Aln Estuary fish survey report (2015 - 2021)

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Summary

The purpose of the biannual Aln Estuary fish survey is to understand the fish species present in the Aln Estuary and the role it plays as an important spawning and nursery ground for North Sea fish species. The surveys help to identify species abundance of fish communities present at each survey site. The fish surveys were based on the Environment Agency Transitional and Coastal Monitoring (TrAC) method. Over a period of 5 years 5,107 fish were identified, and lengths were recorded. The 2021 results were compared with previous years to better understand the demographics of the Aln estuary fish communities and any temporal changes.

Key results:

- In 2021 all species apart from greater sandeel were under their size of maturity indicating the presence of juveniles and therefore the site is likely used as a nursery and/or spawning ground.
- Though fish abundance has varied over time since 2015, there is no overall trend between the years 2015-2021. No surveys were undertaken in 2020 due to the COVID-19 pandemic.
- During the surveys an average of 15 fish species were recorded each year with herring, sprat and sandeel being most abundant.

Introduction

The Aln Estuary Marine Conservation Zone[1] (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. 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 is designated as a protected marine area 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). These habitats can act as spawning and nursery areas for fish species and support migratory and 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. NIFCA work with the EA to carry out this part of estuarine monitoring in this estuary, which is why Transitional and Coastal Monitoring (TrAC) fish surveys have been conducted within the estuary.

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 NIFCA have carried out biannual surveys (in late spring and early autumn) to gain more information of fish population dynamics. There was a break in surveys in 2020 due to the covid-19 pandemic.

This report analyses the fish survey data collected in 2021 and applies the findings to earlier surveys identifying any possible trends for this ecologically important habitat.

Methods

This spring survey was conducted on 24th and 25th May and autumn survey on 30th September and 1st October 2021.

Study site

The study site is located on the Aln Estuary in Northumberland. Three seine nets and two fyke nets were deployed at the mouth of the estuary, below the anchorage and an upstream location; these sites allow for the greatest range of species to be sampled as the salinity varies between sites (Figure 1).

Figure 1. Aln estuary seine and fyke net survey points for 2021.

Survey methodology

Two-day surveys collecting data relating to the fish species present in the Aln Estuary were conducted in May 2021 and late September/early October 2021 to coincide with the spring and autumn migration of juvenile fish species (Ibbotson et al. 2013).

Day One: Two fyke nets set at two locations (Figure 1) 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 2 sites downstream (Figure 1), each location was surveyed twice.

Day Two: The fyke nets were recovered at mid tide using the boat and seine netting using the same methodology as the previous day was carried out at the third site further upstream (Figure 1).

For the seine net part of the 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 was set out in a wide arc returning to the shore (FAO, 2013). The seine net was then pulled ashore by a number of individuals (Environment Agency, 2011) with the ground rope is in permanent contact with therefore allowing the seine net to act as a barrier to prevent fish from escaping (FAO, 2013).

For the fyke net part of the survey, the two fyke nets 10 & 14 mm – 100 cm x (2 x 5.3 mtrs) are a series of interconnecting nets held open by metal rings with one-way entry that acts to trap fish. The fyke net opening (mouth) is attached to a leader that gathers fish to the mouth through the nets into the 'cod-end' of the fyke. The first end of the fyke net was positioned at the upstream end 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. 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 using the Environment Agency 2009 manual "Key to the marine and freshwater fishes of Britain and Ireland" and measured to the nearest millimetre using a fish measuring board (Figure 2).

Figure 2. Species recorded during the 2021 Aln Estuary fish survey

All species caught in both methods described above were collected into buckets. The water in the buckets was oxygenated using an 'air stone pump'. Each individual was identified to species level where possible. For some species it was not possible to identify down to species level, in this case identification was taken to the furthest point possible e.g. Goby spp. The first 50 individuals of each

species are measured from mouth to tail to the nearest millimetre using a fish measuring board (Figure 2). Once an area has been fully sampled all fish are returned to the river. Temperature and salinity values were recorded using a thermometer and salinity refractometer.

Analysis Methodology

The survey has been running from 2012 but usable data is only available from 2015 onwards. For consistency, only data from biannual surveys from 2015 were analysed for annual comparisons of surveys.

Results

Aln Survey (2021)

A total of 415 individuals of 14 species were collected and measured in 2021 fyke and seine surveys from the River Aln Estuary. Overall, the most abundant species recorded were lesser sandeel (*Ammodytes tobianus*) (32% of the total abundance) and least abundant were scorpion fish *(Scorpaenidae sp.),* four-bearded rockling *(Enchelyopus cimbrius)* and three spined stickleback *(Gasterosteus aculeatus)* all being recorded once in 2021.

