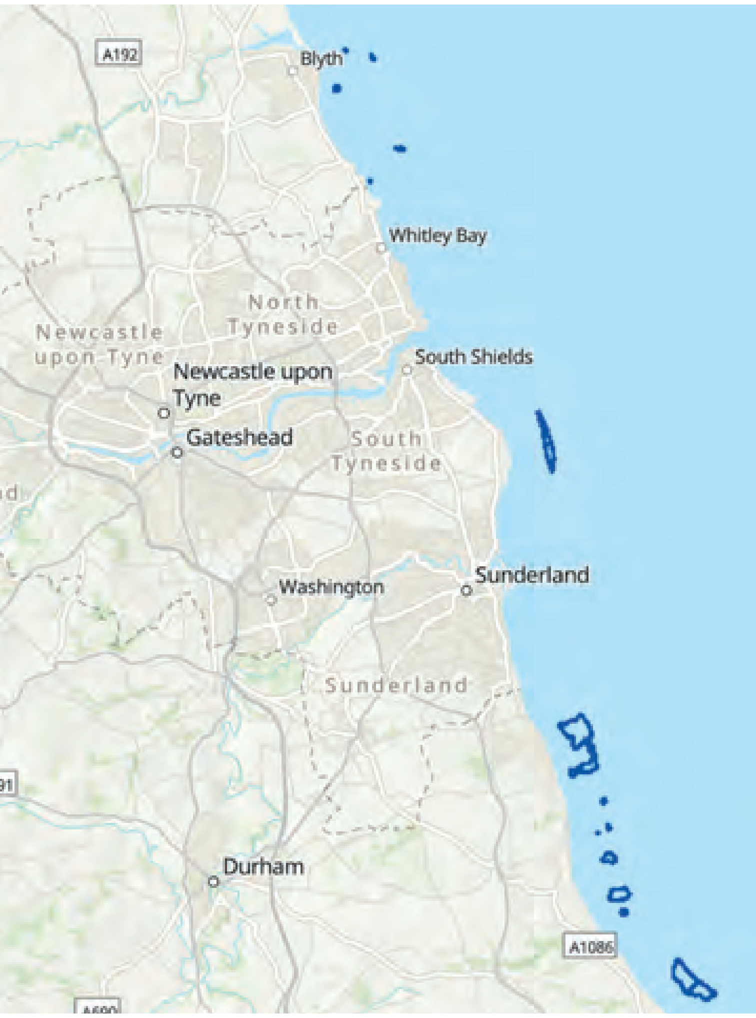


Figure 18. *'Native Oyster Bed Potential' national model outputs, developed by the Environment Agency.*

Table 6. *Summary of marine habitat restoration projects based on the North East England and East Coast of Scotland.*

Project name	Location	Marine habitat/ species	Project partners	Website link
The Dornoch Environmental Enhancement Project (DEEP)	Dornoch Firth, Scotland	Native oyster - *Ostrea edulis*	Glenmorangie Marine Conservation Society Heriot Watt University	https://www.mcsuk.org/ocean-emergency/marine-protected-areas/recovery-projects/uk-projects/oysters-dornoch-firther/
Restoration Forth	Firth of Forth, Scotland	Native oyster - *Ostrea edulis* Common eelgrass - *Zostera marina* Dwarf Eelgrass - *Zostera noltii*	Edinburgh Shoreline Fife Coast and Countryside Trust Heriot Watt University Marine Conservation Society Project Seagrass Royal Botanical Garden Edinburgh Scottish Seabird Centre The Ecology Centre The Heart of Newhaven Community	https://www.wwf.org.uk/scotland/restoration-forth
Stronger Shores partnership	North East, England	Native oyster - *Ostrea edulis* Common eelgrass - *Zostera marina* Kelp forests	South Tyneside Council North Sea Wildlife Trusts Newcastle University Zoological Society of London Groundwork North East and Cumbria Tees Rivers Trust University of Plymouth	https://stronger-shores.com/
Fish for Tees	Hartlepool	Native oyster *Ostrea edulis*	Tees Rivers Trust Stronger Shores	https://www.teesriverstrust.org/oyster-reintroduction
Wilder Humber	Humber Estuary	Native oyster *Ostrea edulis* Seagrass meadows Saltmarsh habitat	Yorkshire Wildlife Trust Lincolnshire Wildlife Trust Orsted	https://www.lincstrust.org.uk/what-we-do/conservation-projects/wilder-humber

4.3 Selection of Licence Areas

As was the case in the Conwy Bay restoration hub, to ensure the best chance of success for native oyster habitat restoration work in the Tyne and Wear restoration hub, potential broadscale restoration sites were carefully selected following a process of modelling larval dispersal and analysing existing substrate and habitat data. These areas were then refined and submitted within the marine license application. Once the wider, broadscale areas had been selected and licenses applied for, surveys and more detailed modelling work took place alongside consultation with the LWG, TWG and local regulators to select the specific reef areas. As described in section 3.3 for Conwy Bay, the areas for restoration work in the Tyne and Wear restoration hub followed a similar model of desk-based analysis (sections 3.3.1 - 3.3.6) and survey work (section 3.4.1).

Photo: Mature oysters in Conwy Bay © ZSL

4.3.1 Larval Dispersal Modelling

The Wild Oysters project installed oyster nurseries into Sunderland Marina and the Port of Blyth at the Tyne and Wear restoration hub. These nursery sites hold up to 1,400 adult breeding oysters, capable of producing up to 190 million larvae each year (Uttley *et al.*, 2023).

Sections 4.1 and 4.2 detailed the highly denuded state of native oyster populations in the wider North East region. There is no evidence of current wild breeding populations within the Tyne and Wear region. Therefore, any future oyster populations on the newly constructed reefs would have to come from the nursery sites or from oysters deployed directly onto the reef post construction. Oysters deployed onto the reef could be either mature oysters that are ready to reproduce but expensive to purchase, or juvenile oysters in the form of lose individuals or 'spat on shell', which can be cheaper to purchase but experience higher mortality and require several years before they are capable of reproducing.

Understanding the hydrodynamics and larval distribution from the nursery sites was therefore an important part of the site selection process to ensuring successful settlement and recruitment of native oysters to seabed restoration sites. Larval dispersal models were from Stantec UK for the Tyne and Wear restoration hub. These models predicted larval dispersal from the two nursery marina sites on various states of the tide during the oyster summer spawning period. Figure 19 demonstrates the modelled maximum concentration of suspended larval particles with no settling velocity from Sunderland Marina across a spring tide discharge and neap tide discharge (all modelled outputs can be found in Appendix 2). Larval distribution was also modelled from the Port of Blyth site and these outputs overlayed to give a summary image of total combined potential larval reach from the two marina sites. When considering the next stages of site selection, areas within the modelled larval plume were considered suitable.

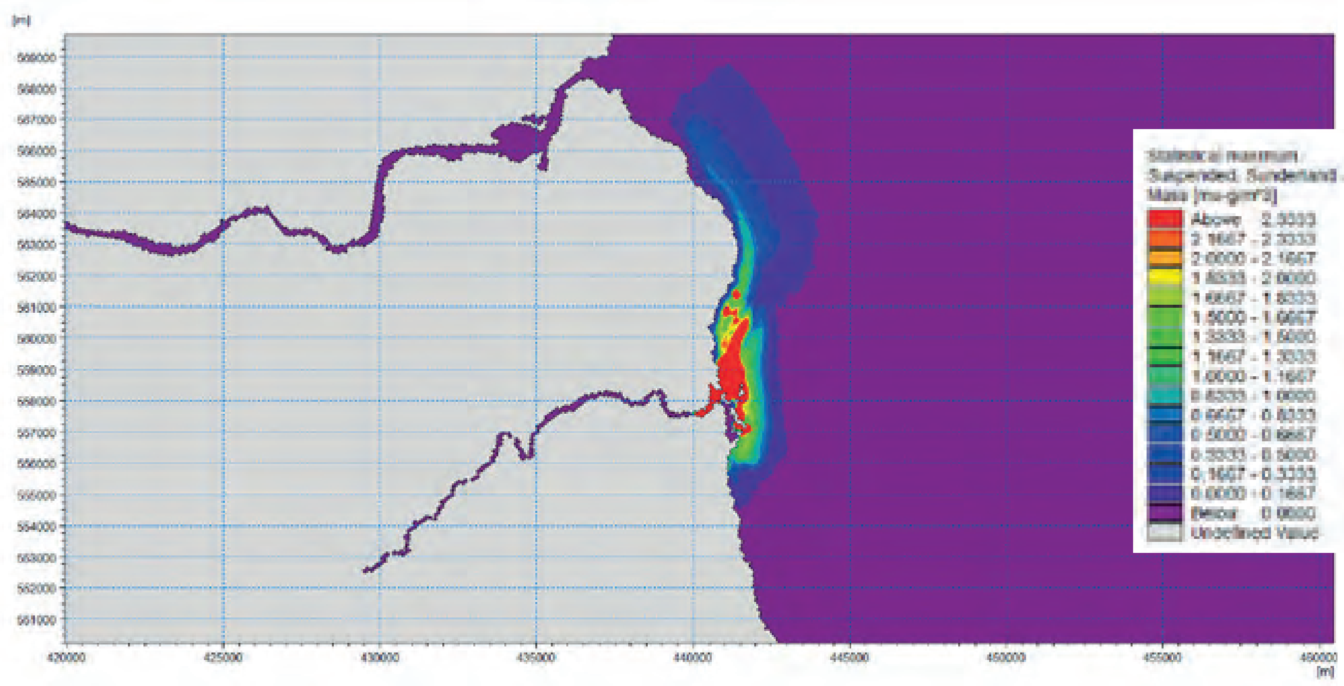


***Figure 19**. Maximum concentration of suspended particles with no settling velocity from Sunderland Marina used to inform reef site selection.*

4.3.2 Interaction with Marine Protected Areas

When selecting a restoration site, it was essential to consider marine designations that may be affected, as such in Tyne and Wear the same HRA screening process was applied as is described in section 3.3.2 for the Conwy Bay restoration hub.

At the Tyne and Wear restoration hub, a HRA was also completed for all designations within a 50km radius of the project site.

The following protected areas were within the 50km buffer zone:

- **Berwickshire and North Northumberland Coast SAC (UK0017072);**
- **Northumberland Marine SPA (UK9020325);**
- **Northumbria Coast SPA (UK9006131) and Ramsar Site (UK11049);**
- **Coquet Island SPA (UK9006031);**
- **Teesmouth and Cleveland Coast SPA (UK9006061) and Ramsar Site (UK11068);**

No Likely Significant Effect could be determined for all features and designated sites screened in the HRA. It was concluded that the project would result in no adverse effect on site integrity on any SAC, SPA, or Ramsar Site, or any of their qualifying features.

> At the Tyne and Wear restoration hub, a HRA was completed for all designations within a 50km radius of the project site.

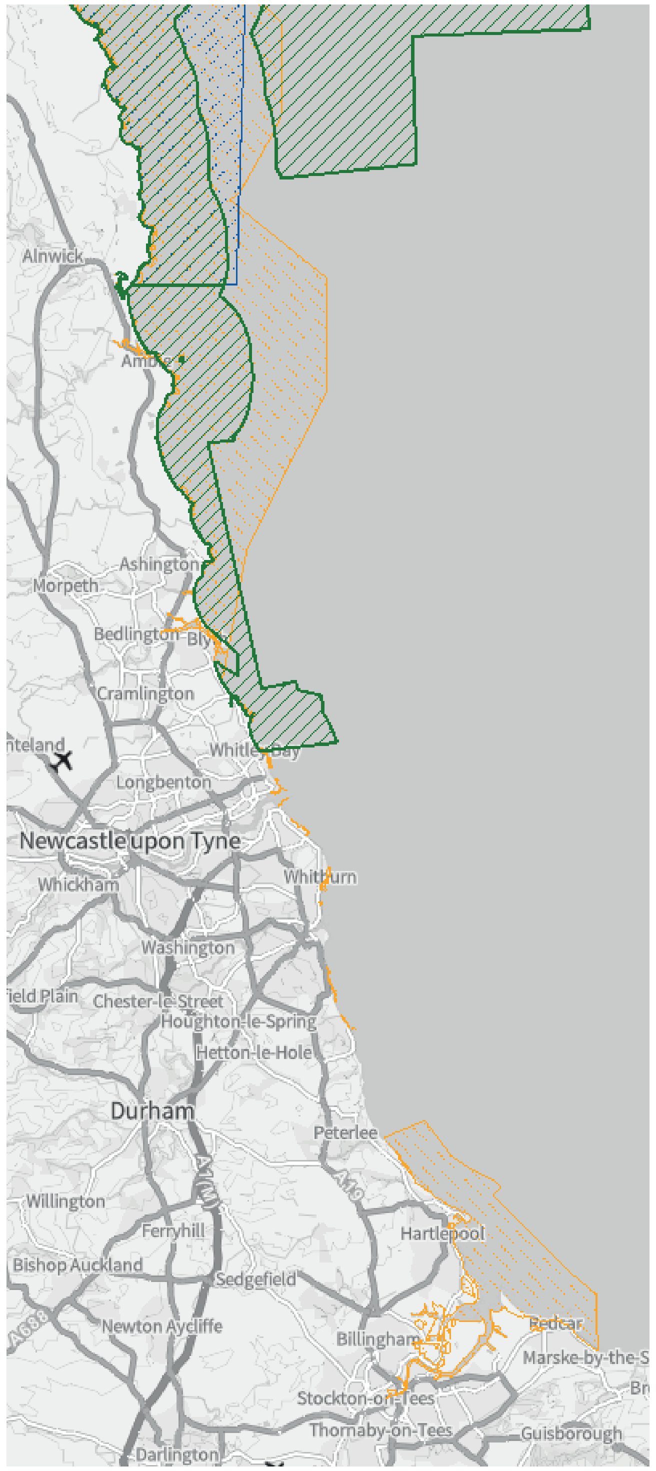


Photo: © Crown Copyright and database rights 2024. Ordnance Survey AC0000851168.

4.3.3 Logistic and Social Considerations

The importance of logistical and social considerations when undertaking seabed restoration for native oysters and the type of activities to consider are covered in section 3.3.5. In the Tyne and Wear restoration hub, the logistical considerations had a significant impact when undertaking site selection. When the publicly available habitat and substrate maps were overlayed with the larval dispersal maps and the designated areas (covered in section 4.3.4), initial sites were suggested in deeper water offshore between Sunderland and Blyth (Figure 20). Benthic surveys were undertaken on these sites to examine ground type and suitability for restoration works. However, during consultation with the local working group and the technical working group it was decided that these offshore sites made the logistical considerations of deployment potentially challenging. The cultch could potentially drift in the currents whilst travelling the further distance to the seabed, and it would be hard to be as accurate as is required by using traditional cultch deployment methods from the surface using an excavator. Initial investigations into alternative deployment methods suggested that success was uncertain, and costs would significantly increase. Therefore, rather than risk developing and trialling a new method of seabed restoration with cultch in an offshore environment, new inshore sites were scoped.

