Ecological Health of the Fish Population in Chichester Harbour

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Introduction

The Transitional Fish Classification Index was developed by the Environment Agency to assess the condition of the quality element 'fish' in transitional (between fresh and marine) waters under the Water Framework Directive (2000/60/EC). It is a multi-parameter index which is designed to detect anthropogenic pressures by comparing the water body to a reference condition site with no anthropogenic influence. The Index can reflect morphological change and general physiochemical quality. More information can be found in WFD-UKTAG (2014) and Coates et al (2007).

The Transitional Fish Classification Index was applied to data collected during small fish surveys conducted by Sussex IFCA, in collaboration with Chichester Harbour Conservancy and with the support of a range of partner organisations, between 2010 and 2014. The Transitional Fish Classification Index was designed to compare estuarine systems against an estuarine reference site. Although Chichester Harbour does not have significant fresh water input, it is classified as an estuary by the Joint Nature Conservation Committee (JNCC). The Index has helped to further understand the ecological health of the Harbour.

Methods

Sampling

Data collection was conducted at five sites within Chichester Harbour 2010-2012. This was reduced to three sites in 2013, due to pressure on time and resources. The sites covered the representative habitats of the Harbour; mud, gravel and mixed sediment. At each site, a beam trawl and a seine net were used, as per the Environment Agency operating guidelines. Surveys were conducted twice a year, in the spring (June) and again in the autumn (September). The fish were identified to species level and the first fifty of each species in each sample were measured (nose to tail tip to nearest mm below).

Metrics

Ten metrics were used in the multi-parameter index to assess overall ecological health (Table 1).

Table 1: The ten metrics used in the Transitional Fish Classification Index.

Community characteristic	Metric number	Metric description
Species diversity and composition	1	Species composition
	2	Presence of indicator species
Species abundance	3	Species relative abundance
	4	Number of taxa that make up 90% abundance
Nursery function	5	Number of estuarine resident taxa
	6	Number of estuarine dependant taxa
	7	Functional guild composition
Trophic integrity	8	Number of benthic invertebrate feeding taxa
	9	Number of piscivorous taxa
	10	Feeding guild composition

Each metric had equal weighting and was assessed for each sample and method. The metrics were given a score of 1-5 based on the calculated value of the measured samples (Table 2).

Table 2: The score thresholds for each metric. Each calculated metric value was converted to a score of 1 to 5.

	Score thresholds				
Metric	**1**	**2**	**3**	**4**	**5**
1	<20	20-40	40-60	60-80	>80
2	<1.8	1.8-3.6	3.6-5.4	5.4-7.2	>7.2
3	<20	20-40	40-60	60-80	>80
4	<1.5	1.5-3.0	3.0-4.5	4.5-6.0	>6.0
5	<1.7	1.7-3.3	3.3-5.0	5.0-6.7	>6.7
6	<2.0	2.0-4.1	4.1-6.1	6.1-8.1	>8.1
7	<1.2	1.2-2.4	2.4-3.6	3.6-4.8	>4.8
8	<2.8	2.8-5.7	5.7-8.5	8.5-11.4	>11.4
9	<1.4	1.4-2.8	2.8-4.2	4.2-5.6	>5.6
10	<0.8	0.8-1.6	1.6-2.4	2.4-3.2	>3.2

The score of each metric was summed then converted into the Ecological Quality Ratio. To determine the overall waterbody EQR, the method-specific EQRs were adjusted for sampling effort, by using a weighted average.

Ecological Quality Ratio

This was the measure of similarity of the samples with the reference conditions. A ratio value of 0 would indicate a severe disturbance, little in common with the reference conditions and therefore a bad ecological status. Whereas a ratio value of 1 would indicate no or minor disturbance, complete similarity with the reference site and therefore high ecological status (Table 3).

Table 3: The Ecological Quality Ratio thresholds and corresponding indicative level of disturbance, the similarity to the reference site and the ecological status.

EQR	Disturbance	Similarity to reference conditions	Ecological status
0.81 - 1.00	No or very little	Very similar	High
0.58 – 0.80	Slight	Quite similar	Good
0.40 – 0.57	Moderate	Similar	Moderate
0.20 – 0.39	Major	A bit similar	Poor
0.00 – 0.19	Severe	Not similar	Bad

Results

The Ecological Quality Ratio, corrected for sampling effort, was calculated for each year 2010 to 2014 (Figure 1). The EQR ranged from 0.74 (2012) to 0.85 (2010). The average EQR was 0.78 (standard deviation 0.038) which was a 'good' ecological status.