Fish Abundance

Overall, fish abundance during 2021 demonstrated in Figure 3 was dominated by the lesser sandeel species (133 individuals), followed by Atlantic herring (*Clupea harengus*) (104 individuals). There were also significant numbers of common goby (*Pomatoschistus microps*) (50), flounder (*Platichthys flesus*) (42) and sprat (*Sprattus sprattus*) (39) (Figure 3). When compared to Autumn, in Spring there is mostly lower abundance of all species with the exception of lesser sandeel (*Ammodytes tobianus*) and European eel (*Anguilla anguilla*). There was a lower species diversity earlier on in the year with nine species recorded in spring and 13 in autumn. The importance of each season for each species can be seen in Figure 4. Of the commercial species, herring and plaice are exclusively recorded in Autumn with no records in the Spring of 2021.

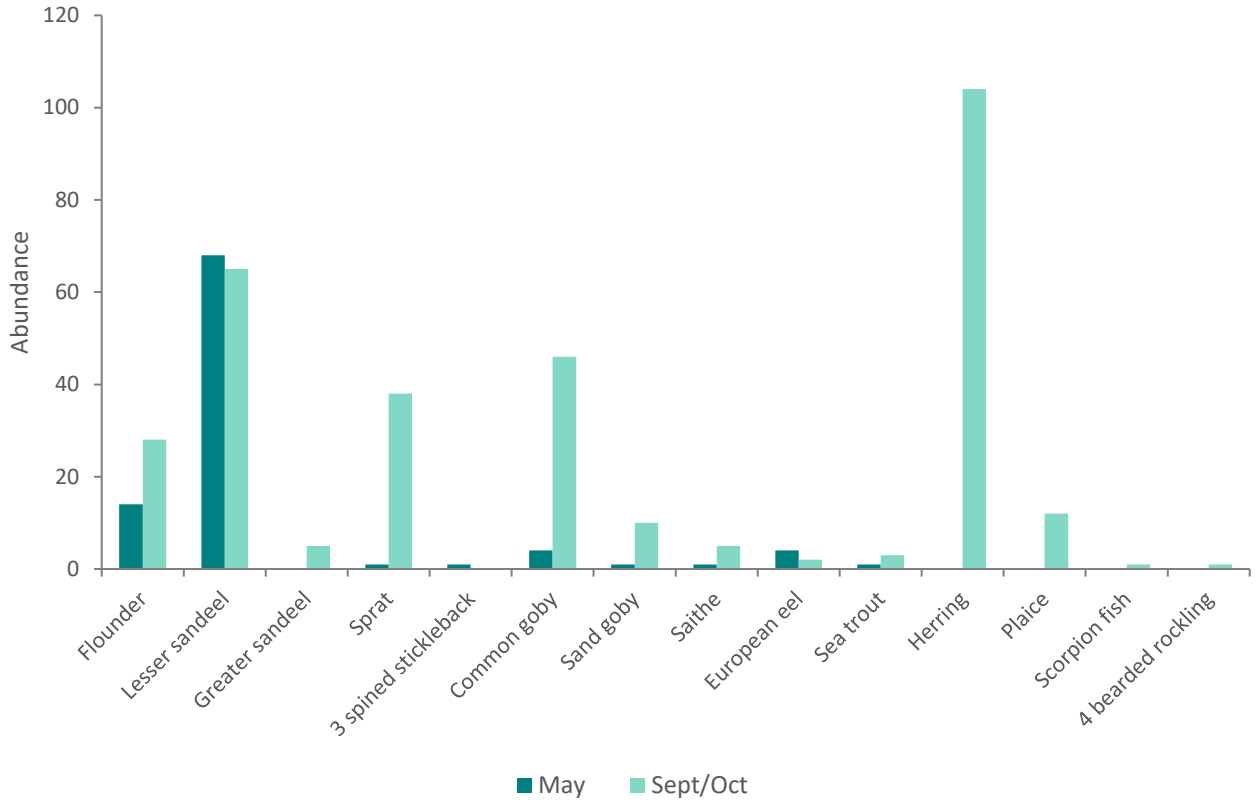


Figure 3. The abundance of the 14 species caught in the 2021 Aln Estuary surveys

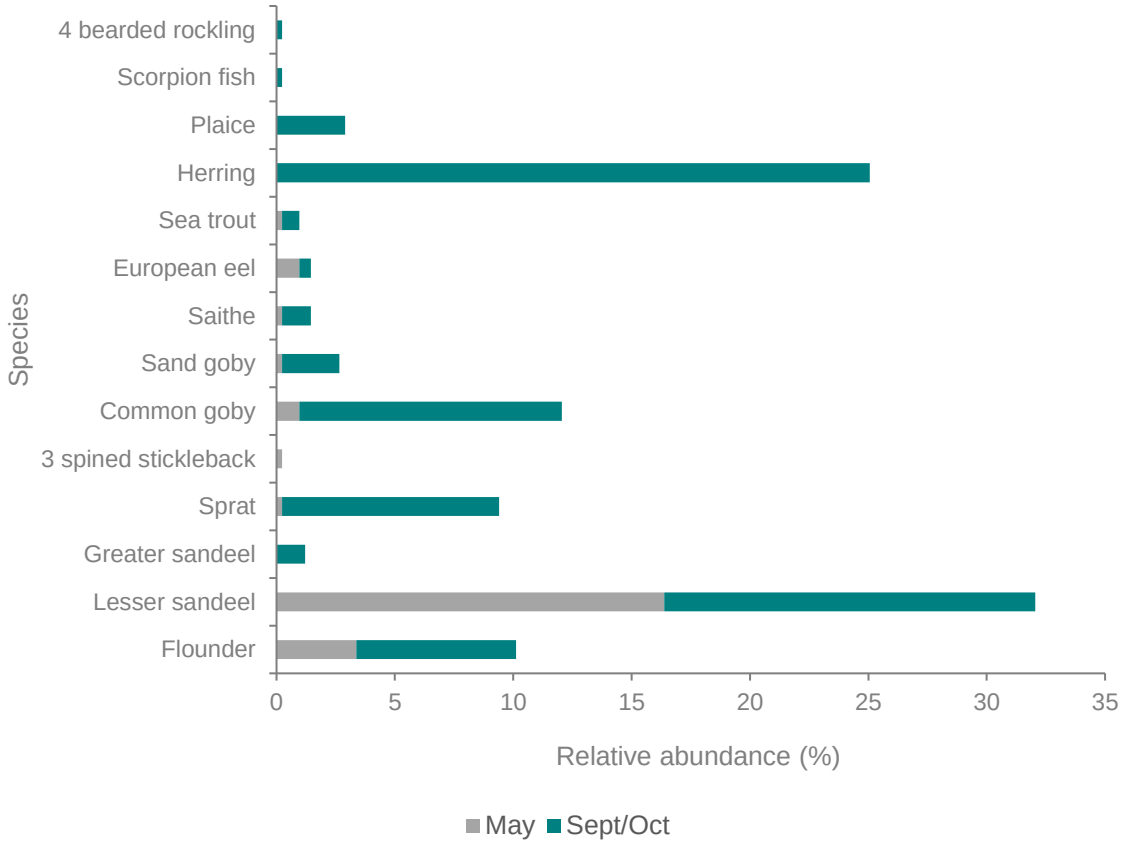