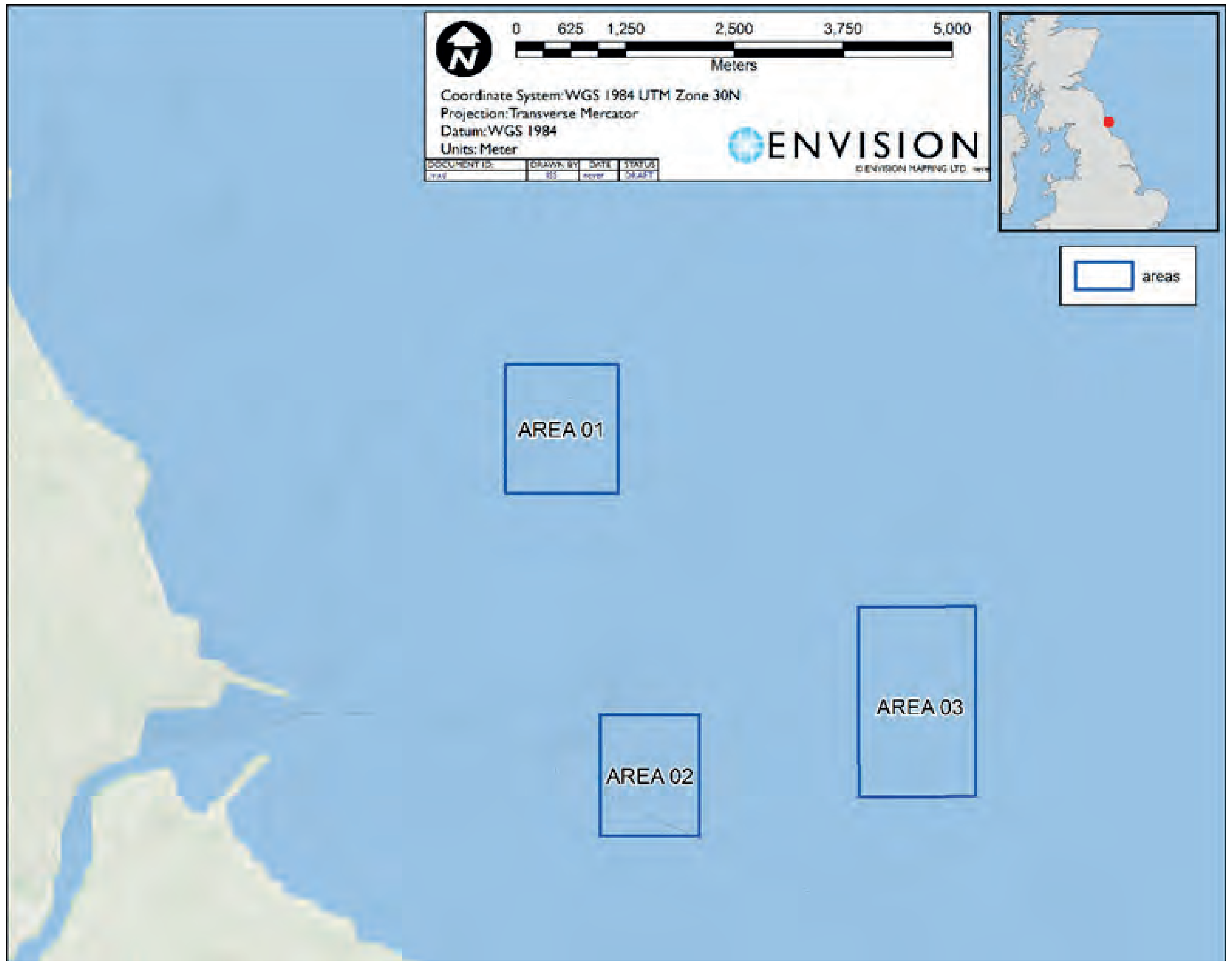


__Figure 20__. The original offshore sites in the Tyne and Wear restoration hub that were selected based on larval dispersal modelling and substrate maps. These sites were surveyed but subsequently abandoned due to logistical issues anticipated during cultch deployment.

4.3.4 Scoping of Inshore Sites

Once the offshore restoration sites suggested were eliminated, a new site suitability model was created to assess the inshore areas around Tyne and Wear for native oyster restoration. This model considered the extent of the larval plume from marina sites, substrate type, vessel activity and the presence of shipwrecks. Separate maps were created for each of these key factors (Appendix 4) and then an overall ranking model assessed the inshore area for the most suitable locations. The site selection was more challenging here due to the high vessel density from the Tyne and Wear rivers and many shipwrecks inshore. Inclusion of the vessel activity and shipwreck presence were two key factors flagged by local regulators as important when working in busy, nearshore sites.

After several rounds of site selection and discussions with regulators and the LWG, three new sites were selected through a site suitability model that overlayed the key factors and highlighted areas that were most suitable. The first, larger site, was submitted north of the River Wear and two smaller sites at the mouth of the River Tyne (Figure 21). Abiotic factors, as covered in section 3.3.4, were also considered for the new Tyne and Wear restoration hub inshore sites to ensure that the areas selected were suitable for native oyster survival and reproduction, each factor assessed is given in Table 1 and was found to be suitable.

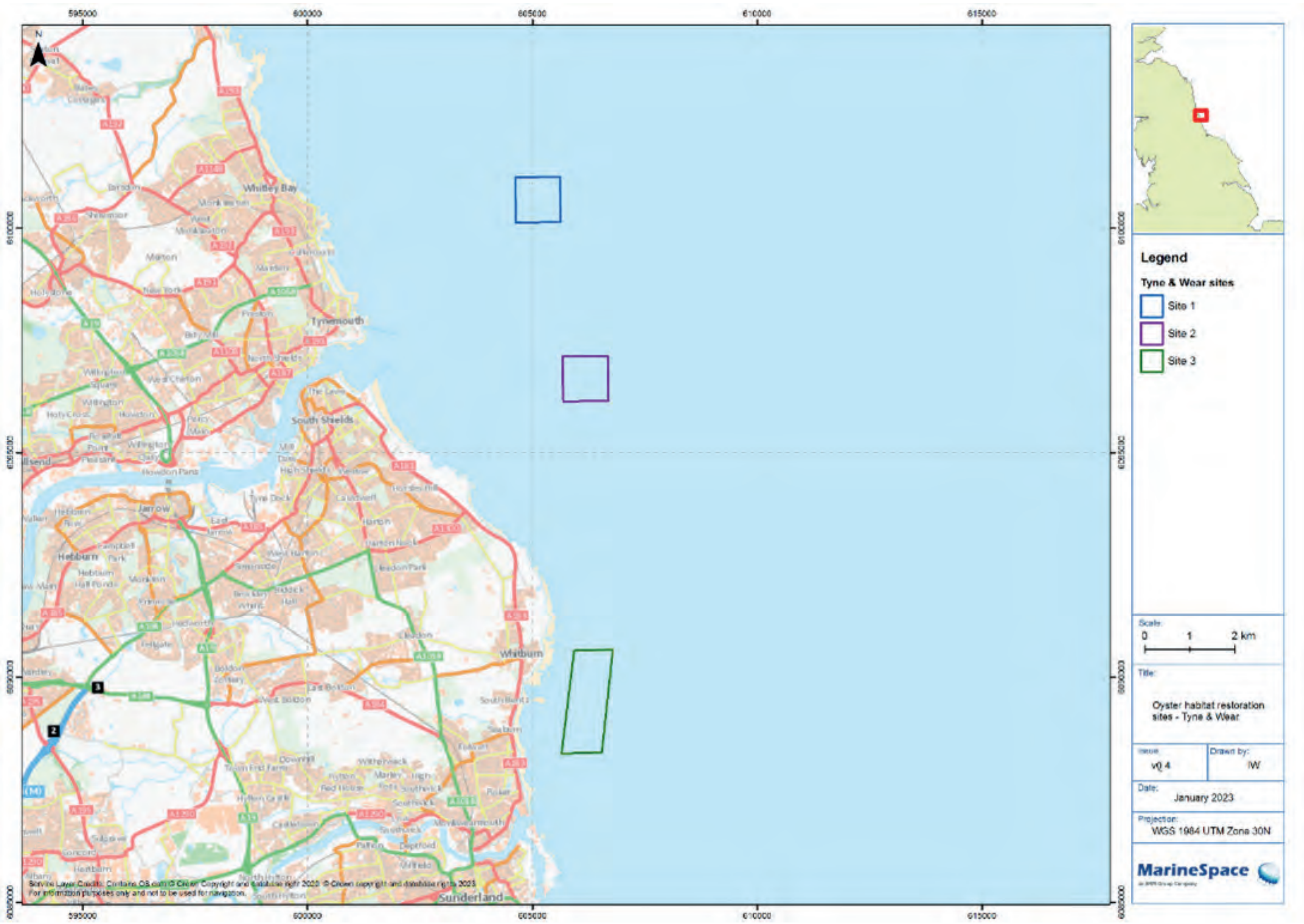


__Figure 21.__ The three sites submitted within the marine licence application at the Tyne and Wear restoration hub.

4.4 Selection of the Reef Location

Section 4.2 describes selection of the broad licence areas in the Tyne and Wear restoration hub. Once licence applications had been made (section 4.5), the focus was on selection of specific reef and control sites within the larger licenced area and identification of specific sites where active deployment of cultch materials and the creation of a reef could occur. Restoration efforts and reef creation are ideally focused in areas of subtidal mixed sediments. Native oysters are a recognised biotope of subtidal mixed sediments (EUNIS code A5.435) and it is deemed as a preferential habitat type for oysters. However, other hard substrates were considered in the absence of subtidal mixed sediment or if other overriding factors made the subtidal mixed sediment present unsuitable for deployment.

The most appropriate reef sites in the Tyne and Wear restoration hub were selected through a process of elimination, considering logistical, biological and environmental constraints. Following detailed seabed surveys, precise reef sites were prioritised through a score-based site selection matrix to determine the most optimal seabed site.

At the Tyne and Wear restoration hub, it was agreed with the LWG that the largest of the inshore sites, the most southern inshore site north of the River Wear near Roker beach (Figure 21) was likely the most suitable area for creation of a new oyster reef. This was due to the increased availability of suitable substrate types inshore, the proximity to the marina site, the reach of the larval plume, and the logistical considerations of reef creation in the deeper River Tyne sites.

To identify suitable areas of sediment and potential restoration areas within the new inshore site, a drop-down video (DDV) survey was initially carried out by The Wild Oysters Project team. These videos provided a crucial insight into the substrate and highlighted several suitable areas of restoration work. The survey also highlighted areas of sandy habitat and of shipwrecks that would be avoided in future site selection survey work.

Following the video survey, the Northumberland Inshore Fisheries and Conservation Authority (NIFCA) was contracted by The Wild Oysters Project to carry out a full benthic ecology survey at the new inshore site to ground-truth the substrate types indicated on publicly available maps and highlight areas suitable for restoration works. The data collected during this survey work was then processed into a habitat mapping report by ENVISION (section 4.4.1).

The most appropriate reef sites in the Tyne and Wear restoration hub were selected through a process of elimination, considering logistical, biological and environmental constraints.

4.4.1 Ground-truthing

ENVISION was contracted by The Wild Oysters Project to process data collected during the NIFCA benthic ecology survey for the selected inshore site. Data was collected from seven locations within the proposed area (Figure 22) on 24th January 2023 to identify the broadscale habitats and fauna present. Multibeam Echosounder (MBES) (Figure 23) and backscatter data (Figure 24), and DDV and still imagery were collected. Subsequently, video imagery and still images were reviewed and analysed to identify conspicuous fauna to help inform baseline biodiversity data and record benthic habitats, sediment type, seabed features and any features of conservation interest.

ENVISION was contracted by The Wild Oysters Project to process data collected during the NIFCA benthic ecology survey for the selected inshore site.

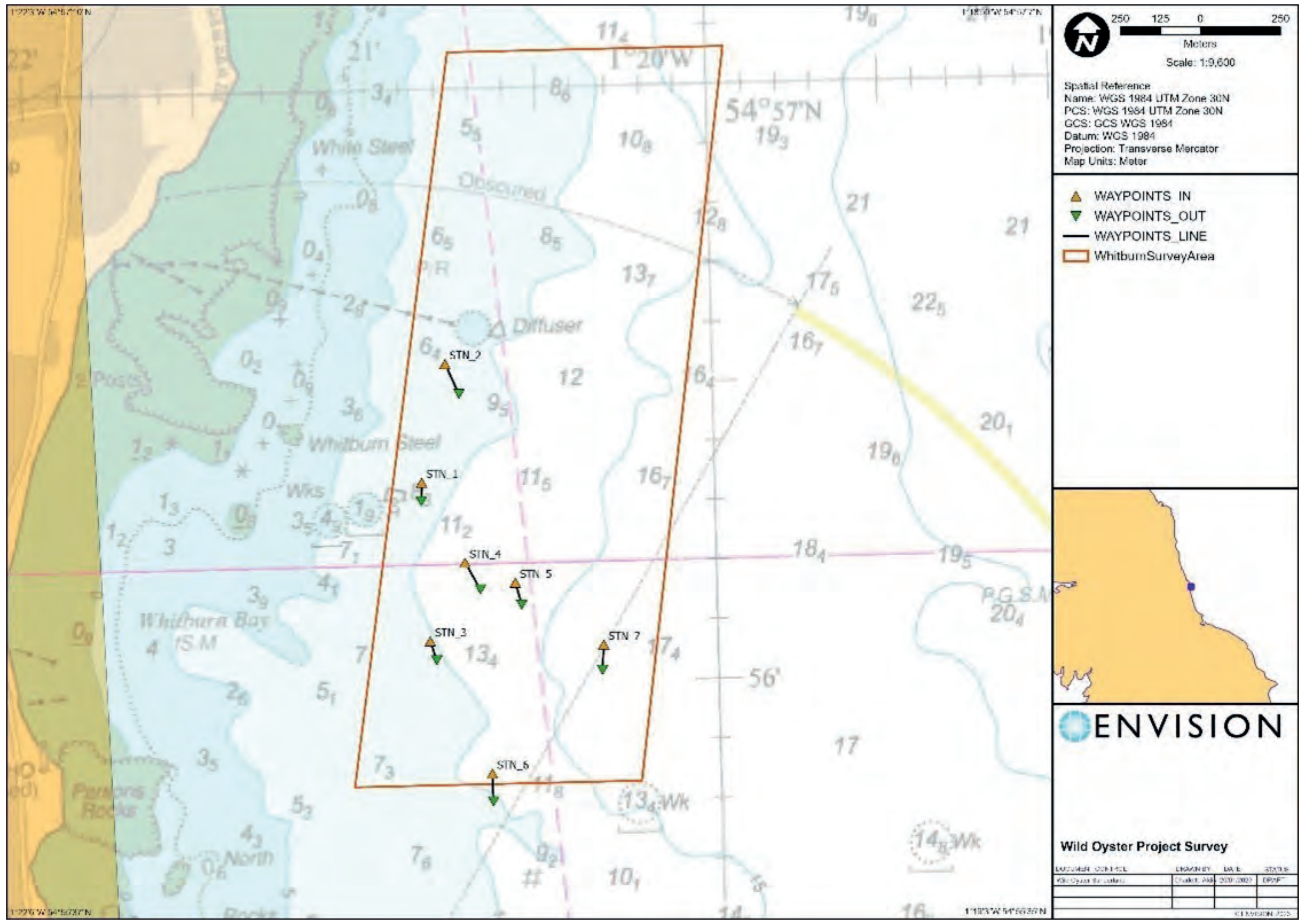


Figure 22. Location of video stations in the inshore Tyne and Wear restoration hub survey site, surveyed with station numbers shown along with start (orange) and end (green) locations of each video sample.

