



ZSL | LET'S WORK
FOR WILDLIFE

THE STATE OF THE THAMES 2021

Environmental trends
of the Tidal Thames

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Cover image: Thames Seal and Thames Clipper, Bill Green | Thames Lens 2018 Winner
| Courtesy of Thames Festival Trust



ZOOLOGICAL SOCIETY OF LONDON

Founded in 1826, ZSL (Zoological Society of London) is an international conservation charity working to create a world where wildlife thrives. ZSL's work is realised through ground-breaking science, field conservation around the world and engaging millions of people through two zoos, ZSL London Zoo and ZSL Whipsnade Zoo. ZSL has been conserving the Tidal Thames environment since 2003.

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Royal Bank
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CONTENTS

EXECUTIVE SUMMARY	6	STATE OF NATURE	44
INDICATORS AT A GLANCE	7	7. Habitats	46
INTRODUCTION – A NATIONAL ASSET	8	8. Connectivity	53
METHODS	10	9. Fish	58
STATE OF THE ENVIRONMENT	12	10. Birds	64
1. Dissolved oxygen	14	11. Marine mammals	70
2. Nutrients	17	STATE OF PLAY	73
3. Biotic index assessment	27	12. Recreation	75
4. Climate change	30	13. Cognitive benefits	80
5. Plastic pollution	36	LOOKING FORWARD	83
6. Chemical contaminants	41	ACRONYMS	84
		GLOSSARY	84
		REFERENCES	86



THE STATE OF THE THAMES 2021 REPORT

The State of the Thames 2021 report sets out the environmental health and trends of the Thames Estuary. Using a series of indicators, it shows where our shared management of this vital estuary is working, as well as highlighting areas that require further intervention. These indicators were selected by technical experts and scientists who work on the Tidal Thames, and it is our intention that the report will generate an ‘action agenda’ that will drive the continued recovery of the Thames for both wildlife and people.

While this report uses a great deal of robust data, it is not a comprehensive representation of all relevant data that exists for the Tidal Thames. If you have, or know of, existing relevant data, please email marineandfreshwater@zsl.org for possible inclusion in future State of the Thames reports.



Estuaries, rivers and wetlands are some of the most threatened ecosystems in the world. Providing the lifeblood for billions of people, they are also some of the most heavily polluted and impacted natural areas. These aquatic ecosystems provide direct benefits and essential services to humans that are rapidly eroding.

Flowing through one of the world's greatest cities, the Tidal Thames is home to myriad wildlife as diverse as London itself. However, the Thames hasn't always been a thriving ecosystem; in 1957 parts of the river were declared biologically dead. ZSL has been working collaboratively since 2003 to restore the Tidal Thames to a biodiverse estuarine ecosystem that provides ecosystem services benefiting our economy and wellbeing. A healthy Thames is also vital in mitigating some of the impacts of climate change. As we increasingly recognise the intrinsic and economic value of nature's services to humans, we hope to see investment in the continued restoration of the river.

This report looks at what changed in those 60 years since the Thames was almost devoid of life. We highlight some of the reductions in pressures and improvements in key species and habitats, and set benchmarks for indicators on how the river is used. However, we also note some key elements of pollution

increasing and evidence of climate change having an impact. We also demonstrate how people engage and benefit from this blue space.

At ZSL, we work towards a wilder and more diverse Britain that is teeming with wildlife. This means continuing the work to reduce pressures, restore species and engage with communities about the positive benefits of a recovering Thames. This report provides a benchmark of where we are and examines how we need to work together to ensure that the Thames continues its journey of recovery to become a global exemplar of a recovered urban estuary.

Dr Andrew Terry, Director of Conservation and Policy, ZSL

EXECUTIVE SUMMARY

The State of the Thames 2021 report determines the health of the Tidal Thames environment. Using 17 indicators selected by scientific and technical experts and available data, long- and short-term trends were calculated to evaluate the current state of the estuary as a healthy, thriving ecosystem that not only sustains wildlife populations, but also provides mental and physical benefits to people. Where there are insufficient data to draw conclusions, the information provided sets a baseline from which to measure progress.

STATE OF THE ENVIRONMENT

The water quality of the Tidal Thames has exhibited some promising improvements. **Dissolved oxygen** concentrations, critical for fish survival, show long-term increases. Further, **phosphorus** concentrations, have reduced in both the long and short term, showing the effectiveness of improved sewage treatment works to reduce harmful levels of nutrients entering waterbodies. Despite these favourable trends, there has been a long-term increase in **nitrate** concentrations, which can negatively affect water quality through enrichment. In addition, the influences of **climate change** are clearly impacting the Tidal Thames, as both water temperature and sea levels continue to rise above historic baselines. This will undoubtedly affect the estuary's wildlife, leading to changes in life-history patterns and species ranges. A benchmark for **plastic** levels in the Tidal Thames has been set, and will need to be monitored closely.

STATE OF NATURE

The picture is brighter for the state of nature, with improving short-term trends identified for natural **habitats**, **birds** and **marine mammals**. However, the historic decline in habitat extent in the Tidal Thames is captured by the long-term analysis of the **habitat conservation** indicator.



Above: A European eel (*Anguilla anguilla*) found at Tilbury. This is a yellow eel, which is one of the eel's later maturation phase. **Image credit:** David Curnick (ZSL).

The number of **fish** species found in the Tidal Thames also showed a slight decline, however further research is needed to determine the cause.

While there have been significant historic losses of the natural habitat to urban development, there are positive indicators of change such as the creation of new 'estuary edges' and saltmarsh habitat, and plans for the re-wetting of floodplains in the Upper Tidal Thames. Reopening migratory paths for fish has set a baseline for **habitat connectivity**.

STATE OF PLAY

Important baselines were set for future analysis of the **Recreation: by the river** and **Recreation: on the river** indicators. While no trends were identified for these indicators, the baseline data show that the Tidal Thames provides a valuable outdoor space where millions of people can improve their physical and mental health and enjoy the water, fostering a sense of community stewardship. There are many organisations, opportunities and activities that allow people to learn about nature and history, and in doing so to access the **cognitive benefits** of the Tidal Thames.

INDICATORS AT A GLANCE

	Indicator	Long-term trend	Short-term trend
State of the environment	Dissolved oxygen	 Improving	 Data stable
	Nutrients: phosphorus	 Improving	 Improving
	Nutrients: nitrate	 Deteriorating	 Data stable
	Biotic Index Assessment	 Data stable	 Data stable
	Climate change: water temperature	 Deteriorating	 Deteriorating
	Climate change: sea-level rise	 Deteriorating	 Deteriorating
	Plastic pollution	 Insufficient data	 Baseline
	Chemical contaminants	 Insufficient data	 Insufficient data
State of nature	Habitats: conservation	 Deteriorating	 Improving
	Habitats: restoration and creation	 Insufficient data	 Baseline
	Connectivity	 Insufficient data	 Baseline
	Fish	 Deteriorating	 Data stable
	Birds	 Improving	 Improving
	Marine mammals	 Improving	 Improving
State of play	Recreation: by the river	 Insufficient data	 Baseline
	Recreation: on the river	 Insufficient data	 Baseline
	Cognitive benefits	 Insufficient data	 Insufficient data

INDICATOR TRENDS:

- 
Improving
 Indicates a trend that is improving in terms of environmental health.
- 
Deteriorating
 Indicates a trend that is deteriorating in terms of environmental health.
- 
Data stable
 Indicates that the data are not trending, are stable.
- 
Insufficient data
 Indicates that there are insufficient data to determine a trend or that this type of analysis is not applicable.
- 
Baseline
 Indicates that while not enough data is available to determine a trend, a baseline has been set for future trend analysis.

Short-term:
Most recent five to 10 years of data.

Long-term:
The full range of data, including beyond the most recent five to 10 years.

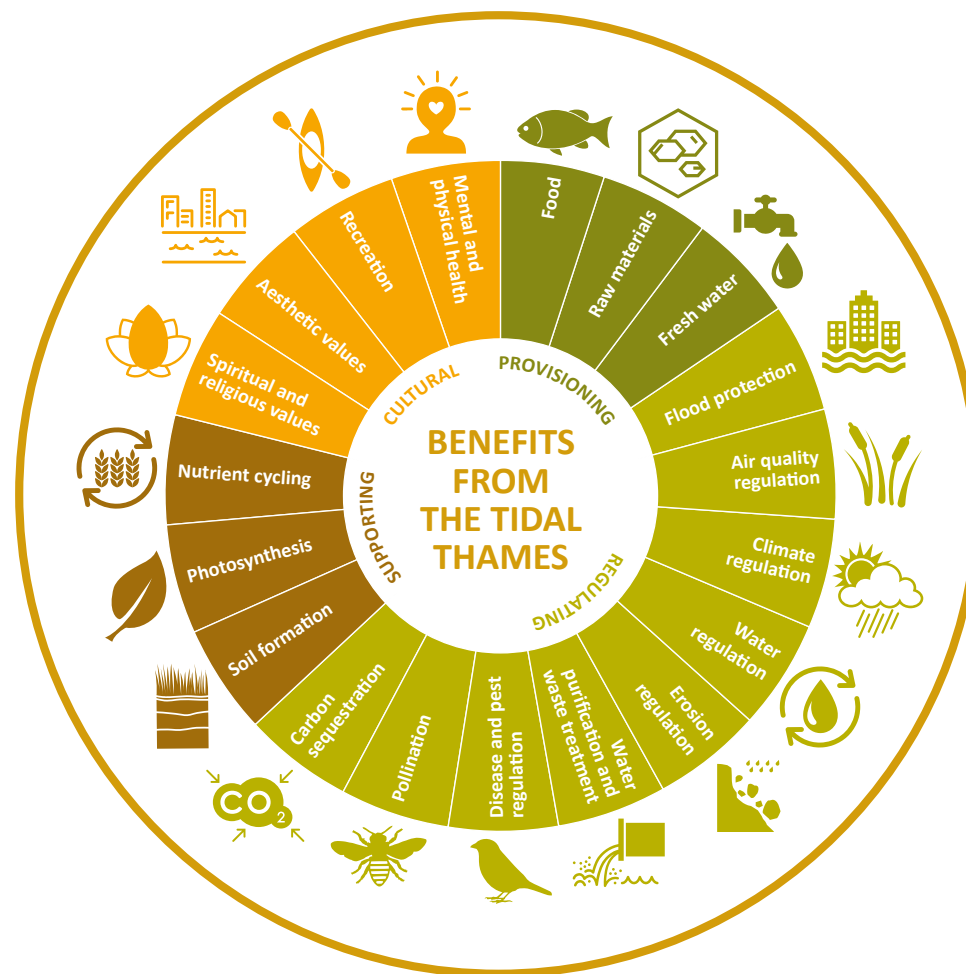
INTRODUCTION – A NATIONAL ASSET

Estuaries such as the Tidal Thames are some of the most productive ecosystems in the world. The Tidal Thames supports 115 species of fish (*Environment Agency*) and 92 species of bird (*British Trust for Ornithology – BTO*), and has almost 600ha of saltmarsh habitat (*Environment Agency*). For the millions of people living alongside it, it crucially provides drinking water, food, livelihoods, recreational opportunities and protection from coastal flooding. Additionally, it underpins human well-being by allowing people to connect with nature. These factors combine to make the Thames one of our greatest natural and public assets.

Despite their importance, estuaries are among the most modified and threatened ecosystems in the world. The benefits they provide, as seen in Figure I, are largely overlooked – being mobile, invisible or silent (Dasgupta 2021). Poor water quality has challenged the health of species along the Tidal Thames, while people's increasing need for land and resources has removed, fragmented and degraded the habitats on which these species depend. This has manifested itself in landmark events such as the 'Great Stink' of summer 1858, when fetid smells from the river drove parliamentarians from Westminster. **In 1957, scientists at the Natural History Museum reported stretches of the Tidal Thames to be, in parts, biologically dead (Wheeler 1958). This meant that the water in the estuary had again become so polluted that very few animals could survive.**

Since then, investment in infrastructure has led to great improvements in the water quality of the Tidal Thames. As a result, it once again provides a rich and varied habitat to an abundance of wildlife, and many benefits to people.

Figure I: Benefits from nature provided by the Tidal Thames. Infographic adapted from the *Living Planet Report* (WWF 2018).



ZSL AND THE TIDAL THAMES

ZSL is a world-renowned conservation organisation and expert in the field of conservation science. ZSL is committed to using this global expertise to work in partnership to improve and secure the ecological functioning of the Tidal Thames by delivering the components necessary for a recovering urban estuary. These include: clean water; abundant wildlife; and connected people. Working together to recover the health of the estuary, our work will underpin a strong economy and ensure a functioning ecosystem that supports both people and wildlife.

Established in 2003, the ZSL Thames Conservation Programme has made the public aware of the importance of the Tidal Thames for wildlife. Londoners now regularly expect to see, and are proud of, seals in the Thames. The European eel (*Anguilla anguilla*), synonymous with London, has had its historic migratory pathways reopened. We have gathered evidence on the importance of the Tidal Thames as a breeding ground and nursery habitat for fish, including smelt (*Osmerus eperlanus*), European seabass (*Dicentrarchus labrax*) and smooth hound (*Mustelus mustelus*), so that we can better manage our activities on the Tidal Thames to protect them. Importantly, we have worked with communities across London to gather evidence of poor water quality to help target investment and improve the Thames for both wildlife and people.



METHODS

INDICATORS

Indicators are widely used to monitor the status and trends of environmental health and to track progress towards environmental targets, such as the United Nations Sustainable Development Goals (SDGs). For this report, we developed a set of 17 indicators with associated metrics to track the status and trends of the Tidal Thames' physical environment, wildlife populations, and benefits to people. The indicators fall into three wider categories: [state of the environment](#), [state of nature](#), and [state of play](#).

DATA

For most indicators, time-series data were taken from a variety of sources, including government agencies, charities and academic institutions. Data used for *The State of the Thames 2021* report aim to cover the 60-year period from 1957 (the year the Tidal Thames was reportedly in its worst state) to the present day. However, the lack of available data for some indicators meant that it was not always possible to cover this entire period. In those cases, the data used start when sampling was standardised to the present-day methodology. For a few indicators, data pre-date 1957.

TRENDS

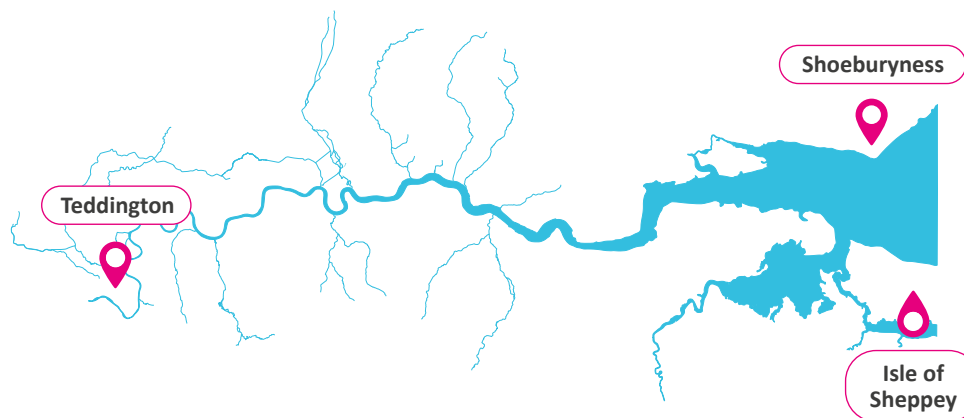
To analyse how these indicators are changing over time, time-series data were used to determine long- and short-term trends using linear regression. 'Short-term' has generally been defined here as the most recent five to 10 years of data, depending on the full range of data available. This range was chosen as a short-term time frame because it allows enough data for a regression analysis, while capturing the most recent trends. 'Long-term' has loosely been defined as the full

range of data, including beyond the most recent five to 10 years. Trends stated in this report were found to be statistically significant ($p\text{-value} \leq 0.05$).

A few indicators did not have time-series data available, in which case a baseline was set for future comparison. A few other indicators did not have any applicable data, in which case the impact of the indicator was described.

STUDY AREA

For the purposes of this report, the Tidal Thames is defined as being from the tidal limit at Teddington to the seaward line just east of Shoeburyness, running from Haven Point on the north shore in Essex to Warden Point on the Isle of Sheppey in Kent. While some indicators include data from tributaries, most indicators focus on the Tidal Thames itself.



PHYSICAL CHARACTERISTICS OF THE TIDAL THAMES

As an estuary, the Tidal Thames is characterised by the mixing of freshwater and saltwater, which creates its rich, productive and diverse ecosystem. Nutrients are brought from both the land above Teddington and the North Sea, feeding the interconnected food web. Many other outputs from our human settlements, industry and agriculture are also introduced into the Tidal Thames environment through its waters.

At 153km, it is one of the longest estuaries in the country. Its width varies from just 100m at Teddington to 7km at Southend. With a tidal range of up to 7m, and two tidal cycles per day, the average flow is 83.9m³ per second of freshwater, which comes from the main river and from the 13 tributaries that flow into the Tidal Thames (Attrill ed. 1998).

153km

long – from the tidal limit

100m–7km

in varying width

7m

of tidal range

2

tidal cycles per day

13

tributaries

83.9m³

per second of freshwater flow

STATE OF THE ENVIRONMENT





While the Thames Tideway Tunnel is expected to help improve water quality, there are other environmental factors that continue to threaten the health of wildlife in the Tidal Thames.

During the 18th century, London's population and industrial activity grew rapidly, resulting in more household and industrial waste being flushed into the Thames (Environment Agency 1997). Ecologically, this led to a decrease in the abundance and diversity of species in the Thames (Environment Agency 1997). This, in turn, had economic impacts, as many fisheries operating in the Tidal Thames collapsed. Despite efforts to improve water quality over the next 100 years, stretches of the river remained lifeless for long periods of time. The increased use of agricultural chemicals was a further source of environmental stress, along with water abstraction for industry and drinking.

The situation improved from 1960 through measures including the expansion of sewage treatment works (STW), limits on water abstraction, and limits on industrial discharges. However, because London's sewage system was largely built in the 1800s when London's population was less than a quarter of what it is today, storm events cause excess sewage to overflow into the Tidal Thames, posing a major threat to water quality (Environment Agency 2019a).

To address this threat, a new London 'super sewer' called the Thames Tideway Tunnel is under construction. The tunnel will run from Acton in the west to Abbey Mills in the east, and from there sewage will be pumped to Beckton STW via the Lee Tunnel. Construction is due to finish in 2025, and once operational it will capture and store most of the millions of

tonnes of raw sewage that currently overflow into the estuary (Tideway 2020).

While the Thames Tideway Tunnel is expected to help improve water quality, other environmental factors continue to threaten the health of wildlife in the Tidal Thames. These include climate-change-induced changes in water temperature, the concerning impacts of chemicals, and a rising tide of plastics.

The following indicators evaluate the environmental factors affecting the ecosystems of the Tidal Thames. **The ambition is for the water quality of the Tidal Thames to be consistently good enough for it to reach its wildlife potential and be enjoyed by people.**



Above: An inside view of the Thames Tideway Tunnel, London's 'super sewer', due to be completed in 2025. Image credit: Courtesy of Tideway.

DISSOLVED OXYGEN



Long-term trend: Improving



Short-term trend: **Data stable**

As dissolved oxygen (DO) in water is necessary for almost all forms of aquatic life, it is considered the most important parameter for evaluating water quality in most waterbodies. While DO concentrations naturally fluctuate because of a combination of physical, chemical and biological characteristics, human activities can have substantial impacts on these characteristics. Understanding DO is important because low levels (less than 45% DO) can cause fish kills and affect predator-prey relationships in the Tidal Thames (UK Technical Advisory Group on the Water Framework Directive 2008).

Right: Tideway Tunnel Boring Machine being transported to a Tideway construction site near Tower Bridge. The new 'super sewer' will reduce the amount of sewage entering the river and, in doing so, improve dissolved oxygen levels. **Image credit:** Courtesy of Tideway.



Background

The Tidal Thames has notoriously faced periods of extremely low dissolved oxygen (DO) that have had devastating effects on the Thames' aquatic ecosystem. These DO drops can be linked to human causes, including sewage effluent overflow and runoff from roads and cities. As an estuary, the Tidal Thames' DO concentrations are also influenced by freshwater flow, tides, temperature, and storm events, among other factors. Warmer water is naturally less able to hold oxygen than colder water, meaning that DO tends to be lower during the summer months. Monitoring DO levels in the Tidal Thames helps to assess the health of the aquatic ecosystem and evaluate the success of water quality improvement efforts.

Analysis

The data used for this analysis were from the Environment Agency's Automated Quality Monitoring System. Since 2007, the Environment Agency has managed nine automated monitoring stations in the Tidal Thames. These devices use sensors to take a measurement every 15 minutes.

The raw data were first cleaned, removing any periods of sensor malfunction, erroneous outliers, and data from any monitoring stations not in place in 2008 to avoid skewing the results. The dataset was split into Upper Tidal Thames (five monitoring stations)¹ and Middle Tidal Thames (two monitoring stations)². Hourly DO averages were then calculated and used to tally the number of hourly averages below 45% DO for each month.³

To correct for the periods of time during which a sensor was not functioning and therefore excluded from the analysis, this value is represented as the monthly percentage of hourly averages that fell below 45% DO.

Findings

The findings for the Upper Tidal Thames show that in all years except 2016, DO fell below 45% (Figure 1.1). The results show obvious spikes in the percentage of hours that DO was below 45% during the summer months, when DO tends to be at its lowest. The worst years for low DO levels were 2009 and 2011. While recent years seem to show improvement in DO levels, there continue to be spikes in some years, for example 2018. The overall improvements seen, particularly after 2011, are likely due to improvements in Upper Tidal Thames STW such as Mogden.

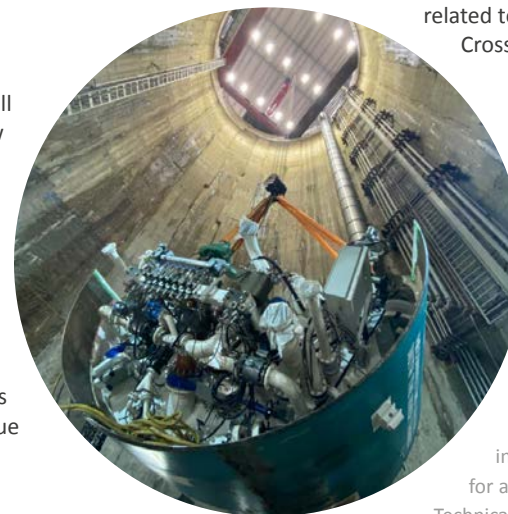
Findings for the Middle Tidal Thames show substantial periods of time between 2008 and 2013 during which DO was below 45%, particularly in the summer months (Figure 1.2). In July 2012, DO was less than 45% for over half of the hours monitored. While these results appear worse than those of the Upper Tidal Thames, it must be noted that the water in the

Middle Tidal Thames has a stronger tidal influence than that in the Upper Tidal Thames, which naturally causes a drop in DO. After 2013, there is a dramatic reduction in the percentage of hours with low DO in the Middle Tidal Thames. This is related to improvements in major STW, including Crossness STW and Beckton STW.

Long-term regression analysis (2007 to 2020) showed a significant long-term improvement in DO overall (p-value = 0.015). However, analysis on short-term data (2015 to 2020) showed data to be stable.

¹ Kew, Chiswick, Hammersmith, Putney and Chelsea. ² Erith and Purfleet.

³ DO was measured below 45% because according to standards set by the WFD, the mandate that regulates water quality in the EU, a river with less than 45% DO for a sustained period of time will fail (UK Technical Advisory Group on the Water Framework Directive 2008).



Above: Tunnel boring machine being lowered to the base of a Tideway shaft to commence tunnel construction. **Image credit:** Courtesy of Tideway.