Figure 4. The relative abundance of the 14 species caught in the 2021 Aln Estuary surveys

Mean length

The results of individual commercial species are summarised in Table 1 and non-commercial in Table 2.

Table 1 Total catch, mean length and size at maturity for the commercially important species during the 2021 Aln Estuary surveys.

Species	Number caught	Mean length (mm)	Size of maturity (mm)	Reference
Lesser sandeel (*Ammodytes tobianus*)	133	109	130	Environment Agency (2009)
Atlantic herring (*Clupea harengus*)	104	67	175	Ellis et al. (2012); ICES (2009)
European flounder (*Platichthys flesus*)	42	120	300	MSEP (2014)
Sprat (*Sprattus sprattus*)	39	57	130	Environment Agency (2009)
Plaice (*Pleuronectes platessa*)	12	59	350	MSEP (2014)
European eel (*Anguilla anguilla*)	6	290	Unknown	
Saithe (*Pollachius virens*)	6	139	554	Jennings et al. (1998)
Greater sandeel (*Hyperoplus lanceolatus*)	5	208	130	Ellis et al. (2012); ICES (2009)
Sea trout (*Salmo trutta*)	4	464	XX	XX
Total	351			

Table 2 Total catch and mean length for the non-commercially important species during the 2021 Aln Estuary surveys.

