ZSL

THE STATE OF THE THAMES

2ND EDITION

Cover image: Two native mute swans wading along the Thames shoreline opposite St Paul's Cathedral.
Above: Starry smoothhound shark (*Mustelus asterias*) as found in the Greater Thames Estuary. **Image credit:** JDScuba – Jake Davies.

ZSL

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 conservation zoos, London and Whipsnade Zoos. ZSL has been conserving the Tidal Thames environment since 2003.

ACKNOWLEDGEMENTS

Thames Water funded the preparation of this report. The content remains independent and Thames Water had no editorial influence over the content.

This report supports the goals of the United Nations Decade on Ecosystem Restoration (2021–2030). Find out more here: https://www.decadeonrestoration.org

ISBN number: Printed version 978-1-915844-98-9. Digital version 978-1-915844-99-6.

Citation: ZSL (2026). ***The State of the Thames 2nd Edition: Environmental trends of the Tidal Thames***. Head, C.E.I., Chen, M., Kemeys, J., Pecorelli, J., and Debney, A.J. (Eds). ZSL, Regent's Park, London, UK.

Editors: Catherine Head, Matt Chen, Jonathan Kemeys, Joe Pecorelli, Alison Debney.
Zoological Society of London, Regent's Park, London, UK.

Design and infographics: hello@ellyalexcreative.co.uk

Authors:
Leon Barron (Imperial), Katherine Beaney (Environment Agency), Philip Belfield (Environment Agency), Olwen Belgrove (ZSL), Wanda Bodnar (Institute of Zoology), Mike Bowen (UK Centre for Ecology & Hydrology – CEH), Peter Bowers Davis (Environment Agency), Matt Chen (ZSL), Simon Clarke (Thames Explorer Trust), Tom Cousins (Environment Agency), Thea Cox (ZSL), Sally Crofts (Thames Water), Anna Cucknell (ZSL), Petra Sovic Davies (SE RT), Mark Davison (Environment Agency), Alison Debney (ZSL), Jason Debney (Thames Landscape Strategy), Neil Dunlop (Environment Agency), Thomas Fitch Taylor (Environment Agency), Professor Ivan Haigh (University of Southampton), Catherine Head (ZSL), Harry Hickes (Environment Agency), Rob Hillman (Environment Agency), Andrew Johnson (UK Centre for Ecology & Hydrology – CEH), Sally Little (Nottingham Trent University), Megan-Rose Macdonald (Environment Agency), Emily McLean (Port of London Authority), Louise McRea (ZSL), Sam Mills (Thames Explorer Trust), Philippa Nicholls (Thames21), Joe Pecorelli (ZSL), Felicity Rhodes (Thames21), James Towson (Thames Water), Martin VanHeerden (Environment Agency), Dave Webb (Environment Agency), Ian Woodward (BTO).

CONTRIBUTORS

CONTENTS

THE STATE OF THE THAMES 2ND EDITION

The second edition of *The State of the Thames* provides a comprehensive assessment of estuarine health and the latest environmental trends within the Tidal Thames. By synthesising recent monitoring data and multi-disciplinary research, this report serves as a vital framework for government, industry and civil society. It empowers stakeholders and the public alike to measure ecological performance and coordinate progress toward the vital goals of conserving and restoring this essential estuary ecosystem.

The report compiles the best available data for 21 indicators of environmental condition, selected by technical experts. Presented in three chapters focusing on the State of the Environment, State of Nature and the State of Play, the report illuminates long- and short-term trends. Where there is insufficient data to draw conclusions, the information provided sets a baseline.

FOREWORD

The River Thames has many faces: the foundational lifeline of London; the long-suffering recipient of litter and sewage; a sanctuary for walkers, joggers and kayakers. The Thames is all these things but, most importantly, it is a major natural ecosystem – supporting hundreds of species of birds, fish and invertebrates, and providing drinking water and green space for millions of people. We all benefit from a thriving Thames, and it deserves our protection.

This Report analyses the health of the Thames, five years on from our first landmark report. It shows the continued recovery of the Tidal Thames, highlighting improvements in water quality, the successful reestablishment of a recovering estuarine ecosystem, and the immense value of the Thames as an asset for human wellbeing. These positive outcomes are a powerful testimony to the hard work of the many people and organisations dedicated to this iconic estuary.

There has been a significant increase in public and political awareness about the health of our nation's rivers, resulting in calls for investment in our national water infrastructure. In London, we have seen the £4.6 billion Thames Tideway Tunnel 'super sewer' become operational in 2025, which is expected to drive further improvements in water quality. We eagerly anticipate gathering the evidence to understand its impact.

However, our work is far from over. We must accelerate large-scale habitat restoration for both habitats and species that will boost resilience and provide access opportunities for local communities. The Thames faces persistent pressures from climate change and increasing levels of nutrients, plastics and forever chemicals – pressures that are set to intensify as London's population grows. And, while progress has been made on wastewater management, we must address the sources of pollution, such as runoff from roads and land management of areas adjacent to the river.

Collaboration remains our most powerful tool. The combination of civil society, public sector, private sector and knowledge institutions working together is essential for success. New legislation, such as the Environmental Improvement Plan, Biodiversity Net Gain and Local Nature Recovery Strategies, coupled with the Mayor's Clean and Healthy Waterway Strategy, provides cautious optimism for the future. We hope these frameworks and emerging high-integrity financing mechanisms, such as blue carbon and biodiversity credits, will drive necessary investment into nature recovery.

Across the globe, people look to the Thames as an inspirational story. Its recovery, from parts of the river being declared biologically dead in 1957, is remarkable. It is our collective responsibility to ensure the Thames continues to be a global exemplar of a thriving ecosystem at the heart of a world-renowned capital city.

Dr Andrew Terry, Director of Conservation and Policy, ZSL

"The Thames is London's lifeblood. It was the cause of London's founding and remains a working river, a haven for wildlife and a source of joy and wellbeing for millions of Londoners.

This report shows the progress that has been made, but also just how much more we must do to protect it from pollution and the climate crisis.

We have made incredible progress cleaning up London's air in recent years, and I'm determined that we do the same with our rivers as we continue to build a greener London for everyone."

Sadiq Khan, The Mayor of London

Image: Tern diving. **Image credit:** Aaron Hart.

EXECUTIVE SUMMARY

This second edition of *The State of the Thames* report determines the health of the Tidal Thames environment. It builds on the first report, published in 2021, and continues to use indicators selected by scientific and technical experts and available data to calculate long- and short-term trends. The assessment has now extended to include 21 indicators to give an overview of the ecosystem's physical environment, how its wildlife is thriving, and the benefits it provides to people surrounding the River Thames. Where there is insufficient data to draw conclusions, the information provided sets a baseline from which to measure progress.

STATE OF THE ENVIRONMENT

Dissolved oxygen, critical for aquatic organisms to respire and survive, shows improving long- and short-term trends, a promising sign for wildlife diversity and health in the Tidal Thames. Many of the pollution indicators, including **plastic pollution**, and the **nutrients**, phosphorus and nitrates, have stabilised in the short term. The phosphorus long-term trend is improving but nitrates show a deteriorating long-term trend. Two new indicators, the **chemicals of concern**, zinc and copper, tell a positive story of improving long-term and short-term trends, and importantly, short-term concentrations are below thresholds that cause harm to invertebrate communities. The effects of **chemicals of emerging concern**, another new indicator, are just beginning to be understood and whilst current data is insufficient to provide trends, it is important to highlight the urgent need for monitoring.

Climate change continues to impact the Thames environment, with **water temperature** and **sea level** in particular increasing in the short term. **Salinity**, another new indicator for this report, shows stability in its long- and short-term trends, but may potentially be influenced by sea level rise in the future. Climate change is anticipated to impact species ranges and life-history patterns as a result of changes in these parameters.

STATE OF NATURE

Overall, it is a mixed picture for the state of nature in the Thames. There are improving short-term trends for **connectivity**, which measures the reopening of migratory pathways for fish. Historically, the Thames has seen huge losses of natural habitat to urbanisation but the **habitat creation** indicator tracks the restoration and creation of habitat along the Estuary. The **protected area** indicator assesses the condition of protected habitats and species, finding that the majority were in favourable condition but some features required conservation attention.

Fish populations have been deteriorating in the long term, but appear to have stabilised in the short term. Wading and wildfowl **bird** populations have both deteriorated over the short term, while the improving long-term trend of waders is thought to be explained by population shifts due to climate change rather than population increases. Finally, **marine mammals** show contrasting trends, with grey seals increasing over the short term, while harbour seal populations have deteriorated in the short term.

STATE OF PLAY

Collecting data on the use of the Thames by local communities is a challenge. However, the number of **recreational** activities **on and by the river** is increasing, underscoring the river's importance to the physical and mental health of millions of people. Assessments of the number of projects and people involved in **learning and volunteering** activities, representing cognitive benefits to local communities, have also increased. There is not enough data to assess a trend for these indicators, but a baseline is set for future trend analysis.

Above: A resting Thames grey seal.

INDICATORS AT A GLANCE

	Indicator	Long-term trend	Short-term trend
State of the Environment	Dissolved oxygen	Improving	Improving
	Nutrients: Phosphorus	Improving	Data stable
	Nutrients: Nitrate	Deteriorating	Data stable
	Chemical: Copper	Improving	Improving
	Chemical: Zinc	Improving	Improving
	Chemicals of emerging concern	Insufficient data	Insufficient data
	Biotic index: Invertebrates	Data stable	Data stable
	Climate change: Water temperature	Deteriorating	Deteriorating
	Climate change: Sea level rise	Deteriorating	Deteriorating
	Salinity	Data stable	Data stable
	Plastic pollution	Baseline	Data stable
State of Nature	Habitat: Protected areas	Baseline	Insufficient data
	Habitat creation	Baseline	Improving
	Connectivity	Baseline	Improving
	Fish	Deteriorating	Data stable
	Birds: Waders	Improving	Deteriorating
	Birds: Wildfowl	Deteriorating	Deteriorating
	Marine mammal: Grey seal	Improving	Improving
	Marine mammal: Harbour seal	Data stable	Deteriorating
State of Play	Recreation: On and by the river	Baseline	Baseline
	Recreation: Learning and volunteering	Baseline	Baseline

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 is not trending, and is stable.

Insufficient data
Indicates that there is 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 5 to 10 years of data.