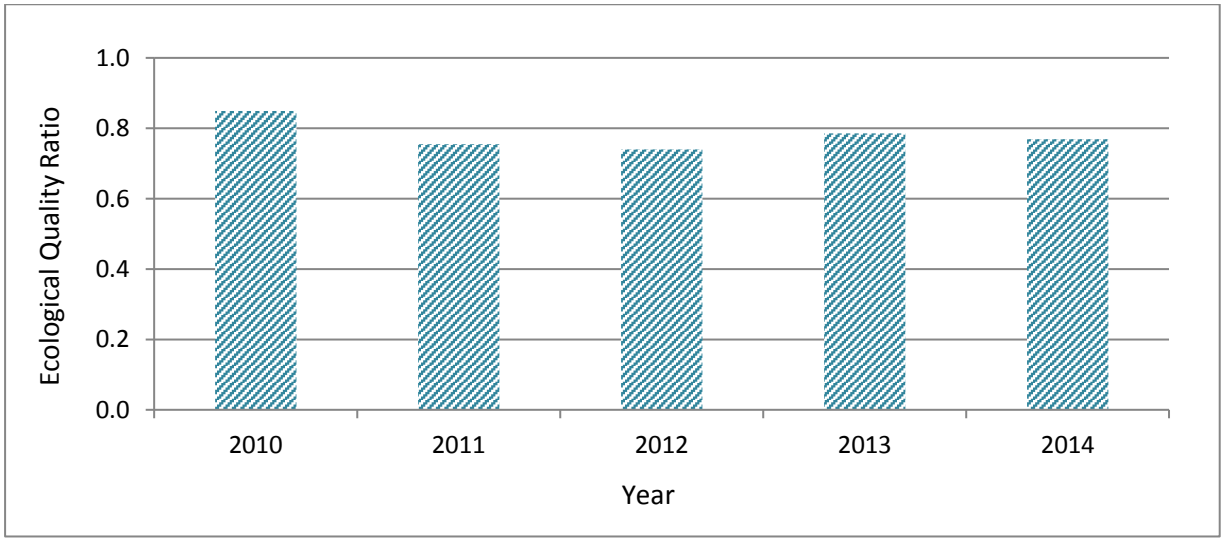

Figure 1: The annual weighted average Ecological Quality Ratio for the years 2010 to 2014.

The EQR for trawling was consistently lower than for seine netting. The average EQR for the beam trawl was 0.51 (standard deviation 0.028) whereas the seine net was 0.83 (SD 0.019). In the sampling effort correction, the seine net was given a larger weighting, as more samples were collected using this method.

Each metric was scored individually from 1 (bad ecological status) to 5 (high ecological status). Metric 2 – presence of indicator species – scored the lowest (1.00). The other metrics were between 3.68 and 4.96 (Figure 2). After the metrics were scored individually, the scores were summed and converted in to the EQR. Following corrections for sampling effort, the final EQR indicated a higher ecological status than that suggested by some of the metrics taken in isolation.