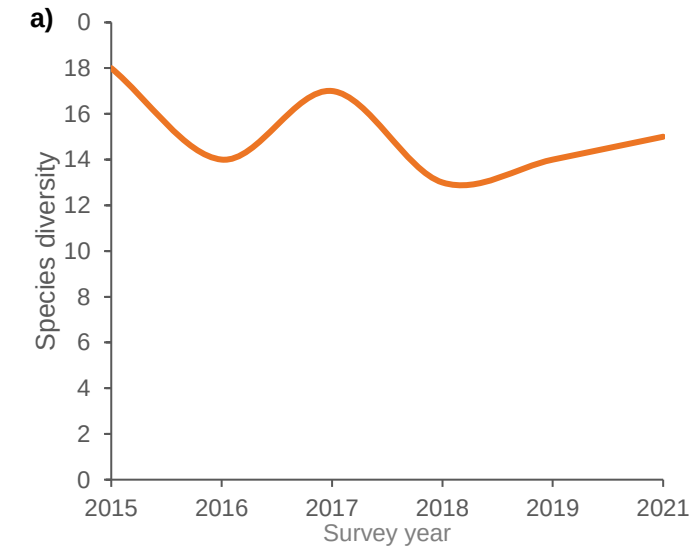
Species	Number caught	Mean length (mm)
Common goby (*Pomatoschistus microps*)	50	61
Sand goby (*Pomatoschistus minutus*)	11	49
Three spined stickleback (*Gasterosteus aculeatus*)	1	58
Scorpion fish (*Scorpaenidae sp.)*	1	82
Four-bearded rockling (*Enchelyopus cimbrius*)	1	202
Total	64	

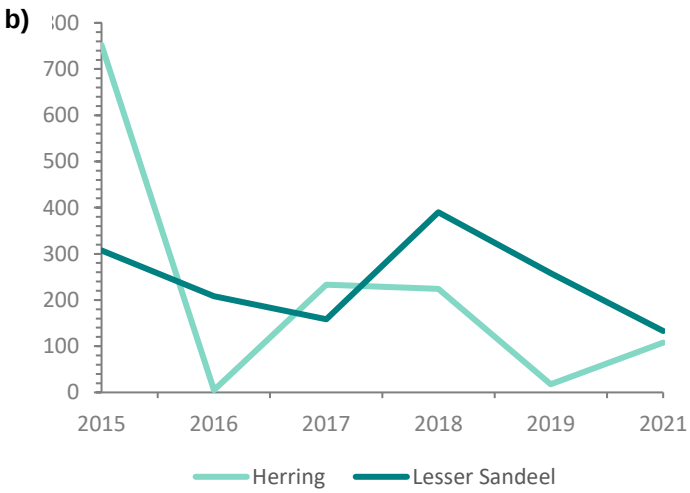
Aln Surveys (2015-2021)

Over 5 years and 10 surveys, 5,107 fish of 22 species have been recorded and measured. The most abundant species across the years reflect similarities to the 2021 fish survey results with the lesser sandeel dominating catch followed by Atlantic herring. Although 2021 was a better year than previous for species diversity it recorded the lowest number of individual fish caught (419) during Aln estuary surveys since 2015.

Species diversity

Species diversity was highest in 2015 with 18 different species recorded; the species diversity peak coincided with the highest total of fish recorded (1,459). The lowest year for species diversity was 2018, and since then annually the species numbers have been steadily increasing (Figure 5a).





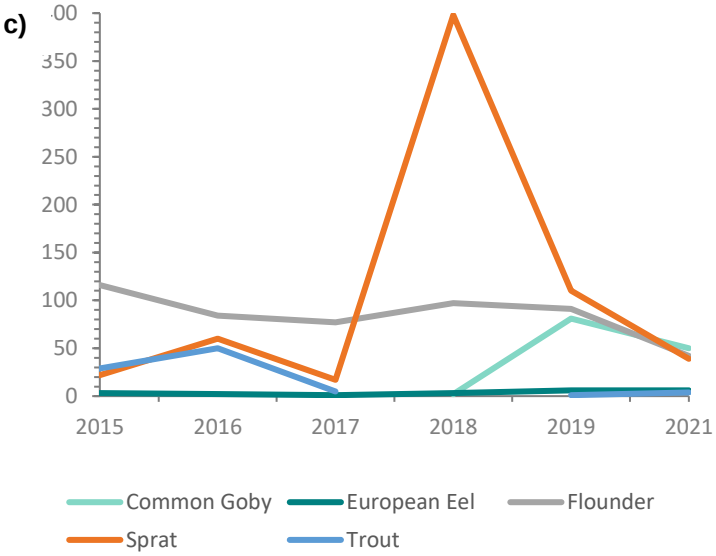


Figure 5. a) The number of total species diversity recorded each year during the Aln estuary surveys, **b)** The total fish abundance of the dominant species, herring and lesser sandeel recorded for the 2015-21 Aln estuary surveys**, c)** Total fish abundance during the biannual Aln Estuary fish surveys for other abundant and commercially important species for the 2015-21 Aln estuary surveys.

Fish Abundance

The differences in notable species abundance from 2015 and onwards can be seen in Figure 5b and 5c. As noted, Atlantic herring and lesser sandeel dominated most years with an exception for

2016 and 2019 where there was a sharp decline in herring recorded, 5 and 18 respectively. Sprat, common and sand goby all increased from 2018 and onwards. Flounder numbers are consistent through the years with a mean value of 85 individuals recorded per year. The least common species across the years included: dab (2015), pipefish (2016) and a 4-bearded rocking (2021), all of which were recorded once.

