

#NNF2 Restoring Wild Oysters to Conwy Bay: Technical Report on Oyster Monitoring and Habitat Restoration

2023-2025



Cover Image: Volunteer monitoring oyster nursery and hands holding native oysters ©
Rhianna Parry

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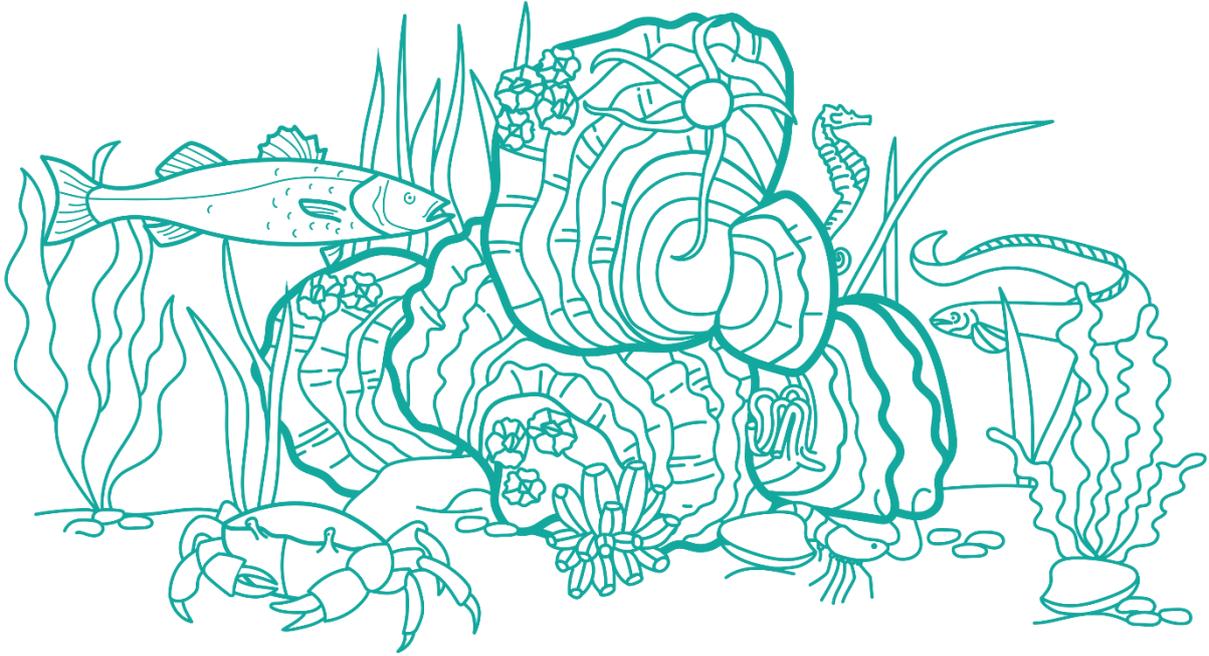
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Acknowledgements

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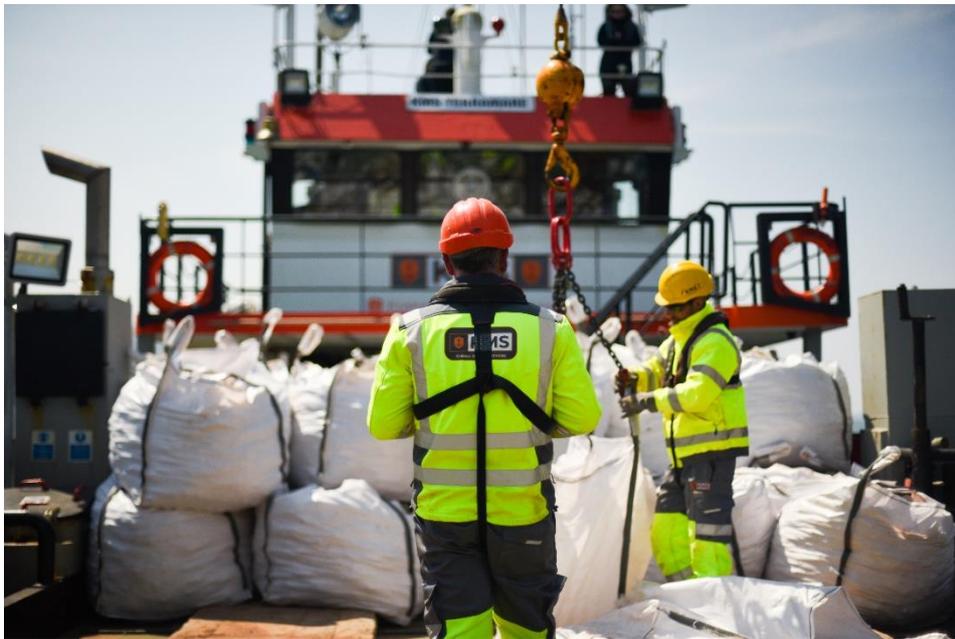
Funder

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Loading vessel for seabed deployment © Lucie Machin

Executive Summary

Native oyster (*Ostrea edulis*) reefs were once widespread around the British Isles and Europe but have declined by ~95% since the mid-19th century. There were once productive native oyster reefs in North Wales in the 18th and 19th centuries, however,

there are now no longer any wild populations remaining. The loss of this habitat has resulted in loss of biodiversity, ecosystem services, and cultural heritage.

This report provides an overview of the Restoring Wild Oysters to Conwy Bay Project (April 2023–August 2025), a two-year collaboration between the Zoological Society of London (ZSL) and Bangor University, funded through the Nature Networks Fund (NNF2). The project aimed to restore native oyster populations to Conwy Bay, while advancing research and strengthening local engagement. The project builds on the foundations of the previous Wild Oysters Project: Conwy Bay (2020–2023), by seeking to scale up native oyster restoration activity, expanding public outreach, and furthering the citizen science volunteer monitoring of oyster nurseries.

The project successfully delivered the first native oyster habitat restoration trial of its kind in North Wales, with the targeted deployment of 45m³ (20 tonnes) of cultch and 2,000 mature oysters at the restoration site. The oyster nurseries located in Conwy and Deganwy marinas continued to play a key research and engagement role, training more than 185 new citizen scientists to monitor them, generating insightful information on oyster survival, reproduction, biodiversity, and ecosystem services.

High survivorship of oysters, the presence of critically endangered species, and increasing taxa associated with mature successional stages highlight the potential of oyster nurseries as a restoration tool. Distinct seasonality in taxa, limited oyster shell growth and changes in oyster spawning are likely affected by environmental conditions, including marina dredging operations. Seabed surveys using multibeam echosounder, and imaging from dropdown video and BRUVs, allow for continue monitoring of the restored site.

The project generated important lessons for future restoration. Early engagement with regulators and timely marine licence applications, accounting additional time for responding to open consultation feedback, are critical, as is sustained dialogue with fishers and local players to build trust, support and incorporate valuable insights into the project. Careful planning is required for the storage, transportation, and deployment of cultch, as the logistical demands of handling large volumes should not be underestimated. Furthermore, the project highlighted the value of funder flexibility, adaptive management, and strong local partnerships.

This report presents the project's development, oyster nursery monitoring results, restoration activities, monitoring programme, results, and key lessons. By capturing both the practical experiences and scientific evidence generated, it provides a foundation to guide future restoration in Conwy Bay and contribute to national knowledge in the field.



Native oyster that has undergone biosecurity cleaning process, ready for deployment into oyster nurseries in Conwy Marina © Zoological Society of London.

1. Introduction

1.1 Native Oyster Restoration

The native oyster, or the European flat oyster (*Ostrea edulis*), is a temperate bivalve species, which settles on hard substrate, such as rock or shell [1]. When present in high densities, native oysters act as ecosystem engineers, forming complex, three dimensional biogenic reefs [2].

These reefs provide important sheltering, feeding, and nursery habitat for a variety of marine species, including commercially valuable fish species [3] They also deliver ecosystem services (Fig. 1) which are vital for environmental and human wellbeing [4]. These include coastal protection through slowing wave and storm surge energy, improved water quality and clarity through the oyster's filter feeding efficiency and contributing to blue carbon cycling [5, 6, 7].

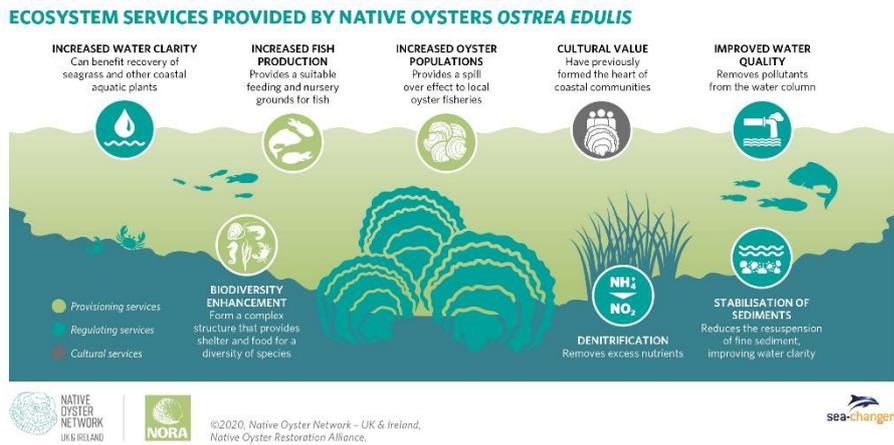


Figure 1. Infographic illustrating the ecosystem services provided by native (Native Oyster Network – UK & Ireland; Native Oyster Restoration Alliance, 2020) © Native Oyster Network – UK & Ireland / NORA.

Historically, native oyster reefs were widespread and abundant around the British Isles and across Europe, commonly associated with estuaries, bays, sheltered inlets, sea locks/loughs/fjords and coastal open seas. Historical populations had an average reef size of 30ha [8]. Since the mid-19th century, native oyster reefs have declined by approximately 95% [9], with the ecosystem recently classed as functionally collapsed under the IUCN Red List of Ecosystems Framework [10]. Despite this severe decline, remnant populations remain in parts of Wales, including in Milford Haven and Swansea Bay [11].

The key drivers that have contributed to the decline in native oyster populations, include a combination of disease, poor water quality, habitat loss, historic overfishing, and competition with invasive non-native species [12,13,14, 15, 16, 17]. Given their significant decline and ongoing threats, restoring native oyster habitat is required to increase habitat extent and connectivity, contributing towards restored ecosystem function and delivery of ecological and societal benefits to coastal waters.

1.1.1 North Wales context

Wales was once renowned for its thriving oyster fisheries, with records showing that Welsh boats landed up to 8,000 oysters daily in the mid-18th century and, in some areas, 15,000–20,000 oysters per day in the mid-1800s [11]. Today, there are two active native oyster restoration initiatives in Wales; 1) the #NNF2 Restoring Wild Oysters to Conwy Bay in North Wales and 2) Natur am Byth activities in Pembrokeshire’s Milford Haven Waterway. Conwy Bay and areas near the River Conwy – including Puffin Island, Anglesey, and the Menai Strait – historically supported productive native oyster beds in the 18th and 19th centuries [11]. Archaeological evidence of oyster shells on the Great Orme dating to the Neolithic and Bronze Age reinforces the species’ long-term regional presence. Conwy’s historical significance is further underlined by shellfish research conducted at the former Fisheries Station in Conwy until its closure in 1999 (Fig. 2).

Experimental trials included the use of lime-coated tiles for larval settlement and investigation into alternative species such as *Ostrea chilensis* and *Crassostrea virginica* [18].

Today, Conwy Bay remains an important shellfish fishing ground, particularly for mussels, lobsters, and crabs, contributing to the local economy and coastal livelihoods. Conwy Bay also lies within the Menai Strait and Conwy Bay Special Area of Conservation [20].



Figure 2. Historical oyster cultivation in North Wales: 1) Building the oyster cultivation tanks at Conwy, 1921, 2) Workers wiring tiles to make bouquets for oyster cultivation, 1921, 3/4) Oyster cultivation at Tal y Foel, Menai Strait, 1960s [19]. © Conwy Archive Service



Project Research Lead, Maria Hayden-Hughes, monitoring oyster nurseries at Conwy Marina. © Zoological Society of London.

1.2 Project Background

The #NNF2 Restoring Wild Oysters to Conwy Bay Project is a two-year collaboration (April 2023–August 2025) between the Zoological Society of London (ZSL) and Bangor

University, funded through the Nature Networks Fund (NNF2). The project continues from The Wild Oysters Project: Conwy Bay (2020–2023; People’s Postcode Lottery funding), which installed oyster nurseries suspended under marina pontoons in Conwy and Deganwy marinas (Fig. 3). The oyster nurseries act as micro-habitats, containing mature native oysters that reproduce and release larvae into the wider Conwy Estuary, while serving as a hands-on engagement tool for local volunteers, schools and community groups.

In 2020, a Local Working Group was established with key representatives (including the Local Conwy Harbour Authority, Natural Resources Wales, Conwy Mussels Co., North Wales Wildlife Trust) to guide project development. A Technical Working Group also met to review site selection and restoration methods. The site selection for the seabed restoration activities, combined desk-based assessment, larval dispersal modelling, and surveys to identify suitable locations for restoration [21]. The desk-based study drew upon seabed habitat maps, substrate composition, water quality data, hydrodynamic data, and available fishing activity data, to narrow down potential areas. Larval dispersal modelling was completed by Bangor University, used to predict potential oyster larvae dispersal. Sites where modelling suggested poor larval retention or limited connectivity were deprioritised, as were those with unsuitable substrate, poor environmental conditions.

The shortlisted sites were validated through groundtruthing, including drop-down video to confirm seabed type and complexity, grab samples for sediment analysis and biodiversity were also completed. Each site was reviewed for substrate suitability, recruitment potential, and accessibility for deployment and monitoring.

The Technical Working Group agreed a reef footprint of 75 × 100 m (7,500 m²) within the Conwy Bay Special Area of Conservation. This location, situated approximately 2 km offshore and within the wider licensed area, was chosen for its suitable geology, conservation value, and low predicted impact on surrounding habitats. In June 2023, the deployment of 650 tonnes of locally sourced gravel was deployed to create suitable settlement habitat. A post-deployment survey revealed uneven gravel distribution, including some peaked areas, which delayed the planned addition of the weathered shell “cultch” and the release of oysters until June 2025.

Further information on post-deployment actions and next steps is provided in section Seabed Restoration. In April 2023, we successfully secured funding from the Nature Networks Fund (round two) to continue to build upon and advance the activities of the previous project.



Conwy river and estuary © Maria Hayden-Hughes

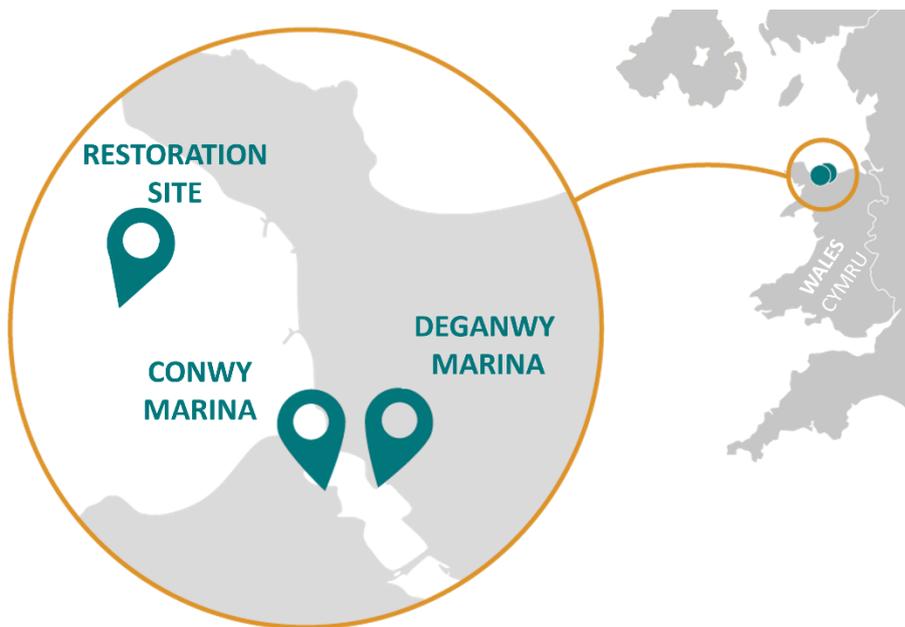


Figure 3. Map of Conwy Bay restoration hub in North Wales indicating the location of Conwy Marina, Deganwy Marina and the seabed restoration site.

1.3 Project Goals

The #NNF2 Restoring Wild Oysters to Conwy Bay Project set out to achieve the following goals:

Goal 1: To improve the condition of native oyster habitat in Conwy Bay, and feed project research and knowledge into national native oyster restoration efforts.

- Conduct surveys to monitor the native oyster restoration trial site.

- Continue biodiversity monitoring to better understand the ecological communities associated with native oyster reefs.
- Consult the local working group to scope and develop the oyster restoration trial.
- Scale up the native oyster restoration trial site, by deploying 10,000 mature native oysters onto the seabed.
- Produce and disseminate a scientific monitoring report summarising restoration activities, findings, and lessons learned—sharing these with the national and European native oyster restoration community.

Goal 2: To support the long-term future of restored oyster beds by engaging a broader range of local people with the cultural and ecological heritage of oysters in Conwy Bay.