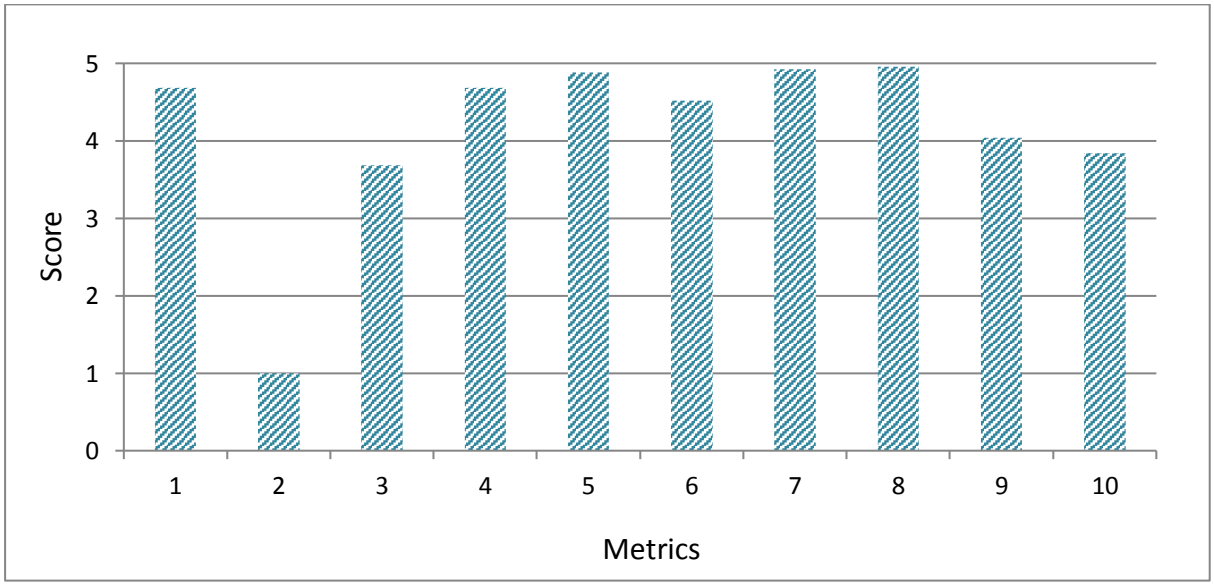

Figure 2: The score allocated to each metric, method-weighted average of all years 2010-2014.

Metric 1 – Species composition

The list of species in each sample was compared to the reference list (the species in the reference conditions site). A Bray-Curtis similarity index was used to determine the percentage similarity.

Similarity for the seine net ranged from 44% in 2014 to 64% in 2010. Similarity for the beam trawl was lower and ranged from 27% in 2010 to 41% in 2012. The weighted average of both methods revealed a trend of decrease over the sampling period from 64% to 40% (Figure 3). Values 40-60% are given a score of 3 (moderate) and values 60-80% are given a score of 4 (good).

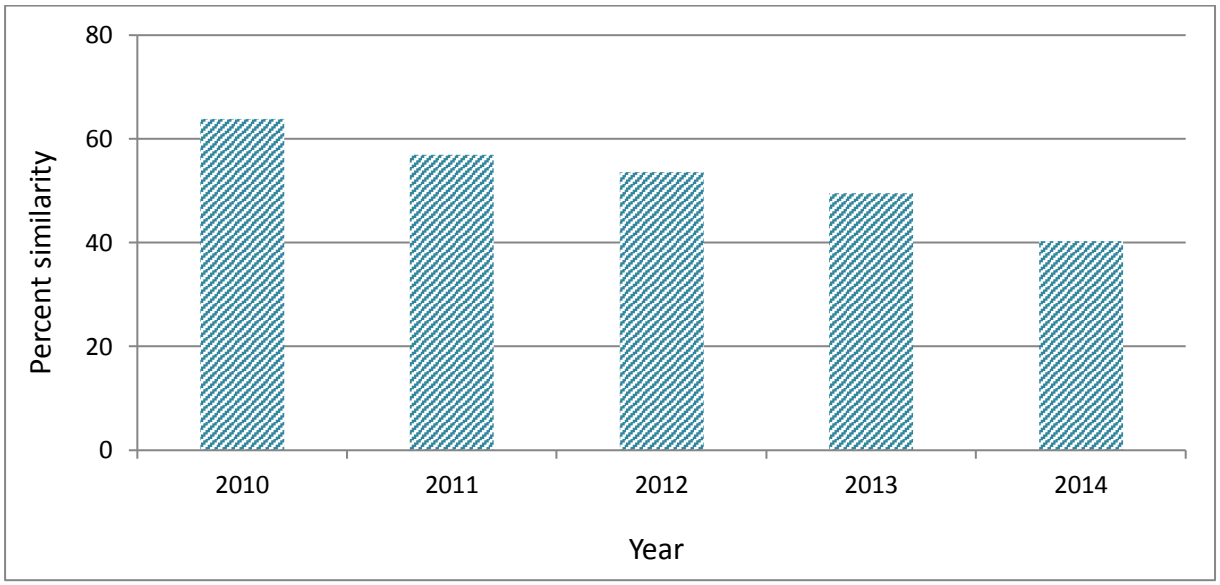

Figure 3: The Bray-Curtis percent similarity values for species composition for each year, method-weighted average.