Salinity and Temperature

As expected, the salinity levels are lower at the survey point furthest upstream compared to close to the mouth of the estuary. This salinity range is greater in Spring compared to Autumn. The average salinity across all points is considerably higher in Autumn (30ppt) compared to Spring (17ppt). Water temperature is fairly consistent across the estuary sample points with a mean of 12°C Spring temperature ranges between 10-14°C and Autumn 11-14°C (Table 3).

Table 3 Salinity and temperature values across the Aln estuary survey points recorded during the 2021 Aln Estuary surveys.

Survey Point	Temperature (C°)		Salinity (ppt)	
	Spring	Autumn	Spring	Autumn
Fyke - lower	10	14	25	32
Seine - mouth	13	11	25	37
Seine - mid	14	11	13	32
Seine - upper	11	11	5	18
Mean value	12	12	**17**	**30**

Discussion

The most abundant and notable species from a commercial and recreational perspective are discussed further using abundance and length data. Factors such as invasive species, predation, water quality changes and nutrient enrichment (from arable run-off), and climate change may contribute to the fish assemblages present in the Aln estuary. However, this is not discussed in detail because the evidence is not available for comparisons.

Aln Survey (2021)

Abundance and Length

Juvenile **lesser sandeel** are common inshore fish in the North Sea, which can be found close to clean, fine sand, in which it burrows, or swims over the sand often in a head-down posture. They are an important mid-trophic-level fish species that transfer zooplankton energy further up the chain to important piscivorous fish species (e.g. mackerel, whiting, Atlantic cod) and protected sea birds (MacDonald et al., 2015). 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). Being of great commercial importance this species is fished offshore (outside the NIFCA district) for non-human consumption (e.g., fishmeal).

Lesser sandeel was the most abundant species recorded at the Aln estuary during 2021 (Figures 3 & 4). Numbers peaked at the mouth of the Aln estuary in spring correlating with the spawning period of January-February and their preference towards cleaner sandy habitats (Régnier *et al*., 2018 & Holland *et al*., 2005). Lower lesser sandeel numbers in the autumn may be related to their winter hibernation period being close.

The mean length for the lesser sandeel was 109 mm (under the age of maturity according to The Environment Agency data and Bergstad, 2001), which could indicate the Aln estuary as an important site for juvenile lesser sandeels.

In 2021, sandeel may have experienced higher predation inshore in early autumn as unusual seabird activity was documented in the region (BirdGuides, 2021). Seabirds such as guillemots and razorbills, for which sandeel are an important prey, were recorded in inshore areas and in estuaries representing an unusual change in these birds behaviour (Anderson *et al* 2014; BirdGuides, 2021; Daunt *et al*. 2008).

Atlantic herring (*Clupea harengus*) is a pelagic species with significant commercial value (outside the NIFCA district) that is widely distributed in the North Sea occupying a similar niche to the lesser sandeel; predating on zooplankton and juvenile fish while being predated by cod, whiting, mackerel, sea birds and marine mammals.

Different stocks of herring spawn at different points of the year. The North Sea stock present in the NIFCA district is dominated by autumn spawners favouring gravel and stone habitats inshore, which could explain the absence of herring in the May survey and the species dominating relative abundance in autumn (Fig.2) (TheFishSite 2010; Dickey-Collas et al., 2010). In addition, the herring were recorded by the mid and low seine rather than the upper seine perhaps because of the species preference to higher salinity concentrations (Marshall & Elliott, 1998).

The mean length of Atlantic herring recorded in the Aln was 67 mm compared to 175 mm size at maturity which indicates the presence of juveniles in the estuary and the value of gravel and stone habitats at the site.

The **common goby** (*Pomatoschistus microps*) is a small goby which is found close inshore in intertidal pools, estuaries, and in slightly brackish drainage ditches and rivers, which could account for the absence in the mouth of the estuary due to the higher salinity found here. It spawns from April to August with the eggs being laid on the hollow surface of an overturned bivalve shell. The spawning period could account for the higher abundance in autumn compared to spring. The common goby was caught in fairly large numbers in the autumn months mostly at the seine mid site. Although it is not a commercially important species it is food source for larger fish and birds. A total of 4 common gobies were caught in spring with sizes ranging from 44 mm to 53 mm and 46 individuals were recorded in autumn with sizes from 38 mm to 80 mm. The largest sand gobies (by length) were recorded in the mid-seine in autumn, illustrating research by Miller (1975) that the species moves downstream with the onset of maturation.

Prior to 2018, NIFCA surveyors were not able to identify Gobies down to species level. Therefore, gobies were recorded as Goby Spp. This makes analysis of individual goby species across survey years difficult.

