Aln Estuary Fish Survey Report (2015 - 2024)

Report prepared by Katy Smart & Vicky Rae

NORTHUMBERLAND INSHORE FISHERIES AND CONSERVATION AUTHORITY
8 Ennerdale Road, Blyth, NE24 4RT
www.nifca.gov.uk

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Summary

The aim of the biannual Aln Estuary fish survey is to understand the fish species present in the estuary and the role it plays as an important spawning and nursery ground for North Sea fish species. The surveys identify the species, collects biometric data and abundances of the fish communities present at specific survey sites, which are then compared to previous years to assess the significance of the site as a nursey and monitor for any temporal changes. Additional data is collected on the physio-chemical properties of the estuary, in the form of temperature and salinity. The fish surveys are based on the Environment Agency Transitional and Coastal Monitoring (TrAC) method. Over nine years 8,279 fish have been identified and recorded, of which 5,115 (62%) biometric measurements have been taken.

Key results for the 2024 survey are:

- Pollock (*Pollachius pollachuis*) was recorded for the first time during the Autumn survey
- Atlantic herring recorded the highest abundance followed by lesser sandeels
- Four European eels were recorded, maintaining a continual record in the Aln Estuary survey.
- The highest number of commercial species were recorded, n = 11
- Shannon Diversity Index scores for species diversity and Evenness Index scores for species composition show a low variation in comparison between all annual surveys (2015 – 2024)
- Comparison of the 2024 fish species and their associated abundances recorded with other annual surveys displayed the highest similarity with the 2017 survey (80%) and the lowest with 2022 (38%)
- Temperature and salinity measurements remained relatively consistent with Spearman's Correlation revealing no significant influence on the species presence or abundance.
- Overall survey results provide evidence that the protected habitat features of the MCZ exhibit a stable secure nursery grounds for the development of important commercial juvenile fish.

Acknowledgments

NIFCA would like to express their sincere appreciation to all the volunteers who have given their time to assist in the collection of data. Without their help, it would not be possible to complete this survey.

Introduction

The Aln Estuary Marine Conservation Zone (MCZ) is the smallest designated MCZ in the UK, covering an area of 38.5 hectares. The site designated in 2013, extends from the upper tidal limit at Lesbury to the estuary mouth adjacent to Alnmouth, on the Northumberland Coast (Figure 1). The estuary harbour is used to anchor small pleasure and fishing boats and is a popular destination for tourists and recreational sea anglers.

The Aln Estuary MCZ is designated for a variety of habitats including intertidal mud, sheltered muddy gravels, coastal saltmarshes and saline reedbeds, as well as estuarine rocky habitats (Net Gain, 2011), which all have the conservation objective to maintain in favourable condition. These habitats can act as spawning and nursery areas for fish species and support migratory and over-wintering birds. Under section 154 of the Marine and Coastal Access Act (MaCAA) NIFCA have a responsibility to manage MCZs and ensure the conservation objectives of MCZs are met and furthered. Given this MCZs estuarine location, the Environment Agency (EA) carry out monitoring for Water Framework Directive (WFD) compliance.

The TrAC fish surveys focus on collecting juvenile abundance data that can be used to determine if the estuary acts as important nursery fish grounds. According to Heupel *et al*. (2007), nursery grounds are identified by: (1) greater site fidelity (2) the area is used frequently every year and (3) higher juvenile abundances are recorded compared to other areas. Another factor to consider is the estuary depth; it is thought that small fish including juveniles are most abundant in shallow areas because these habitats enhance survivorship and growth (Manderson *et al.*, 2004). However, some predators are not limited to deep water by body size or behaviour (Manderson *et al.*, 2004; Linehan *et al.*, 2001).

NIFCA conducted a pilot juvenile/small fish survey at the estuary in May 2012 to gain further knowledge of the estuary (pre-designation) and because of the potential importance of the site for juvenile fish. Since 2015, excluding 2020 (COVID-19 pandemic), NIFCA have carried out biannual surveys (in late Spring and early Autumn) to monitor the fish population dynamics. This report analyses the fish survey data collected in 2024 and applies the findings to earlier surveys identifying any possible trends for this ecologically important habitat.

Methods

Study Site

The study site is located on the Aln Estuary which is located along the Northeast coast of Northumberland (Figure 1). Two types of nets, seine and fyke are deployed to encompass a 24-hour sampling regime across the mouth of the estuary, below the anchorage and at an upstream location. These sites allow for the greatest range of species to be sampled as the salinity and habitat types varies between sites.

Survey Methodology

Two-day surveys for the collection of fish species were conducted on 20th and 21st May and 26th and 27th September 2024 to coincide with the Spring and Autumn migration of juvenile fish species (Ibbotson *et al*., 2013).

For the seine net survey, an estuary seine net 43m in length and 4m in depth (210/12 with 6.5mm and 14mm mesh size), with floats on the head rope and no lead weights on the footrope was deployed from the boat. The first tow line was fastened ashore, and the net set in a wide arc returning to the shore (FAO, 2013). The seine net is then pulled ashore by the survey team (Environment Agency, 2011) ensuring that the ground rope is in permanent contact with the estuary bed to create a barrier to prevent fish from escaping the seine net (FAO, 2013).

For the fyke survey, the two fyke nets consist of interconnecting nets held open by metal rings with a one-way entry to trap fish. They comprise of a 10- & 14-mm mesh size, 100 cm depth x (2 x 5.3m) in length and is connected by a 10-metre centre leader net. The fyke net opening (mouth) is attached to the leader that gathers and directs fish through the mouth and then the interconnecting nets into the fyke's 'cod-end'. The first end of the fyke net was positioned upstream of the site with the net being lowered into the water downstream on an approximate angle of 30º. Once the full net and weights were submerged, the nets were then pulled taught using the buoy rope.

Day One: The two fyke nets are set in the estuary using a small boat at mid-tide (locations were selected based on depth to prevent exposure at low tide) and were left to soak for 24 hours. Seine net surveys were then conducted at the two sites downstream, each location was sampled twice.

Day Two: The fyke nets were recovered at mid tide using the boat and seine netting sampling using the same methodology as the previous day was carried out at the third site further upstream.

For all surveys the species caught were removed from the nets and placed into buckets of oxygenated water (collected at each site). Fish species were identified to species level where possible, using the Environment Agency (2009) manual "Key to the marine and freshwater fishes of Britain and Ireland". For individuals not possible to identify to species level, they were identified to the furthest point possible e.g. Genus level. The first 50 individuals were measured from mouth to tail to the nearest millimetre using a fish measuring board (Figure 2). Once all the fish from the sample had been recorded, all the fish were returned to the estuary. For the seine net sampling, the fish were returned once the second net had been set, to avoid recapture and duplication of the results. Temperature and salinity values were recorded using a thermometer and salinity refractometer at each location at the time of sampling.

The survey has been running from 2012 but usable data for fish abundance and length are only available from 2015 onwards and for abiotic conditions from 2019 onwards and are therefore used for annual comparisons of surveys.

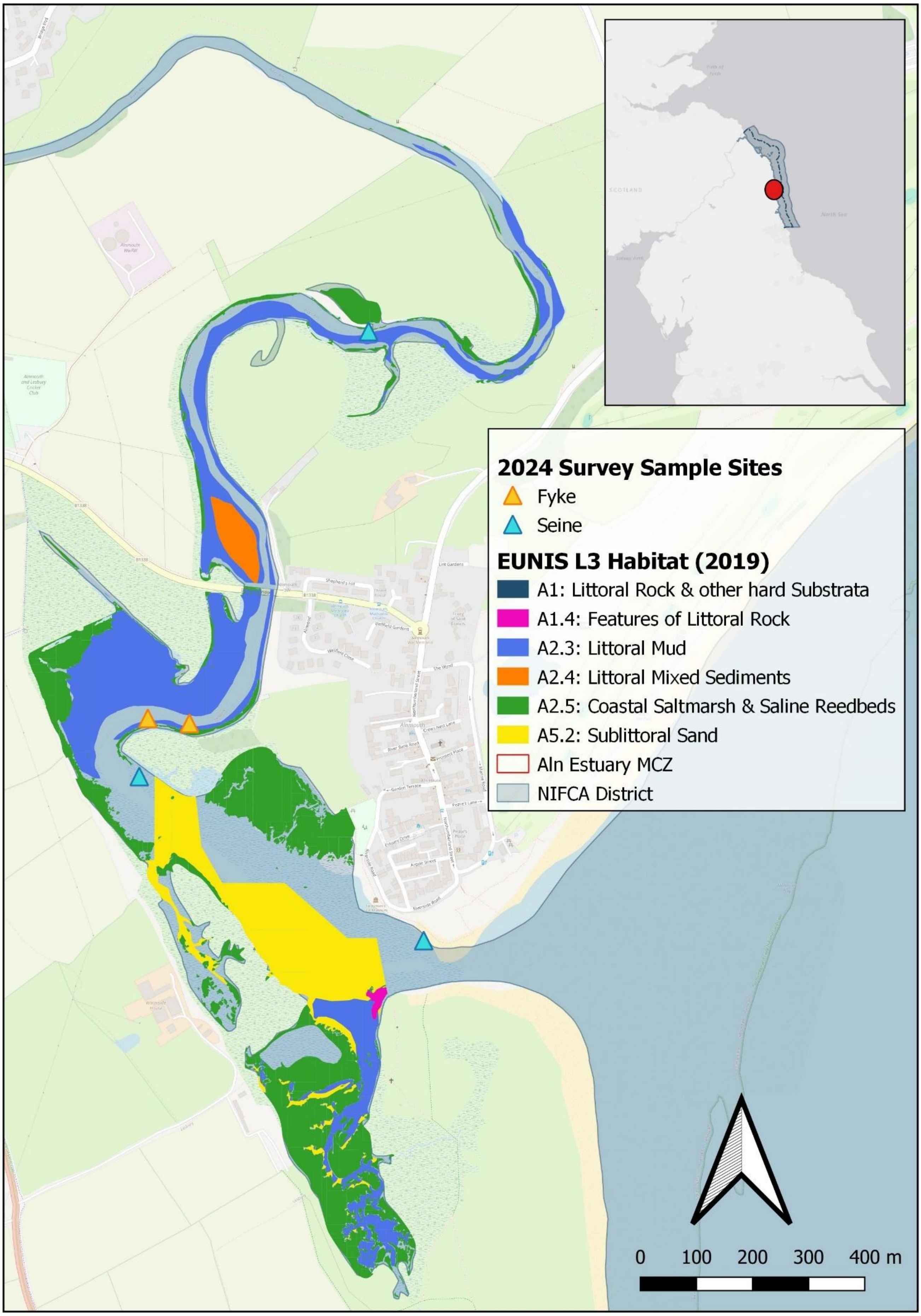


Figure 1 | Main Map: Aln Estuary MCZ EUNIS L3 habitat classification (Pre 2022 Review) & 2024 sample sites. Map Insert: Location of Aln Estuary MCZ in NIFCA's District in the UK.