Metric 2 – Presence of indicator species

The list of species in the sample was compared to the list of indicator species: sturgeon (*Acipenser sturio*), Allis shad (*Alosa alosa*), Twait shad (*Alosa fallax*), European eel (*Anguilla anguilla*), river lamprey (*Lampetra fluviatilis*), smelt (*Osmerus eperlanus*), sea lamprey (*Petromyzon marinus*), salmon (*Salmo salar*) and trout (*Salmo trutta*). The number of indicator species present was counted. This was the lowest scoring metric. There were none of the nine indicator species found in the beam trawl. Only two of the indicator species were found in the seine net; a trout in 2011 and a European eel in 2013. A value of less than 1.8 indicator species was assigned a score of 1. A value greater than 7.2 species would be assigned a score of 5.

Metric 3 – Species relative abundance

The relative abundance (%) of the species in the sample was compared to the relative abundance of the reference assemblages. A Bray-Curtis similarity index was used to determine the percentage similarity.

Similarity for the seine net ranged from 33% in 2014 to 48% in 2010. Similarity for the beam trawl was lower and ranged from 15% in 2012 to 47% in 2013. Similar to Metric 1, the method-weighted average showed a decrease in similarity from 48% in 2010 to 31% in 2014 (Figure 4). Values of 20-40% were given a score of 2 (poor) and values of 40-60% were assigned a score of 3 (moderate).

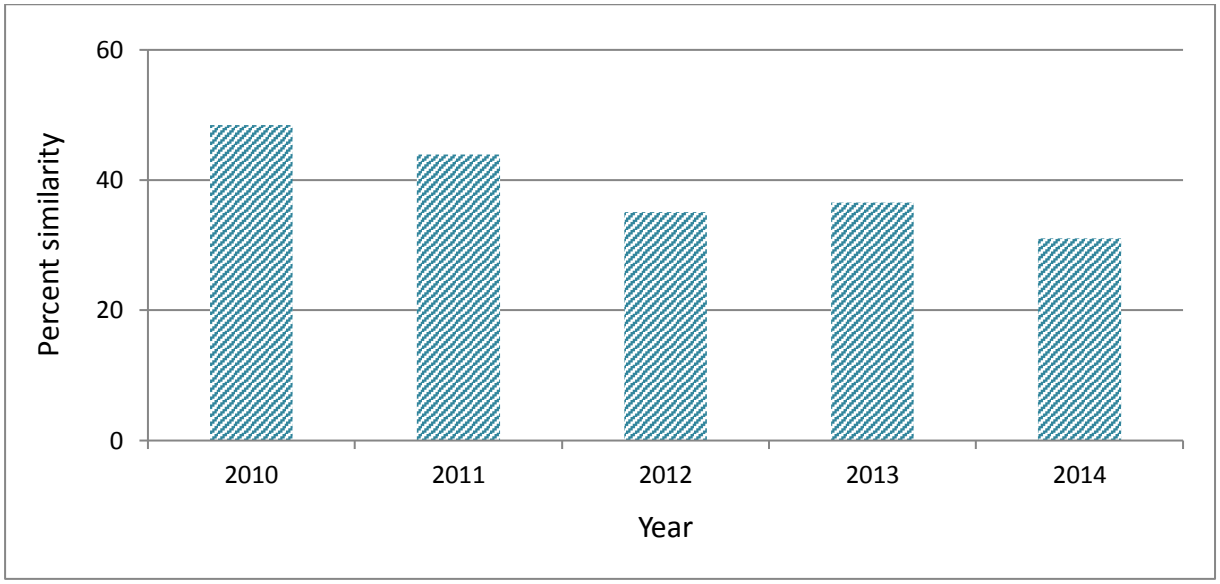

Figure 4: The Bray-Curtis percent similarity values for relative abundance for each year, method-weighted average.

Metric 4 – Number of taxa that make up 90% abundance

The relative abundance of the species in each sample was calculated and ranked. The number of species which contributed to 90% of the abundance were counted.

The number of species which made up 90% of abundance in the beam trawl ranged from just two species in 2012 and 2013 to six species in 2011. There was one species which contributed to the most abundant 90% every year for the trawl which was the common goby (*Pomatoschistus microps*). In fact in 2012, common goby alone accounted for 89% of the abundance in the trawl.

For the seine net, the range was from three species in 2013 and 2014 to seven species in 2010. There were three species consistently in the top 90% abundance for the seine net which were bass (*Dicentrarchus labrax*), herring (*Clupea harengus*) and sand smelt (*Atherina presbyter*).

The weighted average was 4.64 species (SD 1.84) per year. Values of 4.5-6.0 species were assigned a score of 4.