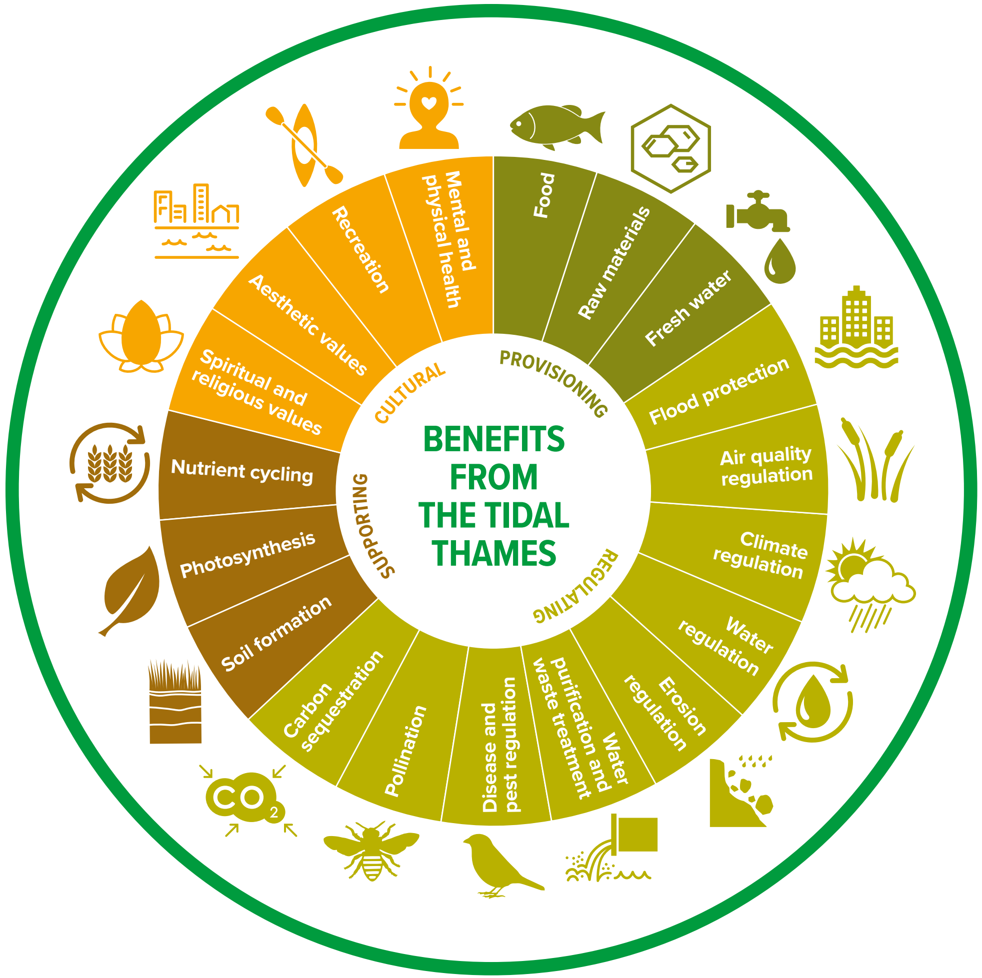
Long-term
The full range of data, including beyond the most recent 5 to 10 years.

INTRODUCTION

The Tidal Thames, for a long time, has been seen as a global success story, an exemplar of environmental recovery after stretches were declared biologically dead by the Natural History Museum (Wheeler 1958). In 2021, ZSL published the first *State of the Thames Report* to measure the environmental changes since that historic low in the 1950s, which resulted in improved water policy leading to significant investment in wastewater treatment. In this follow-up report, we extend the analysis to the end of 2024, which marked the completion of the £4.6 billion Tideway Tunnel 'super sewer'.

Understanding the changing conditions of the Tidal Thames requires a complex set of indicators to interpret a complicated story of a changing world: increased population size means increased pollution; changing agricultural practices will influence the nutrients and chemicals that flow into the river; novel pollutants enter the environment with as yet unknown consequences; and climate change continues to alter the ambient conditions of the dynamic system. Despite these pressures, the Tidal Thames remains one of the most productive ecosystems in Europe, comprising a complex mosaic of wetland habitats that support a rich diversity of life – from seahorses to smoothhound sharks. For the millions of people living alongside it, the Thames continues to provide ecosystem benefits, including jobs, a natural space for mental and physical wellbeing, protection from flooding, drinking water and food. These factors combine to make the Thames one of our greatest natural and public assets.

It is the intention that by presenting the state of the Tidal Thames, decisions can be made that will allow the estuary to continue an upward trajectory and achieve a recovery that will benefit all living things.



Right: Ecosystem benefits provided by the Tidal Thames (ZSL 2021). Infographic adapted from the *Living Planet Report* (WWF 2018).

ZSL AND THE TIDAL THAMES

ZSL is a science-driven conservation organisation that works to restore wildlife in the UK and around the world. Led by our passion for nature, a scientific approach and pioneering spirit, we lead conservation, shape agendas and influence change to protect and restore nature. We continue to deliver our Thames Conservation Programme, established in 2003, to improve and secure the ecological functioning of the Tidal Thames by delivering the components necessary for a recovering urban estuary: clean water, abundant healthy wildlife and connected people.

Our work is fundamentally collaborative, spanning from the urban tributaries that connect London's communities to the diverse coastal wetlands of the Greater Thames Estuary. Since the inaugural *State of the Thames* report published in 2021, our remit has expanded significantly to include constructing wetlands designed to mitigate road-source pollutants and removing concrete embankments and culverts to reinstate natural river systems. We are also actively restoring critical habitats such as intertidal seagrass, saltmarsh and native oyster reefs, which have been severely degraded.

Importantly, we continue to partner with local communities across London to systematically gather essential evidence of poor water quality, often through identifying misconnected outfalls. This robust, citizen-led evidence base helps us target investment strategically to improve the Thames for both wildlife and people. These vital restoration efforts are essential for supporting diverse invertebrate, fish, bird and mammal populations, including flagship species such as the brent goose and the iconic water vole.

Right: ZSL restoring intertidal seagrass in the Greater Thames Estuary.

METHODS

INDICATORS

Indicators are widely used to monitor the status and trends of environmental health and to measure progress towards environmental targets. For this report, we developed a set of 21 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

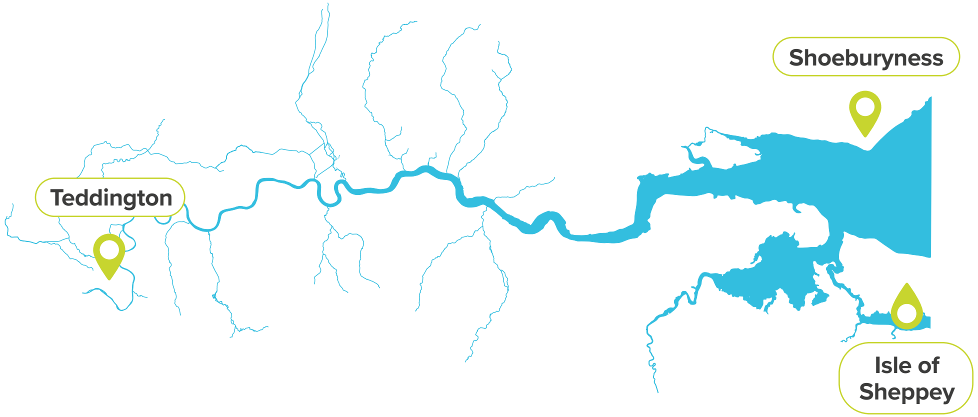
For most indicators, time-series data were taken from a variety of sources, including environmental regulators, NGOs and academic institutions. Data used for the second edition of *The State of the Thames* report aims to cover the 70-year period from 1957 (the year the Tidal Thames was reportedly in its worst state) up to 2024. 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 starts when sampling was standardised to the present-day methodology. For a few indicators, data predates 1957.

TRENDS

To analyse how these indicators are changing over time, time-series data was used to determine long- and short-term trends using a combination of parametric and non-parametric statistical methods. 'Short-term' has generally been defined here as the most recent five to ten 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 ten years. Trends stated in this report were found to be statistically significant (p-value ≤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 and the wider Greater Thames Estuary, most indicators focus on the Tidal Thames itself.



PHYSICAL CHARACTERISTICS OF THE TIDAL THAMES

The Tidal Thames is a vital estuary where the essential mixing of freshwater and saltwater creates a rich, productive, and diverse ecosystem. Nutrients from both the land (above Teddington) and the North Sea fuel a complex, interconnected food web. However, the waters also carry many outputs from our human settlements, industry, and agriculture, impacting water quality and ecosystem health.

At 153 km, the Tidal Thames is one of the longest estuaries in mainland England and Wales and supports some of the most extensive stretches of tidal freshwater and brackish water habitat. Its width varies from just 100 m at Teddington to 7 km at Southend. With a tidal range of up to 7 m, and two tidal cycles per day, the water-filled area at low water is approximately 49 km^2, with tidal channels length in the region of 50 km (Smith and Brown, 2009).

153 km
long – from the tidal limit

100 m – 7 km
in varying width

7 m
of tidal range

2
tidal cycles per day

13
tributaries

49 km^2
water-filled area at low water

STATE OF THE ENVIRONMENT

Image credit: Wanda Bodnar

"While the London Tideway Tunnels are expected to help improve water quality, other environmental factors continue to threaten the health of wildlife in the Tidal Thames."

In the 1950s, the Thames estuary was probably in the worst state it had ever been in. Surveys in this decade recorded oxygen levels at below 5% for 52 km of the tidal reach and a 20 km stretch of the Thames, around the two main outfalls, having no measurable oxygen in the water. No fish populations were present for a 69 km stretch from Kew to Gravesend (Atrill M., 2006).

Water quality improved from the 1960s, through measures that included the expansion of sewage treatment works (STW), limits on water abstraction, and new industrial discharge regulations, until the end of the 1970s, when it was considered 'rehabilitated'. However, this recovery was very fragile due to the age of London's sewerage system, the fourfold increase in population since it was designed and sewage overflow from the combined sewers into the Tidal Thames being triggered with increasing frequency (Environment Agency 2019a).

To address these pressures, the Thames Tideway Improvements were proposed in 2005. These were to expand the capacity of five Tidal Thameside sewage treatment works (completed 2014), build the Lee Tunnel to capture the single worst overflow at Abbey Mills (completed 2016), and create a new London 'super sewer' called the Thames Tideway Tunnel (completed 2025). Now collectively called the London Tideway Tunnels, they can capture 1.6 million tonnes (cubic metres) of untreated sewage which would otherwise flow into the estuary, and which is now pumped to Beckton STW for treatment, improving river water quality and further protecting it from damaging storm overflows.

Whilst we have had significant investment through the Thames Tideway Tunnels to improve water quality, other pressures also impact the state of the environment including climate change influences on both water temperatures and mean sea levels, the emerging understanding of the impacts of 'chemicals of concern' on wildlife, and the continual plastic tide. The following indicators evaluate the environmental factors affecting the ecosystems of the Tidal Thames.