For more information about the project’s public engagement and education results (Goal 2) please refer to the report *#NNF2 Restoring Wild Oysters to Conwy Bay: Celebrating Community Engagement, Education and Culture 2023–2025* [22].

*Table 1. Headline results tracked against Key Performance Indicators (KPI) for the impact of the Conwy Bay restoration hub between the dates of April 2023 to August 2025. * The deployment of clutch and oysters within the timeframe of the project was limited by marine licensing requirements which were resolved in spring 2025, further details below.*

	Category	KPI	Results
Goal 1	Scale up existing oyster reef habitat restoration activities	Deploy 100 tonnes of cultch and release 10,000 mature oysters	Deployment of 20 tonnes of cultch and 2,000 oysters*
Goal 2	Number of students reached with the delivery of educational outreach/ learning modules	3,000 students	3,060 students

Goal 2	Training of citizen scientists in native oyster restoration and monitoring	60 volunteers	185 new and 118 returning volunteers = 303 total, contributing 1,460+ hours
Goal 2	Engagement of the general public during the project	10,000 people	11,280 people



Sand art installation created during Autumn Oyster Fest: Family Fun Day, October 2024, Conwy Morfa Beach. © Soul-2-Sand.

2. Oyster Nurseries

An oyster nursery is a micro-habitat containing mature oysters which will reproduce and release oyster larvae (Fig. 4). Each nursery held between 27 to 54 oysters, with a total of 48 nurseries across both marina sites. Between April 2023 and May 2025, an estimated 2,435 oysters were housed in oyster nurseries across Conwy and Deganwy marinas.

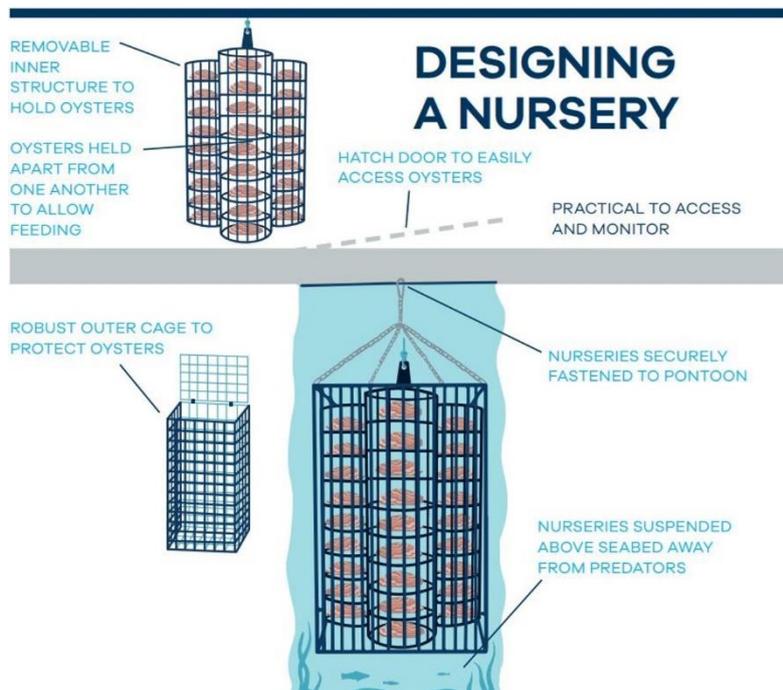


Figure 4. Schematic of the oyster nursery design, structure and installation under the marina pontoon adapted from [23]. © Blue Marine Foundation.

Conwy Bay is within a confirmed designation for the shellfish disease *Bonamia ostreae* (CD05/2015 v2 Anglesey and Caernarfonshire). When sourcing oysters for the nurseries, it was not possible to utilise any genetic resistance and adaptations by using locally sourced broodstock as *Ostrea edulis* was completely absent in North Wales. It was advised by the Cefas Fish Health Inspectorate to use certified disease-free stock. Therefore, oysters were sourced from Loch Ryan in Scotland to ensure there was minimal risk of the spread of disease.

With support from volunteers, oyster health and the associated species in the nurseries were monitored monthly year-round and weekly in summer to assess oyster reproduction.

This helped confirm the suitability of marina sites as larval sources and informed wider restoration efforts in Conwy Bay. Monitoring also aimed to understand ecosystem services, such as improved water quality through oyster filtration and increased biodiversity through mobile fauna surveys.

The following sections report the results from monitoring of the oyster nurseries to better understand:

- 1) Oyster survival and shell growth
- 2) Oyster reproduction
- 3) Water filtration
- 4) Biodiversity of fauna



Clockwise from top: Oyster nursery monitoring session with volunteers © Rhianna Parry; oyster nursery suspended below the marina pontoon; and being retrieved from the water © ZSL

2.1 Oyster survival and shell growth

2.1.1 Data Collection

Supported by volunteers, monthly oyster mortality monitoring began in April 2021 and is ongoing. Each nursery was visually inspected, with non-responsive, gaping oysters recorded as dead and removed. Mortality spikes may signal stress from disease, environmental changes, or limited food availability. Regular survival monitoring is required by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) as part of holding certification [23].

Nurseries were restocked each April with mature broodstock under strict biosecurity measures, see Appendix 1 [21]. Where possible, oysters from the same cohort were kept together to track mortality during acclimatisation.

Shell growth was also assessed as a non-lethal measure of productivity and environmental suitability. Growth typically occurs during summer in response to increased phytoplankton and suspended particulate matter. Photographs of a subsample of oysters were taken annually each May, using pre-marked backgrounds for scale and identification. Images were analysed with BIIGLE and ImageJ to measure shell length, width, and area (Fig. 5).

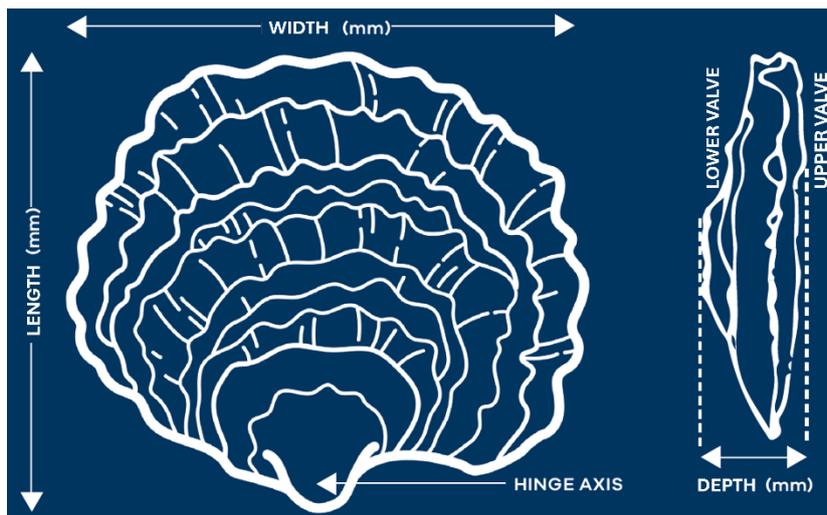


Figure 5. Diagram of oyster shell dimensions; shell length, width and depth, adapted from [23]. © Blue Marine Foundation.

Statistical analysis

Seasonal and spatial effects on oyster mortality were analysed using a two-way ANOVA to test for differences based on season (spring, summer, autumn, winter) and marina location (Conwy or Deganwy). Where significant, post-hoc Tukey HSD tests identified differences between groups.

Oyster growth was assessed over four years (2021–2025) using measurements from a subsample of 100 oysters from the original 2021 cohort. Shell dimensions were tracked annually and plotted over time. ANOVA was used to test for differences in shell length, width, and area by year, followed by Tukey HSD for pairwise comparisons where relevant.

2.1.2 Results

Oyster survival

Monthly mortality rates were plotted over time to assess seasonal trends. Overall survival was high, averaging 83% across both marinas during the #NNF2 project. Mortality was higher in summer, with Conwy Marina showing notably increased rates during the summers of 2022–2024 (Fig. 6, 7).

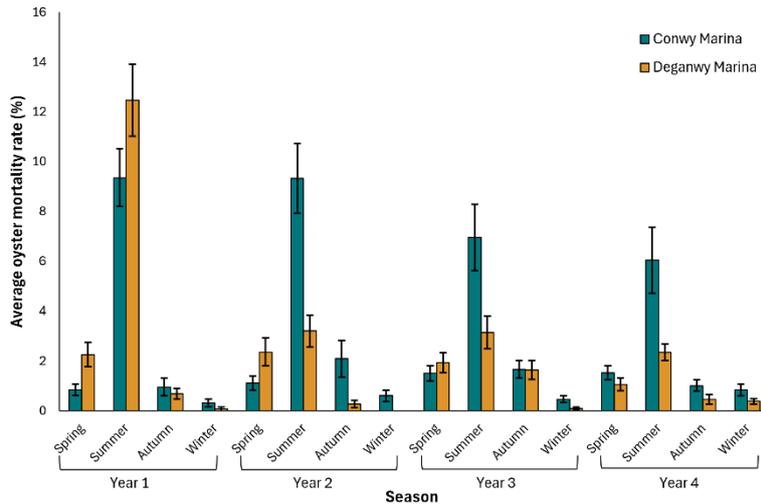


Figure 6. Seasonal average mortality rate (%) ± 1SE for Conwy Marina (green) and Deganwy Marina (yellow) since the oyster nurseries were deployed in April 2021 to March 2025. Season period was classified as: Spring= April–June; Summer= July–September; Autumn= October–December; Winter= January–March.

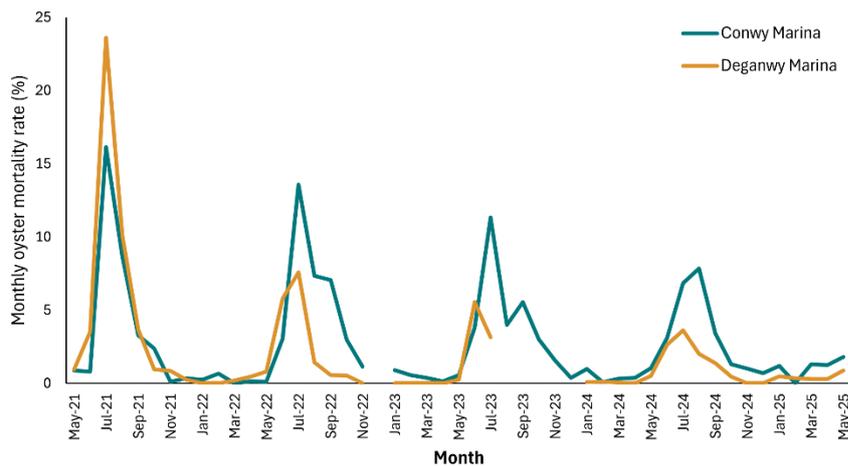


Figure 7. Monthly average mortality rate (%) for Conwy Marina (green) and Deganwy Marina (yellow) since the oyster nurseries were deployed in April 2021 to May 2025. Gaps in the data are due to circumstances that have prevented data collection (i.e. adverse weather conditions).

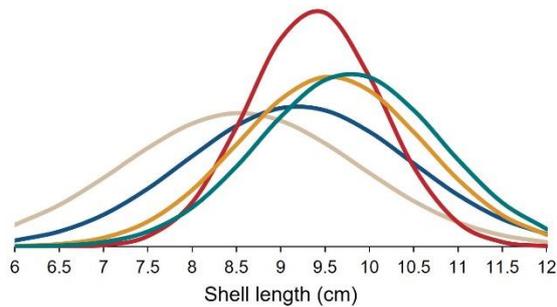
There was a statically significant interaction between the effects of season and marina location on oyster mortality, $F(3, 24) = 4.145$, $p = 0.0168$). Post-hoc testing showed that oyster mortality rate during the summer was significantly different between Conwy Marina and Deganwy Marina ($p = 0.007$). There were no differences in oyster mortality between the locations during the other seasons ($p > 0.05$).

Shell growth

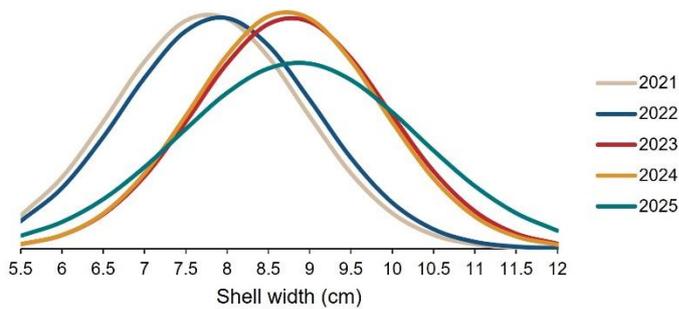
Shell measurement data indicated oyster growth over the four-year monitoring period: May 2021–May 2025 (Fig. 8, 9). There was a statistically significant difference in shell

length between years as determined by one-way ANOVA ($F(4,75) = 2.551, p=0.046$). A Tukey post hoc test determined that shell length was significantly different between 2021 (8.54 ± 0.42 cm) and 2025 (9.79 ± 0.23 cm), $p= 0.025$. No significance was found between other years ($p>0.05$). There was not a statistically significant difference between years for shell width ($F(4,75) = 2.259, p=0.071$), or shell area ($F(4,75) = 1.305, p=0.276$).

A)



B)



C)

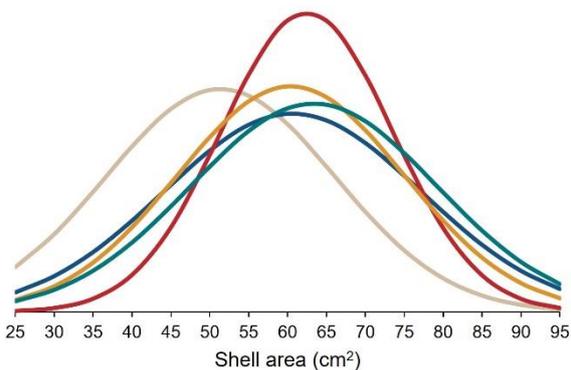


Figure 8. Normal distribution curves of shell dimension measurements taken in May from 2021 to 2025 (n= 100 images): a) shell length (cm), b) shell width (cm), and c) shell area (cm²).

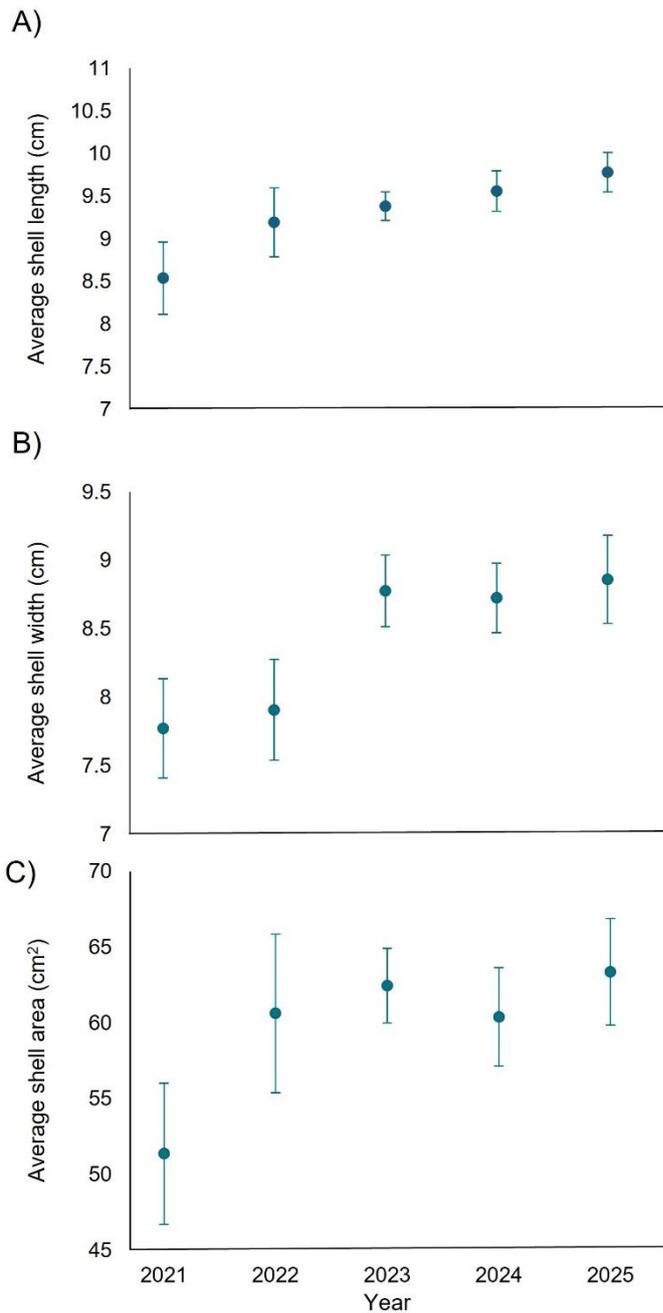


Figure 9. Average oyster shell dimension measurements taken in May from 2021 to 2025 ($n = 100$ images): a) shell length (cm), b) shell width (cm), and c) shell area (cm²).

2.1.3 Discussion

Overall oyster survival in the marinas was high, though clear seasonal variation was observed, with peak mortality during summer, aligning with the spawning season. During this time, oysters invest energy into reproduction [24], making them more vulnerable to stress. While *O. edulis* can tolerate temperature changes [25], combined stressors of spawning and abiotic factors such as temperature shifts, salinity changes, and food availability, can increase mortality [26]. High mortality in summer 2021 likely reflected acclimation after initial stocking. Conwy Marina showed higher summer

mortality from 2022–2025, coinciding with spawning monitoring, which may have contributed to stress despite careful sampling.