Figure 2 | Species recorded during the 2024 Aln Estuary fish survey. From top left going clockwise: flounder, trout, European eel and 5-bearded rockling.

Results

Aln Survey (2024)

A total of 796 individuals were collected and 426 individuals measured during the Aln Estuary 2024 surveys. Overall, 15 species were identified to species level with gobies recorded to genus level in Spring and species level for common (*Pomatoschistus microps*) or sand (*Pomatoschistus minutus*) in Autumn. Identification of goby recordings from previous years have alternated between species and genus level, therefore for the purposes of allowing a comparative analysis for this report all goby species have been grouped to genus level.

Species & Sampling Abundances

Fish abundance during 2024 (Figure 3) was dominated by Atlantic herring (*Clupea harengus*) (n= 327, 41%) and lesser sandeel (*Ammodytes tobianus*) (n= 288, 36%), followed by flounder (*Platichthys flesus*) (n= 80, 10%) and Goby spp. (n= 59, 7%). Of these species, 100% of herring and 69% of goby spp. were caught in the Autumn survey and 98% of lesser sandeel and 75% of flounder caught in Spring. Along with herring, the European eel, sprat, cod and viviparous blenny were solely recorded in Autumn, whereas the greater sandeel was only recorded in Spring. Overall, more individuals were recorded during the Autumn survey (n=428, 54%) and in the ‘upper’ sampling site (n=403, 51%) (Figure 4). Commercial species represented 91% of the composition of fish caught from all samples.

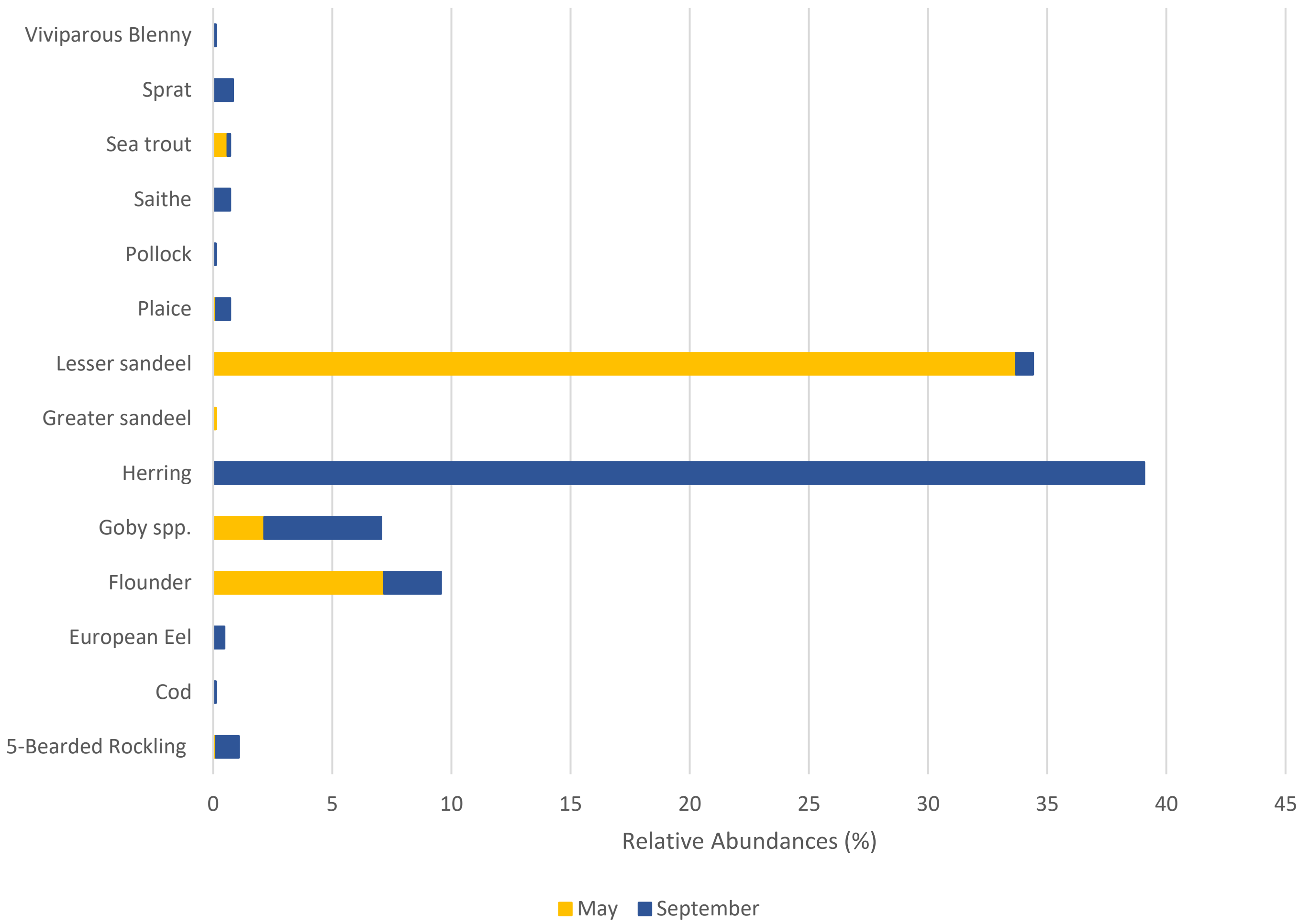


Figure 3 | The relative abundance of the recorded species in the 2024 Aln Estuary surveys.

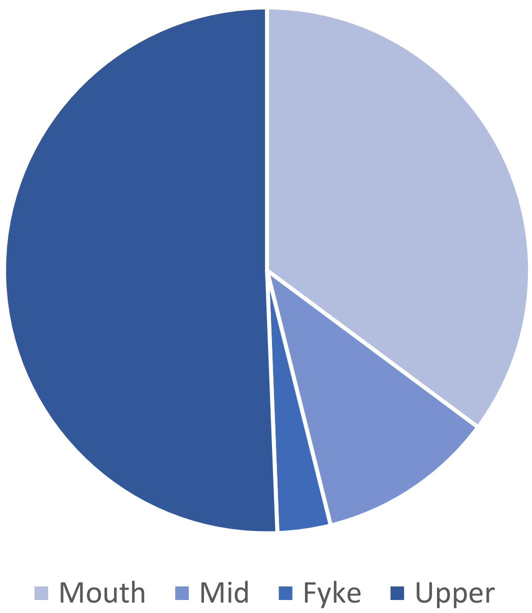


Figure 4 | The spatial abundance of the recorded species in the 2024 Aln Estuary surveys.

Mean Length

The results of individual commercial species are summarised in Table 1, and non-commercial in Table 2. Of all the commercial individuals measured in 2024 (n=356), only 6% (n=21) were recorded over the size of maturity (SOM) in four species: flounder, trout, lesser and greater sandeel. All other individuals measured (n= 335, 94%) were classed juveniles, continuing the trend of all commercial species rolling mean length (2015 – 2024) to be below their SOM, with the exception of trout.

Table 1 | Total catch, mean length, and size at maturity for commercially important species from the 2024 Aln Estuary surveys. Rolling mean refers to the total mean for all individuals measured from 2015 to 2024

Species	Number caught	Mean length (mm)	Rolling mean length (mm)	Size of maturity (mm)	Reference
Atlantic herring (*Clupea harengus*)	327	75	63	175	Ellis *et al.* (2012)
Lesser sandeel (*Ammodytes tobianus*)	288	107	114	130	Froese & Pauly (2024a)
European flounder (*Platichthys flesus*)	80	50	70	110(m) – 170(f)mm	Skerritt (2010)
Atlantic Cod (*Gadus morhua*)	1	147	103	310 - 740	Froese & Pauly (2024b)
Greater sandeel (*Hyperoplus lanceolatus*)	1	184	127	130	Froese & Pauly (2024c)
Pollock (*Pollachius pollachius*)	1	151	151	>580	Cargnelli *et al.* (1999)
Sprat (*Sprattus sprattus*)	7	69	63	101	Froese & Pauly (2024d)
Plaice (*Pleuronectes platessa*)	6	55	64	350	MSEP (2014)
Saithe (*Pollachius virens*)	6	153	153	554	Jennings et al. (1998)
European eel (*Anguilla anguilla*)	4	340	338	450 - 650	Froese & Pauly (2024e)
Sea Trout (*Salmo trutta*)	6	173	187	177 - 228	Taube (1976)
Total	727				

Table 2 | Total catch and mean length for the non-commercially important species during the 2024 Aln Estuary surveys.

Species	Number caught	Mean length (mm)	Rolling mean length (mm)
Goby spp. (Common/ Sand goby (*Pomatoschistus microps/ minutus*)	59	56	52
Viviparous blenny (*Zoarces viviparus*)	1	198	208
Five bearded rockling (*Ciliata mustela*)	9	155	156
Total	69		

Aln Surveys (2015-2024)

Over nine years 18 surveys have been carried out consisting of 108 seines and 36 fykes from the four sites within the Aln Estuary. A total of 8,279 fish have been caught, of which 5,115 (62%) have been measured, and 24 species identified.

Species Diversity

The highest species richness was recorded during 2015 and 2022 (n=15, and goby spp.), of which 10 (63%) were commercially important species. The lowest species richness was recorded in 2018 (n=10, and goby spp.), but still recorded seven commercially important species (64%) in the catch composition. In 2024 the highest number of commercial species were recorded (n=11), which increased from 10 species with Pollock, recorded for the first time since our survey began.

To quantify the Aln Estuary's diversity, (species richness and abundance) and assess for any temporal changes, the Shannon Diversity Index (SDI) and Evenness Index (EI) were calculated for each year (Figure 5). SDI scores revealed low variation of species diversity between survey years, with the highest diversity index score in 2016 (H = 1.696) and the lowest in 2022 (H =1.303). For EI scores are calculated within a range from zero to one, with one representing the maximum evenness. The results present a similar pattern to the SDI, with both the maximum (EH = 0.643, 2016) and minimum (EH = 0.470, 2022) scores present in the same years. These EI scores also highlight the presence of dominant species within our recordings (see Fish Abundance). The consistency of the index scores exhibited across the years are reflective of a relative stable species community presence in the Aln Estuary.