Above: Tunnelling of the Thames Tideway Tunnel, London's 'super sewer', completed in 2025. **Image credit:** Courtesy of Tideway.

DISSOLVED OXYGEN

Long-term trend: **Improving**

Short-term trend: **Improving**

Dissolved oxygen (DO) is necessary for almost all forms of aquatic life; it is considered the most important parameter for evaluating water quality in most water bodies. While DO concentrations naturally fluctuate because of a combination of physical, chemical and biological characteristics, human activities can also have substantial impacts. Responses to DO are species-specific. More sensitive species may survive below 45% DO but will be impacted by biological, physiological, and behavioural effects, such as reduced growth and impaired reproduction, that over time will impact the long-term health of populations (UK Technical Advisory Group on the Water Framework Directive 2008).

Right: Juvenile short-snouted seahorses are present in the Thames.

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, mainly untreated sewage overflow caused when rainfall enters the combined sewerage system. As an estuary, the Tidal Thames' DO concentrations are also influenced by freshwater flow, tides, temperature and storm events. 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.

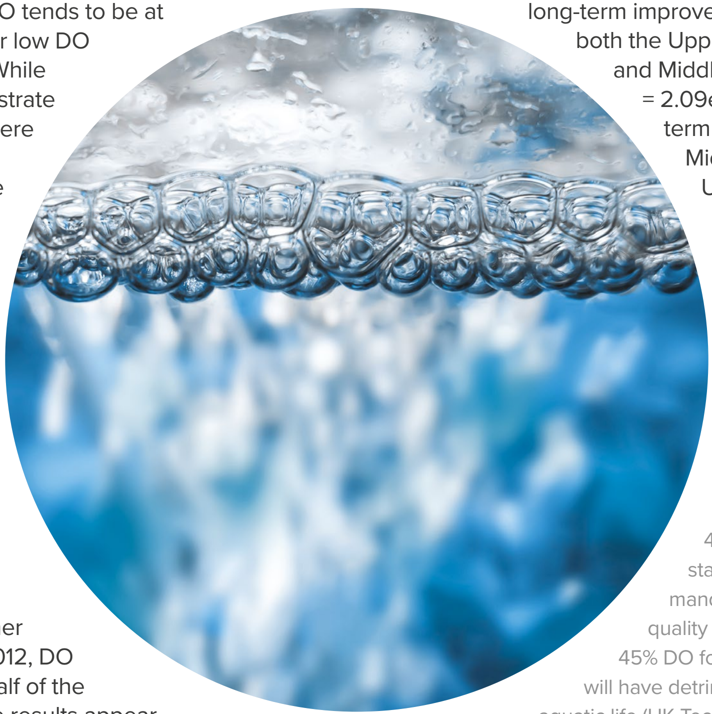
ANALYSIS

The data used for this analysis came 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, 2023 and 2024, DO fell below 45% (Figure 1.1). The results reveal 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 demonstrate improvement in DO levels, there continue to be spikes, for example, in 2022 when there was an extreme heatwave. The overall improvements seen, particularly after 2011, are likely due to improvements in Upper Tidal Thames sewage treatment works such as Mogden.

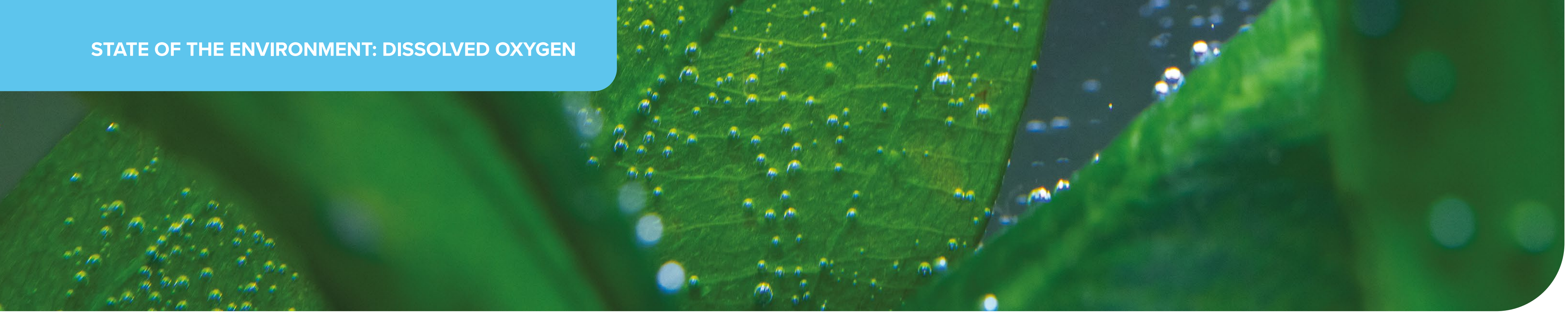
Findings for the Middle Tidal Thames show substantial periods of time between 2008 and 2013 during which DO was below 45%, particularly in the summer months (Figure 1.2). In July 2012, DO was less than 45% for over half of the hours monitored. While these results appear worse than those of the Upper 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 trends (2007–2024) showed a significant long-term improvement in DO overall in both the Upper (p-value = 3.65e-07) and Middle tidal Thames (p-value = 2.09e-13). Analysis on short-term data (2020–2024) of the Middle (p-value = 0.037) and Upper (p-value = 0.039) Tidal Thames also showed significant improvement, though the trend is not as strong as for the long-term dataset.

[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 have detrimental effects on the rivers' aquatic life (UK Technical Advisory Group on the Water Framewater Directive 2008).

Above: Adequate levels of dissolved oxygen are essential to sustain life in the Tidal Thames.



The percent of each month DO fell below 45%
Upper Tidal Thames

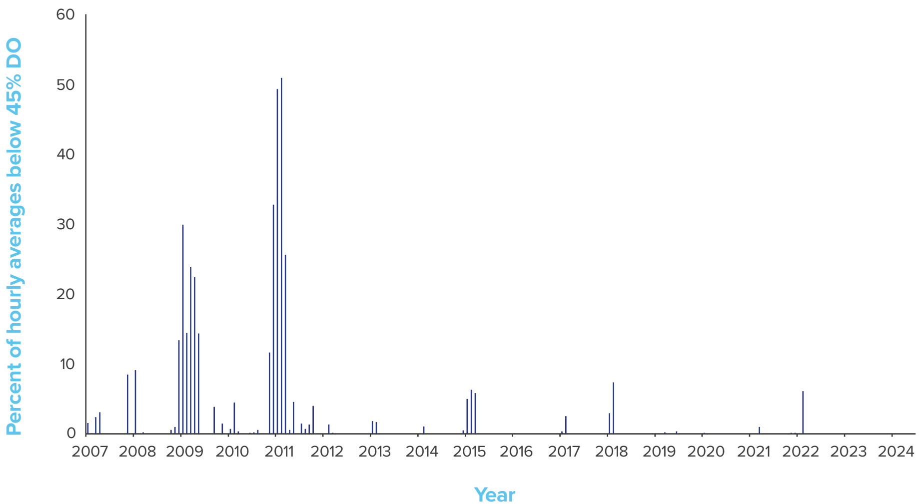


Figure 1.1: Graph showing the percentage of hours in each month when DO was recorded at less than 45% in Upper Tidal Thames monitoring stations (Kew, Chiswick, Hammersmith, Putney and Chelsea).

The percent of each month DO fell below 45%
Middle Tidal Thames

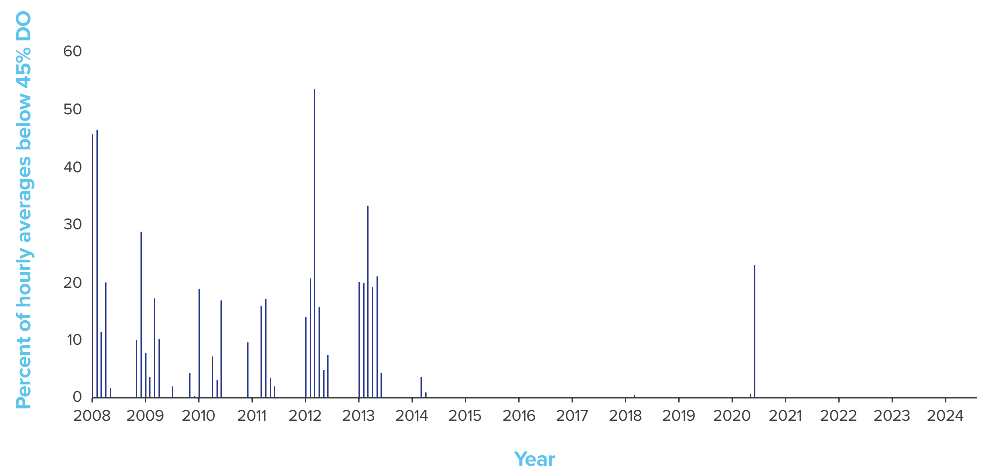


Figure 1.2: Graph showing the percentage of hours in each month when DO was recorded at less than 45% in Middle Tidal Thames monitoring stations (Erith and Purfleet).

THE BUBBLERS

The last significant fish kill occurred in the Tidal Thames in 2011 when the DO levels fell below 20%. This was before the SWTs were extended and improved. For 20 summers, Thames Water ran oxygenation vessels called 'Bubblers', ready to inject replacement oxygen when it fell to levels that put risk to wildlife. Each vessel could inject 30 tonnes of oxygen every day in an affected area. DO fluctuates naturally with higher water temperatures and salinity, reducing the amount of oxygen the water can hold. This is compounded in situations of high organic loading, such as through a release of untreated sewage, when warmer waters speed up biological reactions.

The need for aeration vessels has been greatly reduced since 2013, due to investment and upgrades to sewage treatment works. The Lee Tunnel coming into operation has substantially cut the discharge of raw sewage into the Tidal Thames. This is reflected in the reduction of hours the vessels have been in use each year since 2015 (Figure 1.3). The notable exception to this trend was summer 2022, with the vessels operating for a total of 207 hours. Summer 2022 was a heatwave, marked by the first-ever UK temperatures to exceed 40°C, peaking at 40.3°C on July 19th. The impact of sewage overflows was exacerbated by these high summer temperatures depleting oxygen levels in the river, with DO in the Upper Thames falling below the critical 45% threshold for 6% of the month of August. With the operation of the London Tideway Tunnels, Bubbler use will cease at the end of 2025.