Monthly percentage of hourly averages that fell below 45% DO: **Upper Tidal Thames**

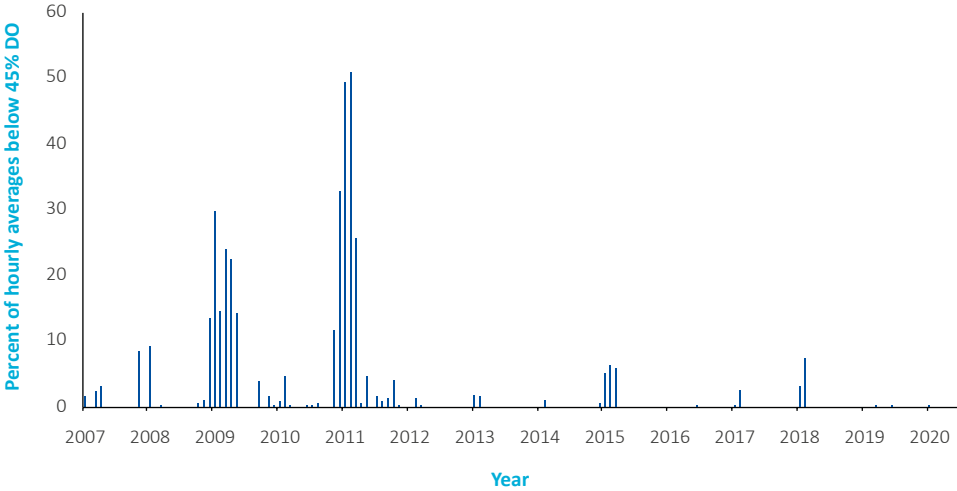


Figure 1.1: Graph showing the percentage of hours in each month when DO was recorded at less than 45% in Upper Tidal Thames monitoring stations (Kew, Chiswick, Hammersmith, Putney and Chelsea).

Monthly percentage of hourly averages that fell below 45% DO: **Middle Tidal Thames**

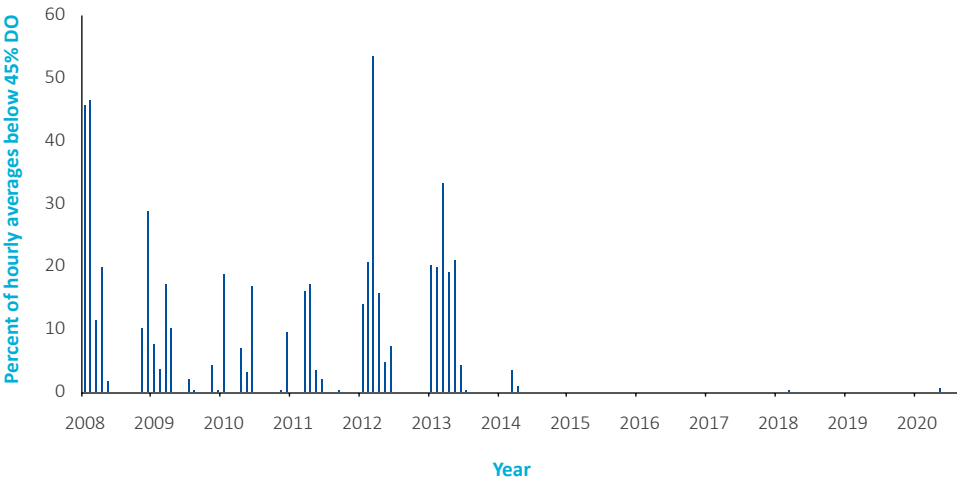


Figure 1.2: Graph showing the percentage of hours in each month when DO was recorded at less than 45% in Middle Tidal Thames monitoring stations (Erith and Purfleet).

NUTRIENTS

While vital for the survival of all organisms, nutrients can also pose a threat to aquatic life. Surplus nutrients from agriculture and sewage can cause excess growth of plant life and algae in a process called eutrophication. Eutrophication can have various damaging ecological impacts, including low DO, blocking light from the water column, and blooms of toxic blue-green algae.

Right: Upgrades and expansions to Beckton Sewage Treatment Works, pictured, have helped treat sewage and therefore reduce nutrient inputs into the river from London's ever-increasing population.



PHOSPHORUS



Long-term trend: Improving



Short-term trend: Improving

Background

Phosphorus concentrations in rivers all over the UK increased rapidly between 1950 and the late 1980s, primarily because of nutrient-rich sewage and runoff from agriculture entering river systems (Environment Agency 2019a). However, phosphorus concentrations have dramatically reduced since the 1990s. This is largely due to improvements in wastewater treatment across the UK, namely phosphorus removal practices. In the Thames Catchment, the STWs have been managed by Thames Water since 1990. Their investment, along with investment from water companies throughout the UK under direction of the Environment Agency's Water Industry National Environment Programme (WINEP), has enabled widespread reductions in phosphorus across the country. Despite these improvements, high phosphorus concentrations continue to be the most common reason why waterbodies do not meet the European Union (EU) Water Framework Directive (WFD) standard of good ecological potential/status in the UK (Environment Agency 2019a).

Furthermore, the risk posed by high phosphorus concentrations is expected to be heightened in the Tidal Thames because of increasing sewage inputs caused by an increasing population,

rising water temperatures due to climate change, and greater stormwater runoff. Nevertheless, improvements in phosphorus concentrations are expected by 2025 in response to WINEP, which sets out environmental requirements for water companies and actions to ensure success.

Analysis

Tidal influence is a major factor affecting nutrient levels in the Tidal Thames. Therefore, the decision was made to focus on the Thames at Teddington – where tidal influence is minimal – as well as monitoring points at the mouths of three freshwater tributaries: the Rivers Lee, Ravensbourne and Darent. These three tributaries were chosen because they had long-term data available, and discharged directly into the Tidal Thames. The water quality data used for this analysis were obtained from the Environment Agency's Water Quality Archive (WIMS). Sampling points closest to the confluences with the Tidal Thames were used, and parameters reflecting measurements of dissolved phosphorus were selected. Recorded phosphorus concentrations over time were then plotted for each tributary; for some tributaries, this went as far back as 1970s, while others began in the 1990s. To assess long- and short-term trends, data for the four rivers were combined and linear regressions were calculated using yearly averages.

To determine the source of phosphorus in the River Thames at Teddington, the 'load apportionment' approach was used

(Bowes *et al.* 2008). The phosphorus concentration data were combined with the daily mean flow on the day of sampling. The nearest gauging station was selected, and the mean flow data were obtained from the UK Centre for Ecology & Hydrology's (CEH) [National River Flow Archive](#).

Findings

All rivers showed declines in phosphorus concentrations over the monitoring periods (Figures 2.1–2.4). Some rivers had sudden step reductions in phosphorus such as the Lee in 2012 (Figure 2.2), which usually indicates a rapid improvement due to the introduction of phosphorus removal at a large STW. The smaller tributaries – the Ravensbourne and Darent – have not seen the same dramatic reductions in phosphorus concentrations (Figures 2.3 and 2.4). However, the occasional large peaks that were observed have disappeared in recent years, again suggesting that STW upgrades are eliminating sporadic pollution incidents.

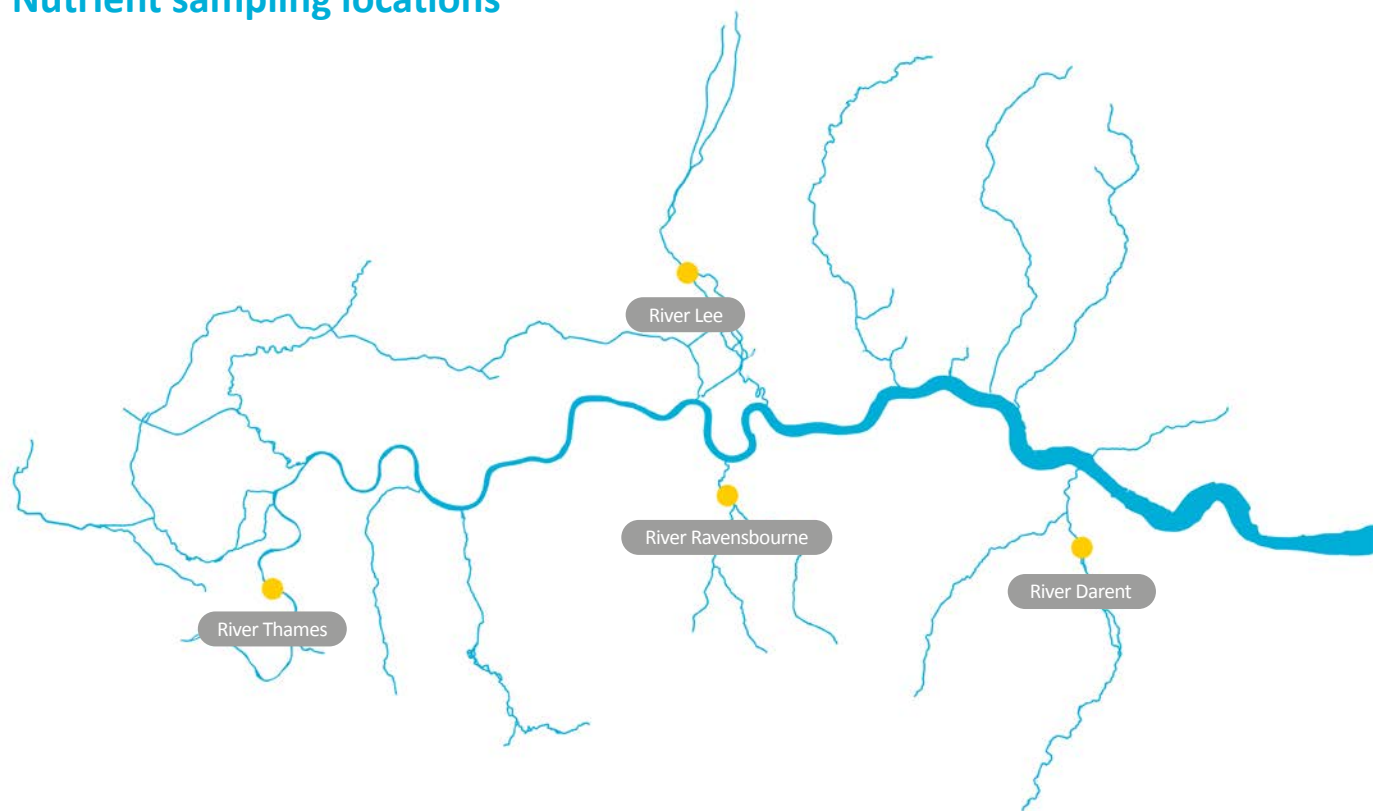
Overall yearly averages were used to calculate long- (1990 to 2020) and short-term (2010 to 2020) trends. Statistically significant long- (p -value = $9.82E-13$) and short-term (p -value = 0.05) decreasing trends were found, demonstrating environmental improvement. This improvement is further observed in the decline in average daily phosphorus loads being deposited into the Tidal Thames from monitored tributaries (Figure 2.6). Despite the decline in phosphorus, chlorophyll

– a pigment found in algae – has shown no signs of decline, suggesting there has been no decrease in algal blooms.

The River Thames at Teddington had a sudden reduction in phosphorous concentrations in 2007. This likely indicates the introduction of STW phosphorus removal at multiple towns and cities in the freshwater catchment throughout the 2000s. This was further confirmed when comparing phosphorus concentrations to flow data, which showed that phosphorus concentrations have declined in recent decades during low-flow conditions (Figure 2.5). Rivers that are dominated by inputs from STW (known as ‘point sources’) always have their highest concentrations during low flow, because of a lack of dilution of the constant inputs from STW (Bowes *et al.* 2008). By the 2010s, phosphorus concentrations were lower, even at low flows, showing a much decreased contribution from sewage effluents.

Despite the observed improvements in phosphorus concentrations, WFD data from 2016 (most recent available data) showed that both the River Lee and the River Ravensbourne in the sampling areas received ‘Poor’ status for phosphorus concentrations, and the River Thames at Teddington received ‘Moderate’ status. The River Darent was the only one of the four to achieve an acceptable level of phosphorus, with the best possible ‘High’ status.

Nutrient sampling locations



Thames phosphorus

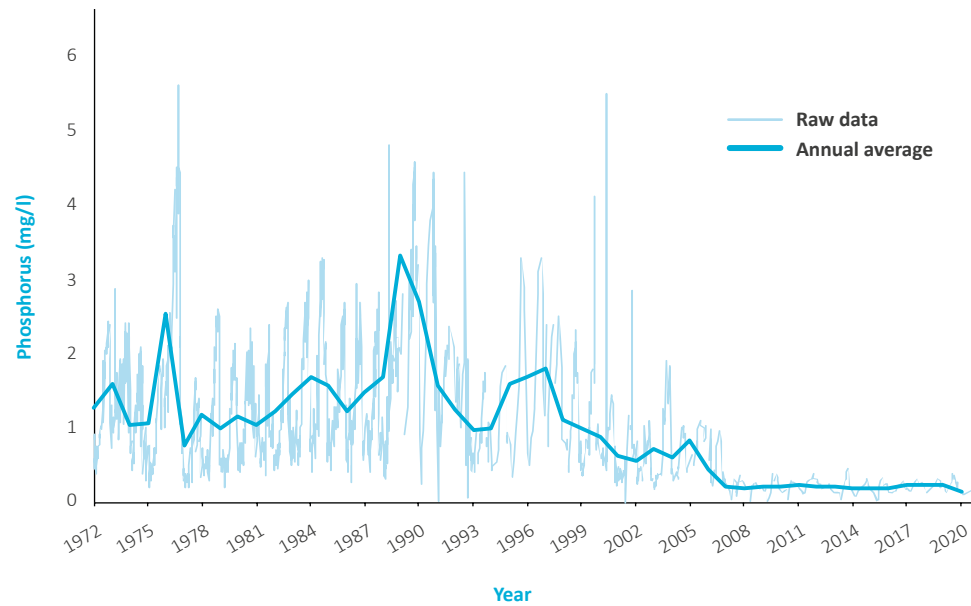


Figure 2.1: Phosphorus concentrations in the River Thames at Teddington.

Lee phosphorus

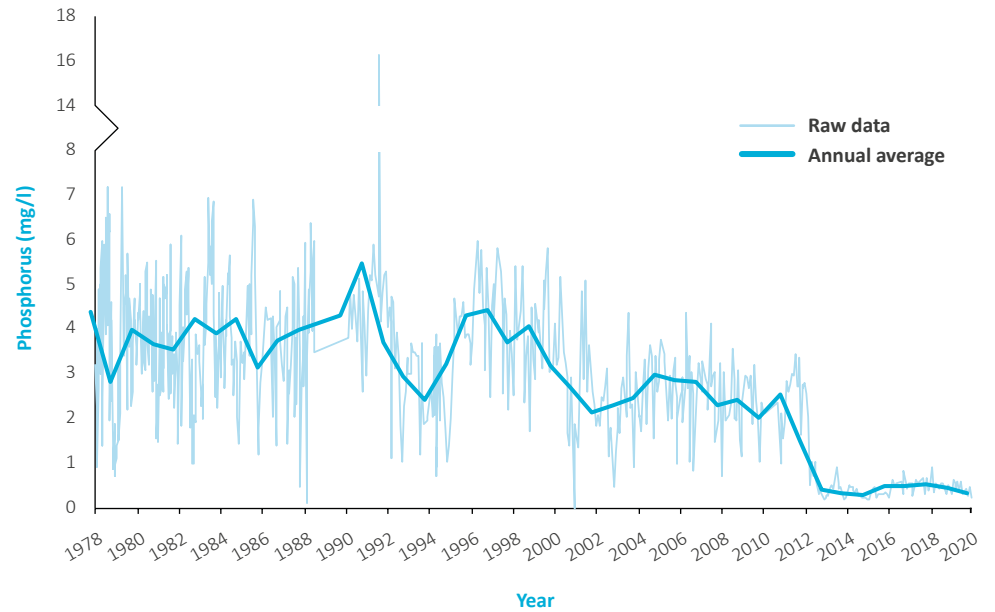


Figure 2.2: Phosphorus concentrations in the River Lee, near its Thames confluence.

Darent phosphorus

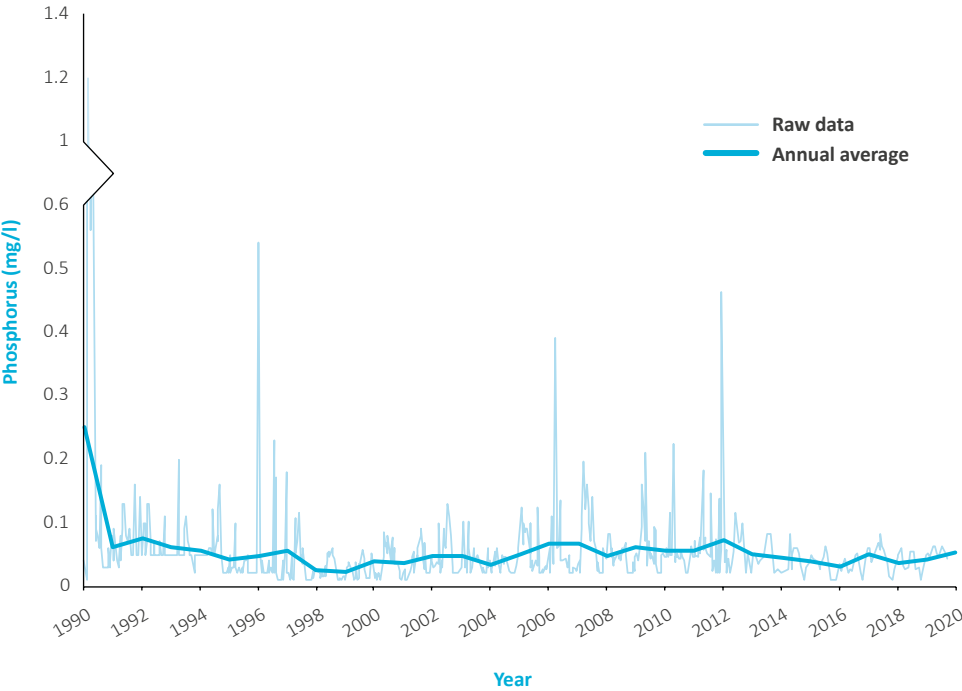


Figure 2.3: Phosphorus concentrations in the River Darent, near its Thames confluence.

Ravensbourne phosphorus

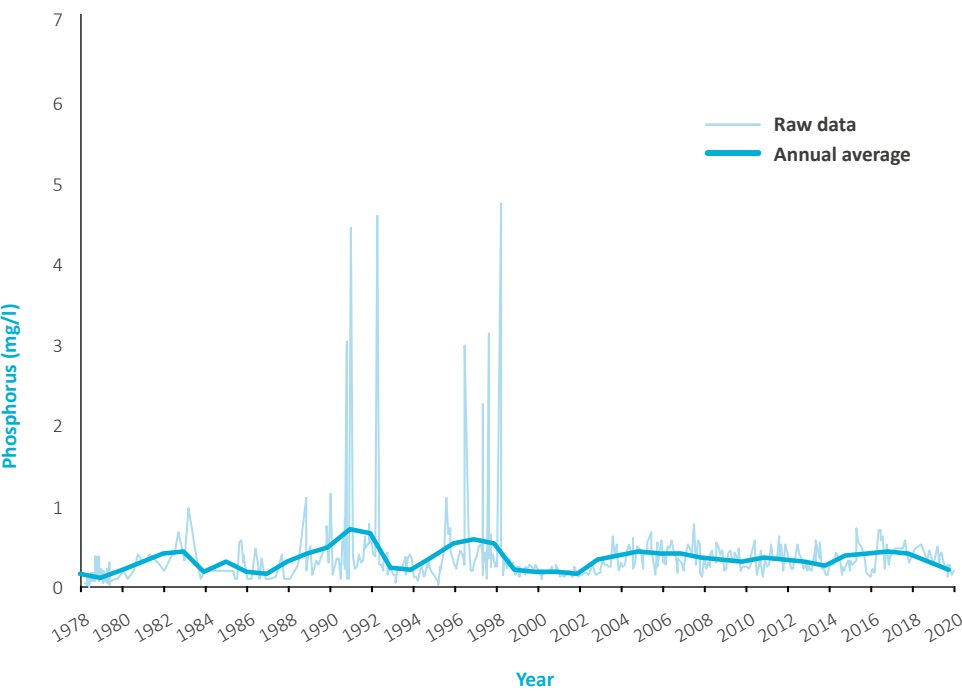
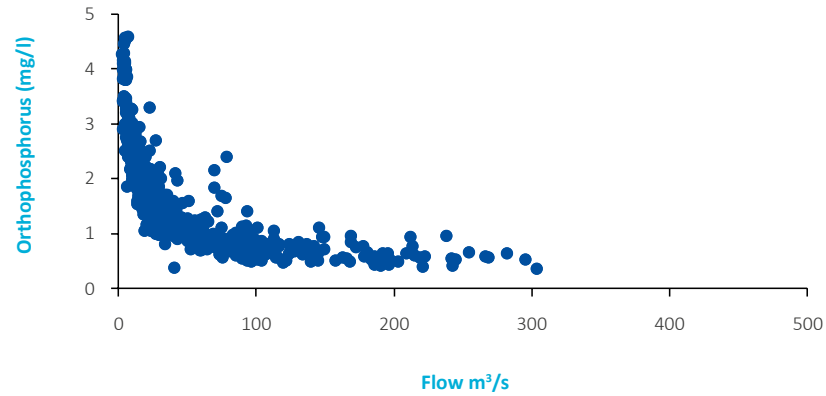
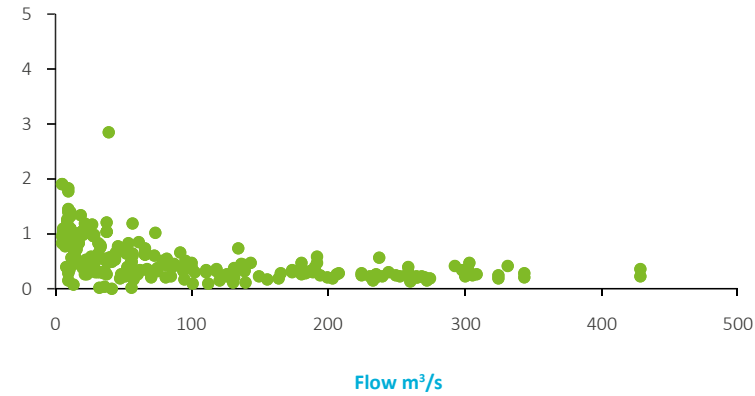


Figure 2.4: Phosphorus concentrations in the River Ravensbourne, near its Thames confluence.

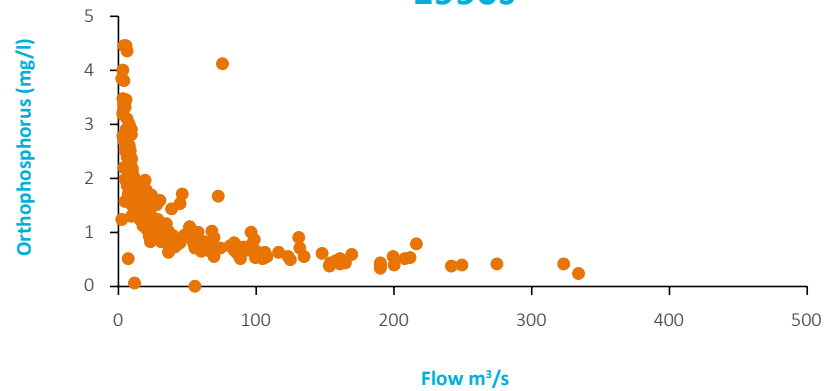
1980s



2000s



1990s



2010s

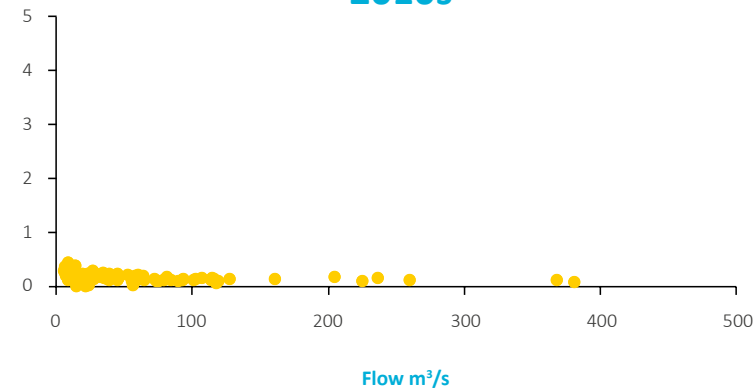


Figure 2.5: Thames orthophosphate (or reactive phosphorus) plotted against flow at the time each sample was taken. The samples taken in the 1980s and 1990s are largely sewage-dominated, with high orthophosphate concentrations occurring at low flow, while high flows see low concentrations. This demonstrates that the source of orthophosphate during this time was likely a point source from a STW. In the 2000s and 2010s, we see reduced orthophosphate concentrations.