European flounder (*Platichthys flesus*) is an important fish species in estuarine communities and is a popular sport fish for angling. It is widespread bottom dwelling flatfish most commonly found within 50 m of the shore within estuaries and other low-salinity waters. Although they are often found in freshwater it returns to deeper water (20-50 m) to breed within a spawning period from January to June. Males reach sexual maturity at approximately 110 mm (2-3 years), and females at 170 mm (Summers 1979; Bos 1999; Drevs et al. 1999); however, age at maturity will almost certainly differ between populations, particularly those with decreased numbers or those heavily fished.

Flounder were found at all survey sites by fyke and seine with higher numbers recorded in autumn (28) possibly reflecting the older individuals present in the estuary compared to spring numbers (14). The lower mean length of spring (53 mm) compared to autumn (153 mm) could support this and

demonstrate the estuary is used through different life stages including many spents (post-spawning adults).

Sprat (*Sprattus sprattus*) is an abundant, small pelagic fish present in northern European waters. It is particularly common in inshore coastal waters. In summer, sprats are found in depths of 10-50 m but they reach higher depths in winter. In all seasons they rise towards the surface at night. The sprat spawns in spring and summer, the eggs and early larvae are planktonic, and drift inshore as they develop. Only one was sprat was recorded in spring compared to 38 in autumn. The mean length of individual recorded was of 27 mm indicating that they were juvenile sprat (Table 1).

The **European eel** (*Anguilla anguilla*) was classified as Critically Endangered by the International Union for Conservation of Nature (IUCN) in 2008 but is an important commercial stock that has been declining since the 1980s (ICES, 2019). New eel regulations and seasonal closures were implemented to help the species recover (ICES, 2002).

The international decline of the species may be reflected in the small numbers recorded with three or below individuals recorded for the years 2015-2018 and just six during the 2019 and 2021 Aln surveys (4 in May and 2 in autumn).

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). The lower number of eels in autumn may reflect the early autumn migration of silver eels because the breeding adult eels may have set off on their migratory journey to the Sargasso Sea in the West Atlantic where spawning occurs.

This species was predominantly caught by the fyke survey which could be partly due to the species being nocturnal and the fykes being set over night.

The eels caught in autumn had a mean body length larger than the spring surveys 320 mm and 275 mm respectively, this is most likely due them building up food reserves for migration. According to Dekker et al. (1998) the ranges of silver eel (final life-stage) sizes were described as 21.2–44.4 cm for males and 26.4–101.0 cm for females. Based on length sizes, five of the six European eel caught at the Aln in 2021 were in the silver life stage of their cycle and therefore closer to migrating.

Trout (*Salmo trutta*) an important commercial and recreational species. Four trout were caught over the 2021 surveys with an average length of 566 mm in autumn compared to one smaller individual caught in spring measuring 156 mm. This size difference could reflect different behaviour within the estuary trout population; the smaller trout could be feeding in the estuary while the larger sized individuals may be feeding at sea and returning to the estuary to spawn.

The higher numbers of individual species and fish assemblages in autumn appear to correlate predominantly with spawning events. The lengths of the species indicate that the site is used for species at various life stages of development including the important juvenile stage demonstrating the importance of the site.

Aln Survey (2015-2021)

Species Diversity

Across 5 years, species diversity is fairly consistent remaining between 13-18 species recorded each year (Figure 5a). The lowest number of species recorded in 2018 could be related to the 'Beast from the East' storms in February of that year. Another possible cause of slight differences to species diversity over the years could be linked to salinity. Salinity changes experienced by fauna in estuaries is likely to have an impact on species diversity and distribution: a projected increase in salinity range may reduce species diversity, as found in the Thames Estuary (Attrill, 2002). Therefore, salinity data would be good to investigate for future reports. In addition, species diversity will be linked to fish identification experience and staff; with little opportunity to practice using the fish identification skills it is important to have identification refreshers and consistent staff completing the surveys. Following fish identification training in 2018 the amount of sand and common goby species recorded increased coinciding with the training.

Fish Abundance

The fish abundances were fairly consistent throughout the years and reflected similar findings to 2021. Temperature and salinity fluctuations appear to influence different aspects of the community, with temperature proving to be the best predictor of total abundance, while salinity influenced the species richness (Marshall 1998). Lesser sandeel abundance has followed seasonal patterns with higher abundance in spring compared to autumn. The exception is 2018, which may be linked to the unusually cold weather between Feb-March. Such weather can cause an influx of cold, fresh water into the estuary which may have impacted the species present. Officers carrying out the survey in May 2018 commented on the clarity of water at the site which may suggest a lack of nutrients with implications for higher trophic levels at the time of the survey. Sprat, common and sand goby all increased from 2018 and onwards which is likely to be linked to a fish identification refresher with staff.