Right: Thames Bubbler. **Image credit:** bryan-jones.com

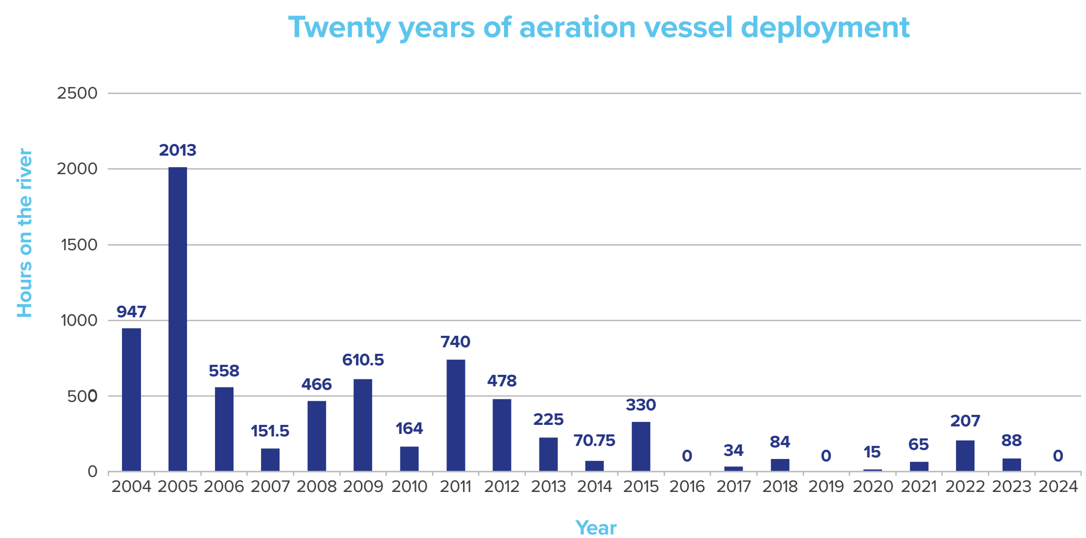


Figure 1.3: The number of hours the aeration vessels, operated by Thames Water, have been deployed on the Thames between 2004 and 2024.

NUTRIENTS

While essential 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 damaging ecological impacts, including low DO, blocking light from the water column and increasing blooms of toxic blue-green algae.

Right: A redshank wader in shallow water surrounded by green seaweed.

PHOSPHORUS

Long-term trend: Improving

Short-term trend: Data stable

BACKGROUND

Phosphorus concentrations in rivers across 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, due to the introduction of the European Union's (EU) Urban Wastewater Treatment Directive, which resulted in all large sewage treatment works (STW) having to introduce phosphate removal processes. 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 water bodies do not meet the 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 heighten due to increasing populations producing more sewage, increased water temperatures and more stormwater runoff.

WINEP has set out environmental requirements for water companies to be actioned by 2025 to address these increased levels and ensure improvements in water quality, including phosphorus concentrations.

ANALYSIS

Tidal influence is a major factor affecting water quality and nutrient concentrations in the Thames Estuary. 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 discharge 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 orthophosphorus concentrations reflecting measurements of dissolved phosphorus were selected. Recorded orthophosphorus 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, yearly averages for the four rivers were separately significance tested using Mann-Kendall tests. 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 was plotted against daily mean flow on the day of sampling. Point source inputs from STWs are relatively constant on a day-to-day basis, and therefore, rivers that are dominated by STW inputs will tend to dilute as river flow increases. Conversely, diffuse agricultural inputs are mobilised during rainfall events, and therefore the nutrient load and/or concentration will increase as rainfall (and river flow) increase. The nearest gauging station was selected, and the mean flow data was obtained from the UK Centre for Ecology & Hydrology's (UKCEH) National River Flow Archive.

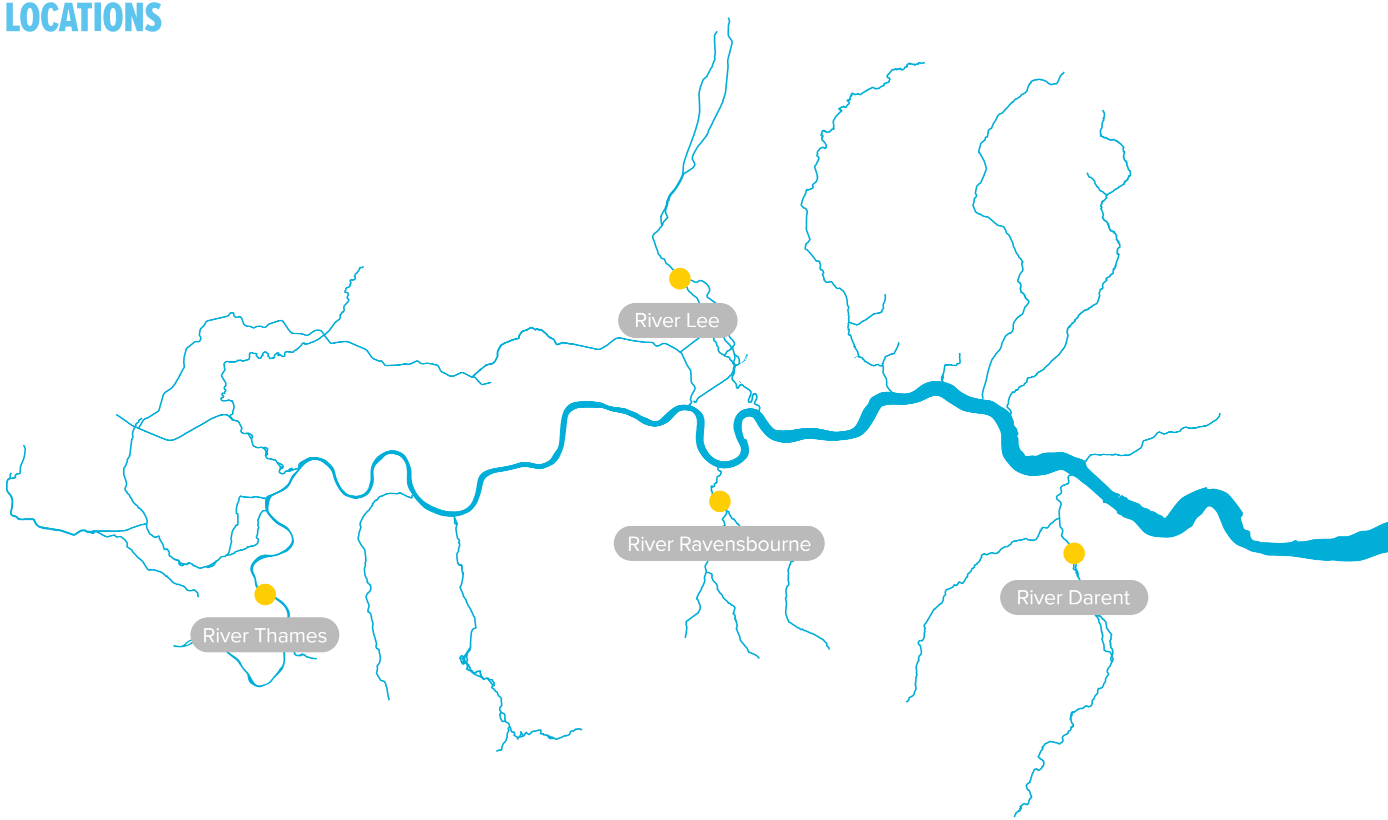
Above: The River Thames at Teddington.

FINDINGS

Long-term dissolved phosphorus concentration trends continue to significantly decrease for three of the rivers (p values: Lee <4.98e^{-10}, Thames <1.033e^{-09}, Ravensbourne <0.001), with the long-term trend for the River Darent remaining stable at low phosphorus concentrations. The Thames and Lee both have the biggest declines, likely because they are downstream of major STWs, which have seen improvements in infrastructure to remove phosphorus in the late 1990s and early 2000s. However, the short-term trends (2020–2024) have stabilised, with the exception of the River Darent which shows a significant decreasing trend ($p < 0.03$) (but note data was only available up to 2022 for this tributary). This stabilisation in some of the short-term trends is contrary to the 2010–2020 short-term trend, which demonstrated significantly decreasing phosphorus.

Reductions in phosphorus concentrations since 2000s at low flow (Figures 2.1 and 2.2) in the Thames demonstrate that this is a result of declining STW inputs. Water companies have been largely responsible for the rapid improvements in the Thames and Lee, and the Thames Tideway should intercept further Phosphorus loads in these rivers. Average daily phosphorus loads (Figure 2.6) for Thames, Ravensbourne and Darent show an increase over the last five years in comparison with the 2010s. Of particular concern are the loads of Ravensbourne and Darent, tributaries which are higher this decade then they have been for the last 30 years. This is likely due to an increase in population density increasing sewage loading to the STW, combined sewage overflow, misconnections, blockages in the foul sewers and failing water company assets sending sewage to river and increasing phosphorus loads. ZSL's Outfall Safari project has recently been evidencing the scale of these issues (ZSI, 2025). As phosphorus loads start to increase, the water companies need to invest in further treatment at STWs and prevent leaks of sewage from aging infrastructure.

NUTRIENT SAMPLING LOCATIONS



Thames phosphorus

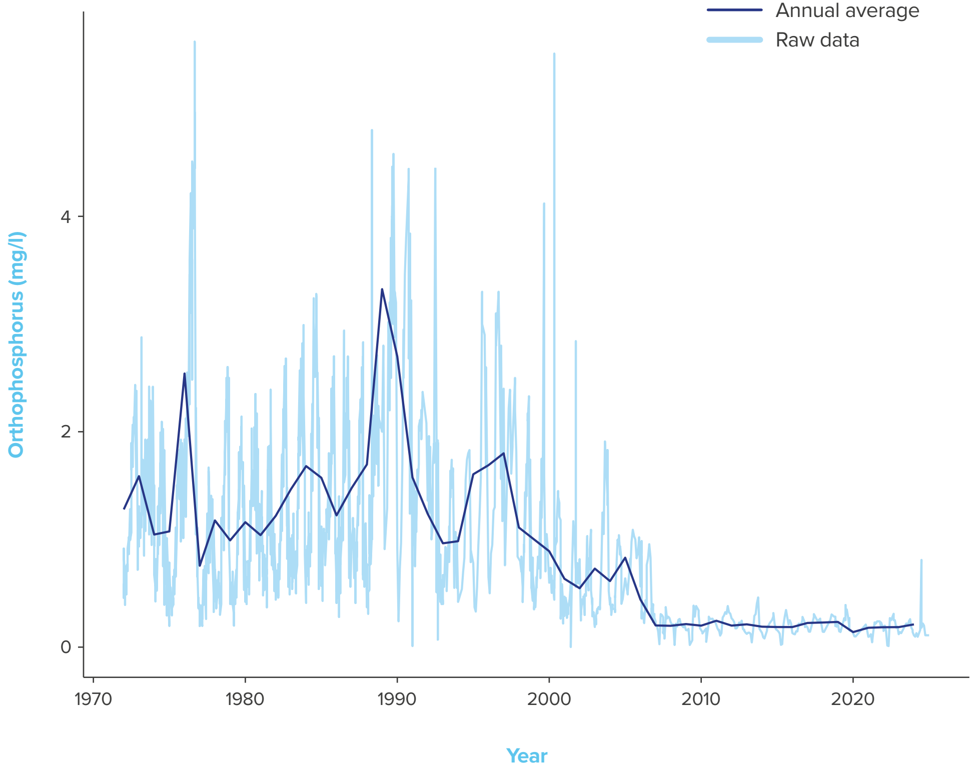


Figure 2.1: Phosphorus concentrations in the River Thames at Teddington.