Average daily orthophosphorus loads to the Thames Estuary

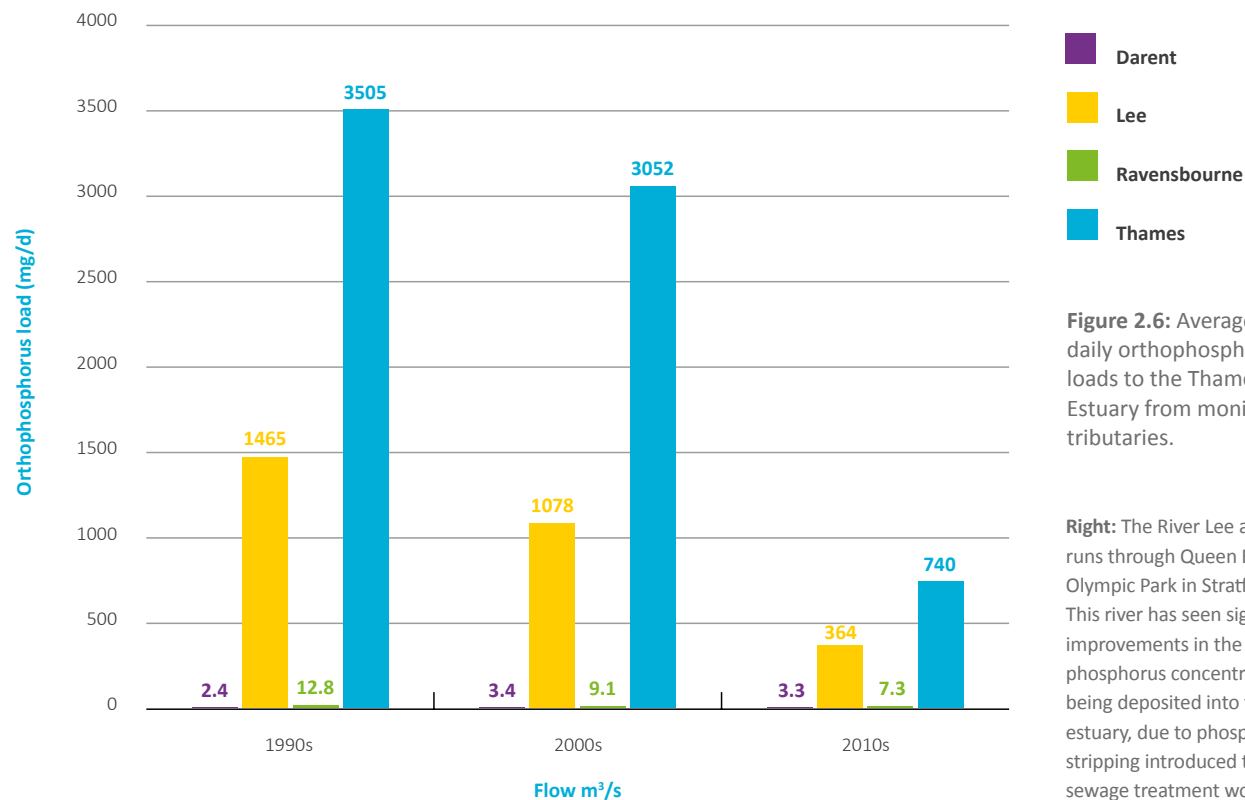


Figure 2.6: Average daily orthophosphorus loads to the Thames Estuary from monitored tributaries.

Right: The River Lee as it runs through Queen Elizabeth Olympic Park in Stratford. This river has seen significant improvements in the phosphorus concentrations being deposited into the estuary, due to phosphate stripping introduced to nearby sewage treatment works.



NITRATE



Long-term trend: **Deteriorating**



Short-term trend: **Data stable**

Background

Nitrate is another nutrient that contributes significantly to eutrophication not only in freshwater, but also in marine, coastal and estuarine environments. The Environment Agency has identified industrial and sewage effluent as the main source of nitrate in London waterbodies, with urban runoff determined to be the secondary source (Environment Agency 2019b). In all other regions across the UK, the main source of nitrate is agriculture, because of the common use of nitrate-rich fertilisers. This contrast shows the extreme impacts that London's high population and industry have on its waterbodies. While nitrate removal plants at STW have been installed in select locations in the UK, broader installation has not occurred largely due to cost considerations.

Analysis

The water quality data used for this analysis were obtained from WIMS. The sampling points that were used in the phosphorus analysis were selected here as well: the River Thames at Teddington, and monitoring points closest to the mouths of three freshwater tributaries – the Rivers Lee, Ravensbourne and Darent. Recorded nitrate levels over time were plotted for each tributary, as well as annual averages. For some tributaries, data went as far back as the 1990s, while others began in the 2000s. To test for statistically significant long- and short-term trends, data for the four rivers were

combined, yearly averages were calculated and linear regression models were fitted.

Findings

According to the data, annual averages of nitrate concentrations in the larger rivers (Thames, Figure 2.6 and Lee, Figure 2.7) were higher on average than in the smaller tributaries (Ravensbourne and Darent). It is interesting to note that none of the tributaries analysed have experienced any major spikes in nitrate concentrations in the past ~20 years (Figures 2.6–2.9).⁴ This could potentially be due to overall improvement and expansion of STW.

While the absence of spikes in nitrate concentrations in recent years can be considered an improvement, overall long-term trends (2000–2020) show a gradual increasing trend in average nitrate levels ($p\text{-value} = 2\text{E-}05$), which indicates a deterioration in environmental quality. Promisingly, however, there was no statistically significant short-term (2010–2020) trend, suggesting that concentrations have stabilised.



⁴ The peaks in nitrate concentrations that have occurred are likely to be linked to storm events.

Thames nitrate

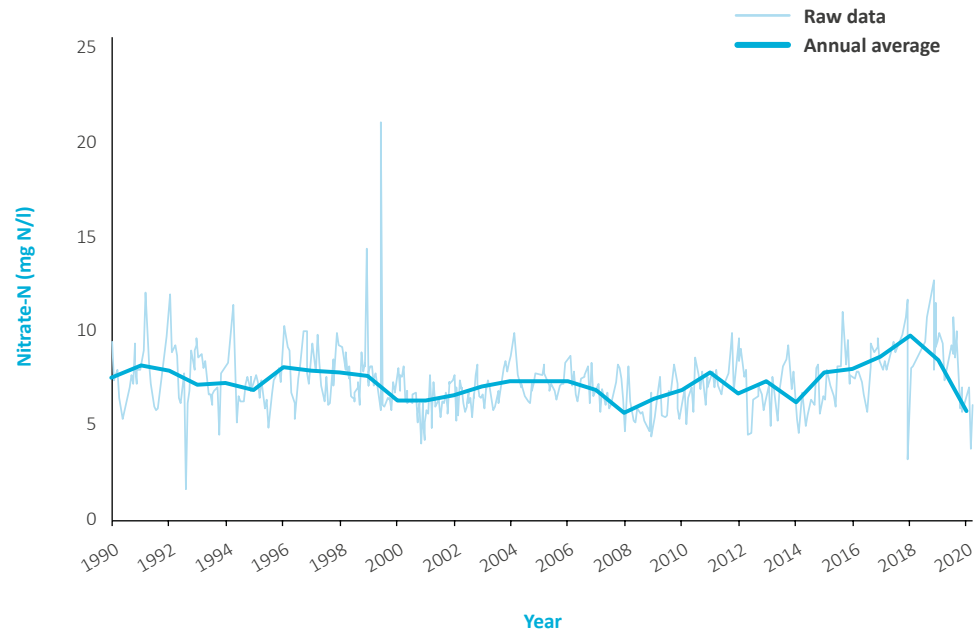


Figure 2.6: Nitrate concentrations in the Thames at Teddington.

Lee nitrate

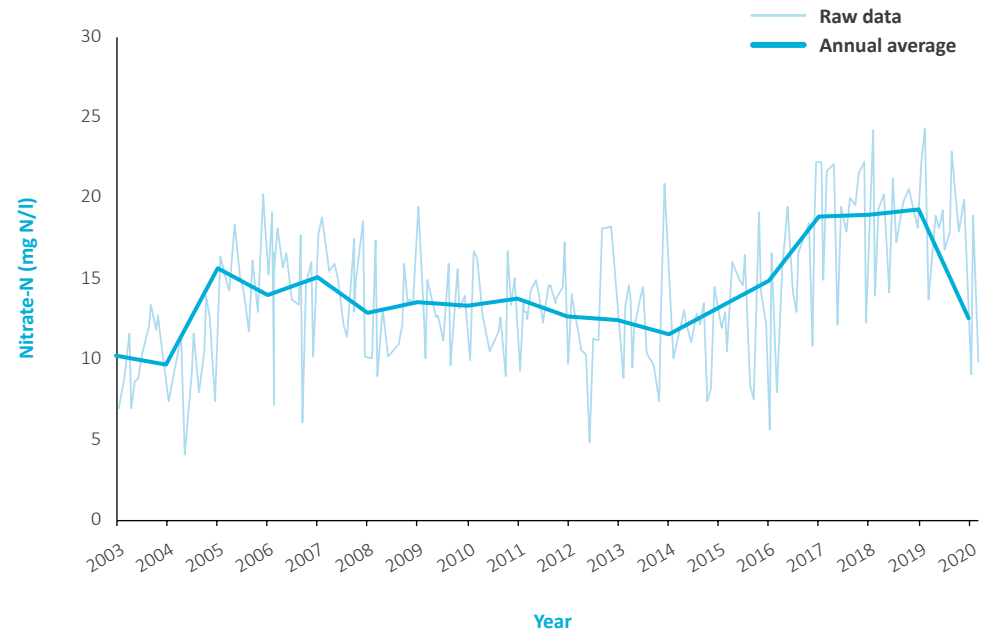


Figure 2.7: Nitrate concentrations in the River Lee.

Darent nitrate

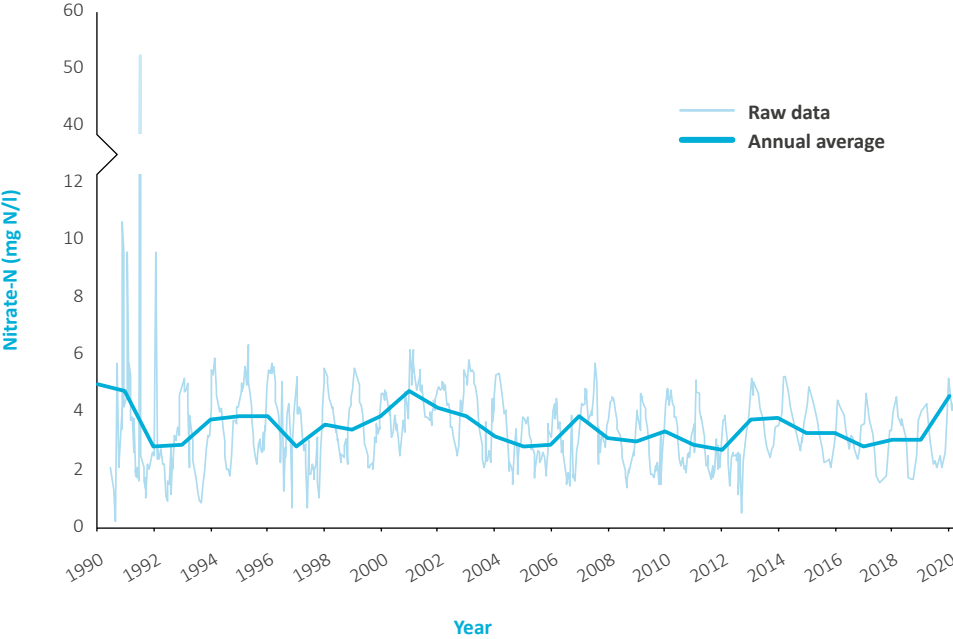


Figure 2.8: Nitrate concentrations in the River Darent.

Ravensbourne nitrate

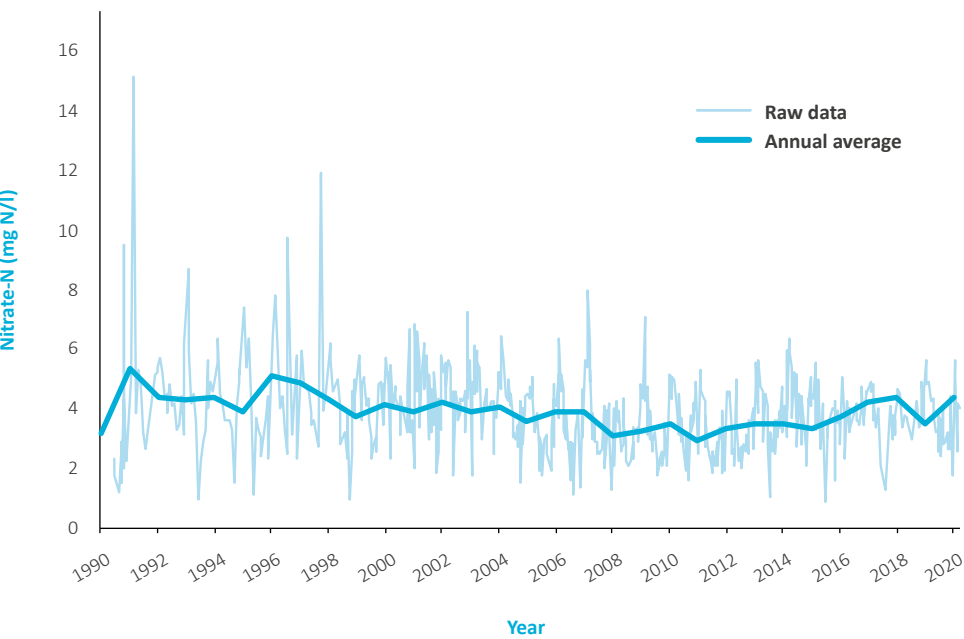


Figure 2.9: Nitrate concentrations in the River Ravensbourne.

BIOTIC INDEX ASSESSMENT



Long-term trend: **Data stable**

Short-term trend: **Data stable**

Aquatic invertebrates have long been recognised and widely accepted in water quality monitoring as indicators of aquatic ecosystem health, with many species known to be sensitive to pollution and habitat modification. The presence, abundance and distribution of these species can therefore reveal a great deal about the condition of the Tidal Thames.



Right: River shrimp (*Gammarus pulex*), commonly found in fresh water across the UK.

Background

The extent to which a waterbody has been impacted by pollution and habitat degradation is sometimes assessed using a biotic index, which measures water quality by using the presence/absence of certain species. These indices are often based on an invertebrate family's sensitivity to pollution and its presence in a waterbody. However, due to the complex estuarine environment, an index has not been developed to assess the status of estuarine health using invertebrate communities. In the absence of an estuarine index, freshwater indices may be applied to freshwater-dominated locations in the Tidal Thames. Changes in a sampling location's index value over time can reveal the impacts of pollution and habitat degradation.

Analysis

This analysis focuses on five Environment Agency sampling points in the Upper Tidal Thames, between Barnes and Teddington, where invertebrate communities have been monitored consistently since 2005. The data were collected using a standardised methodology consisting of a three-minute kick sample, during which a kick net is held downstream while the substrate immediately upstream of the net is kicked to lift invertebrates into the water column, where they wash into the



net. The data were obtained from the Environment Agency's Marine and Freshwater Invertebrates dataset. Some of these data were available to be downloaded online, while data from some monitoring points were made available on request. To account for seasonal variation in invertebrate communities, only summer samples were included in the analysis.

In the absence of an estuarine index, an index commonly used for freshwater environments called the Biological Monitoring Working Party (BMWP) has been used to assess water quality in the Upper Tidal Thames.⁵ The BMWP uses expert-assigned scores for each invertebrate taxonomic family based on its sensitivity to organic pollution (UKTAG WFD 2013). A family with a low score is considered tolerant to pollution, while a family with a high score is extremely sensitive. To apply the index to an invertebrate sample, the score for each family present in the sample is summed together to produce a BMWP score for that sample. This does not take into consideration the number of individuals from each family that are present, only family presence. BMWP can only be applied to the freshwater-dominated regions of the Tidal Thames. For this reason, the analysis is limited to the Upper Thames, though the Environment Agency conducts sampling in other areas of the Tidal Thames.

BMWP SCORE	CATEGORY
0–10	Very poor
11–40	Poor
41–70	Moderate
71–100	Good
>100	Very good

Table 1: BMWP score categories and descriptions (UKTAG WFD 2013).

Findings

BMWP annual average site scores range from 22, or 'Poor' on the BMWP chart, at the lowest (Barnes in 2014) to 121, or 'Very good', at the highest (Teddington in 2009) (Figure 3.1). Overall annual averages range from 34, which falls within the 'Poor' category, to 63, which is considered 'Moderate'. The overall annual averages show no significant long- or short-term trends.

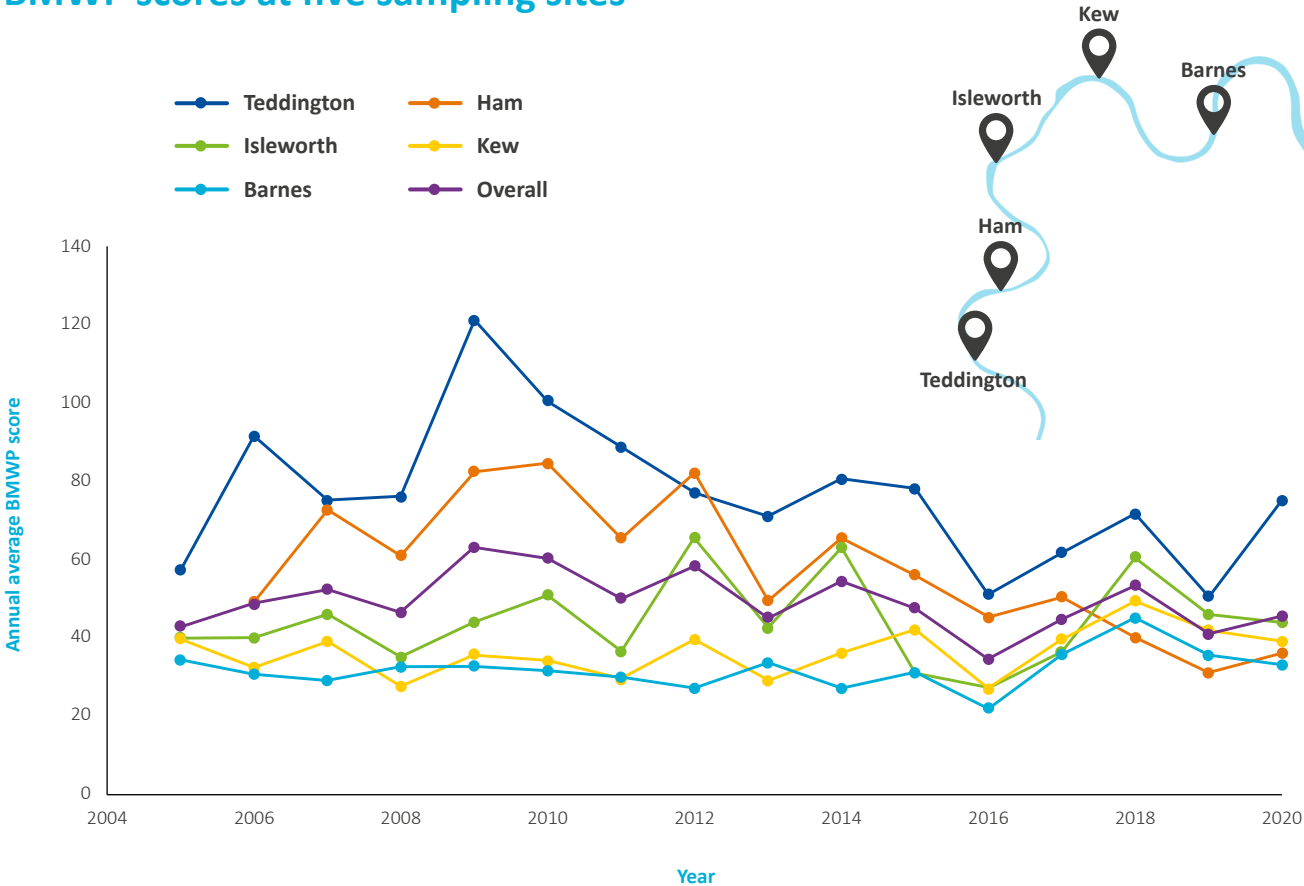
⁵ Analysis was also conducted using Whalley Hawkes Paisley Trigg (WHPT) index values, which displayed trends identical to those found by BMWP.

It must be noted that for some of the sites downstream, in a highly changeable environment, a low score does not necessarily reflect poor water quality due to pollution or degradation. The decline in BMWP scores further downstream may demonstrate the impacts of tidal influence on invertebrate communities, caused by an array of factors including changes in salinity, turbidity and/or temperature. For example, Teddington is the site furthest upstream with the most freshwater influence, and has the highest annual average BMWP score each year. Kew and Barnes are located furthest downstream and tend to have the lowest BMWP scores (Figure 3.1).

Observing how a sampling site's BMWP score changes over time may reflect localised changes to habitat or water quality. For example, Teddington and Ham have both experienced declines in BMWP score over the past 10 years. These declines could be due to changes in freshwater flows, for example due to drought. In contrast, Kew and Barnes have both experienced slight increases.

Figure 3.1: Average summer BMWP scores at five sampling sites between 2005 and 2020, as well as overall average BMWP scores. Locations of sampling sites can be seen on the reference map, with Teddington located furthest upstream.

BMWP scores at five sampling sites



CLIMATE CHANGE

The historic and continued emission of excess carbon dioxide and other greenhouse gases into the atmosphere through anthropogenic activity has increased air and water temperatures globally. It is contributing to other growing threats including habitat loss through sea level rise, ocean acidification, and increases in storm frequency and severity. It is important to monitor the direct impacts of climate change on the Tidal Thames to better understand and highlight these changes, and to plan how to protect both ecosystems and people.

Right: Southend waterfront during Storm Ciara in February 2020.



WATER TEMPERATURE



Long-term trend: Deteriorating



Short-term trend: Deteriorating

Background

The Intergovernmental Panel on Climate Change (IPCC) reports that the average sea surface temperature (SST) of the Atlantic Ocean has increased by 0.41°C in the 1950–2009 period (Hoegh-Guldberg *et al.* 2014). Change in seasonal water temperature is an important indicator of habitat quality for many estuarine species, as even very small increases can affect the growth, behaviour and distribution of wildlife. For example, some fish species such as European seabass (*Dicentrarchus labrax*) have been migrating northward to UK waters in response to warming temperatures (Pinnegar *et al.* 2017). Warmer temperatures also lead to a decrease in DO in the water column and an increase in biological oxygen demand (Najjar *et al.* 2000).

Both natural and anthropogenic factors influence the water temperature of the Tidal Thames. For instance, the tidal influence causes natural fluctuations in water temperature, while inputs of cooling water from industry lining the estuary cause localised warming. Another example of an anthropogenic

impact on temperature is the treated wastewater that is released into the Tidal Thames, which has a higher temperature than receiving waters to encourage bacterial activity that helps break down sewage. Despite the daily variability in water temperatures that the Tidal Thames experiences, analysing long-term data across the estuary can help identify general trends and the possible impacts of climate change.