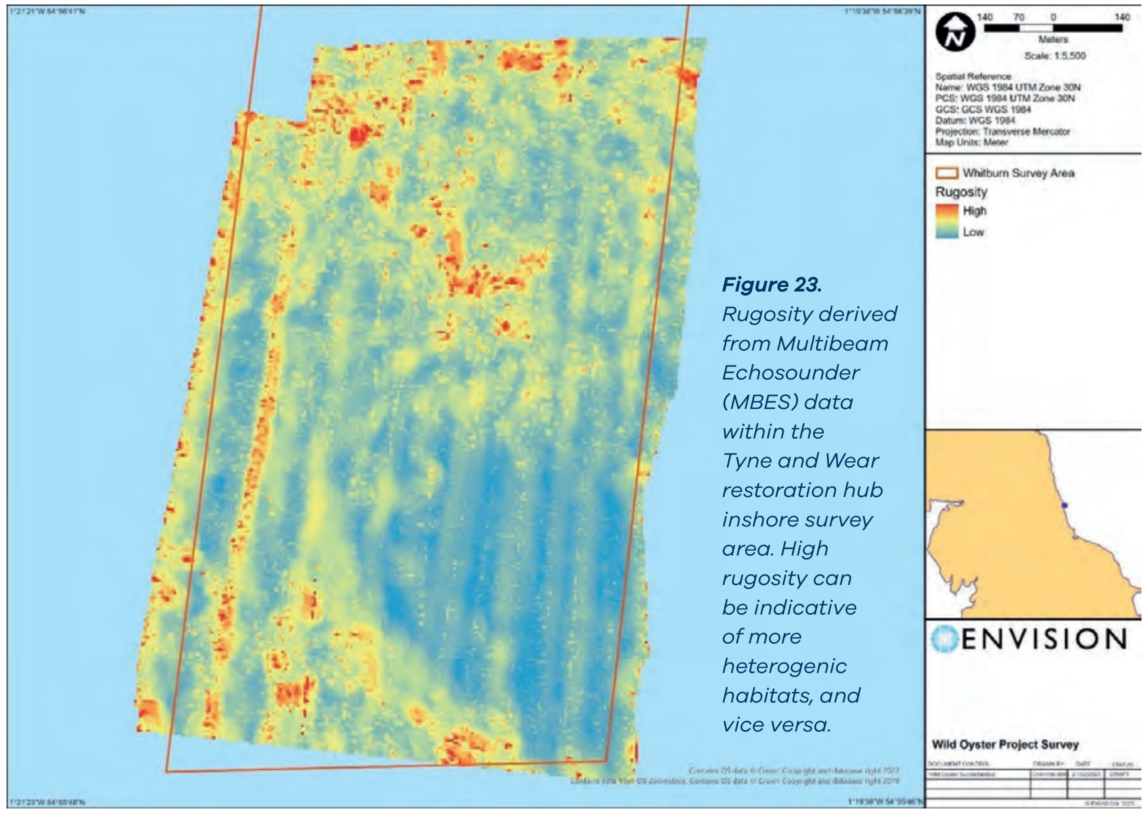


Figure 23. *Rugosity derived from Multibeam Echosounder (MBES) data within the Tyne and Wear restoration hub inshore survey area. High rugosity can be indicative of more heterogenic habitats, and vice versa.*

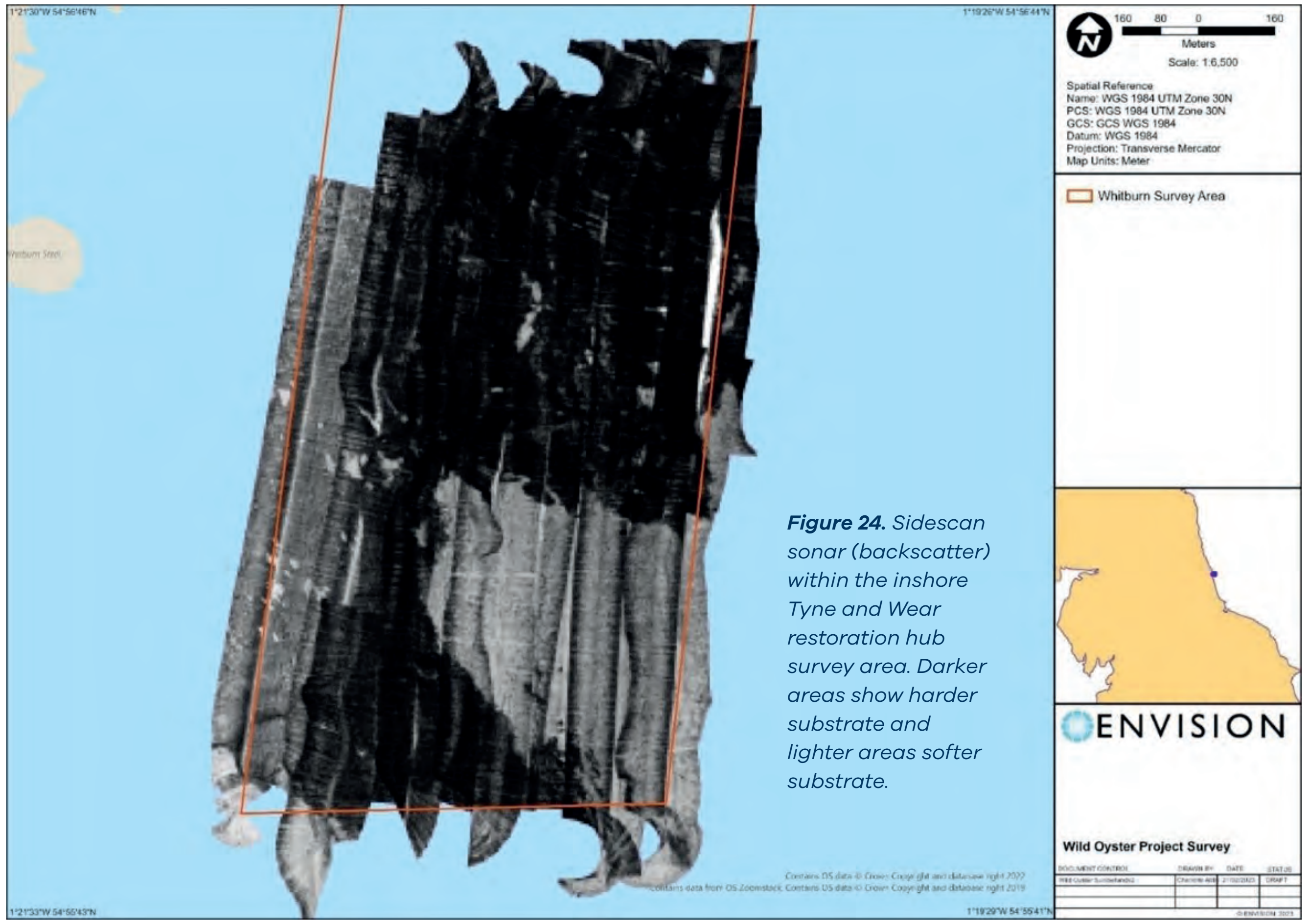


Figure 24. *Sidescan sonar (backscatter) within the inshore Tyne and Wear restoration hub survey area. Darker areas show harder substrate and lighter areas softer substrate.*

The results from analysis of the video and still imagery showed that the seabed at the majority of stations were comprised of hard substrate with a notable presence of silt. Three stations sampled within the survey area were recorded as the BSH EUNIS habitat 'Moderate Energy Circalittoral Rock (A4.2- see purple area on Figure 25)' and one station as 'Moderate Energy Infralittoral Rock (A3.2- orange area on Figure 25)'. Two stations were classed as 'Subtidal Sand (A5.2)' and the one remaining station was split into three segments, with two segments recorded as 'Moderate Energy Circalittoral Rock' and one segment as 'Subtidal Sand'. By combining the bathymetry and backscatter data with the ground-truth sample data from the video and still analysis, habitat maps were created for the whole sample area (Figure 25). This habitat map was assigned a probability rating and a confidence score, following the MESH confidence assessment method (MESH Project, 2008) and a JNCC confidence assessment method (Lillis, 2016). Probability rating and confidence scores were provided to indicate any uncertainty in sample variability. In addition to these substrate types, the survey also highlighted potential areas of low-profile stony reef and potential areas of Sabellaria. Areas of Sabellaria were avoided during site selection and video surveys undertaken on the final selected sites to ensure there was no Sabellaria present. Natural England were consulted with on the areas of potential Stony reef and advised that any stone or gravel deployed during restoration works should resemble the stony reef habitat in terms of size and composition.

Epifauna was abundant within the sample stations allocated as Rock habitats, with the most abundant taxa observed being Echinoderms, such as starfish (*Asterias rubens*) and urchins (*Echinus esculentus*). For those stations allocated as Sand habitats, epifauna was sparse. Other epifauna observed included anemones (Actiniaria), macroalgae, bryozoa (*Flustra foliacea*), crustacea (Brachyura, Caridea, *Necora puber*) and fish (Pleuronectiformes, Gadidae).

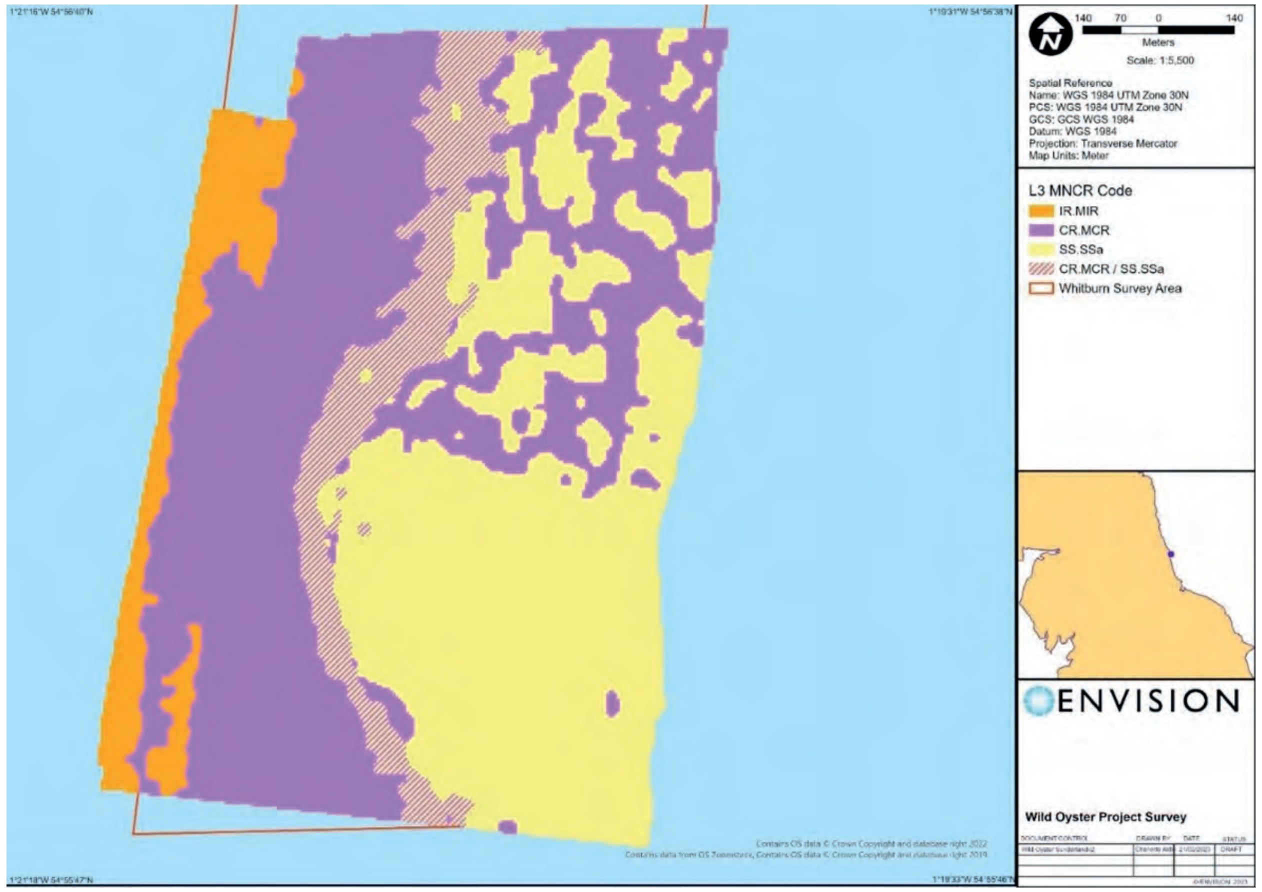
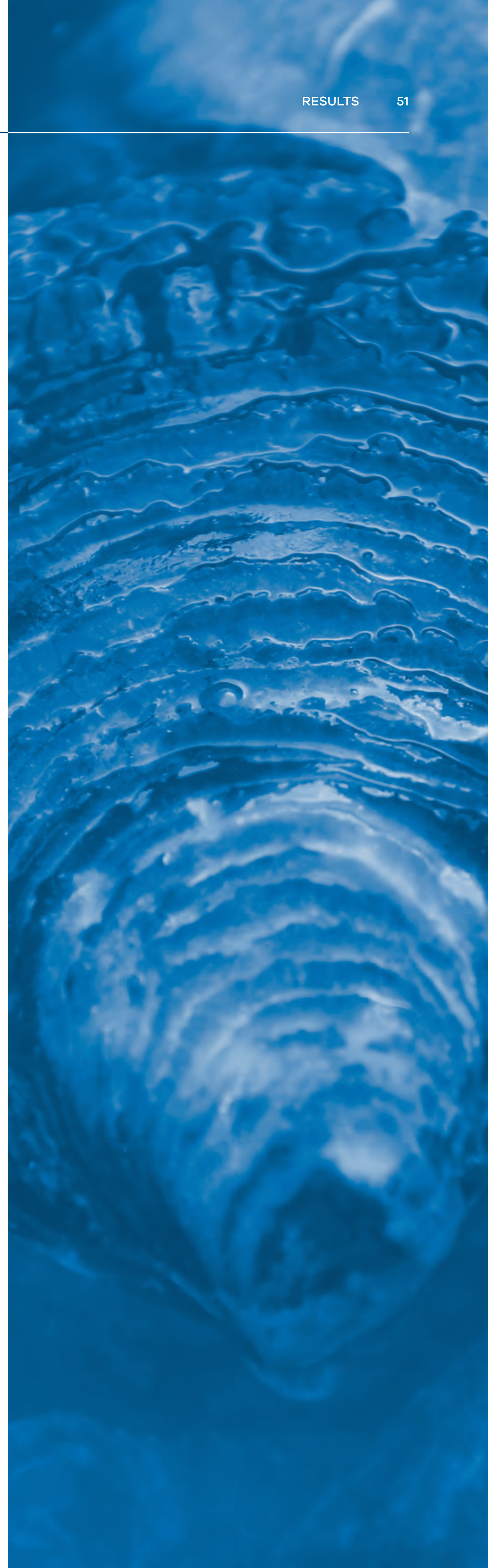


Figure 25. *Predicted distribution of MNCR Level 3 habitats for the Tyne and Wear restoration hub inshore survey area. SS.SSa Sublittoral sands and muddy sands, CR.MCR Moderate energy circalittoral rock, IR.MIR Moderate energy infralittoral rock, CR.MCR / SS.SSa Moderate energy circalittoral rock / Sublittoral sands and muddy sand.*

4.4.2 Final Reef Location

Following the ENVISION survey and report, it was decided by the technical team that in order to ensure that the most suitable area for the reef was selected and to narrow down reef site options, further video surveys would be required to select the final location for the new reef. Therefore, a final series of dropdown video tows were taken across fourteen areas that were highlighted by the previous surveys (Figures 23-25) as potential suitable substrate. From these final videos, two suitable plots were chosen for the new reef site and a nearby control site that ensured suitable hard ground and avoided any of the wrecks that were present in many of the videos. Despite the presence of hard ground, the substrate was extremely uneven and lacked any obvious shell material. It was therefore decided by the TWG that cultch deployment was still necessary in order to increase the shell availability and to create a more uniform bed to deploy mature oysters on.