Lee phosphorus

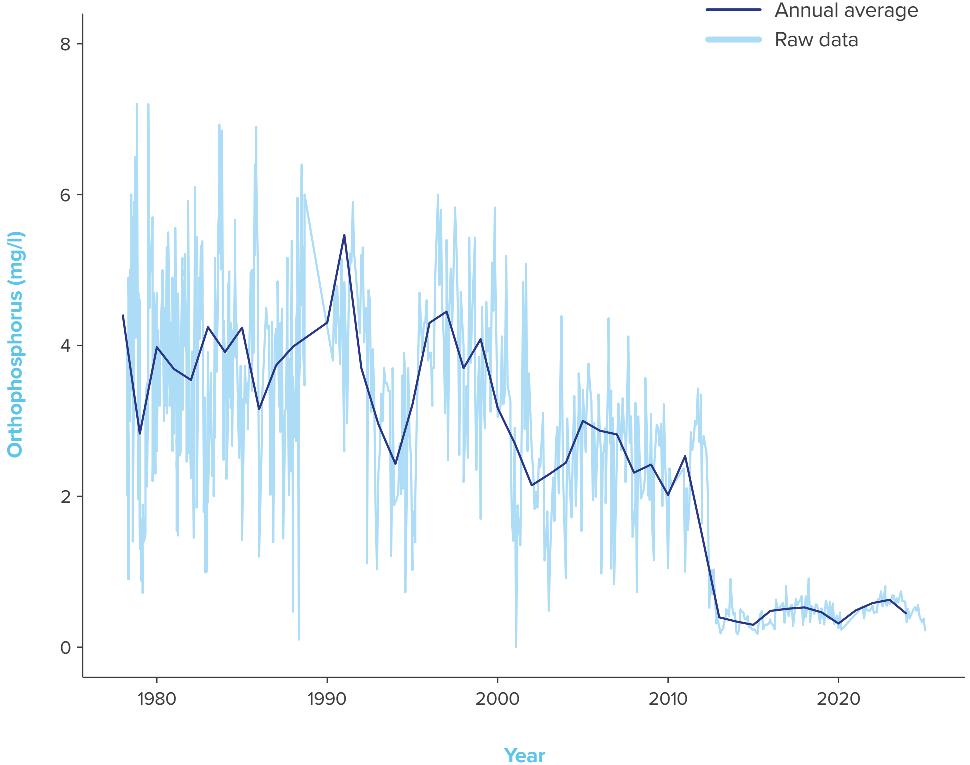


Figure 2.2: Phosphorus concentrations in the River Lee, near its Thames confluence.

Darent phosphorus

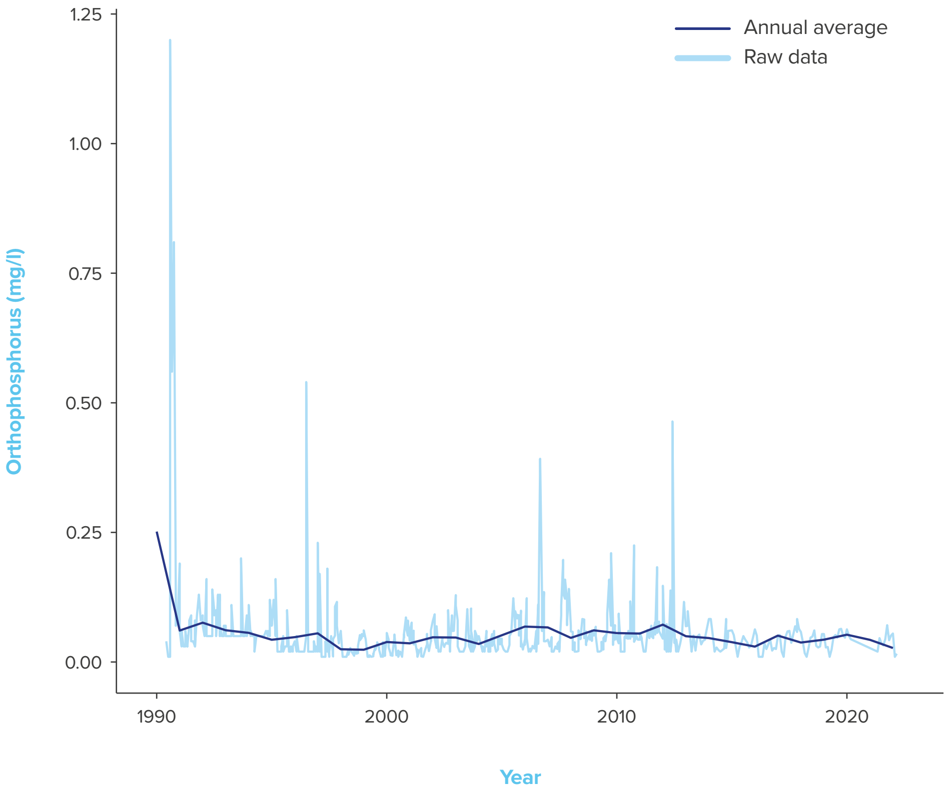


Figure 2.3: Phosphorus concentrations in the River Darent, near its Thames confluence.

Ravensbourne phosphorus

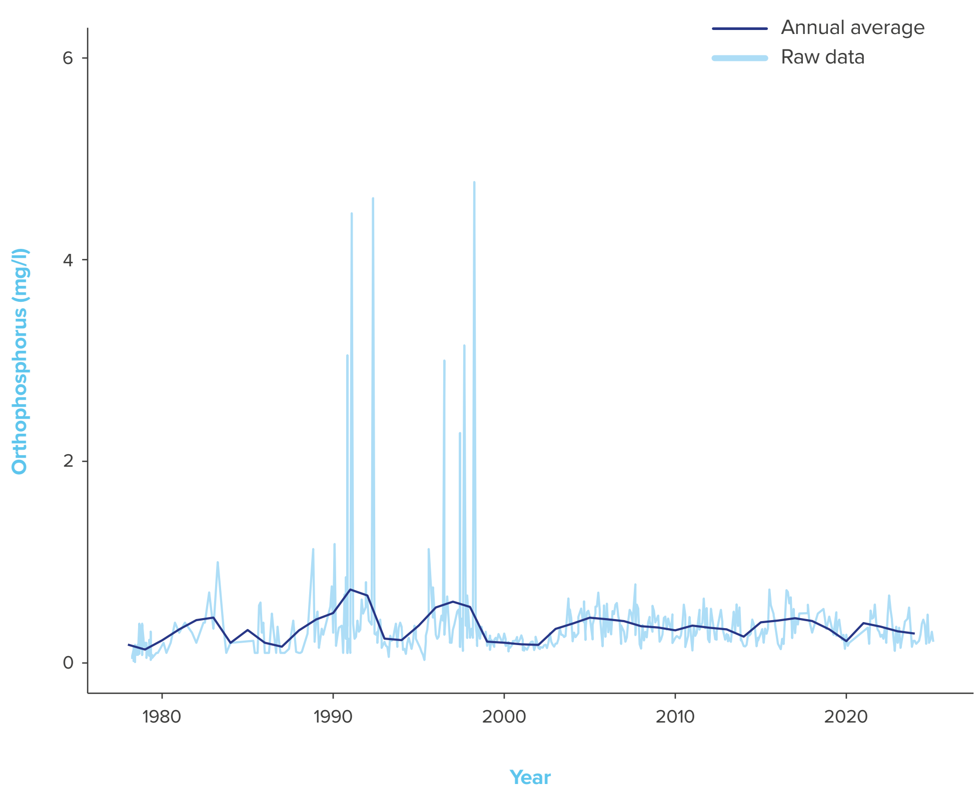


Figure 2.4: Phosphorus concentrations in the River Ravensbourne, near its Thames confluence.