Analysis

The data used for this analysis were taken from the Environment Agency's Automated Quality Monitoring System. The data collected by these sensors for the 2007–2020 period were first manually cleaned, removing periods during which any sensors were not functioning properly. The data were then compiled into two separate datasets: Upper Tidal Thames and Middle Tidal Thames. Upper Tidal Thames included six sensors located between Battersea and Kew, while Middle Tidal Thames included three sensors located between Dartford and Woolwich. Because the impacts of climate change are most likely to first be noticed in the summer and/or winter, average summer and winter temperatures for each year were calculated.⁶ Annual data were then tested for statistically significant trends using linear regression models over two different time frames: long-term (2007–2020) and short-term (2015–2020).

Findings

While linear models fitted to the data in the Middle Tidal Thames show a gradual temperature increase over time in both winter and summer water temperatures (Figures 4.3 and 4.4), these trends were not statistically significant in either the long or short term. This is likely due to deeper waters and more ocean exchange in the Middle Tidal Thames causing greater variability in temperature and no trend.

Summer and winter temperatures in the Upper Tidal Thames (Figures 4.1 and 4.2) both saw a statistically significant long-term increasing trend (summer: p-value = 0.0008, winter: p-value = 0.04). In addition, summer temperatures displayed a statistically significant increasing short-term trend (p-value = 0.03). On average, summer temperatures in the Upper Tidal Thames have been increasing by 0.19°C per year. Since an increase in water temperature is associated with degradation to aquatic ecosystems, this indicator is identified as deteriorating in both the long and short term.

⁶ Summer was defined as June, July, August and September, and winter was defined as December, January and February. Winter temperature were averaged by season, for example the winter of 2011/2012, rather than by year.

Average water temperature:
Summer in the Upper Tidal Thames

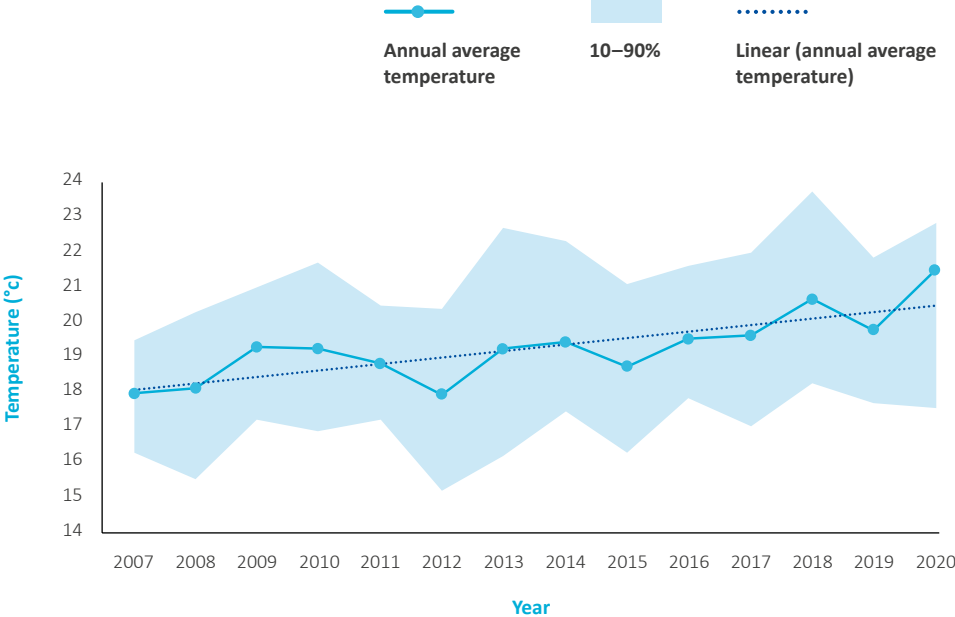


Figure 4.1: Average summer water temperature in the Upper Tidal Thames (between Battersea and Kew). The dotted line shows a linear model fitted to the data, the upper bound of the 10–90% blue area shows the 90% quantile (under which 90% of the data fall), and the lower bound of the 10–90% blue area shows the 10% quantile (above which 90% of the data fall).

Average water temperature:
Winter in the Upper Tidal Thames

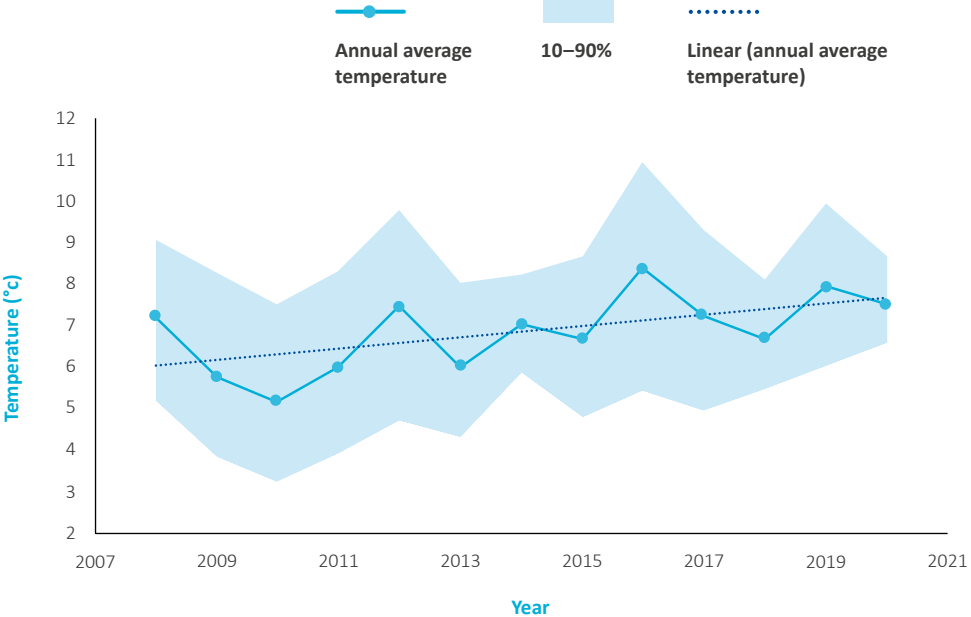


Figure 4.2: Average winter water temperature in the Upper Tidal Thames (between Battersea and Kew). The dotted line shows a linear model fitted to the data, the upper bound of the 10–90% blue area shows the 90% quantile (under which 90% of the data fall), and the lower bound of the 10–90% blue area shows the 10% quantile (above which 90% of the data fall).

Average water temperature:
Summer in the Middle Tidal Thames

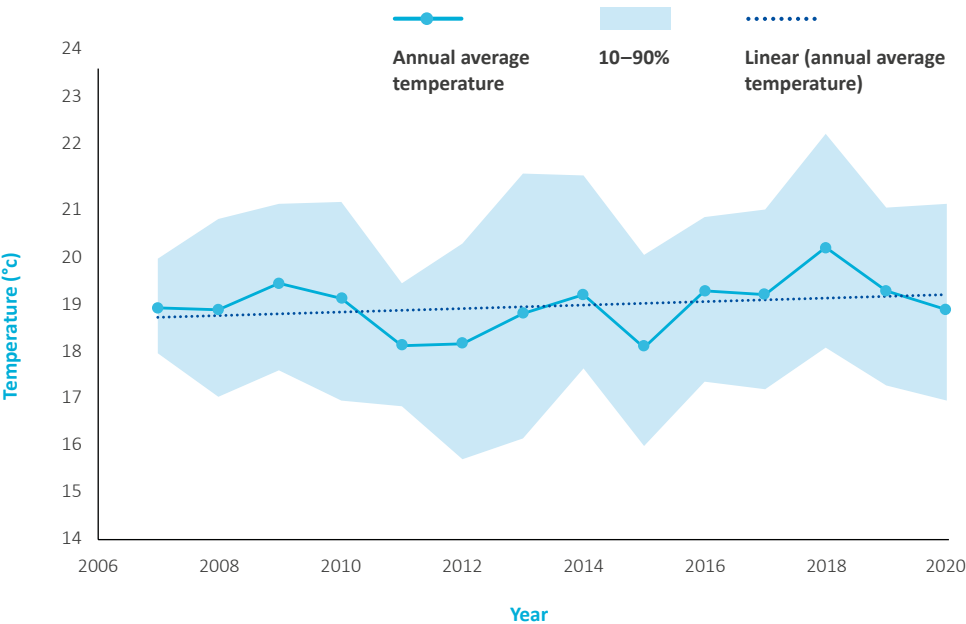


Figure 4.3: Average summer water temperature in the Middle Tidal Thames (between Dartford and Woolwich). The dotted line shows a linear model fitted to the data, the upper bound of the 10–90% blue area shows the 90% quantile (under which 90% of the data fall), and the lower bound of the 10–90% blue area shows the 10% quantile (above which 90% of the data fall).

Average water temperature:
Winter in the Middle Tidal Thames

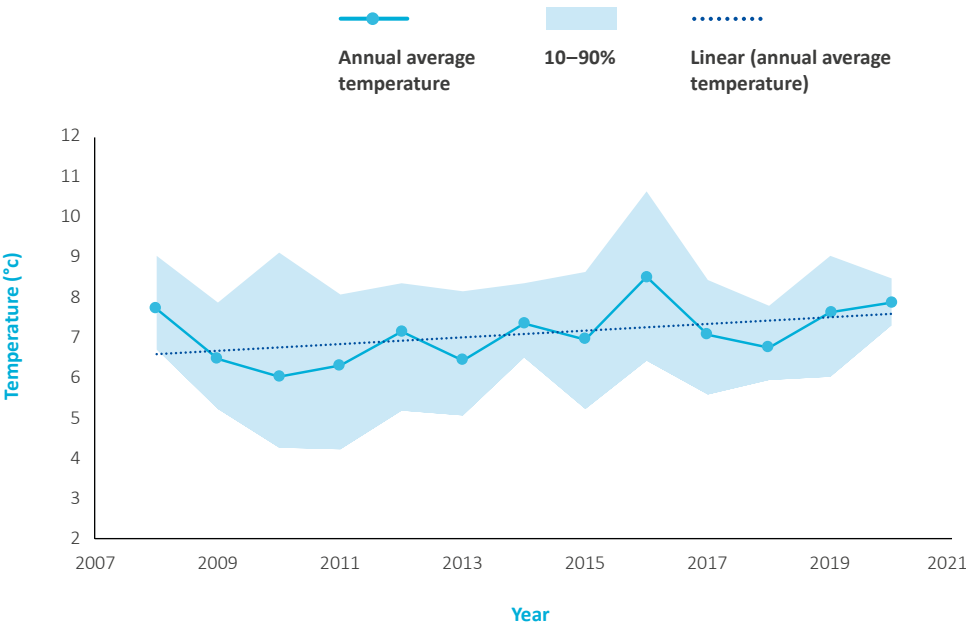


Figure 4.4: Average winter water temperature in the Middle Tidal Thames (between Dartford and Woolwich). The dotted line shows a linear model fitted to the data, the upper bound of the 10–90% blue area shows the 90% quantile (under which 90% of the data fall), and the lower bound of the 10–90% blue area shows the 10% quantile (above which 90% of the data fall).

SEA LEVEL RISE



Long-term trend: **Deteriorating**



Short-term trend: **Deteriorating**



Above: The Thames Barrier, in operation since 1982, helps protect London from flooding.

Background

Global mean sea level rise has several contributing factors, including melting glaciers and ice sheets, and thermal expansion of seawater (Oppenheimer *et al.* 2019). From 2006 to 2018, it was estimated that the global mean sea level was rising at a rate of 3.7mm per year (Fox-Kemper *et al.* 2021). This rate is observed to be increasing over time, which is projected to continue. This phenomenon not only threatens the livelihoods and infrastructure of coastal communities, but also coastal habitats such as saltmarsh, mudflats and seagrass and, in turn, the plant and wildlife populations that rely on them. In the Tidal Thames, these critical habitats have already experienced significant declines over the past century, which heightens the implications of sea level rise.

In recognition of the existing and future impacts of these threats on the Tidal Thames, the Environment Agency has established the Thames Estuary 2100 Plan. As England's first adaptive flood risk plan, it aims to monitor and respond to potential flood risks caused by climate change. This includes analysing how the estuary is changing, adapting existing flood defence structures as required, improving people's access to the river, protecting existing habitats and recreating habitats lost to rising water levels.

Analysis

Sea level rise has been monitored at fixed locations in the estuary since 1911. The data used for this analysis were

provided by the Environment Agency, which had compiled historic tide gauge site records kept by the Port of London Authority (PLA). The Environment Agency and the University of Southampton conducted the analysis for the [10-Year Review of the Thames Estuary 2100 Plan](#), as detailed in Haigh *et al.* (2020) and Environment Agency (2021). A linear model was fitted to mean sea level data at several gauging sites in the Tidal Thames from 1911 to 2018, allowing the average rate of change per year in mean sea level to be calculated for the full monitoring period. To assess whether sea level rise has accelerated in recent years, a linear model was also fitted to mean sea level data at gauging sites from 1990 to 2018. Linear trends from 1911 to 2018 were then compared with those from 1990 to 2018 at each gauging site.

Findings

The results show that sea levels have been increasing on average since monitoring began in 1911 at all gauging sites in the Tidal Thames (Figure 4.5). Comparing linear trends over the full monitoring period (1911 to 2018) with linear trends in recent years (1990 to 2018), every gauging site showed there has been an increase in the average rate of mean sea level rise per year since monitoring began. While Tilbury had the highest average rate of increase from 1911 to 2018 at 2.68 mm/year (+/-0.09), Silvertown surpassed this from 1990 to 2018 with an average rate of change of 4.26 mm/year (+/-0.62).

Change in mean sea level in the Tidal Thames

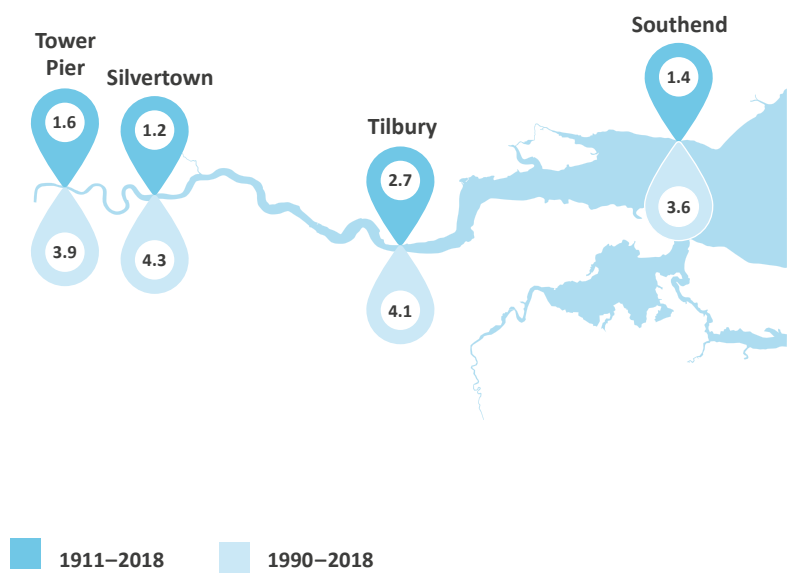
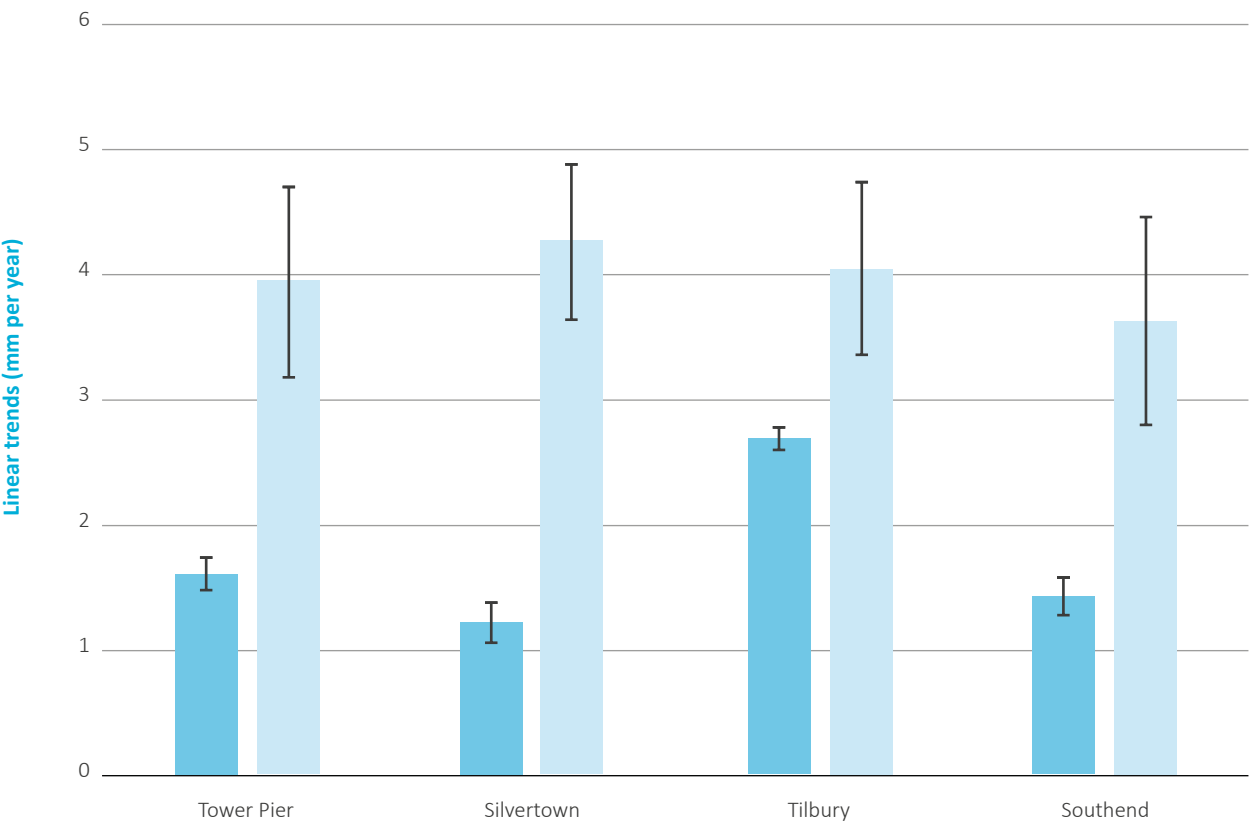


Figure 4.5: Change in mean sea level (mm per year) at four gauging stations in the Tidal Thames over two different time periods: long-term (1911–2018) and short-term (1990–2018). The positive linear trends indicate increases in mean water level at all gauging stations. Negative values would indicate decreases in mean water level.

PLASTIC POLLUTION



Long-term trend: Insufficient data



Short-term trend: **Baseline**

Plastic is the most abundant form of litter in many regions of the world because of the prevalence of single-use plastics. Most plastic pollution in the oceans originates on land, entering the oceans either directly from coastal communities or following transportation by rivers and through estuaries (Lebreton *et al.* 2017). In addition to being a hazard to navigation, plastic can be directly damaging to wildlife through ingestion or entanglement. While data that monitor plastic pollution in the Tidal Thames are relatively new, the data outlined here set an important baseline for future monitoring.

Right: Plastic bottles on the Thames foreshore.

Image credit: Clearwater Photography Copyright.



Image credit (below): Clearwater Photography Copyright.

Background

In the UK, almost 7.7 billion single-use plastic water bottles are used per year, some of which makes its way into the Tidal Thames (BRITA 2016). Some plastics found in the Tidal Thames, such as cotton buds and wet wipes, come from sewage that overflows into the Estuary. This litter not only threatens the Tidal Thames' ecosystem, but it also has a detrimental impact on the perception of the Thames as being 'dirty'. A study conducted by Sylvia Tunstall of Middlesex University in 2000 found that the public regarded litter in the river and on the foreshore as the Estuary's most serious problem (Tunstall 2000).

Significant efforts have been made to remove litter from the Thames. In 1994, the charity Thames21 was established to work with volunteers to clean up the foreshore, while the PLA has installed passive debris collectors (PDCs) in the main river to trap and remove floating litter. More recent initiatives include #OneLess, a collaboration between ZSL, Thames Estuary Partnership (TEP), Communications Inc and Forum for the Future, that aims to stop ocean plastic at source by eliminating the use of single-use plastic water bottles in London (page 39). Another initiative is the PLA's [Thames Litter Strategy](#), aiming to reduce litter on the foreshore by collaborative action involving researchers, businesses and charities, among others. While these initiatives have helped to raise awareness, engage the public and reduce the amount of litter in the Tidal Thames, plastic pollution remains a significant challenge because of the high density of people and the proliferation of single-use plastics (van der Wal *et al.* 2015).

Analysis

The data used in this analysis were taken from [Thames21's Thames River Watch programme](#), which implements litter picks designed to simultaneously dispose of litter that is polluting the river and collect valuable data about litter in the Thames.

Citizen scientists collect data using systematic transect sampling. This process involves counting the number of litter items found within a 1m² area at different sampling points along the foreshore. Once all litter items have been counted and categorised, the items are responsibly disposed of (recycled where possible). To analyse change over time in the amount of plastic, the average number of the five most common plastic items per 1m² area across all sample sites was calculated for each sample year (2015 to 2020). Because there were only five years of data, it was only possible to analyse this indicator for a short-term trend.

Findings

The most frequently found plastic-based items were cotton bud sticks, bottle lids, takeaway containers, polystyrene takeaway containers and cups (Figure 5.1). Of these items, cotton bud sticks were most common in all years, apart from 2019 and 2020. The decline in cotton bud sticks starting in 2018 could be linked to the UK Government's ban on these items. While the ban did not come into effect until October 2020, it was announced in 2019 and widely supported prior to announcement, with major UK retailers removing their sale by the end of 2017.

It is important to note that while plastics dominate some survey sites, at others wet wipe-based products are overwhelmingly the most common item found. These products, many of which contain plastic, are physically altering the foreshore along the Thames by creating large mounds of sediment densely bound together. In Barnes, one mound has grown in height by 1.4m since 2014 and covers an area of 1,000m².

In response, Thames21 has begun organising litter picks focused specifically on tackling wet wipe pollution in the river.