4.5 Marine Licensing and Permissions

To complete the deployment of cultch material, and to conduct pre- and post-reef monitoring work a marine licence was required at both restoration hubs. Under Section 58 of the Marine and Coastal Access Act 2009, a marine licence is required for carrying out a licensable marine activity, summarised as:

- **Deposit any substance or object, in the sea or on or under the seabed;**
- **Construct, alter or improve any works either in or over the sea or on or under the seabed;**
- **Use a vehicle, vessel, aircraft, marine structure or floating container to remove any substance or object from the seabed; and**
- **Carry out any form of dredging, whether or not involving the removal of any material from the sea or seabed.**

The marine licensing authority at the Tyne and Wear restoration hub is the Marine Management Organisation (MMO). A seabed lease was required from The Crown Estate in order to undertake the cultch and oyster deployment activities. The Wild Oysters Project contracted MarineSpace Ltd., a marine planning and environmental services consultancy, to identify all necessary licensing, consultation consenting requirements, and drafting of marine licence applications and associated required documents including environmental assessments, see Table 7. The Wild Oysters Project team provided MarineSpace Ltd with survey data, and selected restoration sites, and reviewed and provided feedback on the drafted documentation.

Table 7. *The required documentation, timelines and costs associated with the licence application process in the Tyne and Wear restoration hub.*

Site	Documents Required	Date Submitted	Consultation	Regulator Costs	Consultancy Costs	Date Granted
Tyne and Wear	The Crown Estate Licence to Install and Use Works Particulars Online application through the MMO online portal; Habitats Regulations Assessment; MCZ Risk Assessment; Supporting Information Document including Environmental Impact Summary; Water Framework Directive Scoping Assessment; and Water Framework Directive Assessment.	6th February 2023	Notice published in a local paper and Fishing News Cost: £1,676	£9,086 (MMO and Cefas consultation) £50 per annum (The Crown Estate)	£14,746.25 (plus, combined project management costs of £3,118.77)	31st August 2023 (6 months, 3 weeks)

4.6 Monitoring and Surveys

Throughout the duration of the project, site selection surveys and reef monitoring surveys were undertaken, a full breakdown of surveys undertaken is given in Table 8.

Site selection surveys (section 4.2 - 4.4) were integral to ensuring that the reefs were deployed in a suitable location. However, the site selection surveys also provided valuable baseline data on substrate and habitat type. This information will be monitored post-reef deployment to track changes over time.

After the final reef and control sites were selected and agreed upon, pre-reef deployment surveys were completed to gather a baseline data to monitor associated biodiversity changes. As with the substrate and habitat baselines, changes in associated biodiversity will be monitored over time to track the impact of the restoration work. The project aims to continue to complete annual reef monitoring surveys detailed in Table 8, to assess the long-term impact of the restoration activities, subject to continuing to successfully gain project funding.

As in Conwy Bay (section 3.6), spat collectors were also deployed in 2023 in the Tyne and Wear restoration hub. Unfortunately, after the extended winter storms in 2023 it was not possible to locate the marker buoys and the frames were therefore unable to be retrieved. New frames have been designed and subject to updated licensing, will be deployed as part of future monitoring works.

Photo: Project team members ready mature native oysters for release onto the newly created reef © Lucie Machin

Table 8. *Summary of the monitoring and survey work undertaken at The Wild Oysters: Tyne and Wear restoration hub.*

Site	Survey Type	Collection Method	Purpose	Replicate	Date completed
Initial 3 offshore sites (Figure 20)	Site Selection / Baseline	Multibeam Echosounder (MBES) and backscatter	Substrate type and rugosity	na	August 2021
Initial 3 offshore sites (Figure 20)	Site Selection / Baseline	Grabs	Ground-truthing substrate and habitat types	30	November 2021
Initial 3 offshore sites (Figure 20)	Site Selection / Baseline	Drop Down Video (ROV)	Ground-truthing substrate and habitat types	18	November 2021
			Scoping of new near-shore sites		
3 nearshore sites, Whit-burn.	Site Selection	Drop Down Video (GoPro)	Ground-truthing substrate and habitat types	6	July 2022
3 nearshore sites, Whit-burn.	Site Selection	Multibeam Echosounder (MBES) and backscatter	Ground-truthing substrate and habitat types	na	January 2023
3 nearshore sites, Whit-burn.	Site Selection	Drop down video (ROV) and still im-agery	Ground-truthing substrate and habitat types	7 video samples (35 images taken from each video)	January 2023
3 nearshore sites, Whit-burn.	Site Selection	Drop Down Video (GoPro)	Ground-truthing substrate and habitat types	14	June 2023
Reef and control site, Whitburn.	Pre-reef Deploy-ment	Drop down video & photos	Shell cover Oyster density Oyster size freq. and spat pres-ence Invasive Non-Native Species Epifaunal sessile invertebrates and macrophytes	200	August 2023
	Pre-reef Deploy-ment	BRUVs	Sample small resident fish and mobile invertebrates, and tran-sient fish and crustaceans	10	August 2023
	Post-reef De-ployment	Multibeam Echosounder (MBES)	Project footprint and height	na	August 2024
	Post-reef De-ployment	Backscatter	Project footprint and height	na	August 2024
	Post-reef De-ployment	Drop down video & photos	Shell cover Oyster density Biodiversity: Invasive Non-Native Species, epifaunal sessile inver-tebrates and macrophytes	200	Planned 2024
	Post-reef De-ployment	BRUVs	Biodiversity: Small resident fish and mobile invertebrates, tran-sient fish and crustaceans	10	Planned 2024
	Post-reef De-ployment	ROV	Verification of location of oysters and cultch prior to commencing biodiversity surveys	3	May/June 2024

4.7 Reef Deployment

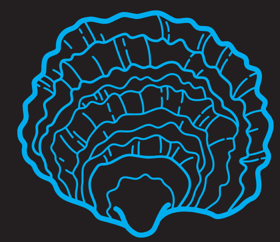
The deployment of cultch material and oysters, to form a native oyster reef, is logistically complicated. The transportation of several hundred tonnes of gravel and weathered scallop shell to a port, onto a barge, followed by deployment at sea is a large operation. At each restoration site, the deployment methods differ based on the available local vessels and infrastructure. It is common practice for oyster restoration projects to deploy both gravel and shell cultch when creating a new oyster reef, with gravel deployed first creating a lifted, uniform bed for the shells and adult oysters to be deployed on.

The size of the planned reef at the Tyne and Wear restoration hub was agreed through the TWG to be 75m X 100m. This size is comfortably within the much larger licenced areas and is small enough to be very low impact on surrounding habitats, yet large enough to provide a substantial area for oyster settlement and to deploy 10,000 mature native oysters on. The volumes of gravel required for the reef was calculated based on the available volume of weathered shell cultch and an appropriate ratio of gravel to cover the reef to an average height of 10cm (Table 9).

In the Tyne and Wear restoration hub, the natural geomorphology was considered when selecting the stone cultch type. The bed type in the Tyne and Wear region is a combination of coastal and offshore sedimentary formations. Common sedimentary rocks found in marine bedrock include sandstone, limestone, shale, and mudstone. The focus area for restoration lies within the historic region known as the Magnesian Limestone plateau (Davies *et al*., 2009; Highley *et al*., 2000). The bedrock underlying the area consists of Permian-age (around 298 to 251 million years old) Magnesian Limestone, which is a type of carbonate rock. The local regulators were consulted on the gravel type and given the favourable nature of limestone for settlement and its presence in the region, locally sourced limestone aggregate was used. At the Tyne and Wear restoration hub 600 tonnes of 50mm magnesium limestone was deployed during reef construction.

This deployed limestone aggregate was then topped with 155 tonnes of scallop shells. The shells had undergone a rigorous biosecurity process (section 1.2.2) and were deployed directly on top of the limestone.

The ratio of shell to gravel used was calculated based on the volume of each material and the total area (75m by 100m) and targeted depth of 0.1m for the reef. The volume of stored shell at each site was calculated based on a conversion of 0.45 tonnes per cubic metre (2.2 cubic metre per tonne) and the remaining volume of gravel required based on the conversion of 1.5 tonnes per cubic metre.



10,000

MATURE NATIVE OYSTERS WERE DEPLOYED

Photo: Volunteers cleaning native oysters to deploy on the Tyne and Wear reef. © Lucie Machin

Photo: The Wild Oysters Project team and local volunteers prepare mature native oysters for release onto the newly created reef . © Lucie Machin

Table 9. Summary table of the Tyne and Wear restoration hub reef deployment

Location	Tyne and Wear restoration hub	Reef located north of the River Wear approximately 1200m from Roker Beach (Sunderland)
Reef Size	75m X 100m (7000m²)	620 tonnes of limestone gravel deployed 155 tonnes of shell cultch (scallop) deployed
Oysters Deployed	10,000	Relaying area: 625m² Relaying density: 16/m²

Native oysters were deployed on the completed reef in the Tyne and Wear restoration hub to provide the reef with an immediate boost in oyster numbers and a local source of larval production. The oysters were purchased from an aquaculture site in Loch Ryan, Scotland. In order to ensure that there was no risk of transfer of disease or non-native invasive species with the delivery of oysters, a stringent Biosecurity Measures Plan (BMP) was followed (section 1.2.3, and Appendix 1). The BMP was developed to ensure all aspects of the project adhered to highest possible biosecurity standards. In order to follow the conditions of the BMP, the heath and disease status of the donor site were assessed, and then all oysters individually cleaned and inspected prior to deployment on the reef. The cleaning and inspection process was a significant undertaking and required the assistance of dozens of local volunteers who were on hand to scrub and wash each individual oyster to remove all debris and other non-oyster organisms. The oysters were then all checked and counted by Wild Oysters Project staff.

4.7.1 Reef Deployment Method

In September 2023, a native oyster reef at the Tyne and Wear restoration hub was created off the coast of Whitburn Bay.

A local vessel operator company was contracted to facilitate the deployment of the cultch material onto the reef site due to their expertise and knowledge of the local area. The vessel contractors sourced a suitable hopper barge vessel with an on-board excavator, named the Sandsend, and subcontracted the vessel to deploy the gravel and cultch material. A support vessel was also provided to provide assistance with the setting and retrieval of the guiding markers and to allow access to the project team and videographer to oversee the deployment activities.

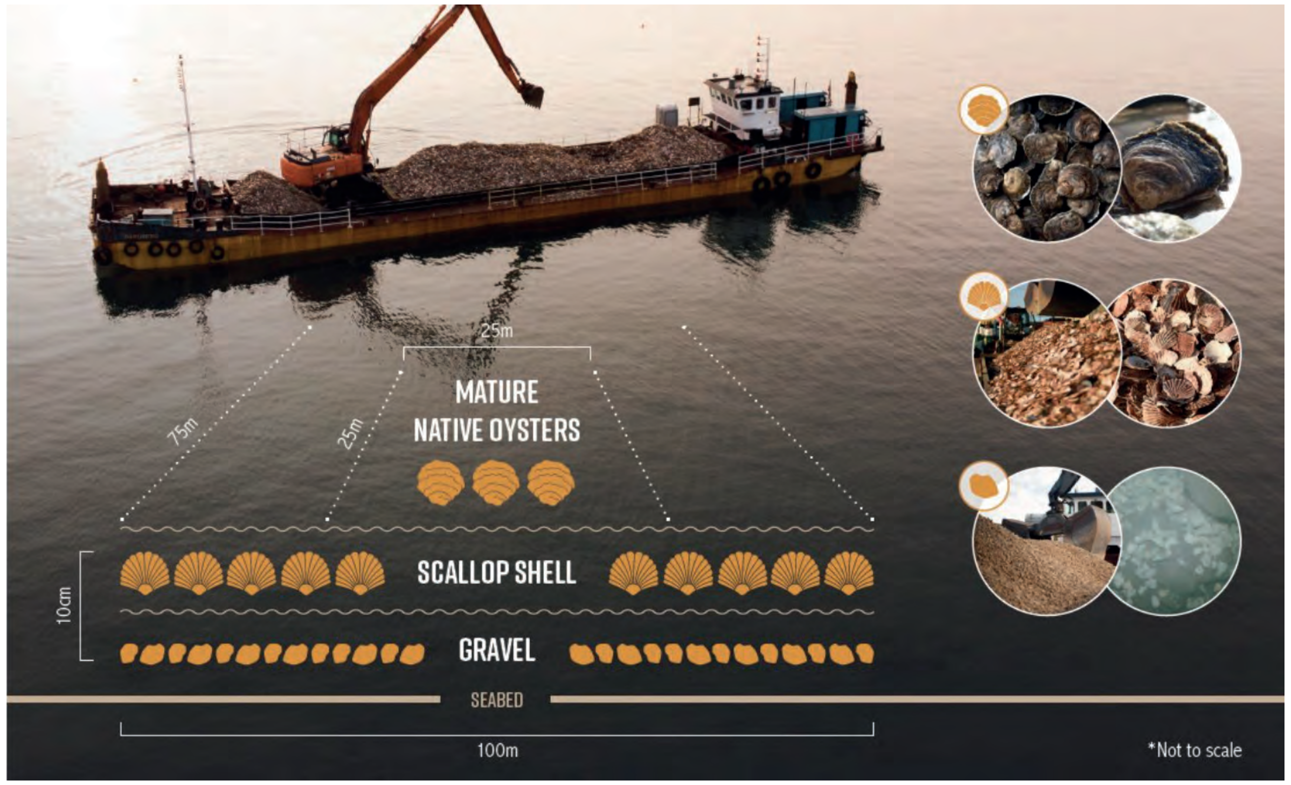
The gravel and shell cultch material was delivered to the South Docks in the Port of Sunderland and loaded directly onto the barge from the quay in the Port of Sunderland.

