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(Research Article)

Fish species diversity and evenness in River Tees Estuary, North Yorkshire, United Kingdom

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Abstract

The River Tees estuary is North Yorkshire's largest estuarine habitat, supporting diversified fisher folks compared to others. The current study was conducted to analyse fish diversity status in connection to important hydrological locational along the course of the Tees. Fish samples and water quality characteristics were gathered from eight sampling locations along the River Tees estuary between June 2023 and April 2024. Fish samples were obtained for four (4) sapling sites, between Tees barrage and the Seal-sand in Middlesbrough. Generally, fisher-folks separate non-target fish after catching them in the river. These fisher-folks were asked not to toss non-target species and are convinced that both target and non-target species are important in study. 10% of the total catch is collected during the study period were frozen in an ice box, and to the laboratory for analysis, whilst samples were sorted and identified at the species level. The diversity status of all fisheries data was analysed using PAST (version 2.15) software. Total of 11,935 individuals were enumerated, representing 25 finfish species. *Salmo trutta fario* had the highest number of individuals counted (1289), while *Cyprinus carpio* had the lowest number (228), accounting for 10.8% and 1.91% of total individuals, respectively along the estuarine of River Tees. Conservation efforts must be enforced to discourage over-fishing from the critical habitat.

Keywords: River Tees; Estuary; North Yorkshire; Conservation; Species diversity

1. Introduction

Estuaries, which combine freshwater from rivers and saltwater from the sea, are dynamic habitats with significant environmental variations (Howarth *et al*., 2011). Estuaries are well recognised in many parts of the world as breeding and nursery grounds for a diverse range of fishes. Estuaries are influenced by both marine and fluvial factors, including tides, waves, and saline water influxes. The mixing of seawater and freshwater generates high amounts of nutrients in both the water column and the sediment, making estuaries one of the world's most productive natural ecosystems (Morales-Williams *et al*., 2021).

Although estuaries present a difficult environment due to salinity variations, many species of fish have found them to be highly favourable sites in which to spawn, develop, and thrive during their early lives; productivity is typically high (Donelly *et al*., 2019). Estuarine habitats are among the most prolific on the planet, producing more organic matter per year than comparable-sized sections of forest, grassland, or agricultural land. They also have significant commercial

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value, bringing economic advantages to tourists, fisheries, and recreational activities (Fay *et al*., 2018). Estuaries' protected coastal waters also support essential public infrastructure, such as harbours and ports used for shipping and transit purposes. The estuary's fish population is very dynamic in terms of both time and space. The majority of current are characterized with the flooding of river-eroded or high tides. Estuaries are often characterised based on their geomorphological features or water circulation patterns (Tomczak, 2020). They can go by a variety of names, including bays, harbours, lagoons, inlets, and sounds, albeit some of these water bodies do not technically fulfil the above description of an estuary and may be completely saline (Osborne, 2017). Short-term changes, such as the day/night cycle, can impact the distribution and abundance of communities through behavioural changes, competition for prey, and other factors (Ross, 2021). The diversity of natural populations is influenced by environmental conditions, which always affect competing populations. Estuaries are areas of physical and biological transition between the land, freshwaters, and the sea (Jepessen, 2015).

Estuaries are dynamic habitats that meet freshwater from rivers and saltwater from the sea, resulting in huge variations in environmental conditions (James *et al*., 2016). Estuaries are well recognised in many parts of the world as breeding and nursery grounds for a diverse range of fishes. Although estuaries present a difficult environment due to salinity variations, many species of fish have found them to be highly favourable sites in which to spawn, develop, and thrive during their early lives; productivity is typically high.

Estuarine ecosystems are among the most prolific on the planet, producing more organic matter per year than comparable sized sections of forest, grassland, or agricultural land. They also have significant commercial value, offering economic benefits for tourism, fishing, and leisure activities. Estuaries' protected coastal waters also support essential public infrastructure, such as harbours and ports used for shipping and transit purposes.

Fisheries population in the estuary is very much dynamic in both temporal and spatial spectrum. Besides intra-annual environmental differences, short-term changes, such as those of the day/night cycle, can also affect the interactions between the distribution and abundance of these communities, such as behavioural changes in the period of activity to that of rest (and vice versa), competition for prey etc (García-Alonso *et al,* 2017). The diversity of natural populations is partially dependent on the environmental variables which always affect the competing populations. Estuaries are areas of physical and biological transition between the land, freshwaters, and the sea (Tomczak, 2000). There are about 20 estuaries throughout the coastal zone of United Kingdom as well as some complex estuarine ecosystems in natural and planted mangrove forest dominated areas, but relatively little is known (Wolanski, 2019) about the fisheries diversity and factors controlling their distribution and abundance.