Plastics in the Tidal Thames

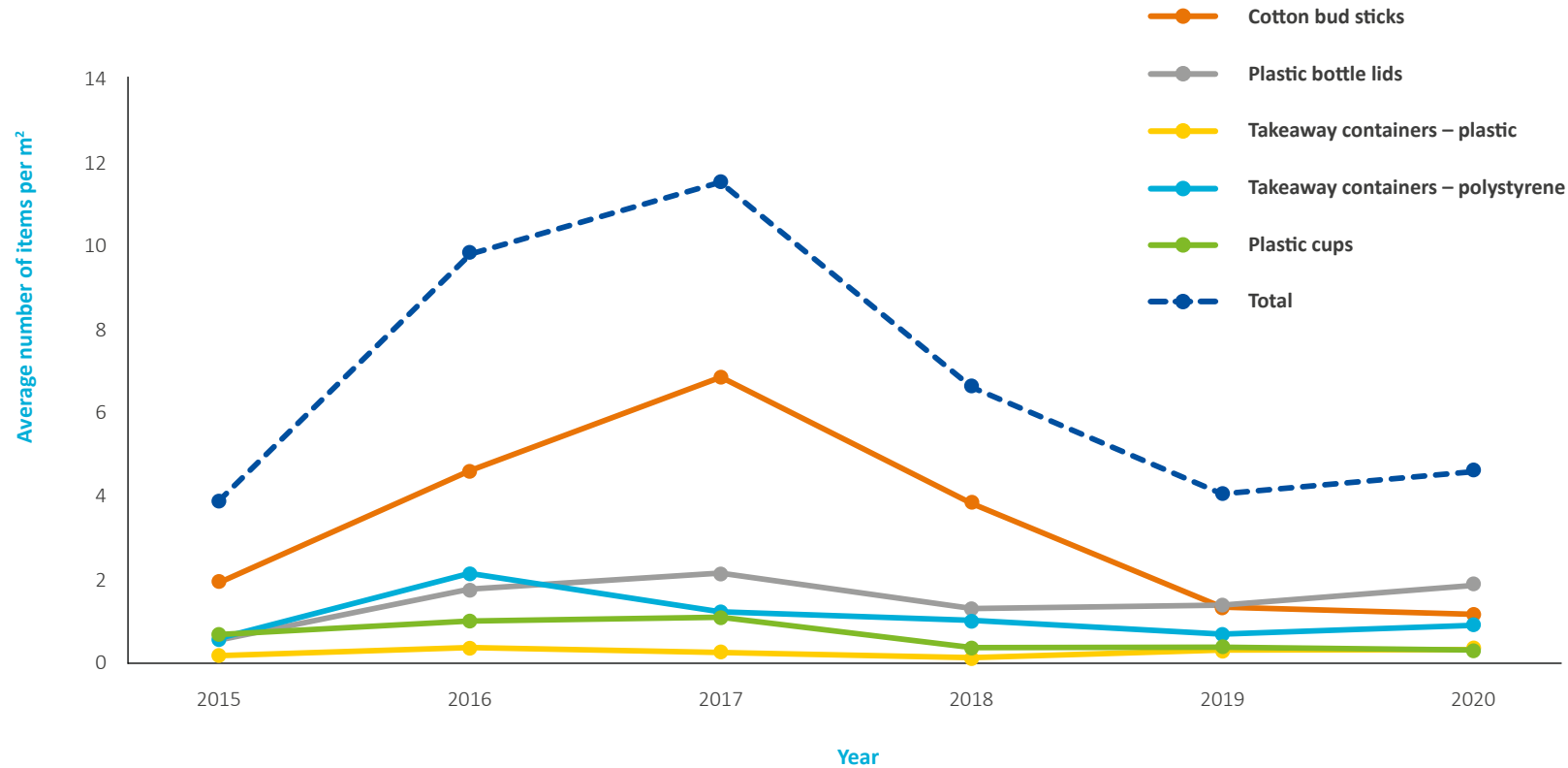


Figure 5.1: Annual average number of the five most common plastic items found per 1m^2 sampling area.

#ONELESS

Launched in 2016, [#OneLess](#) is a collaborative multi-partner project, led by ZSL, that is working to tackle ocean plastic pollution at source by focusing on the ubiquitous and unnecessary single-use plastic water bottle in London. To monitor the extent of plastic bottle pollution in the River Thames and inform policy recommendations, #OneLess partnered with Thames21's Thames River Watch programme to carry out fortnightly bottle counts at sites along the Tidal Thames. For the period 2016 to 2020, 17,770 single-use plastic bottles were counted and removed, of which nearly 50% were water bottles (Chamberlain *et al.*, in review). Initial analysis has revealed a decline in the total number of bottles collected during this monitoring period and peaks in water bottle abundance during spring and summer (Figure 5.2). Although significant differences were recorded between sites, more research is needed to establish what is driving these trends and to understand how plastic litter moves into and along the River Thames.

#OneLess bottle count findings

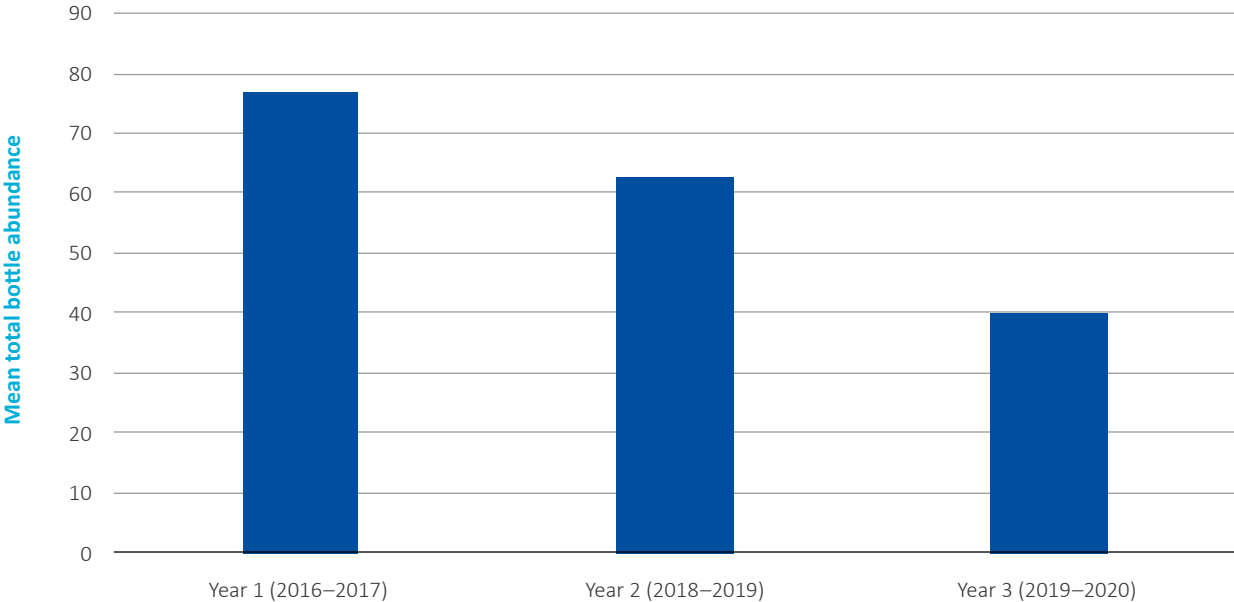


Figure 5.2: Annual average bottle abundance for each year surveyed (Chamberlain *et al.*, in review).

MICROPLASTICS

Microplastics are small plastic pieces that are a growing concern to both ecosystem and human health. They are categorised as ‘primary’ or ‘secondary’: primary microplastics are those purposefully manufactured to be microscopic, and secondary microplastics derive from the breakdown of larger plastics (Cole *et al.* 2011; Wright *et al.* 2013). These microplastics can be ingested by aquatic organisms, which poses potential physiological and toxicological threats.



A recent study published by Rowley *et al.* (2020) analysed water samples taken at two different sample sites in the Tidal Thames to estimate the density of microplastics in the river. Most of the plastics identified (95.3%) were secondary microplastics, mainly films and fragments – likely broken-down pieces of plastic bottles, food wrappers and bags. The average density of microplastics in the Tidal Thames was estimated at 19.5 plastics per m³ and, at any point in time, up to 94,000 microplastics per second are flowing down the Thames through Greenwich. This is higher than the densities estimated for five other rivers elsewhere across the globe (Figure 5.3). An earlier study in 2014 found that over 70% of sampled flounder (*Platichthys flesus*) had ingested microplastics, showing how this high density in the water column can impact wildlife (McGoran *et al.* 2017).

While further research is necessary to confirm the sources of these microplastics, water column samples could be analysed again after 2025, when the Thames Tideway Tunnel is due to be completed, to examine the contribution of sewage overflow to microplastic concentrations.

Image credit (above): Katharine Rowley

STATE OF THE ENVIRONMENT: PLASTIC POLLUTION

Microplastic density

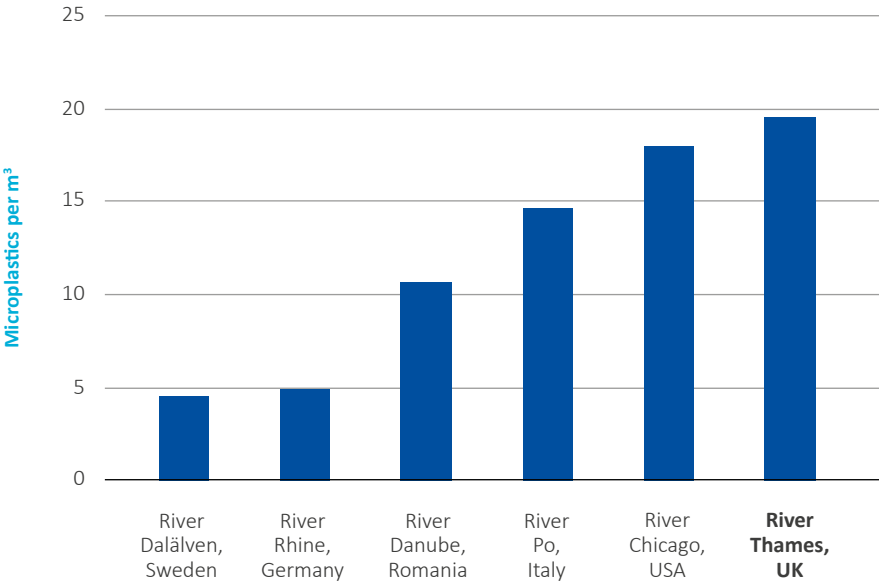


Figure 5.3: Estimates of microplastics per m³ in the Thames compared with five rivers in other regions. **References:** Rivers Dalälven, Rhine, Danube, and Po (Van der Wal *et al.* 2015), Chicago River (McCormick *et al.* 2014), and River Thames (Rowley *et al.* 2020).

CHEMICAL CONTAMINANTS



Long-term trend: Insufficient data



Short-term trend: Insufficient data

A multitude of chemicals are used in industry or in the homes of people living in the Thames catchment, many of which find their way into rivers. A small number of these can be classed as chemical contaminants, which generally refers to chemicals that have come to attention as posing harm to ecosystems and/or humans. Monitoring and controlling these substances, while challenging, is essential to protect the vitality of the Tidal Thames.

Right: Examples of two chemical contaminants that have been found in the Tidal Thames. There are many different sources of chemical contaminants, which can impact different parts of the ecosystem.



Background

While several substances were regulated on an ad-hoc basis in the 1980s, consistent monitoring for chemical contaminants in England only began in 2001 with the introduction of the EU WFD. The WFD’s Priority Substance Directive includes a list of substances that have been identified as harmful to humans and the environment. In England, monitoring for these substances is conducted by the Environment Agency. If one or more of these substances is discovered in levels deemed to be dangerous, the waterbody will ‘fail’ in water quality, and measures must be put in place to reduce contaminant concentrations.

Chemicals that are damaging to the aquatic environment but that are not necessarily a risk to human health may be overlooked because, when identifying priority substances, the WFD places more weight on chemicals that are dangerous to human health. For example, of the top 10 chemicals ranked by the threat they pose purely to aquatic organisms as defined by Johnson *et al.* (2017) (Table 2), only four are currently considered a priority substance under the WFD (copper, zinc, iron and chlorpyrifos). As a result, many of these chemicals go unmonitored in most river systems including the Tidal Thames, except on an irregular basis.

RANKING	CHEMICAL	CATEGORY	WFD PRIORITY SUBSTANCE?
1.	Copper	Metal	Yes
2.	Aluminium	Metal	No
3.	Zinc	Metal	Yes
4.	17α-ethynylestradiol (EE2)	Medicinal	No
5.	Linear alkylbenzene sulfonates (LAS)	Personal care/consumer products	No
6.	Triclosan	Personal care/consumer products	No
7.	Manganese	Metal	No
8.	Iron	Metal	Yes
9.	Methomyl	Agricultural	No
10.	Chlorpyrifos	Agricultural	Yes

Table 2: The top 10 highly ranked chemicals of concern, based on Johnson *et al.* 2017’s methodology using the ratio of medians of all ecotoxicity data.

TRIBUTYLTIN

According to the Environment Agency's WFD 'Reasons for not Achieving Good Status' data, the only priority substance found in the Tidal Thames since 2014 (earliest available data) at dangerous levels was tributyltin (TBT) compounds. Until it was banned globally in 2001 because of its serious impacts on wildlife, TBT was used as a biocide in anti-fouling paint to prevent the growth of algae and barnacles on the hulls of ships, quayside constructions and fishing nets. After TBT was banned and removed from the market, concentrations in the Tidal Thames reduced dramatically. Figure 6.1 displays Environment Agency TBT monitoring data from 1997 to 2018.

Despite the improvements displayed by the monitoring data, TBT has persisted in the Tidal Thames at dangerous concentrations according to the WFD. Most recently, in 2016 several monitoring sites in the Tidal Thames 'failed' under the WFD because of high concentrations of TBT. This demonstrates the persistent danger of harmful chemicals that enter our waters, and the need for consistent monitoring.

Annual average TBT levels in the Tidal Thames

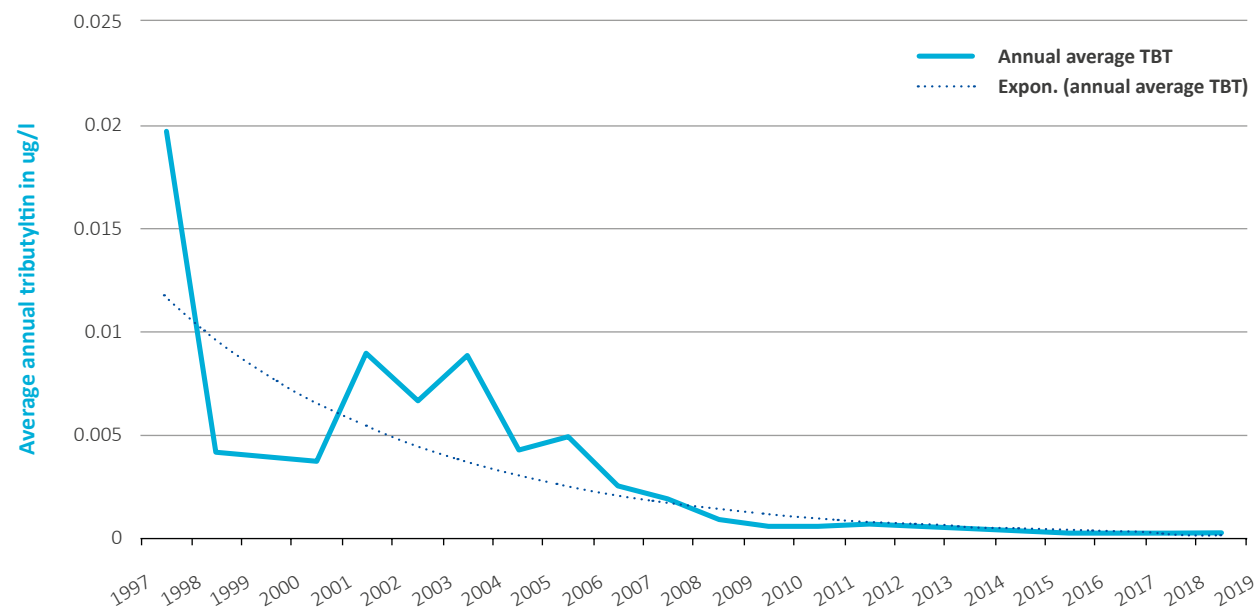


Figure 6.1: Annual average TBT levels using monitoring data from across the entire Tidal Thames. The blue line shows annual average values, while the dotted line shows an exponential model fitted to the data.

STATE OF NATURE



“

A resilient future for both people and wildlife will depend on protecting remaining natural habitats, reconnecting and restoring habitats, and innovating new ways to maximise opportunities for wildlife in the urban environment.

Estuaries are some of the most productive ecosystems on the planet. Rich in nutrients that feed the food chain, they also provide a variety of habitats for a range of species, and thus support a wealth of biodiversity.

The importance of these habitats to the Thames and to the species they support is largely invisible, yet they underpin vital ecosystem services such as water quality regulation, food production, natural flood defences and carbon sequestration.

Estuaries have also long been the focus of human settlement and industry. Consequently, the Tidal Thames is much altered from its natural state. Despite this, it still contains many valuable, varied habitats that are critical for a diverse array of wildlife that co-exists successfully with people. A resilient future for both people and wildlife will depend on protecting remaining natural habitats, reconnecting and restoring habitats, and innovating new ways to maximise opportunities for wildlife in the urban environment.

This section describes the current state of nature. **The ambition is for the Tidal Thames to function ecologically, providing resilient and connected habitats that enable wildlife to thrive.**



Above: A juvenile short-snouted seahorse (*Hippocampus hippocampus*) found in 2017 at Greenwich during juvenile fish surveys. It is believed that this species is resident in the Thames. The presence of this sensitive species indicates that the Tidal Thames is a recovering estuarine ecosystem.

HABITATS

Estuaries are where rivers meet the sea, making them uniquely important natural features. Tidal dynamics and the influence of fresh and marine water make for a rich mix of subtidal, intertidal and terrestrial habitats. The Thames upstream of Hammersmith tends to be freshwater, between Hammersmith and Greenwich tends to be slightly saline or brackish, and downstream of Greenwich is marine.

While this environmental variance creates a complex network of diverse and internationally important habitats within the Tidal Thames, these habitats have faced significant loss. Two of the main contributing factors are i) land claim for infrastructure and development and ii) the building of flood defences, disconnecting land from the river. As a result, the Tidal Thames in central London is thought to be one third of its original width. In the face of this decline, it is essential that the remaining extent of these internationally important habitats are protected, and that efforts are made to restore as much natural habitat as possible.



HABITAT CONSERVATION



Long-term trend: **Deteriorating**



Short-term trend: **Improving**



Above: Saltmarsh in Leigh National Nature Reserve, Essex.

Background

One way to cultivate ecosystem resilience is through conserving existing habitat extent. This involves efforts to ensure that the quality and footprint of remaining natural habitat are maintained and, if possible, increased by providing legal protection against development pressures. Formal protection efforts primarily include designating sites as Sites of Importance for Nature Conservation (SINCs), Sites of Special Scientific Interest (SSSIs), Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and Marine Conservation Zones (MCZs), among others. There are 15,531ha of SSSIs, four SPAs, two SACs and one MCZ all partially or wholly in the Tidal Thames, along with other local nature reserves (Port of London Authority n.d.).

Quantifying change in habitat extent over the past century, including before and after protections were introduced, is one way to assess the effectiveness of habitat protection efforts. There are robust data showing change in saltmarsh extent which, as a sensitive coastal and estuarine habitat, provides a suitable example.

Saltmarsh

Saltmarsh is a dynamic, intertidal habitat and critical resource for many species. For this reason, it has been identified as a priority habitat by the UK Government. There are several priority species associated with saltmarsh in the Tidal Thames, such as the saltmarsh shortspur beetle (*Anisodactylus poeciloides*), juvenile fish including European seabass, and wading birds such as the dunlin (*Calidris alpina*). As a coastal habitat sensitive to anthropogenic pressures, saltmarsh across the UK has been in decline for many years: 85% of UK saltmarsh has been lost since the 1800s through a combination of pressures (RPA 2020). The

following analysis investigates the change in saltmarsh extent within the Tidal Thames over the past 100 years.

Analysis

UK saltmarsh extent has been mapped periodically throughout history. To track change over time, Tidal Thames saltmarsh maps from four different data collection periods were compared:

1. Historic saltmarsh extent mapped from 1888 to 1913 (Ordnance Survey maps from National Library of Scotland digital georeferenced map database⁷)
2. Historic saltmarsh extent mapped from 1944 to 1968 (Ordnance Survey maps from National Library of Scotland digital georeferenced map database)
3. Saltmarsh extent mapped from 2004 to 2011 (Environment Agency, using aerial imagery)
4. Most recent saltmarsh extent mapped from 2012 to 2018⁸ (Environment Agency, using aerial imagery)

⁷ Data from the National Library of Scotland were originally in the form of historic ordnance survey maps. Using QGIS, the areas of saltmarsh in the Tidal Thames were replicated into QGIS polygons. This process was completed for two sets of maps, the earliest available dating from 1888 to 1913, and the other from 1944 to 1968.

⁸ To focus this analysis on habitat conservation, these data excluded any restored saltmarsh area.

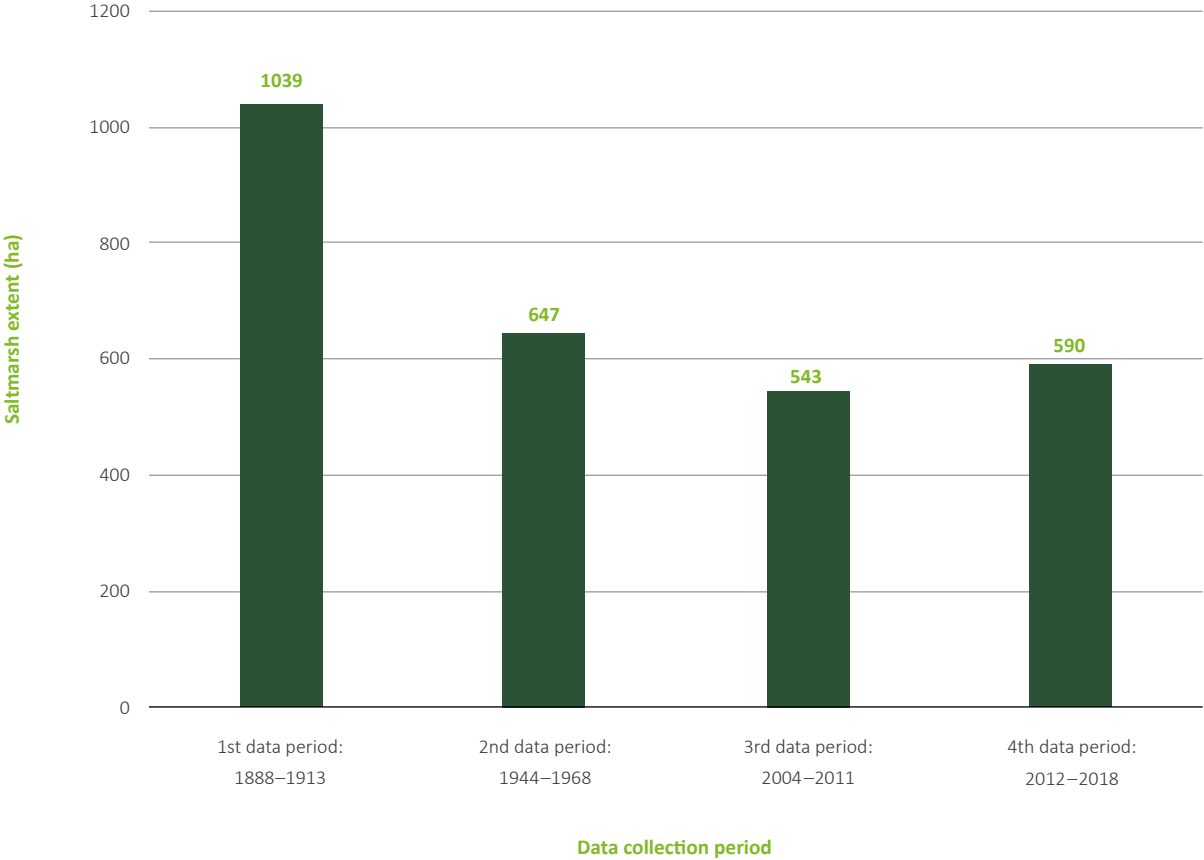
The total saltmarsh area for each data collection period was then calculated. The total areas for each of the four time frames were compared with one another to determine the area of saltmarsh lost during each timestep.

Findings

The findings show that during the first data collection period (1888 to 1913), there were 1,039ha of saltmarsh in the Tidal Thames (Figure 7.1). By 1944 to 1968, this had dropped by 37% to 647ha. At this time, few sites had been designated as protected areas, and the building of bunds and coastal defences that disconnected the marsh from the estuary contributed largely to saltmarsh decline. In 2004 to 2011, saltmarsh area was found to have dropped by a further 16% to 543ha since the 1944 to 1968 mapping. The fourth data collection period (2012 to 2018) shows an 8% increase in saltmarsh area, with total area found to be 590ha. This observed increase in recent years suggests that existing habitat protection could be contributing to a gradual increase in saltmarsh area.

Figure 7.1: Total saltmarsh extent in the Tidal Thames during each of the four data collection periods (1888–1913, 1944–1968, 2004–2011, and 2012–2018).

Saltmarsh extent in the Tidal Thames



HABITAT RESTORATION AND CREATION



Long-term trend: Insufficient data



Short-term trend: Baseline



Above: The North Greenwich Peninsula Terraces, constructed on the foreshore in front of the O2 in 1997, represent successful implementation of Estuary Edges principles. **Image credit:** Courtesy of Thames Estuary Partnership.

