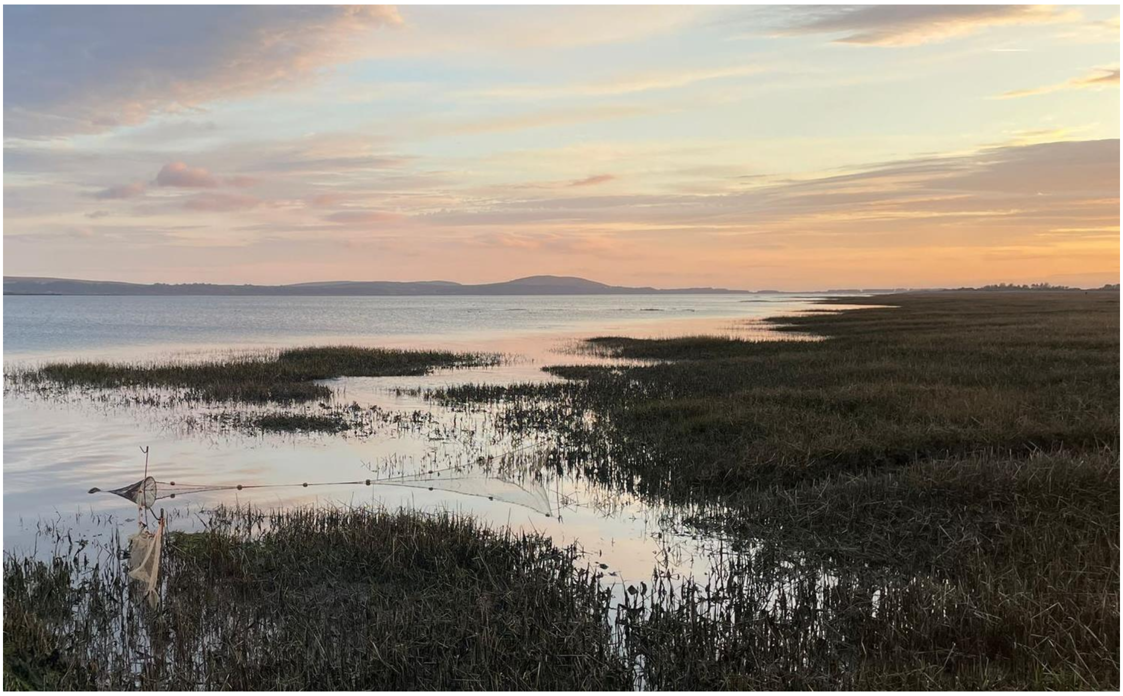
Estimating production of finfish in saltmarshes on the South Wales coast



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Sasha Shute

Declarations

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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Abstract

Saltmarshes are widely recognised as important nursery habitats for juvenile fish, yet their contribution to fish production remains underexplored. Globally, saltmarsh habitats have declined by 50%, leading to a rapid expansion of restoration projects. This study estimates annual fish production across three estuarine habitat types: saltmarsh, managed realignment (restored saltmarsh), and unvegetated shores. Monthly seine and fyke net surveys, conducted over 12 months at 17 sites within the Carmarthen Bay estuaries, recorded fish species, abundance, and size. Fish production was quantified using the Increment Summation Method. Six commercially valuable species and three species of conservation interest were identified. European bass contributed 73% (0.06385 g WW m^{-2} $year^{-1}$) of the total annual production (0.0866 g WW m^{-2} $year^{-1}$), showing highest productivity in unvegetated shores. Notably, production of Atlantic herring was measurable only in saltmarsh habitats (0.00443 g WW m^{-2} $year^{-1}$), while production of European eel was restricted to managed realignment sites (0.00035 g WW m^{-2} $year^{-1}$). However, the managed realignment has yet to achieve the full ecological functionality of natural saltmarshes, as evidenced by lower overall fish densities compared to saltmarsh and unvegetated shores (managed realignment: 475 individuals per km^2; saltmarsh: 8,596 individuals per km^2; unvegetated shores: 5,189 individuals per km^2). Four of the six commercially important species exhibited higher production in saltmarsh than in other habitats, underscoring the role of saltmarshes in enhancing finfish productivity. As the first UK study to estimate finfish production in saltmarshes, this research establishes critical baseline data for saltmarsh fish communities in South Wales. The findings highlight the ecological importance of saltmarshes and suggest that the managed realignment must advance further to fully replicate their functionality for fish.

Lay summary

Saltmarshes are recognised as important habitats for young fish to grow and develop. These wetland areas, flooded by the sea, provide shelter and food for juvenile fish. However, there's still not enough research that looks at exactly how much fish these habitats produce. With half of the world's saltmarshes already lost, many projects are now focused on restoring them. This study aimed to measure how much fish is produced annually in three different types of estuarine habitats: natural saltmarshes, managed realignment areas (which are manmade saltmarshes), and unvegetated shores (sandy estuarine beaches).

Researchers collected data by conducting monthly surveys over a year at 17 different sites within the Carmarthen Bay estuaries in South Wales. They used special nets to catch fish, recording what species were present, how many there were, and how big they were. The goal was to understand how productive each habitat was in supporting fish populations.

Six species of fish that are important for commercial fishing, such as Atlantic herring, were identified, along with three species that are of conservation interest. To calculate the fish production in each habitat, the researchers used a method called the Increment Summation Method, which helps work out how much fish biomass is produced over time.

European bass, a commercially valuable species, made up the majority of the fish production. It contributed 73% of the total fish biomass produced across all the habitats, with the most productive areas being the unvegetated shores. However, some species were more selective about where they lived. For example, European eels, which are endangered, were only found in managed realignment, while other species, like Atlantic herring, were only found in saltmarshes.

Interestingly, while the managed realignment did provide some benefits for certain fish, they weren't as effective as natural saltmarshes in supporting most species. Managed realignment had the lowest overall fish densities compared to both saltmarshes and unvegetated shores. In fact, four out of the six commercially important fish species had higher production rates in natural saltmarshes than in either restored saltmarshes or unvegetated areas. This suggests that saltmarshes play a key role in enhancing fish productivity, providing vital nursery habitats that support the growth of young fish.

This study is particularly significant because it provides the first estimates of fish production from UK saltmarshes, offering critical baseline data on the fish communities in South Wales. These findings underline the ecological importance of saltmarshes, especially in terms of their role in supporting commercially valuable and endangered fish species. The research also highlights that while restoring saltmarshes is essential, it takes time for these restored habitats to fully function like natural ones. As climate change and coastal development continue to threaten these crucial ecosystems, this study underscores the need to continue restoration efforts to protect both fish populations and the broader coastal environment.

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Introduction

Saltmarshes are dynamic and highly productive intertidal habitats (Townend et al., 2011). The topography is varied, consisting of three main features: creeks, pools, and flats; the pools and creeks are devoid of vegetation and have soft, muddy benthic substrates that are the first to be submerged on a flooding tide, while the vegetated flats sit above the creeks and pools, typically becoming submerged only towards the higher end of the tidal cycle (Zedler et al., 1999). These combined topographies create a unique environment. Saltmarshes provide ecosystem services including coastal defence, carbon sequestration, water filtration, nutrient cycling, habitat, and fish nurseries (McKinley et al., 2018). Due to these services, the habitat has been granted several legal protections: BAP, SSSI, and Annex I habitat (European Commission, 2021; JNCC, 2007; Rees et al., 2019). However, with the combination of sea level rise and anthropological developments involving land reclamation, the UK has lost 85% of saltmarsh over the last 200 years, while globally at least 50% of saltmarsh cover has been lost (Barbier et al., 2011; Hansen and Reiss, 2015). The continued degradation of saltmarshes threatens their long-term stability and the critical functions they provide. Given their vulnerability to both human activities and climate change, conservation efforts are essential to ensure their persistence and the benefits they offer to coastal and estuarine ecosystems.

1. Ecosystem functioning in UK saltmarshes

UK saltmarshes generate 400 - 500 g/m2 of organic carbon annually (Boorman, 2003). This production stems from a diverse array of organisms, including plants like sea purslane and cord grass, algae such as water felt and bladderwrack, along with phytoplankton, and microphytobenthos (Boorman, 2003; Polderman, 1978; Svensson et al., 2007).

Invertebrate species are the primary consumers of the resulting production and detritus (Créach et al., 1997). For predatory fish such as European bass (*Dicentrarchus labrax*) and European flounder (*Platichthys flesus*), invertebrates are a significant prey source, comprising amphipods, ragworms, crabs, and shrimp (Hampel et al., 2005). Grey mullets (*Chelon ramada, Chelon labrosus,* and *Liza aurata*) as detritivores feed on detritus and algae (Cardona, 2015). Production from the vegetation and the benthic community provides a range of food sources for juvenile fish as they develop, and their diets change (Boesch and Turner, 1984).

In addition to plentiful food sources, saltmarsh vegetation and complex topographic structures provide shelter from predators and strong currents for the juvenile fish (James et al., 2019). Due to the benefits afforded to juvenile fish by the saltmarsh habitat it was theorised that they would serve as optimal nursery grounds for some fish species (Vernberg, 1993).

2. Research progress on fish use of saltmarshes

Successful recruitment rates are crucial to maintaining a population (Caley et al., 1996). Nursery habitats enhance fish populations by offering conditions that favour the growth, development, and protection of the recruiting juveniles (Munro and Bell, 1997). Fish often have R-selected life cycles – producing many offspring with no parental care and low survival rates (Adams, 1980). Juvenile survival is a critical factor in fish population sustainability, as early life stages are particularly susceptible to environmental pressures and predation (Jørgensen and Holt, 2013). Investigating the nursery habitats contributing to a fish stock is key to understanding how to sustain and protect them (Beck et al., 2001).

The saltmarshes of North America have been extensively researched since the 1970s (Cain and Dean, 1976). Numerous fish species have been identified using North American saltmarshes as a nursery habitat (Endresz, 2020; Rogers et al., 1984; Whitfield, 2017). However, the qualification of what makes a “fish nursery habitat” is highly debated and the current agreed-upon definition stands at “a habitat where a species exhibits higher than average juvenile density, growth, survival or movement to adult habitat” (Lefcheck et al., 2019).

Investigation into the saltmarsh fish assemblages in Europe began in the 1980s (Boesch and Turner, 1984; Cattrijsse et al., 1994; Costa et al., 1994; P. Laffaille et al., 2000). The nursery value of European saltmarshes has not explicitly been assessed; however, the data concurs with the North American studies that most fish entering the systems are juveniles (Costa et al., 2001; Joyeux et al., 2017; Lafage et al., 2021; Mathieson et al., 2000; Veiga et al., 2006). Due to geographical and geological differences between North American and European saltmarshes, findings on fish habitat use in one region may not directly apply to the other; however, they still provide valuable insights into broader trends (Allen, 2000).

Grey mullet and European bass consistently dominate saltmarsh fish assemblages in Europe and the UK, indicating the habitat's importance as a nursery habitat for both species. Fish assemblages in UK saltmarshes were not studied until the early 2000s and are spatially limited to southeast England (Colclough et al., 2005, 2004; Green et al., 2012, 2009; McCormick et al., 2021; Pickett et al., 2004; Stamp et al., 2023).

Loss of fish nursery habitats reduces the already low juvenile survival rates, significantly impacting the recruitment of adult populations (Rochette et al., 2010; Sundblad et al., 2014). Saltmarsh habitat loss has been linked to declining fish production (Teal and Howes, 2005) - in the Forth estuary it is estimated there was a 66% reduction in fish production after intertidal land reclamation (McLusky et al., 1992).

3. Development and application of fish production models

The first fish production models were developed in the 1970s and include size-based models, age-structured models, and production/biomass (P/B) ratios (Cowley and Whitfield, 2002; Dolbeth et al., 2010, 2008; Gillespie and Benke, 1979; MacLeod et al., 2022; Randall and Minns, 2000; Wong and Dowd, 2016). Models are useful tools for translating biological complexities into meaningful insights (Allman and Rhodes, 2004). Calculating finfish productivity from a habitat provides a quantitative measure of the ecosystem service provided for both commercial stocks and stocks of conservation species, which can then be compared between different habitats (Seitz et al., 2014). Metrics like productivity translates ecosystem services into understandable terms, making it a useful tool to inform and encourage investment in the conservation and protection of the habitat (Syukur et al., 2021).

Since 2008, fish production from coastal ecosystems has been estimated using the Increment Summation Method (ISM) (Dolbeth et al., 2010, 2008; Erzini et al., 2022; Franco et al., 2010), which is a size-based approach that categorises fish into distinct cohorts based on lengths and tracks the cohort's growth over time. The output of this model is in grams (wet weight) produced per square meter annually (g WW m^{-2} $year^{-1}$) (Winberg, 1971). ISM provides a detailed approach to assessing production, where each cohort's production is assessed individually from one sample event to the next. Through ISM, monthly, seasonal, and annual changes in productivity can be observed on a species level.

Several studies have assessed the productivity of estuaries and coastal lagoons (Cowley and Whitfield, 2002; Dolbeth et al., 2010, 2008; Erzini et al., 2022). The production from the five most abundant species in the Minho and Mondego estuaries of Portugal ranged from 0.66 – 6.73 g WW m^{-2} $year^{-1}$ (Dolbeth et al., 2010). Two studies have exclusively assessed productivity from a saltmarsh habitat, both focused solely on the productivity of one species (Franco et al., 2010; MacKenzie and Dionne, 2008). Mediterranean saltmarshes produce 0.21 – 0.52 g WW m^{-2} $year^{-1}$ of flounder (Franco et al., 2010).

This study uses ISM to estimate productivity from commercial and conservation species in saltmarshes, managed realignment, and unvegetated estuarine shores in South Wales. This will allow for a direct comparison between the three estuarine habitats.

4. Sampling techniques for fish in saltmarshes: fyke and seine nets

As saltmarsh consists of varied terrains, they can be difficult to sample (Adam, 1990). Therefore, to effectively sample fish assemblages in the habitat, a combination of methods is required to account for the full scope of the environment. Multiple sampling techniques are needed to assess fish assemblage and habitat utilisation. Popular methods are drop samplers, pop nets, fyke nets, seine nets, beam trawls, mark and recapture, and acoustic tracking (Harrison-Day et al., 2020; Pickett et al., 2004; Ricci et al., 2017). This study uses a combination of fyke and seine netting, replicating the same methods used in studies based on other UK saltmarshes for direct comparability (Colclough et al., 2005; Elliott and Hemingway, 2002).

Both techniques used have their advantages and disadvantages. Fyke nets generally catch a wider diversity of fish species with lower abundances, while seine nets catch fish in higher frequencies with lower diversity (Crinall and Hindell, 2004). Seine nets are active nets deployed from shore, relatively nonselective but may target mid-water species best (Lyons, 1986). Seine nets are versatile so can be used creatively to suit the topography, which is useful in a dynamic environment (Johnson et al., 2007). Fyke nets are static nets deployed in the creeks of the saltmarsh, filtering the water of the creek through the net on the ebbing tide (Harrison-Day et al., 2020). Fyke nets target benthic species best (Breen and Ruetz, 2006), and may be better than seine netting for capturing highly mobile species, as the movement from seine netting can alert the fish and cause them to move before they are captured. Using these techniques in conjunction maximises data collected in abundance and diversity (Clark et al., 2007; Franco et al., 2022).

5. Objectives of study

The research will advance knowledge of fish assemblages in UK saltmarshes, expanding to four saltmarshes along the coast of South Wales which have not been included in previous studies. This study is one of the first in the UK to quantify productivity of finfish species from saltmarsh habitat with objectives of (1) comparing fish assemblage data interannually (October 2022 and 2023), (2) assessing variation in fish assemblage between (i) native saltmarsh, (ii) restored saltmarsh and (iii) unvegetated estuarine coastline, (3) analyse spatio-temporal trends in fish assemblages in South Wales, and (4) comparing finfish production in terms of biomass per unit area per annum.

Materials and Methods

1. Study location

This research focuses on the saltmarshes of South Wales' Burry inlet and Three Rivers estuaries. Saltmarsh sites were surveyed in four clusters: Cwm Ivy, Crofty, Llanelli Wetlands, and Laugharne Castle. Cwm Ivy is a managed realignment, a man-made saltmarsh, while the rest are natural saltmarshes. Control sites were selected within the same estuaries as the saltmarsh sites, on shores with no saltmarsh vegetation and sandy or muddy benthos (hereafter referred to as "unvegetated"). Two unvegetated clusters were surveyed; one in the Burry inlet at Llanelli Beach, and one in the Three Rivers estuaries at St Ishmael. Each cluster was sampled over a day with two fyke nets and one seine netting site (except from Llanelli wetlands where only one fyke net was set up). In total seventeen sites were sampled in each survey, eight in saltmarshes, three in managed realignment, and six in unvegetated. Over the year monthly surveys were carried out at every site during spring tides, from September 2023 to August 2024.

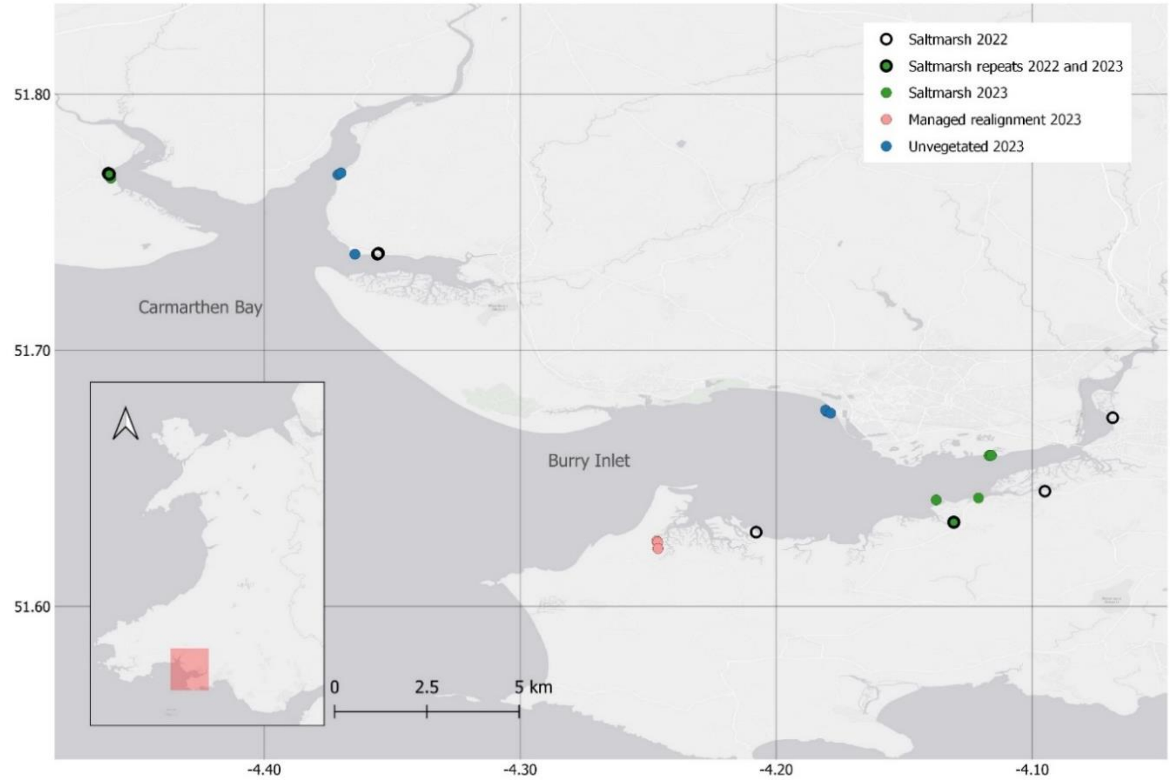

Figure 1 Locations of sites sampled throughout 2022 (empty black circle) and 2023 (coloured circle), in South Wales' Burry Inlet and Carmarthen Bay. Sampling across three habitat types: saltmarsh (green), managed realignment (red), and unvegetated (blue). Sampling was conducted with either seine nets or fyke nets. Two saltmarsh sites have been sampled with seine nets in both 2022 and 2023, indicated by a black circle filled in green.