Shell growth of adult oysters was estimated to be 0.3–0.6 cm/year [27]. In Conwy Marina, growth ranged from 0.18–0.66 cm/year. Limited growth in the nurseries suggests suboptimal environmental conditions, such as low food availability, sediment levels, or restricted water flow. Dredging to maintain marina depth may have increased suspended particulate matter (SPM), reducing feeding efficiency. While oysters can tolerate short spikes in SPM, prolonged exposure above 60 mg/l hinders growth [28, 29]. Additionally, marina gates close for around 12 hours daily, restricting water exchange and food supply. Chlorophyll levels >0.5 µg/l are needed for growth [28, 30, 31]. Despite these challenges, the low mortality rates and some shell growth recorded in the marinas over the past 4 years were an encouraging sign for wider restoration efforts in Conwy Bay.

2.2 Oyster Reproduction

2.2.1 Data Collection

Spawning was monitored at Conwy Marina each summer from 2022 to 2025 (ongoing). Weekly, a random subsample of at least 20 oysters was non-lethally anaesthetised using a 5% magnesium chloride (MgCl₂) solution to relax the abductor muscles which hold the oyster shell closed [32]. The internal cavity was checked for larvae, and development stages were identified by colour; newly fertilized eggs or embryos known as ‘white sick’, early stage trochophores as ‘grey sick’, and completely developed Veliger ‘D’ larvae as ‘black sick’ prior to broadcast release [33] (Fig. 10).

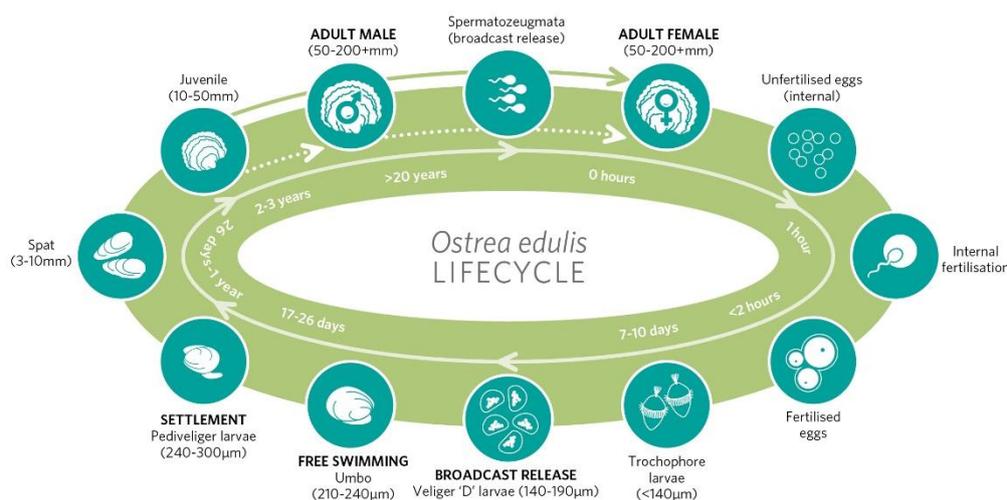


Figure 10. Life cycle of *Ostrea edulis* [29], adapted from [13].

Spat and juvenile oysters were observed settling on broodstock shells, with some forming clusters known as ‘Cloks’ (three or more joined oysters), an early-stage reef

formation [34,35]. In March 2024, settlement was quantified, and oyster sizes recorded to estimate age classes and assess local recruitment.



Images of spawning monitoring to collect oyster larvae samples to measure abundance and an example of an oyster cluster known as a 'Clok' © Rhianna Parry.

Laboratory analysis

If present, larval samples were collected, preserved using Lugol's iodine and later analysed in the laboratory to estimate total fecundity and the number of larvae produced per oyster. Once preserved, 1ml was extracted and diluted in 999ml of water. A 1ml aliquot of this 1000ml solution was then placed on a Sedgewick rafter counting slide and all larvae were counted.

2.2.2 Results

Fecundity

Oysters were found brooding larvae earlier in consecutive years from 2022 to 2025. Larvae were first recorded on 9 June 2022, 1 June 2023, 24 May 2024 and 13 May 2025 in Conwy Marina. Larvae were observed in 14 per cent, 9.7 per cent and 4.7 per cent of oysters in the years 2022, 2023 and 2024 respectively. Sampling in 2025 is ongoing. The majority of larval samples collected were in the ‘white sick’ larval development stage (Fig. 11).

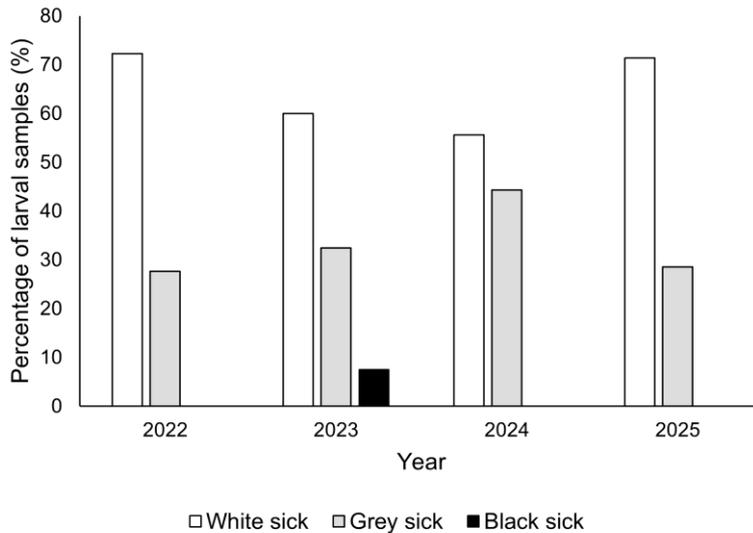


Figure 11. Percentage of larval samples at each development stages; ‘white sick’, ‘grey sick’, ‘black sick’, recorded at Conwy Marina during the spawning seasons in years 2022, 2023, 2024 and 2025 (ongoing).

Larval abundance varied between 22,500 to 6.1 million per oyster. The average number of larvae recorded has decreased in consecutive years with a reduction by 43% in 2024 when compared to 2022 (Fig. 12). Kruskal-Wallis H test showed there was a significant difference in the number of larvae brooded in Conwy Marina between 2022 to 2025, $\chi^2(3) = 8.9775$, $p = 0.029$ though post hoc pairwise comparisons failed to identify differences between individual years ($p \geq 0.05$).

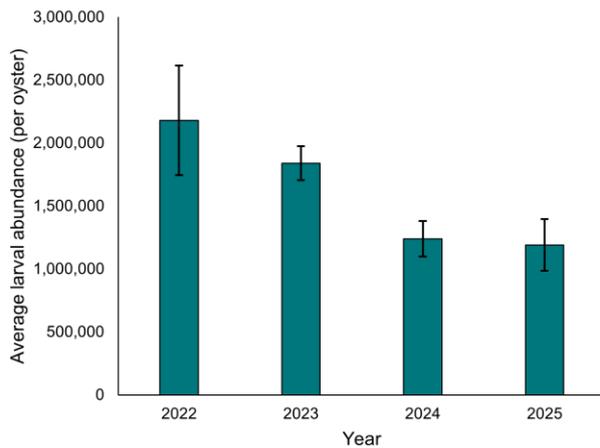


Figure 12. Average number of larvae per oyster ± 1SE at Conwy Marina recorded during the spawning seasons in years 2022, 2023, 2024 and 2025 (ongoing).

Results were extrapolated to estimate the annual percentage of spawning oysters from the total broodstock held in Conwy Marina. Utilising the proportion of oysters spawning in Conwy Marina it was estimated that the total number of larvae released from this location was 173 million larvae in 2022, 181 million larvae in 2023 and 62 million larvae in 2024. In Conwy Marina, approximately a total of 416 million larvae have been released during the spawning seasons between 2022 to 2024. Although monitoring of spawning did not take place in Deganwy Marina, it is expected that a similar number of larvae were released from that location based on the abundance and health of oyster populations.

In March 2024, oyster settlement was observed attached to the shell of 10% of the adult broodstock in Conwy Marina. Between 1 to 5 oysters were recorded being connected. The age class of settled oysters varied from <1- to 3 years of spat and juvenile life stages. Of all oysters where settlement was observed, 16% were categorised as ‘Cloks’.

Effect of oyster spawning on broodstock mortality

Monthly oyster mortality rates were compared to the number of oysters brooding larvae from May 2021 to July 2025 to assess the impact of reproduction on survival (Fig. 13). Spawning was not monitored in 2021, but high summer mortality that year aligned with acclimation after initial stocking. Across all years, mortality peaked during the summer spawning season, coinciding with brooding activity. The highest mortality followed peak brooding in 2022, 2023, and 2024. Monitoring for 2025 is ongoing.

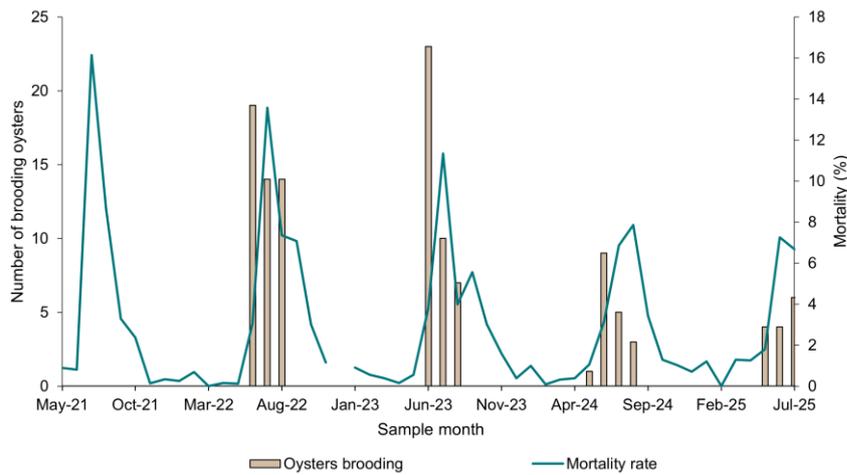


Figure 13. Total number of oysters brooding larvae (grey bars), and oyster mortality rate as a percentage (green line) per month throughout the sampling period May 2021–July 2025 in Conwy Marina.

Temperature impact on spawning

Seawater temperature was recorded using a HOBO UA-002-64 Pendant Waterproof Temperature & Light Intensity Logger and compared to the total number of larvae recorded per oyster (Fig. 14). Larvae were recorded at temperatures between 12.8°C to 19.4°C, with peak larval abundance occurring between 17.2 to 17.5°C for years 2022, 2023 and 2024.

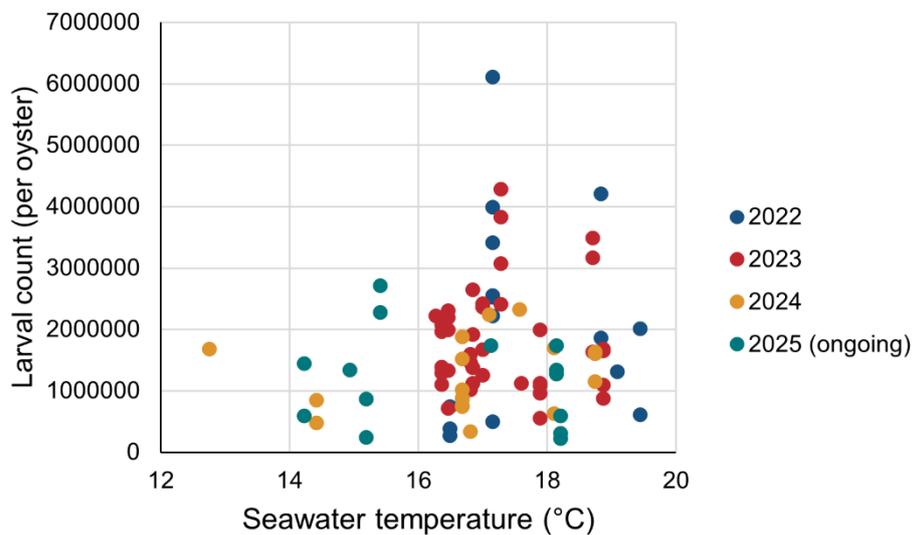


Figure 14. Number of larvae collected per oyster compared to seawater temperature during the summer spawning season between 2022 to 2025 (sampling ongoing) in Conwy Marina.

Temperature sum (or degree days) reflects accumulated heat above a base threshold, estimated at 6.75–7 °C for oyster gonad development [36, 37]. At Conwy Marina, temperature sum from 1 January was compared to larval counts

(Fig. 15). Larvae were recorded between 648- 1356 degree days, 416- 1120 degree days, 383- 1322 degree days in the years 2022, 2023 and 2024, respectively. In 2025, larvae were first recorded at 277 degree days. Peak larval abundance occurred at 648 (2022), 833 (2023), and 943 (2024) degree days.

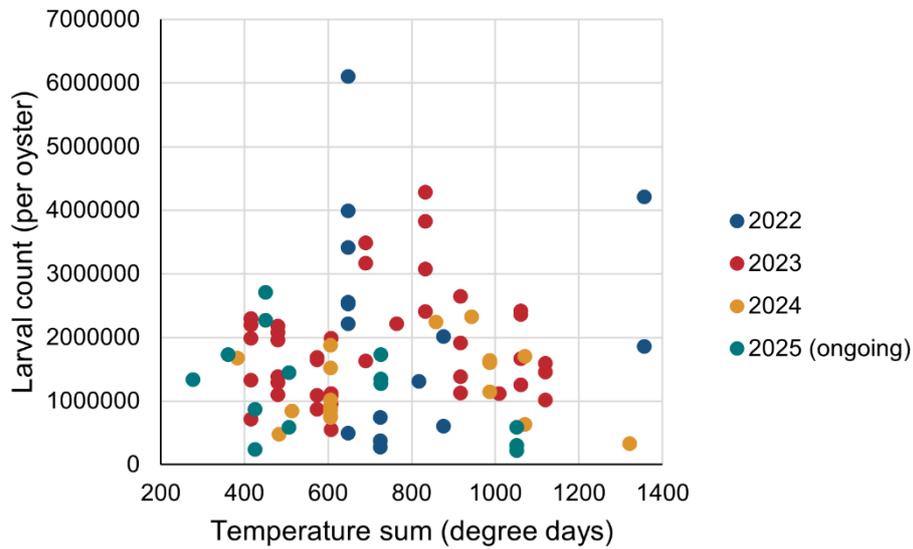
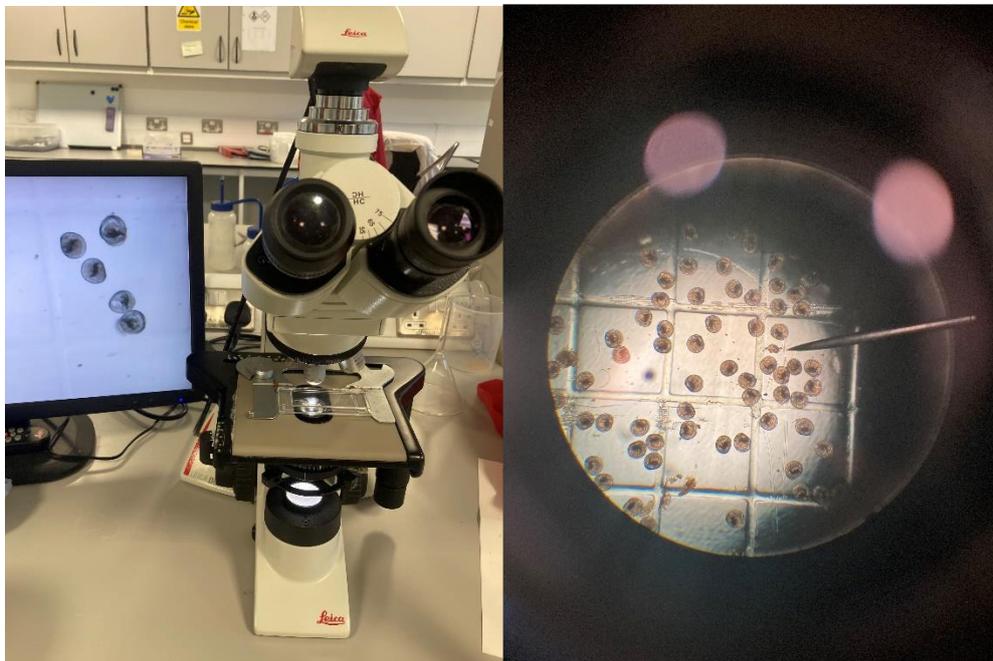


Figure 15. Larval abundance per oyster for temperature sum (degree days) collected from Conwy Marina during the summer spawning season between 2022 to 2025 (sampling ongoing).



Leica DM1000 compound microscope and digital image capture system processing oyster larval sample © Maria Hayden-Hughes

2.2.3 Discussion

The percentage of breeding oysters has reduced between 2022 to 2024 which would not indicate a healthy and growing population while the presence of 'Clok' clusters indicates some local recruitment.

As sequential hermaphrodites, native oysters initially mature and reproduce as males, transitioning between sexes in subsequent cycles [38,39]. Temperature influences the reproductive potential of native oysters indirectly by affecting the sex ratio [37, 40]. Warmer temperatures may lead to more oysters remaining male [40], potentially explaining the reduction in brooding frequency at Conwy Marina, though sex ratios were not assessed.