Guiding markers were deployed to mark out the coordinates of the oyster reef site and were corroborated with the onboard GPS system on the barge during deployment.

A total of 600 tonnes of locally sourced limestone gravel was deployed over the course of two days from the barge. The gravel was spread as evenly as possible using the excavator arm whilst navigating from one side of the marked box to the other. The same process was then repeated over two further days to deploy 155 tonnes of shell cultch, to achieve an overall 10cm uniform reef height, with up to a maximum of 50cm in height. On board systems of scans and a remotely operated vehicle (ROV) were used to identify an estimated reef height and coverage upon completion of works, providing imagery and data to evidence this.

Following the successful deployment of 750 tonnes of cultch, two local charter vessels were contracted from Sunderland Marina to allow The Wild Oysters Project team to deploy the previously cleaned and checked 10,000 mature native oysters on to the reef.

The deployment of the mature native oysters completed the habitat restoration and reef deployment work in the Tyne and Wear restoration hub.



Above. Illustration of native oyster habitat restoration on the seabed. Includes the deployment of cultch deposited by a barge at the Tyne and Wear restoration hub, and shows 25 x 25m box with oysters laid in the middle of the site. © Lucie Machin

5. SUCCESSES

There have been many achievements and successes since project inception. The Wild Oysters Project set up very effective local working groups with the contribution of many dedicated and knowledgeable local representatives, which was essential to the project's success. The project also established Technical Working Groups and built strong relationships with the local regulatory authorities at each site, including Natural Resources Wales, the Marine Management Organisation and Natural England. These relationships were vital in ensuring that the correct processes were followed and gave the project greater likelihood of success through the input of specialist local knowledge.

The project followed a thorough and detailed site selection process to find a suitable seabed site for native oyster restoration in each of the restoration hubs. This process has been set out clearly in this report and can be replicated by other restoration practitioners to advance and expand native oyster restoration efforts across the UK.

Collaboration and partnership were another key success of the project. The Wild Oysters Project collaborated with local delivery partners Groundwork North East and Cumbria and Bangor University to deliver restoration hubs in England and Wales. The success of this project was borne out of the unique area of expertise each partner organisation provided.

Photo: Barge deploying scallop shell during reef construction in the Tyne and Wear restoration hub. © Lucie Machin

Other successful experiences of working in paid partnerships with other organisations included working with NIFCA in Tyne and Wear to conduct survey work and using ENVISION to process the images. Commissioning ENVISION to process survey images, and Hebog Environmental Ltd. to process grab samples was a good investment for project team capacity. The marine licensing process was successfully navigated and all planning and preparation for reef deployment completed by the project team and with vital input and assistance from the local working groups and technical working groups. The commissioning of MarineSpace Ltd to complete the license applications for each site was again a successful paid partnership and significantly aided the application process.

The project has delivered a successful community engagement and education programme, including the training of local citizen science volunteers. The project reached over 30,500 students at various education levels with online materials, in-class sessions and site visits, inspiring a new generation of marine stewards to take forward the legacy of this project. In addition, over 400 citizen scientist volunteers were trained to collect scientific monitoring data, and over 82,000 people were engaged at events. At the conclusion of the project, 428 volunteers had contributed 4,694 volunteer hours to the project. The monitoring and maintenance of the oyster nurseries can be labour intensive, therefore the support of volunteers has been essential for collecting all of the biodiversity data that was summarised in The Wild Oysters Project Nursery Report (Uttley *et al.*, 2023). Furthermore, the biosecurity measures required the cleaning of thousands of native oysters, which was made possible by the support of our dedicated project volunteers. The project received fantastic support from local volunteers, who were extremely keen to engage and learn about the project.

Finally, the greatest achievement of the project was successful deployment of new native oyster reefs. The project constructed a new native oyster reef and deployed 10,000 mature native oysters onto the reef in the Tyne and Wear restoration hub. The method of deployment at the Tyne and Wear restoration hub worked extremely well, with the use of a local vessel operator and contractors with a good knowledge of the local area ensured a smooth running of operations. The first stages of a new native oyster reef have been built in Conwy Bay and plans are in place to complete this work. During the deployment of 10,000 oysters at the Tyne and Wear restoration hub, the North Shields Fish Quay generously provided a location on site for the oyster cleaning event to take place. A further success of the event taking place here was ad-hoc engagement with the local fishing community. We then commissioned the use of two local charter vessels to deploy the oysters onto the reef site.

6. LESSONS LEARNT

Engaging on oyster reef deployment

The project found that engagement with key local representatives and members of the public was critically important. Quarterly local representative engagement through the Local Working Groups during both project development and delivery were extremely beneficial and vitally important. Prior to future reef deployment activities, organising several open consultation meetings to share upcoming activities with wider community members would ensure all those interested are informed and have the opportunity to provide feedback.

At both of the project sites, substantial outreach and engagement was conducted. Through the installation of the nurseries; outreach and volunteer trips; online, press and media releases; engagement with the local regulators; and the formation of the LWGs, it was believed that all local representatives were engaged in the project and actively inputting. The LWG meetings were set up with accessibility and inclusivity in mind, such as avoiding tide times for fishing, school pick-ups and other likely inconvenient times, and were open to any local representatives with an interest in the project. The LWG was consulted during the site selection process and prior to restoration activities.

A specific example of the importance of early and thorough engagement is in the Conwy Bay restoration hub. In Conwy Bay, the Conwy Mussels Co. provided a letter of support for the project during initial funding applications and were active members of the LWG. However, there were other local fishers that were not members of the LWG and were unaware of the project and the planned restoration activities.

During the first stage of reef deployment, concerns were raised by members of the local fishing community that there had been insufficient engagement and that they were not aware of the planned works. This was unfortunate and disappointing to hear as considerable effort had been made by the project to engage with the local community and no responses were received by NRW Marine Licensing during the public consultation period. Meetings were subsequently held with the local fishing community, information about the project given and key figures invited to join the LWG to improve communication of project activities.

It is strongly recommended that substantial efforts (such as quayside discussions, public open consultation and contacting local and national fishing representative bodies) be made to ensure that no community representatives are absent from the LWG, all have an opportunity to provide feedback during project development and are informed of the planned restoration work.

Photo: Deployment of mature native oysters onto the new reef in the Tyne and Wear restoration hub. © Lucie Machin

Cultch storage and deployment

The storage and deployment of large volumes of cultch can be challenging. Identifying locations to store large volumes of cultch material can be difficult and costly. This is particularly important if the type of shell cultch that is to be used is untreated and requires weathering. Going forward and for new oyster restoration projects, the availability of sufficient and suitable storage areas should be a primary consideration in site selection.

Methods of cultch deployment vary depending on local conditions, vessel availability and cultch type. During cultch deployment in the Conwy Bay restoration hub, it was found that the bag deployment technique was not effective (Section 3.7.1). The discharge spouts in the bags were too small for the size of gravel and resulted in regular blockages. These issues were mitigated by a reduction of the size of gravel, but the technique remained slow, labour intensive and expensive. Deploying via bags led to an uneven distribution of cultch and several areas above the maximum reef height included in the marine license application. There is no risk to navigation and the appropriate steps are being taken to level the peaks to within the height assessed in the HRA. As this levelling was an unforeseen activity, it was not listed within the approved activities. Consultation with NRW has resulted in all works of the reef creation put on hold whilst a new licence application specifically to level the gravel layer of cultch is applied for. In addition, there has been ongoing monitoring work completed to track any natural redistribution of the gravel. In comparison, the method of deployment that was utilised in the Tyne and Wear restoration hub, deployment from a barge with an excavator (Section 4.7.1) was extremely quick and resulted in an accurate, even distribution of cultch.

The key lesson learnt during cultch deployment was to overestimate the maximum reef height described in the MLA to allow for an uneven distribution of cultch and to include relevelling activities within the approved activities to ensure that the reef height can be managed if necessary.

Finally, mobilising the movement of large volumes of cultch material to align with weather windows and vessel availability when it comes to the loading of vessels and deployment of cultch material at sea is challenging. Therefore, the deployment windows planned should have sufficient time to allow for delays and rearrangements.

Vessel availability

The third key lesson taken from the seabed restoration aspect of the project was to fully assess the work vessel options and availability prior to deciding on a site for restoration. The lack of deployment vessel options in Conwy Bay created significant logistical difficulties and has caused delays in the project delivery timeline.

The project also experienced a long wait time for the deployment vessel to come into port at the Tyne and Wear restoration site due to a vessel damage issue, this impacted the rest of the timeline of deployment, so it is key to factor in contingency time into deployment planning.

Therefore, it is recommended that a long lead time for identifying and acquiring vessels is accounted for, or selecting sites with larger fleets would help remedy this in future.

Seasonality

Due to the delay in the award of a marine licence, the project team subsequently deployed the reef in the Tyne and Wear in September, which was not ideal for our post-reef monitoring surveys when storms are more prevalent, and water visibility is affected. This can be factored into timeline planning in future.

Marine licencing

The final lesson taken from the experiences of The Wild Oysters Project was surrounding licensing. The process to secure a seabed lease from The Crown Estate was straightforward, quick and inexpensive. In comparison, the process to secure the marine licence for each site was lengthy and expensive. Significant additional costs were added due to the use of a consultancy to undertake the consenting process for the project. However, the considerable requirements of the marine licence application process would have required additional capacity within the team had this not been outsourced.

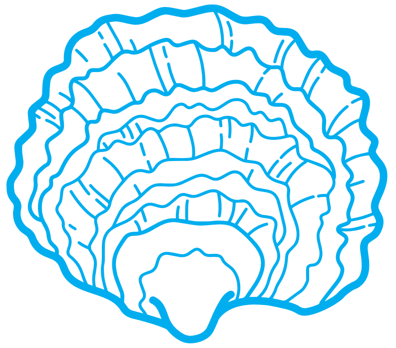
There was a considerable difference in the licensing process and licence costs between the two Wild Oysters Project sites. Firstly, a Band 2 licence was issued in Conwy Bay and a Band 3 licence issued in the Tyne and Wear. The higher band in the Tyne and Wear has both time and cost implications.

In the Conwy Bay restoration hub, NRW marine advisors sat on the LWG and TWG and provided their expert guidance on the project. The marine licence application was submitted to a separate marine licensing team within NRW. In the Tyne and Wear restoration hub, a Natural England representative was a member of the LWG and provided guidance on the site selection.

Any consultation completed by regulators during the licence application process was chargeable advice (Table 3 and 7).

There was also a significant difference in the time taken for each application to pass through the consultation process. The Conwy Bay licence was granted approximately three and a half months after application submission. This was under the estimated statutory response time of four months (Natural Resources Wales / Permitting service levels in Natural Resources Wales). The Tyne and Wear licence was granted seven months after submission, over the MMO target turnaround of 13 weeks (The marine licence application timeline - GOV.UK (www.gov.uk)).

With regards to costings and timings, the key lesson learnt during The Wild Oysters Project was that licence applications should be submitted well in advance of the deadline for which it is required. In addition, attention should be paid to the band of the licence and associated costs considered. The Band 3 licence issued in the Tyne and Wear restoration hub had no maximum cap on the chargeable consultation fees. This should be taken into account prior to the decision to embark on a restoration project and also when allocating funding and capacity to the licensing process. If sufficient funding is not available to outsource the application and consenting processes, then additional capacity within the team should be allocated.



The key lesson learnt during cultch deployment was to overestimate the maximum reef height described in the MLA to allow for an uneven distribution of cultch and to include relevelling activities within the approved activities to ensure that the reef height can be managed if necessary.

7. CONCLUSION

The completion of The Wild Oysters Project saw the accumulation of three and a half years of engagement, outreach, scoping and restoration works. The project amassed an impressive outreach and education record, reaching a combined total of over 100,000 people. The comprehensive restoration scoping works considered all environmental and social factors prior to restoration work commencing and consequently set the project in a strong position to move forward with active seabed restoration.

The Wild Oysters Project delivered a new native oyster reef in the Tyne and Wear region. The reef covers 7,500m^2 and was topped with 10,000 mature native oysters to kickstart the recruitment process. The foundations for a new reef have been laid in Conwy Bay, and despite the challenges faced during reef deployment, plans are in place to complete these seabed restoration works.

Significant progress has been made towards restoring native oysters in the two Wild Oyster Project restoration hubs. Lessons learnt during the scoping, planning and deployment stages of the project improved the technical understanding of restoration methods and monitoring methods through project delivery. Throughout the course of the project, The Wild Oysters team continuously fed back to the Local Working Groups and shared project updates widely across the European wide networks of restoration practitioners. This dissemination of successes and valuable learnings with similar projects will help to advance oyster restoration efforts across the UK and Europe.

Photo: Barge deploying scallop shell during reef construction in the Tyne and Wear restoration hub. © Lucie Machin

8. LEGACY AND CONTINUATION FUNDING

Continuation funding has been secured in both restoration hubs to ensure that the efforts of The Wild Oysters Project are taken forward and advanced in both restoration hubs. The Wild Oysters Project will continue to work closely with local partners to monitor the new native oyster reefs, and in time, scale up oyster restoration works.

Conwy Bay

In Conwy Bay, continuation funding was secured through two grants from The Nature Networks Fund, delivered by The National Lottery Heritage Fund in partnership with the Welsh Government. The first grant runs from April 2023 to April 2025 pledging £249,919 of funding to enhance the coastal habitat condition in Conwy Bay through native oyster restoration.

A further grant of £235,556 was secured from the Nature Networks Fund for the period from July 2024 to March 2026. The project, 'Connecting Conwy: A plan for seascape scale recovery of coastal habitats in Conwy Bay and the Menai Strait' aims to research and increase the resilience, connectivity, and health of the Conwy Estuary, and the Menai Strait and Conwy Bay SAC, working with existing local coastal partnerships and engaging a wider range of people, to conduct the groundwork needed to develop a plan together for marine habitat recovery locally.

The project will enable a better understanding of the current local presence and distribution of marine habitats, including seagrass, native oysters, saltmarsh and blue mussel, and explore further the barriers to recovery.

The project will see collaboration between Wild Oysters Project partners, NRW and local representatives to build upon existing modelling and mapping work and continue native oyster restoration activities in Conwy.

Tyne and Wear

In the Tyne and Wear restoration hub, continuation funding has been secured through the Stronger Shores Partnership. Funding runs from 1st April 2023 until 31st March 2026.

The Stronger Shores Partnership, led by South Tyneside Council with funding from Defra, has pledged £420,000 of funding to continue and scale up the delivery of the Tyne and Wear restoration hub.