2. Sampling technique: Fyke netting

In saltmarsh creeks, winged fyke nets were deployed: 10 mm mesh wings 5 m long, 8 mm mesh D ring trap 50 cm high, 6.5 mm mesh cod end net (as used in other saltmarsh assessments in the UK e.g. Colclough, 2018). The small mesh sizes ensure juveniles are accounted for in the samples (Stamp et al., 2023). Due to the distinct topographies of saltmarsh habitats, each fyke netting site required a unique sampling plan. Appropriate fyke netting sites were determined by several factors: accessibility, maximising area sampled, and position in relation to other sites. Using local tidal graphs from Tides4fishing.www and in-person observations, a fixed tidal height was determined at which the nets were to be deployed on the flooding tide, and a fixed tidal height at which they were to be removed (see tidal heights in appendix 6).

The theory of selective tidal transport explains that fish enter the saltmarsh on the surface of the flooding tide and exit in the deeper water on the ebbing tide (Gibson et al., 2001). The wings of the net face upstream, so that as the tide floods the saltmarsh water (and nekton) flow around the net up into the saltmarsh and as the water exits through the creeks the nekton are channelled into the cod end. Nets were retrieved on the ebbing tide when 50cm of water was left in the creek (top of D ring visible), to minimise fish mortality by limiting the fish’s time out of water and exposure to crabs. Fyke nets were placed at the bottom of the creeks on the edge of the saltmarsh to maximise the area sampled. To avoid the entrapment of protected air-breathing animals, such as the Eurasian otter (*Lutra lutra*) and common scoter (*Melanitta nigra*), otter guards were used to cover the mouth of the nets (Larocque et al., 2012).

In unvegetated habitats, fyke nets were set up so that they submerged at the same tidal height as the nearest saltmarsh fyke nets submerged, with the wings set at a 40º angle.

To calculate fish density the area sampled by the fyke net must be known. Flats and creeks higher up the intertidal drain into the fyke nets, all contributing to the area sampled.

Using QGIS, a polygon was drawn from the position of the fyke up to the high-water point including all tributaries into the creek (Butcher et al., 2005). The area sampled was estimated as the area within the polygon, this was repeated for each fyke net.

3. Sampling technique: Seine netting

Seine netting was carried out during the high tide between the set up and retrieval of fyke nets. Site selection ensured no pseudo-replication by choosing areas that would not later drain into the creeks with the previously deployed fyke nets. Seine net sampling took place 30 mins before high tide to 30 mins after, using a 15 m x 2 m 3 mm knotless mesh net (as used in other saltmarsh fish surveys in the UK e.g. Colclough, 2018). Seine netting occurred during daylight and nighttime depending on the tide and daylight hours. At each seine site, three replicates were taken. When sampling over vegetated saltmarsh flats the standard beach seine methods were employed, ensuring the lead line was tight to the floor (for details see Johnson et al., 2007; Franco et al., 2022). Seine netting in saltmarsh pools: both poles start close together at the back of the pool with the lead line sitting on the bottom, the poles pull around closely to the sides, with operators joining up at the other end of the pool. Saltmarsh pools were less frequently sampled as they are often entirely covered at high tides. Unvegetated sites were sampled 30 mins before high tide to 30 mins after, the seine net was used as a typical beach seine. Llanelli WWT and St Ishmael were not accessible at the full height of a high tide so were sampled on the flooding tide as close to the high tide as possible.

The area sampled in each seine haul was calculated by multiplying the length of the seine net (15 m) by the maximum water depth reached in the sample (this varied by site and tidal height). This measurement of area sampled was used to calculate densities.

4. Data collection

Coordinates of sites were taken in the field using “pin my location” function in Google Maps, later verified with Google Maps satellite imaging. Timings of each netting were recorded, at deployment and retrieval of each net.

Once captured, fish were transferred into a 40 L bucket. Using a hand net, fish were sub-sampled from the bucket. Individuals were identified to a species level based on photo identification guides. Any individuals that were not identified with certainty in the field were photographed and later identified. The first 15 individuals of each species were measured with a 60 cm WaterMark Ultimate Fish Board. Once measured fish were immediately placed into a filled 40 L bucket and then released back into the water they were taken from (Bertelli & Unsworth, 2014). Fish spent a maximum of 1 min out of the water. Abundance, lengths, date, gear, habitat type, site name, and timing of deployments were recorded in one data sheet for each sample taken (see appendix 7).

5. Data analysis

a) Data organisation

Species were sorted by significance into commercially important, conservation interest, and non-focal species, see Table 1. Only species with either commercial importance or conservation interest designation were included in the analysis.

Raw data was entered into Excel spreadsheets, with a sheet for abundance data and a sheet for length data. Date, gear used, habitat type, site name, and timing of deployments were entered in the data sheets for each sample taken. Abundance data was imported into R studio (R Core Team, 2021). Subsets were created to separate groups from one another using the metadata columns with the packages dplyr and tidyr (Vaughan, 2023; Wickham et al., 2024).

b) Data visualisation

Density was calculated by dividing total abundance by the total area sampled. Densities from fyke and seine netting were combined to provide a comprehensive assessment of the habitat. While differences between netting types were evident due to the challenges of quantifying fyke net data, fyke nets were included to ensure the detection of certain species and life stages that were not captured with seine nets. Although this approach may have diluted density estimates derived from seine netting, it provided a more complete representation of the fish community. Descriptive statistics for density measures such as total, mean, standard deviation, SEM, and range were extracted for each subgrouping. These were then transformed into graphs using ggplot2 package (Wickham, 2016). The package ggplot2 was also used in creating all bar graphs, time series, and dot plots. The package cowplot was used to generate multipaneled plots (Wilke, 2024).

To assess community composition across the three habitats, Non-Metric Multidimensional Scaling (NMDS) was performed using the Bray-Curtis dissimilarity matrix. The vegan package (Oksanen et al., 2024) was employed to compute the dissimilarity matrix and carry out the NMDS analysis with two dimensions. The NMDS plot generated during the analysis visually represents the similarity of species composition across different habitats. Each point corresponds to a sampling instance, with points that are closer together representing more similar species compositions.

c) Statistical testing

Permutation tests were conducted to assess the significance of differences in mean abundances of each species between October 2022 and October 2023 seine hauls. T-tests were not deemed appropriate as the data was found to be non-normally distributed, hence using the non-parametric permutation tests (Godfrey, 1992).

Monthly variations in focal species density were analysed with visualisation of density over study period to assess seasonal trends from October 2023 to August 2024.

Differences in community composition across the three habitat types were assessed using a Bray-Curtis dissimilarity matrix, and visualised in an NMDS plot, focusing on the nine focal species of this study. The aim was to identify overarching differences and similarities in the composition of important species between the unvegetated, saltmarsh, and managed realignment habitats.

A Permutational Multivariate Analysis of Variance (PERMANOVA) was performed to test for significant differences in community composition across the three habitat types, using the vegan package. The analysis was based on a Bray-Curtis dissimilarity matrix, calculated from species density data across saltmarsh, unvegetated, and managed realignment habitats, with habitat type as the main factor in the model. Statistical significance was assessed using 999 permutations. If significant differences were detected, a pairwise PERMANOVA was conducted using the pairwiseAdonis package to assess species composition differences between specific pairs of habitat types (Martinez Arbizu, 2017).

Due to the non-normal distribution of the data, as indicated by histograms, Q-Q plots, and Shapiro-Wilk tests, Kruskal-Wallis tests were used to assess differences in the median densities (individuals per km^2) of commercial fish species across the three habitat types (Ostertagová et al., 2014). When a significant difference was found, Dunn's post-hoc test with Bonferroni correction was applied using the dunn.test package to evaluate pairwise differences between habitat types (Dinno, 2024).

d) <u>Estimating fish production using Increment Summation Method</u>

In R studio, length data was subset by species and habitat type (R Core Team, 2021). In the package TropFishR data sets were transformed into length frequency files (Mildenberger et al., 2017). Length-frequency histograms were generated for each month of sampling for each species in each habitat. Cohorts were identified by using R studio to identify significant peaks in the length frequency data. Peaks in the distribution were identified based on two key parameters: (1) minimum threshold—a point in the frequency data was considered for peak evaluation only if its value was at least two; and (2) minimum prominence—a peak was considered significant if it was at least one unit higher than the surrounding values.

Mean length, standard deviation of length, and proportion were calculated for each identified cohort. Cohorts in consecutive months were assessed to determine if they could belong to one cohort, using water temperatures and known growth rates. Once a cohort has been traced through two or more months it can be used to calculate production using the following equations.

To calculate the total abundance of each cohort the proportion of the cohort in the length sample was multiplied by the total abundance of the species in that subset.

$$\begin{aligned} &Total\ of\ cohort\ in\ month\ t \\ &\quad = Proportion\ of\ cohort\ in\ measured\ individuals\ in\ month\ t \\ &\quad \times total\ number\ of\ species\ recorded\ in\ month\ t \end{aligned}$$

Density of a cohort was determined by using the previously calculated "area sampled" and the total abundance of the cohort.

$$\begin{aligned} &Density\ of\ cohort\ in\ month\ t \\ &\quad = Total\ of\ cohort\ in\ month\ t \div Total\ area\ sampled\ in\ month\ t \end{aligned}$$

The mean length of each cohort each month was extracted and converted into wet weight (g) using species-specific length-weight equations. All calculations were repeated for the same cohort in the consecutive month. Density and mean wet weight were then inputted to the Increment Summation Equation.

$$P_{cn} = \sum_{t=1}^{t=0} (\frac{N_t + N_{t+1}}{2}) \times (W_{t-1} - W_t)$$

The resulting value is production in grams per meter squared for the time between the first sample event to the second. This was repeated for every consecutive month for each identifiable cohort. All months were summed together to give a value in grams per meter squared annually (g m^{-2} year $^{-1}$) for that species.

All individuals considered in the production estimation were juveniles, as adults were rarely present and when they were numbers were too low for cohort detection. Table 2 details the lengths at different life stages for each focal species.

6. Literature search on focal species life history

After completing all sampling, focal species were identified based on their commercial significance or conservation interest. For the purposes of this study, species were classified into three designations: commercial, conservation, or non-focal. Commercial designations were assigned using information from the "Human uses" section of each species' FishBase profile (Froese and Pauly., 2022). Conservation designations were assigned based on the species' legal protection status in the UK, as determined through a comprehensive review of relevant legislation and literature. Non-focal species were those that did not meet the criteria for either commercial or conservation significance.

A targeted literature search was conducted to investigate the potential drivers of seasonal peaks in the populations of focal species, with a specific focus on their feeding habitats and spawning events within local waters. The search included peer-reviewed studies, government reports, and ecological surveys relevant to the species of interest. Major scientific databases such as Web of Science, and Google Scholar were used to identify studies using search terms such as "[Species Name]" AND "feeding behaviour" OR "spawning" AND "seasonality" AND "Bristol Channel."

For each focal species, age (in years) and total length at maturity (TL, in cm) were obtained from the FishBase Life History Tool (Froese and Pauly., 2022).

Data for annual production estimates were collected specifically for focal species to ensure direct comparability with this study. Estimates were sourced from various studies and reports, with the methodology for production estimation varying among sources. All production estimates were derived from assessments of whole estuarine systems, providing a comprehensive view of the annual production for each focal species.

Results

Over a year of monthly sampling, totalling 72 days of fieldwork and 307 netting events, 8,606 individual finfish across 20 species were recorded. Of these, 6140 were from eight commercially important species: Atlantic herring (*Clupea harengus*), European sprat (*Sprattus sprattus*), European bass (*Dicentrarchus labrax*), Thinlip mullet (*Chelon ramada*), Thicklip mullet (*Chelon labrosus*), Golden mullet (*Liza aurata*), European flounder (*Platichthys flesus*), and sand smelt (*Atherina presbyter*). Additionally, 350 individuals were recorded from three species of conservation importance: lesser sandeel (*Ammodytes tobianus*), sea trout (*Salmo trutta trutta*), and European eel (*Anguilla anguilla*) (see Table 1). Hereafter all mullet species are referred to as one grouping under the name grey mullet, as no distinction is made between the species commercially.

Table 1 Throughout the study, eight species of commercial importance, three species of conservation interest, and eleven non-focal species were observed.

Common name	Latin name	Significance
Atlantic herring	*Clupea harengus*	Commercial importance
Common goby	*Pomatoschistus microps*	Non-focal species
European bass	*Dicentrarchus labrax*	Commercial importance
European eel	*Anguilla anguilla*	Conservation interest
European flounder	*Platichthys flesus*	Commercial importance
European sprat	*Sprattus sprattus*	Commercial importance
Fifteen spine stickleback	*Spinachia spinachia*	Non-focal species
Five bearded shore rockling	*Ciliata mustela*	Non-focal species
Golden mullet	*Liza aurata*	Commercial importance
Greater pipefish	*Syngnathus acus*	Non-focal species
Lesser sandeel	*Ammodytes tobianus*	Conservation interest
Rudd	*Scardinius erythrophthalmus*	Non-focal species
Sand goby	*Pomatoschistus minutus*	Non-focal species
Sand smelt	*Atherina presbyter*	Commercial importance
Sea trout	*Salmo trutta trutta*	Conservation interest
Thicklip mullet	*Chelon labrosus*	Commercial importance
Thinlip mullet	*Chelon ramada*	Commercial importance
Three spine stickleback	*Gasterosteus aculeatus*	Non-focal species
Top mouthed gudgeon	*Pseudorasbora parva*	Non-focal species
Worm pipefish	*Nerophis lumbriciformis*	Non-focal species

1. <u>Year-on-year fish abundance comparison: October 2022 and 2023</u>

For commercially important species such as Atlantic herring, no statistically significant difference in mean abundance was found between the two years ($Z = -1.8514$, $p = 0.074$, based on 10,000 permutations). Similarly, for the conservation species, the European eel, no statistically significant difference in mean abundance was observed ($Z = -1.5635$, $p = 0.292$, based on 10,000 permutations).

Across repeated sites, five more focal species were recorded in October 2023 compared to October 2022 (Table 2). While data collection methods differed slightly between years—with more samples taken within pools in 2022 and more over flats in 2023— the results provide a comparative overview of species abundance across the two sampling periods. Notably, the mean abundance of Atlantic herring increased dramatically, showing a 25-fold rise in October 2023 compared to October 2022 (Table 2). European sprat also exhibited a more than 20-fold increase in mean abundance between the two years. However, the mean abundance of European Bass demonstrated a three-fold decrease from 2022 to 2023.

Table 2 Comparison of mean abundance of fish in October 2022 and October 2023 shows variation in trends. Atlantic herring and European sprat exhibited significant increases in mean abundance in October 2023 compared to October 2022, whilst grey mullet show limited variation between years. Mean abundance per seine haul (± SE and range of values) of focal species from October 2022 and October 2023 only, grouped by commercial and conservation importance. Repeat sites refer to only the locations sampled in both the 2022 and 2023 surveys.

Species	Oct 2022			Oct 2023			Repeat sites Oct 2022			Repeat sites Oct 2023		
	Mean ± SE		Range	Mean ± SE		Range	Mean ± SE		Range	Mean ± SE		Range
Commercial												
Atlantic herring	0.23	±0.23	5	5.78	±4.57	0 – 41	0		0	0		3
European sprat	0.18	±0.14	3	4.11	±3.75	0 – 34	0		0	0		0
European bass	2.82	±1.42	25	0.78	±0.40	0 – 3	0		0	1.17	±0.54	3
Grey mullet	6.27	±1.49	22	8.00	±2.00	0 - 19	4.29	±2.17	16	9.50	±2.38	15
European flounder	0		0	0.11	±0.11	0 – 1	0		0	0.17	±0.16	1
Sand smelt	0.55	±0.31	6	0.56	±0.38	0 - 3	0		0	0.83	±0.54	3
Conservation												
European eel	0		0	0.11	0.11	1	0		0	0.17	±0.17	1

Commercially important species exhibited varying trends between the two years (Table 2). For example, Atlantic herring (mean ± SE: 5.78 ± 4.57 in 2023) and European sprat (mean ± SE: 4.11 ± 3.75 in 2023) showed marked increases in mean abundance, while European bass saw a decline (mean ± SE: 2.82 ± 1.42 in 2022, 0.78 ± 0.40 in 2023).

Additionally, grey mullet mean abundance showed an increase at repeated sites, rising from 4.29 ± 2.17 in 2022 to 9.50 ± 2.38 in 2023. No species were present in every sampling, and some, like European eel, were only caught once in October 2023 and not at all in 2022.

Atlantic herring, European sprat, grey mullet, and European flounder all showed higher mean abundances in 2023 compared to 2022, while sand smelt abundance remained relatively unchanged (mean ± SE: 0.55 ± 0.31 in 2022 and 0.56 ± 0.38 in 2023) (Figure 2, Table 2).

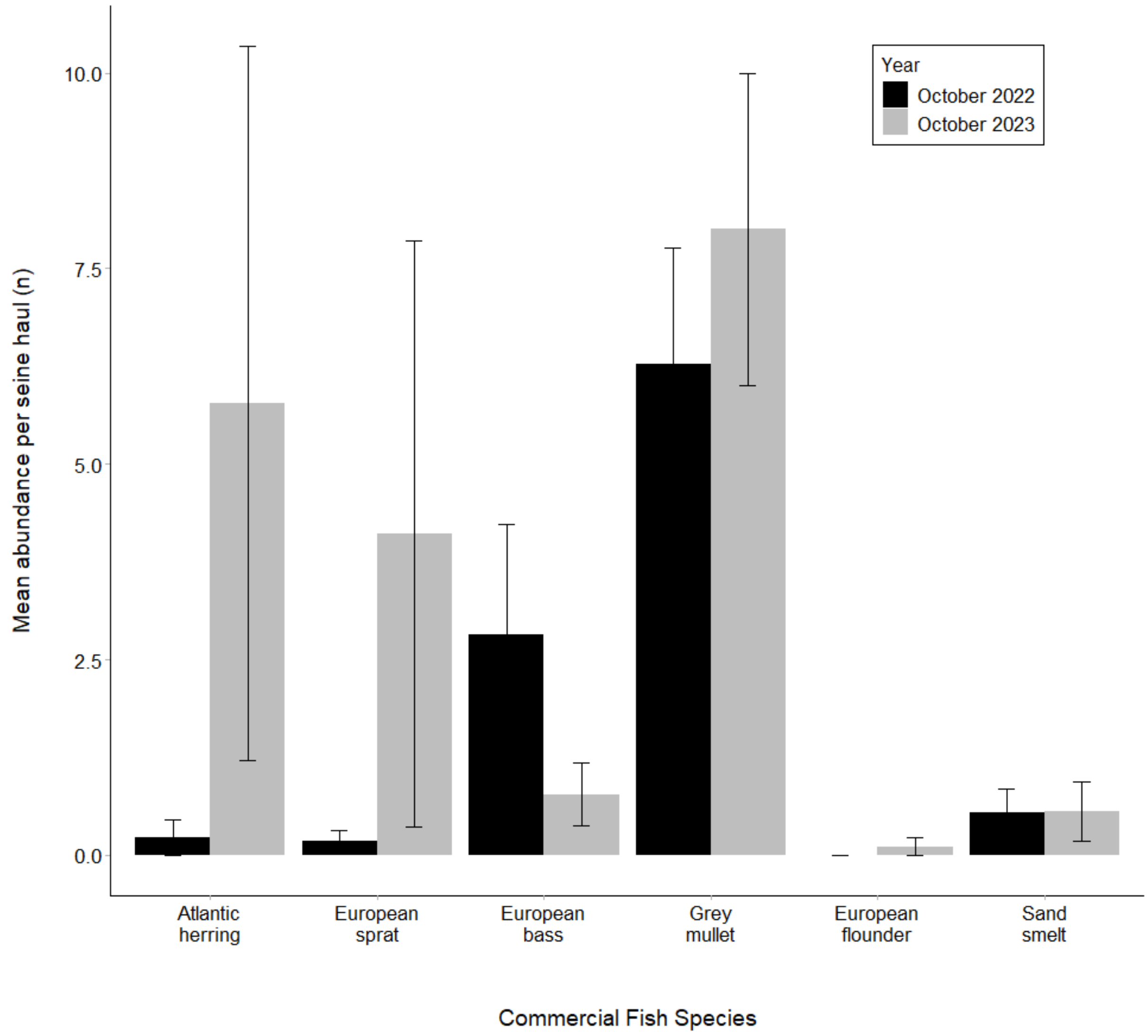

Figure 2 Atlantic herring and European sprat showed the greatest increases in mean abundance between October 2022 and October 2023, while European bass exhibited a decline. This figure shows the changes in mean abundance per seine haul for focal species between all sites sampled in October 2022 and all sites sampled in October 2023. Error bars represent standard error of the mean (± SE).