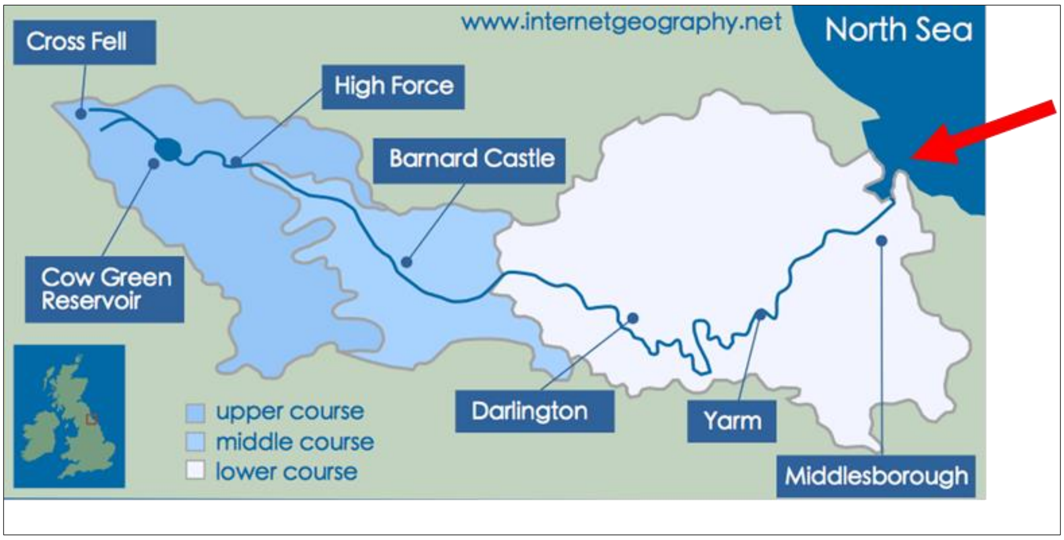
2. The Coastal Zone of United Kingdom

There are about 1130 estuaries throughout the coastal zone of United Kingdom as well as some complex estuarine ecosystems in natural and planted mangrove forest dominated areas, but relatively little is known (Vonlanthen, 2016) about the fisheries diversity and factors controlling their distribution and abundance. Fish and shrimp assemblage structure in the estuaries of United Kingdom has not been well studied; although there are some scattered works on different biological aspects of the coastal estuarine system of United Kingdom (Gerlach, 2018), none of them examined the species assemblage structure (Selman, 2013). River Tees estuary is one of the largest estuarine ecosystems of United Kingdom, much of which is still unknown, unmanaged and unmonitored. Fish are the most significant living species, providing the majority of the country's nutritional protein. This sector also creates jobs, which are vital to the council's economy. However, given the foregoing, the current study attempted to describe the structure of fin fish assemblages in the River Tees estuary in connection to main hydrological and climatic parameters.

3. Methodology

3.1. Description of the Study Area

The River Tees in England rises on the eastern slope of Cross Fell in the North Pennines and runs eastward for 85 miles (137 km) to the North Sea in the northeast of England (Leatherdale, 2018). Its coordinates is 54.7006°N 2.4673°W, with an elevation of 2,474 *ft* (754 m). The river drains 710 square miles (1,800 km^2) and has a number of tributaries including the River Greta, River Lune, River Balder, River Leven and River Skerne, whilst reservoirs were erected in the higher reaches, such as Cow Green (Harrison, 2013). The source of the river at Teeshead just below Cross Fell is at an elevation of about 2,401 feet (732 m). It flows east-north-east through an area of shake holes through Carboniferous Limestone. Below Viewing Hill, it turns south to the Cow Green Reservoir constructed to store water to be released in dry conditions to satisfy the industrial need for water on Teesside.



Source: www.internetgeography.com, 2023

Figure 1 Map showing the course along River Tees and the Estuary mouth (See Red arrow)

3.2. Data Collection

The study area is divided into four sampling stations for measuring hydrological parameters and collecting finfish species. Data were collected from June-September, 2023, straddling the summer season, as it has been reported that larger abundances of fish during these period. Thus, during this study period, 25 samples were obtained from 4 locations using two samplings every month. According to the National Rod Fishing byelaws for England, (2019) Estuarine Set Bag Nets (ESBN) have been banned from fishing in all rivers on the British soil, due to its destructive nature, hence, this was not be utilised by fisherman in the Tees River estuarine. Aside from ESBN, Set Gill Nets and Drift Gill Nets were employed for fishing in this estuary.