Stronger Shores is underpinned by a desire to improve understanding of the benefits of marine habitats such as kelp, seagrass and oyster reefs with regards to coastal erosion, flood risk, climate change and biodiversity management. The funding will enable the Tyne and Wear restoration hub to continue for a further three years, to deliver oyster nursery site engagement, and to scale up efforts to restore native oyster habitat.

> The Wild Oysters Project will continue to work closely with local partners

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Above: Weathered scallop shells, an ideal settlement substrate for native oyster larvae. **Photo by** Maria Hayden-Hughes ©.

NATIVE OYSTER HABITAT RESTORATION REPORT APPENDICES

Appendix 1

The Wild Oysters Project:
Biosecurity Measures Plan

Introduction

Background
The European flat oyster (*Ostrea edulis*) or native oyster once formed extensive beds in European seas. Oysters are 'ecosystem engineers' and reefs contribute substantially to biodiversity and provide protection and nursery grounds for juvenile fish and other species. Native oysters are filter feeders, cleaning waterways by removing impurities such as nitrogen. In the mid-20th century populations across Europe suffered a collapse from pressures of overfishing, pollution, disease and invasive species. The loss of this habitat has not only affected the health of marine ecosystems but also coastal communities. Oysters have been a staple food since pre-Roman times and were once the subsistence food of London. Over 700 million oysters were consumed in London alone in 1864, but 100 years later total landings for England fell to just 3 million oysters. Wild native oyster stocks have declined by over 95% in the UK and native oyster beds are now one of the most threatened marine habitats in Europe.

Project description
The Wild Oysters Project will create three rehabilitation hubs across the UK in England, Wales and Scotland to recover native oyster populations and the services they provide. At each site, the project will engage, enthuse and mobilise coastal community groups, schools and businesses to take part in the restoration and be guided by a Working Group comprised of local stakeholders. Each local restoration hub will provide a model for community restoration and use best practice from established projects including Blue Marine's Solent Oyster Restoration Project and the Essex Native Oyster Restoration Initiative.

Key activities at each of the sites will include:

Oyster nurseries: In order to increase the number of breeding oysters within the site, oysters will be placed at high densities in cages that are hung from existing marina pontoons, below the surface of the water. Forty-eight nurseries will be installed within two marinas at each site with the view to rolling out to further marinas. Marina pontoons allow easy access to oysters and will form the basis of Wild Oysters community outreach programme.

Seabed restoration: Oysters need a substrate of old shells or stones to anchor themselves and successfully grow. Due to hundreds of years of exploitation, the vast majority of existing oyster reef habitat has been destroyed. To help re-establish wild oyster beds, areas of seabed will be restored within each site. These restoration sites will be monitored annually.

The need for a Biosecurity Measures Plan
The Wild Oysters Project intends to restore oysters in each of the seabed locations through two activities:

- Translocation of native oysters to create broodstock reserves;
- Targeted introduction of 'cultch' (shells and gravels) to promote oyster settlement.

Restoration of native oysters through these methods carries inherent risks that must be considered seriously when planning and undertaking activities. The main risks posed by these activities are through the translocation of infectious shellfish diseases and the introduction of Invasive Non-Native Species (INNS).

The Wild Oysters Project recognises these two risks as major threats to biodiversity worldwide as well as locally at restoration sites. However, with appropriate biosecurity measures in place it is possible to restore native oysters safely and effectively.

This Biosecurity Measures Plan (BMP) has been developed in order to ensure all aspects of the project adhere to highest possible biosecurity standards. The BMP will also ensure that all aspects of the project adhere to national international regulation listed here:

Aquatic animal health:
The Aquatic Animal Health (England and Wales) Regulations 2009 which implement Council Directive 2006/88/EC (as amended) on animal health requirements for Aquatic animals and products thereof and the prevention and control of certain diseases in aquatic animals in Scotland.

Invasive non-native species:
- EU Directive 92/43/EC on the Conservation of Natural Habitats and of Wild Fauna and Flora (the Habitats Directive 1992)
- Wildlife and Countryside Act 1981 (England and Wales)
- Natural Environment and Rural Communities Act 2006 (England and Wales)

Guiding principals
The Wild Oysters Project Biosecurity Measures Plan is underpinned with a number of guiding principles to ensure all risks are minimised, these principles are; the Health status of Donor sites, and Biosecurity of Cultch.

Health status of Donor sites
The movement of live native oysters poses potential risks, as outlined in the section above. In order to reduce these risks, there are several criteria that the donor site (where oysters are being translocated from) must fulfil and a number of checks that need to be made prior to translocation.

Donor sites:
Donor sites must fulfil the following criteria:

All donor sites must be of equal or higher health status (with regards to notifiable shellfish diseases) than receiving sites.

Donor sites must not have high-risk invasive species present that are not present at the receiving site.

Where possible, donor populations will come from within the same body of water as the restoration site.

All donor sites to be agreed with the Fish Health Inspectorate prior to deployment.

Biosecurity of Cultch
The placement of large amounts of cultch poses significant biosecurity risk, however it is possible for these to be removed through best practice. Cultch will need to be certified as bio-secure prior to deployment.

Marine sources of cultch:
Cultch that has been sourced from the marine environment will need to be weathered to ensure that it is clean from any biological material that may pose a biosecurity risk.

Cultch will be weathered for a minimum of six months. During this time cultch will be turned to ensure that all cultch is exposed to UV and allow biological material to degrade. Cultch may, if possible, be cleaned to remove epibionts and any remaining flesh.

Before deployment, sub-samples of cultch will be taken and analysed to ensure all cultch is free from live biological material.

Clean sources of cultch
Some sources of cultch can be safely used without the need for weathering as they do not pose a biosecurity risk. These include sources of cultch such as gravels and shells that have previously been treated heat treated, such as cockle shell aggregates.

Biosecurity risk assessment

Risk assessment

The following table assesses the full risks posed by the project and the proposed mitigation to reduce the risks:

	Identified Risk	Probability (high/med./low)	Impact	Risk Limitation Measure
1	**Infectious agent transferred by movement of live shellfish onto site**	*High*	*High*	*Before introducing any shellfish discuss the condition and provenance of the stocks with the supplier. If there are any doubts do not introduce the shellfish.*
	As above			Review of the disease status and provenance of donor stock to ensure they are free from notifiable disease.
	As above			Visit the site of any proposed source of shellfish where possible to inspect the stock visually for any signs of disease/biosecurity measures carried out on donor site.
	As above			Do not accept batches of shellfish onto the site if they are showing signs of any infection or unaccounted mortality.
	As above			Batches of shellfish from different sites are to be kept separate from each other where possible.
	As above			Examine the stock on a regular basis. Stock health to be noted and records kept for inspection by relevant FHI. Remove mortalities (from nurseries) when they occur and dispose of in a way that does not increase the risk of spread of infection to other stock – disposed of on site where mortalities occur. Mortalities in each batch recorded and records kept.
	As above			Be aware of diseases that have serious implications for the operation and reputation of the business. For listed disease in O.edulis, they are susceptible to *Bonamia ostreae* and Marteilia refringens.
	As above			Record all shellfish movements to allow proper traceability onto and off site – these will be recorded in the prescribed format in the relevant FHI movement book.
	As above			If suspicion of ill health/disease withhold shellfish from sale/purchase until condition is diagnosed/cured
	Import of shellfish from abroad	High	High	Be aware of the provenance of the stock when buying from any supplier. Assess the potential quality of the shellfish by checking the supplier is operating to good biosecurity measures. Do not hesitate to ask for details of fish health surveillance programmes and disease records for the supplying site. All imported stock should be correctly health certified where appropriate. Always contact competent authority at least 5 working days in advance of imports from any new supplier – this enables the relevant Fish Health Inspectorate to help identify any possible problems with the intended shipment.
2	**Invasive Non-Native Species (INNS) transferred onto site by movement of shellfish**	High	High	Be aware of INNS present at source sites for oysters and whether they differ from those present at site of translocation
	As above			Check all oysters for the presence of INNS on surface of shell. Ensure all oysters are cleaned and have all biota removed from the surface at source site.
	As above			Make sure all equipment being used at both sites is cleaned at source site and dried to ensure any INNS are destroyed.
3	**Infectious Agent transferred to or from the site via water or equipment**	Medium	High	Equipment used to transfer shellfish to be specific for each holding unit or be disinfected after use.
	As above			Equipment and containers used to hold or transfer shellfish between sites to be disinfected prior to and after use.
4	**Change in environmental conditions**	High	High	Monitor conditions and do not transfer or grade shellfish at periods likely to be stressful.
	As above			Record details of observations in work diary and use these to inform future decisions.
5	**Awareness of current disease designations**	N/A	N/A	Keep up to date with current disease designations and conditions set out within them.

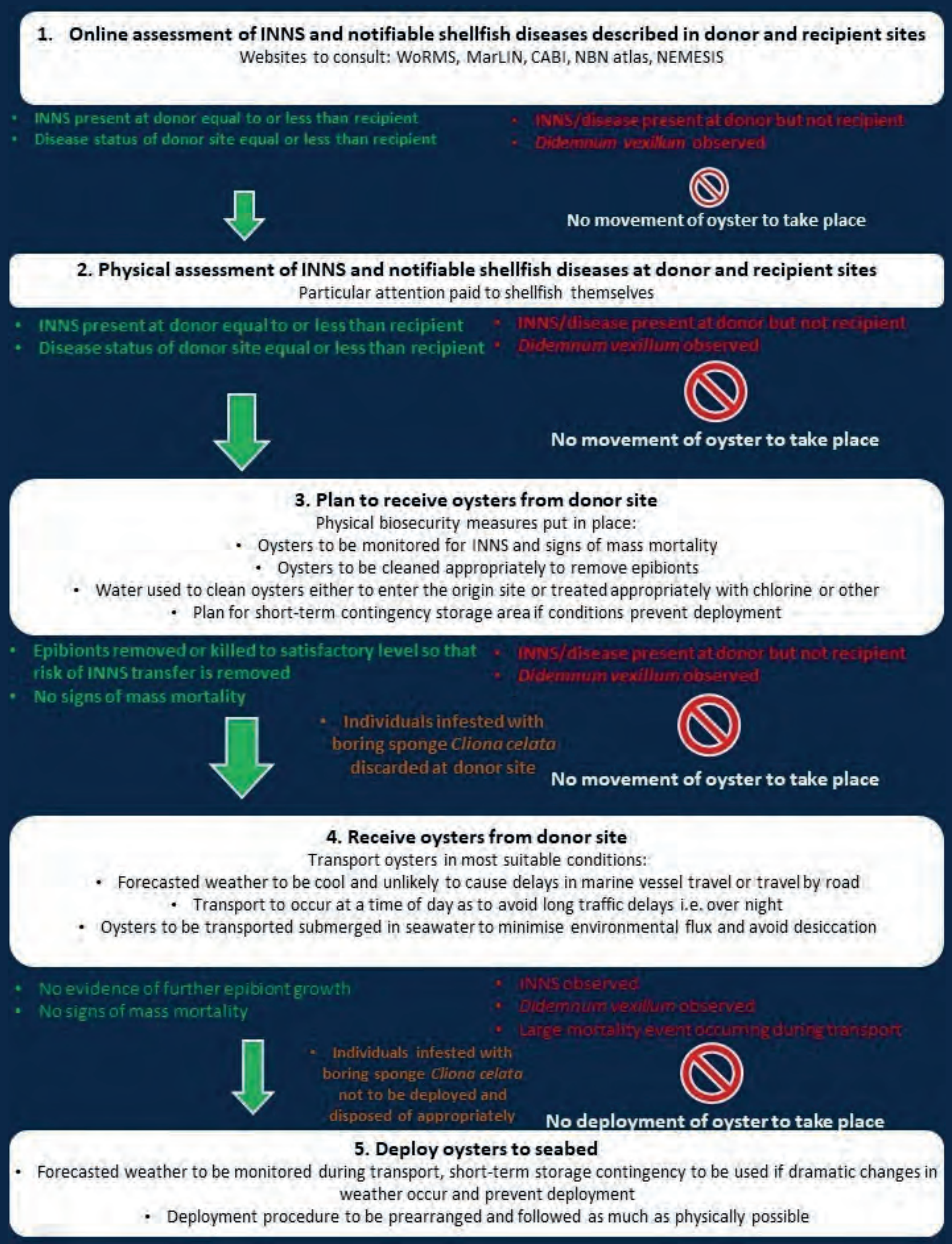
Monitoring the Plan

Stock health inspection	
Mortality levels in each batch or zone	Mortalities removed and recorded in work diary.
Results of health inspections	Keep all documents from competent authority in region we are working in, private consultants reports etc.
Shellfish movements on and off site	Record in movement books.
Shellfish movements within the site	Record details of grading or where batches are combined.
Disposal of waste	Responsible waste and (where appropriate) effluent water disposal.

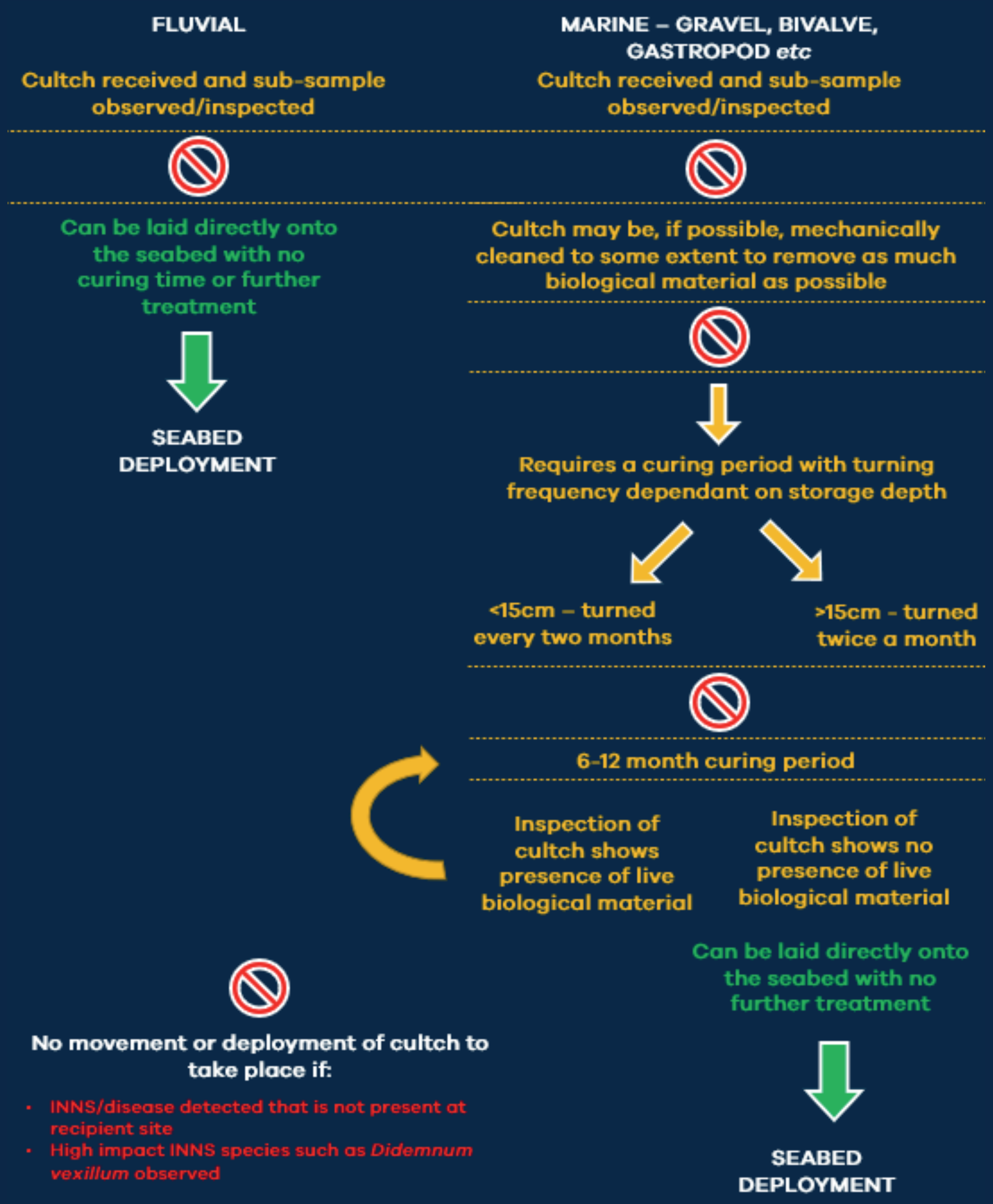
Actions to Take in the Event of Clinical Disease

Record	Action to Take
Inform Cefas	Inform competent authority in region you are working in.
Continuing unexplained mortality	Inform competent authority in region you are working in to arrange for disease screening.
Need to dispose of dead shellfish	Identify a suitable and legal way to dispose of waste from the site, try to avoid long-term storage of this material.