2. Monthly trends in fish density across habitats

The monthly densities of Atlantic herring, European bass, European flounder, and lesser sandeel peaked during the summer, while European sprat, grey mullet, sand smelt, sea trout, and European eel, showed densities peaks in the autumn (Figure 3).

Notable differences in density were observed between species. Atlantic herring reached the highest monthly density, exceeding 7,500 individuals per km^2 in July, while sea trout had the lowest density peak at just 10 individuals per km^2. Most species exhibited sharp spikes in density over one to three months, with relatively low values for the remainder of the year, except for European bass, grey mullet and European eel, which maintained more stable densities throughout the year.

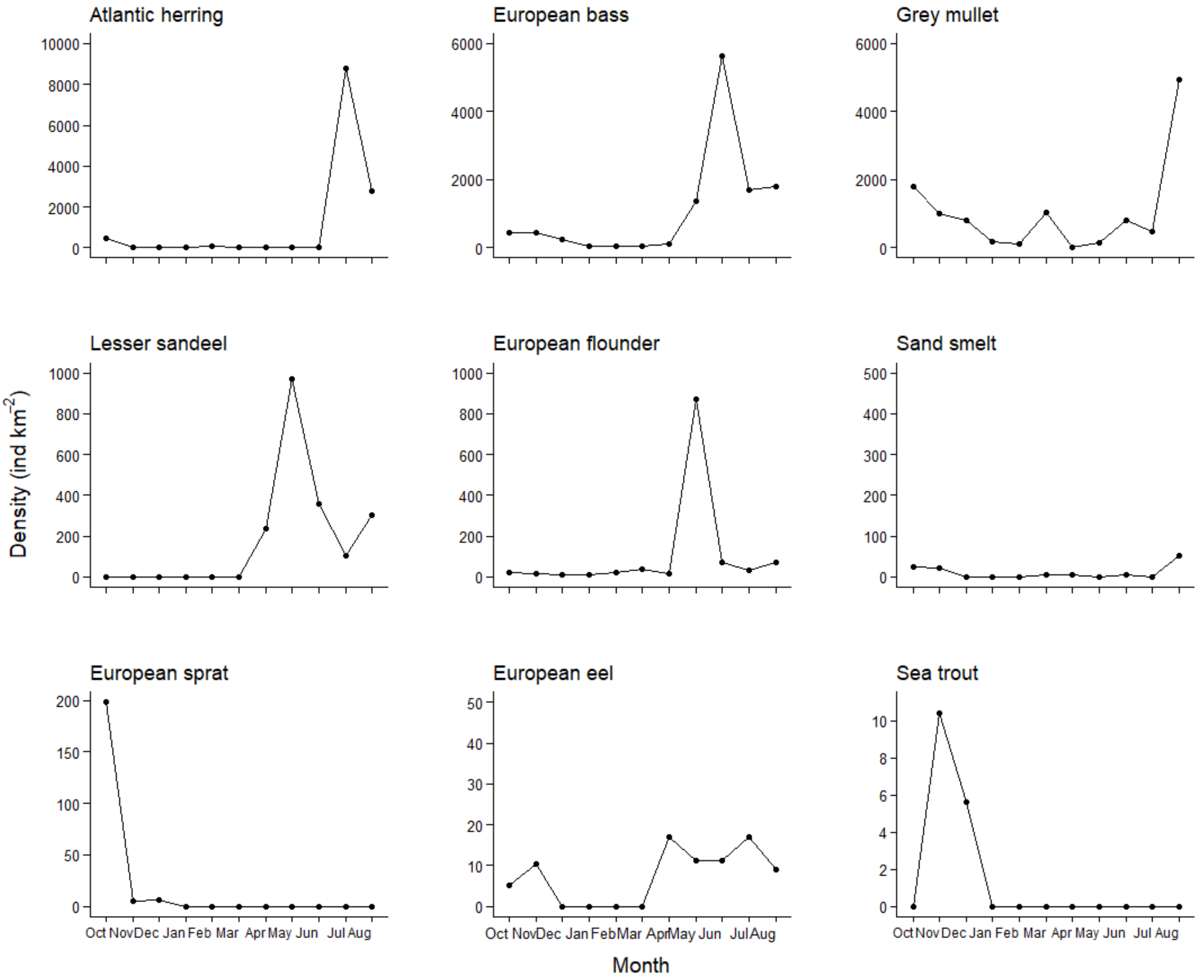

Figure 3 Atlantic herring had the highest monthly density of any species surpassing 7,500 individuals per km^2 in July, while sea trout had the lowest peak at just 10 individuals per km^2. Total monthly densities for each species are shown from October 2023 to August 2024. Species exhibited distinct seasonal peaks, with some reaching maximum density in the summer (e.g., Atlantic herring, European bass), while others peaked in autumn (e.g., European sprat, European eel). Data are compiled across all three habitat types, to give an overview of species density trends in the estuaries South Wales. Please note the variability in y axis.

Separating the monthly densities by habitat type revealed variations in the timing of density peaks for the same species (Figures 4 and 5). European flounder densities were highest in March in the managed realignment, April in the unvegetated habitat, and May in the saltmarsh. European bass densities peaked in June in both the saltmarsh and managed realignment but reached their highest in July in the unvegetated habitat. Grey mullet densities peaked in August for both the saltmarsh and unvegetated habitats, while in the managed realignment, the peak occurred in November. Sand smelt exhibited a two-month difference in peak density, with the unvegetated habitat peaking in June and the saltmarsh in August.

For conservation species, where abundances were far lower, trends were less visible. However, for European eel, distinct seasonal differences were observed across habitat types. In the managed realignment, densities remained relatively stable from April to November, whereas in the saltmarsh, a sharp density peak was recorded in October, with no further occurrences. Sea trout densities peaked in November in Saltmarshes, and December in unvegetated, with no presence in either habitat at any other point in the year.

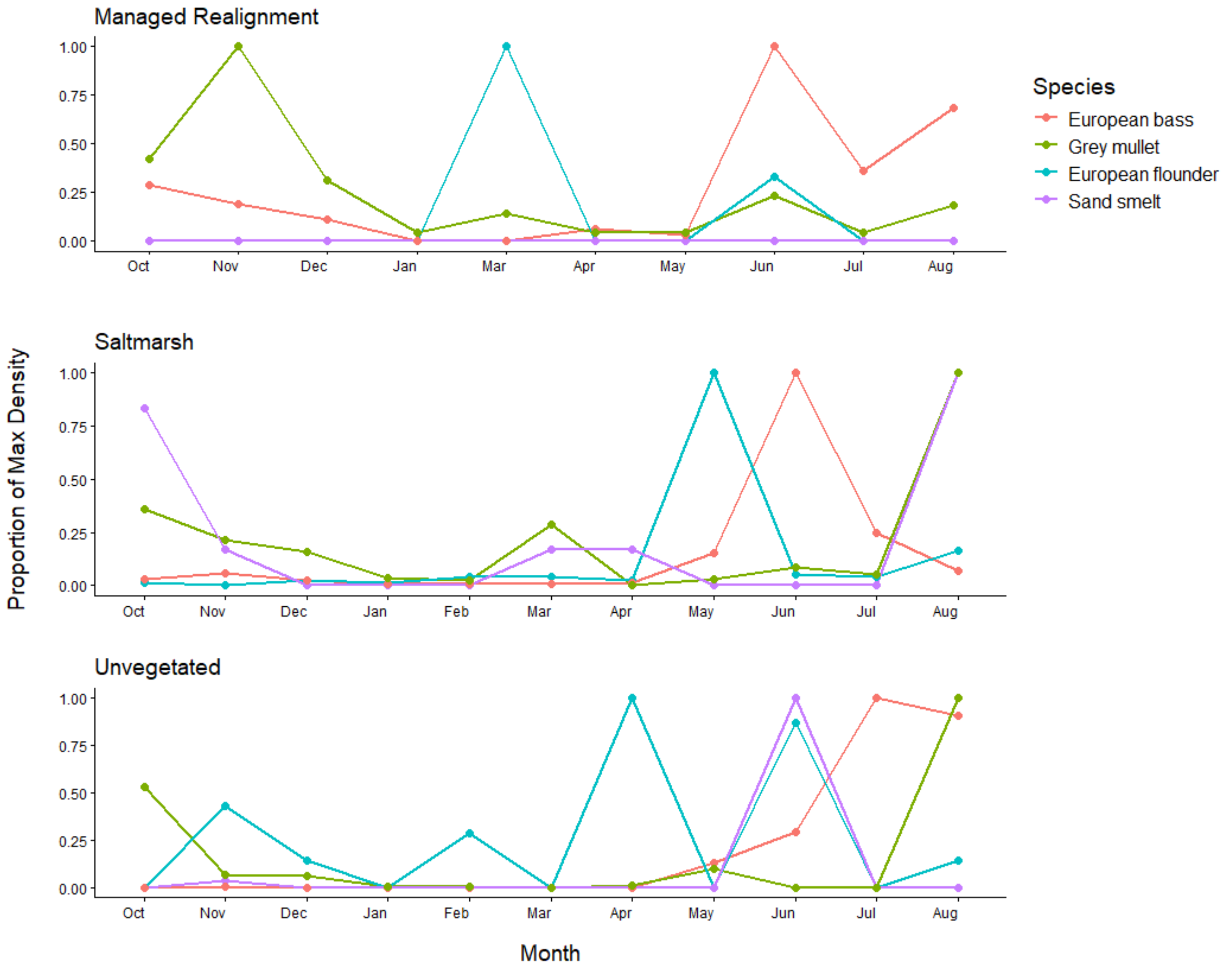

Figure 4 Commercial species densities exhibited distinct peaks depending on habitat type. Monthly densities were normalised as a proportion of the maximum monthly density recorded for each species to facilitate comparison across multiple species. The plot includes data for the three habitat types: unvegetated, saltmarsh, and managed realignment. Atlantic herring and European sprat were only recorded in Saltmarsh habitat so are removed from this analysis.

Figure 5 The density of European eel remained consistently above 0.5 from April to July in the managed realignment habitat but was recorded at 0 in the saltmarshes during the same period. Monthly densities were normalised as a proportion of the maximum monthly density recorded for each species to facilitate comparisons across multiple species. The plot includes data for the three habitat types: unvegetated, saltmarsh, and managed realignment.

3. Potential drivers of seasonal peaks

The drivers behind seasonal peaks in focal species were primarily attributed to spawning events occurring earlier in the year, leading to a notable increase in abundance during the peak month. Additionally, other contributing factors included specific feeding behaviours and year-round residency patterns. These drivers are summarised in Table 3, which provides a detailed overview of the identified sources for each species' seasonal peaks.

Table 3 Many of the drivers for seasonal peaks are caused by earlier spawning events. European eel did not show evidence of a single seasonal peak but remained fairly constant with two high points in April and July.

Species	Month of peak	Mean FL ± SD (cm)	Reason for peak	Reference
Atlantic herring	July	5.1 ± 1.4	Result of autumn/winter spawning	(Farrell et al., 2022)
European sprat	October	5.5 ± 0.9	Result of spring spawning	(Henderson and Henderson, 2017)
European bass	June	3.0 ± 2.5	Result of spring spawning	(Lincoln et al., 2024)
Grey mullet	August	3.6 ± 1.9	Results of spring/summer spawning	(Claridge and Potter, 1985)
European flounder	May	3.0 ± 4.4	Result of winter/spring spawning	(Rotchell et al., 1999)
Sand smelt	August	10.1 ± 0.5	Seasonal feeding behaviour	(Wheeler, 1969)
Lesser sandeel	May	9.5 ± 0.8	Seasonal feeding behaviour	(van der Kooij et al., 2008)
Sea trout	November	17.5 ± 7.5	Post-smolt returning to estuary for feeding	(Davidsen et al., 2014)
European eel	April	29.8 ± 7.1	Residential yellow eels	(Walker et al., 2014)
European eel	July	27.8 ± 2.4	Residential yellow eels	(Walker et al., 2014)

4. Comparative analysis of fish populations in three estuarine habitats

Habitat type was found to have a significant effect on species composition ($F = 1.7782$, $p = 0.03$), accounting for 14.48% of the total variance ($R^2 = 0.14482$). A statistically significant difference between managed realignment and saltmarsh habitats was revealed ($F = 2.8287$, $R^2 = 0.1681$, $p = 0.018$, adjusted for multiple comparisons), explaining 16.81% of the variance in species composition between these two habitats.

In contrast, the comparisons between managed realignment and unvegetated habitats ($F = 1.9325$, $R^2 = 0.1620$, $p = 0.258$) and between saltmarsh and unvegetated habitats ($F = 0.9356$, $R^2 = 0.0494$, $p = 1.000$) were not statistically significant after adjusting for multiple comparisons. These results suggest that while species compositions differ significantly between the managed realignment and saltmarsh habitats, there are no significant differences between the other habitat pairs.

This pattern is reflected in the NMDS plot (Figure 6), which shows substantial overlap in species composition between the unvegetated and saltmarsh habitats, with minimal overlap between the managed realignment habitat and the other two. The plot provides a good fit for the data, with a stress value below 0.1.

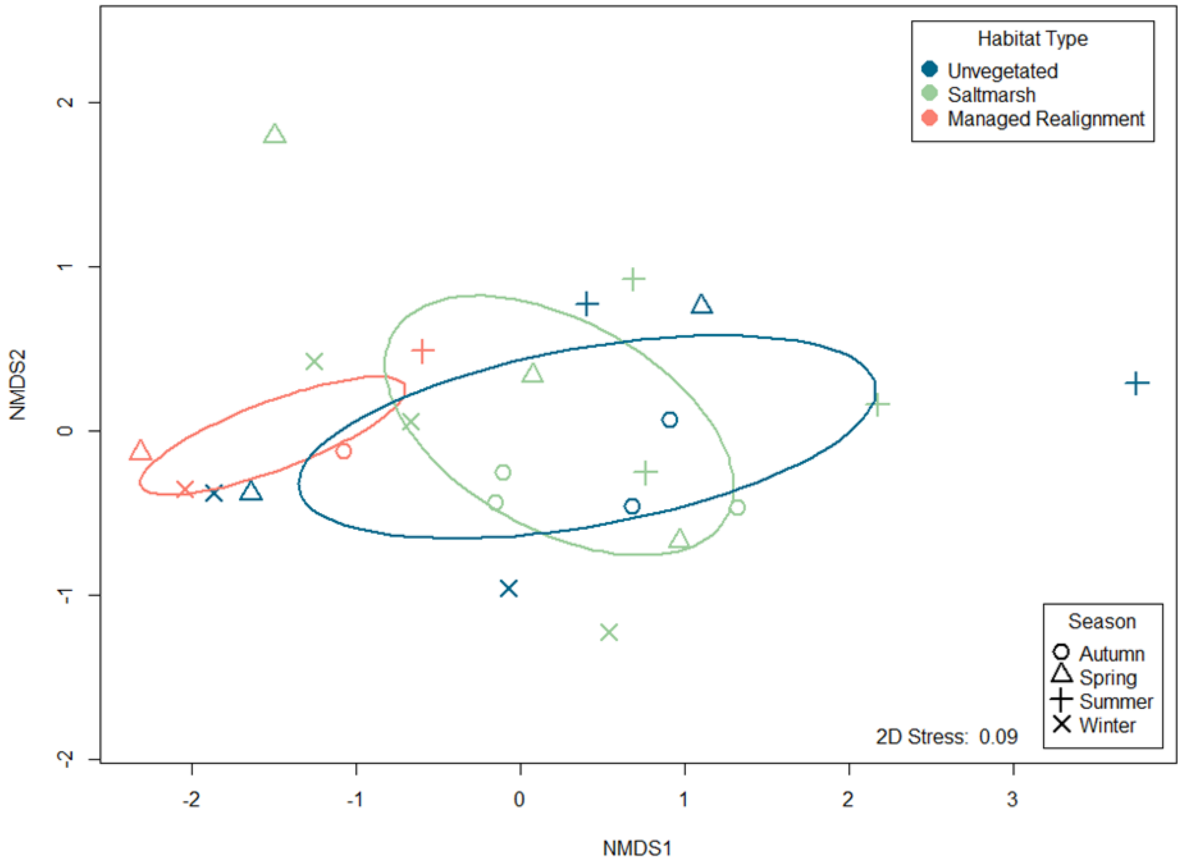

Figure 6 The species composition of the unvegetated and saltmarsh habitats shows considerable overlap, indicating similar species compositions. In contrast, the managed realignment habitat differs from both, with minimal overlap in species composition. This NMDS plot focuses on the species composition of the nine focal species in this study. Each point represents the species composition of one habitat in one season.

Overall, the total density of commercially important species was highest in the saltmarsh habitat, with 8,080 individuals per km², followed by the unvegetated habitat at 5,180 individuals per km², and the managed realignment habitat at 456 individuals per km². Four of the six commercially important species—Atlantic herring, European eel, European flounder, and grey mullet—had higher total densities in the saltmarsh than in any other habitat (Figure 7). In contrast, European bass and sand smelt exhibited highest densities in the unvegetated habitat. Only three commercial species—European bass, European flounder, and grey mullet—were recorded in the managed realignment habitat, all at lower densities than in the other two habitats.

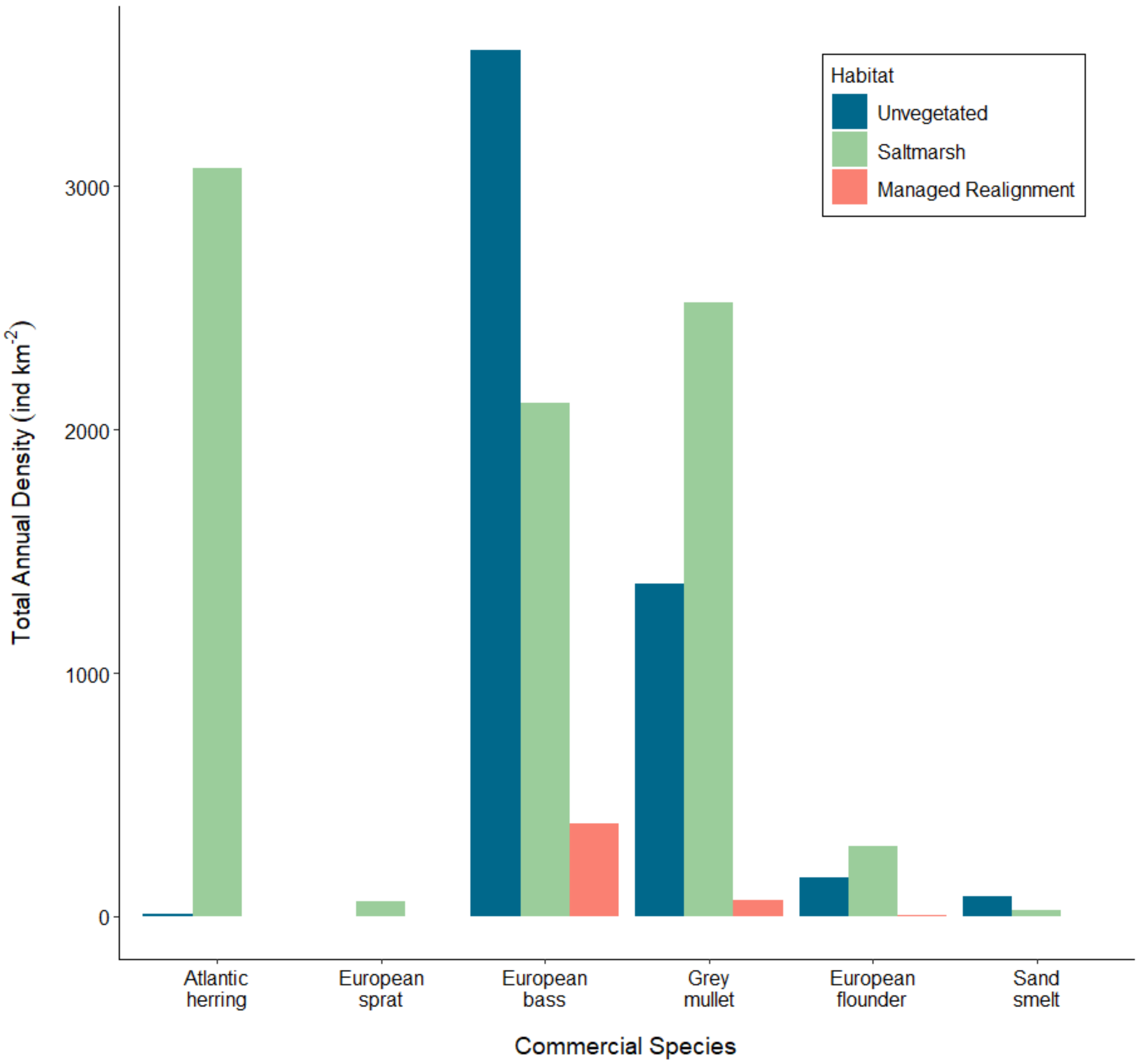

Figure 7 Atlantic herring were almost exclusively found in the saltmarsh habitat, with only one individual recorded in the unvegetated habitat and none in the managed realignment habitat. The saltmarsh habitat exhibited the highest total density for most species, while the managed realignment habitat consistently showed lower densities. The figure displays the total annual density (individuals per km²) of six commercially important species across three habitat types.