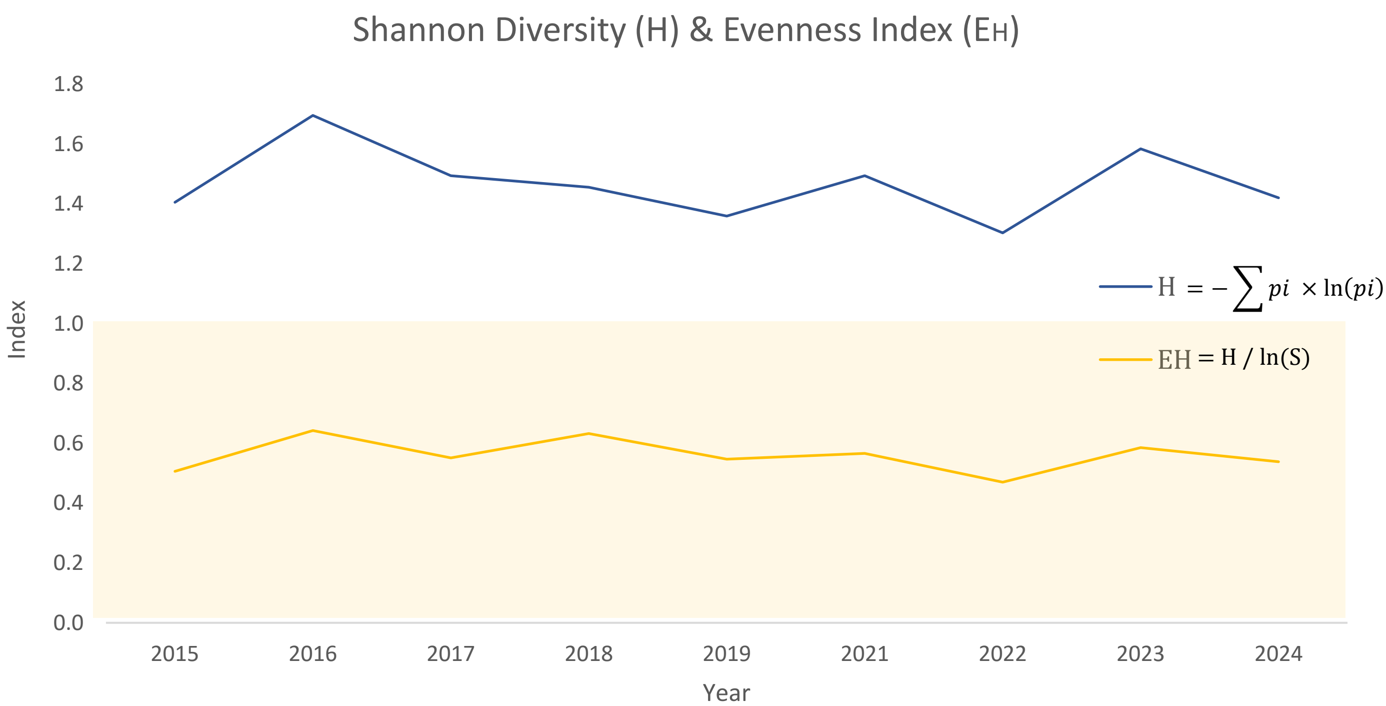
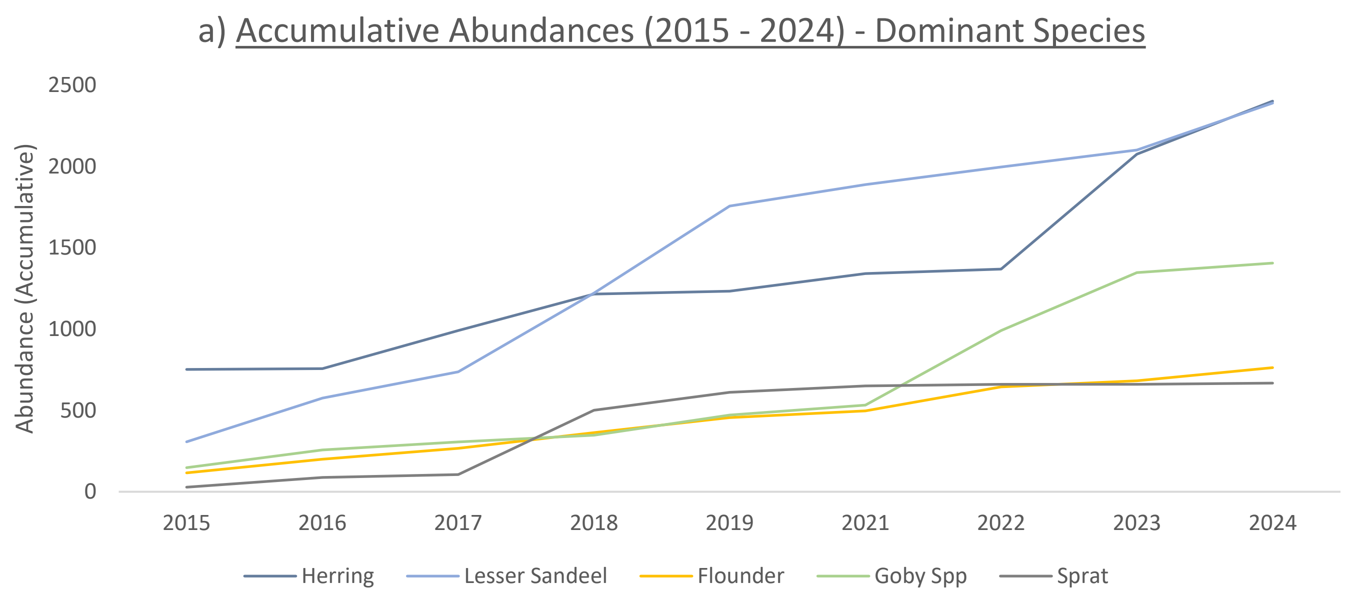


Figure 5 | Annual Shannon Diversity and Evenness Index scores for the Aln Estuary surveys. Pale yellow box represents the EH scale range on the y-axis, 0-1.

Fish Abundance

As highlighted in the EI scores (Figure 5), there is species dominance in the catch composition. These dominant species are the Atlantic herring (n=2,402), lesser sandeel (n=2,390) and goby spp. (n=1,406), accounting for 75% of the total number of individuals recorded (Figure 6a). European flounder, saithe and European eel have also been recorded every year although in lower number (Figure 7). Six species have only been recorded in one year, these are a dab (2015), pipefish (2016), four-bearded rockling (2021), thick- lipped grey mullet (2022), salmon (2023), and pollock (2024).



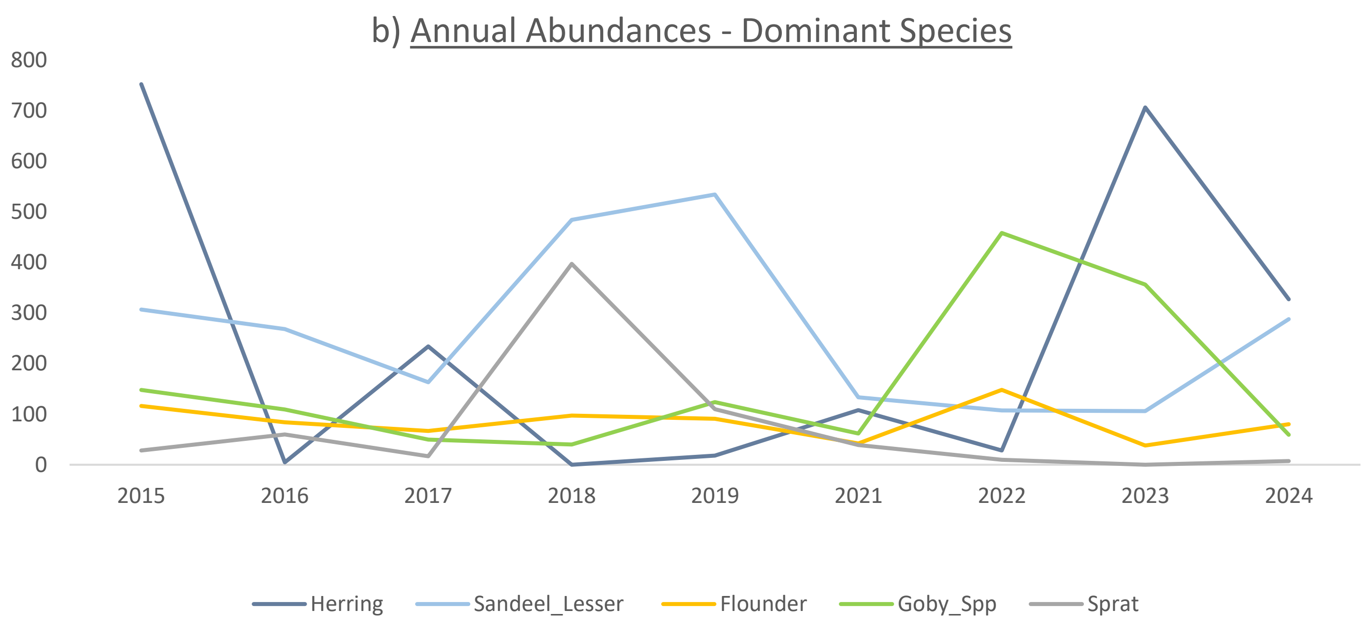
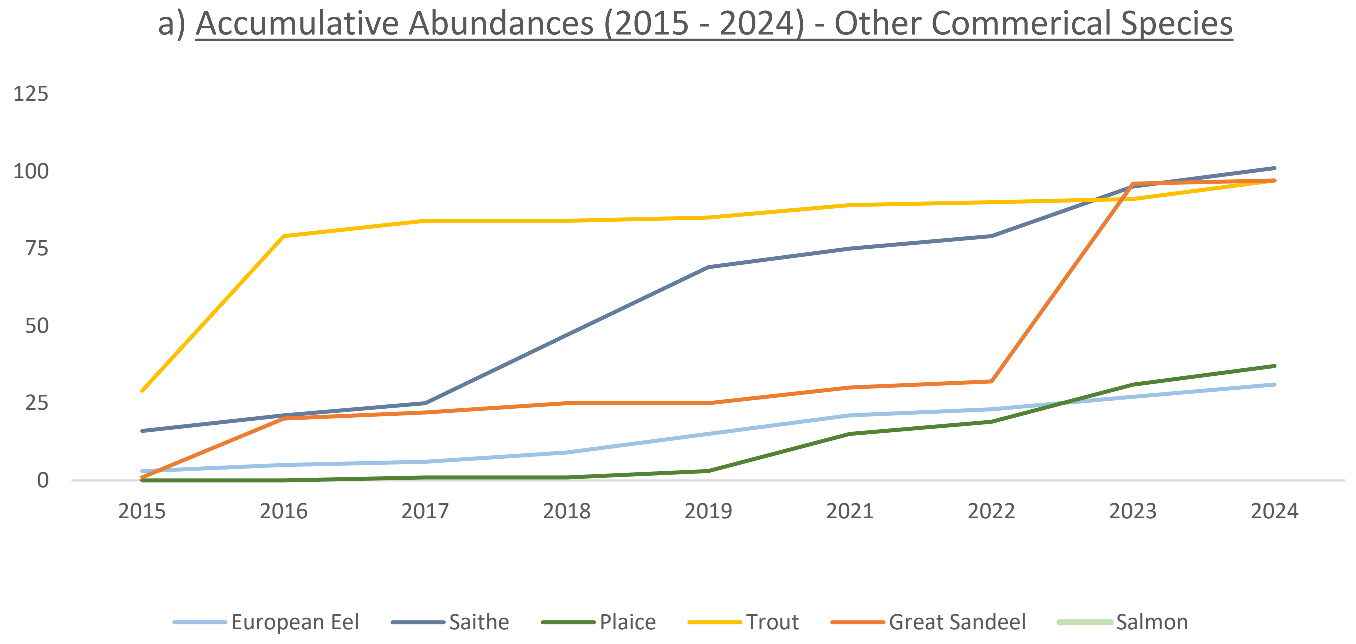