Biosecurity Measures Plan Schematic



1. Source and type of cultch

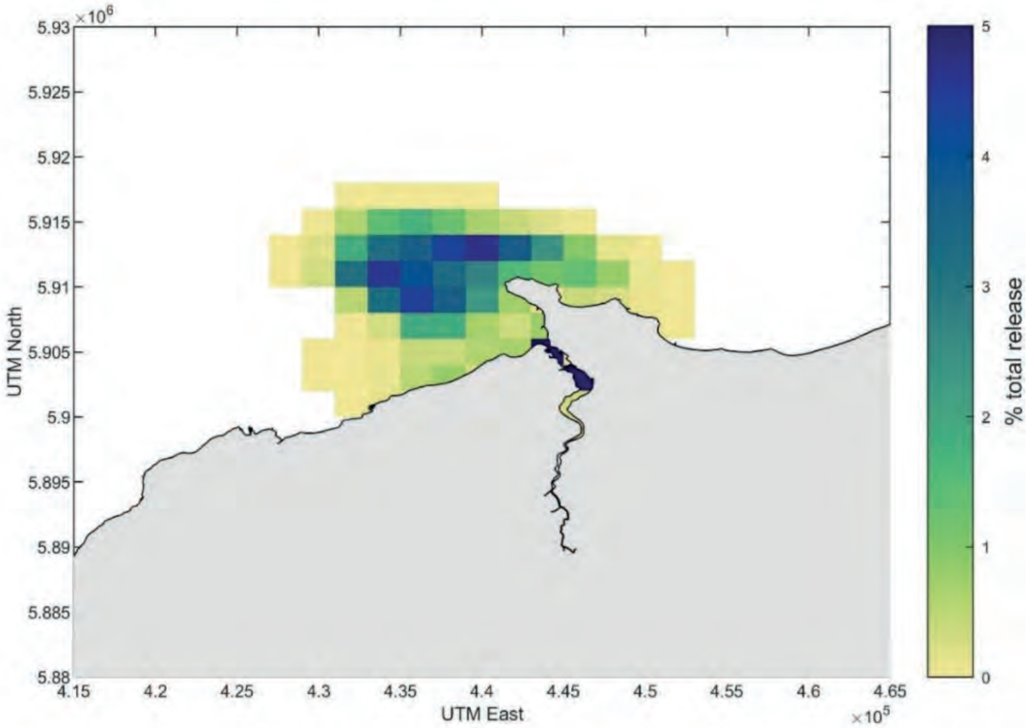


Appendix 2

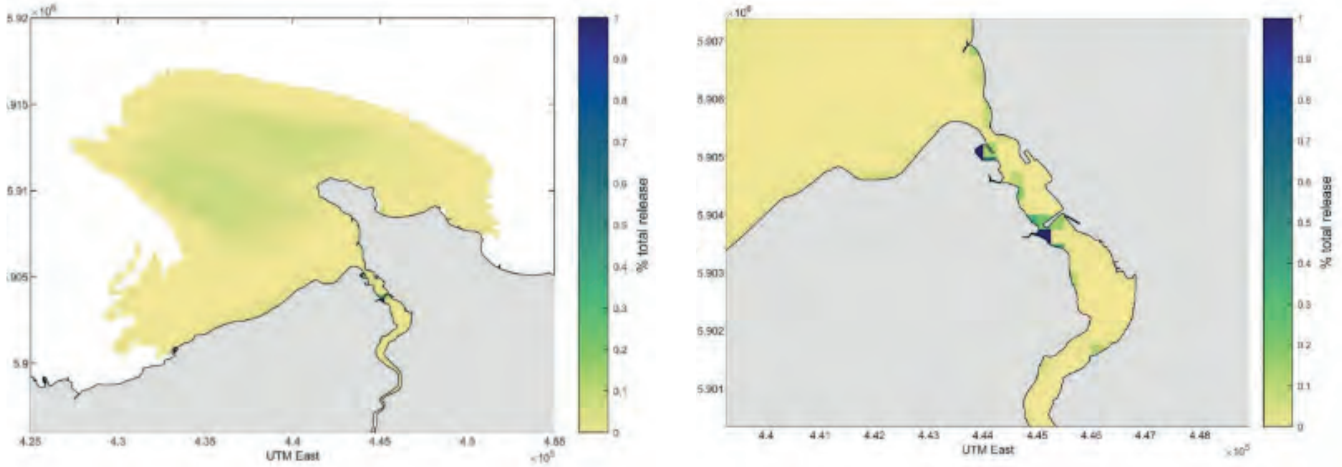
Larval Projection Models

Larval Projection Model Outputs for the Conwy Bay restoration hub

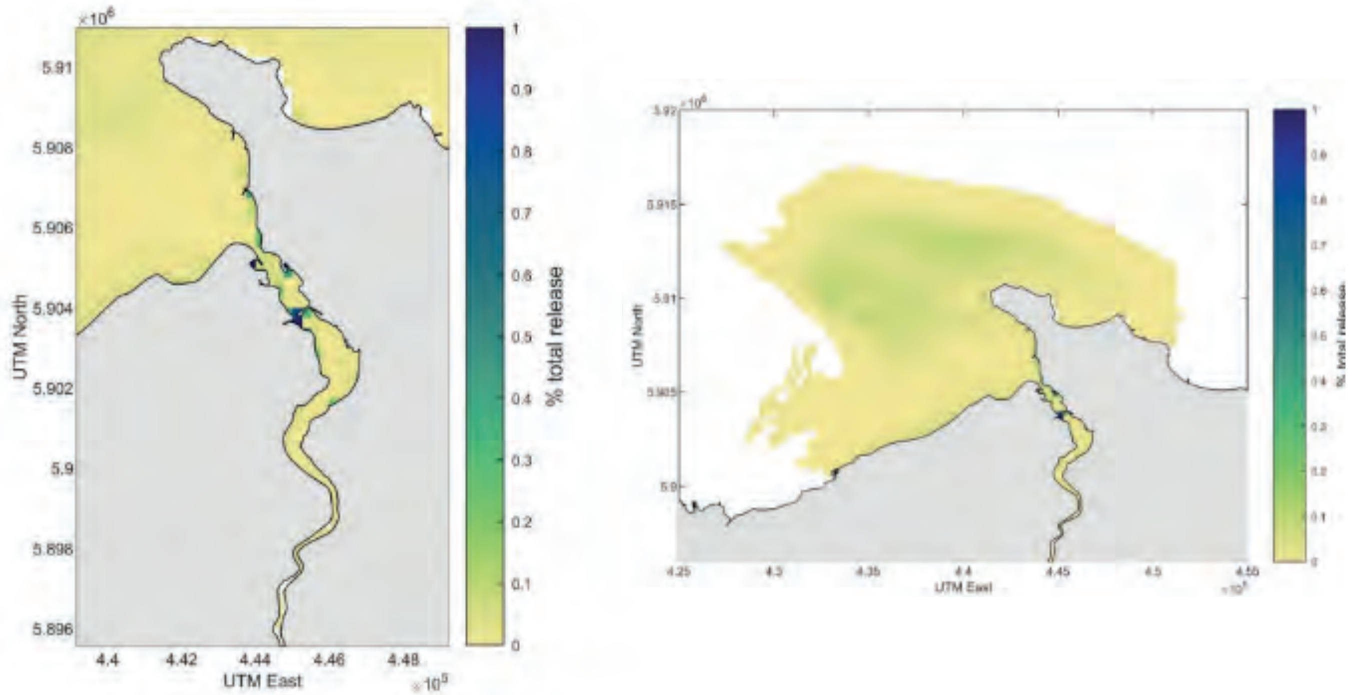
(from Hayden-Hughes *et al*., 2022)



Density of particle locations between 7-10 days (inclusive) from release, for all particles released in May-October, from both marina sites. The density has been gridded on a 2000 x 2000 m grid.

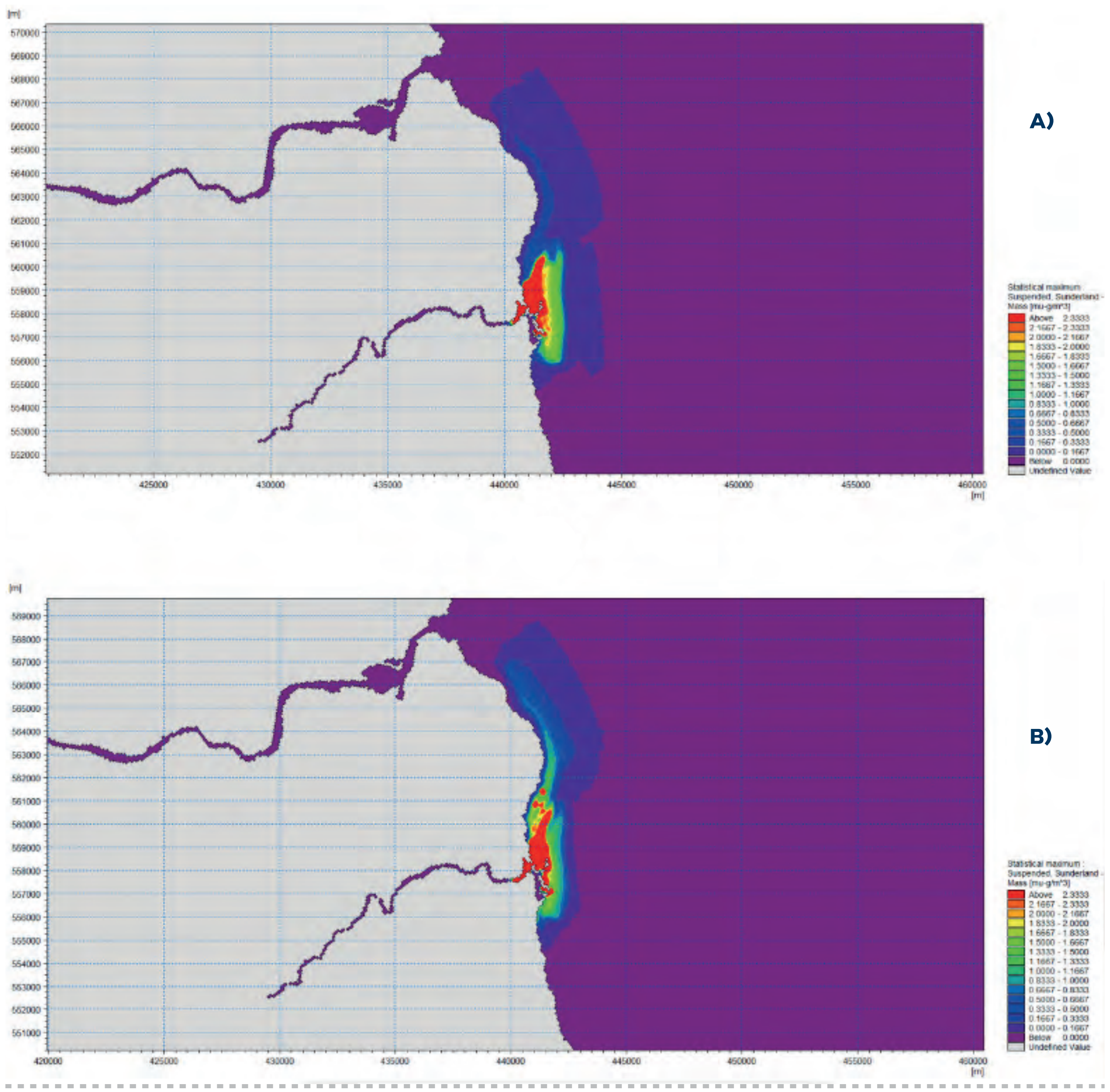


Density of particle locations between 7-10 days from release, for all releases in May-October from Conwy Marina only. Plotted on 250 x 250 m grid showing all dispersal (upper panel) and lower Conwy Estuary only (lower panel).