Background

In the highly urbanised, modified environment of the Tidal Thames, one of the ways to build ecosystem resilience is through habitat restoration and creation. Increasing space for nature in an urbanised estuary involves making space for water by softening built flood defences to work with nature-based solutions or natural processes where possible. Due to the limited number of such projects in the Tidal Thames, and the variation between project types, calculating a metric that demonstrates restoration progress is difficult. Instead, notable efforts of habitat restoration and creation in the Tidal Thames are highlighted and described below.

Habitat creation: Salt Fleet Flats Reserve

Habitat creation projects are sometimes used to compensate for habitat destruction or depletion caused by development within estuaries. One such example in the Tidal Thames is Salt Fleet Flats Reserve, located near the mouth of the Thames on its southern bank. This intertidal habitat, including 59ha of mudflats and 6ha of saltmarsh, was created by DP World to compensate for habitat removed when constructing DP World London Gateway Port (DP World 2016). Finished in 2016, the reserve has since become an important habitat for a range of wading birds. This project, in which the sea wall was breached and the tidal influence transformed the area back into intertidal habitat, is a successful example of managed realignment in the Tidal Thames.

Habitat creation: Estuary Edges

The area of the Tidal Thames between high water and low water includes a range of habitats that support diverse invertebrates that provide food for fish and birds. As well as foraging in these areas, fish also use them as refuges from

predation, for spawning and as rest areas from strong tidal flows. However, these important natural areas have been massively reduced by historic and ongoing development along the river. This encroachment has led to a loss of foreshore and an increase in tidal current, which can be so strong that it challenges a fish's ability to swim against it.

Riverside developers are being encouraged to incorporate bio-engineered solutions to mimic foreshore habitat and encourage vegetation growth into both new designs and existing Thames-side infrastructure, thereby creating 'stepping stones' for migrating wildlife. These efforts have been led by organisations including the TEP, PLA, Environment Agency, Jacobs, Tideway, the Institute of Fisheries Management (IFM) and ZSL, which have collaborated on a project called [Estuary Edges](#).

Estuary Edges provides guidance for planners and developers to maximise the biodiversity value of infrastructure, for example by setting back flood defences to allow space for intertidal terraces or by replacing concrete or brick with materials that allow vegetation to grow. There are now 17 Estuary Edges sites in the Tidal Thames, including the successful example of North Greenwich Peninsula Terraces that were constructed on the foreshore just in front of the O2 Arena in 1997. These terraces were created by setting flood defences back 10m and planting native saltmarsh species. The first ecological surveys were carried out by TEP, Institute for Fisheries Management (IFM), and ZSL in 2017 as part of a review of the design guidance. With surveys difficult to finance, TEP is leading student and community training programmes to ensure the sites can be monitored annually for fish and flora, with plans to expand to invertebrates and birds.

INVASIVE SPECIES

As a highly disturbed environment, the Tidal Thames has become susceptible to the settlement of invasive non native species (INNS). A total of 96 non-indigenous freshwater species were identified in the entire Thames catchment between 1800 and 2010, at an average invasion rate of 0.43 species per year (Jackson & Grey 2012). While some introduced species cause no apparent harm to the ecosystems they occupy, others can sometimes be associated with damaging impacts such as disease introduction and species hybridisation. Among the invasive species that have become prominent in the Tidal Thames are the zebra mussel (*Dreissena polymorpha*), the quagga mussel (*Dreissena rostriformis bugensis*), and the Chinese mitten crab (*Eriocheir sinensis*), pictured right.

The various pressures facing this environment make it difficult to measure the direct impacts of invasive species. However, the presence and spread of several invasive non-native species highlights the vulnerability of the Tidal Thames. Healthy, diverse ecosystems are more resistant to the risks posed by introduced species (Didham *et al.* 2005). Therefore, efforts to improve habitat quality, increase habitat extent and strengthen ecosystem function will help protect the Tidal Thames from these threats.



BLUE CARBON

Harmful levels of carbon are being emitted into the atmosphere through the burning of fossil fuels. At the same time, however, carbon is being removed from the environment and stored in soils, plants and sediments through a process called carbon sequestration. Although carbon is sequestered at a much slower rate than it is emitted, this process can help reduce the harmful impacts of carbon emission on the global climate.

‘Blue carbon’ refers specifically to carbon that is captured and stored in coastal and marine ecosystems. Its role in climate change mitigation has been recognised globally, with vegetated aquatic ecosystems such as tidal marshes, seagrass meadows and mangrove forests sequestering and storing more carbon (per unit area) than terrestrial forests. Sediments have been found to store carbon 10 times more rapidly than terrestrial sediments and, if undisturbed, can store this carbon for thousands of years (National Ocean Service 2020).

Tidal Thames habitats, such as mudflats, wetlands, tidal marshes, reedbeds and saltmarsh, are currently acting as critical blue carbon stores. Their role in offsetting the damaging impacts of human activities makes these habitats even more valuable and further justifies their protection. This role also contributes to the social and economic benefits of restoring these habitats in the Tidal Thames and their value for biodiversity.



NEW TECHNIQUES IN HABITAT RESTORATION

It is now accepted that marine protection is not enough to turn the tide for ecosystem recovery. Early restoration projects have proven to be successful in improving species abundance and diversity, as well as providing nature-based solutions to address socio-economic challenges. The year 2021 marks the start of the United Nations Decade on Ecosystem Restoration, which is a great opportunity for the Tidal Thames to showcase examples of successful habitat restoration.

Many restoration techniques that are being used all over the UK present promising possibilities for use in the Tidal Thames. One such technique has already been implemented in the Tidal Thames to restore saltmarsh. The Essex Wildlife Trust has used managed realignment, a technique in which a built flood defense structure is breached, at Two Tree Island near Leigh-on-Sea to restore saltmarsh that had been lost. In other areas of the UK, advances have been made in the restoration of sublittoral marine habitats such as oyster reefs and seagrass. The Essex Native Oyster Restoration Initiative (ENORI) is a collaborative project chaired by ZSL involving conservation organisations, academia, government and the local oyster industry. This project is restoring native oyster habitat off the coast of Mersea Island in Essex, Greater Thames Estuary, by laying down large piles of cultch (old shell and gravel) on the seabed to provide settlement substrate and encourage young oysters from a protected broodstock to settle.

In the freshwater zone, there is also great potential to restore priority habitats such as marginal wetlands and wet woodland habitats. The Thames Landscape Strategy (TLS) is championing the restoration of these habitats through the Rewilding Arcadia project, which is reconnecting the floodplain with the Tidal Thames. In addition, backwater habitats will be created, providing new spaces for invertebrates, fish and vegetation.



Above: Cultch being deployed in the Blackwater, Mersea Island, Essex. **Image credit:** Courtesy of ENORI.

CONNECTIVITY



Long-term trend: Insufficient data⁹



Short-term trend: **Baseline**

A healthy, thriving estuarine system maintains connectivity into both freshwater tributaries and marginal wetlands, allowing aquatic species to move freely at all life stages to find essential feeding and breeding grounds and shelter from predation. Barriers to connectivity can have detrimental consequences for aquatic life, such as limiting essential migration routes for some fish. There are 13 tributaries that flow into the Tidal Thames and many adjacent wetlands stretch along its length, both of which provide vital habitats for fish and other wildlife (Attrill ed. 1998). This section assesses the extent to which connectivity within the Tidal Thames river system has been disrupted.

⁹ While there are substantial eel recruitment data for the Thames tributaries, it is difficult to link that information to connectivity. The barrier and pass data used here are not a time-series, meaning that trends could not be calculated.

Right: Eel pass at Lea Bridge under construction in July 2020.



Background

Species are considered anadromous if they migrate from marine waters into freshwater rivers to spawn, such as sea trout (*Salmo trutta morpha trutta*). Other species such as the European eel are catadromous, maturing in freshwater habitats before migrating to the ocean to spawn. Loss of connectivity between these freshwater, coastal and marine habitats poses a direct threat to the life cycle of such fish.

Barriers to river connectivity can also have damaging impacts on localised species such as bream (*Abramis brama*), and can prevent some species of juvenile fish from accessing essential nursery habitats, for example European smelt. These disruptions to the ecology of both migratory and non-migratory species can lead to fish population declines, which have broader implications throughout the food chain.

The Tidal Thames and its associated tributaries and wetlands are characterised by heavy river engineering. While effective at protecting the surrounding communities from damage caused by flooding, these barriers can have detrimental impacts on aquatic processes and biodiversity by limiting access to essential habitats. In response, fish passes have been built alongside some dams, weirs and sluices to provide safe passage for fish. Given the morphological differences between eels and other fish species, separate eel passes are constructed with crawling media that allow for eels to migrate upstream. In the Tidal Thames, organisations including the Environment Agency, South East

Rivers Trust (SERT) and ZSL have been working to install these passes and have been tracking their success through species monitoring programmes.

Analysis

To assess the connectivity between the Tidal Thames and its major freshwater tributaries, the length of each tributary open to a) eel migration and b) migration of other fish species (hereinafter referred to as 'multispecies fish') was calculated. This was done by identifying the first barrier on each tributary impassable to each. To conduct this analysis, data from the TEP's Greater Thames Estuary Fish Migration Roadmap database were used, as well as additional information from local conservation organisations including South East Rivers Trust, the Environment Agency and Thames21.

Findings

The results for eel connectivity show that, in total, about 230km of tributaries are connected to the Tidal Thames for eel migration. Of the 13 tributaries of the Tidal Thames, five have barriers impassable to eels at the confluence with the Thames

(Figure 8.1). Results for multispecies fish connectivity show that a total of about 87km of unrestricted tributary length is open to migration of other species of fish from the Tidal Thames. Six tributaries have impassable barriers at or very near the confluence with the Thames (Figure 8.2).



Existing connectivity can be largely attributed to passes that have been installed, especially for eels. There are 29 eel passes that help to connect the Tidal Thames to its tributaries, and three multispecies fish passes. Efforts to identify impassable barriers for eels and other fish species, and to install passes on the Thames and its tributaries, are ongoing.

While not included in the above analysis due to a lack of data, it is important to consider the impacts that tidal sluices can have by preventing fish from accessing essential marginal wetland habitats that run the length of the Tidal Thames.

Should the data become available, future connectivity analysis should also include tidal sluices that limit the access of aquatic wildlife to wetlands.

Above: Multispecies fish pass on the Hogsmill, installed by SERT (contractor Land & Water) in 2018. This pool pass solution was one of several passes installed to restore passage across a heavily modified section of channel. **Image credit:** Courtesy of SERT.

Eel connectivity

● First barrier impassable to eels

◆ Barrier with eel pass

— River open to eel migration

- 1 River Crane
- 2 River Brent
- 3 River Lea
- 4 River Roding
- 5 River Beam
- 6 River Ingrebourne
- 7 Mardyke
- 8 River Darent
- 9 River Cray
- 10 River Quaggy
- 11 River Ravensbourne
- 12 River Wandle
- 13 Beverley Brook

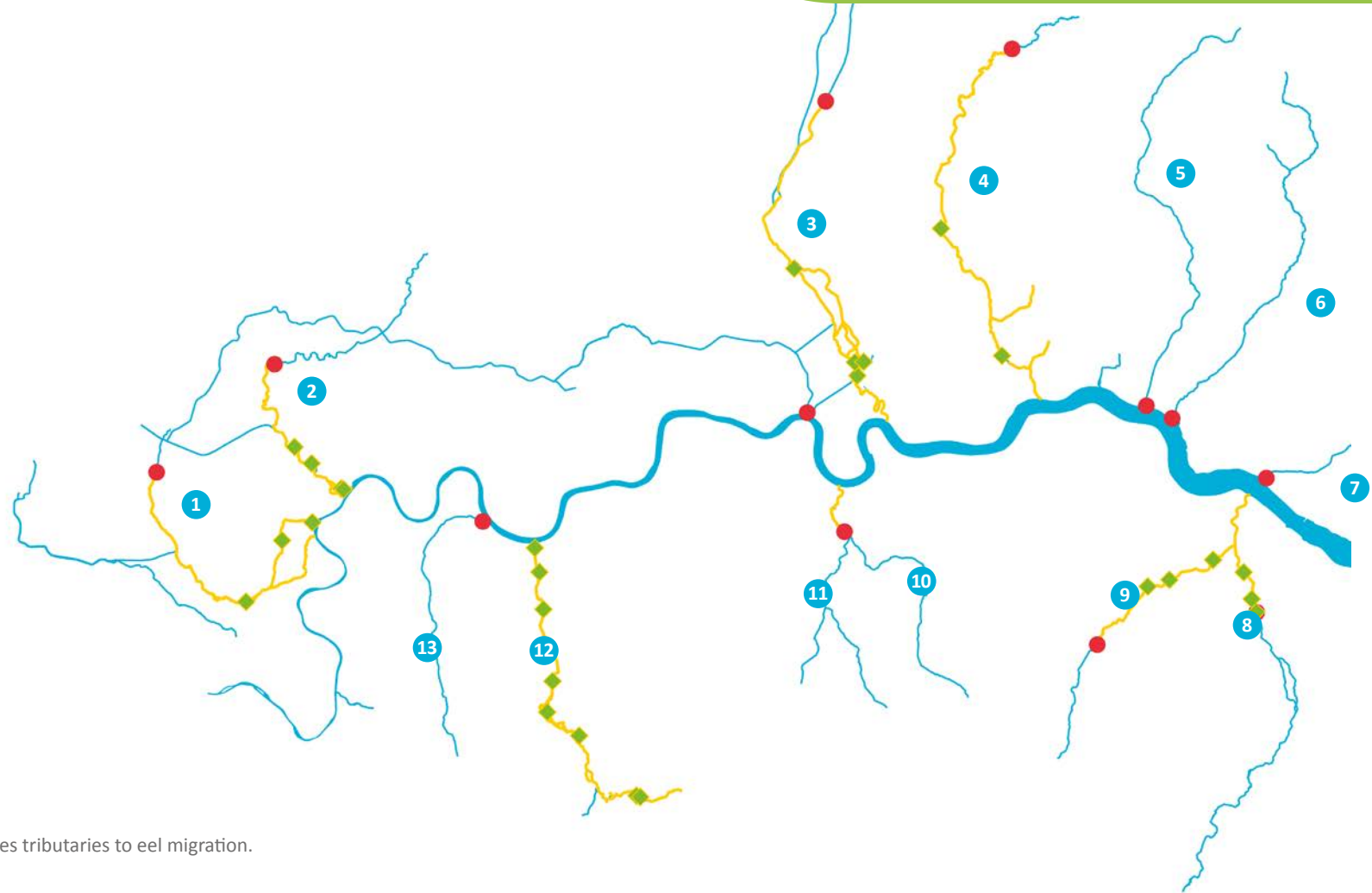


Figure 8.1: Connectivity of Tidal Thames tributaries to eel migration.

Multispecies fish connectivity

- First barrier impassable to multispecies fish
- ◆ Barrier with multispecies fish pass
- River open to multispecies fish migration

- 1 River Crane
- 2 River Brent
- 3 River Lea
- 4 River Roding
- 5 River Beam
- 6 River Ingrebourne
- 7 Mardyke
- 8 River Darent
- 9 River Cray
- 10 River Quaggy
- 11 River Ravensbourne
- 12 River Wandle
- 13 Beverley Brook

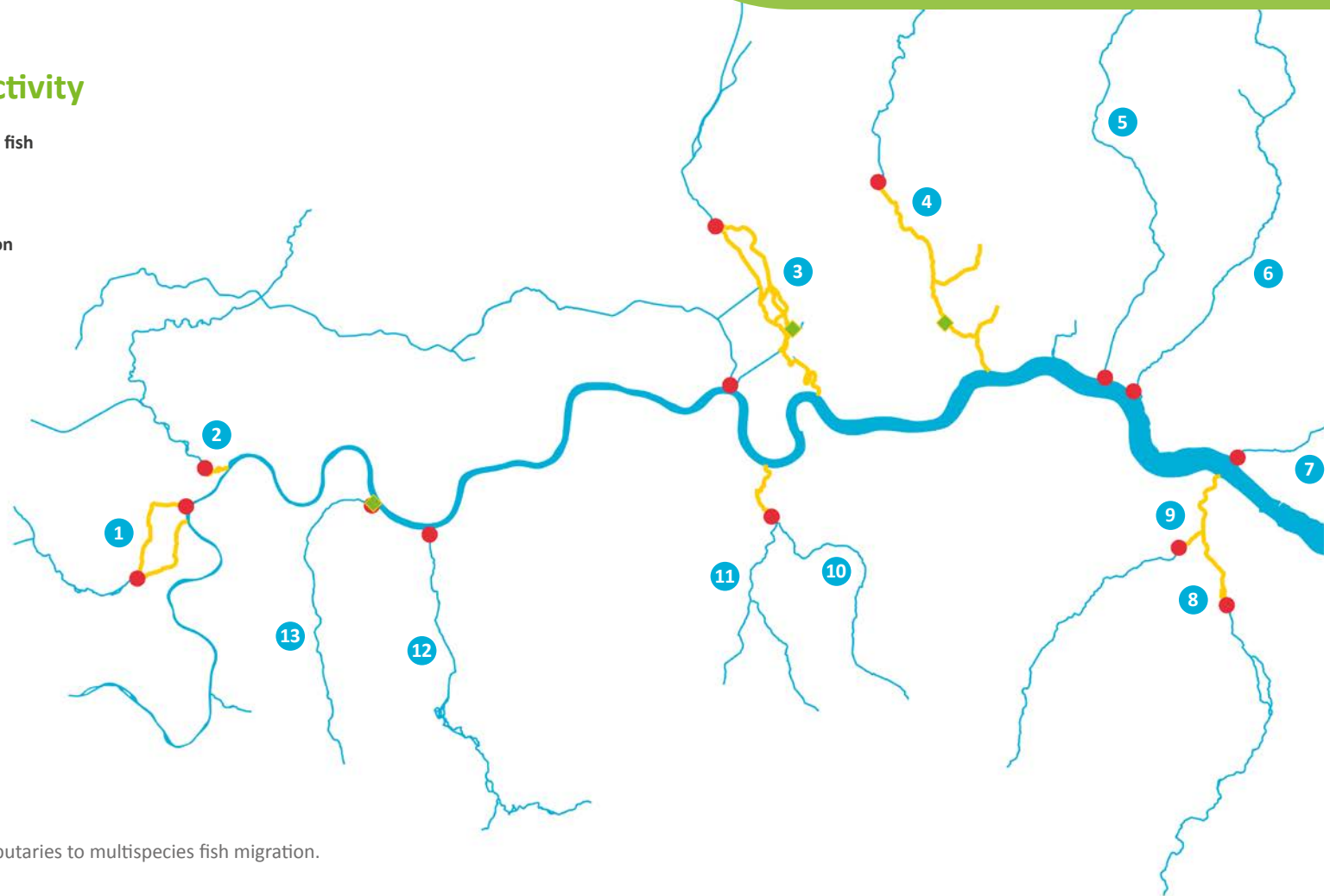


Figure 8.2: Connectivity of Tidal Thames tributaries to multispecies fish migration.

EUROPEAN EEL

The European eel is an iconic migratory species, spawning in the Sargasso Sea before making its way to rivers such as the Tidal Thames and its tributaries to mature. Recruitment, i.e. the number of new arrivals joining the population, has shown significant and concerning declines since the 1980s. This has led to the International Union for Conservation of Nature (IUCN) classifying the species as Critically Endangered.

Due to its behaviour and life cycle, the European eel is heavily dependent upon connectivity. Human-made structures in the Thames and its tributaries can consequently add significant barriers to eel movement between freshwater and marine environments. To help understand the spatial and temporal distribution of eel migration throughout the Thames River Basin District, ZSL has been coordinating the upstream monitoring of eel migration with the help of many volunteer citizen scientists. Monitoring data are fed into the Environment Agency's Thames Eel Management Plan, which identifies the priority locations where connectivity needs to be restored. ZSL works closely with the Environment Agency and other stakeholders to restore connectivity for eels by building eel passes in priority locations. Since 2010, a total of 104 eel passes have been constructed at high-priority sites within the Thames River Basin District.

Right: A glass eel, which is one of the early phases of the European eel's life cycle, on the gravel foreshore.



FISH



Long-term trend: **Deteriorating**¹⁰



Short-term trend: **Data stable**

Estuarine environments such as the Tidal Thames play a critical role in the life cycle of many fish species. For some species, estuaries provide a nursery habitat with plenty of food and protection during early life stages. Others pass through estuaries, either up into freshwater or out to sea during migration, while a small number are adapted to spending their entire life cycle in the dynamic estuarine environment. As fish are a critical component of the estuarine food web, their abundance, diversity and distribution in an estuary can help assess its ecological status and resilience.

¹⁰ While the data analysed for this section resulted in a deteriorating long term trend, it is important to note that the number of fish species have increased from 0 in 1957 when the Tidal Thames was declared biologically dead, to over 115 fish species in recent years.

Right: Environment Agency seine net sampling on the Thames to assess fish populations.



Background

The Tidal Thames once had a thriving fishery supporting bankside fishing communities. However, the decline in water quality made the Tidal Thames inhospitable to most species, and from 1920 to 1964, fish were largely absent from Fulham downriver to Tilbury (Attrill ed. 1998). Improvements to water quality since the 1960s have facilitated the return of both resident and migratory fish species to the Tidal Thames, enabling them to thrive in the Thames' critical habitats.

ZSL has been working with the Environment Agency, Bournemouth University and the Institute of Fisheries Management to undertake fish surveys on early-life-history stages to understand where, when and how fish spawn in the Tidal Thames, and how larvae and juveniles use the estuary. The main findings of the study, funded by Tideway, are that the Tidal Thames acts as a nursery ground for over 20 species of fish, which use the whole of the estuary, including both mid-stream waters and estuary margins (Zoological Society of London 2019). This evidence shows the critical need to manage and protect these habitats using management strategies such as essential fish habitat ([page 63](#)).

Analysis

The Environment Agency has been monitoring fish in the Tidal Thames since the 1970s using mixed sampling methods. The associated data were used to analyse changes in fish species' diversity in the Tidal Thames. To account for the variability caused by different sampling methods, this analysis focuses on one of these methods, seine net sampling, which began in 1989.

Seine nets are long rectangular nets that, when in the water, form a semi-circle, with someone holding each end. To further account for varying numbers of samples between years, the annual average number of species per sample was calculated. Finally, to determine whether different areas of the Tidal Thames (Lower, Middle, Upper, Figure 9.1) experienced different trends over time, each area was analysed separately.

Findings

Seine net samples in the Lower Tidal Thames had only been taken for the last five years of the full data range (2010 to 2015), and the average number of species per sample for the Lower Tidal Thames over these five years showed stable data. Therefore, species per sample are plotted for only the Middle and Upper Tidal Thames. Overall average species per sample across all years for Lower Tidal Thames was 4.35, Middle was 5.37, and Upper was 4.92.

The plotted data show a general decline in species per sample in both the Middle and Upper Thames. While there is considerable variability in the data, linear models fitted to the data show a gradual decline over time. Long-term (1989–2015) and short-term (2006–2015) trends were calculated using linear regression with the combined data for the whole Tidal Thames. There was a

statistically significant long-term trend (p -value = 0.002) showing a decline in number of species per sample. However, there was no statistically significant short-term trend (p -value = 0.21) suggesting data has stabilised. While the slight long-term decline in species per sample might be due to changes in sampling methods, it could be an indication of pressures on

fish populations either in the Tidal Thames, or further afield. While the data analysed here reflects a long-term decline, there have been great improvements in fish diversity and abundance since 1957 when stretches of the river were declared biologically dead, and very few species were present. Since then, there have been over 115 fish species recorded in the Tidal Thames, which is a promising indication of ecosystem recovery.

Due largely to the complexities of gathering data in the challenging dynamic environments of estuaries, they are relatively understudied compared with other ecosystems. This has led to a significant need for more evidence to improve our understanding of the critical role that estuaries play in supporting fish communities, particularly for early life stages. A better understanding of the ecology of young fish in estuaries is necessary to develop restoration and conservation programmes.