Figure 6 | 2015 – 2024 abundances for most dominant species (a) accumulative and (b) annual



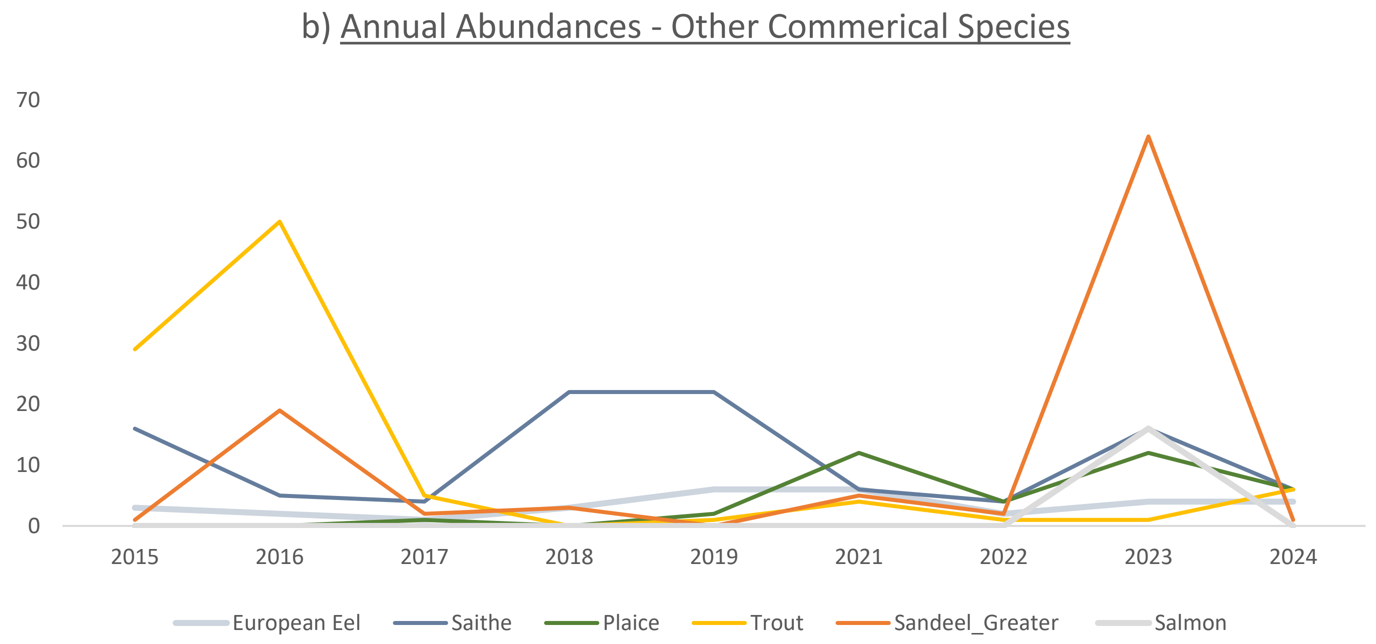


Figure 7 | 2015 – 2024 abundances for other commercially important species (a) accumulative and (b) annual.

Comparison of the inter-annual species presence and absence, and their associated abundances between each survey year was calculated using the Bray Curtis Index (BCI) score (Table 3). The similarity percentages revealed high annual variations; the highest scoring 80% between 2017 and 2024, and the lowest 26% between 2019 and 2023. The overall average similarity score is 50.6%, representing an intermediate variation of species and abundances recorded across all survey years.

Table 3 | Bray- Curtis Index showing the species population similarity for species composition & abundance comparison between each annual survey. Highlighted percentages represent the highest (Green) and lowest (Red) scores.

	2015	2016	2017	2018	2019	2021	2022	2023	2024
2015	-	-	-	-	-	-	-	-	-
2016	53%	-	-	-	-	-	-	-	-
2017	56%	55%	-	-	-	-	-	-	-
2018	54%	50%	57%	-	-	-	-	-	-
2019	51%	71%	45%	70%	-	-	-	-	-
2021	42%	58%	75%	44%	46%	-	-	-	-
2022	39%	48%	41%	28%	43%	44%	-	-	-
2023	70%	28%	43%	31%	26%	36%	38%	-	-
2024	71%	62%	80%	63%	55%	61%	38%	49%	-

Salinity and Temperature

The 2024 salinity and temperature readings taken at each sampling site are presented in Table 4. As expected, the salinity levels are lower at the survey point furthest upstream which is more heavily influenced by the river flow, compared to closest to the mouth of the estuary, which is influenced by the sea. Differences between each of the sites were more pronounced in the Autumn survey, exhibiting a wider range (±29ppts) compared to the Spring measurements (±21ppts). Water temperature was similar across all sample points with only a one- and two-degree difference measured in Spring and Autumn for all sample sites.

Table 4 | Salinity and temperature measurements recorded at each sampling site during the 2024 Aln Estuary surveys.

	Temperature (C°)		Salinity (ppt)	
	Spring	Autumn	Spring	Autumn
Fyke	12	10	24	10
Seine - mouth	12	12	36	39
Seine - mid	13	11	36	36
Seine - upper	12	10	15	10
Mean value	**12.25**	**10.75**	**27.75**	**23.75**
Rolling Mean (2019 – 2024) [1]	**12.00**	**13.03**	**26.90**	**26.55**

Comparing the 2024 averages to the rolling mean (Figure 7), the Autumn readings for both temperature and salinity were lower than the mean values. These lower-than-average results are most likely caused by the local climatic conditions of lower-than-average summer temperatures reported for June, July and August (Met Office 2024) and a prolonged rainfall event across the NE region from 25th to 27th September (Environment Agency 2024).

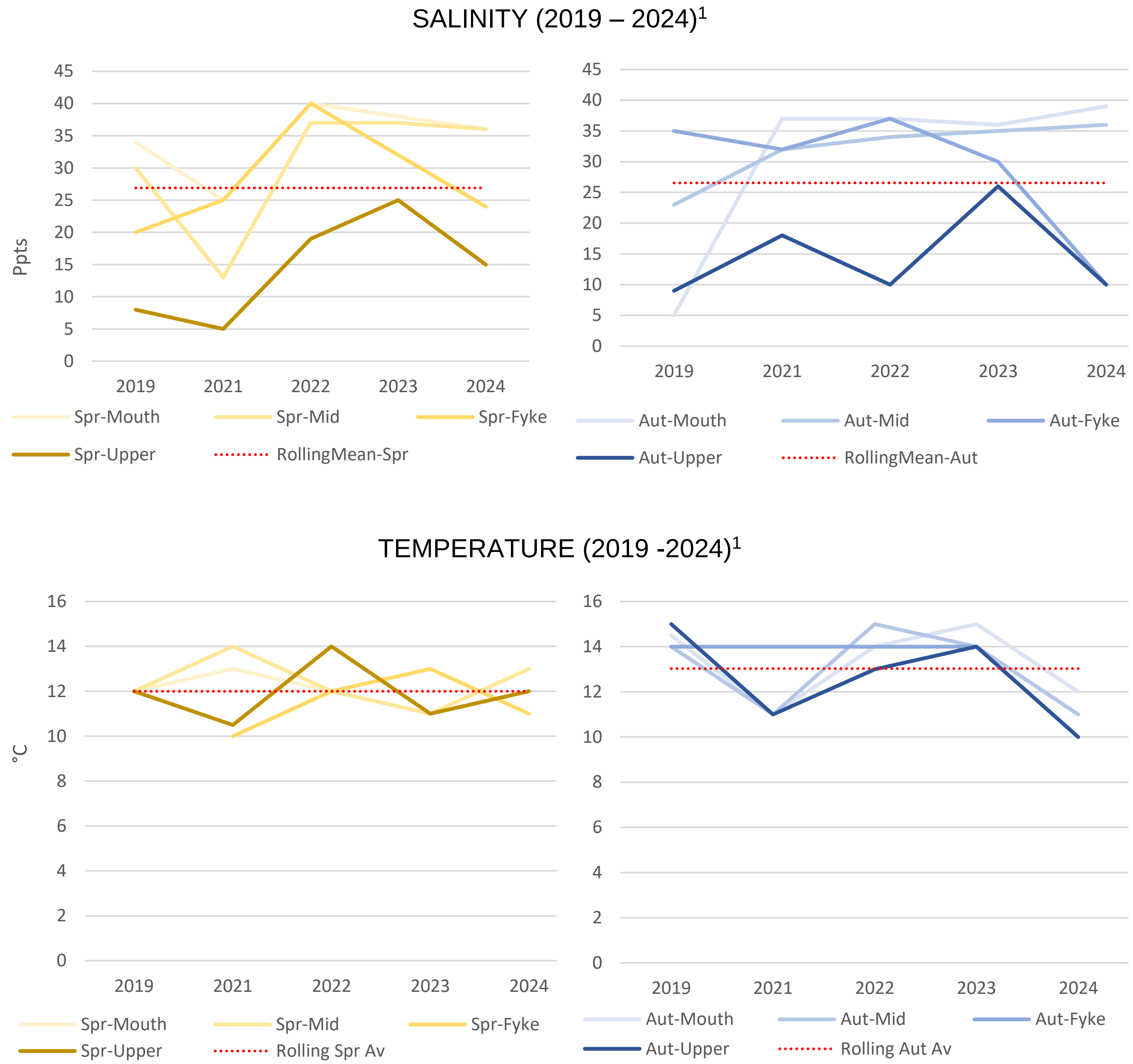


Figure 8 | Salinity & Temperature measurements taken from each sampled site per year for Spring (left) and Autumn (right) surveys.

Estuarine habitats have highly varied physio-chemical environments (Whitfield & Elliott 2005) which influence fish assemblage composition and abundances. Four factors believed to be the primary drivers are salinity, temperature, turbidity (Whitfield 2021) and dissolved oxygen (Marshall & Elliott 1998). Temperature is influential for fish abundances and salinity for species richness (Marshall and Elliott 1998). Using Spearman's correlation neither temperature nor salinity recorded in the Aln Estuary have shown to significantly influence ($p > 0.05$) the fish assemblages (Figure 20). For temperature, there was a very weak positive correlation with abundance ($R= 0.11$) and a very weak negative with species richness ($R= -0.12$). For salinity, both abundance and species richness were weakly correlated ($R=-0.2$, -0.24 respectively).