Metric 5 – Number of estuarine resident taxa

Each species was assigned one of six functional guilds: estuarine resident (entire life in estuaries), fresh water (present only in low salinity), diadromous (migrate between marine and fresh water during different life stages), marine seasonal (use estuaries for part of the year), marine juvenile (use estuaries during juvenile life stage) and marine adventitious (marine species which inhabit estuaries temporarily).

On average, there were 6.36 species (SD 0.99) in the estuarine resident guild per year. There were the least number of taxa in 2014 (5.0) and the most in 2012 (7.2). Estuarine resident species included gobies, sand eels, sea scorpions and pipe fish. A value of 5.0-6.7 estuarine resident taxa was assigned a score of 4.

Metric 6 – Number of estuarine dependant taxa

Each taxa was assigned one of six functional guilds, as for Metric 5. The number of species in the marine juvenile and marine seasonal guilds were counted.

There was an average of 7.52 species (SD 1.7) per year considered to be estuarine dependant. This ranged from 5.8 species in 2013 to 10.0 species in 2010. Marine juvenile species included sand smelt, herring, bass, black bream, sole and plaice. Marine seasonal species included golden grey and thick lipped mullet, garfish and sprat. A value of 6.1-8.1 estuarine dependant taxa was assigned a score of 4.

Metric 7 – Functional guild composition

Each taxa was assigned one of six functional guilds, as for Metrics 5 and 6. The number of different functional guilds present in the sample was counted.

There was an average of 4.68 (SD 0.18) functional guilds present per year. There were 4.6 guilds for 2011/12/13/14 and 5.0 guilds in 2010. A value of 3.6-4.8 functional guilds was assigned a score of 4.

In total, the most common functional guild was marine adventitious (16 species), followed by estuarine resident (13). There were 8 species in the marine juvenile guild and four species in both the diadromous and marine seasonal guilds. There were no fish in the fresh water guild.

The marine adventitious species included dragonets, lesser weever, wrasse, blenny, red mullet and mackerel. Diadromous species included European eel, three-spined stickleback, thin lipped mullet and sea trout.

Metric 8 - Number of benthic invertebrate feeding taxa

Each taxa was assigned one of five feeding guilds; benthic invertebrate, piscivorous, zooplankton, detritus and omnivorous. The number of species in the benthic invertebrate guild were counted.

There was an average of 11.84 species (SD 3.05) in the benthic invertebrate feeding guild per year. The least number of species (8.6) was in 2013 and the most (16.0) was in 2010. A value of 8.5-11.4 species was given a score of 4 and a value of >11.4 species was given a score of 5. Species in the benthic feeding guild included dragonets, gobies, dab, plaice, flounder, sole and wrasse.

Metric 9 – Number of piscivorous feeding taxa

Each taxa was assigned one of five feeding guilds, as in Metric 8. The number of species in the piscivorous feeding guild were counted.

There was an average of 2.56 species (SD 0.90) in the piscivorous feeding guild per year. 2012 and 2014 both had the least number of species (1.8) whereas 2010 had the most (4.0). A value of 1.4-2.8 species was given a score of 2. Greater than 5.6 species would be a score of 5. Piscivorous feeding species included European eel, bass, pollack and sea trout.

Metric 10 – Feeding guild composition

Each species was assigned one of five feeding guilds, as in Metrics 8 and 9. The number of feeding guilds present in the sample was counted.

There was an average of 3.84 (SD 0.09) feeding guilds per year. The most number of guilds was 4.0 in 2010, all the other years had 3.8 feeding guilds. A value of greater than 3.2 guilds was given a score of 5.

Overall, the most common feeding guild was benthic invertebrate (24 species), followed by zooplankton (12). There were 6 species in the piscivorous feeding guild and three in the detritus guild. There were no species in the omnivorous guild.
Zooplankton species included sand smelt, herring, sprat, pipefish, mackerel and black bream. Species in the detritus guild included thick lipped, thin lipped and golden grey mullets.

Discussion

Overall, the ecological health of the fish population in Chichester Harbour, as sampled by Sussex IFCA 2010-2014, was considered to be 'good'. The average Ecological Quality Ratio was 0.78. It was fairly consistent across the five years, ranging from 0.74 in 2012 to 0.85 in 2010. This was higher than expected, considering the anthropogenic modifications to the Harbour, the level of recreational activity, fishing pressure and eutrophication risk. This indicates that there is a healthy fish population in the Harbour and it is assumed, this is indicative of a healthy wider ecosystem.