Above: Adult female dace (*Leuciscus leuciscus*). While typically found in freshwater, dace also spend some of their time in brackish water.

Seine net sampling locations

- Lower Tidal Thames
- Middle Tidal Thames
- Upper Tidal Thames

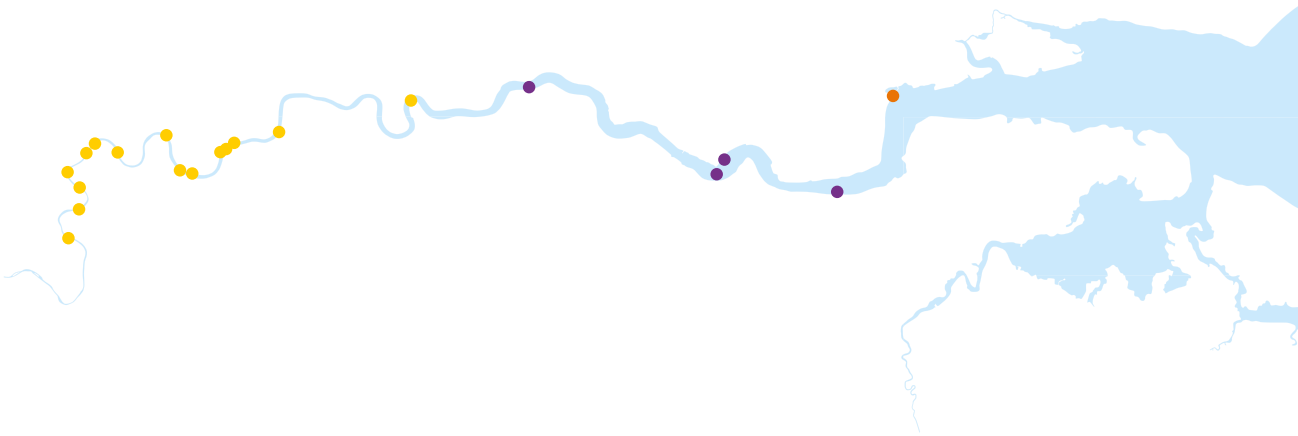


Figure 9.1: Map of Environment Agency fish sampling locations in the Tidal Thames. Sampling locations are divided into Lower, Middle, and Upper Tidal Thames.



Above: Juvenile sea bass (*Dicentrarchus labrax*) found in the Tidal Thames.

Middle Tidal Thames



Figure 9.2: Annual average number of species per sample found in the Middle Tidal Thames in 1989–2015. The points display the annual average, and the dotted line shows a linear model fitted to the data.

Upper Tidal Thames



Figure 9.3: Annual average number of species per sample found in the Upper Tidal Thames in 1989–2015. The points display the annual average, and the dotted line shows a linear model fitted to the data.

EUROPEAN SMELT

The Tidal Thames provides a nationally important spawning area for a smaller cousin of the salmon, the European smelt (*Osmerus eperlanus*), which curiously smells of cucumber. Adult smelt migrate upriver to spawn in estuaries or rivers. The juveniles then use the tidal river or upper estuaries as a nursery to grow, before moving into the marine section of estuaries and shallow inshore waters to join the resident adult population. The Thames Estuary was considered as a candidate MCZ, with smelt as one of its features of conservation importance, though unfortunately it was not designated.

Smelt are particularly sensitive to pollution, making them an important indicator species for waterway health. By the time of the Great Stink in 1858, smelt had completely disappeared from the Thames. This had economic implications, as the previously thriving smelt fishery in the Tidal Thames was lost. Its smelt population has since recovered, thanks to improvements in water quality, and it is believed that the Tidal Thames now hosts one of the largest populations of breeding smelt in the UK (Colclough and Coates 2013).

ZSL has undertaken a spawning study and an acoustic tagging study to better understand how this species uses the estuary. These studies have shown that smelt migrate upriver through central London, as far as Putney and possibly further. Spawning studies suggest that spawning may take place around Wandsworth, and there have been indications of further breeding sites. The tagging study was the first time fish had been tracked through central London, and showed that the tagged individuals used strong tidal currents to swim from where they were tagged in Canvey Island to reach as far upstream as Putney.



ESSENTIAL FISH HABITAT

Essential fish habitat (EFH) is a fisheries management approach that aims to safeguard fish populations by protecting the habitats that fish depend upon throughout their life cycles for spawning, feeding, breeding and safely maturing (Cross *et al.* 1997). EFH can be anything from coastal habitats such as saltmarsh, that act as nursery grounds, to open waters where some species feed and spawn. In the USA, regional fisheries councils are required to identify EFH for several hundred species, using distribution, abundance and life-history data (Cross *et al.* 1997). Federal law mandates that identified EFH is then carefully managed and protected.

This fisheries management strategy has been identified as an effective model that could be implemented in the Tidal Thames to protect the habitats that fish populations rely upon. The Kent and Essex Inshore Fisheries and Conservation Authority (K&EIFCA) is keen to adopt this more holistic approach to fisheries management, which would not only support fish communities, but would also have far-reaching benefits for the entire ecosystem. Our economy and fishing industry benefit from sustainable fisheries supported by productive habitats that provide high-quality seafood.

Right: An aerial view of the saltmarshes of Benfleet & Southend Marshes.



BIRDS



Long-term trend: Improving



Short-term trend: Improving

While some birds spend all year in UK habitats, others are migratory and spend only part of the year. Because of its mild winter temperatures compared with northern Europe, the UK acts as an ideal winter habitat, or as a temporary stopover during winter migrations. Many of the winter migrators are wading birds and wildfowl that rely on wetlands and intertidal mudflats, such as those of the Tidal Thames. No matter the time of year, or duration of stay, the Tidal Thames provides critical habitats for a range of bird species.

Right: Redshank (*Tringa totanus*), a wading bird that overwinters in the Tidal Thames in nationally significant numbers.



Background

The intertidal habitats of the Tidal Thames provide vital foraging grounds for migratory and non-migratory birds. Seven of the protected areas in the Tidal Thames were designated because of their internationally important numbers of waders and wildfowl. These include the Thames Estuary and Marshes SPA and Ramsar site, which were designated because of the frequent presence of protected species including the avocet (*Recurvirostra avosetta*) and the hen harrier (*Circus cyaneus*). Wading birds are a group of mostly long-legged species that forage for invertebrates in the mudflats of the Tidal Thames. Wildfowl are another group of waterbird species found in the Tidal Thames, which includes ducks, geese and swans. While the feeding strategies of these groups vary, both groups tend to be found across a range of habitats, including mudflats and saltmarsh. The analysis presented here explores the extent to which abundance of wader and wildfowl populations in the Tidal Thames have changed over the past three decades.

Analysis

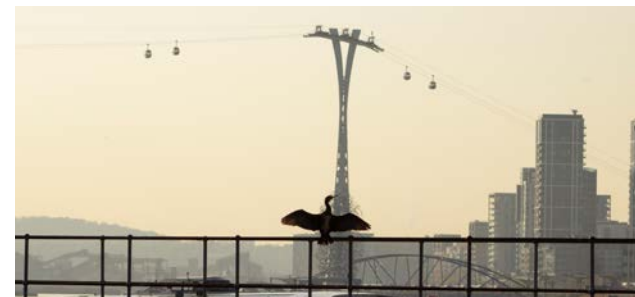
The data used for the current analysis were counts from the BTO/Royal Society for the Protection of Birds (RSPB)/Joint Nature Conservation Committee (JNCC) Wetland Bird Survey.¹¹ The dataset was reduced to include only survey sites in the Tidal Thames. Following the Living Planet Index methodology (Cullen *et al.* 2009), a Living Thames Index (LTI) value for each year was calculated for both wildfowl and waders, representing changes in relative population abundance.¹² The yearly index values were

calculated by aggregating an array of population-count time-series data covering different species, locations and populations. Annual index values were then calculated and plotted to analyse the change over time.¹³ To ensure the most accurate results, this analysis begins in 1993, when the number of species surveyed increased significantly. For more information on how to calculate the LTI, please see Appendix II.

Findings

The time-series analysis shows that wader populations in the Tidal Thames almost doubled on average from 1993 to 2017 (Figure 10.1). While the LTI shows an increase in wader population abundance in the Tidal Thames from 2008 to 2017, UK-wide trends show a gradual decline in wader populations during this time. The likely explanation for this difference is general population distribution shifts caused by climate change (See [page 67](#) for more information).

While the average LTI for wildfowl shows a decline, the confidence intervals are wide and straddle the baseline, meaning that there is a large amount of variation in the underlying species trends (Figure 10.2). The average decline generally aligns with national trends, which have shown gradual declines over the past 20 years. While the causes of these declines are likely to vary between species, habitat loss and pollution in both wintering and breeding grounds are two primary threats to wildfowl populations.



Above: A cormorant (*Phalacrocorax carbo*) dries its wings at sunrise overlooking the River Thames. **Image credit:** New Dawn, Wendy Bohan | Thames Lens 2020 Shortlist | courtesy of Thames Festival Trust

¹¹ Contains Wetland Bird Survey (WeBS) data. WeBS is a partnership jointly funded by the BTO, RSPB and JNCC, in association with the Wildfowl and Wetlands Trust (WWT), with fieldwork conducted by volunteers.

¹² Full lists of species can be found in Appendix I.

¹³ An index value above one represents higher relative abundance on average than the baseline year of 1993 (baseline year population = index value of 1), while an index value below one represents a decline in relative abundance on average.

Living Thames Index – wading birds

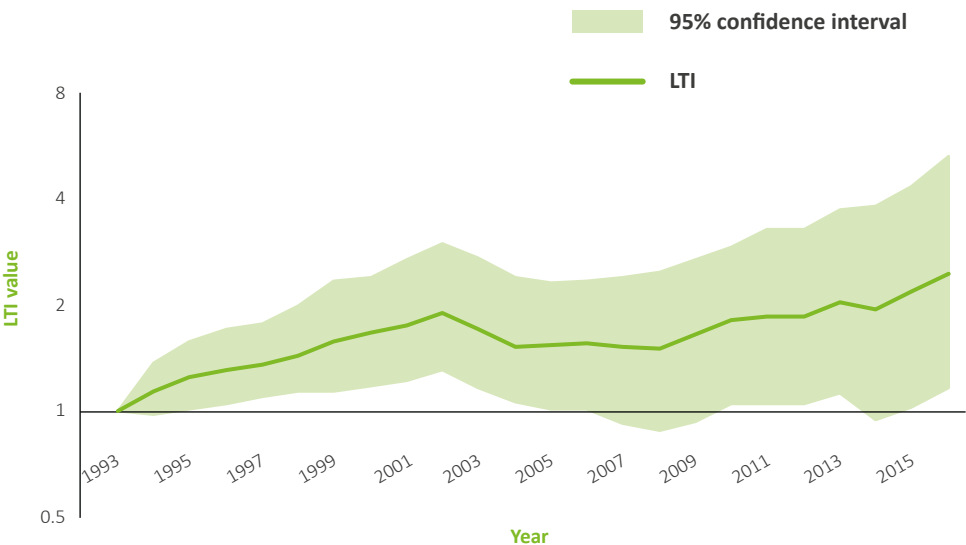


Figure 10.1: Change in LTI values for waders, 1993–2017. Results are displayed at log scale. The dark green line shows calculated LTI values, while the shaded areas shows 95% confidence interval.

Living Thames Index – wildfowl

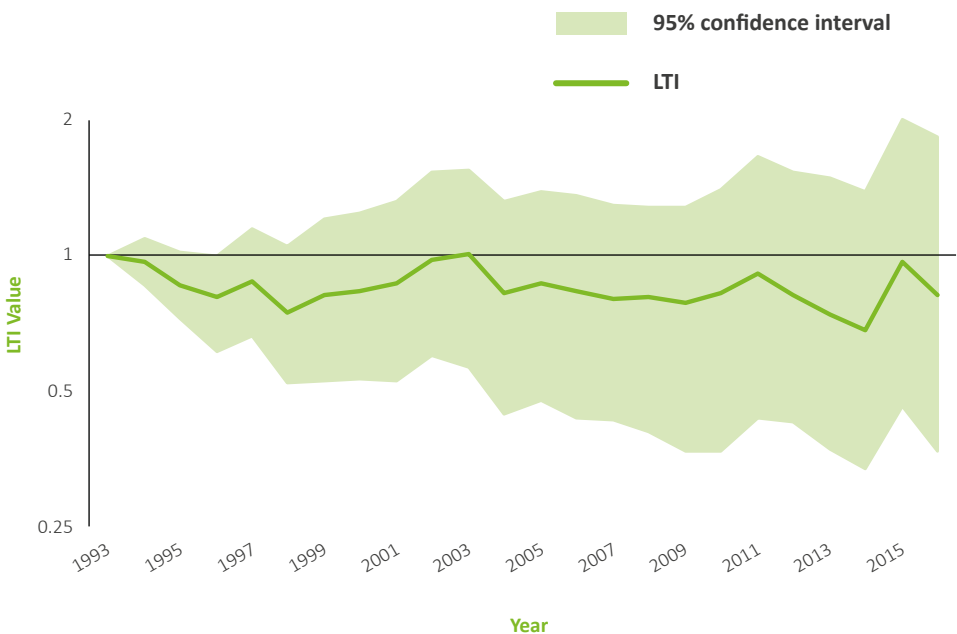


Figure 10.2: Change in LTI values for wildfowl, 1993–2017. The dark green line shows calculated LTI values, while the shaded areas shows 95% confidence interval.

IMPACTS OF CLIMATE CHANGE ON SPECIES DISTRIBUTION

Temperature changes caused by climate change can lead to shifts in species' population distributions, which in turn can affect species' interactions. One such shift has been observed in populations of migratory wading birds that overwinter in the UK. Estuaries on the east coast of the UK have generally been more advantageous to some migrating waders than estuaries on the UK's west coast. This is in part due to the greater amount of food sources in east coast estuaries, because of muddier estuarine environments and therefore larger invertebrate populations. Furthermore, many waders migrating south from breeding grounds in the Arctic first make landfall on the east coast of the UK, meaning that there is a lower energy cost associated with overwintering in the east rather than the west. Despite these advantages, lower winter temperatures in the east of England pose a threat to wader populations, and therefore a proportion of waders instead migrate to the western UK estuaries. However, as winters become warmer due to climate change, the risk of cold temperatures is gradually being alleviated. This means that a smaller proportion of waders is overwintering in these western waters, and consequently greater numbers may be seen in eastern estuaries such as the Tidal Thames (Wright *et al.* 2008). Therefore, while the increase in waders in the Tidal Thames appears at first sight to be a success story, it may in fact be a symptom of population shifts caused by climate change.

Right: Great egret (*Ardea alba*) in the foreground, with foraging brent geese (*Branta bernicla*) in the background, on the mud flats of the Thames Estuary near Southend on Sea, Essex.



AVOCET

The avocet (*Recurvirostra avosetta*) is a migratory wading bird that is popular with bird watchers. It is recognisable by its black and white patterned feathers, its long legs for wading into tidal mud, and its slender, upturned bill, which it uses to sieve sand for aquatic insects, larvae, crustaceans and worms.

Part of the avocet's popularity in the UK can be attributed to its inspiring conservation success story. Due to habitat loss, hunting and egg-collecting, by 1842 the avocet had become extinct as a breeding species in Britain. Its return is believed to have been an unexpected consequence of wartime impacts. During the Second World War, some coastal areas in East Anglia were flooded to protect Britain from invasion (Stroud *et al.* 2003). There was very little human disturbance in these coastal areas during the war, making them an ideal breeding habitat for the avocet, which had recolonised these areas by 1947. Measures have since been put in place to safeguard avocet populations, including protection from hunting, and expansion of breeding and feeding grounds. As a result, overall UK avocet populations have been growing steadily since their recolonisation.

In the Tidal Thames, the avocet is a priority species for the three coastal SPAs within this region, meaning that these areas are managed to protect avocet populations. Due to these protections and overall increases in breeding pairs across East Anglia, the population of avocet in the Tidal Thames has more than doubled in the past 30 years. In 2016, there was an annual average of 537 individuals counted, compared to 152 in 1993 (Figure 10.3).



Change in number of avocets in the Tidal Thames

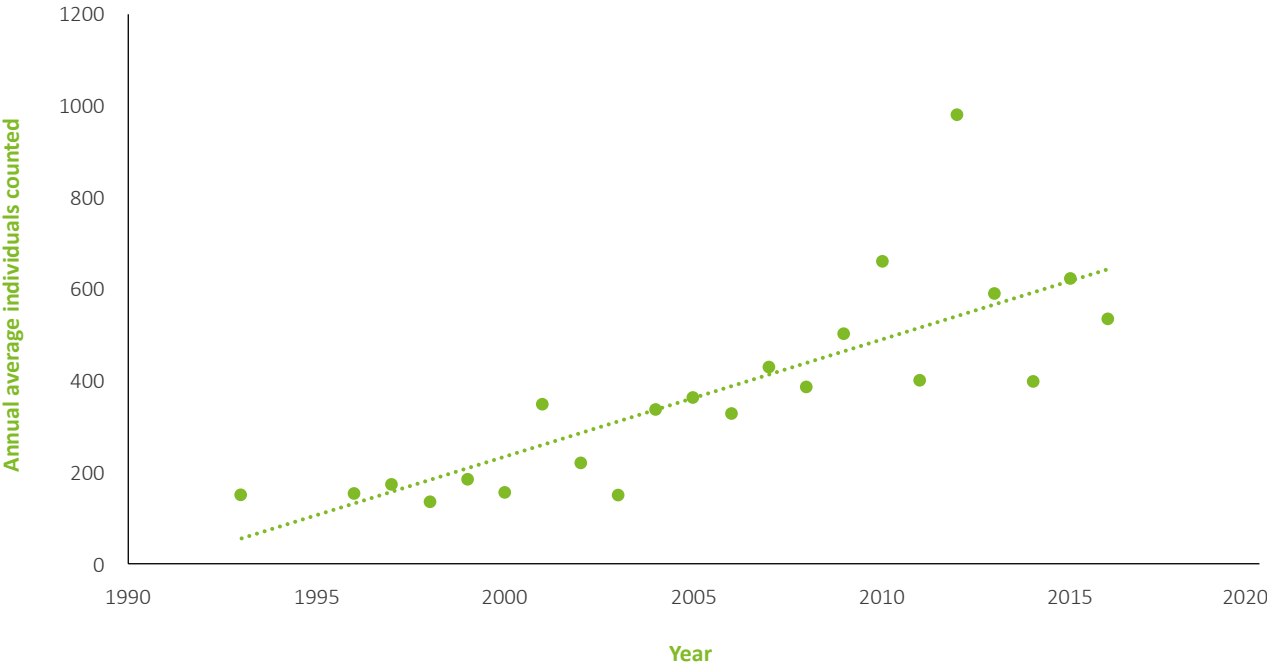


Figure 10.3: Avocet counts in the Tidal Thames, 1993–2017, using BTO’s Wetland Bird Survey data, with linear model fitted.



MARINE MAMMALS



Long-term trend: Improving



Short-term trend: Improving

There are two resident marine mammal species in the Tidal Thames, the grey seal (*Halichoerus grypus*) and the harbour seal (*Phoca vitulina*), both of which are dependent on the estuary for habitat and food, with harbour seals also using it as a place to birth their pups. In addition to these two residents, there is a range of mammal species that will sometimes visit the estuary. The shallow depths of the estuary prevent larger animals such as whales from being regular visitors, although some species such as minke (*Balaenoptera acutorostrata*) are known to make infrequent visits. Harbour porpoises (*Phocoena phocoena*) are transient visitors that are found in the Thames Estuary. A recent study found that there is a significant, year-round presence of porpoises (Cucknell *et al.* 2020).

Right: Harbour seals (left and right, foreground) and a grey seal (right, background) hauled out on the Thames foreshore.





Above: Aerial image taken as part of the Thames seal surveys. Captured by Anna Cucknell, ZSL.

Background

Both the harbour seal and the grey seal can be seen in the Thames as far upstream as the tidal limit at Teddington, through central London and in abundance across the outer estuary. They use the river margins, muddy coastal areas, and sandbanks to 'haul out' (lay on the foreshore to rest). Both species are generalist feeders, eating most fish species and some crustaceans, and will vary their diet depending on season and prey availability. Until the early 2000s, little was known about the number of seals present in the Tidal Thames (Cox *et al.* 2020). Starting in 2003, population surveys were completed by the Sea Mammal Research Unit (SMRU), ZSL and Bramley Associates. The annual surveys now cover from Gravesend in the west, to Felixstowe in the north, Deal in the south and all the coastline and sandbanks in-between.

Analysis

The Thames seal surveys followed a nationally accepted methodology. Surveys were completed during the harbour seal moult period, when the number of seals hauled out at low tide is generally at its highest and least variable, thereby providing a reliable index of abundance (Morris *et al.* 2021).¹⁴ A light aircraft was used to take aerial images from an approximate altitude of 500ft. Photographs were later analysed, and seals in the photographs counted. Population estimates can be calculated by adjusting counts for the proportion of the populations expected to be hauled out (not at sea, and therefore countable) during the survey window.

Findings

The 2019 Thames population estimate for harbour seals was ~900 and for grey seals was ~3,200. Since the surveys began in 2003, there has been a clear and steady increase in both harbour and grey seal populations in the Thames Estuary (Cox *et al.* 2020). The increase in harbour seal populations is of particular interest, as the status of other harbour seal populations around the rest of the UK is variable. It is not yet clear why seal populations are increasing in the Thames, but it could be due to both increases in pup production, and movement into the area from other colonies. Despite increasing numbers, these charismatic creatures continue to face challenges such as habitat loss caused by developments. It will be important to continue to monitor the long-term trends in seal numbers in the Thames, particularly in the national context.

¹⁴ Data used here excluded the section of the Thames that flows through central London because 1) surveys were completed from a light aircraft that would not be permitted to fly low over the river, and 2) the survey method counted seals as they were hauled out on mudflats and sandbanks, which is less common in the London section of the Thames.

Harbour seal counts in the Greater Thames Estuary

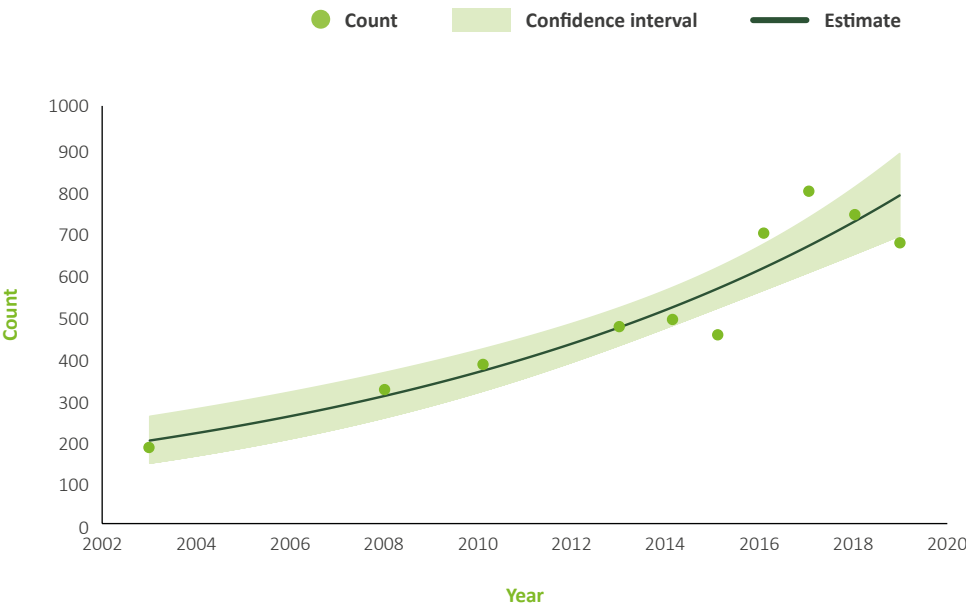


Figure 11.1: The points on the graph show the count data for harbour seals from 2003 to 2019, with a model fitted to the data. The green area shows a 95% confidence interval.