Mean monthly densities were highest in the unvegetated habitat for European bass, grey mullet, European flounder, and sand smelt, whereas Atlantic herring and European sprat exhibited higher mean monthly densities in the saltmarsh habitat (Table 4). Managed realignment invariably showed the lowest mean monthly density values for all commercial species.

The mean monthly density of European bass in the unvegetated habitat was >20 times higher than in the saltmarsh and 500 times higher than in the managed realignment. Atlantic herring reached its peak density in the saltmarsh, where it was six times greater than in the unvegetated habitat. European sprat was recorded exclusively in the saltmarsh habitat. The mean densities of grey mullet and European flounder showed minimal differences between the saltmarsh and unvegetated habitats, with a variation of less than 10%.

Table 4 Managed realignment consistently exhibited the lowest density values for all species, while the unvegetated habitat had the highest densities for most species, particularly European bass. Mean density refers to the total monthly densities (individuals per km^2) divided by number of months.

Species	Habitat	Mean Density (ind km^{-2}) ± SE	Range
Atlantic herring	Managed Realignment	0	0
	Saltmarsh	13024.8 ± 10366.3	114486.7
	Unvegetated	2020.2 ± 2020.2	22222.2
European sprat	Managed Realignment	0	0
	Saltmarsh	158.2 ± 141.2	1566.1
	Unvegetated	0	0
European bass	Managed Realignment	373.6 ± 143.2	1362.5
	Saltmarsh	9215.4 ± 5542.8	62402.4
	Unvegetated	194947.7 ± 57088.8	1040889.0
Grey mullet	Managed Realignment	75.1 ± 28.1	287.8
	Saltmarsh	10078.9 ± 4309.5	
	Unvegetated	11087.1 ± 6453.9	67448.9
European flounder	Managed Realignment	5.7 ± 4.3	42.6
	Saltmarsh	195.2 ± 136.1	49350.0
	Unvegetated	202.4 ± 84.4	772.7
Sand smelt	Managed Realignment	0	0
	Saltmarsh	97.1 ± 49.4	457.9
	Unvegetated	2104.6 ± 2013.5	22222.2

Statistically significant differences in median densities (individuals per km²) were found between habitat types for Atlantic herring, European bass, grey mullet, and European flounder, while no significant differences were observed for sand smelt or European sprat.

For Atlantic herring, there was a significant difference in median densities between habitats, $H(2) = 20.68$, $p = 0.0003$. Densities were significantly higher in saltmarsh habitat (mean ± SE: 13024.8 ± 10366.3) compared to both unvegetated habitat (mean ± SE: 2020.2 ± 2020.2, $p = 0.0003$) and managed realignment habitat (mean ± SE: 0 ± 0, $p = 0.00006$). No significant difference was found between the unvegetated and managed realignment habitats.

A significant difference in median densities across habitats was observed for European bass, $H(2) = 7.16$, $p = 0.03$. Saltmarsh habitat (mean ± SE: 9215.4 ± 5542.8) had significantly higher densities than managed realignment habitat (mean ± SE: 373.6 ± 143.2, $p = 0.015$), while no significant differences were detected between other habitat types.

A significant difference was also found for grey mullet densities, $H(2) = 12.7$, $p = 0.002$. Saltmarsh habitat (mean ± SE: 10078.9 ± 4309.5) had significantly higher densities than managed realignment habitat (mean ± SE: 75.2 ± 28.1, $p = 0.0007$), and unvegetated habitat (mean ± SE: 11087.1 ± 6453.9) also had higher densities compared to managed realignment habitat, $p = 0.03$. No significant difference was observed between saltmarsh and unvegetated habitats.

For European flounder, a significant difference in median densities across habitats was found, $H(2) = 11.18$, $p = 0.004$. Saltmarsh habitat (mean ± SE: 195.2 ± 136.1) had significantly higher densities than managed realignment habitat (mean ± SE: 5.7 ± 4.3, $p=0.001$), and unvegetated habitat (mean ± SE: 202.4 ± 84.4) also had higher densities compared to managed realignment habitat, $p = 0.04$. No significant differences were observed between saltmarsh and unvegetated habitats.

For sand smelt and European sprat, no significant differences in median densities were found between habitats, $H(2) = 5.3, p = 0.07$, and $H(2) = 6.1, p = 0.053$, respectively.

Overall, saltmarsh habitat had significantly higher fish densities for the commercially important species Atlantic herring, grey mullet, and European flounder compared to managed realignment. No species had significantly higher densities in unvegetated habitat than in saltmarsh habitat. In all cases where significant differences in density were observed, managed realignment habitat had lower densities than at least one other habitat type.

Overall, the total density of conservation species was highest in the saltmarsh habitat, with 516 individuals per km^2, followed by the managed realignment habitat at 19 individuals per km^2, and the unvegetated habitat at 9 individuals per km^2 (Figure 8). All three conservation species were present in the saltmarsh habitat, whereas only one species was recorded in each of the unvegetated and managed realignment habitats. Notably, European eel exhibited a higher total density in the managed realignment habitat compared to the others. Lesser sandeel were exclusively found in the saltmarsh, and sea trout were observed at low densities in both the unvegetated and saltmarsh habitats.

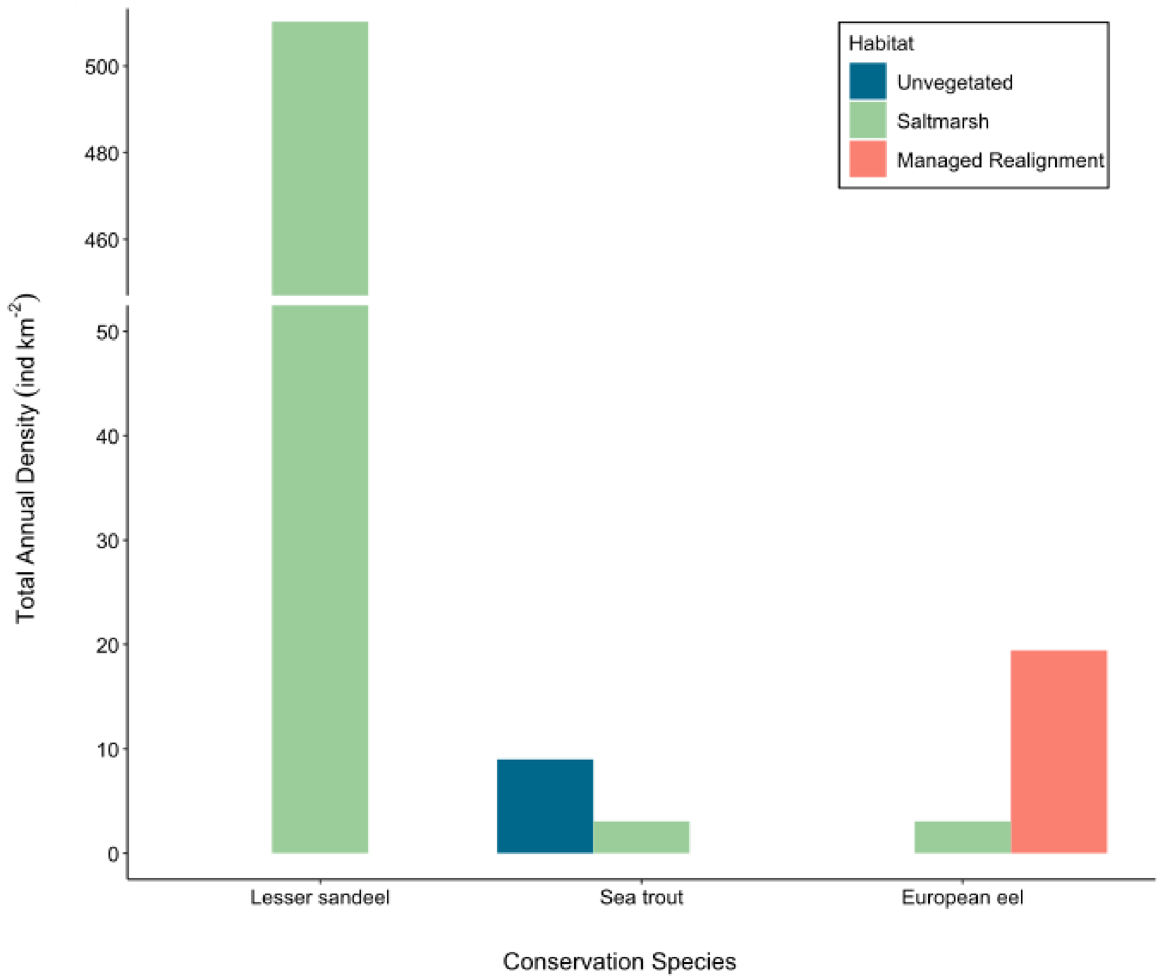

Figure 8 European eel was the only species to exhibit a higher total density in the managed realignment habitat compared to other habitats. Each of the three species showed their highest density in a different habitat. The saltmarsh habitat had the highest total density, while the unvegetated and managed realignment habitats had lower total densities. The figure shows the total annual density (individuals per km²) of three conservation species across the three habitat types.

The mean densities in Table 5 reflect similar patterns to the total densities shown in Figure 8, with no single habitat dominating across all three species. However, the mean densities more clearly highlight the marginal difference between sea trout densities in the saltmarsh and unvegetated habitats, with only a 6% higher density in the unvegetated habitat. In contrast, the difference between the saltmarsh and managed realignment densities is more pronounced, revealing that the managed realignment habitat has a mean density seven times higher than that of the saltmarsh.

Table 5 Lesser sandeel were only observed in the saltmarsh habitat, sea trout had the highest density in the unvegetated habitat, and European eel in the managed realignment habitat. Mean density is calculated as the total monthly densities (individuals per km²) divided by the number of months.

Species	Habitat	Mean Density (ind km^{-2}) ± SE	Range
Lesser sandeel	Managed Realignment	0	0
	Saltmarsh	2305.7 ± 1201.9	13204.1
	Unvegetated	0	0
Sea trout	Managed Realignment	0	0
	Saltmarsh	9.6 ± 9.6	105.5
	Unvegetated	10.2 ± 10.2	111.8
European eel	Managed Realignment	19.4 ± 5.9	42.6
	Saltmarsh	2.6 ± 2.6	29.1
	Unvegetated	0	0

Statistically significant differences in median density across habitat types were identified for lesser sandeel and European eel, while no significant differences were observed for sea trout.

For lesser sandeel there was a significant difference in median densities across habitats, $H(2) = 10.86, p = 0.004$. Densities were significantly higher in saltmarsh habitat (mean ± SE: 2305.7 ± 1201.9) compared to both unvegetated habitat (mean ± SE: 0 ± 0, $p = 0.006$) and managed realignment habitat (mean ± SE: 0 ± 0, $p = 0.007$). No significant differences were observed between the unvegetated and managed realignment habitats.

In the case of European eel, a significant difference in median densities across habitats was revealed, $H(2) = 12, p = 0.002$. Managed realignment habitat (mean ± SE: 19.4 ± 5.9) had significantly higher densities than both saltmarsh habitat (mean ± SE: 2.6 ± 2.6, $p = 0.009$) and unvegetated habitat (mean ± SE: 0 ± 0, $p = 0.002$). No significant differences were found between the unvegetated and saltmarsh habitats.

Conversely, sea trout did not reveal a significant difference in median densities across the habitat types, the Kruskal-Wallis test yielded $H(2) = 0.94, p = 0.6$.

Overall, saltmarsh habitat supported significantly higher densities of lesser sandeel, whereas managed realignment habitat was most favourable for European eel.

While habitat differences reveal general patterns, site-specific variations offer additional insight. Figure 9 illustrates how individual sites within each habitat type contribute to the overall density patterns. The saltmarsh site Laugharne displays the highest total density across the five focal species: Atlantic herring, grey mullet, European bass, lesser sandeel, and sand smelt. The managed realignment site Cwm Ivy holds the lowest (or joint lowest) total density value for the six focal species: Atlantic herring, grey mullet, lesser sandeel, European sprat, sand smelt, and sea trout.

For some species, a single site accounts for the majority of their overall density. For example, the density of Atlantic herring and lesser sandeel at Laugharne accounts for >90% of their total densities across all habitats. European sprat was recorded predominantly at the saltmarsh site at Llanelli WWT. Additionally, European eel density at Cwm Ivy represents over 50% of the species' total density.

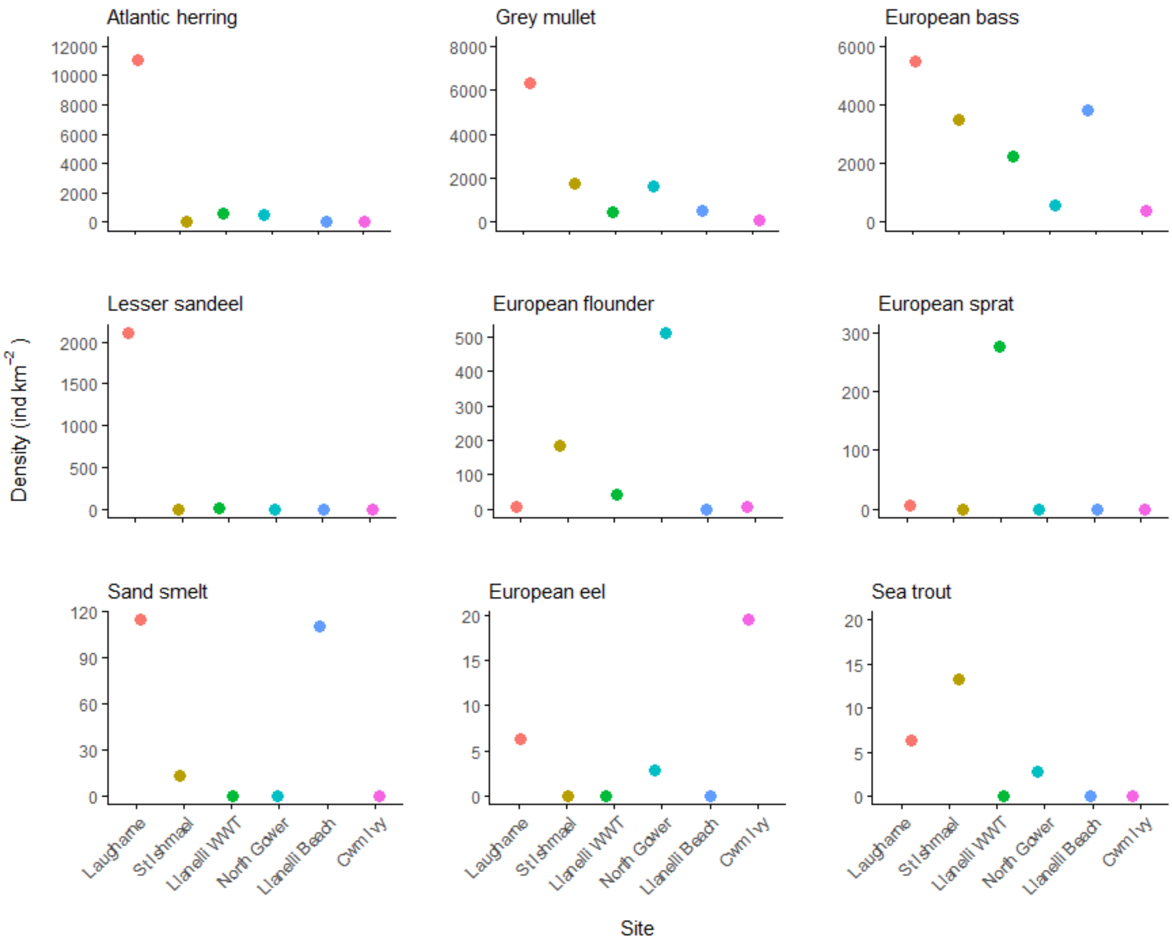

Figure 9 The saltmarsh site at Laugharne had the highest overall density for five species. European sprat recorded the highest density at the Llanelli WWT site, 15 times greater than at any other site. European eel density peaked at the Cwm Ivy site. Saltmarsh sites include Laugharne (red), Llanelli WWT (green), and North Gower (turquoise). Unvegetated sites include St Ishmael (yellow) and Llanelli Beach (blue). The managed realignment site consists solely of Cwm Ivy (pink). The mean densities shown represent the total annual density at each site. Please note the variability in y axis scale.

5. Fish production estimates

Total cumulative production was highest in the saltmarsh habitat for Atlantic herring, European flounder, grey mullet, and lesser sandeel. The unvegetated habitat exhibited lower total productivity for all species except European bass. In the managed realignment habitat, measurable production was only observed for European flounder during the summer.

The highest overall cumulative production was recorded for European bass in the unvegetated habitat (0.05282 g WW m^2), followed by the saltmarsh habitat (0.01102 g WW m^2). European bass accounted for 74% of the total cumulative production across all species and habitats, contributing 0.06385 g WW m^2 out of the total 0.0866 g WW m^2. While the unvegetated habitat showed the highest total cumulative production (0.05972 g WW m^2), removing European bass from the analysis reduces this value to 0.0069 g WW m^2, which is less than half of the production in the saltmarsh habitat.

All individuals considered in the production estimation were juveniles, as adults were rarely present. When adults were observed, their numbers were too low for effective cohort detection and did not contribute to the production estimates. Lengths used to determine the classification of “adult” and “juvenile” are detailed in Table 6, specifically the lengths at maturity.

Table 6 Focal species age and length at maturity calculated using the Life-history tool on Fishbase.se.

Species	Age at maturity (years)	Length at maturity (Total length cm)
Atlantic herring	2.5	20.5
European sprat	1.5	8.5
European bass	6.3	46.2
Thinlip mullet	2.7	29.3
Thicklip mullet	3	30.3
Golden mullet	2.1	24.6
European flounder	3	26.7
Sand smelt	1.1	9.7
Lesser sandeel	1.9	12.3
Sea trout	2.8	51.7
European eel	4.3	40

Table 7 The saltmarsh habitat had the highest cumulative production for four species, while the unvegetated habitat had the highest production for European bass, and the managed realignment habitat had the highest production for European eel. Production was calculated for six of the nine focal species, as it was only possible when the same cohort was detected across multiple months. Dashes represent where no measurable production was detected.