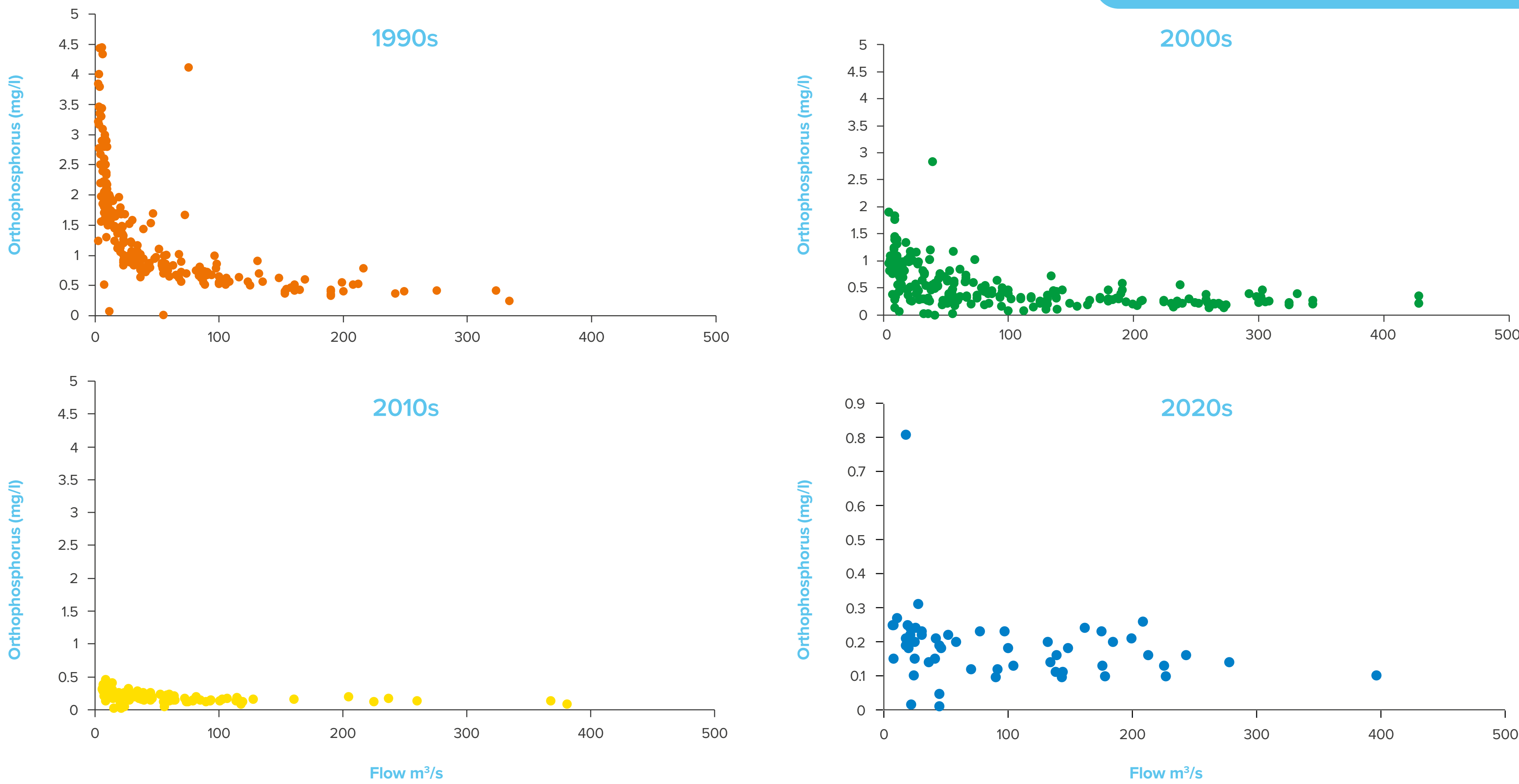
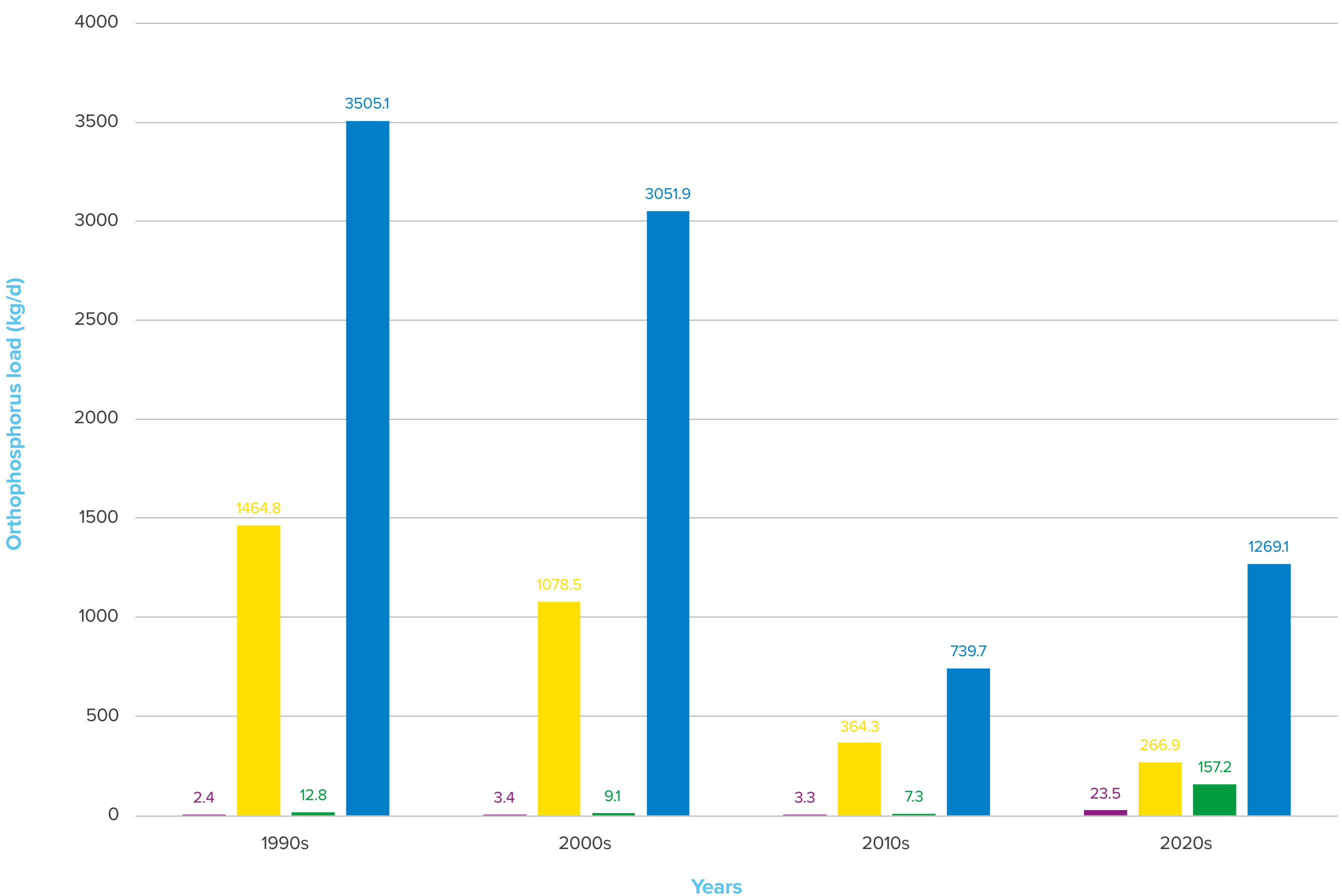
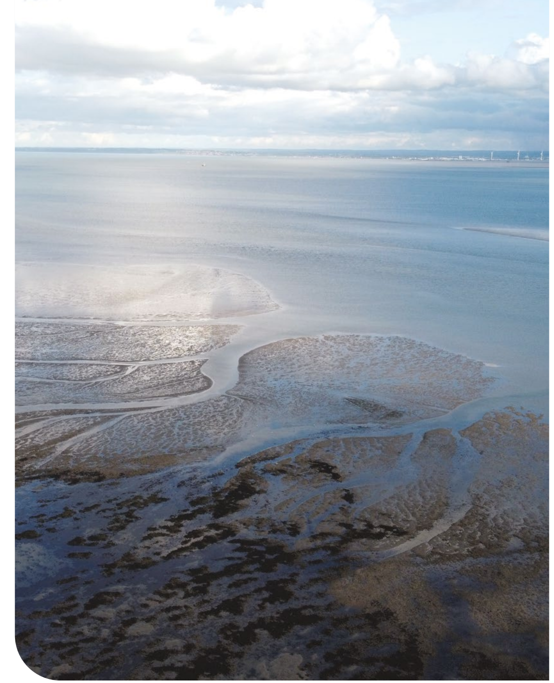


Figure 2.5: Thames orthophosphate (or reactive phosphorus) plotted against flow at the time each sample was taken. The samples taken in the 1990s are largely sewage-dominated, with high orthophosphate concentrations occurring at low flow, while high flows see low concentrations. This demonstrates that the source of orthophosphate during this time was likely a point source such as an outfall pipe from a STW. In the 2000s, 2010s and 2020s we see reduced orthophosphate concentrations. Note change in scale of orthophosphorus in 2020s.

Average daily orthophosphorus loads to the Thames Estuary





Above: Aerial view of the Thames Estuary at low tide.

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

NITRATE

Long-term trend: Deteriorating

Short-term trend: Data stable

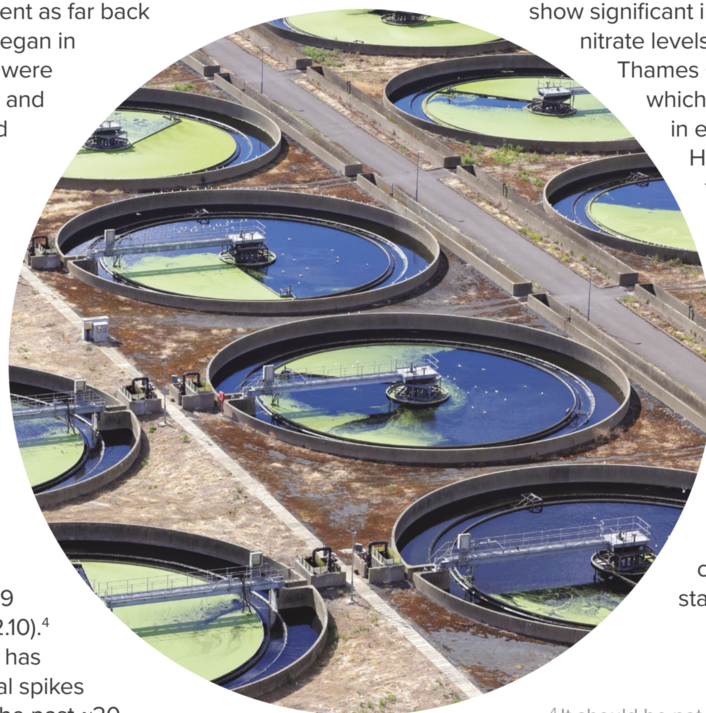
BACKGROUND

Nitrate is another nutrient that can contribute 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 water bodies, 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 water bodies. However, much of the nitrate in the tidal section of the River Thames will be derived from nitrate-rich groundwater inputs from the chalk geology of the upstream Thames catchment to the west of London. 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 concentrations 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. Yearly averages were calculated for each tributary and plotted with raw background data. To test for statistically significant long- and short-term trends in annual averages in each of the four rivers, Mann-Kendall tests were run.



FINDINGS

Annual averages of nitrate concentrations in the larger rivers (Thames, Figure 2.7 and Lee, Figure 2.8) are higher on average than in the smaller tributaries (Darent, Figure 2.9 and Ravensbourne, Figure 2.10).[4] Notably the Lee (Figure 2.8) has experienced fairly substantial spikes in nitrate concentrations in the past ~20 years, this may be due to an increasing population pressure around this tributary or may be due to lower flows in these years resulting in a higher proportion of nitrate-rich groundwater. Other small peaks in nitrate concentrations across the four rivers may also be linked to storm events.

Long-term trends in the Thames, Lee and Darent show significant increasing trends in average nitrate levels (p-value: Lee <0.001, Thames <0.001, Darent <0.0002), which indicates a deterioration in environmental quality. However, the Ravensbourne tributary shows a significant decreasing trend in average nitrate levels (p-value $<3.85e^{-05}$). Taken together the long-term trend shows a significant gradual increase in annual average nitrate concentrations (p-value: $4.76e^{-11}$). There were no statistically significant short-term (2020–2024) trends, suggesting that concentrations have stabilised.

[4] It should be noted that annual nitrate concentration decreases in 2020 may be due to a lack of monthly data in this year due to the COVID-19 pandemic (data were only available for 3 of the 12 months).