Temperature is also a key factor influencing the variability in larval occurrence [41, 42]. Temperature sum is a strong predictor of spawning, with a threshold of 404–554 degree days when oyster spawning is initiated [29]. Larval sampling in 2023, and 2024 supported this, but was recorded earlier in 2025 (at 277 degree days). Temperature can influence the timing of spawning and the peak of larval occurrence, although it is unlikely a limiting factor. Lunar cycles and food availability can also influence timing, viability, and fecundity [43, 29].

Both marinas are sheltered, shallow (up to 4m) and operate tidal gates restricting water exchange for approximately 12 hours daily. This can lead to stratification and reduced food supply, with >1.68 chl in $\mu\text{g/l}$ required for gonad development [30, 31 28]. Shallower water bodies can exhibit a more rapid and pronounced response to atmospheric conditions compared to open coastal environments [44, 45]. The oysters are within an artificial reef-like environment in the nurseries in the marinas but the data into the likelihood of oyster spawning is critical for planning the deployment of settlement substrates [46], to support wider seabed restoration in the Conwy estuary.



Shrimp, Palaemon spp. © Georgie Bull

2.3 Water Filtration

2.3.1 Data Collection

Native oysters can filter up to 200 litres of seawater per day [4]. For this project, filtration estimates were based on the number of live oysters in nurseries at Conwy and Deganwy marinas (April 2023–May 2025), using a conservative rate of 3 litres/hour/oyster [47], assuming 24-hour filtration. Actual filtration rates may vary with environmental and biological factors such as temperature, season, oyster size and health, food availability, water flow, and disturbance.

2.3.2 Results

Between April 2023 and May 2025, a total of 2,435 oysters were housed in oyster nurseries across Conwy and Deganwy marinas. Resulting in a total of approximately 112 million litres of seawater filtered by the oysters in the oyster nurseries, throughout the duration of the project. This volume is equivalent to approximately 45 Olympic sized swimming pools.

2.3.3 Discussion

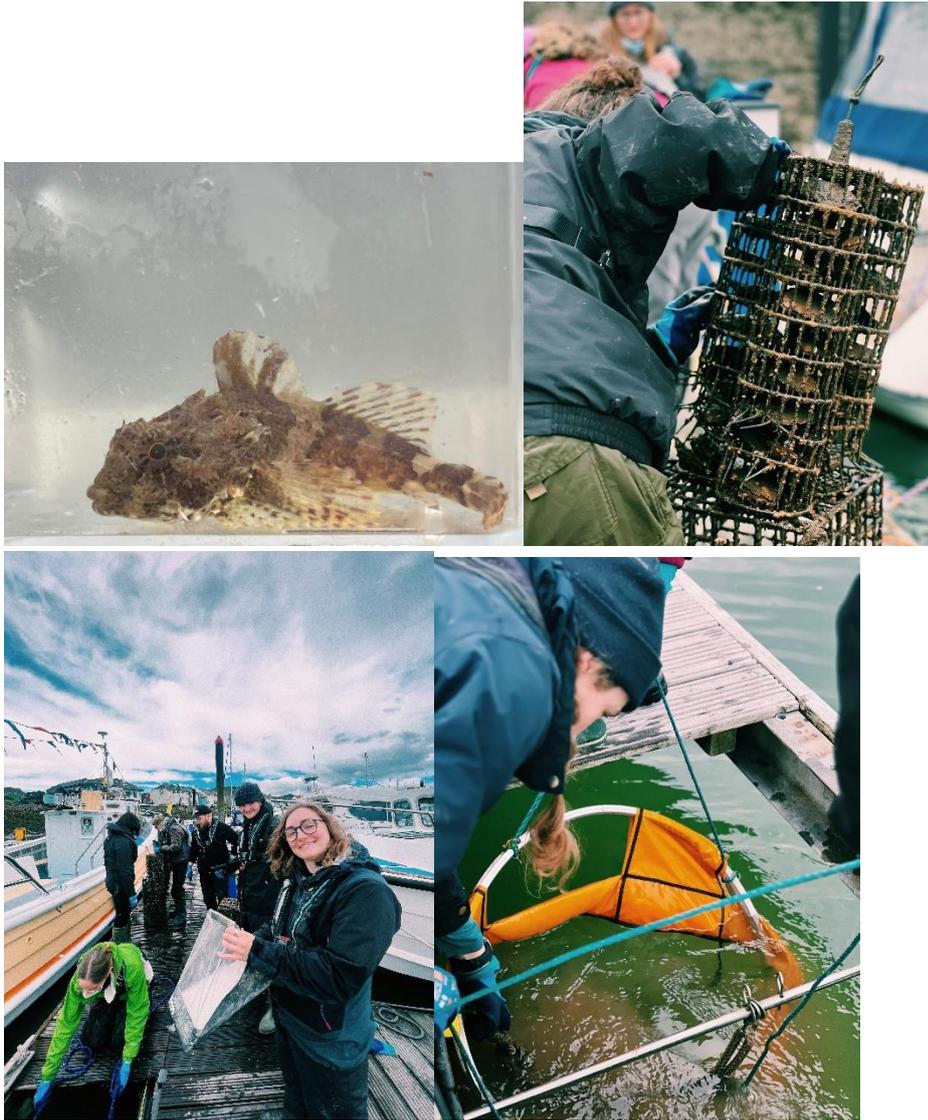
By filtering over ~112 million litres of seawater in the Conwy Estuary, this project has demonstrated a significant ecosystem service potential of native oyster restoration and husbandry. Native oysters contribute to improved water clarity, nutrient cycling, and support the health of coastal ecosystems [6]. Highlighting that even small-scale interventions, such as oyster nurseries in marina sites, can have a meaningful environmental benefit.

2.4 Biodiversity of Fauna

2.4.1 Data Collection

The biodiversity of fauna associated with the oyster nurseries, both mobile species and sessile epifauna settled on the oyster shells, was monitored from March 2021 to the present. Mobile fauna were assessed monthly using a 1 mm mesh net to sample the same six biodiversity nurseries in both Conwy and Deganwy marinas. Captured fauna was sieved, sorted, and identified to the lowest possible taxonomic level, see for full methodology [48]. Sessile epifauna were assessed via photographs of a subsample of oysters from each nursery, taken on a marked background for scale and identification. The epifaunal community from 2021 to 2023 was described reporting the lower convex side of the shell housed a greater abundance and richness of epifauna than the upper flat shell [48]. The lower convex valve had on average 95% more individuals per m². The photographs captured in 2024 and 2025 have not yet been analysed due to limited staff capacity. The report also demonstrated no significant difference in species assemblages found between the marinas from 2021 to 2023. Therefore, to optimise efficiency of staff capacity, monitoring over the NNF2 project (April 2023 to May 2025) continued in Conwy Marina only.

Environmental data were collected monthly, including seawater temperature (via HOBO UA-002-64 Pendant Waterproof Temperature & Light Intensity Loggers), salinity (refractometer), and insitu sea state and precipitation observations. Additional data (air temperature, humidity, wind, UV index, visibility, and tides) were sourced externally.



Oyster nursery biodiversity monitoring at Conwy marina © Rhianna Parry.

2.4.2 Statistical Analyses

Analyses were conducted to address the following research question: How does the mobile faunal community change over time?

This question was addressed through the following objectives:

- Is there seasonal and annual variability in community composition?
- Do environmental variables play a role in determining community structure?
- Which taxa show distinct temporal patterns or interactions with the environment?

To understand how community composition changed over seasonal and annual temporal scales at Conwy Marina, the abundance of taxa with more than 10 individuals observed during any month were presented. Species richness, evenness and Shannon Weiner diversity index were calculated for each season. The abundance of individual taxa from each nursery were summed over season.

The baseline assessment in March 2021 and first month of monitoring in April 2021 were excluded to allow comparison over four years. The Bray – Curtis index was used to create a resemblance matrix and ANOSIM (Primer) and associated nMDS used to test for a significant difference in community composition with season. Communities in summer were clearly different from those in other seasons, hence summer data were used to examine differences among years. SIMPER identified discriminatory species which drove annual differences in community composition during summer.

A PERMANOVA and PERMDISP were conducted to understand the contribution of season and year in determining community composition. A positive PERMDISP test indicated a dispersion effect may be present. However, a balanced design allows PERMANOVA to withstand unequal variances [49].

The effect of environmental variables driving change in communities was established using BEST (Biota and / or Environmental matching) analysis and visualisation using bubble plots. A draftsman plot and Pearson correlation coefficients illustrated acceptable auto – correlation (< 0.95) between all variables [50] (Fig. 16).



Figure 16. Flowchart of the statistical analysis of mobile biodiversity data

2.4.3 Results

Descriptive statistics and brief overview of taxa observed

Over the full monitoring period, a total of 79 mobile and sessile taxa have been recorded in Conwy and Deganwy marinas. From the start of NNF2 in April 2023, 10 new taxa and 9,984 individuals were recorded in Conwy Marina. Common taxa included *Beroe Cucumis* (comb jelly), *Pleurobrachia pileus* (sea gooseberry), and *Pholis gunnellus* (butterfish). Polychaeta, including *Malmgrenia lunulata* (scaleworm) and various crustacea were abundant, especially Amphipoda, Isopoda, and *Praunus flexuosus* (Chameleon shrimp). Decapods were also prolific, with *Palaemon* spp. being the most abundant taxa (Fig. 17). Preliminary assessment suggested both seasonal and annual changes in abundance. *Palaemon* spp. showed distinctly greater abundances during autumn, whilst records of Amphipoda decreased between the years 2021 and 2022 from 5,668 to 817 individuals and remained low through 2023 and 2024.

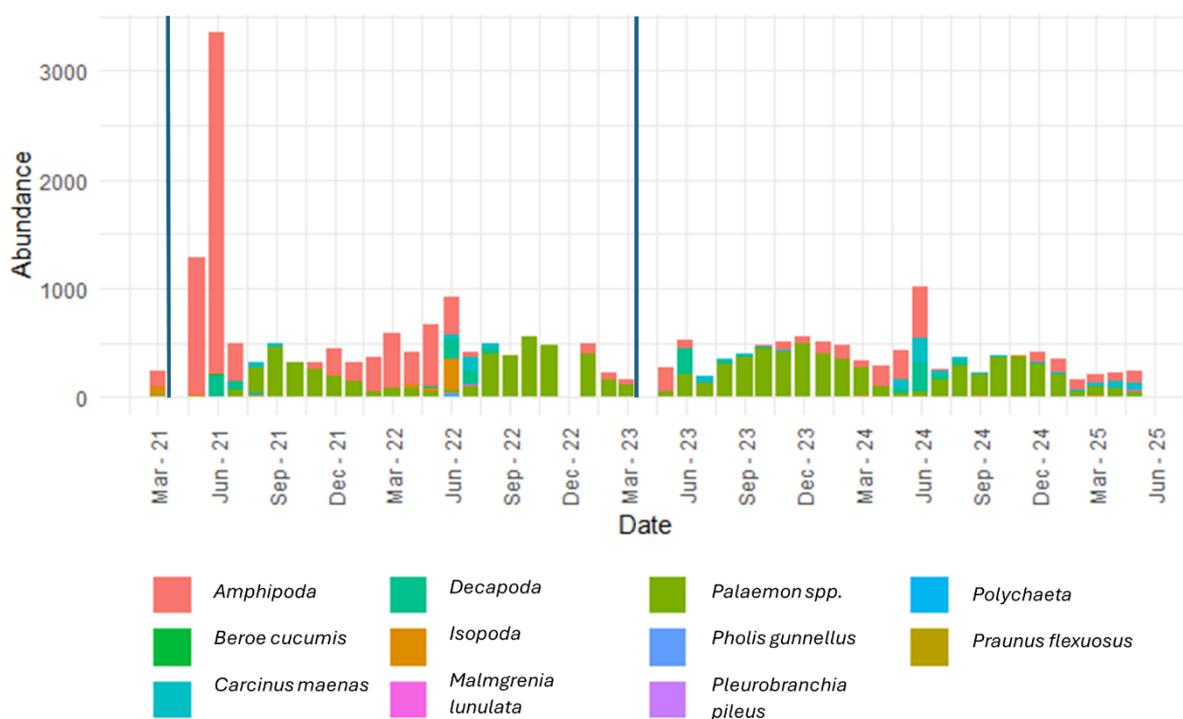
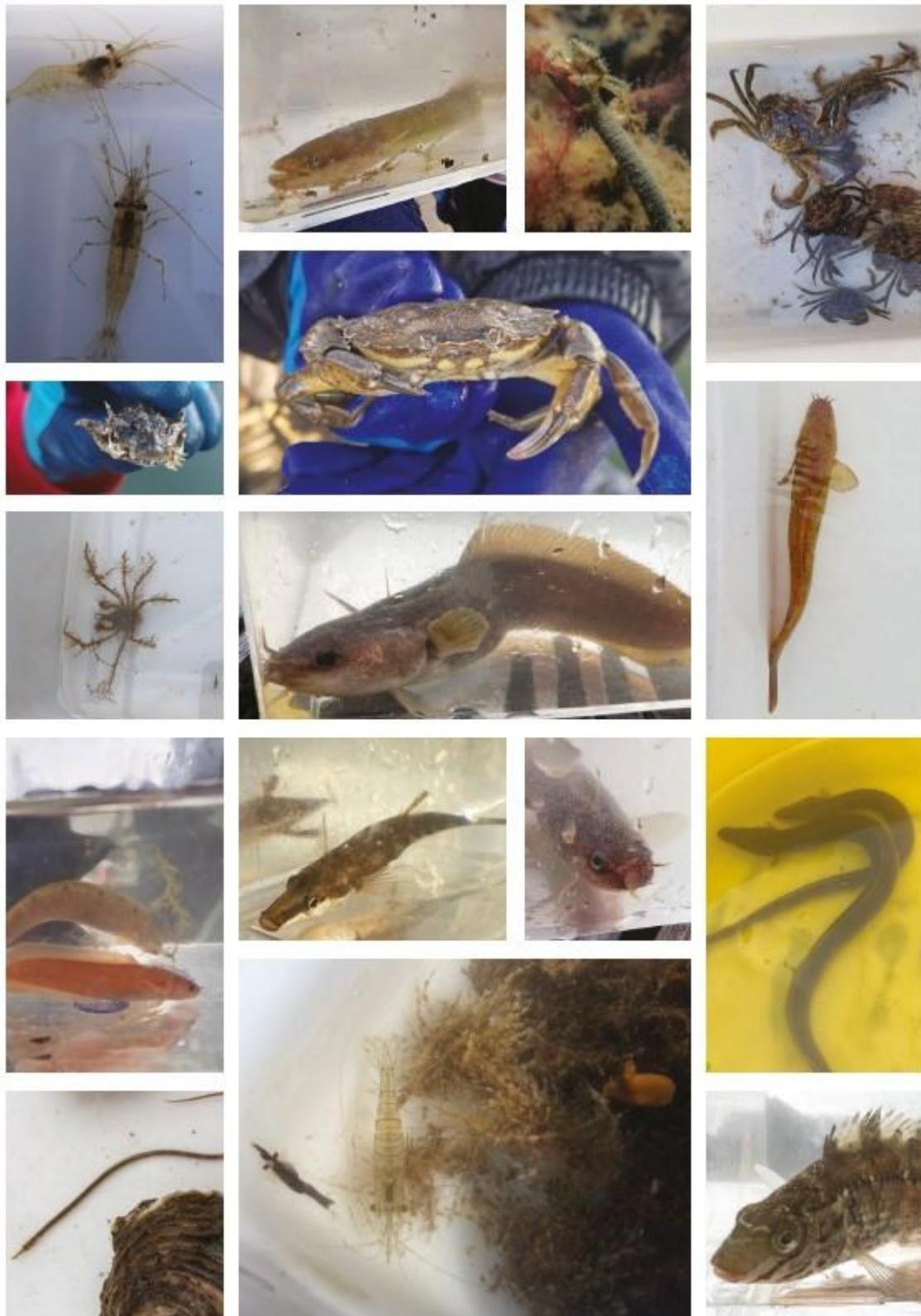


Figure 17. The monthly abundance of mobile fauna that showed more than 10 individuals in any monitoring event. The vertical blue lines indicate baseline assessment in March 2021 and commencement of NNF2 in April 2023.



Example of mobile taxa recorded in oyster nursery biodiversity monitoring © Rhianna Parry

Taxonomic diversity indices to show seasonal effect

Community composition was assessed using Shannon diversity, species richness, and evenness, revealing clear seasonal and annual changes (Fig. 18). Amphipods dominated early, especially in the first three months, showing that oyster nurseries are quickly colonised, initially by a few dominant species. Species richness peaked at 17 during summer and declined to 7 taxa during winter. Similarly, species diversity and evenness increased during spring and summer and declined during autumn and winter. An ANOSIM confirmed a significant difference in community composition between seasons (ANOSIM; $R = 0.591$, $p = 0.001$), with all pairwise comparisons being significant ($p = 0.001$). An nMDS plot demonstrated dissimilarity in community composition between seasons, with slight similarity in winter and spring (Fig. 19).