Species	Habitat	Production (g WW m^{-2})				Total Cumulative Production
		Autumn	Winter	Spring	Summer	(g WW m^{-2} $year^{-1}$)
Atlantic herring	Managed Realignment	-	-	-	-	-
	Saltmarsh	0.00015	0.00031	-	0.00396	0.00443
	Unvegetated	-	-	-	-	-
European bass	Managed Realignment	0.00017	0.00012	-	-	0.00030
	Saltmarsh	-	0.00047	0.00039	0.01017	0.01103
	Unvegetated	0.00154	-	0.04549	0.00579	0.05282
Grey mullet	Managed Realignment	-	-	-	-	-
	Saltmarsh	0.00217	0.00069	0.00025	0.00736	0.01046
	Unvegetated	0.00635	0.00055	-	-	0.00690
European flounder	Managed Realignment	-	-	-	-	-
	Saltmarsh	-	-	-	0.00005	0.00005
	Unvegetated	-	-	-	-	-
Lesser sandeel	Managed Realignment	-	-	-	-	-
	Saltmarsh	-	-	-	0.00026	0.00026
	Unvegetated	-	-	-	-	-
European eel	Managed Realignment	-	-	-	0.00035	0.00035
	Saltmarsh	-	-	-	-	-
	Unvegetated	-	-	-	-	-
Total	Managed Realignment	0.00017	0.00012	-	0.00035	0.00065
	Saltmarsh	0.00232	0.00147	0.00064	0.02180	0.02623
	Unvegetated	0.00789	0.00055	0.04549	0.00579	0.05972
	All	0.01038	0.00214	0.04613	0.02794	0.08660

For European bass, spring was the most productive season, with a production value of 0.04588 g WW m^2. Excluding European bass, summer had the highest overall productivity, with a total cumulative production of 0.01198 g WW m^2, followed by autumn with 0.00867 g WW m^2. In summer, all six species had measurable production, whereas in other seasons, only Atlantic herring, European bass, and grey mullet were productive. Notably, there was no measurable productivity for any species in March and April (Figure 10).

Grey mullet exhibited production peaks at different times across habitats. In November, grey mullet experienced a significant productivity peak in the unvegetated habitat (0.00635 g WW m^2 $month^{-1}$), with a smaller peak in the saltmarsh in October (0.00169 g WW m^2 $month^{-1}$). However, the largest peak in grey mullet productivity in the saltmarsh occurred in July (0.00536 g WW m^2 $month^{-1}$).

Similarly, European bass productivity peaked at different times across habitats: in November for the managed realignment habitat (0.00017 g WW m^2 $month^{-1}$), in May for the unvegetated habitat (0.04548 g WW m^2 $month^{-1}$), and in July for the saltmarsh habitat

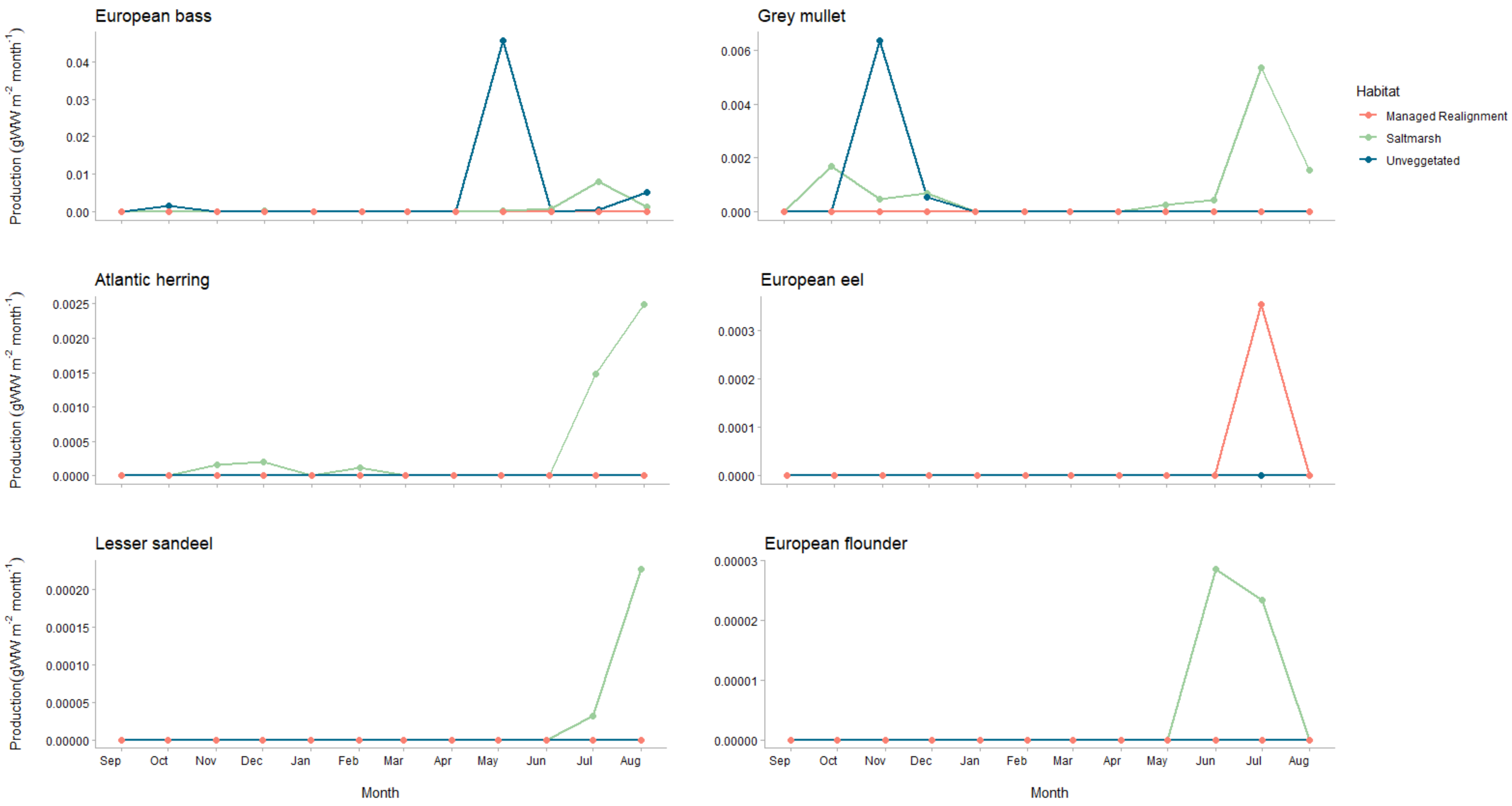

Figure 10 Throughout the study period European bass have been the most productive species across all habitats. The most significant peak in production of European bass is in the unvegetated habitat in June 2024. Atlantic herring exhibited a large peak in production from June to August.

To provide context and facilitate comparison, Table 8 presents production estimates from other studies focusing on European estuaries. Only estimates for the focal species of this study are included; however, other species were part of these studies, meaning the values presented do not represent total annual production. Notably, Atlantic herring and lesser sandeel have not previously had production estimates from European estuaries; therefore, no comparative figures are available for these species.

Table 8 Comparison of production estimates in European estuaries, specifically for commercial and conservation species focused on in this study.

Location	Study Period	Gear	Estimation method	Species	Production (g WW m-2 year-1)	Reference
Ria de Aveiro, Portugal	1999 - 2000	Seine net	Instantaneous growth	European bass	0.015 - 0.596	(Pombo et al., 2007)
Ria de Aveiro, Portugal	1999 - 2000	Seine net	Instantaneous growth	Grey mullet	0.312 - 0.997	(Pombo et al., 2007)
Ria de Aveiro, Portugal	2000 - 2000	Seine net	Instantaneous growth	European eel	0.05 - 0.024	(Pombo et al., 2007)
Mondego estuary, Portugal	2003 - 2006	Beam Trawl	Increment summation	European bass	0.14 - 0.44	(Dolbeth et al., 2008)
Mondego estuary, Portugal	2003 - 2006	Beam Trawl	Increment summation	European flounder	0.07 - 0.13	(Dolbeth et al., 2008)
Venetian Lagoon, Italy	2004 - 2005	Seine net	Increment summation	European flounder	0.21 -0.52	(Franco et al., 2010)
Carmarthen Bay, Wales	2023 -2024	Seine & fyke net	Increment summation	Atlantic herring	0.00443	Present Study
Carmarthen Bay, Wales	2023 -2024	Seine & fyke net	Increment summation	European bass	0.06385	Present Study
Carmarthen Bay, Wales	2023 -2024	Seine & fyke net	Increment summation	Grey mullet	0.01736	Present Study
Carmarthen Bay, Wales	2023 -2024	Seine & fyke net	Increment summation	European flounder	0.00005	Present Study
Carmarthen Bay, Wales	2023 -2024	Seine & fyke net	Increment summation	Lesser sandeel	0.00026	Present Study
Carmarthen Bay, Wales	2023 -2024	Seine & fyke net	Increment summation	European eel	0.00035	Present Study

Discussion

This study provides the first insights into the role of saltmarsh and managed realignment habitats in supporting finfish stocks in South Wales. The results indicate important differences in finfish productivity between habitats, with saltmarshes showing high productivity, while the managed realignment site, Cwm Ivy, appears less productive. This suggests that managed realignment habitats may not function in the same way as natural saltmarshes in supporting finfish populations.

1. <u>Stable fish populations between October 2022 and 2023</u>

Surveys conducted in October 2022 and October 2023 revealed no significant interannual changes in the mean abundances of each focal species. This lack of variation aligns with similar patterns observed in other studies on saltmarsh fish communities. For instance, Laffaille et al. (2000) reported minimal interannual variation in the composition of fish communities in Mont Saint-Michel Bay during a three-year study period (1996–1999). Interannual differences in estuarine species abundances are often attributed to environmental changes or habitat disturbances (Mathieson et al., 2000; Laffaille et al., 2000; Veiga et al., 2006; Dolbeth et al., 2008). The relatively stable environmental conditions in the study region, including consistent tidal regimes and minimal habitat disturbances, likely explain the observed consistency in species abundance between 2022 and 2023.

While overall species composition remained stable and there were no significant differences, individual species exhibited considerable variation between years. For example, the mean abundance of European bass declined by 72% in 2023. This variation may be partly due to differences in surveying efforts between the two years. Both years' surveys followed consistent methods in terms of gear (seine netting) and time of day (early mornings). However, variations in the specific sub habitats surveyed, particularly in 2022, when saltmarsh pools were sampled more frequently due to tidal conditions preventing full submersion of vegetation, may have influenced species abundance. Saltmarsh pools and flats are known to differ in their ecological roles and species composition (MacKenzie and Dionne, 2008). Pools tend to sustain higher microbial activity and a greater diversity of invertebrates due to their constant water availability (Noel, 2023). This may attract predatory species such as European bass (Hampel et al., 2005), potentially explaining the higher abundance observed in 2022.

2. <u>Fish density varied significantly between seasons</u>

Pooling the data from all habitats surveyed, each of the nine focal species exhibited density peaks from late spring through to autumn, a pattern consistent with seasonal trends observed in estuarine studies across the British Isles (Claridge et al., 1986; Green et al., 2009; Koutsogiannopoulou and Wilson, 2007). The timing of these peaks varied by species: lesser sandeel and European flounder peaked in May, while sprat reached its highest densities in October. These differences are closely linked to species-specific spawning events, which influence when juveniles recruit into estuarine habitats (Claridge et al., 1986; Martinho et al., 2007). For example, European flounder densities peaked in May due to an influx of post-settlement juveniles, following their winter spawning event between February and March (Rotchell et al., 1999). Similarly Atlantic herring's sharp peak in July can be linked to the previous autumns spawning event, due to the size of the individuals caught (Farrell et al., 2022). In contrast, the sharp May peak in lesser sandeel densities can be attributed to their seasonal feeding behaviours, lesser sandeels spend the summer months feeding actively in the water column, before burrowing into the sand during the winter, leading to a pronounced increase in their presence in early summer (van der Kooij et al., 2008).

Atlantic herring, European bass, grey mullet, and European flounder were recorded in the saltmarsh habitat year-round. Although these species were present at much lower densities during the winter months (December–February), they were consistently recorded throughout the entire winter period. Previous studies conducted in Essex and the adjacent Southwest Dutch saltmarshes found that European bass and common goby are the only finfish species to utilise saltmarsh as a nursery habitat year-round (Cattrijsse et al., 1994; Green et al., 2009). However, the continuous presence of three additional species (Atlantic herring, grey mullet, and European flounder) in South Welsh saltmarshes suggests a difference in the use of saltmarshes as nursery habitats, compared to the Essex and Dutch saltmarshes. The South Welsh saltmarshes, influenced by the warmer and more saline waters of the Atlantic, along with their extreme tidal ranges (Uncles, 2010), may support a broader range of species year-round than the cooler, less saline waters and moderate tidal fluctuations of the North Sea (Ducrotoy et al., 2000), where the Essex and Dutch saltmarshes are located. These differences in temperature, salinity, and tidal dynamics likely contribute to the observed divergence in habitat functionality (Maes et al., 2004; Selleslagh and Amara, 2008), allowing species like Atlantic herring, grey mullet, and European flounder to use South Welsh saltmarshes throughout the year. This highlights the importance of expanding UK saltmarsh studies outside of just southeast England.

Distinct seasonal peaks were observed within species, varying across habitat types, suggesting that juvenile fish use different habitats in varying ways throughout the year. Habitats within estuaries can provide unique benefits for juvenile fish during critical growth stages (Day et al., 2021). Saltmarshes offer structural complexity that provides protection from predators (Boesch and Turner, 1984; Hampel et al., 2005; James et al., 2019). Unvegetated shores also offer a degree of protection due to their shallow waters reducing predation risk, but they lack the enhanced protection provided by saltmarshes physical structures. Another key factor influencing habitat use is food availability, which plays a crucial role in the survival and growth of juveniles (Le Pape and Bonhommeau, 2015). Both saltmarshes and unvegetated estuarine shores provide abundant food sources, such as invertebrates and crustaceans (Boesch and Turner, 1984; Day et al., 2021; Whitfield et al., 2024). However, prey in unvegetated shores may be more accessible due to the open environment, allowing juveniles to forage with greater efficiency (Grønkjær et al., 2007; Nordström and Booth, 2007; Perry et al., 2018). Thus, while juveniles may seek saltmarsh habitats for predator avoidance, they may use unvegetated shores for more efficient foraging grounds. This highlights the importance of habitat connectivity in estuarine ecosystems, as juvenile fish can move between habitats to meet their various needs (James et al., 2019; Pessanha et al., 2021; Swadling et al., 2024; Unsworth et al., 2008). The availability of both protected and open feeding habitats can help optimise survival and growth, underscoring the need to maintain ecological linkages between diverse habitat types (Freeman et al., 2024; Perry et al., 2018)

3. Distinct fish communities between saltmarsh and managed realignment habitats

Saltmarsh and unvegetated habitats showed substantial overlap in community composition, suggesting they support similar species assemblages, likely due to their roles as important habitats for juveniles within estuarine systems (Pihl et al., 2002). In contrast, the community composition of the managed realignment habitat showed little overlap with the two natural estuarine habitats. The difference in species composition between the managed realignment and saltmarsh habitats suggests that the restored habitat may not yet have the full ecological function of a natural saltmarsh, which could be affecting its role as a habitat for fish. Although there was no significant difference in species composition between the managed realignment and unvegetated habitats, the minimal overlap in the NMDS indicates differences in species presence that may reflect variation in habitat use or functionality.

The clear separation of the managed realignment habitat from both natural habitats suggests that it may not yet be fully integrated into the broader estuarine system, which could be currently limiting its functionality for fish. As estimated by Tupper & Able (2000), full ecosystem functioning in managed realignment projects may take 12 to 21 years to develop. Given that the managed realignment site was only breached in 2014 (Dale et al., 2021), the observed lack of overlap with natural estuarine habitats is likely due to ongoing ecological succession, as the habitat continues to integrate into the estuarine system. Continual monitoring will be crucial to determine whether community composition converges with natural habitats as the managed realignment site matures, and to assess when, or if, full ecosystem functionality is achieved (Garbutt et al., 2006). This managed realignment site faces a unique challenge in its ecological succession due to the sea wall being breached at only a single point. This limited breach restricts drainage, which may slow ecological succession until the wall is fully removed and natural processes can operate unimpeded. Additionally, the sea wall acts as a physical barrier to fish movement, providing only a single-entry point to the marsh. This restricted access may contribute to the observed low fish abundances within the site.

4. Fish habitat preferences highlight saltmarsh dominance

The higher mean monthly densities observed in the saltmarsh habitat for five of the nine focal species suggest that this habitat provides favourable conditions for a range of species. In contrast, the unvegetated habitat supported higher densities for only two species, which may indicate that these species are better adapted to open environments or have different habitat preferences. With only four focal species recorded, the managed realignment habitat appears to have a reduced ability to support a diverse fish population.

Despite the lack of significant differences in mean densities between the saltmarsh and unvegetated habitats for certain species, the higher densities of Atlantic herring and lesser sandeel in the saltmarsh highlight the importance of vegetated areas for these species, particularly during critical life stages. Similarly, the high density of European eel in the managed realignment habitat suggests that these areas may offer unique conditions that favour European eel populations, warranting further investigation into the ecological characteristics of realigned habitats.

Atlantic herring were recorded having the highest total annual density among all focal species in the saltmarsh habitat, exceeding 3,000 individuals per km^2, as well as the highest mean annual density. This finding is consistent with studies from Essex saltmarshes, where Atlantic herring were also found in notably high abundances (Colclough et al., 2005; Green et al., 2009). Atlantic herring were consistently caught in the saltmarsh habitat throughout the year, with only one individual recorded in the unvegetated habitat. This result suggests a strong preference for saltmarsh habitats over unvegetated estuarine shores, highlighting the important role of saltmarshes in supporting commercially valuable fish stocks. Atlantic herring are among the UK's most commercially important fish species (Peverley and Stewart, 2021). In 2019, the value of Atlantic herring landings in the UK was estimated at £47.3 million (Pauly and Zeller, 2015). However, as a schooling species, the high recorded densities may also reflect the tendency of herring to aggregate in large groups rather than individual habitat preference alone(Gallego and Heath, 1994). This behaviour could contribute to the observed patterns, as schools moving through saltmarsh areas may lead to higher localised catch rates. Nonetheless, the consistent presence of herring throughout the year suggests that saltmarshes provide important resources for this species.

Lesser sandeel were exclusively recorded in the saltmarsh habitat with total annual density estimated at 510 individuals per km². The lesser sandeel, though not of large commercial value, plays a crucial role in marine ecosystems as a key prey species (Furness, 2002; Smith et al., 2014). They are an important food source for a variety of marine predators, including seabirds such as Puffins and Kittiwakes, marine mammals like Harbour Porpoises and Seals, and even Minke Whales, where they can comprise up to 54% of the whale's diet (Engelhard et al., 2014; García-Vernet et al., 2021; Staudinger et al., 2020). Their ecological importance has led to recent legal protection in the UK (UK Government, 2024). Although lesser sandeels are typically associated with soft, sandy substrates for burrowing (Hùines and Bergstad, 2000), these findings suggest that juvenile lesser sandeel may use nearby saltmarsh habitats during certain life stages, potentially for foraging. As a schooling species (Pitcher and Wyche, 1983), their exclusive presence in the saltmarsh habitat may be influenced not only by habitat preference but also by their tendency to form dense aggregations. This behaviour could result in concentrated catches in specific areas, potentially exaggerating their apparent habitat use. However, further research is needed to confirm whether this behaviour reflects a broader habitat preference or simply localised habitat use.

Throughout this study, the critically endangered, European eel were the only species to indicate preference for the managed realignment habitat (Ammar et al., 2021; Lyach, 2022; Richards et al., 2020). They were consistently recorded in managed realignment from April to August, with fewer European eels found in the saltmarsh habitat, appearing only in September and October. This difference in European eel densities between the two habitats may be related to the managed realignment's proximity to the sea, as it is the closest site in the estuary. European eel colonisation densities are often highest in habitats nearer to the sea, as these areas are the first encountered during their upstream migration, with densities typically decreasing as distance from the sea increases (Degerman et al., 2019; Domingos et al., 2006; Verhelst et al., 2018). Additionally, European eel in the yellow stage (in which all captured individuals were) exhibit high site fidelity (Verhelst et al., 2018). Therefore, the proximity of the managed realignment to the sea could explain the higher densities observed there. As previously discussed, the managed realignment site is not fully connected to the broader estuarine system, likely due to successional constraints imposed by the single tidal entry and exit point. Additionally, freshwater inputs influence the site, and the combined effects of restricted tidal exchange and freshwater influence may contribute to making this habitat more suitable for the European eel. Other factors, such as water depth, vegetation cover, and burrowing substrate, also influence habitat preference and may vary between the managed realignment and saltmarsh habitats (Laffaille et al., 2009, 2004, 2003; Verhelst et al., 2018).