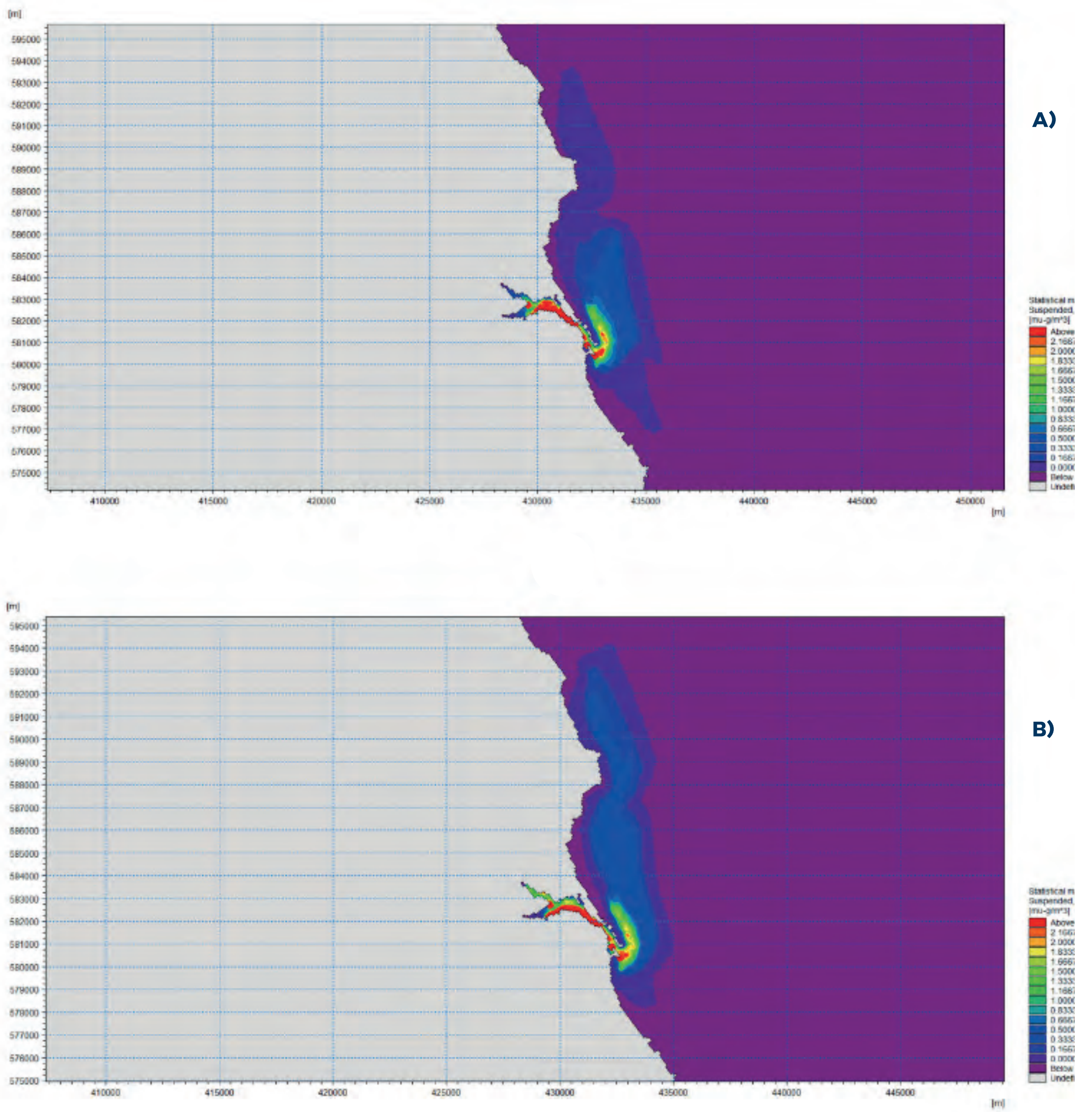


Density of particle locations between 7-10 days from release, for all releases in May-October from Deganwy Marina only. Plotted on 250 x 250 m grid showing all dispersal (upper panel) and lower Conwy Estuary only (lower panel).

Larval Projection Model Outputs for the Tyne and Wear restoration hub



Maximum concentration of suspended particles from Sunderland Marina with no settling velocity: a) Spring tide discharge; b) Neap tide discharge



Maximum concentration of suspended particles with no settling velocity from the Port of Blyth: a) Spring tide discharge; b) Neap tide discharge

Appendix 3

Score Based Site Selection Matrix

A sample of the score-based site selection is provided below. The data from the site selection survey work was set out and ranked for each of the sample points within the survey area. These scores were then combined to give a ranked score for each sample position. Areas of Medium Resemblance Stony Reef were disregarded. Areas that possessed many high scoring sample points in a tight cluster were then put forward as potential reef areas (figure 15 in the report).

Site	Abbey Rocks	Abbey Rocks	Abbey Rocks	Abbey Rocks	Abbey Rocks	Abbey Rocks
Station	A1	A2	A3	A4	A5	A6
Annex 1 Stoney reef	Low_Stony	Low_Stony	Low_Stony	Med_Stony	Low_Stony	NA
Score	3	3	3	1	3	5
Depth Estimate	1	7	2.5	4	3	7
Score	1	4	2	2	2	4
BSH	A5.1 Coarse Sediment	A5.1 Coarse Sediment	A5.1 Coarse Sediment	A5.4 Mixed Sediment	A5.4 Mixed Sediment	A5.3 Mud and Sandy Mud
Score	4	4	4	5	5	1
Textural Group Classification	Gravelly Sand	Gravel	Gravel	Muddy Gravel	Muddy Sandy Gravel	Muddy Sand
Score	4	5	5	4	3	1
Average Gravel content	16.6%	99.9%	86.7%	64.9%	56.3%	0.0%
Score	2	5	5	4	4	1
Average Mud content	2.6%	0.0%	0.3%	25.8%	6.3%	23.7%
Score	5.00	5.00	5.00	4.00	5.00	4.00
Average Sand content	80.8%	0.1%	13.0%	9.2%	37.4%	76.3%
Score	1.00	5.00	4.00	5.00	4.00	2.00
Total Score / 35	20	**31**	**28**	**25**	**26**	**18**

Score	1	2	3	4	5
Annex 1 Stoney reef	Med_Stony		Low_Stony		N/A
Depth	0.1 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	8.1+
BSH	A5.3 Mud and Sandy Mud	A5.2 Sand and Muddy Sand		A5.1 Coarse Sediment	A5.4 Mixed Sediment
Textural group classification	Muddy Sand	Slightly Gravelly Muddy Sand, Slightly Gravelly Sand	Muddy Sandy Gravel	Gravelly Sand, Muddy Gravel	Gravel

Station scores ranked

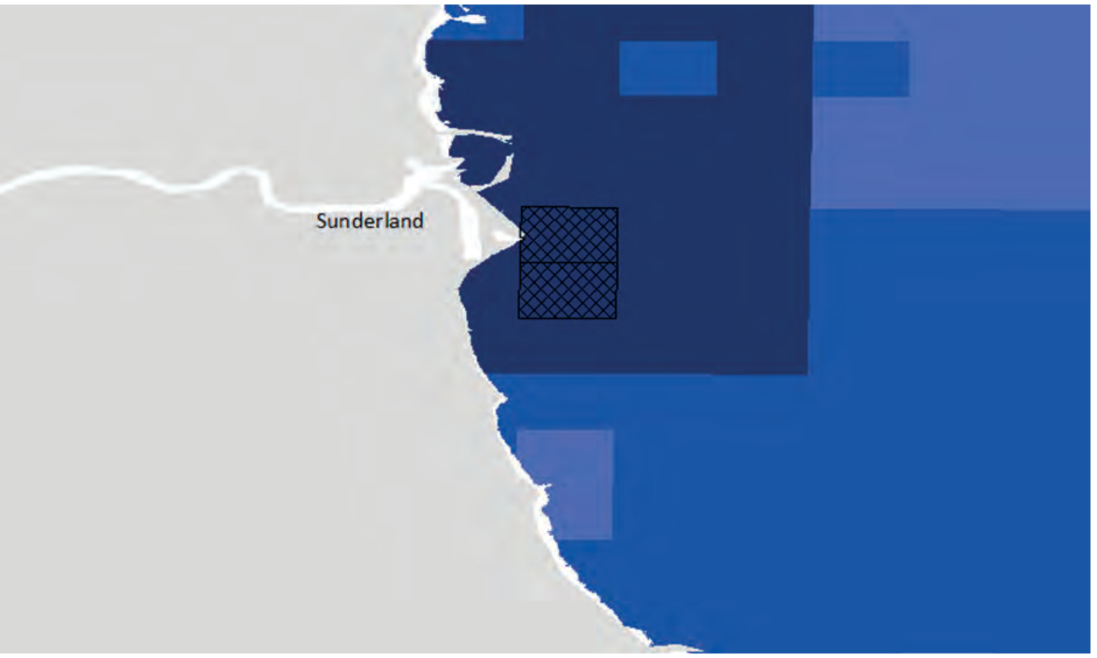
Note- Red highlighted stations were excluded from selection as these sites were indicated as sites of potential medium resemblance stony reef.

Site	Station	Total Score / 35
Abbey Rocks	A2	**31.00**
West Bwrling Rock	WB1	**30.00**
West Bwrling Rock	WB2	**30.00**
Bwrlingau Rock	B1	**29.00**
Bwrlingau Rock	B5	**29.00**
Abbey Rocks	A3	**28.00**
West Bwrling Rock	WB4	**28.00**
Bwrlingau Rock	B4	**27.00**
Abbey Rocks	A5	**26.00**
Abbey Rocks	A4	**25.00**
Bwrlingau Rock	B6	**21.00**
Bwrlingau Rock	B7	**21.00**
West Bwrling Rock	WB7	**21.00**
Abbey Rocks	A1	**20.00**
Bwrlingau Rock	B8	**20.00**
Bwrlingau Rock	B9	**20.00**
Bwrlingau Rock	B10	**20.00**
Abbey Rocks	A6	**18.00**
Bwrlingau Rock	B2	**18.00**
Abbey Rocks	A7	**17.00**
Abbey Rocks	A8	**17.00**
Abbey Rocks	A9	**17.00**
West Bwrling Rock	WB3	**17.00**
West Bwrling Rock	WB5	**17.00**
West Bwrling Rock	WB6	**17.00**
West Bwrling Rock	WB8	**17.00**
West Bwrling Rock	WB9	**17.00**
West Bwrling Rock	WB10	**17.00**
Abbey Rocks	A10	**16.00**
Bwrlingau Rock	B3	**3.00**

Appendix 4

T&W Inshore Site Selection Maps

Site Suitability Model



Site Suitability Model for the inshore area considered for the Tyne and Wear reef. Darker areas depict more favorable areas. This map is an amalgamation of the four parameters shown individually below (Shipwreck presence, substrate type, larval dispersal and vessel density). The hashed areas show the areas initially suggested but after further video analysis of the wider area, a new plot to the north (Figure 22 in the seabed report) was selected.

Shipwrecks data

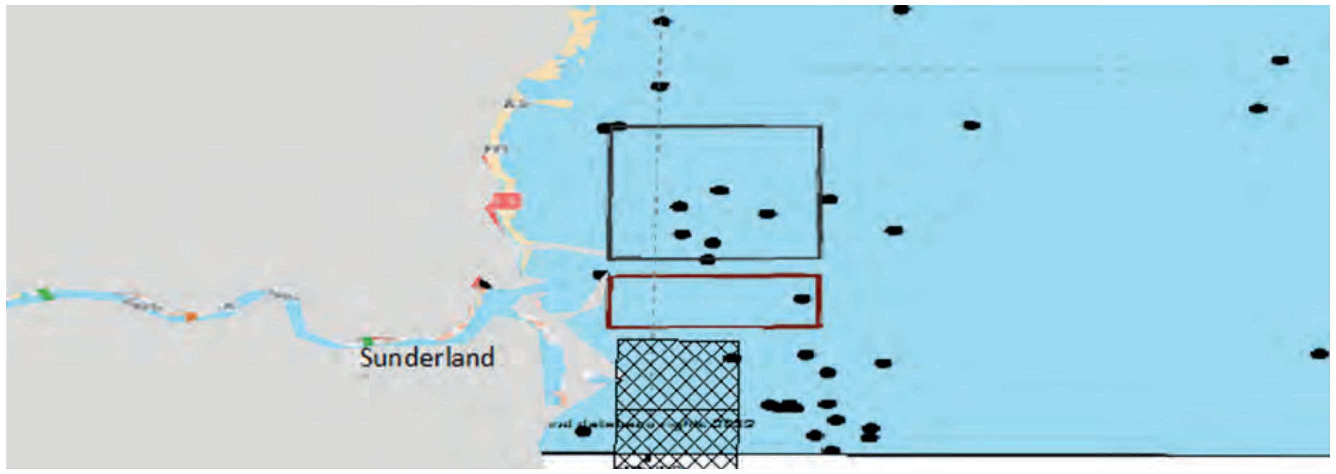
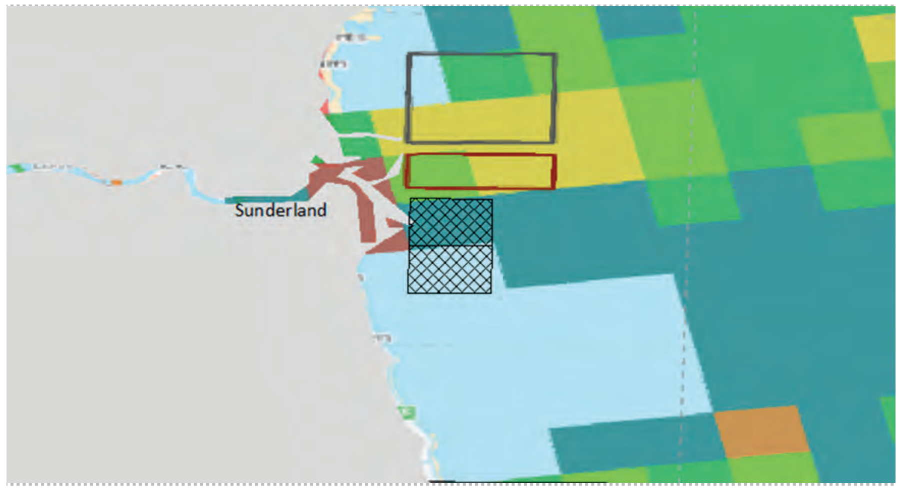


Figure showing the shipwreck locations which might require buffers from restoration activity. The hashed boxed were the original suggested inshore sites that were superseded by the two larger rectangles following video survey work.

Vessel Density data



Recorded vessel density in the inshore site. Blue, cold colours depict the lowest traffic, and warmer colours depict a greater density of vessel presence.

Substrate maps

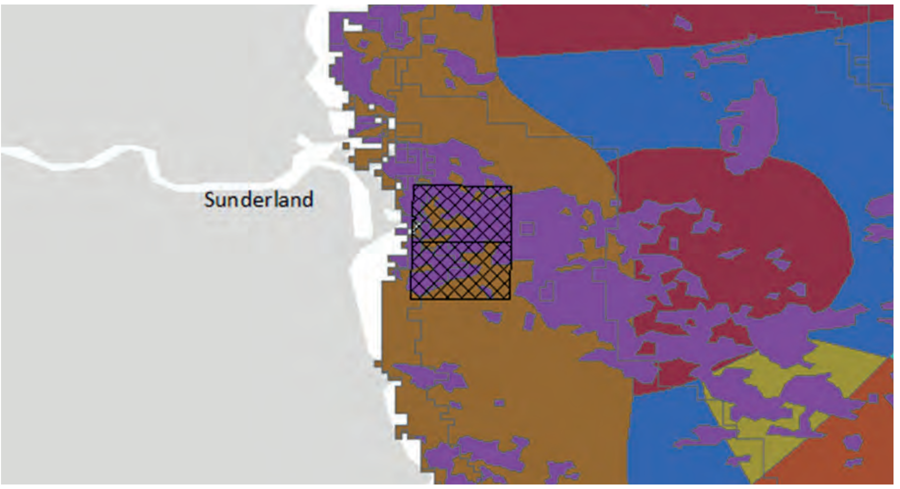


Figure showing the substrate type in the inshore scoping area. Purple and brown areas are rocky hard substrates and were considered suitable for restoration work.

Larval Plume

Figure depicting the model larval plume from the Sunderland marina site in the orange hashed area.

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