Grey seal counts in the Greater Thames Estuary

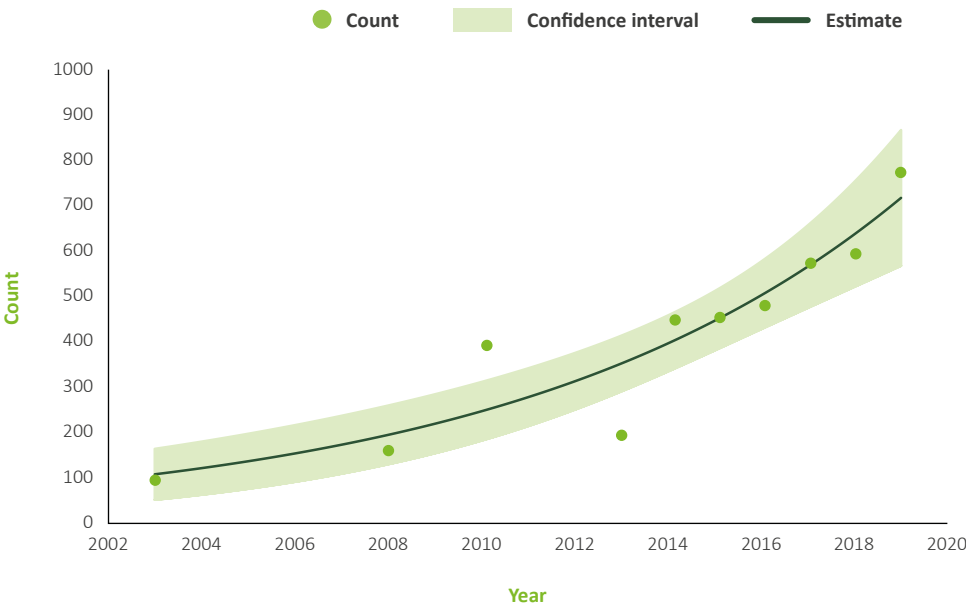


Figure 11.2: The points on the graph show the count data for grey seals from 2003 to 2019, with a model fitted to the data. The green area shows a 95% confidence interval.

STATE OF PLAY



“

A healthy estuary provides a safe, nurturing environment, and therefore many opportunities for people to learn about the value of this vital ecosystem.

The intangible human benefits provided by the natural world are classified specifically as ‘cultural ecosystem services’. Among these are recreational, spiritual, mental and physical benefits. Estuaries and other blue spaces, or places on or by waterbodies, have been found to have tremendous benefits in terms of both mental and physical well-being. Evidence shows that, in the UK, living close to blue spaces is correlated with an increase in physical activity (Brown 2020). The same government-commissioned study also found that blue spaces make people feel happier than green spaces (Brown 2020).

As a blue space that also serves as a geographical, economic and cultural hub for millions of people, the Tidal Thames provides many cultural ecosystem services to residents and visitors alike. For example, the River Thames serves an important purpose in some spiritual festivals, such as Hounslow’s Ganesh Chaturthi Festival. Another example is the archaeological value of the Tidal Thames and its foreshore, which provides the perfect location for a permit-required activity known as mudlarking, which involves searching for historic or valuable items hidden in the mud.¹⁵ Some cultural services are closely tied to the estuary’s

ecosystem health, such as recreation and cognitive benefits. A healthy estuary provides a safe, nurturing environment, and therefore many opportunities for people to learn about the value of this vital ecosystem.

The ambition is for people to have the space, opportunity and motivation to connect with the Tidal Thames, allowing them access to the well-being and cognitive benefits that being close to nature can bring.



¹⁵ It is important to note the mudlarking on the Tidal Thames foreshore requires a permit, which can be applied for through the Port of London Authority.

RECREATION

There are two general categories for blue space recreation: on the river and by the river. On the river, people take part in kayaking, rowing and canoeing, among other activities. By the river, popular activities involve walking, running and cycling. While the exact relationship between environmental quality of blue spaces and number of leisure users is unknown, studies suggest that there is a positive relationship (Breen *et al.* 2018). This suggests that a healthy, thriving Tidal Thames would attract more people on and by the river.



ON THE RIVER

ROWING

is the most popular activity on the river



5,800

people take part in rowing on the Tidal Thames every year



CANOEING AND KAYAKING

are the second most popular activities on the river



Up to **80** sporting events take place every year on the Thames, including the University Boat Race and the Great River Race



9.9 MILLION

passenger journeys took place on the river in 2019

No time-series data could be found documenting recreational use of the Tidal Thames. However, many organisations have collected data and published reports that give a snapshot of the most popular activities undertaken by people on the river.

In 2016–2017, London Sport conducted a survey of sport organisations operating on the Tidal Thames to understand the use of the river. The results showed that rowing is the most popular sport activity undertaken on the river, with over 60% of the 145 responding organisations indicating that they offer this activity (London Sport 2017). An amenity report commissioned by the PLA further estimated that around 5,800 people take part in rowing on the Tidal Thames every year (Oxford Economics 2015). The next most popular sports were found to be canoeing and kayaking (London Sport 2017). There are also up to 80 sporting events every year on the Thames, including the Great River Race (in which oarsmen from across Europe bring their boats to compete) and the Oxford–Cambridge University Boat Race.

The PLA amenity report also found that there were 9.8 million passenger journeys on the river in 2014 (Oxford Economics 2015). Of these, they estimated that 1.5 to 2 million were tours and charters, most likely either social events or undertaken by tourists visiting the city. A further 3 million were river bus journeys, which were likely undertaken by commuters, residents and tourists. In 2019, the total number of passenger journeys on the river was 9.9 million.

A continuation of these studies and reports would provide robust time-series data to determine any potential changes in recreational river use.

BY THE RIVER

From the Upper Tidal Thames at Teddington to the study boundary at Southend, the river is bordered by 121km of public footpaths, 6.4km² of parks and gardens, 12 beaches, and 5.8km² of nature reserves. These areas attract both residents and tourists, who visit to take part in various leisure activities including walking, running, cycling and relaxing by the river. Efforts have been made over the years to make these areas more accessible for these outdoor activities. The Thames Path, which extends 294km from the Cotswolds to the Thames Barrier at Woolwich, was made a National Trail in 1996. These accessible blue spaces provide important ecosystem services to their users, namely mental and physical health benefits. Estimating the annual number of visits to these recreation areas gives an indication of how many people are receiving these benefits.

Analysis

The analysis for this indicator was conducted using the University of Exeter's [Outdoor Recreation Valuation Tool](#) (ORVal), which uses a recreation-demand model and results from the Monitor of Engagement with the Natural Environment (MENE) survey to theoretically estimate the number of outdoor recreation users in outdoor areas across England. The MENE survey is conducted on behalf of Natural England, the Department for Environment, Food and Rural Affairs (DEFRA) and the Forestry Commission and has at least 800 respondents per week, throughout the year, from across England. All MENE survey responses are compiled from the start of the MENE survey in 2009 to create the

recreation-demand model. For this reason, it was not possible to conduct a time-series analysis. Instead, this analysis sets a baseline for future comparison and gives interesting insight into the number of visits to Thames's riverside outdoor areas for recreation.

The ORVal tool identifies three categories of outdoor recreation areas: paths, parks, beaches and nature reserves. Any path, park, nature reserve or beach that directly bordered the Thames on either side of the river was selected. The ORVal model calculates the total annual visitor numbers for each recreation area.¹⁶ These numbers were summed for the three types of outdoor areas. See Appendix III for a list of the names and ID numbers of the areas included.

Findings

The results showed an estimated 39.1 million recreational visits per year in total to any Thames riverside recreation area. Broken down by outdoor area type, there were 16.8 million annual visits to the Thames riverside paths, 12.2 million annual visits to riverside parks, 1.9 million annual visits to nature reserves and 8.2 million visits to beaches (Figure 12.1). These areas are not only a space for physical activities, but they also provide places for people to visit, relax and enjoy the aesthetic value of the Tidal Thames.



¹⁶ While ORVal compiles spatial data from a number of sources (OpenStreetMap, Natural England, etc), the developers cannot guarantee that all outdoor recreational areas are included. This introduces the possibility of under-estimating the true number of visits.

Visits to Thames riverside outdoor recreation areas



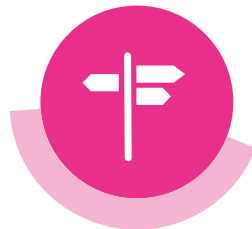
BEACHES 21%



NATURE RESERVES 5%



PARKS 31%

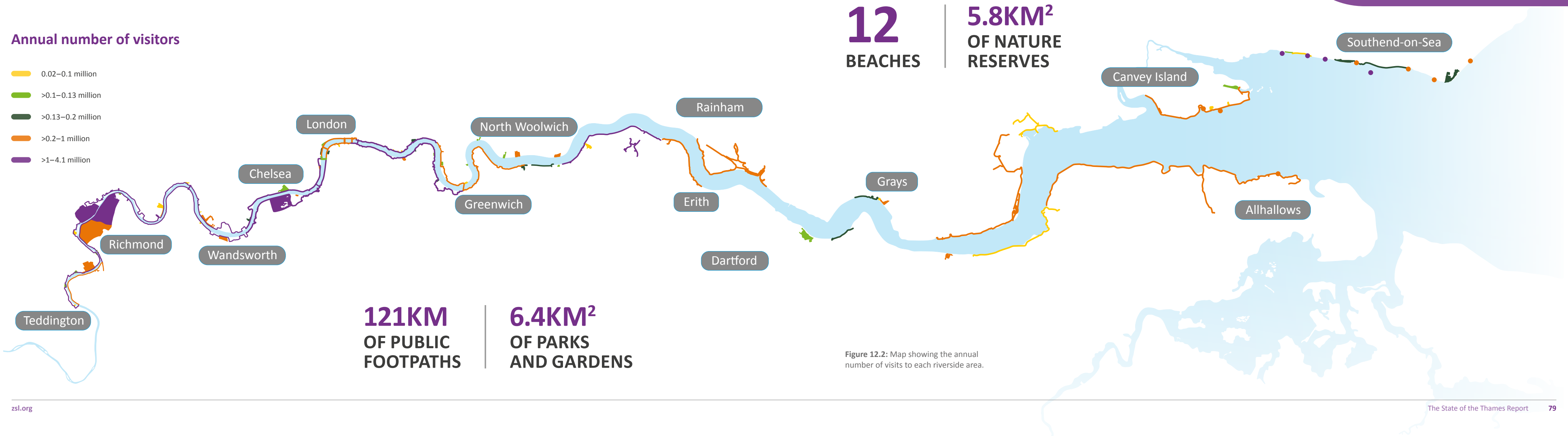


PATHS 43%

Figure 12.1: Percentage of total annual visits to each type of outdoor recreation area



Image credit: Pulling Together,
Claire Darke | Thames Lens 2017
Instagram Winner | Courtesy of
Thames Festival Trust



COGNITIVE BENEFITS

In the context of ecosystem services, ‘cognitive benefits’ are the learning and understanding we derive from the natural world. People gain numerous cognitive benefits from nature, including knowledge about the environment, scientific discovery and engineering advancements inspired by nature’s designs. As a diverse environment, accessible to millions of people, the Tidal Thames is an important source of cognitive benefits. While this section provides some examples of the existing opportunities that help people access these benefits, there are many more.

Image credit (right): For all of Our Existence, Brendan Conway
| Thames Lens 2020 Shortlist | Courtesy of Thames Festival Trust



Festivals

While festivals by the Tidal Thames date back hundreds of years, they experienced a decline during the 19th century and early 20th century, when the river was in its worst state. Riverside festivals have experienced a resurgence in the past 30 to 40 years in London, following movements to improve the state of the river.

The [Thames Festival Trust](#) first began in 1997 as a weekend festival on the South Bank featuring food, feasts, performances, night carnivals, a craft market, art workshops and more. Since then, it has evolved into a month-long celebration of the river, encompassing a wide range of events and opportunities. These events take place all along the Thames from Hampton Court Bridge to Dartford Crossing, and span culture, environment and heritage connected to the river. TEP's annual Tour of the Thames Boat Trip, covering environment, society and history, can now also be accessed as a virtual tour on their website, ensuring people can experience the Tidal Thames from anywhere.

Another Thames-based festival, Tidefest, has continually grown in attendance and popularity since its launch in 2014: from several hundred attendees in its first year, to several thousand visitors in recent years. It aims to help families connect with the river and learn about its wildlife and heritage through events and activities such as river dipping for aquatic wildlife, guided walks and mudlarking.

Some people regard the Thames as a sacred river. One of the most colourful festivals celebrated in its waters is the annual

Hindu Ganeshotsav (pictured below). This celebration takes place in Hounslow, Kingston, Richmond and Southend, where devotees immerse an idol of Lord Ganesh into the Thames while praying, dancing and singing.

Volunteering

Volunteering can be a way to learn about and connect with a natural environment. Thames21 provides opportunities for people of all ages to get involved in cleaning up the city's rivers and streams. This organisation engages with about 7,000 volunteers every year to achieve a variety of goals, including clearing litter from waterways, creating habitats and controlling problematic introduced non-native species. There are also many informal volunteers who act as stewards of the Thames, and whose daily contributions to the river's maintenance and upkeep must be acknowledged.

School visits

Incorporating the Tidal Thames into the school curriculum in London is important in order to support students' understanding of the world around them and their connection

to the local environment. The [Thames Explorer Trust](#) has tailored trips for schools to visit the foreshores of the Tidal Thames, which offer students the opportunity to learn about the ecology of the Thames through fieldwork and to explore the heritage and history of London. In 2019, 8,490 children under 18 years of age took part in the Thames Explorer Trust's foreshore programmes.¹⁷ The Thames Explorer Trust also makes this Thames-focused learning available to schools in the form of outreach, with 8,200 children engaging in such outreach programmes in 2019.

In addition to school children, the Thames Explorer Trust also provides opportunities for adults to learn about the Tidal Thames. In 2019, they engaged with 1,207 adults (aged 18 and over) at events and tours.

¹⁷ The 2019 numbers are reported as the most recent, because 2020 engagement numbers were greatly impacted by the Covid-19 pandemic. These numbers are from direct communication with the Thames Explorer Trust.



Image credit (above): Courtesy of Thames Landscape Strategy.



Citizen science

Citizen science is the collection and analysis of scientific data by members of the public, typically as part of a collaborative project with professional scientists. Many citizen science projects take place in and around the Tidal Thames and its tributaries, all providing opportunities for community members to learn more about the importance of this habitat and its associated species.

ZSL conducts numerous citizen science projects in the Tidal Thames and its tributaries, all of which improve understanding of the ecosystem and supported species. For example, ZSL trains volunteer citizen scientists to take part in '[Outfall Safaris](#)'

on rivers in London, which locate sources of pollution from misconnected pipework and sewer blockages. In addition, ZSL works with over 100 trained citizen scientists each year to monitor the upstream migration of the European eel. Data from this study informs international eel conservation planning and local conservation action for eels. A final example is ZSL's [Thames Marine Mammal Sightings Survey](#), in which members of the public submit the details of any sightings of marine mammals in the Thames to improve knowledge and understanding of mammal use of the Thames. Numbers of sightings have increased over the years, and in 2020, there were over 550 sightings submitted.

There are many other organisations that conduct valuable citizen science projects to improve knowledge and understanding of the Thames environment. For example, Thames21's [Thames River Watch](#) programme works with citizen scientists to record data about litter in the Tidal Thames, and to clean this litter from the river. Meanwhile, Earthwatch's [Thames WaterBlitz](#) aims to collect as many water samples as possible across the Thames catchment, with the help of citizen scientists, to produce a high-resolution 'snapshot' of the state of the water environment.

Above: Volunteers cleaning the Thames foreshore at low tide.

LOOKING FORWARD

The findings of this report highlight the improvements that have been made to the water quality of the Tidal Thames, the subsequent re-establishment of a thriving estuarine ecosystem, and the ways in which the Tidal Thames is an asset to human well-being. These results are testimony to the collaborative hard work of many people and organisations, such as the Environment Agency which has pushed hard for greater investment in STW to increase the treatment level of wastewater entering rivers. Part of this work involves establishing management structures, such as those within the WFD that underpin the protection and continual recovery of the Tidal Thames.

As well as the successes, this report also identifies the threats currently facing the Tidal Thames. Climate change, high nutrient levels, plastics and industrial chemicals are among the issues demanding our attention. However, we must recognise that many organisations are making great efforts to combat these pressures and improve the environment health of the Tidal Thames. The efforts spearheaded by these organisations, which are actively appealing for collaboration, require collective action and assistance if they are to be sustainable and successful.

Finally, this report identifies potential opportunities for safeguarding and enhancing the Tidal Thames ecosystem. Emerging habitat restoration techniques offer ways in which historically degraded habitats could be returned to the Tidal Thames. Growing appreciation of the river and its wildlife suggests strong public support for such projects.

The State of the Thames 2021 report should be used as a baseline to monitor future improvement and deterioration in the Tidal Thames. Ideally, the report would be repeated every three to five years, adding or removing indicators as necessary.

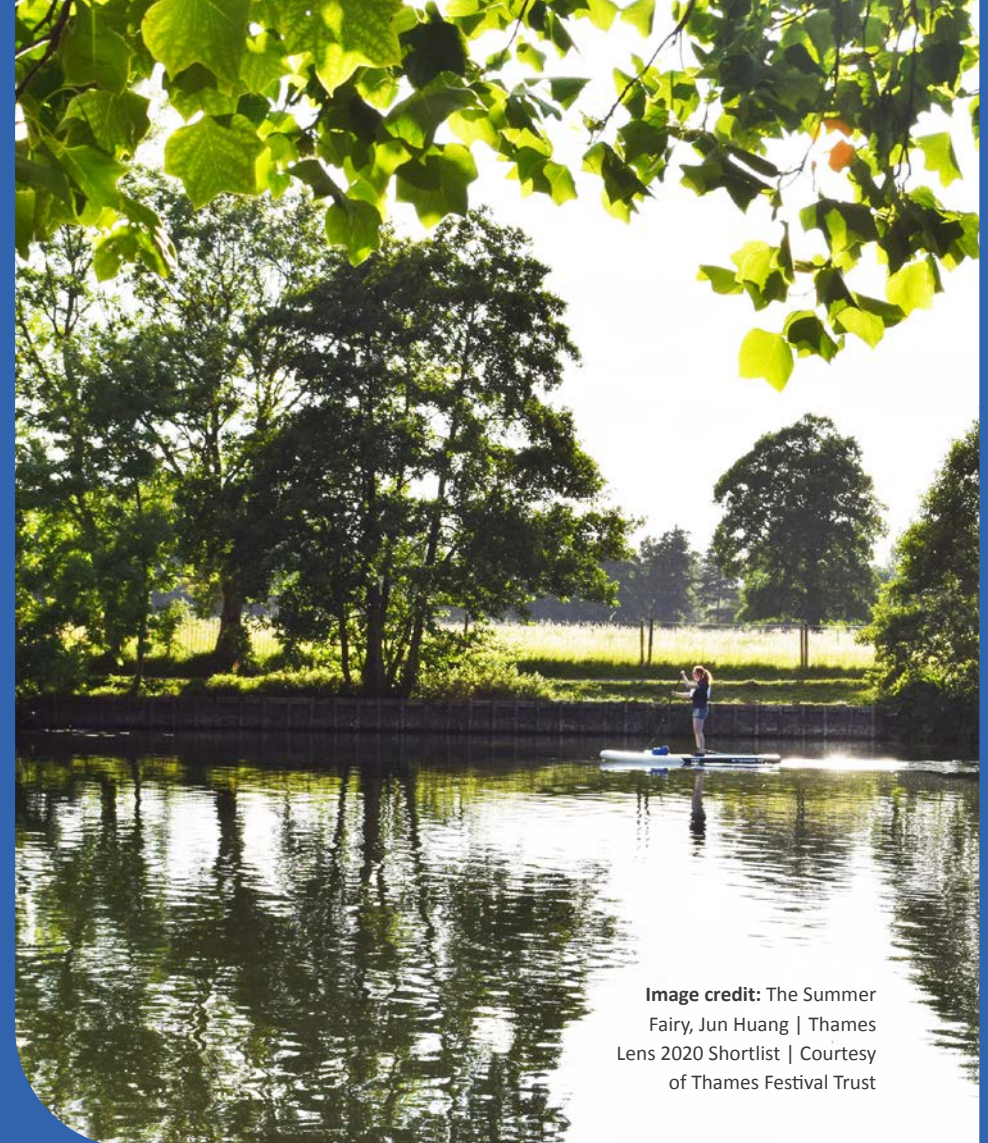


Image credit: The Summer Fairy, Jun Huang | Thames Lens 2020 Shortlist | Courtesy of Thames Festival Trust

ACRONYMS

BMWP: Biological Monitoring Working Party	PDC: passive debris collector
BTO: British Trust for Ornithology	PLA: Port of London Authority
CEH: UK Centre for Ecology & Hydrology	SAC: Special Area of Conservation
CSO: combined sewer overflow	SINC: Site of Importance for Nature Conservation
DO: dissolved oxygen	SMRU: Sea Mammal Research Unit
EFH: essential fish habitat	SPA: Special Protection Area
ENORI: Essex Native Restoration Oyster Initiative	SSSI: Site of Special Scientific Interest
IPCC: Intergovernmental Panel on Climate Change	SST: sea surface temperature
KEIFCA: Kent and Essex Inshore Fisheries and Conservation Authority	STW: sewage treatment works
LTI: Living Thames Index	TBT: tributyltin
MENE: Monitor of Engagement with the Natural Environment	TEP: Thames Estuary Partnership
MCZ: Marine Conservation Zone	TLS: Thames Landscape Strategy
ORVal: Outdoor Recreation Valuation Tool	WFD: Water Framework Directive
	WIMS: Environment Agency's Water Quality Archive

GLOSSARY

Algal bloom: a rapid increase or accumulation of algae in freshwater or marine water systems.	Coastal squeeze: the loss of intertidal habitat in front of sea defences.	Managed realignment: removal of part or all existing coastal defence structures to allow coastal flooding, creating new intertidal zones.
Anadromous: migrating upriver from the sea to spawn.	Cognitive benefits: the learning and understanding we derive from the natural world.	Mudlarking: searching for historic or valuable items hidden in mud.
Anthropogenic: caused by humans or their activities.	Confluence: the point where two rivers meet.	p-value: a number describing the likelihood that the trend in the data could have occurred by random chance.
Blue space: places on or by waterbodies.	Ecosystem services: contributions of ecosystem structure and function to human well-being.	Recruitment: the process by which new individuals are added to a population.
Brackish: slightly salty.	Estuary: the tidal mouth of a river, where freshwater and saltwater mix.	Spawn: to produce or deposit eggs in water.
Carbon sequestration: a natural or artificial process by which carbon dioxide is removed from the atmosphere.	Eutrophication: the process by which a body of water gradually becomes enriched with minerals and nutrients.	Strand line: a line on the foreshore resulting from a water level that is higher than the present.
Catadromous: migrating downstream to the sea to spawn.	Invasive species: organism that causes ecological/economic harm in an environment where it is not native.	Sublittoral: the seashore zone lying immediately below the intertidal zone and extending to about 200m depth or to the edge of the continental shelf.
Chlorophyll: a green pigment responsible for absorbing light to provide energy for photosynthesis.	Macrophyte: an aquatic plant that grows in or near water.	Tributary: a river or stream flowing into a larger river or lake.
Citizen science: the collection and analysis of scientific data by members of the public, typically as part of a collaborative project with professional scientists.	Macroplastic: plastic items ≥ five millimetres in size.	
	Microplastic: plastic particles < five millimetres in size.	



Credit (above): Good Morning London!, Rahael Ross | Thames Lens 2019 Instagram winner | Courtesy of Thames Festival Trust

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Appendices

Appendices are available to view and download from zsl.org/stateofthethames



Credit (above): The Quantum Cloud, Alison Medd | Thames Lens 2020 Shortlist | Courtesy of Thames Festival Trust



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