5. Location-driven differences in species densities across sampling sites

Variation in total species densities was observed across the surveyed saltmarsh sites: Laugharne, Llanelli WTT, and North Gower. These sites differ in factors such as size, freshwater input, vegetation composition, and grazing pressures. Laugharne, the smallest of the saltmarsh sites and located in the Three Rivers estuaries, is the only site without grazing pressure. In contrast, Llanelli WTT and North Gower, both situated within the Burry Inlet, experience varying levels of grazing. Llanelli WTT is grazed seasonally by cattle, while North Gower is grazed year-round by cattle, sheep, and horses.

The highest total density of European flounder was recorded in the North Gower, while Llanelli WTT exhibited the highest total density of European sprat. However, Laugharne exhibited higher total densities for seven of the focal species compared to the other saltmarsh sites. Notably, lesser sandeel were exclusively recorded at Laugharne, potentially due to the presence of a nearby Sand Eel burrowing site. Sand Eels forage close to their burrows and return to them at night (Freeman et al., 2004; Reay, 1970; Winslade, 1974; Wright et al., 2000).

The differences in species distribution across these sites may be attributed to grazing pressure, which is known to negatively impact feeding opportunities for fish in saltmarsh habitats (Friese et al., 2018; P Laffaille et al., 2000). The absence of grazing at Laugharne facilitates the development of taller, denser vegetation (Davidson et al., 2017), providing increased protection and food availability for juvenile fish. These factors may make Laugharne a more favourable habitat, explaining the higher densities observed at the site. Beyond the local factors such as grazing, the broader environmental conditions of the estuarine systems themselves may also influence species distribution patterns.

St. Ishmael, an unvegetated site in the Three Rivers Estuary, ranked second most frequently in terms of overall species densities. This suggests that both Laugharne and St. Ishmael, located within the Three Rivers Estuary, exhibit higher species densities for several focal species compared to the sites in the Burry Inlet. Although the two estuaries are geographically close and both situated within Carmarthen Bay, the observed variation in fish densities suggests that they may function differently in terms of habitat suitability and nursery ground potential. These differences could be influenced by distinct environmental factors such as freshwater input, tidal influence, and estuarine geomorphology (Marshall and Elliott, 1998; Selleslagh et al., 2009). The Three Rivers Estuary may provide more favourable conditions for juvenile fish, while the Burry Inlet may not support the same level of species density. This highlights the importance of investigating how different estuaries function for fish communities, as even closely situated estuarine systems can exhibit distinct ecological roles that influence fish populations (Lafage et al., 2021; Sheaves, 2016; Valesini et al., 2014).

6. Higher fish production in saltmarshes for majority of focal species

For all comparable species, the annual production in this study is lower than that observed in other estuaries. For example, the annual production of European bass in the Mondego estuary was, in its least productive year, two-fold larger than that in this study. These lower production values may be attributed to differences in sampling techniques. The present study used fyke netting, which was standardised using the "total possible area sampled" likely providing a conservative estimate of total densities and potentially underestimating production values. However, some authors have theorised that productivity increases with decreasing latitude (Cowley and Whitfield, 2002), the estimates in this study may support that hypothesis.

Saltmarsh habitat supported the highest levels of production for Atlantic herring, grey mullet, European flounder, and lesser sandeel, while unvegetated habitat supported the highest production for European bass. When considering total cumulative production, unvegetated habitats had the highest overall productivity in terms of g WW m^{-2} $year^{-1}$. Unvegetated habitats were particularly productive for European bass, followed by saltmarsh and managed realignment, with the highest level of production observed in spring at 0.045 g WW m^{-2} in unvegetated habitats. European bass were found in high densities in both unvegetated and saltmarsh habitats, with a higher mean density in unvegetated. Juvenile European bass are typically dominant in estuarine environments, in higher abundance during spring and summer due to increased prey availability (Cattrijsse et al., 1994; Cattrijsse and Hampel, 2006; Green et al., 2009; Hyder et al., 2018; Kelley, 1988; Mathieson et al., 2000). Their generalist diet and opportunistic predatory behaviour allow them to feed on a wide range of prey, from copepods to small fish (Cabral and Costa, 2001; Hampel et al., 2005). In this study, European bass appeared to divide their time evenly between both habitats, with no difference between mean density. Although historically a large focus has been placed on saltmarsh habitats as nursery grounds for European bass, a recent study reflects similar findings that sandy shores and saltmarsh habitats are equally used by juvenile European bass in estuaries (Freeman et al., 2024). This equal division may be a reflection of the ecological flexibility of juvenile European bass, which as generalists are capable of exploiting different habitat features. Each habitat may offer different advantages to the species; for example, presence of saltmarsh vegetation enhances the abundance of suitable prey for European bass (Ford et al., 2013; Friese et al., 2018; Laffaille et al., 2000; Stamp et al., 2023), while unvegetated shores elevate foraging efficiency (Grønkjær et al., 2007; Nordström and Booth, 2007; Perry et al., 2018). As predatory fish, the relative ease of locating and capturing prey in unvegetated habitats might explain the higher mean densities of European bass observed there. European bass accounted for 74% of total productivity (0.0866 g WW m^{-2} $year^{-1}$) summed from all three habitat types. Similarly, Dolbeth et al (2008) found European bass to be one of the most productive species in the Mondego estuary. Given European bass' disproportionate effect on overall production values, they will be excluded from the following interpretation to provide a clearer understanding of the productivity of other species in the system.

Upon removing European bass, it was revealed that saltmarsh had the highest total cumulative production (0.0152 g WW m^{-2} $year^{-1}$), followed by unvegetated (0.0069 g WW m^{-2} $year^{-1}$), and managed realignment (0.004 g WW m^{-2} $year^{-1}$). The higher productivity in saltmarsh habitat aligns with its well-established ecological role in providing structural complexity and rich invertebrate communities, creating ideal conditions for juvenile fish (Boesch and Turner, 1984; Costa et al., 2001; Endresz, 2020; Joyeux et al., 2017; Lafage et al., 2021; Veiga et al., 2006; Vernberg, 1993; Whitfield, 2017). In contrast, the managed realignment is still in an early successional stage, likely limiting its capacity to support fish populations to the same extent as fully established saltmarshes (Colclough et al., 2005; Garbutt et al., 2006; Tupper and Able, 2000). While unvegetated habitats provide some benefits, previously discussed (Freeman et al., 2024; Whitfield, 2020), overall productivity remains lower than in saltmarshes. The high productivity observed in saltmarsh habitats in this study highlights their critical ecological role in estuarine systems, reinforcing their importance as essential habitats for the early life stages of many commercially and ecologically important fish species.

The high productivity observed in saltmarshes in this study strengthens the argument for their importance as key nursery habitats within estuarine ecosystems. Given the continued global decline of saltmarshes due to coastal development and climate change, these findings highlight the need for targeted conservation and restoration efforts. While managed realignment projects offer a potential solution to saltmarsh loss, the lower productivity observed in the Cwm Ivy site suggests that restored habitats may take years or even decades to reach full ecological functionality and require careful planning. The restricted tidal exchange caused by the single sea wall breach may be limiting the site's development, emphasising the need for improved hydrological connectivity in future realignment projects. Long-term monitoring will be essential to assess whether these sites can ultimately support fish populations at levels comparable to natural saltmarshes.

Beyond the context of South Wales, these results contribute to a broader understanding of how saltmarshes function as fish nurseries across the UK and globally. Differences in fish production across sites suggest that local environmental conditions, such as hydrodynamics, tidal regimes, and connectivity to the broader estuarine system, may play a key role in determining saltmarsh productivity. As the UK continues to implement habitat restoration initiatives, understanding the conditions that optimise saltmarsh functionality will be crucial in ensuring these habitats can sustain biodiversity and contribute to long-term fisheries management.

7. Future research

This study faced several limitations that provide valuable avenues for future research. A primary limitation lies in the quantification of data collected using fyke nets. As static gear, fyke nets were deployed for varying periods under different flow conditions, making accurate quantification inherently challenging (Breen and Ruetz, 2006; Harrison-Day et al., 2020). Although efforts were made to derive quantitative data from fyke net catches—given the valuable information they provided, which seine nets did not capture—the resulting density estimates are likely conservative. Moreover, the limited availability of species-specific catch efficiencies for fyke nets in this type of system constrained our ability to adjust for the gear's inefficiencies.

Similarly, the use of seine nets presented challenges related to catch efficiency, which depends on species, size, and habitat characteristics (Allen et al., 1992; Bayley and Herendeen, 2000; Pierce et al., 1990). Catch efficiency for seine nets is typically reduced in areas with high vegetation density (Pierce et al., 1990). Conversely, fyke nets are more effective in saltmarsh creeks, where water is funnelled through the nets, limiting nekton's ability to avoid capture. In open, unvegetated habitats, however, nekton could more easily evade fyke nets, further complicating data collection. Addressing these challenges through future studies will enhance the precision of density estimates in saltmarsh ecosystems.

A key area for future research is improving the quantification of fish data collected using fyke and seine nets in saltmarshes. Future studies could focus on refining species-specific catch efficiencies for fyke nets under varying flow conditions. Similarly, further work should explore species-specific catch efficiencies for seine netting in densely vegetated habitats to account for the impact of obstructions (Pierce et al., 1990). Standardized sampling protocols that account for these differences will improve the reliability of fish density estimates in saltmarsh habitats.

Another significant limitation of this study is its temporal scope. Long-term data are necessary to assess interannual variation, as a single year of data may underestimate the contribution of younger cohorts, limiting understanding of the system's overall productivity (Dolbeth et al., 2008; Pombo et al., 2007). Establishing a longer-term dataset through continued fish surveys will enable more precise estimates of annual production and species composition, providing a clearer picture of interannual variation in saltmarsh ecosystems.

Additionally, future research should investigate differences in species composition among saltmarsh sub-habitats, such as pools, creeks, and flats. Previous studies suggest that sub-habitats are used differently depending on species and life stage (MacKenzie and Dionne, 2008; Virgin et al., 2020). Notably, pools offer refuge and feeding opportunities during low tide, unlike creeks and flats, which drain completely (Able et al., 2005; Allen et al., 2017). This study focused primarily on vegetated flats using seine nets and creeks using fyke nets. Incorporating additional sampling methods, such as push nets for smaller tidal pools, could offer further insights into how fish utilize the diverse topography of saltmarshes.

Another important consideration for future research is identifying the drivers behind high fish production in saltmarsh ecosystems, as suggested by the variation observed between saltmarsh sites, such as Laugharne and North Gower. Factors including water quality, salinity, vegetation structure, and prey availability are likely to play crucial roles (Green et al., 2009; Mathieson et al., 2000). Understanding these influences will enhance knowledge of the role of saltmarshes within estuarine ecosystems, ultimately guiding more effective conservation and management strategies.

Conclusion

This study demonstrates that saltmarshes in South Wales are preferred by juveniles, rather than adults, of several important commercial and conservation species, reinforcing that saltmarshes function as critical nursery habitats (Cattrijsse and Hampel, 2006). Four focal species were found year-round in saltmarshes in South Wales, indicating a broader year-round species presence than recorded in saltmarshes in Southeast England (Green et al., 2009). Saltmarsh supported higher levels of production for the majority of focal species in this study. The use of multiple estuarine habitats by various species (e.g. European bass and grey mullet) was evident by distinct seasonal peaks across different the habitat types. European bass did not show a preference for saltmarshes over unvegetated shores, aligning with findings from the Colne and Blackwater estuaries (Freeman et al., 2024).This study reveals that species density varies not only by habitat type but also by location (i.e., estuary), indicating site-specific influences on distribution. Notably, the managed realignment site did not exhibit the same high species densities observed in natural saltmarshes.

These findings highlight the importance of preserving and restoring saltmarsh habitats to support healthy fish populations and the long-term viability of marine resources. Additionally, this study provides the first fish production estimates from UK saltmarshes, establishing essential baseline data to inform future research and conservation efforts aimed at enhancing the ecological functioning of both natural saltmarshes and managed realignments.

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Appendices

Appendix 1 Statement of expenditure

Category	Item	Description	Cost (Inc VAT & Delivery
Sampling equipment	Micromesh Fry Seine Nets - 15 mtrs x 2.7 mtrs	Beach Seine net for juvenile fish sampling	£714.00
	Small Mesh Fyke Net for Eels and Fish - Single or Double. - 5 Hoop Small Mesh Single D	Three small fyke nets for creek sampling of nekton.	£990.00
	Spare Leaders / Wings - 5mtr Leader, 53cm Fyke	Leaders to extend fyke net as in other saltmarsh studies.	£108.00
	WaterMark Ultimate Fish Board 24"/60cm	Fish measuring board for minimal trauma when measuring.	£100.00
	Otter Guard	Otter guard for fyke net to prevent capture of air breathing animals.	£13.50
	Athletico Scuba Diving Bag	Bag to carry the Seine net in.	£29.99
	Bag for Fyke Net	Bag to carry the Fyke net in.	£25.96
	Waders	4 pairs of waders for field work.	£239.95
	Buckets	Buckets to hold fish for processing.	£14.00
	Roof Rack	Roof rack to carry top box.	£214.82
	Top Box	Top box to carry all the equipment.	£179.99
	Protective covers for car	Floor mats and seat covers to prevent damage to car.	£44.48
	Waterproof phone case	Waterproof phone case so phone can be taken into field.	£22.48
Travel Expenses	Milage	Milage paid when using own car	£915.93
Total			**£3613.10**

Appendix 2 Statement of contributions

SS – Sasha Shute, MSc by Research Candidate

NE – Dr. Nicole Esteban, Academic Supervisor

RU – Dr. Richard Unsworth, Academic Supervisor

SC – Steve Colclough, External expert in the field

IN – Ida Nielsen, Project Supervisor - Natural Resources Wales

AS – Alex Scorey, Project Supervisor - Natural Resources Wales

LP – Lauren Pennack, Year in Industry Student

MRC – Martin Reina Canitrot, Year in Industry Student

RP – Romilly Pope, Year in Industry Student

LH – Laura Hutchinson, Dissertation Student

AW – Abbie Wallace, Dissertation Student

DA – Dani Aguirre–Howes, Student

SV – Scott Van Haren, Student

GB – Grace Balchin, Student

MC – Momo Craddock, Student

AW – Alfie Watton, Student

TG – Tom Green, Student

MCP – Matteo Caravati-Pringle, Student

MW – Miny Walker, External volunteer

AJ – Amelia Jones, MRes Student

AE – Amira Ellery, MRes Student

AF – Amy Fisher, MRes Student

SC – Sophia Coveny, MarCEL research group

NK – Nupur Kale, MarCEL research group

HS – Dr. Holly Stokes, MarCEL research group

LB – Lucy Bundenburg, Student

OD – Ollie Duke, Student

WR – Will Russel, Student

GK – George Kirby, Student

TW – Ted Walker, Student

Contributor Role	**Contributors**
Conceptualisation	IN, AS, RU, NE,
Data collection	SS, LP, MRC, RP, DA, SV, LH, AW, GB, MC, AW, TG, IN, AS, NE, MCP, MW, AE, AJ, SC, NK, HS, AF, LB, OD, WR, GK, TW
Data Curation	SS
Formal Analysis	SS
Funding Acquisition	NE
Investigation	SS
Methodology	SS, NE, RU, SC
Project Administration	NE, IN, AS, SS
Resources	NE
Supervision	NE, RU, IN, SC
Visualisation	SS, NE
Writing – Original draft preparation	SS
Writing – Review & editing	SS, NE

Appendix 3 Ethics Approval

Swansea University
Prifysgol Abertawe

Approval Date: 07/02/2023

Research Ethics Approval Number: 2 2023 5906 5129

Thank you for completing a research ethics application for ethical approval and submitting the required documentation via the online platform.

Project Title	Seine netting to assess fish abundance and diversity, Wales
Applicant name	DR Nicole Esteban
Submitted by	DR Nicole Esteban /
Full application form link	https://swansea.forms.ethicalreviewmanager.com/Project/Index/7545

The Science and Engineering ethics committee has approved the ethics application, subject to the conditions outlined below:

Approval conditions

1. The approval is based on the information given within the application and the work will be conducted in line with this. It is the responsibility of the applicant to ensure all relevant external and internal regulations, policies and legislations are met.
2. This project may be subject to periodic review by the committee. The approval may be suspended or revoked at any time if there has been a breach of conditions.
3. Any substantial amendments to the approved proposal will be submitted to the ethics committee prior to implementing any such changes.

Specific conditions in respect of this application:

The application has been classified as Low risk to the University.

No additional conditions.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees. It complies with the guidelines of UKRI and the concordat to support Research Integrity.

Science and Engineering Research and Ethics Chair

Swansea University.

If you have any query regarding this notification, then please contact your research ethics administrator for the faculty.

- For Science and Engineering contact FSE-Ethics@swansea.ac.uk
- For Medicine, Health and Life Science contact FMHLS-Ethics@swansea.ac.uk
- For Humanities and Social Sciences contact FHSS-Ethics@swansea.ac.uk

Appendix 4 Risk assessment

Science fieldwork risk assessment (UG/PGT/PGR)

You must not carry out fieldwork until this risk assessment has been approved by your Supervisor. See the Fieldwork Risk Assessment Guidance document to complete this form.

Risk Assessment Outcome:

Risk Rating: Negligible/Low risk **Submitted Date:** 13 Sep 2023
Approved Date: 14 Sep 2023 **Approved by:** Nicole Esteban

Student Details

Student Number:	[redacted]	**Project Supervisor:**	Dr Nicole Esteban
Course:	Research Study	**Level:**	7

Assessor:	Sasha Shute	**Assessment Date:**	22/09/2023
Contact Number:	[redacted]	**No. of Participants:**	1
Next of Kin:	Justin Shute	**Next of Kin Contact Number:**	[redacted]
Name of field assistant(s) - Lone working is only permitted in exceptional circumstances, with the agreement of your Supervisor.			
Lauren Pennack Romilly Pope			
Brief outline of the research / fieldwork activity*			
We will be visiting a number of salt marshes across South West Wales, at these locations we will carry out Seine and Fyke netting. The catch will be transferred into buckets and then processed to identify the species, length, and weight of each individual, this will all be recorded. The fish will then be released back to the water.			
List of methods to be used. Use the button 'Add Method' below to add each method details.			
Seine Netting			
Fyke Netting			
Ethics approval number:			
Activity Start Date:*	26/09/2023	**Activity End Date:***	25/09/2024
Location of activity (site name, region etc.):*			
Swansea Bay, Swansea. North Gower, Swansea. Llanelli wetlands, Llanelli. Ferryside, Carmathen. Laugharne, Carmarthen.			
UK Map Reference or LAT LON (if outside UK):			
What 3 words Reference (what3words.com):			
Nearest hospital with A&E (incl. postcode for use with a satnav / app):*			
Morriston hospital, Heol Maes Eglwys, Cwmrhydyceirw, Moriston SA6 6NL. Glangwili Hospital, Dolgwili Rd, Carmarthen SA31 2AF.			
Approx. distance from field site:	up to 30 mins.		
Is there mobile phone coverage?	Yes		
If there is no phone reception, how will you summon help?			
Get to the nearest house or building and ask to use a phone to call an emergency number.			
Contact Name for Check-in/Safe return (Ensure that they know where you are going, your expected return time, your Supervisor's name).			
Nicole Esteban			
Frequency of check-ins/Communication Plan (e.g. start and end of each day)			
Start and end of each day/activity.			
Map of field site (Identify route to nearest hospital with an A&E Department)			

Risk Assessment - Hazards

- **Fill in the grid with the appropriate information. Extend the table as required.**
- **See Examples of some hazards associated with fieldwork in Fieldwork Risk Assessment Guidance document.**

Step1	**Step2**				**Step3**			
Description of Hazard	**Who may be harmed and how**	**S**	**L**	**R**	**Controls/actions required (to eliminate/reduce the risk)**	**S**	**L**	**R**
Entrapment in mud	Myself or my assistants when in the salt marsh, may get trapped and unable to move through the mud.	2	2	4	Ensure everyone is dressed suitably for the muddy conditions. Ensure we are always working in a small group and checking on one another, so if someone is stuck we are able to help pull them out. Have a rope with us, at all time, we are able to use to pull each other out. When working in the creeks always have on person on the bank with the rope.	1	1	1
Tidal	The tide could come in and leave us in deeper water than planned.	2	2	4	Ensure we are aware of the tide times and and monitor the current time and tide. Make sure planning is done before hand with regard for the tide, so that we are not caught out. Wear waterproof clothing so that if we are caught out by the tide we are prepared. Have waterproof phone case so that if we do get caught out we're still able to call for help.	1	1	1
Hypothermia	If myself or assistants get unintentionally wet or if the weather is abnormally cold we could become hypothermic.	3	1	3	Ensure everyone is wearing appropriate clothing to remain warm and dry. Have spare dry clothing and blankets in the car. Keep an eye on weather predictions and plan accordingly.	2	1	2
Minor injury's	My assistant or myself may incur minor injury's from everyday equipment like buckets and rulers.	2	2	4	Have a first aid kit on site with us. Take care when handling equipment.	1	1	1
Drowning	My assistant or myself could accidentally end up in deeper water than planned for and may go into shock and potenially drown.	3	2	6	Plan routes using maps so we have safe routes to follow. Be aware of tide times. Stay in small groups. Take a throw line to the site. Check up on each other regularly. Wear wetsuits so in the event of entering the water we are prepared and not wieghed down by clothing.	2	1	2
Getting tangled up in nets	Anyone working with the Seine nets or Fyke nets could become tangled in them.	1	2	2	Take care when handling the nets and follow proper procedure. Work together in groups when handling the nets.	1	1	1
Getting lost in the saltmarsh at night.	We will be setting up nets in the night time. it is easy to get confused with out daylight and get lost as the saltmarshes are vast.	1	2	2	To prevent this we will have charged phones on us with maps to help us get out of the marsh. We will each have a head torch on us and one spare in the bag. Addionally we are going to repeat the same sites each time, so we will develop known routes to and from the sites, we will make sure to stick to these routes. We have gone and seen each site in the day to parpare where we will sample in night.	1	1	1

Falling down creeks in the night.	The creeks can be hard to see in the day and even harder in the night.	1	3	3	Head torches will help us see where the creeks are to avoid falling. We will move slowly and carefully. We will always remain in a tight group.	1	1	1
Getting stuck in a creek during setup.	The sides of the creeks are often steep and slippery, making it hard to exit sometimes.	1	3	3	One person will always remain on the bank with a throw line to be able to pull the others up in the event the bank is too steep/slippy. Another option to exit would be to walk up the creek to where the bank is less steep and slippy.	1	1	1
Risk (R) = (SxL): LOW (1-2), MODERATE (3-5), HIGH (6-9).								
Coronavirus: Whilst coronavirus remains in circulation you must include this hazard in your risk assessment.								