Salinity and Temperature

The salinity in the North Sea is about 35 ppt (ICES, 2021). In the Aln estuary, similar to other estuaries, higher salinity levels were recorded nearer the mouth of the estuary. Increased rainfall can decrease salinity in estuaries increasing the freshwater input; higher temperatures can decrease salinity. Global currents and ocean circulation can also impact salinity but to a lesser extent at local

scales. All organisms have unique tolerances and responses to salinity changes as discussed above. As salinity increase it has a negative impact on the amount of dissolved oxygen.

Water temperature is a good indicator of estuary health. Dissolved oxygen is critical for the animals and plants that live in the water. The higher the water temperature the less oxygen can be dissolved. Therefore, seasonal changes are an important indicator of habitat quality for many estuarine species some of which are detailed further below. The temperature can also tell us what species can survive in the environment as all organisms have a finite temperature range.

Conclusions

Overall, the 2021 surveys continue the trends identified in 2015-19 surveys. The surveys provide a valuable snapshot of what species are living in the Aln Estuary. This year the 14 different types of fish included a good mix of freshwater and marine juveniles that use the estuary as a valuable nursery area. 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 commercially and recreationally important juvenile fish species.

The surveys have demonstrated the importance of the Aln estuary for several species (lesser sandeel, herring, flounder, sprat) noted in the report. With higher abundances of more frequently caught species, herring and sprat, in the September/October. The estuary is important for the trout particularly the upper site; the larger trout were probably intercepted while moving to breeding grounds further upstream. Some of the other species caught are probably resident to the area, particularly the sticklebacks, rockling, and scorpion fish.

The mean lengths of species recorded were below size at maturity for most commercially important species (with the exception of greater sandeel). This suggests that a large proportion of the individual recorded were juveniles and the Aln Estuary is an important site for juvenile fish. It must be noted that the size at maturity values in Table 1 are approximations and may not be accurate for species found in the Aln Estuary, however value obtained are significantly higher than mean lengths for all species recorded (except greater sandeel).

Salinity and temperature data availability is sparse since 2015 with annual differences for data recorded and equipment used. Therefore, confidence in the assessment of long-term trends and spatial variability relating to species abundance and diversity is low.

Future work

Potential future work could study the relationship of salinity and temperatures seasonal variability against species diversity and distribution. Running fish identification training a few days before the survey to the whole team every year would improve species recording accuracy.

References

Anderson, Helen & Evans, Peter & Potts, Jacqueline & Harris, Michael & Wanless, Sarah. (2014). The diet of Common Guillemot Uria aalge chicks provides evidence of changing prey communities in the North Sea.

Beck, M.W., Heck, K.L. Jr, Able, K.W., Childers, D.L., Eggleston, D.B., Gillanders, B.M., Halpern, B.S., Hays, C.G., Hoshino, K., Minello, T.J., Orth, R.J., Sheridan, P.F. and Weinstein, M.P. 2003. The role of nearshore ecosystems as fish and shellfish nurseries. Issues in Ecology, 11: 1–12.

Bergstad, Odd & Høines, Åge & Krüger-Johnsen, Maria. (2001). Spawning time, age and size at maturity, and fecundity of sandeel, Ammodytes marinus, in the north-eastern North Sea and in unfished coastal waters off Norway. Aquatic Living Resources. 14. 293-301.

Bird Guides (2021). Investigation launched as auk crisis worsens. Available at: https://www.birdguides.com/news/investigation-launched-as-auk-crisis-worsens/ [Accessed: 08/11/2021].

Bos, A.R., (1999) Tidal transport of flounder larvae (Pleuronectes flesus) in the Elbe River, Germany. Archive of Fish. and Mar. Research. 47; 47-60

Daunt F., Wanless S., Greenstreet S. P. R., Jensen H., Hamer K. C., Harris M. P.. The impact of the sandeel fishery closure on seabird food consumption, distribution, and productivity in the northwestern North Sea, Canadian Journal of Fisheries and Aquatic Sciences, 2008, vol. 65 (pg. 362-381)

De Silva, S.S. Food and feeding habits of the herring *Clupea harengus* and the sprat *C. sprattus* in inshore waters of the west coast of Scotland. *Marine Biology* **20,** 282–290 (1973).

Dekker, W., Van Os, B. and Van Willigen, J. 1998. Minimal and maximal size of eel. Bulletin Francais de laPeche et de la Pisciculture 349: 195–197.