Samples of fish obtained were sorted and species-level identified in the lab. Total number of each species were recorded on a monthly and location basis. Species diversity and species richness indices were assessed using Shannon–Wiener diversity, while a post-hoc Tukey HSD test was employed to identify significant differences at the 0.05 level of probability. The diversity status of all fisheries data was analysed using PAST (version 2.15) software.

$$H = \sum_{i=1}^{S} Pi * logPi$$

Where S is the total number of species and P_i is the relative cover of i_{th} species.

Post-Hoc Tukey HSD test $qs \frac{[YA-YB]}{SE}$

4. Results

Table 1 Summation of identified fish species and their respective frequency and percentage

Common names	Scientific name	Feeding	Frequency	Percentage (%)
Salmon	*Salmo salar*	Carnivore	980	8.2
Sea Trout	*Leuciscus cephalus*	Carnivore	834	6.9
Brown Trout	*Salmo trutta fario*	Carnivore	1,289	10.
Grayling	*Thymallus thymallus*	Carnivore	382	3.2
Common Barbel	*Barbus barbus*	Herbivore	462	3.8
Bleak	*Alburnus alburnus*	Herbivore	762	6.3

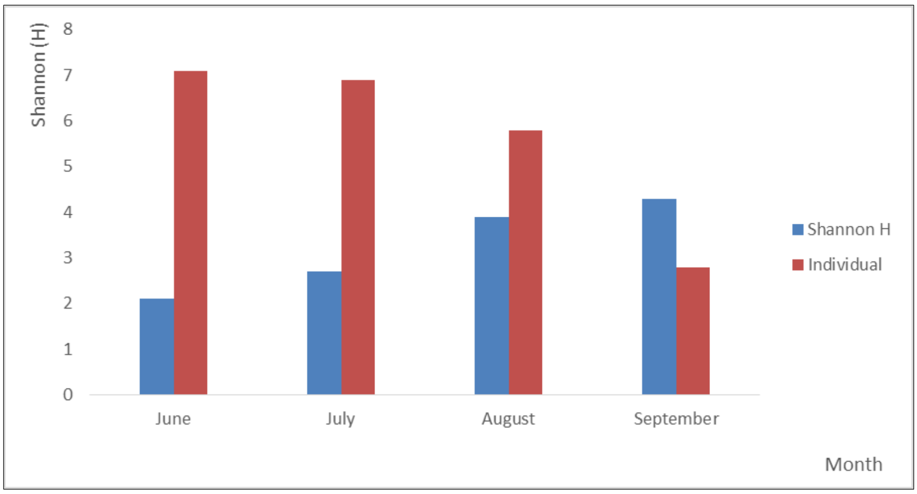
Bream	*Abramis brama*	Carnivore	239	2.0
Bullhead	*Cottus gobio*	Herbivore	272	2.2
Chub	*Leuciscus cephalus*	Herbivore	251	4.0
Common Carp	*Cyprinus carpio*	Herbivore	262	2.2
Dace	*Leuciscus leuciscus*	Herbivore	491	4.1
Eel	*Pungitius pungitius*	Carnivore	871	7.3
Grass Carp	*Ctenopharyngodon idella*	Herbivore	441	3.7
Gudgeon	*Gobio gobio*	Herbivore	283	2.4
Minnow	*Phoxinus phoxinus*	Omnivore	250	2.1
Mirror Carp	*Cyprinus carpio*	Omnivore	228	1.9
Perch	*Leuciscus cephalus*	Herbivore	298	2.5
Pike	*Esox lucius*	Herbivore	289	2.4
Roach	*Leuciscus cephalus*	Herbivore	257	4.1
Rudd	*Scardinius erythrophthalmus*	Herbivore	282	2.7
Ruffe	*Gymnocephalus cernuus*	Herbivore	252	4.0
Stickleback	*Gasterosteus aculeatus*	Herbivore	292	2.4
Tench	*Tinca tinca*	Herbivore	393	3.3
Zander	*Stizostedion lucioperca*	Herbivore	494	4.1
Rainbow Trout	*Oncorhynchus mykiss*	Carnivore	391	3.3
		Total	11,935	100.0

Source, Field Survey, 2023

Table 2 Summation of identified fish species and their respective frequency and percentage