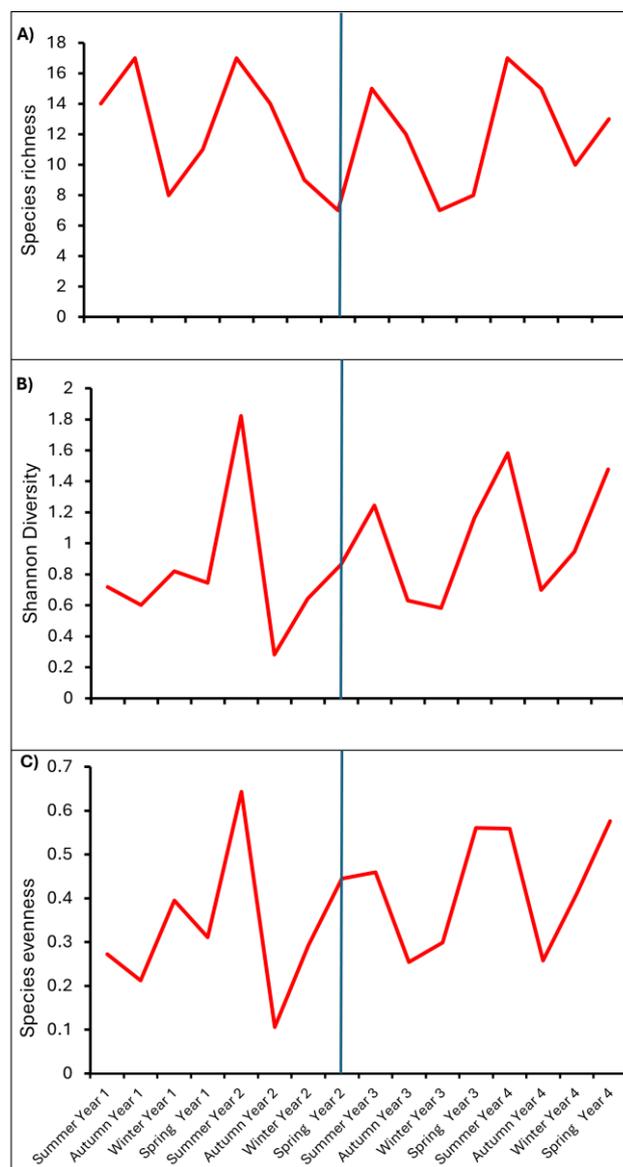


Figure 18. Species richness (A), Shannon Weiner diversity index (B), and species evenness (C) of the mobile fauna observed from June 2021 to May 2025 in Conwy Marina. The blue line represents the start of NNF2.



Species identification of biodiversity found during sampling © Rhianna Parry

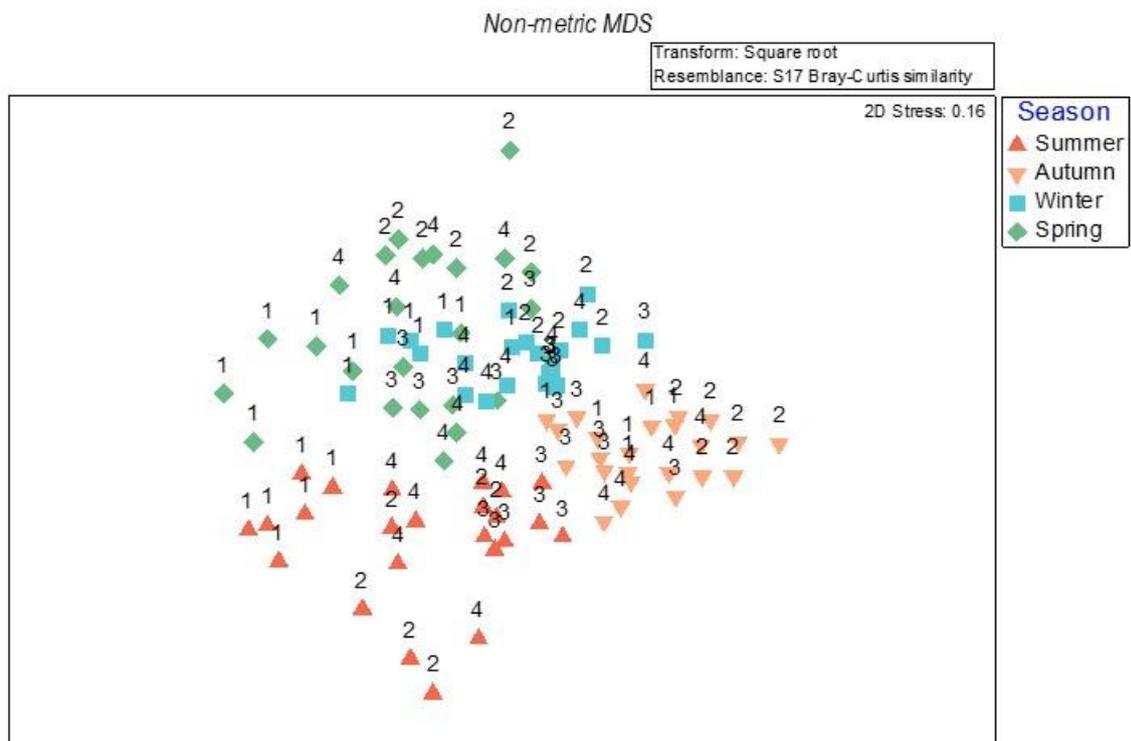


Figure 19. A nMDS plot based on a Bray – Curtis resemblance matrix, of seasonal species abundances for mobile taxa observed in oyster nurseries in Conwy Marina. A stress value of 0.16 indicates the plot has visualised actual differences accurately in a 2D space.

Effect of year

The nMDS plot also showed distinct dissimilarity in community composition during summer. An nMDS plot using summer data only, further highlighted annual changes with a slight overlap between years 2, 3 and 4 (Fig. 20). An ANOSIM, using summer abundances only, demonstrated a significant difference in community composition over years, (ANOSIM; $R = 0.762$, $p = 0.001$), with all pairwise combinations being significant ($p < 0.05$). This indicates inter-annual variability over the same months.

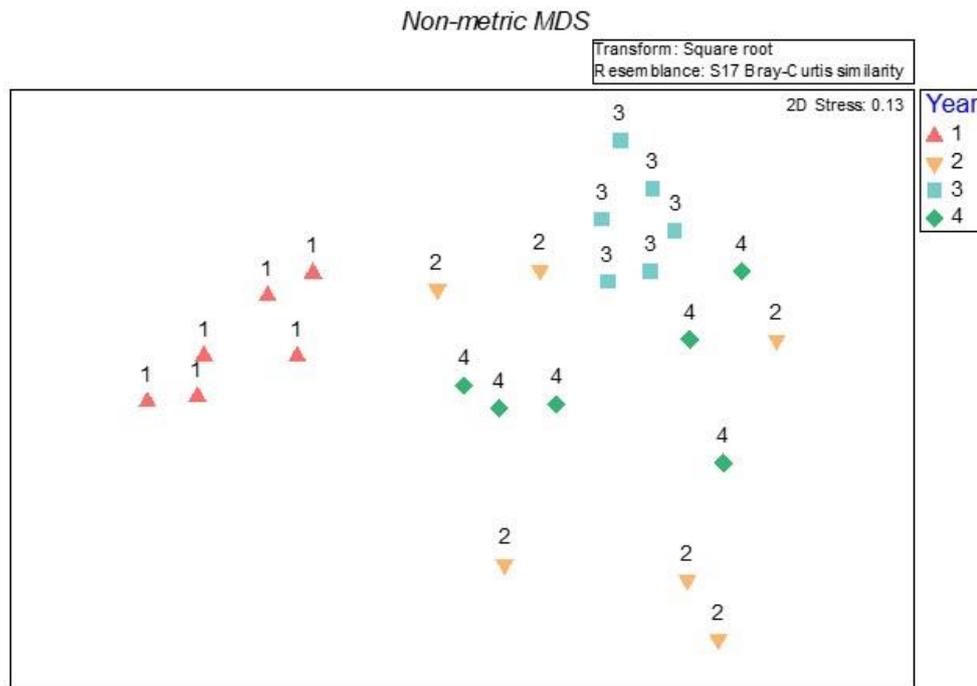


Figure 20. An nMDS plot showing dissimilarity in annual species abundances in oyster nurseries over four summers in Conwy Marina. A stress value of 0.13 indicates the plot is representative of actual differences.



Conwy Marina sunset © Boatfolk, Conwy Marina

SIMPER analysis identified Amphipoda, Isopoda, *Beroe cucumis*, Decapoda, *Carcinus maenas*, and *Palaemon* spp. as key contributors to yearly differences, though *Beroe cucumis* remained low in abundance (Tab. 2). In Conwy Marina, Amphipoda abundance dropped sharply after the first year, confirming its role as an early successional species (Fig. 21). Isopoda peaked in 2022 before declining by 97% in 2023, while *Palaemon* spp. peaked in 2023 and then decreased, suggesting both serve as intermediate species. Decapoda increased steadily, with *Carcinus maenas* rising rapidly from 2023 to 2024 (Fig. 21).

Table 2. SIMPER (similarity percentages) analyses showing dissimilarity of summer mobile faunal communities in oyster nurseries during four years in Conwy Marina. Average dissimilarity and the percentage contribution of the top three species for each pairwise combination is given.

	Year 1	Year 2	Year 3	Year 4
Year 1		Av. dissim: 43.69 Amphipoda (38.56%) Isopoda (12.97%) <i>Carcinus maenas</i> (7.62%)	Av. dissim: 43.75 Amphipoda (55.25%) <i>Palaemon</i> spp. (10.01%) <i>Beroe cucumis</i> (5.78%)	Av. dissim: 41.20 Amphipoda (40.75%) <i>Carcinus maenas</i> (11.08%) Decapoda (8.88%)
Year 2			Av. dissim: 34.53 Isopoda (22.46%) Amphipoda (15.34%) <i>Carcinus maenas</i> (9.27%)	Av. dissim: 33.77 Isopoda (20.93%) Amphipoda (16.03%) Decapoda (12.63%)
Year 3				Av. dissim: 30.73 Amphipoda (21.23%) Decapoda (14.66%) <i>Carcinus maenas</i> (14.32%)
Year 4				

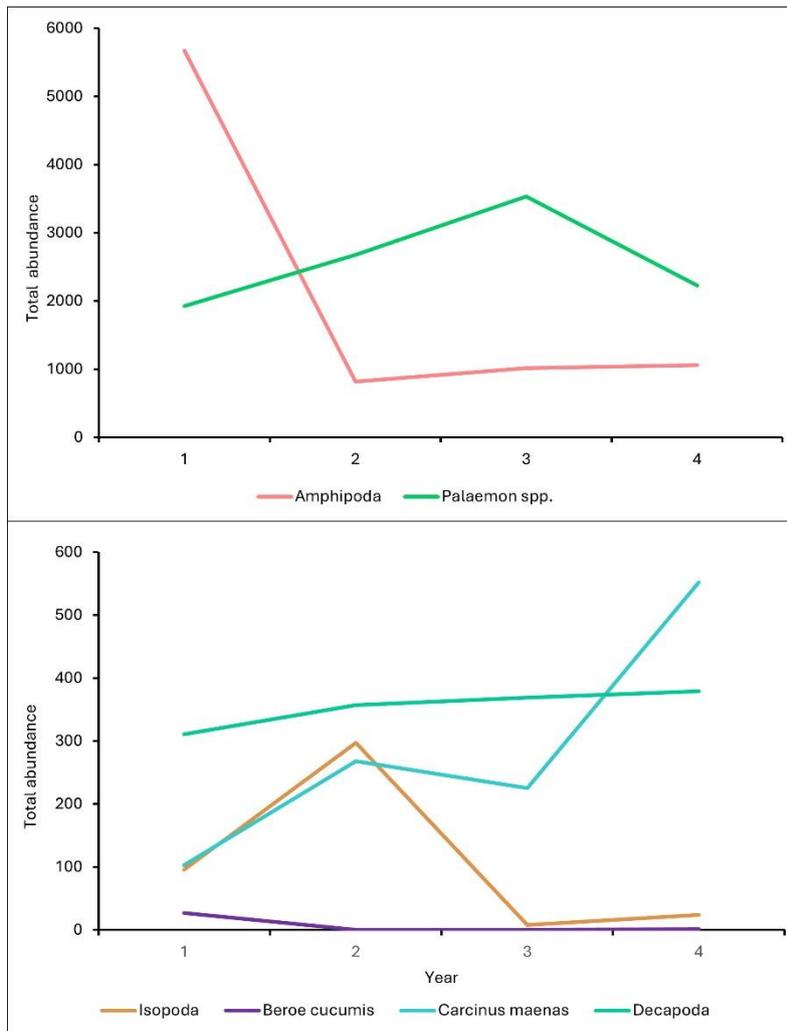


Figure 21. The total annual abundance of the top six discriminating species from SIMPER analyses during summer months in Conwy Marina, from June 2021–May 2025.

Interaction between season and year

Distinct annual differences indicate successional change over long temporal periods, shifting from smaller, pioneering opportunistic species to larger predatory species. However, marked changes in abundance with season warranted to determine if a seasonal and annual interaction was at play. A PERMANOVA test demonstrated that the best explanation for a change in species abundances over time was indeed an interaction between both season and year (PERMANOVA; pseudo-F (9) 4.839, $p = 0.001$).

Environmental conditions

With environmental variables defining seasons and interannual variability, it was necessary to assess changes in abundances alongside environmental conditions. BEST results showed the top performing model in predicting assemblages alongside environmental conditions was a combination of air and water temperature, humidity and UV (0.406). Bubble plots showed how environmental conditions predominately changed with season rather than year (Fig. 22).

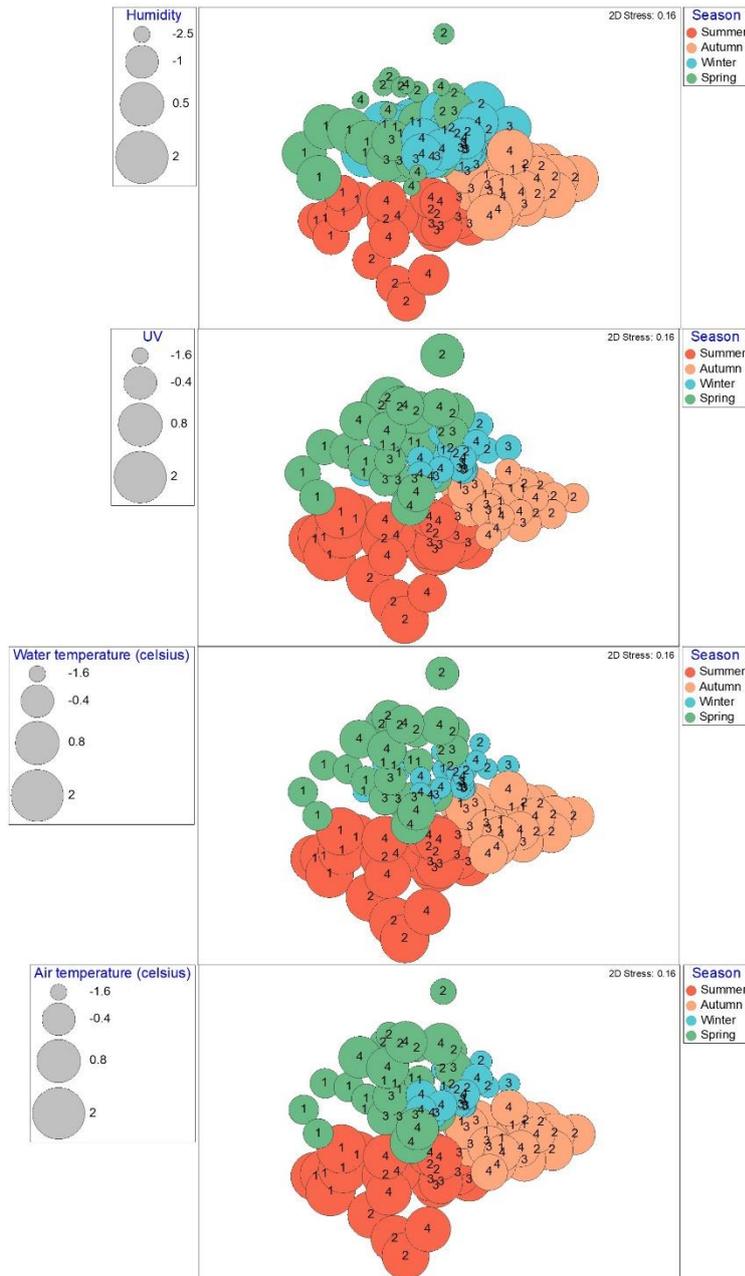


Figure 22. MDS plots showing seasonal dissimilarity between species abundance. Each season is labelled with years and overlaid with A) humidity, B) UV, C) water temperature ($^{\circ}$ C) and D) air temperature ($^{\circ}$ C).

Specific species

A further insight into the interaction between taxa and environmental variables, highlighted that Amphipoda were more abundant at warmer water temperatures and with greater UV (Fig. 23, 24). The greatest abundance occurred at a water temperature and a UV index of 16.35 $^{\circ}$ C and 5 respectively. These patterns could relate to changes in the productivity of the water column. An offset between peaks in water temperature and *Palaemon* spp., reaffirmed distinct autumn abundances (Fig. 25).