Drevs, T., Kadakas, V., Lang, T., & Mellergaard, S., (1999) Geographical variation in the age/length relationship in Baltic flounder (Platichthys flesus). ICES J. of Mar. Sci. 56; 134-137

Dickey-Collas, Mark & Nash, Richard & Brunel, Thomas & van Damme, Cindy & Marshall, C. & Payne, Mark & Corten, Ad & Geffen, Audrey & Peck, Myron & Hatfield, Emma & Hintzen, Niels & Enberg, Katja & Kell, Laurence & Simmonds, E.. (2010). Lessons learned from stock collapse and recovery of North Sea herring: A review. ICES Journal of Marine Science. 67. 1875-1886.

Environment Agency. (2011). Seine netting for monitoring fish. Operational instruction 145.

FAO (2013). Fishing Gear Types. Beach Seine Nets. Available at: http://www.fao.org/fishery/geartype/202/en [Accessed: 08/11/2021].

Frederiksen, M., Furness, R.W. and Wanless, S., 2007. Regional variation in the role of bottom-up and top-down processes in controlling sandeel abundance in the North Sea. Marine Ecology Progress Series, 337, pp.279-286

Heupel, M.R., Carlson, J.K. and Simpfendorfer, C.A. 2007. Shark nursery areas: concepts, definition, characterization and assumptions. Marine Ecology Progress Series, 337: 287–297.

Holland, Gayle & Greenstreet, Simon & Gibb, Iain & Fraser, Helen & Robertson, Michael. (2005). Identifying sandeel Ammodytes marinus sediment habitat preferences in the marine environment. Marine Ecology-progress Series - MAR ECOL-PROGR SER. 303. 269-282. 10.3354/meps303269

Ibbotson AT, Riley WD, Beaumont WR, Cook AC, Ives MJ, Pinder AC, Scott LJ (2013) The source of autumn and spring downstream migrating juvenile Atlantic salmon in a small lowland river. Ecol Freshw Fish 22:73–81.

ICES, 2002 pg. 98 Report of the EIFAC/ICES Working Group on Eels. ICES Document CM 2003/ACFM: 06

Linehan, J.E., Gregory, R.S., Schneider, D.C., (2001). Predation risk of age-0 cod (Gadus morhua) relative to depth and substrate in coastal waters. Journal of Experimental Marine Biology Ecology: 263: 25– 44.

ICES. 2019. European eel (Anguilla anguilla) throughout its natural range. In Report of the ICES Advisory Committee. ICES Advice 2019, ele.2737.nea. 10.17895/ices.advice.4825.

ICES. 2021. ICES Report on Ocean Climate. Available at: ICES Oceanography - IROC (Accessed 9 May 2022).

Manderson, J.P., Pessutti, J., Hilbert, J.G., Juanes, F. (2004). Shallow water predation risk for a juvenile flatfish (winter flounder; Pseudopleuronectes americanus, Walbaum) in a northwest Atlantic estuary. Journal of Experimental Marine Biology and Ecology: 304: 137-157.

Marshall, S. and Elliott, M., 1998. Environmental influences on the fish assemblage of the Humber estuary, UK. Estuarine, Coastal and Shelf Science, 46(2), pp.175-184.

Miller, P.J., 1975. Age structure and life-span in the common goby, *Pomatoschistus microps*. *Journal of Zoology*, 177, 425-448.

Miller, P.J., 1986. Gobiidae. P. 1019 - 1085. Fishes of the North-eastern Atlantic and Mediterranean. In Whitehead, P.J.P., Bauchot, M.-L., Hureau, J.C., Nielson, J., & Tortonese, E. (eds.), Paris: UNESCO, vol. 3

MSEP (2014). The Marine Socio-Economics Project. Recreational Sea Angling (RSA): Minimum Landing Sizes (MLS). Available at: http://www.mseproject.net/newsletter/doc_download/136-2-minimumlanding-sizes [Assessed: 14/01/2016].

Net Gain. 2011. Final recommendations. Submission to Natural England & JNCC, Version 1.2 Hull: Net Gain.

Régnier, T., Gibb, F. M., and Wright, P. J. (2018). Temperature effects on egg development and larval condition in the lesser sandeel, *Ammodytes marinus*. *J. Sea Res.* 134, 34–41. doi: 10.1016/j.seares.2018.01.003

Summers, R.W., (1980). The diet and feeding behaviour of the flounder Platichthys flesus (L.) in the Ythan estuary, Aberdeenshire, Scotland. Est. Coast. Shelf Sci. 11; 217-232

The Fish Site (2010) Available at: https://thefishsite.com/articles/herring-stocks-in-the-north-sea (Accessed: 11 Nov 2021).

Westerberg H., Miller M.J., Wysujack K., Marohn L., Freese M., Pohlmann J.D., Watanabe S., Tsukamoto K., Hanel R. 2018. Larval abundance across the European eel spawning area: An analysis of recent and historic data. Fish & Fisheries. 19: 890–902.