[1] No 2020 data due to COVID pandemic

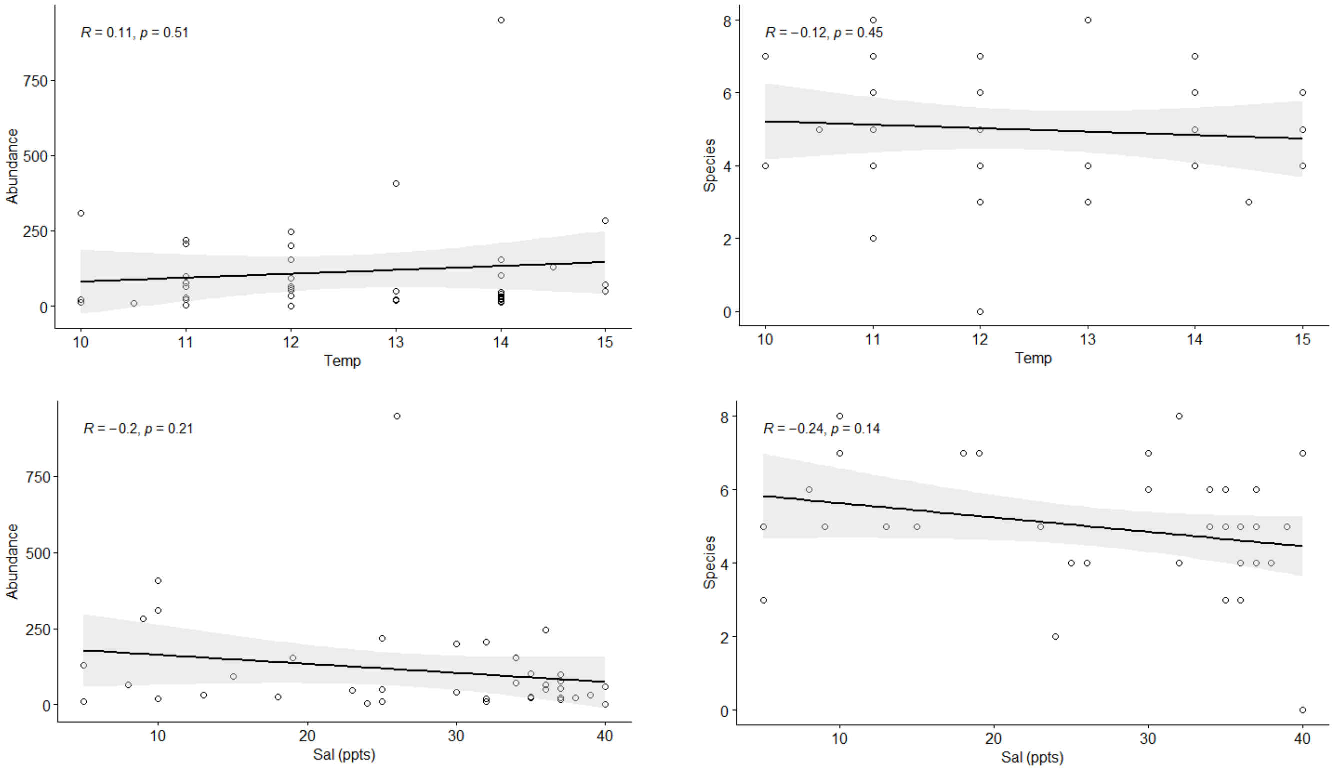


Figure 9 | Spearman correlation plots displaying temperature and salinity associations with abundance and species richness. Scatterplots created in RStudio

Discussion

The most abundant and significant species recorded in the 2024 Aln Estuary surveys, are examined further for their use of its habitats and its relative function and importance to the species.

Atlantic herring (*Clupea harengus*) is a pelagic species with stocks distributed across the northwestern and northeastern Atlantic. Not only an important prey species for cod, whiting, mackerel, sea birds and mammals, this species has significant commercial value (outside the NIFCA district) in the North Sea. Having historically suffered substantial declines from heavy exploitation and recruitment failures (Dickey-Collas *et al.*, 2010) the fishery today is considered sustainably harvested within its managed precautionary stock limits. Despite this the population is viewed as declining within the limits, with research linking recruitment failures to climatic factors, such as SST and lower food availability (Payne *et al.,* 2009).

The North Sea Atlantic herring stock is made up of four components, with one of their spawning grounds located off the coast of Northumberland (Coull *et al.,* 1998). Atlantic herring spawn at different times of the year, and the North Sea stock are primarily Autumn (as opposed to Spring) spawners, taking place between August and October (Henderson 2014). Spawning occurs at a depth of 10 – 80m on coarse sediment habitats and once hatched the larvae drift inshore towards their nursery grounds (thefishsite 2010), remaining for up to two years before migrating offshore (ICESa, no date). At the time of their first Spring, the Autumn spawned herring will reach about 50mm in length (Stevenson & Scott 2005). The average length of the Aln Estuary population in

Spring is 50mm and 67mm in Autumn, indicating the herring juveniles present on our survey originate from the previous Autumn spawning event.

In other studies of estuarine fish communities, juvenile herring have been found in high abundances utilising saltmarsh and muddy sediment habitats for shelter and food availability (Green *et al.,* 2012, Stamp *et al.,* 2022). This habitat preference is also exhibited in the Aln Estuary with 68% of all individuals caught in the upper sampling site (Figure 9), with littoral mud habitat. Research has also revealed juveniles to have a wider salinity tolerance compared to adults, which narrows as they mature and migrate back to the marine environment as adults (Stevenson & Scott 2005). This ontogenetic shift has not been observed in the Aln Estuary's with larger individuals (>100mm) recorded at both the mouth (n=6) and upper (n= 16) sites and is likely to occur at a larger size nearer the onset of maturity. All Aln Estuary individuals have been measured below Atlantic herring SOM (175mm), the largest 130mm (Figure 10). This highlights the continue significance of this site as a nursery ground for supporting recruitment into the North Sea Atlantic herring stocks.

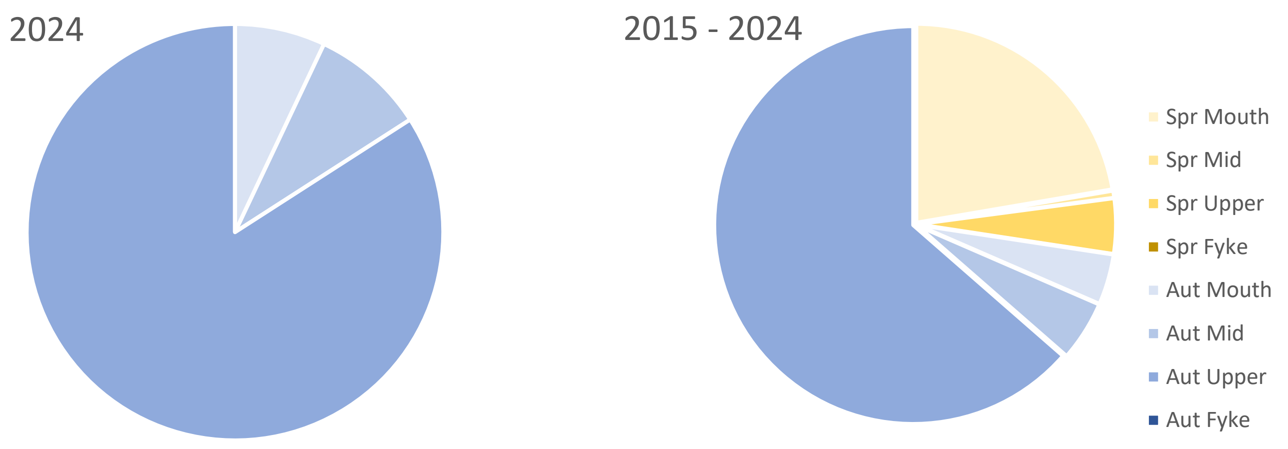


Figure 10 | Distribution & seasonality of Atlantic herring recorded during (left) 2024 and (right) 2015 – 2024

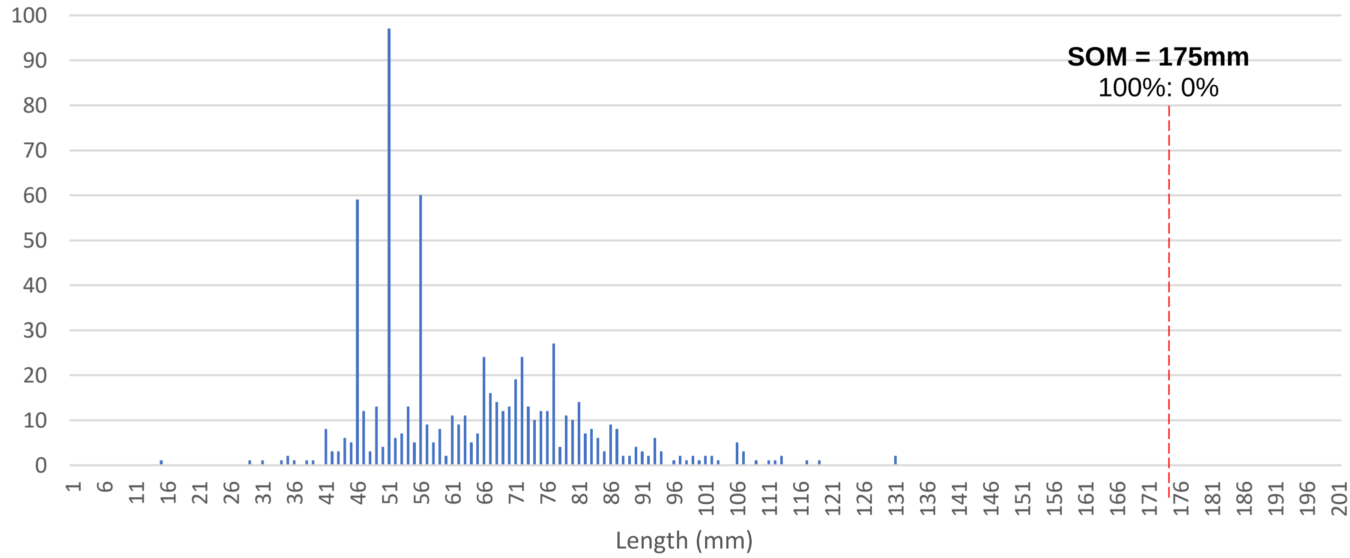


Figure 11 | Size distribution bar graphs for Atlantic herring showing all individuals measured 2015 – 2024. Red dash line represents size of maturity.