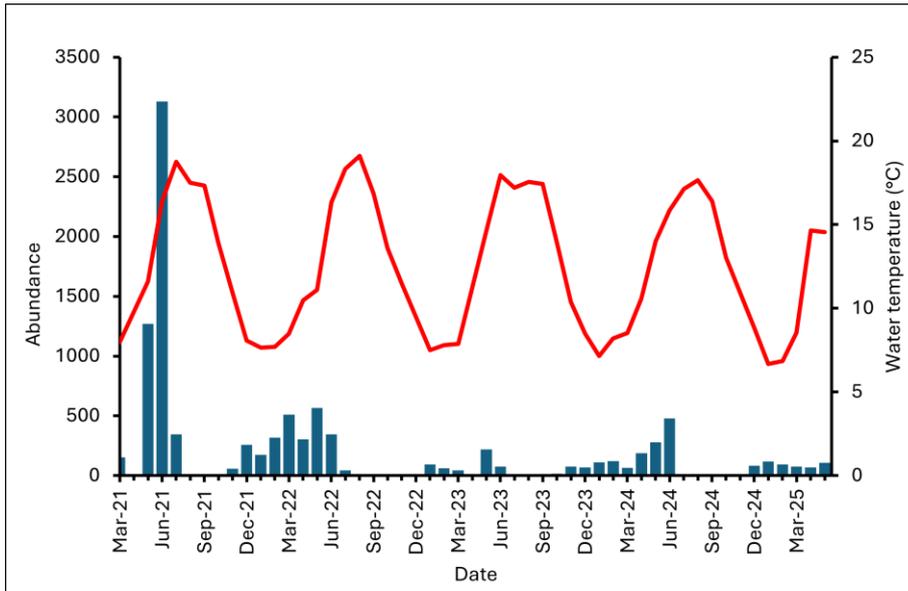


Figure 23. The monthly abundance of Amphipoda within oyster nurseries in Conwy Marina (blue bars) with water temperature (red line), from March 2021 (baseline assessment before nursery deployment) to May 2025.

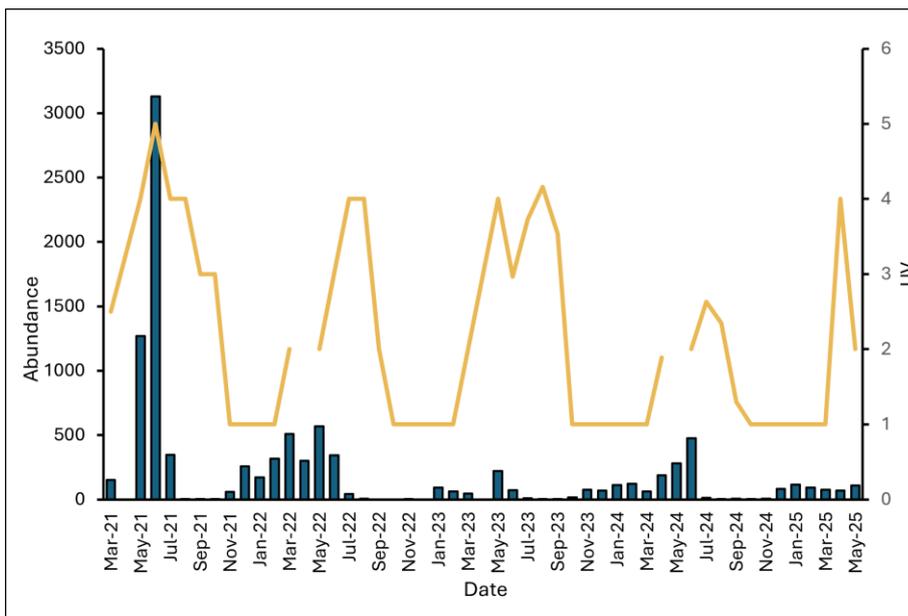


Figure 24. The monthly abundance of Amphipoda within oyster nurseries in Conwy Marina (blue bars) with UV (yellow line), from March 2021 (baseline assessment before nursery deployment) to May 2025.

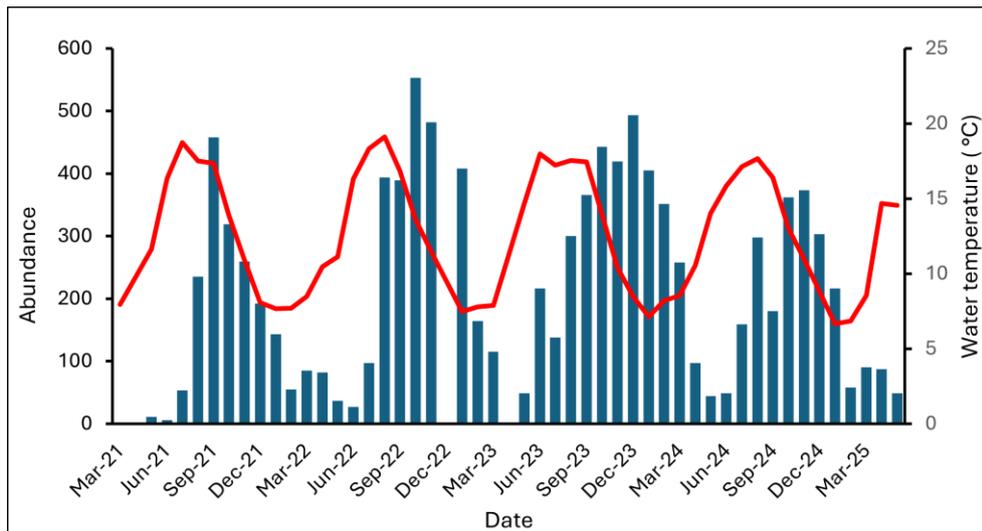


Figure 25. Monthly abundance of *Palaemon* spp. in Conwy Marina (blue bars) with water temperature (red line), from March 2021 (baseline assessment before nursery deployment) to May 2025.

A total of 85 *Anguilla anguilla* (European eel) were observed in Conwy Marina over the full monitoring period, with 41 observations during NNF2. Abundances in 2022 were more than double those observed in 2021 and coincided with peaks in water temperature (Fig. 26). The first appearance of adult European eels occurred in July 2021 and were observed for 3 months. In 2024, eels were first observed in April and were present for six months. Earlier appearances and a longer presence may reflect environmental and successional change. Juvenile and adults were observed, indicating oyster nurseries function as habitat for eels at different life stages.

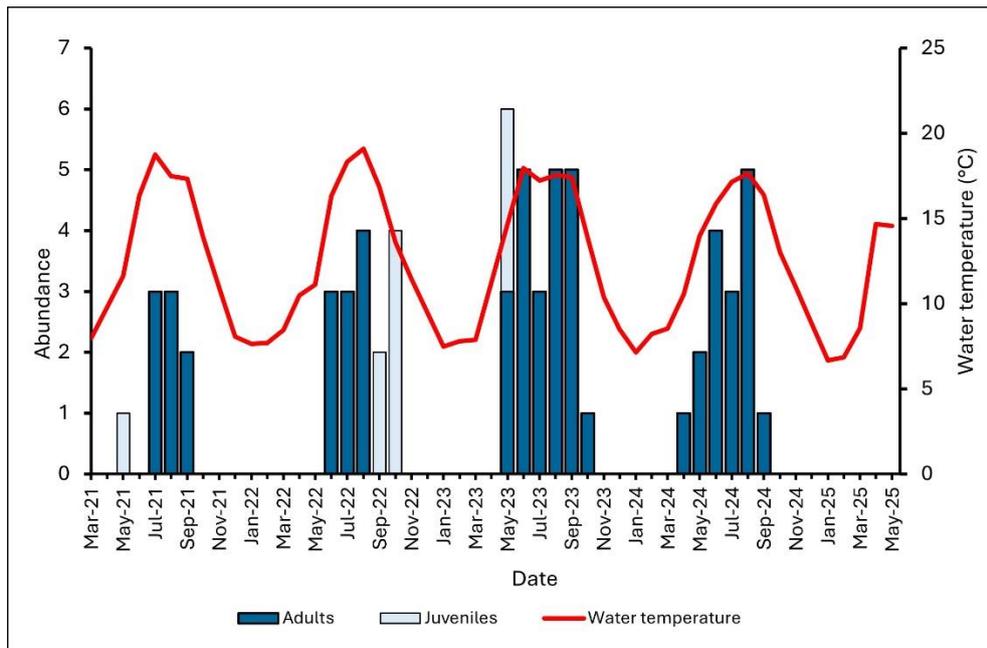


Figure 26. The monthly abundance of adult (dark blue bars) and juvenile (light blue bars) *Anguilla anguilla* (European eel) within oyster nurseries in Conwy Marina with water temperature (red line), from March 2021 (baseline assessment before nursery deployment) to May 2025.

2.4.4 Discussion

In Conwy Marina, nurseries were quickly colonised and hosted diverse communities, with seasonal and yearly changes reflecting environmental variation and ecological succession. Rapid colonisation and an increase in species richness following deployment, suggests oyster nurseries attract biota. Artificial oyster reefs can provide heterogenous substrate with high structural complexity and surface area, serving as refuge from predators [51], with species such as fish, *Palaemon* spp., and decapods using oyster habitat for shelter [52]. Predatory species observed, like European seabass use oyster habitat as feeding ground [53], and likely are attracted by the prey rich habitat of the oyster nurseries in Conwy Marina.

Succession

Species richness initially rose while species diversity and evenness were low following initial stocking, showing dominance by a few opportunistic species which is typical in newly established habitat where only adaptable and opportunistic taxa, such as Amphipoda, can survive [54]. Amphipoda can utilise interstitial spaces between oysters [55], feeding on phytoplankton and detritus common in estuarine environments [56, 57], and reproducing frequently, hence why they are an early successional species [58, 54]. Amphipoda fuel higher trophic levels, such as *Palaemon* spp. [57 59]. Food web dynamics of these taxa can help explain the respective changes in abundances.

The increased abundance of decapods and *C. maenas* reflect a transition to complex nursery communities. Feeding efficiency in predatory species is increased in environments of high structural complexity, where contact between aggressive conspecifics is minimised [60]. Continued monitoring of oyster growth and sessile assemblages can help understand the effect of habitat heterogeneity on biotic interactions.

Whilst species composition changes, there is some overlap between 2022, 2023 and 2024 summer assemblages. Dredging takes place in Conwy Marina between November and January each year and up to 28,000 tonnes of sediment is removed [61]. Dredging is likely to reoccur before full recovery of communities [62], due species sensitivity to sedimentation [63].

Seasonality

Seasonality was specific to taxa. Amphipods reproduce during summer, aided by an increase in water temperature [54]. Meanwhile, *Palaemon* spp. reproduce during late summer, hence increased abundances in autumn [64]. Prey sources for both silver and elver eels were recorded (Fig. 27), hence the use of nurseries as nocturnal foraging areas and shelter [65]. Low winter abundances coincide with the catadromous migratory behaviour of adults to the Sargasso Sea for reproduction [65]. Eels are sensitive to contaminated water which can impede life history processes [66]. A thriving population of European eels suggests good water quality in Conwy Bay, likely aided by oysters. This project demonstrates how oyster restoration initiatives also act to conserve a critically endangered species [67].

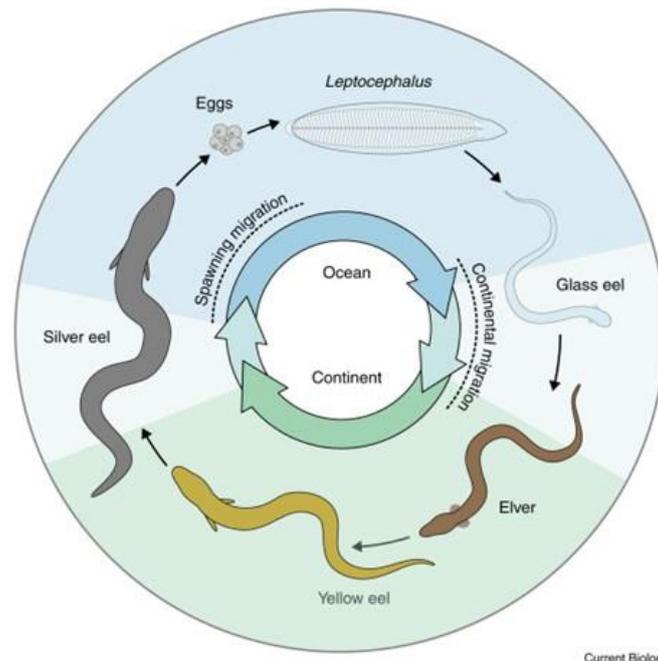


Figure 27. The life cycle of *Anguilla anguilla*, Critically Endangered European eel, sourced from [65]



Underwater images of juvenile shore crab (left) and peacock fan worms on oyster nursery (right) in Conwy Marina © Georgie Bull.

2.5 Successes and Lessons Learnt

Time

Oyster nurseries are an effective engagement tool, but time and capacity requirements should be revised in any similar projects. Weekly spawning monitoring using a non-lethal method was a time consuming and labour-intensive activity. However, it was essential to understanding and quantifying the role of the nurseries as a larval pump.

Collaboration

Partnering with an academic or research institution is beneficial for developing scientific design, to collect and analyse data to inform best restoration practices.

Citizen Science

Citizen scientists provide vital support to staff to achieve project goals. Volunteers have guidance in field sampling and data collection, offering opportunities to upskill and gain experience working in marine conservation, improve team building and communication skills, and connecting with other people.

2.6 Conclusion: Oysters Nurseries

The oyster nurseries have shown that even in a constrained environment such as a marina, broodstock oysters can survive, reproduce, filter large volumes of water, and support diverse associated communities. While constrained by dredging and reduced water exchange, the nurseries provide a valuable larval source, habitat and engagement tool.

3. Seabed restoration: Cultch and Oyster Deployment

3.1 Project Overview

The project’s seabed restoration activities aimed to enhance the condition of native oyster habitat in Conwy Bay, by restoring suitable settlement substrate using cultch, and introducing mature native oysters with the aim of establishing a self-sustaining population.

In June 2023, 650 tonnes of locally sourced limestone gravel (32–110mm) were deployed (within the restoration site in West Bwrling licence area, Fig. 28) to form the base of the reef; the gravel was selected to match the local seabed composition and provide suitable conditions for oyster settlement. The deployment involved transporting material to a hardstanding near Conwy Marina, loading it into tonne bags, and transferring it by landing craft for placement on the seabed.

The deployment was guided by marker buoys and on-board navigation systems, ensuring the material was deployed within the marine licence boundaries. The aim was for the gravel to form a uniform base layer, for subsequent shell cultch and mature native oysters.

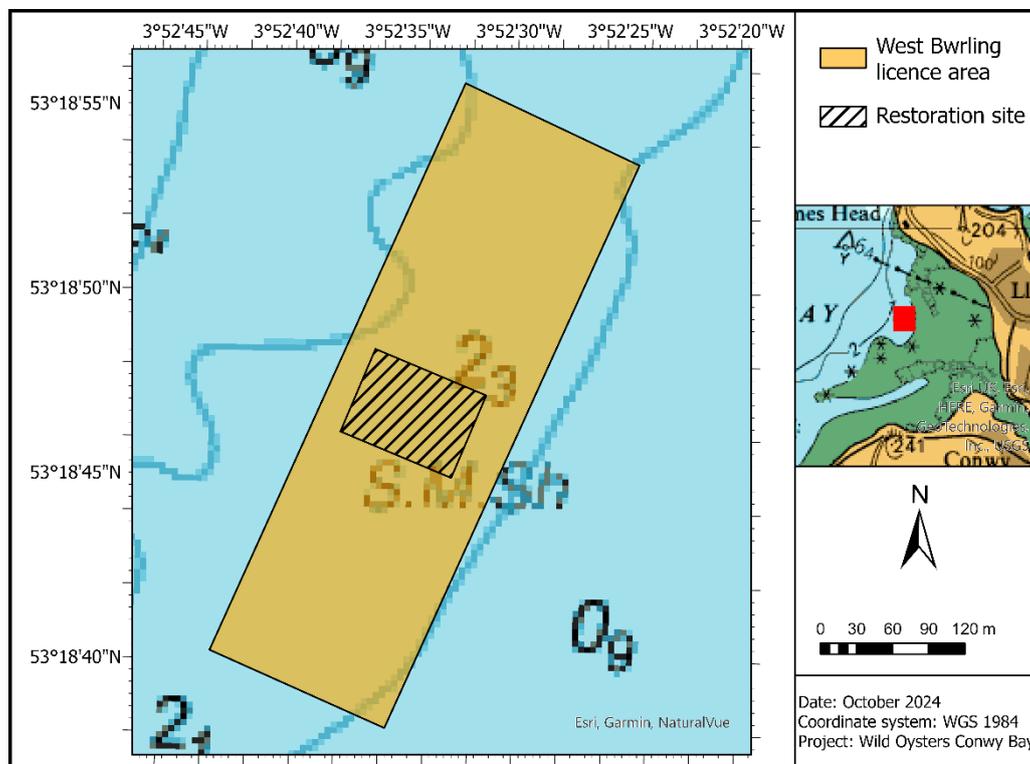
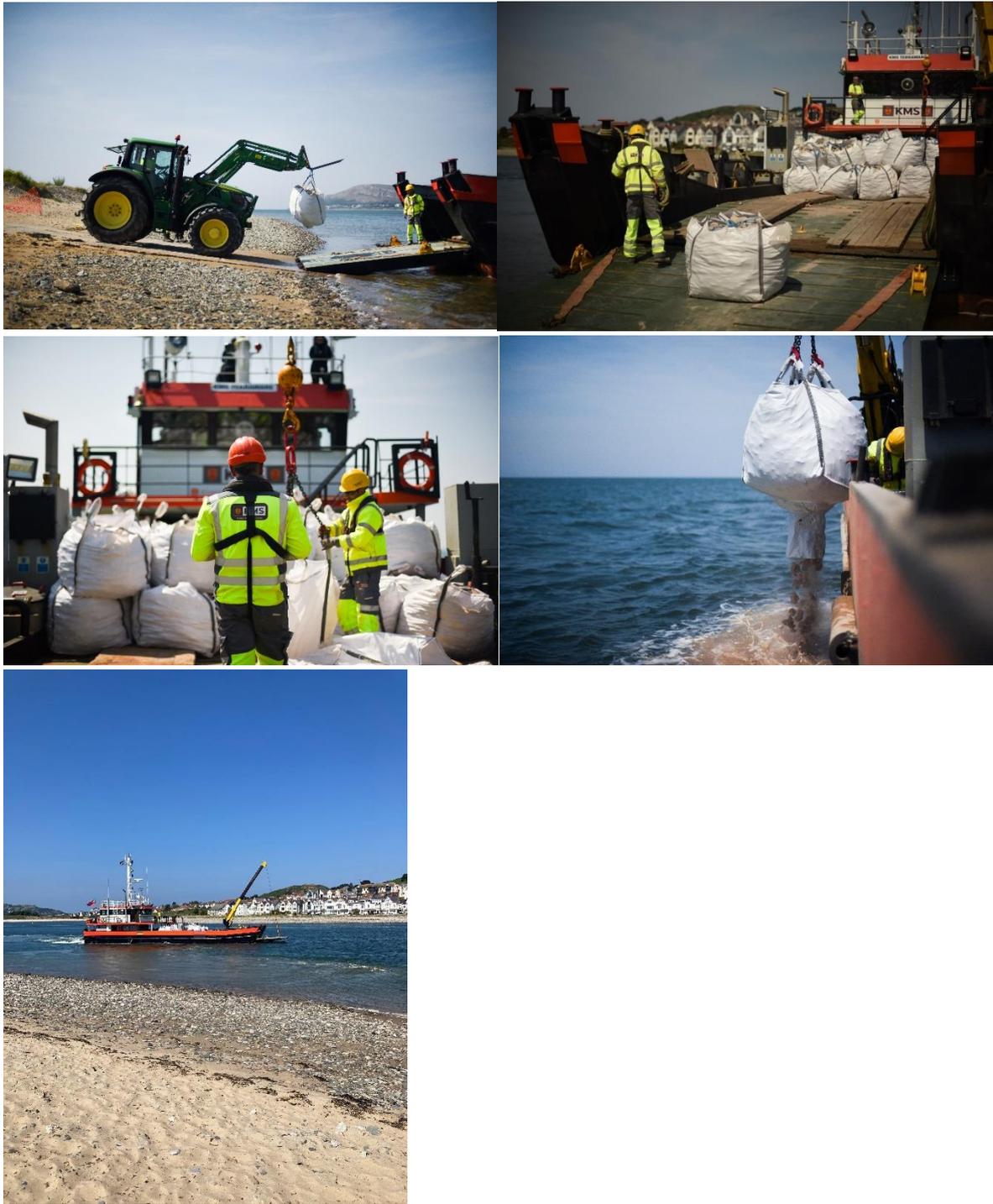