Are you working near water?	Yes
If yes, please address the following questions:	
What, if any, is the degree of immersion (i.e. none, boat, wade, swim etc.)	
Wade	
What is the nature of the wet environment (river, beach, still water etc.)	
Saltmarsh.	
Can you and your field assistant(s) swim?	Yes
In moving water, specify any additional hazards to consider regarding the rate of flow, tides, water temperature etc.	
Will need to keep note of the tide times, as if we are not vigilant the tide could come in while we are working, and put us in deeper water than planed for.	
I will assess flow rate and risk on-site before entering the water and monitor throughout the experiment. ☐	
If applicable: What are the tidal times for the dates(s) of activity?	
Is the water polluted?	No
If yes, what protection measures are you taking?	

Work in or around water is potentially dangerous. Additional personal protective equipment (PPE) is required. You and your assistant(s) need to know how to use these items.	**PPE Buoyancy aid**	
	Throw Line	Yes
	Wet suit/dry suit/ waders/boots required (specify)?	Yes Wetsuit and boots
	Other (specify)?	No

National Emergency Tel: 999. University Switchboard +44 (0)1792 205678 (non-emergency).

Working method statement

Detail here the field methods you will be using and any controls / actions you will take to reduce the risk. Include Standard Operating Procedures or append references as appropriate.

We will be using Seine netting to capture fish in the salt marsh. This poses the risk of getting caught up in the net, to reduce the risk we will ensure to follow the proper procedures for using the net and make sure to put it away neatly, the Seine net will always be operated by 2 or more people at a time. Another risk that seine netting poses is getting stuck in the mud that is beneath the water we are sampling, to reduce this risk we will ensure everyone is wearing appropriate gear (like waders or wetsuits) so that if we do get stuck the discomfort is minimised, to reduce the risk of getting stuck we will only enter the water when absolutely necessary and with other people aware that is what we are doing. To deploy fyke nets we will have to go deeper into the salt marsh at low tide, the tide then becomes a risk factor. To avoid being caught by the tide, and ending up in deep water, we will plan around the tide times, make sure to keep note of where the tide is and where it is heading at all times. Here in the marsh the substrate will be muddy and this means we risk getting stuck in the mud, to minimise the discomfort we will be wearing suitable clothing like waders or wetsuits, and to reduce the risk of being stuck for a prolonged period we will make sure to stay in the group and check on one another regularly. When removing the fish from the nets we will wear gloves, to avoid cutting our hands on the nets or any injuries from animals caught in the nets, like crabs. We will be processing the fish using buckets and rulers on site, we will make sure to do this in an area that does not risk getting stuck in the mud and with the tide times in mind.

Personal checks (student):

In signing this form, I agree that:

- ☑ I consent to this information being shared in accordance with the General Data Protection Regulations.
- ☑ I have assessed the risks associated with the activity. I will put in place the controls / activities identified in the risk assessment. I understand that no research activity can be totally risk free.
- ☑ I have discussed with my Supervisor any disability or medical condition that may affect my Health and Safety in the field. I will discuss with them any additional controls or reasonable adjustments that I require.
- ☑ I will notify my contact that I will be in the field, I will communicate with them according the agreed communication plan. I will take with me appropriate contact numbers and means for summoning help.
- ☑ I have established the location of the nearest hospital with an accident and emergency department. I have included the post code for the hospital as this may assist if using a sat. nav.
- ☑ I have a plan in the event that mobile phones will not work on site either due to reception or failure of equipment.
- ☑ I have a map and compass for location and navigation in the field (tick only if required).
- ☑ I am familiar with the use of all field equipment and will work within the approved method statements.
- ☑ I will secure written permission to access the field site and will carry with me a copy of the agreement including any permits to collect samples.
- ☑ I will ensure that all participants are suitably equipped and capable of working safely in the field.
- ☑ I will brief my field assistant(s) and advised them of emergency procedures. I will discuss the work plan, risks and safety arrangements with the field assistant(s) as part of my briefing.
- ☑ I will access the site with due care (following the Country Code).
- ☑ I will engage politely and professionally with any members of the public with whom I interact during fieldwork and take the time to explain to them what I am doing if this is appropriate.
- ☑ I will work safely in a manner respectful of others.
- ☑ I will log all accidents and "near-misses" using the adverse event system (https://www.swansea.ac.uk/about-us/safety-and-security/health-and-safety/report-it/) and ensure that my Supervisor is informed.
- ☑ I will work safely, implementing the controls identified within the risk assessment. In the event that my methods change or that the environment changes I will dynamically re-assess the risk and cease the activity if the environment or activity becomes unsafe or if conditions move beyond the scope of this assessment.

Appendix 5 Site survey characteristics including gear type, sampling period and location. The year 2022 is represented by October only, 2023 by October-December and 2024 by January-August.

Cluster	Site name	Method	Year	Coordinates (Decimal Degrees)
Cwm Ivy	Middle Creek	Fyke	2023, 2024	51.625573, -4.246668
Cwm Ivy	South Creek	Fyke	2023, 2024	51.625094, -4.246295
Cwm Ivy	Cwm Ivy	Seine	2023	51.622601, -4.246206
Cwm Ivy	Cwm Ivy	Seine	2024	51.627215, -4.248690
N/A	Weobely Castle	Seine	2022	51.62898, -4.20786
North Gower	Crofty playground	Seine	2022, 2023, 2024	51.632471, -4.131028
North Gower	Crofty	Fyke	2023, 2024	51.64156, -4.13755
North Gower	Pen-Clawdd	Fyke	2023, 2024	51.64233, -4.12101
N/A	Pen-Clawdd	Seine	2022	51.63288, -4.13066
N/A	Loughor	Seine	2022	51.64501, -4.09508
Llanelli WWT	Llanelli WWT	Fyke	2023, 2024	51.65894, -4.11688
Llanelli WWT	Llanelli WWT	Seine	2023, 2024	51.659019, -4.114064
Llanelli Beach	Llanelli Beach	Seine	2023, 2024	51.675450, -4.178758
Llanelli Beach	Llanelli Beach South	Fyke	2023, 2024	51.676077, -4.180313
Llanelli Beach	Llanelli Beach North	Fyke	2023, 2024	51.676635, -4.180732
St Ishmael	Kidwelly	Fyke	2023, 2024	51.737064, -4.363060
St Ishmael	Ferryside	Fyke	2023, 2024	51.768557, -4.371200
St Ishmael	Ferryside	Seine	2023, 2024	51.769244, -4.370037
Laugharne	Castle North	Fyke	2023, 2024	51.768967, -4.460058
Laugharne	Castle South	Fyke	2023, 2024	51.76718, -4.45993
Laugharne	Castle	Seine	2022, 2023, 2024	51.770735, -4.458806

Appendix 6 Tidal heights of deployment and retrieval for each fyke net placed across all habitat types.

Site name	Habitat type	Deployment height (m)	Retrieval height (m)
Cwm Ivy – Middle Creek	Managed realignment	5.63	6.25
Cwm Ivy – South Creek	Managed realignment	6.00	7.19
Crofty	Saltmarsh	6.25	7.5
Pen-Clawdd	Saltmarsh	6.75	8.13
Llanelli WWT	Saltmarsh	5.65	6.7
Llanelli Beach South	Unvegetated	5.07	6.8
Llanelli Beach North	Unvegetated	5.07	6.8
Kidwelly	Unvegetated	4.25	4.5
Ferryside	Unvegetated	4.5	5
Laugharne Castle North	Saltmarsh	4.25	5.25
Laugharne Castle South	Saltmarsh	4.5	5.5

Appendix 7 Data sheet for recording data collected in field work.

Site name:	Gear:	Start time:
Coordinates:	Date:	Finish time:

Species	L/W	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Tally
	Length																
	Weight																
	Length																
	Weight																
	Length																
	Weight																
	Length																
	Weight																
	Length																
	Weight																
	Length																
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	Weight																
	Length																
	Weight																
	Length																
	Weight																
	Length																
	Weight																

Appendix 8 Documentation of data collection effort. Sampling schedule September 2023 – August 2024.

Month	Date	Time	Site	Activity
September	26/09/2023	13:00		Pick up
September	26/09/2023	13:15	Marina	Set up Fyke net
September	26/09/2023	13:55	Brynmill	Arrive at parking
September	26/09/2023	14:00	Brynmill	Set up Fyke net
September	26/09/2023	15:30	Brynmill	Seine net Brynmill site
September	26/09/2023	16:45	Marina	Seine net Marina site
September	26/09/2023	18:00	Marina	Retrieve fyke net
September	26/09/2023	18:40	Brynmill	Retrieve fyke net
September	27/09/2023	16:00		Pick up
September	27/09/2023	17:00	Laugharne	Arrive at parking
September	27/09/2023	17:30	Laugharne	Seine net North
September	27/09/2023	18:30	Laugharne	Seine net South
September	27/09/2023	21:00	Laugharne	Set up Fyke net north site
September	27/09/2023	TBD	Laugharne	Finish fyke net set up
September	27/09/2023	TBD	Laugharne	Set up Fyke net south site
September	27/09/2023	23:00	Laugharne	Go home
September	28/09/2023	06:00		Pick up
September	28/09/2023	07:00	Laugharne	Arrive at parking
September	28/09/2023	TBD	Laugharne	Retrieve nets
September	28/09/2023	10:00		Go home
September	28/09/2023	16:30		Pick up
September	28/09/2023	17:00	Llanelli	Arrive at parking
September	28/09/2023	17:30	Llanelli	Seine net
September	28/09/2023	20:30	Llanelli	Set up Fyke net 1
September	28/09/2023	TBD	Llanelli	Set up Fyke net 2
September	28/09/2023	22:30	Llanelli	Go home
September				
September	29/09/2023	07:15		Pick up
September	29/09/2023	07:45	Llanelli	Arrive at parking
September	29/09/2023	TBD	Llanelli	Retrieve nets
September	29/09/2023	20:00		Pick up
September	29/09/2023	20:40	Cwm Ivy	Arrive at parking
September	29/09/2023	TBD	Cwm Ivy	Set up Fyke net 1
September	29/09/2023	TBD	Cwm Ivy	Set up Fyke net 2
September				
September	30/09/2023	07:00		Pick up
September	30/09/2023	07:40	Cwm Ivy	Arrive at parking

September	30/09/2023	08:10	Cwm Ivy	Arrive at site
September	30/09/2023	TBD	Cwm Ivy	Retrieve fykes
September	30/09/2023	18:10		Pick up
September	30/09/2023	18:50	Crofty	Arrive at parking
September	30/09/2023	19:00	Crofty	Seine net
September	30/09/2023	22:30	Crofty	Set up Fyke net
September	30/09/2023		Pen-clawdd	Set up Fyke net
September	30/09/2023			Go home
September				
September	01/10/2023	08:20		Pick up
September	01/10/2023	08:55	Pen-clawdd	Arrive at parking
September	01/10/2023		Pen-clawdd	Retrieve fyke
September	01/10/2023		Crofty	Retrieve fyke
September	01/10/2023			Pick up
September	01/10/2023	18:15	Ferryside	Set up Fyke net
September	01/10/2023	20:15	Ferryside	Start seine net sampling
September	01/10/2023		Ferryside	Retrieve fyke
October	13/10/2023	03:15		Pick up
October	13/10/2023	03:30	Brynmill	Set up Fyke net
October	13/10/2023	03:40		Drive
October	13/10/2023	03:50	Marina	Arrive
October	13/10/2023	04:00	Marina	Set up Fyke net
October	13/10/2023	06:10	Marina	Start seine net
October	13/10/2023	06:55		Drive
October	13/10/2023	07:05	Brynmill	Arrive
October	13/10/2023	07:10	Brynmill	Start seine net
October	13/10/2023	08:15	Brynmill	Retrieve net
October	13/10/2023	08:35		Drive
October	13/10/2023	08:45	Marina	Retrieve net
October	14/10/2023	03:40		Leave Swansea
October	14/10/2023	04:20	Llanelli	Arrive at gates
October	14/10/2023	04:45	Llanelli	Deploy both nets
October	14/10/2023	06:45	Llanelli	Seine net
October	14/10/2023	09:00	Llanelli	Watch for fykes
October	15/10/2023	04:00		Leave Swansea
October	15/10/2023	04:30	Crofty	Arrive at car park
October	15/10/2023	04:50	Crofty	Deploy fyke
October	15/10/2023	05:20	Pen-clawdd	Deploy fyke
October	15/10/2023	07:30	Crofty	Seine net

October	15/10/2023	09:15	Pen-clawdd	Retrieve net
October	15/10/2023	09:35	Crofty	Retrieve net
October	17/10/2023	04:00		Leave Swansea
October	17/10/2023	05:00	Laugharne	Arrive at car park
October	17/10/2023	05:30	Laugharne	Deploy North site
October	17/10/2023	05:45	Laugharne	Deploy South site
October	17/10/2023	07:05	Laugharne	Start seine net
October	17/10/2023	09:05	Laugharne	Finish seine net
October	17/10/2023	10:10	Laugharne	Retrieve South net
October	17/10/2023	10:40	Laugharne	Retrieve North net
October	18/10/2023	04:50		Leave Swansea
October	18/10/2023	05:30	Cwm Ivy	Arrive at car park
October	18/10/2023	05:55	Cwm Ivy	Deploy nets
October	18/10/2023	08:30	Cwm Ivy	Seine net
October	18/10/2023	11:30	Cwm Ivy	Retrieve nets
October	19/10/2023	05:45		Leave Swansea
October	19/10/2023	06:45	Ferryside	Arrive at car park
October	19/10/2023	07:00	Ferryside	Deploy net
October	19/10/2023	09:15	Ferryside	Seine net
	19/10/2023	10:15	Ferryside	Retrieve net
November	11/11/2023	14:10		Leave Swansea
November	11/11/2023	14:50	Llanelli Beach	Arrive at car park
November	11/11/2023	15:10	Llanelli Beach	Deploy fyke
November	11/11/2023	16:20	Llanelli Beach	Seine net
November	11/11/2023	16:33	Llanelli Beach	Sunset
November	11/11/2023	19:10	Llanelli Beach	Retrieve fyke
November	11/11/2023	21:10		Latest time home
November	12/11/2023	14:10		Leave Swansea
November	12/11/2023	14:55	Llanelli WWT	Arrive at gates
November	12/11/2023	15:20	Llanelli WWT	Deploy both fykes
November	12/11/2023	16:05	Llanelli WWT	Seine net
November	12/11/2023	16:31	Llanelli WWT	Sunset
November	12/11/2023	19:40	Llanelli WWT	Retrieve fykes
November	12/11/2023	21:40		Latest time home
November	13/11/2023	14:40		Leave Swansea
November	13/11/2023	15:25	Cwm Ivy	Arrive at car park
November	13/11/2023	15:40	Cwm Ivy	Deploy both fykes
November	13/11/2023	16:30	Cwm Ivy	Sunset
November	13/11/2023	17:45	Cwm Ivy	Seine net

November	13/11/2023	20:00	Cwm Ivy	Retrieve fykes
November	13/11/2023	22:00		Latest time home
November	14/11/2023	15:10		Leave Swansea
November	14/11/2023	15:50		Arrive at car park
November	14/11/2023	16:00	Crofty	Deploy fyke
November	14/11/2023	16:20	Pen-clawdd	Deploy fyke
November	14/11/2023	16:28		Sunset
November	14/11/2023	18:45	Crofty playground	Seine net
November	14/11/2023	20:10	Pen-clawdd	Retrieve fyke
November	14/11/2023	20:40	Crofty	Retrieve fyke
November	14/11/2023	22:40		Latest time home
November	16/11/2023	03:50		Leave Swansea
November	16/11/2023	04:50	Laugharne	Arrive at car park
November	16/11/2023	05:00	North Laugharne	Deploy fyke
November	16/11/2023		South Laugharne	Deploy fyke
November	16/11/2023	06:50	Laugharne	Seine net
November	16/11/2023	07:38	Laugharne	Sunrise
November	16/11/2023	09:30	South Laugharne	Retrieve fyke
November	16/11/2023	09:55	North Laugharne	Retrieve fyke
November	16/11/2023	12:00		Latest time home
November	17/11/2023	04:20		Leave Swansea
November	17/11/2023	05:20	Kidwelly	Arrive at car park
November	17/11/2023	05:30	Kidwelly	Deploy fyke
November	17/11/2023	05:50	Ferryside	Deploy fyke
November	17/11/2023	06:40	Ferryside	Seine net
November	17/11/2023	07:49	Ferryside	Sunrise
November	17/11/2023	10:10	Ferryside	Retrieve fyke
November	17/11/2023	10:40	Kidwelly	Retrieve fyke
	17/11/2023	12:40		Latest time home
December	11/12/2023	13:50		Leave Swansea
December	11/12/2023	14:35	Llanelli WWT	Arrive at gates
December	11/12/2023	15:00	Llanelli WWT	Deploy both fykes
December	11/12/2023	15:45	Llanelli WWT	Seine net
December	11/12/2023	19:00	Llanelli WWT	Retrieve fykes
December	12/12/2023	13:45		Leave Swansea
December	12/12/2023	14:30	Cwm Ivy	Arrive at car park
December	12/12/2023	14:50	Cwm Ivy	Deploy both fykes
December	12/12/2023	17:15	Cwm Ivy	Seine net
December	12/12/2023	18:50	Cwm Ivy	Retrieve fykes