There are three types of **sandeel** that are commonly found across the North Sea, *Hyperoplus lanceolatus*, *Ammodytes tobianus* and *Ammodytes marinus*. *A. marinus* is found in deeper waters from 20m to 80m depth and prior to the prohibition on fishing for sandeels within English waters (March 2024), supported a large fishery in the English waters of the North Sea. *H. lanceolatus* (greater sandeel) and *A. tobianus* (lesser sandeel) are found in intertidal waters and have both been recorded within the Aln Estuary. Considered to be the most important forage fish species in the North Sea (Engelhard *et al.,* 2014), it is a high energy mid-trophic species that transfers zooplankton energy further up the chain to piscivorous fish (e.g. mackerel, whiting, Atlantic cod) and protected species of sea birds (MCCIP 2018). Their position within the food web creates high spatial and temporal variability because their abundance can be controlled by food availability and/or intensity of predation (Frederiksen et al., 2007).

In 2024 the **lesser sandeel** was the second most abundant species recorded, with the majority caught during the Spring survey (98%). This strong seasonal trend is mostly influenced by their life history strategy, burying themselves over winter for six to eight months after spawning and in combination with decreasing light, temperature and prey availability. They will then emerge early Spring to feed in the water column (van der Kooij *et al.* 2008, Henriksen *et al.* 2024).

As with the juvenile herring population, the lesser sandeel exhibits a spatial preference in the Aln Estuary (Figure 11) most likely driven by habitat availability (Régnier *et al.*, 2018 & Holland *et al.*, 2005). Favouring sandy sediments (Henriksen *et al.* 2024) sandeels will burrow in the sediment overnight, and swim over it in a head-down posture during the day. This habitat is found at the mid and mouth sampling sites, and where 85% of all individuals have been recorded.

Sandeel SOM is 130mm (Froese & Pauly 2024a), and in 2024 the average length of the individuals measured was 104mm, with a rolling mean (2015 – 2024) of 114mm, both below the SOM. Of the 1,571 individuals measured from all surveys, 1,234 (78%) were below SOM (Figure 12), showing the continued importance of this site as a nursery ground for the lesser sandeels.

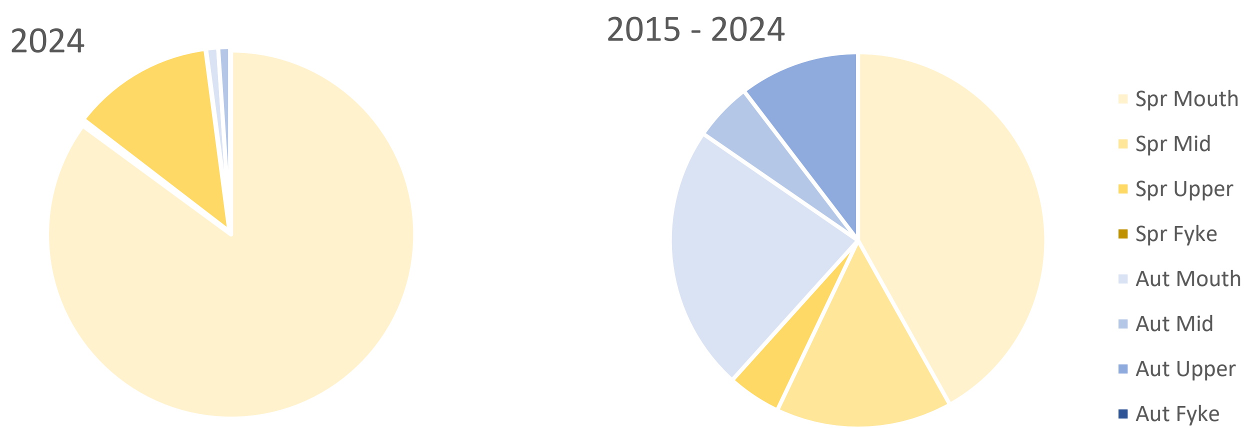


Figure 12 | Distribution & seasonality of lesser sandeel recorded during (left) 2024 and (right) 2015 - 2024

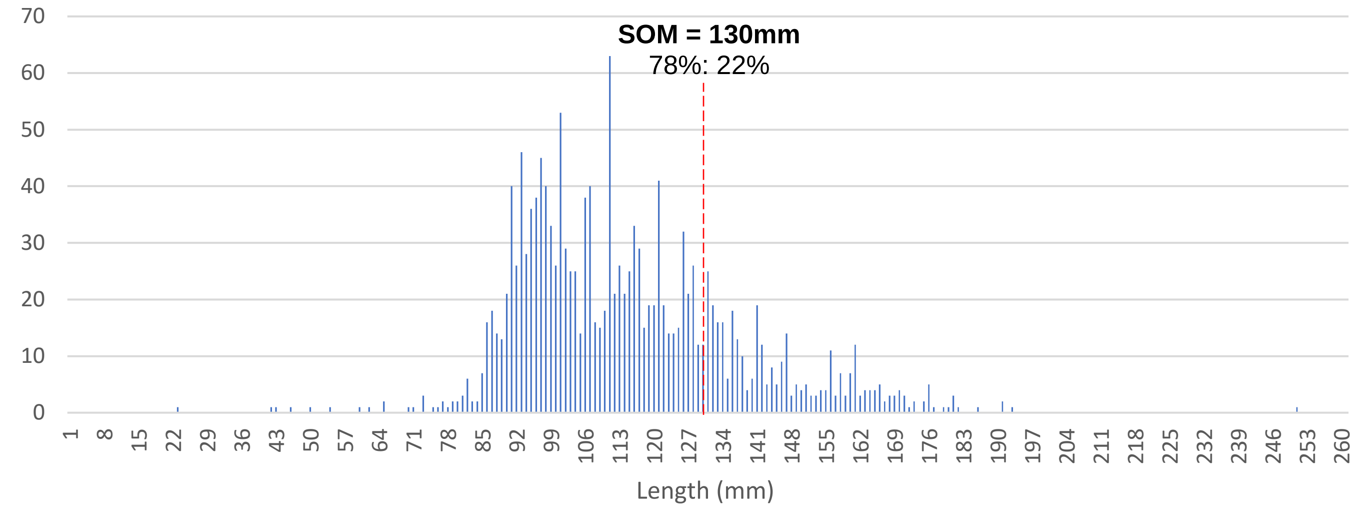


Figure 13 | Size distribution bar graphs for Lesser sandeel showing all individuals measured 2015 – 2024. Red dash line represents size of maturity.

European flounder (*Platichthys flesus*) is an important fish species in estuarine communities and a popular sport fish for angling. It is a bottom dwelling flatfish commonly found within 50m of the shore in estuaries and other low-salinity waters. Although often found in freshwater, adults return to deeper marine water (20-50m) to breed during the spawning period January to June. SOM for males is approximately 110 mm and for females 170 mm; however, these sizes will most likely differ, especially for populations heavily fished (Skerrit, 2010).

Flounders have consistently been observed in every survey and are the only species to have been caught at every sampling site via seine or fyke net (Figure 13). The majority of individuals are caught during the Spring surveys (72%) with an increasing abundance moving upstream. In all surveys the upper site has recorded the lowest average size (47mm), with Spring (av = 38mm) individuals measuring smaller compared to Autumn (av = 78mm), inferring the youngest individuals are located at the upper site in Spring, possibly influenced by habitat and food availability (Summers, 1980) and then migrating downstream as they mature. Although environmental factors affect growth rates, juvenile flounders are on average 80mm by their first year (Skerritt, 2010), indicating that the upper sampling site sizes are a 0-age group, originating from a spawning event at the beginning of the same year. Following this rational it is highly likely that the fish unidentified from the 2023 survey due to their minute size (9mm<>34mm) were a younger cohort of the Flounder 0-age group than previously recorded.

Since 2015, 744 individuals have been recorded, with 90% and 82% measuring below the female and male SOM respectively (Figure 14). This presents the Aln Estuary as an important nursery for Flounders with a predominantly juvenile population and a minor adult resident assemblage.

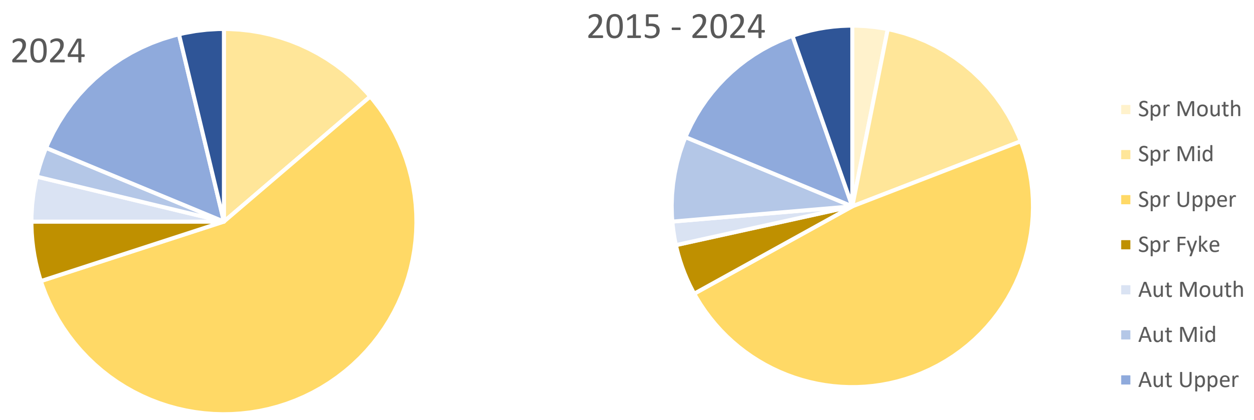


Figure 14 | Distribution & seasonality of European flounder recorded during (left) 2024 and (right) 2015 - 2024