Thames nitrate

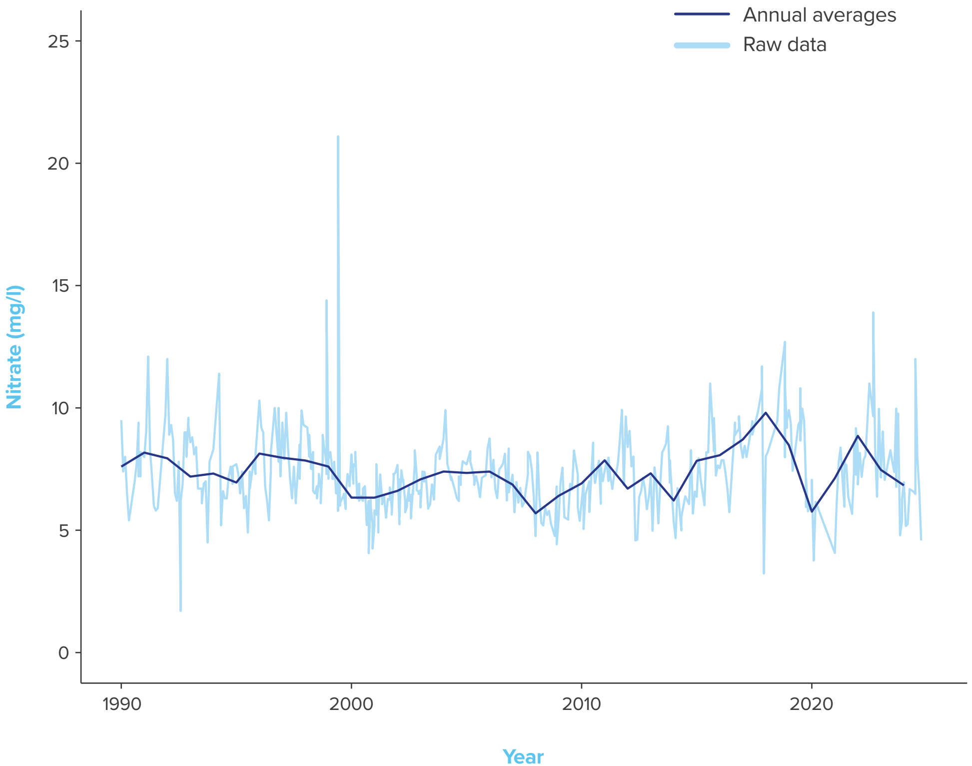


Figure 2.7: Nitrate concentrations (mg NO^3/L) in the Thames at Teddington.

Lee nitrate

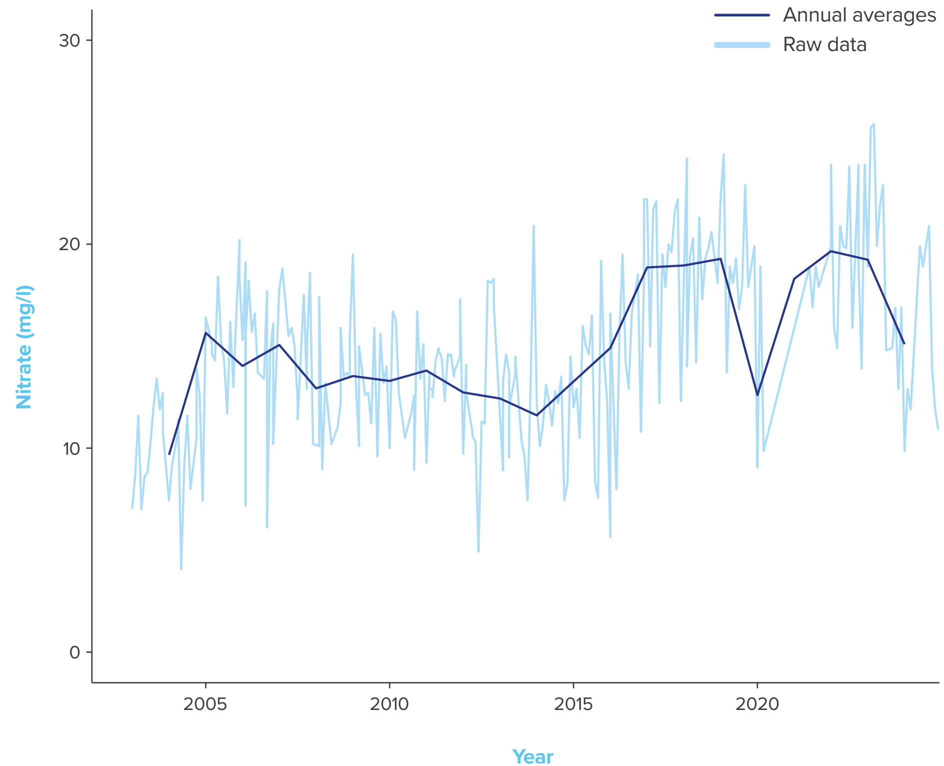


Figure 2.8: Nitrate concentrations (mg NO^3/L) in the River Lee.

Darent nitrate

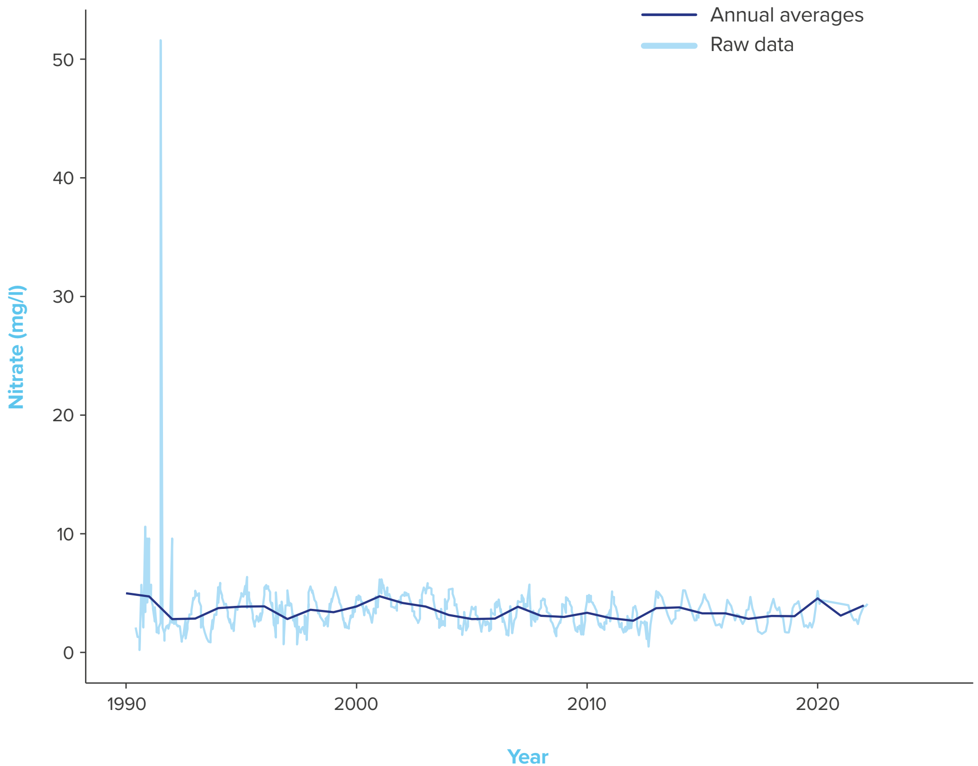


Figure 2.9: Nitrate concentrations (mg NO3/L) in the River Darent.

Ravensbourne nitrate

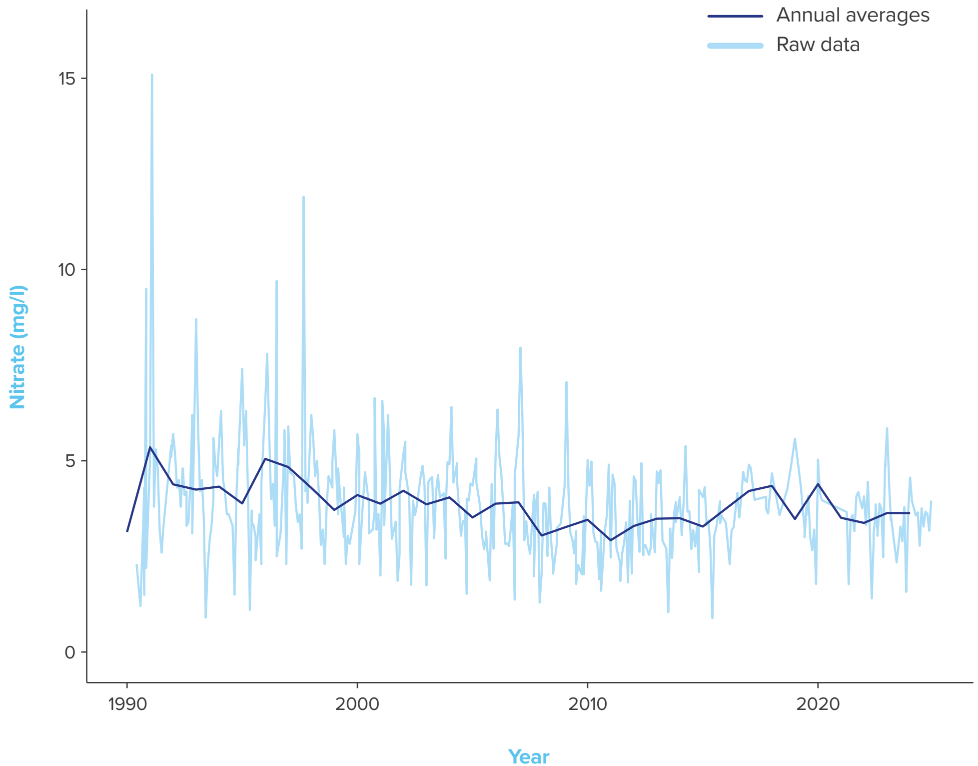


Figure 2.10: Nitrate concentrations (mg NO3/L) in the River Ravensbourne.

CHEMICAL CONTAMINANTS

CHEMICALS OF CONCERN

Long-term trend – copper: Improving

Short-term trend – copper: Improving

Long-term trend – zinc: Improving

Short-term trend – zinc: Improving

A multitude of chemicals find their way into the rivers of the Thames catchment that are used in industrial processes, agriculture, medicines and household goods. A small number of these can be classed as chemical contaminants, which generally refers to chemicals that pose a risk to ecosystems and/or humans. Monitoring and controlling these substances, while challenging, is essential to protect the vitality of the Tidal Thames.

Right: Port of Tilbury (London) on the Thames.