Figure 28. Map of the restoration site within the West Bwrling licence area located in the Conwy Estuary.



Images showing the process of loading the bagged gravel cultch onto the deployment vessel, and subsequent deployment at the restoration site. © Lucie Machin.

3.2 Marine Licensing and monitoring

3.2.1 Monitoring and Adaptive Management

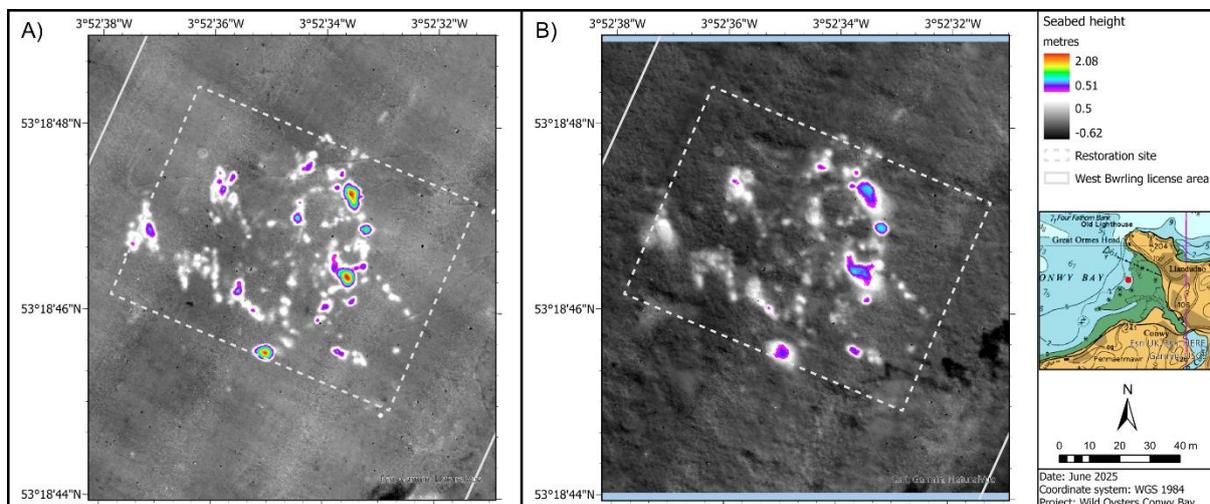
In July 2023, a planned post-deployment multibeam survey by Bangor University's research vessel confirmed that the gravel remained within the restoration footprint and marine licence coordinates but had formed peaks exceeding the 0.5 m reef height

specified in the marine licence’s supplementary materials. As the original Habitats Regulations Assessment (HRA) did not assess the reef heights above this threshold, the project proactively paused further deployment of shell cultch and oysters to allow for consultation with regulators and consideration of potential solutions.

The project team acted promptly and transparently, informed all relevant regulators, shared survey data with the UK Hydrographic Office, Conwy Harbour Master, and Natural Resources Wales, and sought advice from our Technical Working Group. A Local Notice to Mariners was issued, and the Conwy Harbour Authority confirmed there was no navigational risk.

Whilst continuing to monitor the distribution of the gravel, potential methods, including the use of a marine plough or divers, to level the peaks were scoped, costed, and presented to the Local Working group and Welsh Fishermen’s Association for feedback and consultation.

Further bathymetry surveys took place in November 2023, May 2024, August 2024, and March 2025, along with drop-down video and baited-remote underwater video (BRUV) surveys to track the change in gravel height and habitat development. Gravel peaks continued to remediate naturally as seabed height had reduced by 1.12m from July 2023 to March 2025 (Fig. 29). There was no evidence of translocation of material outside of the restoration site.



*Figure 29. Bathymetry seabed survey results highlighting the reduction in seabed elevation within the restoration site in the West Bwrling licence area from **A) July 2023**: maximum peak height 2.08m following limestone deployment and **B) March 2025**: maximum peak height 0.96m. Seabed height had **reduced by 1.12m** over 20 months from July 2023 to March 2025. (© British Crown and OceanWise, 2023. All rights reserved. Licence No. EK001-20180802. Not to be used for Navigation).*

3.2.2 Marine Licencing Process

With restoration activities on hold pending the resolution of the gravel peaks, the project submitted a Band 2 marine licence application (MLA) in June 2024 via the Marine Licence portal to permit mechanical seabed levelling using a local marine plough (DEML2449) [68]. The work was proposed to provide a proactive solution to the gravel peaks, and to enable the project to continue with the deployment of shell cultch and native oysters.

The MLA underwent statutory consultation with relevant bodies, organisations, and the public. In September 2024, the application was placed on hold pending additional information and response from Welsh Government Marine and Fisheries Division requested by Natural Resources Wales (NRW) Marine Licensing to address points raised during consultation.

In February 2025, following completion of a second formal consultation process, it was agreed there were no concerns with allowing the gravel to continue levelling naturally. The MLA (DEML2449) was therefore withdrawn [68], and efforts refocused on a targeted deployment of shell ‘cultch’ and oysters complying with the marine licence, to deliver our intended objectives but limit any risk.

3.3 Revised Restoration Plan

The project developed a modified restoration plan that ensured compliance with the marine licence, met project objectives, and was agreed in collaboration with the local working group and Welsh Fishermen’s Association. The evidence demonstrating the natural redistribution of gravel over time provided confidence to proceed with a considered and adapted plan, designed to avoid exceeding the 0.5m bed level.

Several scenarios were developed and presented to the Technical Working Group, including small-scale cultch and oyster deployment within or adjacent to the restoration site, and an oyster-only deployment. The project consulted with regulators, Welsh Government Marine and Fisheries Division, Natural Resources Wales Marine Licensing, as well as the Welsh Fishermen’s Association. This resulted in an agreed approach of a small-scale research trial of 20 tonnes of cultch and 2,000 oysters within the restoration site to test the feasibility of oyster restoration in Conwy Bay.

In June 2025, the project team successfully deployed 45m³ (20 tonnes) of cultch material and 2,000 mature native oysters within a 32 x 20 m area in the West Bwrling licence area (Fig. 30). The cultch material was deployed using a 5-metre rubble chute, to control the flow of materials, to ensure no new areas above 0.5m in height are formed. Following the shell cultch deployment, 2,000 mature native oysters were relayed in batches along transects within the area to provide a local source of larvae. The oysters were purchased from an aquaculture site in Loch Ryan, Scotland. A

stringent biosecurity measures plan was followed to limit the risk of transfer of disease or non-native invasive species; see Appendix 1 in [21].

This represented the first small-scale research trial to test the feasibility of native oyster seabed restoration in Conwy Bay and was made possible by the continued engagement through the Local Working Group and Technical Working Group.



Images from the deployment activities of rubble chute used to distribute the cultch onto the seabed and trays of native oysters (left to right). © Rhianna Parry.

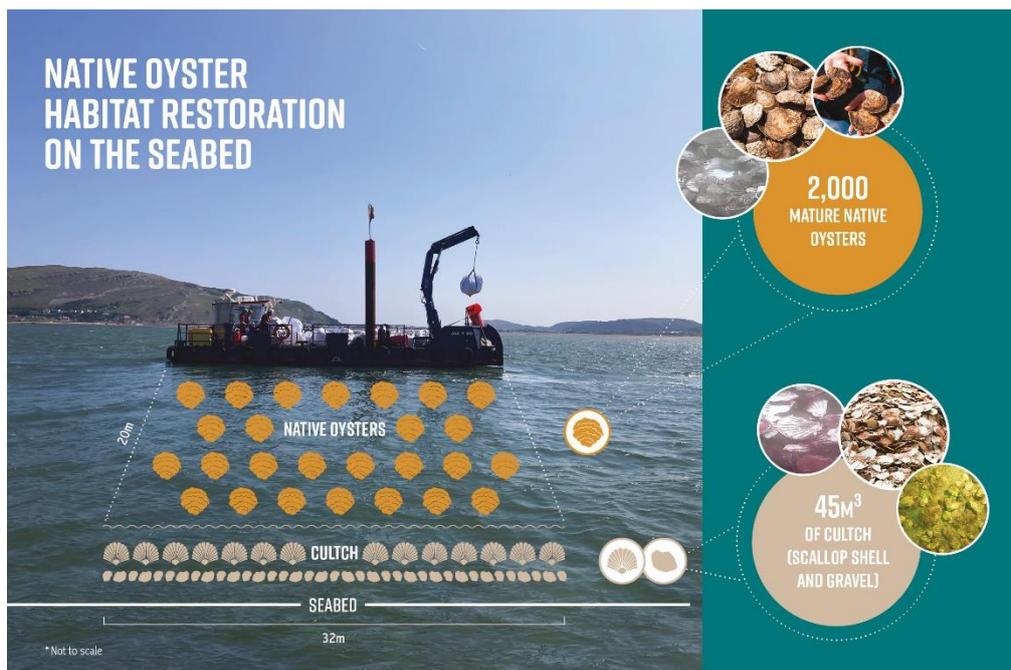


Figure 30. Infographic showing the native oyster habitat restoration activities carried out on the seabed, including the deployment of 45m³ of cultch (scallop shell and gravel) and 2,000 mature native oysters.



Image from the deployment activities of a tractor loading bags of cultch onto the Conwy Harbour Authority vessel

3.4 Monitoring and Research

Data gathering is an important aspect of oyster restoration to inform best practices and next steps. Monitoring has been completed throughout the duration of the project to aid site selection and quantify a baseline of key metrics (Tab. 3). Monitoring aims to measure ecological changes and assess the performance of the project in meeting restoration goals using a Before-After-Control-Impact (BACI) design i.e. conducting surveys at the restoration site and a control site, both before and after restoration (Fig. 31). Similar fauna and broadscale habitats existed at both sites prior to any seabed deployment activities. The control site remains unchanged and was used as a point of comparison.

The information gathered aims to better understand the impact of the restoration activities.

The following research questions will be investigated:

- What is the size frequency distribution of the restored oyster population?
- How does the project footprint and structure change overtime?
- What is the associated community within restored oyster habitat in Conwy, how does it change over time and differ between control and restoration sites?

Table 3. Summarising the seabed restoration monitoring plan. Data collected to assess the project footprint and reef height, infaunal invertebrates, mobile species, habitat and sessile species, shell cover, oyster density, oyster size and settlement.

Monitoring metric	Method	Frequency
Project footprint and reef height	Multibeam echosounder data	Pre & post deployment, annually
Mobile species	BRUV survey (3 in reef site, 3 in control site)	Pre & post reef deployment, annually
Habitat & sessile species Shell cover Oyster density Oyster size	Drop down video & stills (100 stills per reef site and 100 per control site).	Pre & post reef deployment, annually



Bangor University inshore survey vessel, Macoma © Maria Hayden-Hughes

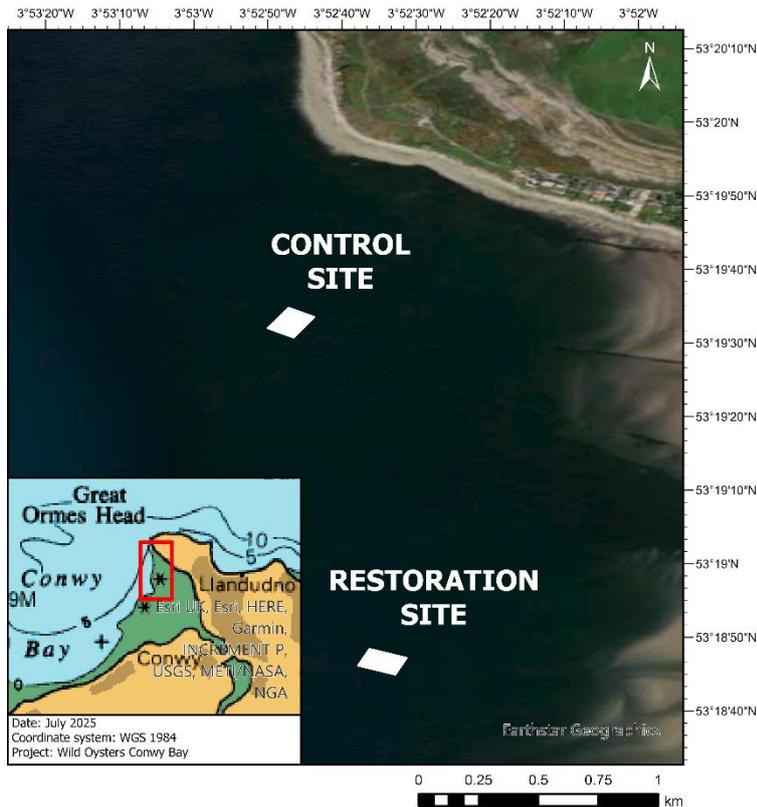


Figure 31. Location of restoration site and control site within Conwy Bay. Basemap sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community. © British Crown and OceanWise, 2023. All rights reserved. Licence No. EK001-20trained802. Not to be used for Navigation).

Three survey techniques were applied to assess the restoration site and the control site; 1) Multibeam echosounder, 2) Drop-down camera (Fig. 32), 3) Baited remote underwater video (BRUV) (Fig. 33). A multibeam echosounder was used to measure discrete depths capturing bathymetry data to assess project footprint and seabed height. These surveys have been completed biannually to assess the remediation of the gravel on the seabed. A drop-down camera survey was conducted annually collecting imagery to assess biodiversity: invasive non-native species, epifaunal sessile invertebrates and macrophytes, shell cover and oyster density (post-deployment). Imagery analysis was completed by ENVISION Ltd. to identify the benthic habitats present in these areas by recording the substrate and epifauna present and providing semi-quantitative data to support this. The imagery was also reviewed for features of conservation interest, including Annex I reef assessment [69, 70]. A BRUV survey was completed to assess the abundance of small resident fish and mobile invertebrates, transient fish and crustaceans.