December	13/12/2023	14:20		Leave Swansea
December	13/12/2023	15:30	Laugharne	Arrive at car park
December	13/12/2023	15:45	North Laugharne	Deploy fyke
December	13/12/2023	ASAP	South Laugharne	Deploy fyke
December	13/12/2023	17:45	Laugharne	Seine net
December	13/12/2023	20:00	South Laugharne	Retrieve fyke
December	13/12/2023	ASAP	North Laugharne	Retrieve fyke
December	15/12/2023	04:20		Leave Swansea
December	15/12/2023	04:50		Arrive at car park
December	15/12/2023	05:00	Crofty	Deploy fyke
December	15/12/2023	ASAP	Pen-clawdd	Deploy fyke
December	15/12/2023	07:00	Crofty playground	Seine net
December	15/12/2023	09:00	Pen-clawdd	Retrieve fyke
December	15/12/2023	ASAP	Crofty	Retrieve fyke
December	16/12/2023	04:00		Leave Swansea
December	16/12/2023	05:00	Ferryside	Arrive at car park
December	16/12/2023	05:15	Ferryside	Deploy fyke
December	16/12/2023	ASAP	Kidwelly	Deploy fyke
December	16/12/2023	08:07	Kidwelly	Seine net
December	16/12/2023	ASAP	Kidwelly	Retrieve fyke
December	16/12/2023	10:45	Ferryside	Retrieve fyke
December	17/12/2023	06:10		Leave Swansea
December	17/12/2023	06:50	Llanelli Beach	Arrive at car park
December	17/12/2023	07:10	Llanelli Beach	Deploy fyke
December	17/12/2023	08:30	Llanelli Beach	Seine net
December	17/12/2023	11:10	Llanelli Beach	Retrieve fyke
December				
January	25/01/2024	15:25		Leave Swansea
January	25/01/2024	16:10	Llanelli WWT	Arrive at gates
January	25/01/2024	16:30	Llanelli WWT	Deploy both fykes
January	25/01/2024	17:15	Llanelli WWT	Seine net
January	25/01/2024	20:00	Llanelli WWT	Retrieve fykes
January	26/01/2024	15:00		Leave Swansea
January	26/01/2024	16:15	Kidwelly	Arrive at car park
January	26/01/2024	16:30	Kidwelly	Deploy fyke
January	26/01/2024	ASAP	Ferryside	Deploy fyke
January	26/01/2024	17:30	Ferryside	Seine net
January	26/01/2024	ASAP	Ferryside	Retrieve fyke
January	26/01/2024	21:00	Kidwelly	Retrieve fyke

January	27/01/2024	15:45		Leave Swansea
January	27/01/2024	17:00	Laugharne	Arrive at car park
January	27/01/2024	17:15	North Laugharne	Deploy fyke
January	27/01/2024	ASAP	South Laugharne	Deploy fyke
January	27/01/2024	18:55	Laugharne	Seine net
January	27/01/2024	20:50	South Laugharne	Retrieve fyke
January	27/01/2024	21:00	North Laugharne	Retrieve fyke
January	29/01/2024	05:00		Leave Swansea
January	29/01/2024	05:30	Crofty	Arrive at car park
January	29/01/2024	05:40	Crofty	Deploy fyke
January	29/01/2024	ASAP	Pen-clawdd	Deploy fyke
January	29/01/2024	08:00	Crofty playground	Seine net
January	29/01/2024	09:40	Pen-clawdd	Retrieve fyke
January	29/01/2024	ASAP	Crofty	Retrieve fyke
January	30/01/2024	06:05		Leave Swansea
January	30/01/2024	06:45	Llanelli Beach	Arrive at car park
January	30/01/2024	07:00	Llanelli Beach	Deploy fyke
January	30/01/2024	08:10	Llanelli Beach	Seine net
January	30/01/2024	10:10	Llanelli Beach	Retrieve fyke
January	31/01/2024	05:05		Leave Swansea
January	31/01/2024	05:50	Cwm Ivy	Arrive at car park
January	31/01/2024	06:10	Cwm Ivy	Deploy both fykes
January	31/01/2024	08:45	Cwm Ivy	Seine net
January	31/01/2024	11:00	Cwm Ivy	Retrieve fykes
February	23/02/2024	15:00		Leave Swansea
February	23/02/2024	15:40	Llanelli WWT	Arrive at gates
February	23/02/2024	16:10	Llanelli WWT	Deploy fyke
February	23/02/2024	17:00	Llanelli WWT	Seine net
February	23/02/2024	19:50	Llanelli WWT	Retrieve fyke
February	24/02/2024	16:00		Leave Swansea
February	24/02/2024	16:45	Llanelli Beach	Arrive at car park
February	24/02/2024	17:00	Llanelli Beach	Deploy fyke
February	24/02/2024	18:00	Llanelli Beach	Seine net
February	24/02/2024	20:20	Llanelli Beach	Retrieve fyke
February	25/02/2024	15:25		Leave Swansea
February	25/02/2024	16:25	Laugharne	Arrive at car park
February	25/02/2024	16:40	North Laugharne	Deploy fyke
February	25/02/2024	ASAP	South Laugharne	Deploy fyke

February	25/02/2024	18:30	Laugharne	Seine net
February	25/02/2024	20:45	South Laugharne	Retrieve fyke
February	25/02/2024	21:05	North Laugharne	Retrieve fyke
February	27/02/2024	04:50		Leave Swansea
February	27/02/2024	05:20	Crofty	Arrive at car park
February	27/02/2024	05:30	Crofty	Deploy fyke
February	27/02/2024	ASAP	Pen-clawdd	Deploy fyke
February	27/02/2024	07:30	Crofty playground	Seine net
February	27/02/2024	09:20	Pen-clawdd	Retrieve fyke
February	27/02/2024	ASAP	Crofty	Retrieve fyke
February	28/02/2024	04:35		Leave Swansea
February	28/02/2024	05:35	Kidwelly	Arrive at car park
February	28/02/2024	05:45	Kidwelly	Deploy fyke
February	28/02/2024	ASAP	Ferryside	Deploy fyke
February	28/02/2024	06:20	Ferryside	Seine net
February	28/02/2024	10:00	Ferryside	Retrieve fyke
February	28/02/2024	ASAP	Kidwelly	Retrieve fyke
March	23/03/2024	13:40		Leave Swansea
March	23/03/2024	14:40	Cwm Ivy	Arrive at car park
March	23/03/2024	15:00	Cwm Ivy	Deploy both fykes
March	23/03/2024	17:20	Cwm Ivy	Seine net
March	23/03/2024	20:00	Cwm Ivy	Retrieve fykes
March	24/03/2024	15:10		Leave Swansea
March	24/03/2024	15:50	Llanelli WWT	Arrive at gates
March	24/03/2024	16:10	Llanelli WWT	Deploy fyke
March	24/03/2024	17:00	Llanelli WWT	Seine net
March	24/03/2024	20:00	Llanelli WWT	Retrieve fyke
March	25/03/2024	14:50		Leave Swansea
March	25/03/2024	15:50	Laugharne	Arrive at car park
March	25/03/2024	16:05	North Laugharne	Deploy fyke
March	25/03/2024	ASAP	South Laugharne	Deploy fyke
March	25/03/2024	18:00	Laugharne	Seine net
March	25/03/2024	20:15	South Laugharne	Retrieve fyke
March	25/03/2024	20:30	North Laugharne	Retrieve fyke
March	26/02/2024	15:50		Leave Swansea
March	26/02/2024	16:35	Crofty	Arrive at car park
March	26/02/2024	16:50	Crofty	Deploy fyke
March	26/02/2024	ASAP	Pen-clawdd	Deploy fyke

March	26/02/2024	18:45	Crofty playground	Seine net
March	26/02/2024	20:30	Pen-clawdd	Retrieve fyke
March	26/02/2024	ASAP	Crofty	Retrieve fyke
March	27/02/2024	16:10		Leave Swansea
March	27/02/2024	17:10	Kidwelly	Arrive at car park
March	27/02/2024	17:20	Kidwelly	Deploy fyke
March	27/02/2024	ASAP	Ferryside	Deploy fyke
March	27/02/2024	18:00	Ferryside	Seine net
March	27/02/2024	21:20	Ferryside	Retrieve fyke
March	27/02/2024	ASAP	Kidwelly	Retrieve fyke
March	28/03/2024	17:15		Leave Swansea
March	28/03/2024	18:00	Llanelli Beach	Arrive at car park
March	28/03/2024	18:10	Llanelli Beach	Deploy fyke
March	28/03/2024	19:20	Llanelli Beach	Seine net
March	28/03/2024	21:50	Llanelli Beach	Retrieve fyke
April	22/04/2024	15:45		Leave Swansea
April	22/04/2024	16:30	Llanelli WWT	Arrive at gates
April	22/04/2024	16:45	Llanelli WWT	Deploy fyke
April	22/04/2024	17:30	Llanelli WWT	Seine net
April	22/04/2024	20:10	Llanelli WWT	Retrieve fyke
April	23/04/2024	15:00		Leave Swansea
April	23/04/2024	16:00	Cwm Ivy	Arrive at car park
April	23/04/2024	16:20	Cwm Ivy	Deploy both fykes
April	23/04/2024	18:45	Cwm Ivy	Seine net
April	23/04/2024	21:15	Cwm Ivy	Retrieve fykes
April	24/04/2024	16:00		Leave Swansea
April	24/04/2024	17:00	Laugharne	Arrive at car park
April	24/04/2024	17:10	North Laugharne	Deploy fyke
April	24/04/2024	ASAP	South Laugharne	Deploy fyke
April	24/04/2024	19:00	Laugharne	Seine net
April	24/04/2024	21:00	South Laugharne	Retrieve fyke
April	24/04/2024	ASAP	North Laugharne	Retrieve fyke
April	25/04/2024	16:50		Leave Swansea
April	25/04/2024	17:20	Crofty	Arrive at car park
April	25/04/2024	17:30	Crofty	Deploy fyke
April	25/04/2024	ASAP	Pen-clawdd	Deploy fyke
April	25/04/2024	19:45	Crofty playground	Seine net
April	25/04/2024	21:30	Pen-clawdd	Retrieve fyke

April	25/04/2024	ASAP	Crofty	Retrieve fyke
April	27/04/2024	06:20		Leave Swansea
April	27/04/2024	07:00	Llanelli Beach	Arrive at car park
April	27/04/2024	07:10	Llanelli Beach	Deploy fyke
April	27/04/2024	08:15	Llanelli Beach	Seine net
April	27/04/2024	10:30	Llanelli Beach	Retrieve fyke
April	28/04/2024	06:20		Leave Swansea
April	28/04/2024	07:20	Kidwelly	Arrive at car park
April	28/04/2024	07:30	Kidwelly	Deploy fyke
April	28/04/2024	ASAP	Ferryside	Deploy fyke
April	28/04/2024	08:50	Ferryside	Seine net
April	28/04/2024	11:00	Ferryside	Retrieve fyke
April	28/04/2024	ASAP	Kidwelly	Retrieve fyke
May	21/05/2024	14:50		Leave Swansea
May	21/05/2024	15:50	Kidwelly	Arrive at car park
May	21/05/2024	16:00	Kidwelly	Deploy fyke
May	21/05/2024	ASAP	Ferryside	Deploy fyke
May	21/05/2024	17:00	Ferryside	Seine net
May	21/05/2024	19:40	Ferryside	Retrieve fyke
May	21/05/2024	ASAP	Kidwelly	Retrieve fyke
May	22/05/2024	14:30		Leave Swansea
May	22/05/2024	15:30	Cwm Ivy	Arrive at first gate
May	22/05/2024	15:50	Cwm Ivy	Deploy both fykes
May	22/05/2024	18:10	Cwm Ivy	Seine net
May	22/05/2024	20:40	Cwm Ivy	Retrieve fykes
May	23/05/2024	15:20		Leave Swansea
May	23/05/2024	16:20	Laugharne	Arrive at car park
May	23/05/2024	16:30	North Laugharne	Deploy fyke
May	23/05/2024	ASAP	South Laugharne	Deploy fyke
May	23/05/2024	18:30	Laugharne	Seine net
May	23/05/2024	20:45	South Laugharne	Retrieve fyke
May	23/05/2024	ASAP	North Laugharne	Retrieve fyke
May	25/05/2024	05:10		Leave Swansea
May	25/05/2024	05:50	Crofty	Arrive at car park
May	25/05/2024	06:00	Crofty	Deploy fyke
May	25/05/2024	ASAP	Pen-clawdd	Deploy fyke
May	25/05/2024	07:30	Crofty playground	Seine net
May	25/05/2024	09:10	Pen-clawdd	Retrieve fyke

May	25/05/2024	ASAP	Crofty	Retrieve fyke
May	26/05/2024	06:00		Leave Swansea
May	26/05/2024	06:40	Llanelli WWT	Arrive at gates
May	26/05/2024	06:50	Llanelli WWT	Deploy fyke
May	26/05/2024	07:55	Llanelli WWT	Seine net
May	26/05/2024	10:30	Llanelli WWT	Retrieve fyke
May	27/05/2024	07:40		Leave Swansea
May	27/05/2024	07:50	Llanelli Beach	Arrive at car park
May	27/05/2024	08:00	Llanelli Beach	Deploy fyke
May	27/05/2024	08:55	Llanelli Beach	Seine net
May	27/05/2024	10:10	Llanelli Beach	Retrieve fyke
June	03/06/2024	14:10		Leave Swansea
June	03/06/2024	14:50	Llanelli Beach	Arrive at car park
June	03/06/2024	15:00	Llanelli Beach	Deploy fyke
June	03/06/2024	16:00	Llanelli Beach	Seine net
June	03/06/2024	17:40	Llanelli Beach	Retrieve fyke
June	04/06/2024	14:30		Leave Swansea
June	04/06/2024	15:15	Llanelli WWT	Arrive at gates
June	04/06/2024	15:30	Llanelli WWT	Deploy fyke
June	04/06/2024	16:10	Llanelli WWT	Seine net
June	04/06/2024	19:20	Llanelli WWT	Retrieve fyke
June	05/06/2024	15:10		Leave Swansea
June	05/06/2024	15:50	Crofty	Arrive at car park
June	05/06/2024	16:00	Crofty	Deploy fyke
June	05/06/2024	ASAP	Pen-clawdd	Deploy fyke
June	05/06/2024	18:00	Crofty playground	Seine net
June	05/06/2024	19:30	Pen-clawdd	Retrieve fyke
June	05/06/2024	ASAP	Crofty	Retrieve fyke
June	06/06/2024	15:10		Leave Swansea
June	06/06/2024	16:10	Laugharne	Arrive at car park
June	06/06/2024	16:20	North Laugharne	Deploy fyke
June	06/06/2024	ASAP	South Laugharne	Deploy fyke
June	06/06/2024	18:20	Laugharne	Seine net
June	06/06/2024	20:40	South Laugharne	Retrieve fyke
June	06/06/2024	ASAP	North Laugharne	Retrieve fyke
June	08/06/2024	04:10		Leave Swansea
June	08/06/2024	05:10	Cwm Ivy	Arrive at first gate

June	08/06/2024	05:20	Cwm Ivy	Deploy both fykes
June	08/06/2024	07:50	Cwm Ivy	Seine net
June	08/06/2024	10:15	Cwm Ivy	Retrieve fykes
June	09/06/2024	05:50		Leave Swansea
June	09/06/2024	06:50	Kidwelly	Arrive at car park
June	09/06/2024	07:00	Kidwelly	Deploy fyke
June	09/06/2024	ASAP	Ferryside	Deploy fyke
June	09/06/2024	07:40	Ferryside	Seine net
June	09/06/2024	10:40	Ferryside	Retrieve fyke
June	09/06/2024	ASAP	Kidwelly	Retrieve fyke
July	04/07/2024	14:50		Leave Swansea
July	04/07/2024	15:50	Kidwelly	Arrive at car park
July	04/07/2024	16:00	Kidwelly	Deploy fyke
July	04/07/2024	ASAP	Ferryside	Deploy fyke
July	04/07/2024	17:00	Ferryside	Seine net
July	04/07/2024	19:40	Ferryside	Retrieve fyke
July	04/07/2024	ASAP	Kidwelly	Retrieve fyke
July	05/07/2024	15:20		Leave Swansea
July	05/07/2024	16:20	Laugharne	Arrive at car park
July	05/07/2024	16:30	North Laugharne	Deploy fyke
July	05/07/2024	ASAP	South Laugharne	Deploy fyke
July	05/07/2024	18:15	Laugharne	Seine net
July	05/07/2024	20:00	North Laugharne	Retrieve fyke
July	05/07/2024	ASAP	South Laugharne	Retrieve fyke
July	06/07/2024	15:20		Leave Swansea
July	06/07/2024	16:20	Cwm Ivy	Arrive at first gate
July	06/07/2024	16:30	Cwm Ivy	Deploy both fykes
July	06/07/2024	19:10	Cwm Ivy	Seine net
July	06/07/2024	21:50	Cwm Ivy	Retrieve fykes
July	07/07/2024	16:10		Leave Swansea
July	07/07/2024	17:50	Crofty	Arrive at car park
July	07/07/2024	18:00	Crofty	Deploy fyke
July	07/07/2024	ASAP	Pen-clawdd	Deploy fyke
July	07/07/2024	19:50	Crofty playground	Seine net
July	07/07/2024	21:30	Pen-clawdd	Retrieve fyke
July	07/07/2024	ASAP	Crofty	Retrieve fyke
July	09/07/2024	06:10		Leave Swansea
July	09/07/2024	06:55	Llanelli WWT	Arrive at gates

July	09/07/2024	07:10	Llanelli WWT	Deploy fyke
July	09/07/2024	08:00	Llanelli WWT	Seine net
July	09/07/2024	10:40	Llanelli WWT	Retrieve fyke
July	10/07/2024	08:05		Leave Swansea
July	10/07/2024	08:45	Llanelli Beach	Arrive at car park
July	10/07/2024	09:00	Llanelli Beach	Seine net
August	03/08/2024	15:20		Leave Swansea
August	03/08/2024	16:20	Kidwelly	Arrive at car park
August	03/08/2024	16:30	Kidwelly	Deploy fyke
August	03/08/2024	ASAP	Ferryside	Deploy fyke
August	03/08/2024	17:10	Ferryside	Seine net
August	03/08/2024	20:20	Ferryside	Retrieve fyke
August	03/08/2024	ASAP	Kidwelly	Retrieve fyke
August	04/08/2024	15:40		Leave Swansea
August	04/08/2024	16:40	Laugharne	Arrive at car park
August	04/08/2024	16:50	North Laugharne	Deploy fyke
August	04/08/2024	ASAP	South Laugharne	Deploy fyke
August	04/08/2024	18:45	Laugharne	Seine net
August	04/08/2024	21:00	North Laugharne	Retrieve fyke
August	04/08/2024	ASAP	South Laugharne	Retrieve fyke
August	05/08/2024	15:50		Leave Swansea
August	05/08/2024	16:50	Cwm Ivy	Arrive at first gate
August	05/08/2024	17:00	Cwm Ivy	Deploy both fykes
August	05/08/2024	19:30	Cwm Ivy	Seine net
August	05/08/2024	22:20	Cwm Ivy	Retrieve fykes
August	07/08/2024	06:10		Leave Swansea
August	07/08/2024	06:40	Crofty	Arrive at car park
August	07/08/2024	06:50	Crofty	Deploy fyke
August	07/08/2024	ASAP	Pen-clawdd	Deploy fyke
August	07/08/2024	08:30	Crofty playground	Seine net
August	07/08/2024	10:00	Pen-clawdd	Retrieve fyke
August	07/08/2024	ASAP	Crofty	Retrieve fyke
August	08/08/2024	06:50		Leave Swansea
August	08/08/2024	07:30	Llanelli WWT	Arrive at gates
August	08/08/2024	07:40	Llanelli WWT	Deploy fyke
August	08/08/2024	08:45	Llanelli WWT	Seine net
August	08/08/2024	11:00	Llanelli WWT	Retrieve fyke

August	09/08/2024	07:40		Leave Swansea
August	09/08/2024	08:20	Llanelli Beach	Arrive at car park
August	09/08/2024	08:30	Llanelli Beach	Deploy fyke
August	09/08/2024	09:20	Llanelli Beach	Seine net
August	09/08/2024	10:50	Llanelli Beach	Retrieve fyke