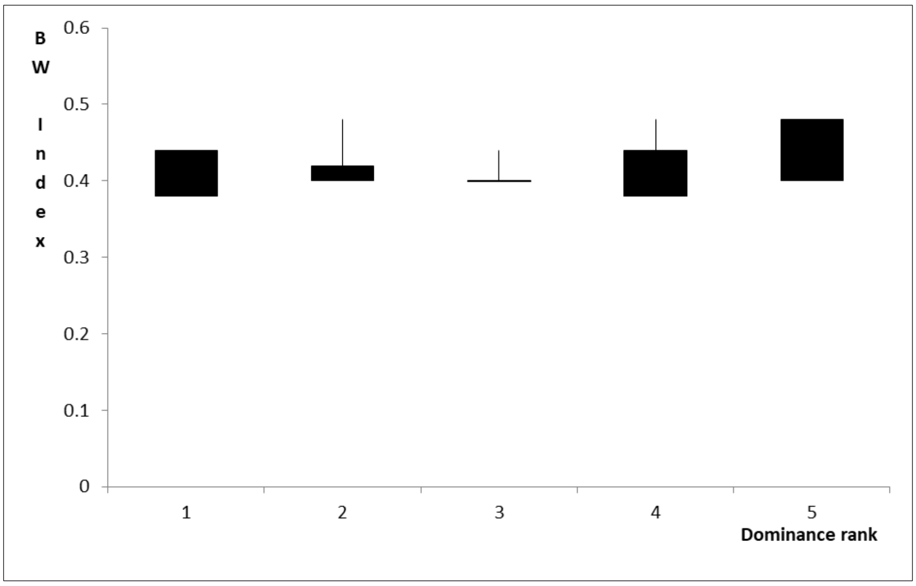
Sampling location Points	Frequency	Percentage (%)
Station 1	4,321	36.2
Station 2	2,917	24.4
Station 3	1,799	15.1
Station 4	2,898	24.3
	11,935	100.0

Source, Field Survey, 2023



Source: www.internetgeography.com, 2023

Figure 2 Map showing the course along River Tees and the Estuary mouth where the study took place



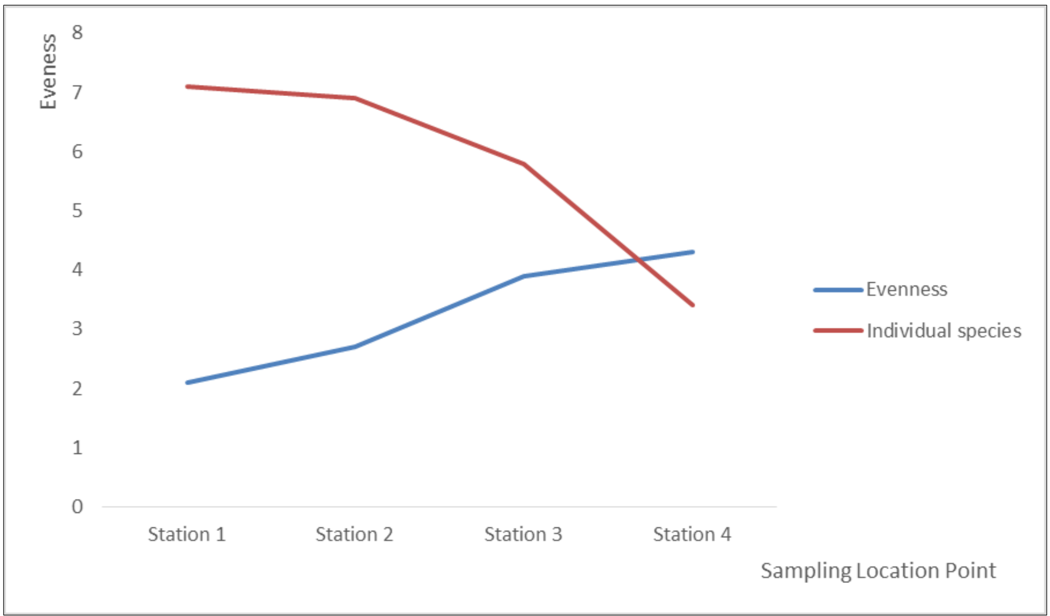
Source: Field Survey 2023

Figure 3 The relationship between mean body weight index (g/cm3) and dominance rank of sampled fishes

Table 3 Summary of the statistics of richness and diversity in relation to the location of sampling

Sampling location Points	*N*	Mean Species *n*=25	Std. Deviation	Variance	Kurtosis	Std. Error of Kurtosis
Station 1	4,321	172.84	11.78	0.29	-1.125	.061
Station 2	2,917	116.68	9.46	0.23	-0.110	.061
Station 3	1,799	71.96	6.31	0.18	-0.098	0.2
Station 4	2,898	115.92	9.37	0.16	-0.061	.061
Total	11,935	447.4	0.51673	0.86		