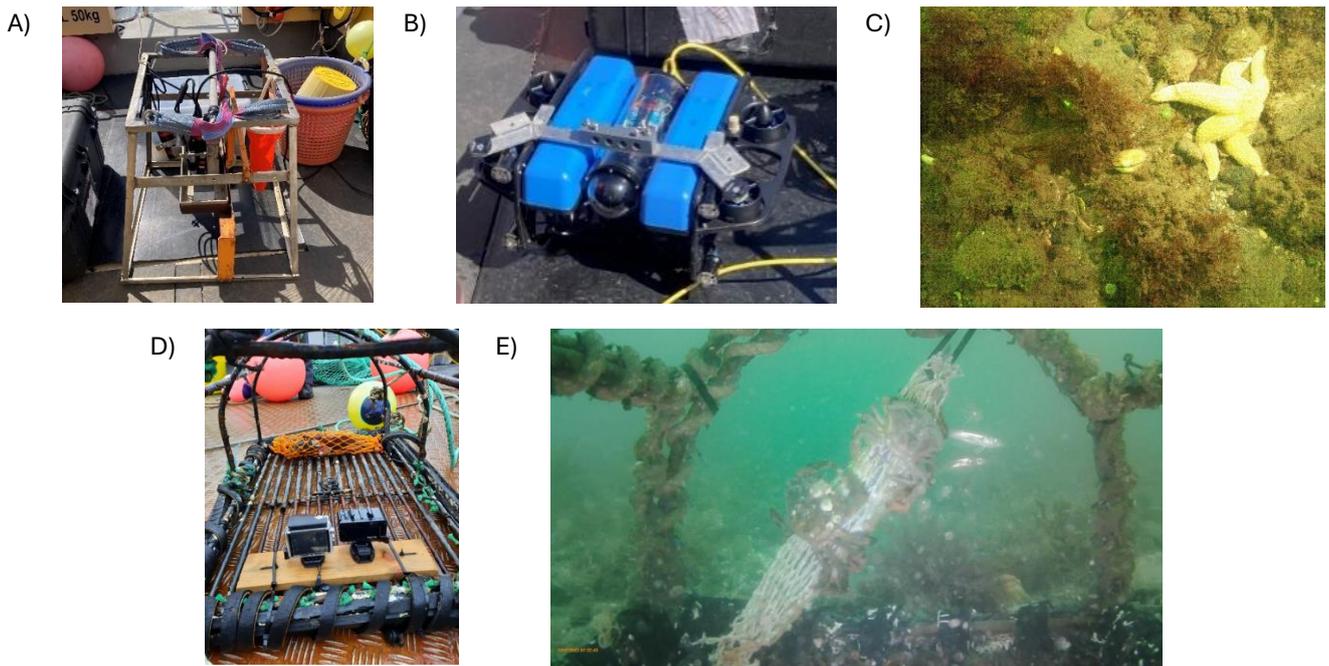


Figure 32. Camera survey equipment: a) drop-down camera survey equipment using a SubC Rayfin camera and light with 10cm lasers for scale (Rayfin-PLE-6000- MCBH6-LO-*Bangor), b) Blue Robotics BlueROV2, c) an example of imagery captured, d) Baited remote underwater video (BRUV) survey equipment repurposing a traditional creel base with a GoPro and Suptig LED waterproof video light (method by [71]), and e) an example of imagery captured.

A seabed bathymetry and drop-down video survey were completed post-cultch and oyster deployment in summer 2025. These survey results supported that the cultch material and oysters were successfully deployed within the restoration site (Fig. 33). Image analysis following the oyster and shell cultch deployment in June 2025 is ongoing.

The project aims to continue to conduct surveys annually, but ongoing monitoring is subject to continued project funding.



Image of scallop shell ‘cultch’ and oysters deployed onto the seabed within the restoration site in Conwy © Rhianna Parry

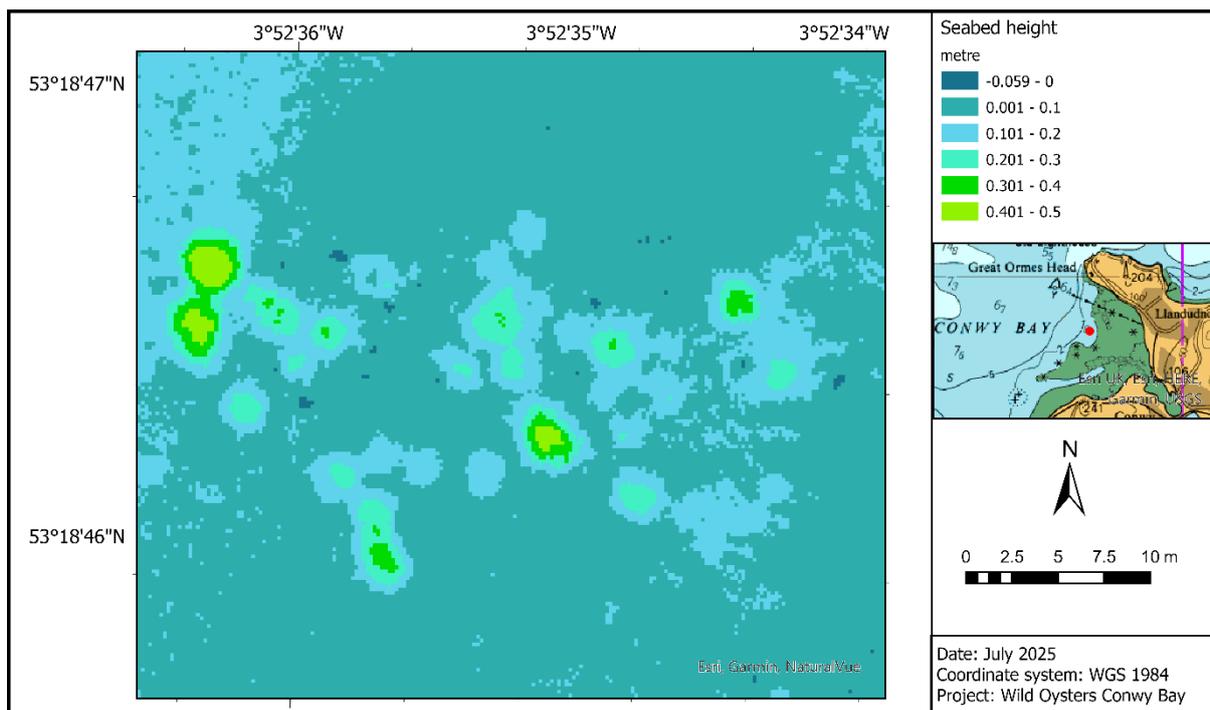


Figure 33. Bathymetry seabed survey results from July 2025 after the scallop shell ‘cultch’ and oyster deployment. ©British Crown and OceanWise, 2023. All rights reserved. Licence No. EK001-20180802. Not to be used for Navigation.

3.4.1 Biophysical modelling

Previously, biophysical modelling was completed to understand the hydrodynamics and potential larval dispersal from the oyster nurseries in the marina; see section 3.3.1

in [48]. In addition, it was also important to predict larval dispersal from the restoration site to understand larval retention or identify potential areas where larvae may settle.

Theoretical ‘particles’ were used to simulate the dispersal of *Ostrea edulis* larvae from the restoration site. Particle movement was driven by currents generated from the TELEMAC 2D (depth-averaged) hydrodynamic model known as “offline” Lagrangian particle tracking (Tab. 4).

The model incorporated water discharge data for the River Conwy, and surface wind data. No larval behaviours were incorporated. To capture variability over the full spring-neap tidal cycle, particles were released every 12 hours over 137 days. Each particle was tracked at 10-minute intervals for 20 days post-release, representing a 20-day pelagic larval duration (PLD). These positions were then mapped onto a 1 km × 1 km grid to produce density maps, or ‘heatmaps’, where particle density is expressed as a percentage of the total number of particles (Fig. 34). The results focus on particle distributions across the following time intervals from release:

1. 0–7 days
2. 7–10 days
3. 10–15 days
4. 15–20 days

Table 4. Table of dispersal metrics. Dispersal area has been counted from the number of 1 km² grid cells in or through which particles are transported during the 20-day pelagic larval duration (PLD).

Site	PLD	Maximum dispersal area (km ²)	Mean density (%)	Maximum density (%)
Reef	0-7 days	223	0.4	3
	7-10 days	265	0.3	2
	10-15 days	356	0.2	3
	15-20 days	536	0.1	3

The highest dispersal occurs in the first 7 days from release (Fig. 34). The dispersal from the restoration site nearly doubles in areal extent from 223 km² (0–7 days) to 536 km² (15–20 days). The mean density decreases throughout the time periods considered here. The maximum dispersal density is low (2–3%), indicating no high retention zones for particles released from this site. Dispersal was greatest into the Conwy Estuary, but particles were transported throughout the Menai Strait and Conwy Bay Special Area of Conservation and along the eastern coast of Anglesey. Based on the modelling results, larval retention within the restoration site was predicted to be low. It was difficult to identify potential areas where larvae may settle. Further ground-truthing and

settlement trials will be necessary to understand how larval dispersal may influence oyster recruitment. Oyster condition, gonad development and larval abundance may be additional monitoring metrics to assess.

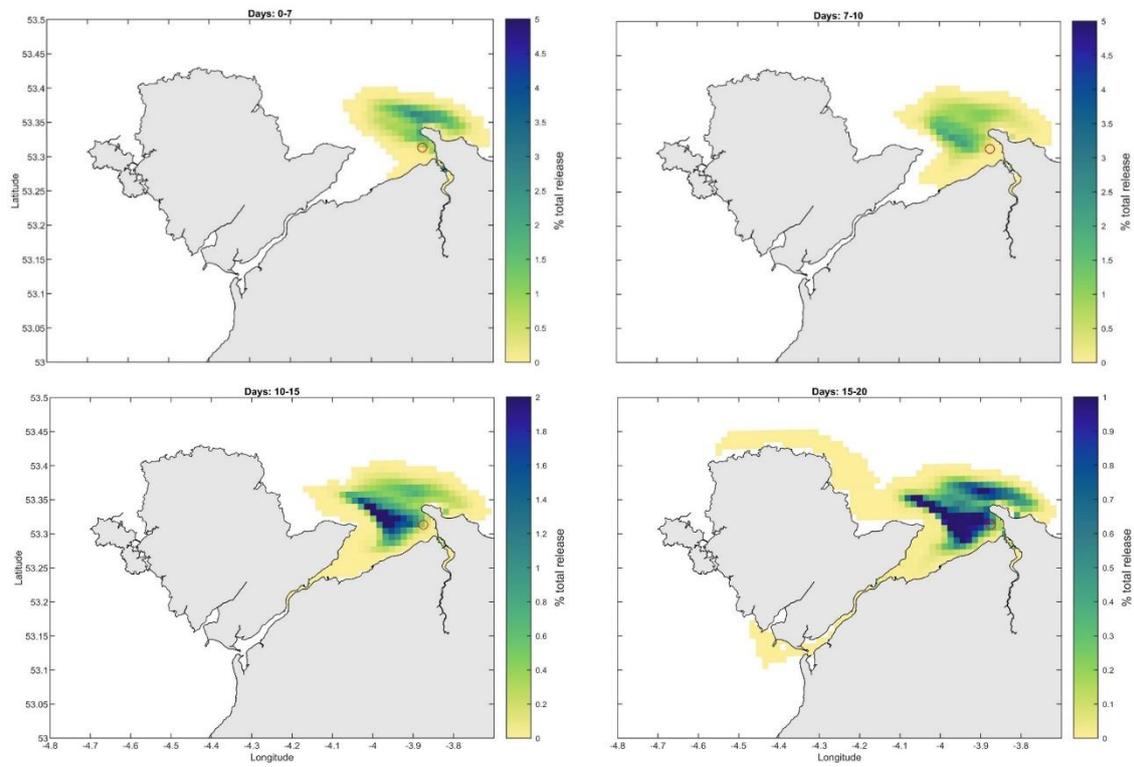


Figure 34. Biophysical modelling outputs of larval dispersal plume at 0–7 days, 7–10 days, 10–15 days, and 15–20 days. The red circle denotes the restoration site where the theoretical particles were released.

3.5 Key Lessons from Seabed Restoration

The seabed restoration phase of the project provided valuable learnings that will directly inform future marine habitat restoration projects in Conwy Bay and across the UK. Strong local relationships, transparent consultation, and adaptive management were central to maintaining momentum, building trust, and achieving the project's goals.

Key lessons include:

Marine licence considerations

Apply for marine licences as early as possible, build in extra time to appropriately respond to consultation responses and dialogue with regulators. Where possible, include some flexibility regarding specifics, such as reef height and exact deployment methods, to allow for adaptation to realities on the ground.

Space to adapt

Marine habitat restoration in the UK is an emerging field, with methodologies and best practices evolving as projects grow. Therefore, project design must allow room for trial, error and innovation, whilst maintaining compliance with licensing and funding requirements.

Challenging logistics

Large tonnage of cultch weathering, storage, transportation, and deployment are resource intensive and often limited by local infrastructure, such as the availability of vessels with sufficient deck space or suitable on-board cranes. These challenges highlight the need for considered planning and strong partnerships with local operators.

Oyster supply

A major constraint for oyster restoration projects is the continued lack of a reliable and consistent supply of oysters that meet specific restoration criteria, such as genetic suitability or disease status. Sourcing oysters from outside the local area poses significant biosecurity risks that are costly and time-consuming to manage and cannot be fully eliminated. In addition, it can be difficult to align funding timelines with the oyster production timeline and fishing season.

Strong stakeholder engagement

Involve regulators, government teams, local fishers, and key community representatives from the outset, and engage them at key decision points to build trust and secure buy-in. Formal engagement through a Local Working Group and Technical Working Group provided structured opportunities for input, with meetings scheduled around fishers' availability to ensure their perspectives are represented.

Some of these lessons came with challenges that caused delays, particularly when navigating the marine licencing, consultation and logistical challenges raised by the gravel cultch peaks. However, the flexibility and understanding shown by our funders, combined with the commitment of our partners and Local Working Group, have enabled us to adapt the project, and achieve the project outcomes.



Image oysters in trays prior to deployment onto the seabed within the restoration site in Conwy © Rhianna Parry

3.6 Conclusions: Seabed Restoration

The successful deployment of 20 tonnes of cultch and 2,000 mature native oysters represents a pioneering restoration trial in the Conwy Bay Estuary. This work has demonstrated the complexities and the possibilities of native oyster habitat restoration, directly contributing to Goal 1 of the Project, to improve the condition of native oyster habitat in Conwy Bay, and feed project research and knowledge into national native oyster restoration efforts.

Despite the challenges and delays posed by gravel cultch peaks, and the resulting marine licensing and consultation processes, the project delivered North Wales' first native oyster habitat restoration trial. This was made possible through adaptive management, open communication with local fishers, regulators, government teams, and community representatives, alongside the flexibility of funders combined with the commitment and expertise of local partners. Consequently, the project was able to adapt to challenges, maintain momentum and support, and achieve its restoration objectives.

Completing scientific monitoring surveys has been important for the development of the project's restoration plan, providing baseline data, and evaluation of the restoration outcomes. Surveys have been undertaken using multibeam echosounder, drop-down camera, and BRUV to assess reef footprint, height, oyster density, associated fauna, and changes in community composition relative to a control site. Continued monitoring in future years will be essential to assess oyster survival, settlement, biodiversity enhancement, and the long-term feasibility of reef establishment.

The project has generated valuable insights, that will be used to inform the next steps of the project but also feed into research and knowledge on national oyster restoration

efforts. The lessons learned, around licensing, engagement with local players, cultch deployment logistics and the need for flexibility, will help to streamline future projects and contribute towards the long-term goal of restored self-sustaining native oyster reefs in the UK.



Image of Wild Oysters Conwy Bay project team deploying oysters within the restoration site in Conwy © Rhianna Parry



Image of Conwy Bay © Maria Hayden-Hughes

4. Legacy and Next Steps

The #NNF2 Restoring Wild Oysters to Conwy Bay Project has a lasting legacy through strengthened partnerships, community involvement, and on-the-ground restoration. The project built strong relationships with the Local Working Group members, while citizen scientists developed skills and contributed valuable data from oyster nursery monitoring.

The project has also contributed to capacity building within the region, strengthening awareness, knowledge and understanding of marine habitat restoration, to support future work. The deployment of cultch and oysters on the seabed has laid the foundation for habitat recovery, enhancing biodiversity and providing a site for future monitoring. Together, these activities have generated both practical restoration experience and robust scientific evidence to inform future work.

This knowledge, combined with local partnerships and community support, has shaped the design of a follow-on project: *#NNF3 Connecting Conwy: A plan for Seascape-Scale Recovery of Coastal Habitats in North Wales* (August 2024–March 2026). Delivered in partnership between Bangor University and the Zoological Society of London and funded through the Nature Networks Programme (Round 3), this project aims to build upon pilot work to establish the groundwork for a long-term seascape-scale restoration plan in the Menai Strait and Conwy Bay SAC.

The project will focus on three key goals:

Goal 1: Habitat Presence & Barriers

Improve understanding of local habitat distribution (seagrass, native oysters, saltmarsh, blue mussel) and barriers to recovery, through desk studies, updated habitat suitability mapping, targeted surveys, and invasive species assessment.

Goal 2: Native Oyster Restoration

Continue restoration activities in Conwy Bay as a case study, including monitoring existing work, validating habitat suitability maps, identifying trial sites, and assessing restoration feasibility in the Menai Strait.

Goal 3: Community Engagement

Build public understanding of marine habitats and restoration through training, citizen science, and outreach, while offering opportunities for early-career researchers and local communities to participate directly.

Through these activities, #NNF3 will expand the project's scope from native oysters, to creating an evidence base needed to create a seascape plan for restoring multiple habitats across Conwy Bay and the Menai Strait Special Area of Conservation.



Volunteers holding native oysters onboard a boat visiting the seabed restoration site
©Rhianna Parry

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