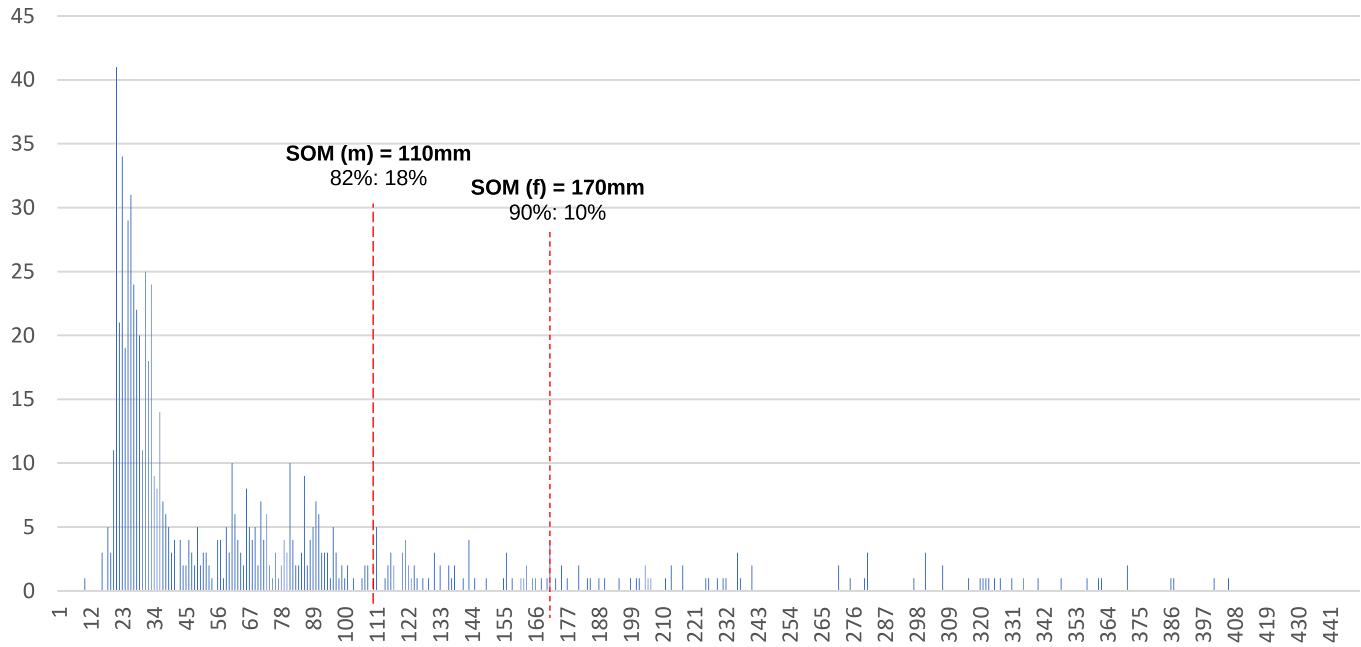


Figure 15 | Size distribution bar graphs for European flounder showing all individuals measured 2015 – 2024. Red dash line represents size of maturity

The **common** (*Pomatoschistus microps*) and the **sand goby** (*Pomatoschistus minutus*) are small species, considered abundant across the coastline of the UK. Both occupy similar ecological niches, found in coastal waters, tide-pools, lagoons, saltmarshes, and estuaries, with a preference for sandy or muddy sediment bottoms. They feed on polychaetes and amphipods, and although not an important commercial species, are a significant prey species to other fish and bird species. They are the third most abundant species recorded and have been observed at every seine sampling location, in the sandy mouth (0.005), mid (29%) and the muddy upper (70%) sites (Figure 15).
Their lifespan is from one to two years, with both species maturing between seven to 12 months, 40mm in length (Riley 2007, Riley 2003). Despite having the same SOM, each species have different growth maximums, for sand gobies <100mm, and common gobies <64mm (Riley 2007, Riley 2003). They also have contrasting spawning periods; sand gobies are summer spawners, June to August and common gobies winter spawners, February to September (Riley 2007, Riley 2003).

Over nine surveys, 1,023 gobies have been measured, ranging 25mm to 83mm in length (Figure 16), with an average of 52mm. Only 7% of all these individuals measured were below 40mm, showing that 93% of our samples consisted of mature individuals and represent a resident assemblage within the Aln Estuary.

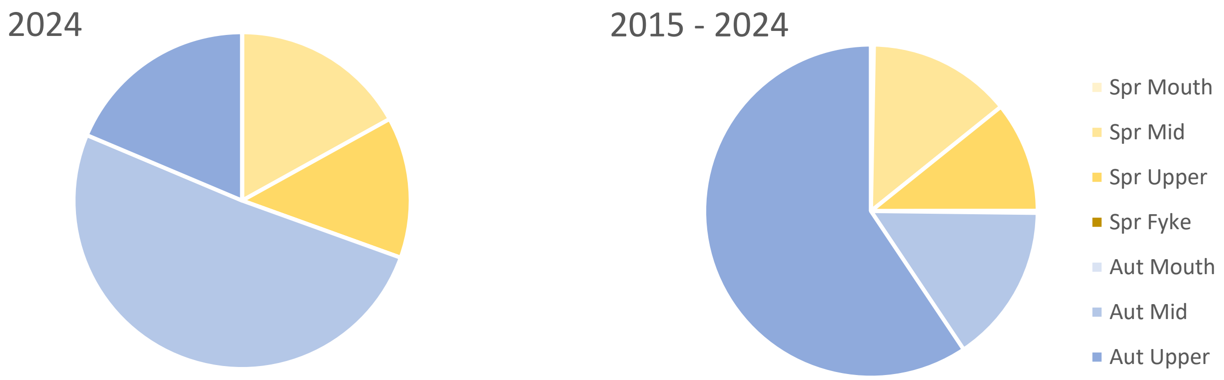


Figure 16 | Distribution & seasonality of goby spp. recorded during (left) 2024 and (right) 2015 - 2024

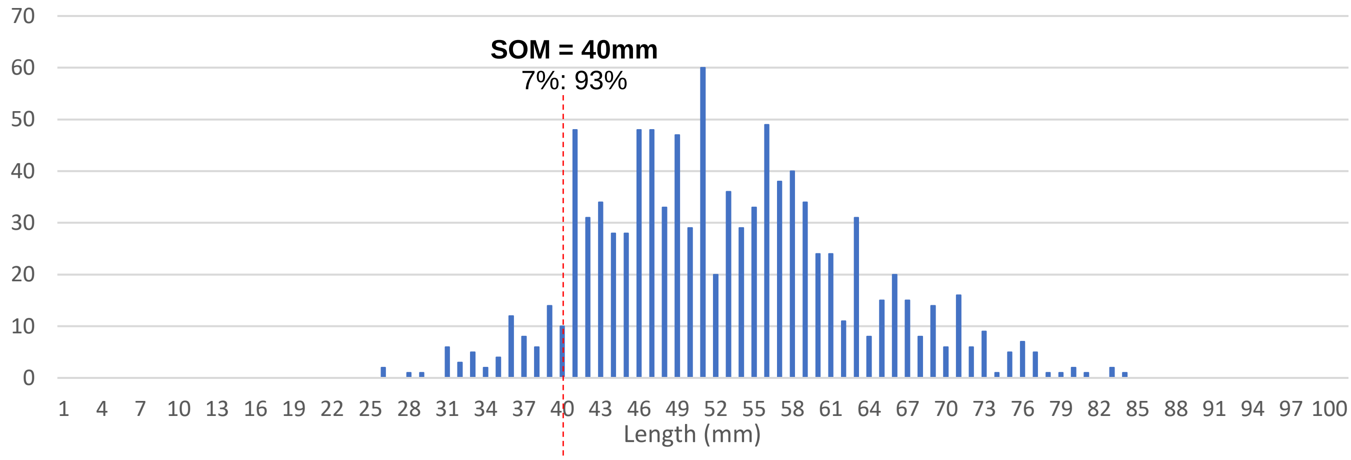


Figure 17 | Size distribution bar graphs for goby spp. showing all individuals measured 2015 – 2024. Red dash line represents size of maturity

Saithe (*Pollachius virens)* is a valued commercial species widely distributed across the north Atlantic. In the northeast Atlantic region, there are four management units, one of which is the North Sea Stock (Myksvoll *et al.* 2021). Exploitation of this species has historically been high, resulting in a decline of North Sea landings during the mid-1970's. Since then, their stock has fluctuated (Saha *et al.* 2015) and today it is managed using the precautionary approach and considered sustainably fished but close to its reference points (ICESb, no date).

Saithe prefer a cold thermal environment (between 4°C - 15°C) and a deepening of their distribution recorded within the North Sea is theorised to be the result of increasing bottom sea temperatures (Dulvy *et al.* 2008). They have a seasonal migration between deeper offshore feeding grounds to inshore shallow spawning areas from January through to the end of March. The larvae initially develop pelagically in the coastal areas, adapting to a demersal lifestyle when reaching three to five cm in length (Reecht *et al.* 2020), and continue their juvenile development in protective coastal habitats (Jakobsen 1985). Research of Saithe development grounds have identified sandeels as an important food source for smaller juveniles about 30cm in length, two years old. Their dependency on this food source lessens as they grow and is believed to contribute to their eventual migration to offshore feeding grounds when they mature (Nedreaas 1987). Individuals will start maturing at three years, but most at four to six years, approximately 46cm – 61cm in length (ICESb no date).

Despite saithe not being recorded as one of the most dominant species in the Aln Estuary surveys (n=101), has been observed every year. In general, this species is caught during the Autumn (n=85, 84%), primarily in the fyke net (n=89, 88%) (Figure 17), with all individuals measuring well below SOM (Figure 18). To date no individuals have been recorded at the upper sampling site, which perhaps is attributed to their preferred food availability. All individuals caught are less than two-year-old juveniles and as research suggests will have a higher reliance for sandeels as a food source, which are primarily found at the mouth and mid sampling sites. Therefore, although not recorded in high numbers, saithe's consistent presence suggests that the Aln Estuary provides a stable safe environment for their development into adulthood.

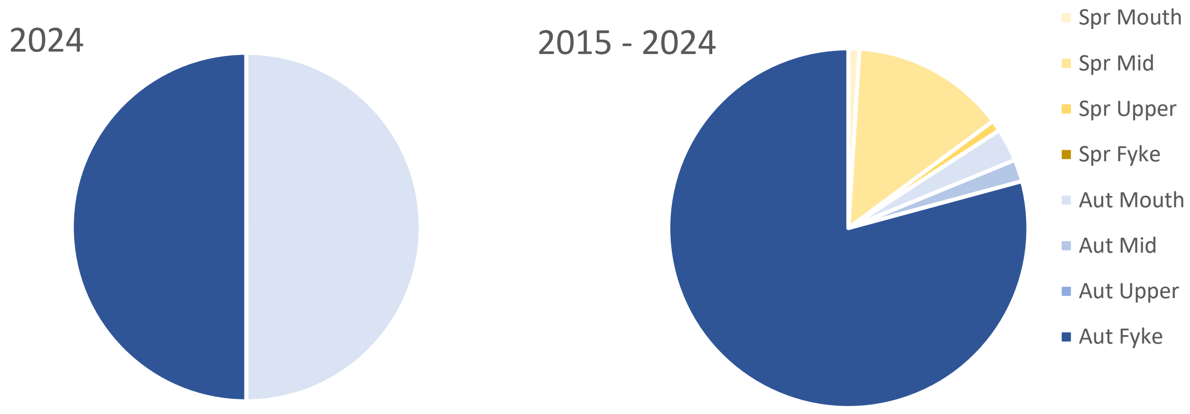


Figure 18 | Distribution & seasonality of saithe recorded during (left) 2024 and (right) 2015 - 2024