Source: Field Survey 2013-2015



Source: www.internetgeography.com, 2023

Figure 4 Species evenness along the sampling points

5. Discussion

A total of 11,935 individuals were counted, representing 25 finfish species (Table 2). Among them are *Barbus barbus, Alburnus alburnus, Abramis brama, Cottus gobio Leuciscus cephalus, Cyprinus carpio, Leuciscus Leuciscus, Pungitius Pungitius, Ctenopharyngodon idella, Gobio gobio,* and *Phoxinus Phoxinus*. *Salmo trutta fario* had the most individuals counted (1289), while *Cyprinus carpio* had the fewest (228), accounting for 10.8% and 1.91% of total individuals, respectively (see Table 1). Throughout the study period, Station 1 had the most captured fish (4168), whereas Station 3 had the fewest (1952) (see Table 2). The monthly abundance (individuals) varied significantly across all sampling zones. The biggest number of fish captured was recorded in September. Monthly abundance in each sampling zone declined significantly from June to July before gradually increasing from August to September. The Shannon Wiener diversity index (H′) and species evenness were determined for each month and station (Figures 2 and 3). After polling all 25 samples, the overall H′ value was 2.625. The Shannon diversity index was highest (2.98) at station 1, and lowest (2.01) at station 3. Shannon diversity index values were higher in September (2.90) and lower in July (2.788). There was no significant change in the mean Shannon diversity index between stations and months. The evenness value for the pooled 25 samples was 7.7543. Station 6 had the highest evenness richness value of 6.863, while station 3 had the lowest, 5.519. March had a higher evenness richness rating of 6.750125, while June had a lower value of 6.107875. Similar to the Shannon diversity index, there was no significant difference in mean evenness richness values between stations and months. The Evenness index value for the pooled 25 samples was 0.2542625, with the highest (0.5584) and lowest (0.3558) poled Evenness observed at stations 4 and 1, respectively. The highest evenness value was 0.598 in June, with the lowest value being 0.350938 in April. The mean value of evenness value did not alter significantly across months, however there was a significant variance between stations. The dominance diversity index value for the pooled 25 samples was 0.037465. After aggregating all of the results from each sampling station, the maximum dominance index value (0.073523) was found in station 3 and the lowest value (0.01734) in station 4. The highest monthly dominance diversity index value was 0.104823 in September, while the lowest value was 0.062065 in July. There was a significant variance in the mean value of the dominance diversity index across months and stations. The current study also varies from (Selman et al, 2018) in that the findings showed that estuarine resident species constitute a relatively insignificant part of the fish fauna available in an estuary and are generally all small-sized fish. *Salmo trutta fario*, *Salmo salar,* and *Leuciscus cephalus* are the most abundant species in the estuary, accounting for 10.0%, 8.2%, and 6.9% of total capture, respectively. The highest number of *S. trutta fario* was found at station 1, while the lowest number was found at station 3. During June and September, no new species were discovered, but only a few species were observed in August. A significant increase in numbers was noted from August to September; the last month this species was at its peak, which could be attributed to their breeding season. Another prominent species, *Alburnus alburnus*, was found in abundance at station 2, which is located between the Tees Barrage and the Snout of Tees. This can be linked to the current beneficial environmental conditions. In terms of dominant species, this analysis differs from those of Gerlach (2017) and Osborn (2020). The species abundance found in the Tess River estuary is made up of a small number of species with a significant contribution and a large number of species with minor contributions, which is a frequent feature of estuarine faunal populations (Silva, 2021).

6. Conclusion

River Tees estuary is North Yorkshire's largest estuarine system, having a large body of water that provides ideal conditions for the quantity of fish. The existing environmental circumstances appear to be more beneficial for fisheries distribution at the aforementioned estuary. Also, the enforcement of the National Rod Fishing byelaws for England, (2019), banning the Estuarine Set Bag Nets (ESBN), due to its destructive nature, have contributed significantly to the population growth of the fishes with the study area of River tees estuary. Enormous fresh water discharge from the upper and lower Tees was seen to have provided a large space for the dispersal of numerous species of fishes, with different characteristics.

Recommendation

Overall, the Tees estuary's fish biodiversity requires greater attention. It is critical to note that in order to maintain healthy aquatic ecosystems and sustain human life, the aquatic composition and biodiversity of the River Tees estuary must be protected and preserved in order to ensure sustainability for future generations, who will be able to enjoy the numerous benefits that fish provide in North Yorkshire, United Kingdom.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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