Metric 2 (presence of indicator species) scored the lowest of the ten metrics. There were only two samples which contained an indicator species. This could have been due to a number of reasons associated with the specific characteristics of Chichester Harbour. There is not a significant freshwater input compared to most estuaries. This may have influenced the presence of diadromous fish such as salmon, trout and eels. Regional fluctuations in the populations of the indicator species may also be a factor. Some indicator species have been caught during other fish surveys conducted by Sussex IFCA. Eels have been found at the nearby site of Medmerry and smelt have been found on Rye Harbour beach.

Metric 1 (species composition) and metric 3 (species relative abundance) indicated a decreasing trend over the sampling period. The similarity of species composition in Chichester Harbour compared to the reference conditions decreased from 64% to 40% and the similarity of relative abundance decreased from 48% to 31%. This was a concerning trend, indicating departure from the reference conditions. There was also a decrease in the number of species which made up 90% of the abundance (metric 4). This suggested that the samples were increasingly becoming dominated by just a few species which could be out-competing other species and reducing diversity, as well as skewing the data. In 2013, 74% of the total samples was juvenile herring and in 2014, 65% of the total catch was bass.

Metric 5 (number of estuarine resident species) scored highly, indicating a similar number of estuarine resident species compared to the reference site and suggesting that the Harbour is home to a variety of species all year round. Metric 6 (number of estuarine dependent species) also scored highly, though slightly lower than metric 5. This suggested that the Harbour was important for juveniles of various species and as a habitat for fish which used the harbour seasonally. In recognition of its importance for juvenile fish, Chichester Harbour is designated as a Bass Nursery Area. The fish surveys conducted by Sussex IFCA have found that juvenile bass (average length 67mm) were the most abundant species in 2011, 2012 and 2014, and second most abundant in 2010 and 2013. Bass are important to both recreational and commercial fisheries, so these nursery areas are important to protect the juveniles and support the future of the fishery.

Metric 8 (number of benthic invertebrate feeding taxa) scored highly, suggesting that the Harbour supported a healthy population of fish which fed on benthic invertebrates and it is assumed that there was therefore a healthy population of benthic invertebrates. Metric 9 (number of piscivorous feeding taxa), however, scored less highly. There were few fish which fed on other fish in Chichester Harbour, compared to the reference site. This could be due to the large relative abundance of bass out-competing other piscivorous fish. It could also be due to the low relative abundance of piscivorous diadromous fish (eg trout and eel) which were not abundant in Chichester Harbour due to the small fresh water inputs, a factor unrelated to feeding guild composition. The feeding guild composition (metric 10) scored highly, suggesting that there was a healthy variety of fish in the Harbour, although there were no omnivorous species. Most species in the omnivorous guild were in the freshwater functional guild and therefore were not found in Chichester Harbour where there was not fresh water.

The Environment Agency conduct fish surveys in transitional and coastal water bodies under the Water Framework Directive. The water bodies closest to Chichester Harbour which are monitored by the Environment Agency are the Adur in West Sussex and Southampton Water in Hampshire. In 2014, the Ecological Quality Ratio for Southampton Water was 0.64 and for the Adur was 0.56 (Longley and Rudd, 2014). The EQR for Chichester Harbour in 2014 was 0.77, higher than both Southampton Water and the Adur.

Whilst the overall Ecological Quality Ratio was considered to be good, there is room for improvement. Considering the anthropogenic impacts on the Harbour, aiming for a pristine quality would be unrealistic but general improvements in water quality would be beneficial to the Harbour as a whole. The fish component could be a useful tool for monitoring the overall ecological health of the Harbour. Chichester Harbour has numerous conservation designations (Special Area of Conservation, Special Protection Area, Ramsar site, Site of Special Scientific Importance, Area of Outstanding Natural Beauty) and the fish are an important part of a cohesive healthy ecosystem.

Continued monitoring of the fish population will help to further the understanding of the Harbour, its ecological quality, trends over years, seasonality, the use of the Harbour by fish and the role of fish as a component of the wider ecosystem. It could also help to understand changes caused by climate change. Sussex IFCA is proposing to continue conducting fish surveys twice a year but moving towards every other year. No surveys were conducted in 2015 but are planned for 2016 and 2018. It will be interesting to monitor the trends identified in this analysis as the dataset develops into the future.

References

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