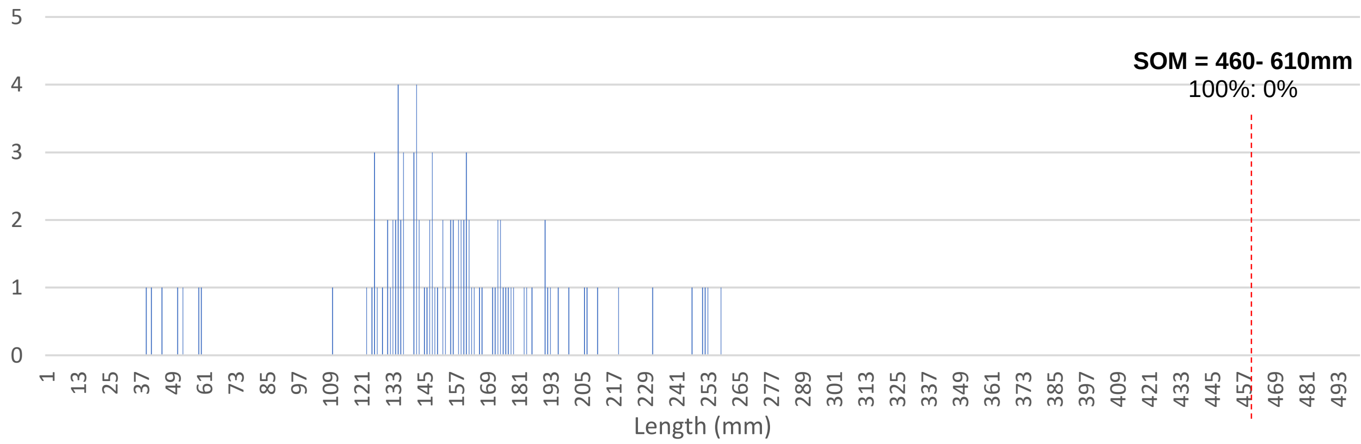


Figure 19 | Size distribution bar graphs for saithe, showing all individuals measured 2015 – 2024. Red dash line represents the beginning range for size of maturity

The **European eel** (*Anguilla anguilla*) was classified as Critically Endangered by the International Union for Conservation of Nature (IUCN) in 2008, after it was determined that recruitment for this species had dramatically declined (~95%) since the 1980s (ICES, 2019). The Eels (England and Wales) Regulation (2009) were implemented to help the recovery of the stock with a permitted fishery, closed seasons, and unobstructed passage of eels in rivers and estuaries. The species has a complex life cycle, which includes a significant period of their adult lives spent in fresh or estuarine waters at the yellow eel life stage (up to 50 years) followed by the final silver eel life stage before spawning migration to the Sargasso Sea in the Atlantic Ocean (Westerberg *et al.,* 2018). Recent tracking research by Wright *et al.,* (2022) recorded slower than previously calculated migration speeds which supports an 18month migration (previously hypothesised to take 6months) which co-insides with the spawning period, beginning December, peaking February/ March and ending in May.

In total, 31 European eels have been caught in the Aln Estuary surveys and although observed in low numbers they have been recorded every year. The greatest number of individuals caught in the annual surveys were six in 2019 and 2021, and the least one in 2017. European eels become inactive during the winter months, initiated by changes in the photoperiod (Rohtla *et al.,* 2022) and/ or changes in temperature (Westerberg & Sjöberg 2014), staying dormant in mud burrows from November/ December until April/ May. All but one individual has been recorded during the Autumn survey, which could be attributed to their dormancy period. Interestingly the only individual recorded during the Spring was also the only eel to be caught at the upper site in the seine net. As a nocturnal species lying inactive during the day under rocks, in weeds or muddy sediments, all others have been recorded from the fyke nets left to soak overnight.

The lengths of each life stage vary significantly throughout their distribution, influenced by latitude and populations density, with their extremes recorded as 54mm to 92mm for glass eels, up to 69mm and 1,330mm for yellow eels and 210mm to 1,480mm for male silver eels and 264mm to 1,010mm for females (Dekker *et al.,* 1998). Eel lengths caught in the Aln Estuary vary from 241mm to 505mm (Figure 19), which classifies these individuals as either in the mid to late yellow eel or at very beginning of the mature silver eel life stage. The continuous presence of European eels throughout the surveys signifies that the Aln Estuary provides essential stable habitat for European eels to develop during the long yellow eel life stage, before maturing and embarking on their long migration back to their breeding grounds.

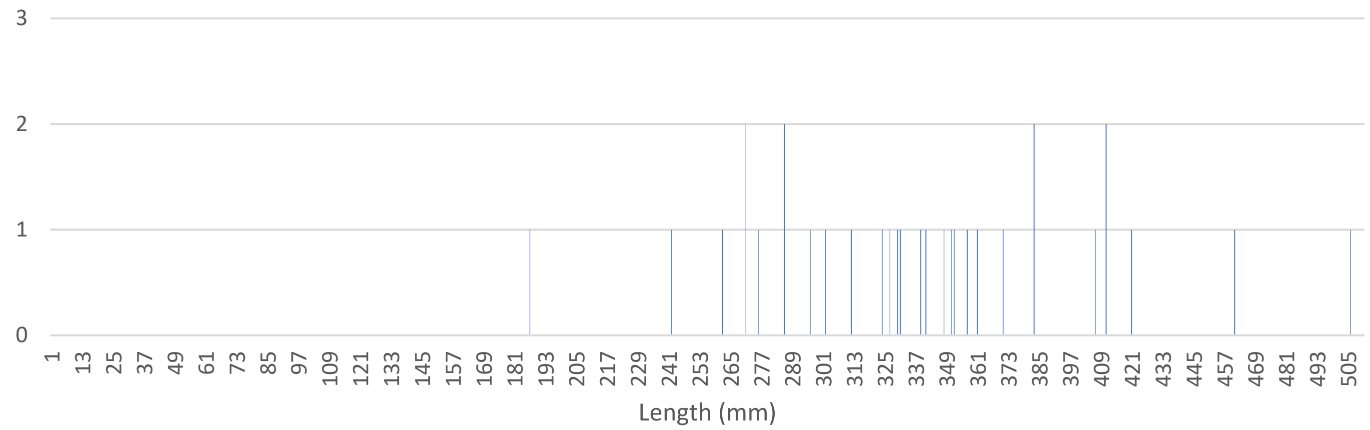


Figure 20 | Size distribution bar graph for European eel showing all individuals measured 2015 – 2024

Aln Survey (2015-2024)

Species Diversity

In total 24 species have been identified in nine years of surveying, pollock recorded for the first time in 2024. Of these 21 have been identified to species level and three to genus level. Despite some gobies being identified as either sand or common, inconsistences with their identification have led to grouping to genus level for an overall analysis. Only one flatfish species was unidentified in 2023 due to its minute size but following previous survey years these were most likely a younger cohort of flounders from a later spawning event that year. Six species and gobies have been recorded and seven species only once.

Annual variation of species diversity is low, with 10 to 15 species recorded each year and similar SDI scores (H = 1.696 – 1.303), indicating a stable fish assemblage within the Aln Estuary. The lowest number of species were recorded in 2018 (n=10), possibly influenced by the 'Beast from the East' storms in February of that year. Only five species were recorded during the 2018 Spring survey and represents the lowest number of species recorded in any seasonal survey. Other variations in species richness could be linked to changes in the physio-chemical environment (Whitfield 2021), discussed further under 'Salinity and Temperature' below. Additionally, species richness will be linked to fish identification experience and staff; with little opportunity to practice using the fish identification skills between surveys it is important that surveyors attend identification refresher courses, and that consistent staff complete the surveys.

Fish Abundance

Despite the Aln Estuary exhibiting a low inter-annual species richness variation, the Bray-Curtis similarity scores reveal a high inter and intra-annual fluctuations (26% – 80%) in their population dynamics. Most intra-annual variations are seasonal, with the Atlantic herring, goby spp. and European eels recorded in higher numbers in Autumn and flounders and lesser sandeels in Spring. Species have also displayed spatial preferences, with 85% of lesser sandeels recorded in the mouth and mid sampling sites and 68% of Atlantic juvenile recorded at the upper sampling site. These spatial differences in species abundance are most likely driven by species habitat preference; lesser sandeels preferring sandy sediment for burrowing and juvenile herring muddy, saltmarsh habitat for shelter and food availability.

Salinity and Temperature

Temperatures in the Aln Estuary exhibit low seasonal and annual variations (10-15°C), which is likely too narrow to influence the fish assemblages present. Salinity is more varied, influenced by river flow, rainfall, air temperature and tidal regime. The Aln Estuary salinity is highest at the mouth, (av. 32.7ppt), slightly below the average salinity of the North Sea, 35 ppt (ICES, 2021) and decreasing upstream (av., mid 31.2ppt and upper 15.25ppt). Lower than average levels were recorded at all sites in the 2021 Spring survey (Figure 8). Although these extremely low salinities did not reveal any changes to species richness, the species abundances are the lowest recorded in Spring (n = 96, 2015 – 2023 average = 376). However, lower than average salinity measurements recorded in other surveys have not shown to have the same impact.

All organisms have unique tolerance and responses to salinity changes and as some species distribution is determined by habitat preference (e.g. lesser sandeel and sandy sediments), more data is required to identify impacts of salinity on the fish site specific assemblages (Marshall & Elliot 1998). To date, data collection for temperature and salinity has been sparse and different equipment has been used for sampling. No trends or influences of these factors have been identified on the fish assemblages and could be due to the Aln Estuary exhibiting a low temporal and spatial range of temperatures, as well as demonstrating salinity levels within tolerance for the species present. It is recommended that temperature and salinity data is continued to be collected to increase the dataset to strengthen the robustness of future correlation assessments.

Conclusions & Recommendations

The results from the 2024 survey continue to evidence the importance of the Aln Estuary MCZ habitats as a nursery ground for fish assemblages, most notably for the commercial species, the lesser sandeel, Atlantic herring, European flounder, saithe and European eel. The mosaic of habitats within the estuary facilitates a diversity of juvenile species to inhabit the small MCZ, with juvenile Atlantic herring and European flounders showing a preference for the saltmarsh, European eels for littoral mud and juvenile lesser sandeels a preference for the sublittoral sand habitats. The continued recording of high abundances, low variation in species diversity, favourable physio-chemical factors and species consistently recorded every year provides evidence that the protected habitats feature of the MCZ provide a stable secure environment for the development of important commercial juvenile fish.

NIFCA surveys will continue to provide a baseline count of juvenile species at the sampling sites, which will be used to monitor the status of the important commercial and recreational juvenile fish species. Additional data for temperature and salinity will also be collected, complimented by reviewing online climate data to improve our understanding for fluctuations in the environmental conditions, in addition to monitor for climate change stressors and subsequent suitability of the habitat for juvenile development. With the success of identifying goby individuals to species level in the Autumn survey, it is recommended that a magnify glass is included in the equipment list to assist in their species identification differentiating by the shape of their gill gaps.

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