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 Water Framework Directive (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 water body 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 ten chemicals ranked by the threat they pose purely to aquatic organisms as defined by Johnson *et al*. (2017) (Table 1), 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. Here, we focus on copper and zinc, as the top two **priority substances** found in Table 1.

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 1: The top ten highly ranked chemicals of concern, based on Johnson *et al*. 2017's methodology using the ratio of medians of all ecotoxicity data.

ANALYSIS

The dissolved copper and zinc data used for this analysis were obtained from WIMS. Annual averages from across the whole Tidal Thames were calculated and plotted from 1990, when the consistency of monitoring in this dataset improved. To test for statistically significant long- and short-term trends in the data, Mann-Kendal tests were used.

FINDINGS

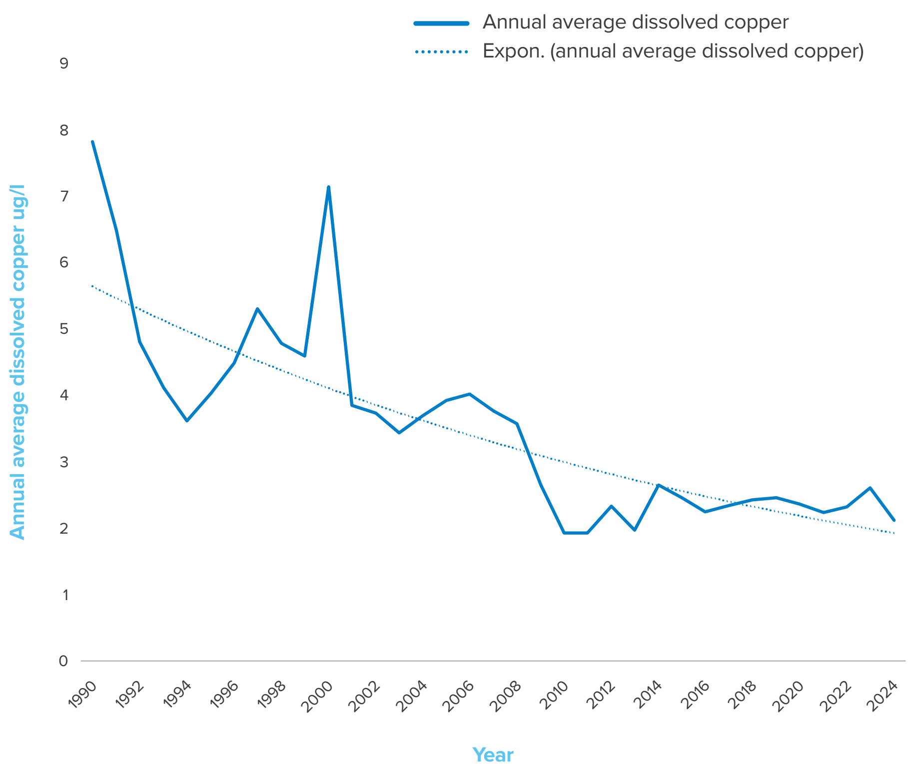
The long-term trend in annual average dissolved copper concentrations has significantly declined since the 1990s across the Tidal Thames ($p = 1.08e^{-07}$), from an average annual peak of 7.8 ug/L in 1990 down to 2.1 ug/L in 2024, but with substantial fluctuations (Figure 3.1). In the short term, these concentrations have also continued to significantly decline ($p = 0.03$), although this decline has slowed. Furthermore, dissolved copper concentrations have been below 3.3 ug/L since 2009. This is the ecotoxicology threshold above which concentrations have been shown to significantly reduce invertebrate family richness with the potential to have knock-on effects up the food chain (Johnson *et al* 2025).

The long-term trend in annual average dissolved zinc concentrations has also significantly declined ($p = 0.001$), with notable fluctuations over the years, from 14.7 ug/L in 1990 to 7.3 ug/L in 2024 (Figure 3.2). Concentrations have also significantly declined in the short term ($p = 0.03$), although this decline has slowed. Dissolved zinc concentrations have been below the ecotoxicology threshold of 14.2 ug/L since 2005. Similar to copper, this is the threshold above which concentrations have been shown to significantly reduce invertebrate family richness, with the potential to have knock-on effects up the food chain (Johnson *et al* 2025).

The declines seen in both metal concentrations since the 1990s in the Tidal Thames can in part be attributed to the major improvements in STWs in the 1990s and early 2000s. These improvements also sit alongside reductions in atmospheric pollution associated with the end of coal-burning, with the concomitant increase in soil pH, and possibly also some reduction in society's domestic consumption of metal products. While the declining concentrations in the Tidal Thames are encouraging, they should be treated with some caution as episodic runoff events can have very high zinc and copper concentrations that would be categorised as highly toxic and are unlikely to be detected by routine monitoring (Johnson *et al* 2025).

Right: A view from the shore at Battersea along the river Thames.

Annual average dissolved copper concentrations



Annual average dissolved zinc concentrations

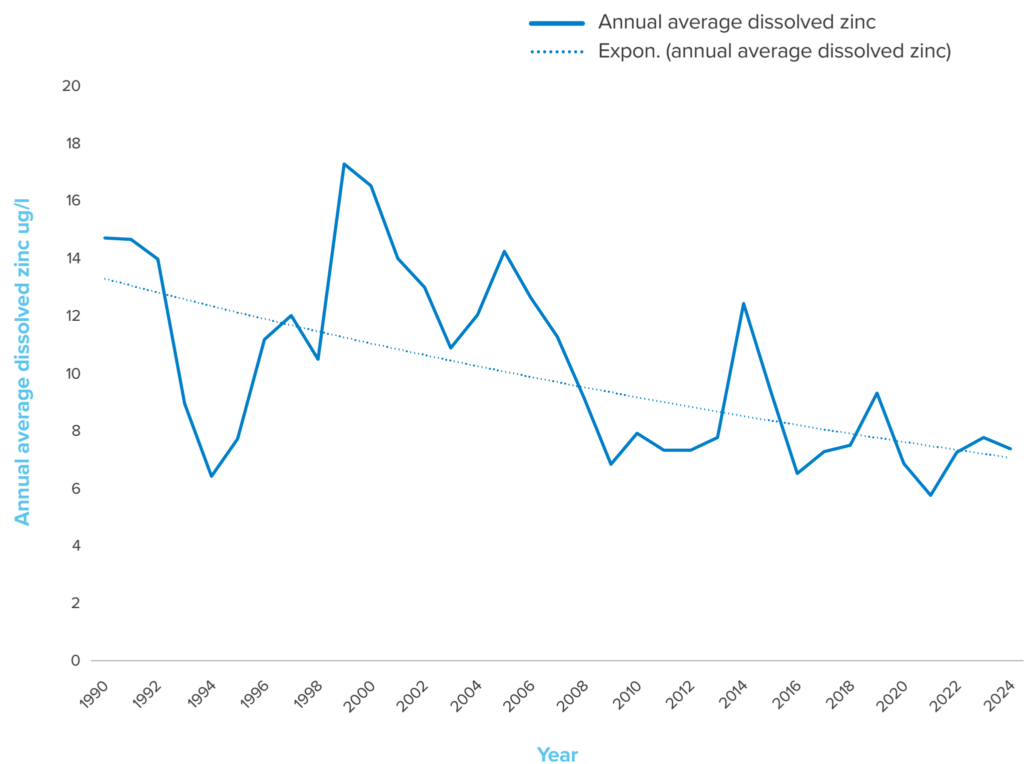


Figure 3.1: Annual average dissolved copper concentrations using monitoring data from across the entire Tidal Thames from 1990 to 2024. The blue line shows annual average values, while the dotted line shows an exponential model fitted to the data.

Figure 3.2: Annual average dissolved zinc concentrations using monitoring data from across the entire Tidal Thames from 1990 to 2024. The blue line shows annual average values, while the dotted line shows an exponential model fitted to the data.

CHEMICALS OF EMERGING CONCERN

Long-term trend: Insufficient data

Short-term trend: Insufficient data

Contamination of the aquatic environment from both forever chemicals and chemicals of emerging concern (CEC) is a growing problem globally. An ever-increasing variety of substances are detected in environmental waters as analytical techniques evolve. Aquatic ecosystems and people are exposed to a broad mixture of compounds from a variety of sources. CECs include pesticides, pharmaceuticals (human and veterinary), lifestyle products and personal care products.

Right: Pharmaceuticals discarded in household waste.

BACKGROUND

The European Union Water Framework Directive (EU WFD) includes fewer than a hundred chemical substances across two lists for regulation and/or monitoring: a 'priority substances' list of 45 chemicals or chemical groups; and a 'watch list' of 26 CECs, which require more urgent understanding regarding their occurrence, fate and effects across multiple environmental compartments.

In 2019, the Environment Agency reported occurrence of 41 pharmaceuticals and two lifestyle products in a large-scale study of the River Thames, from its source to the North Sea; it identified the urbanised, tidal region within Central London as the most impacted by CECs (White *et al* 2019). More recently, a study led by Imperial College London analysed the largest spatiotemporal dataset of its kind for any major capital city globally (Egli *et al* 2023).

ANALYSIS

The study identified and monitored large numbers of CECs across the River Thames and its major tributaries in 2019–2021 (n = 390) using novel direct-injection liquid chromatography-mass spectrometry methods. A total of 10,029 measured environmental concentrations (MECs) were obtained for 66 unique CECs. The study then prioritised these CECs based on risk by calculating a risk quotient (Egli *et al* 2023).[5]

FINDINGS

Three of these CECs were categorised as high-risk (RQ >10), seven as medium risk (RQ >1.0), and the others as low (RQ 0.1–1.0) or insignificant risk (<0.1). Table 2 shows the top five highest risk compounds.

Imidacloprid, found to be of the highest risk, is a neonicotinoid insecticide which was banned in agriculture in 2018. However, imidacloprid and other substances similarly banned for usage in agriculture are still being sold and used for other purposes, including parasiticide treatments for pets in the UK. Concentrations as low as 0.013 ug/L are considered toxic to freshwater species. Recommended actions include increased monitoring, stewardship and regulation of veterinary parasiticides to minimise potential pollution impacts on freshwater ecosystems. Two of the top five highest risk CECs are antibiotics, and there is widespread concern that even low concentrations could interact with microorganisms that could lead to antimicrobial resistance and interfere with natural microbial functions within the environment. Finally, diclofenac, a non-steroid anti-inflammatory (NSAI) drug and analgesic, was also found to be of high risk. This CEC has been the focus of many published environmental occurrence studies and is one of two pharmaceutical compounds identified by the Environment Agency (the other is clarithromycin) as CECs (White *et al*., 2019). It can be harmful to aquatic organisms, and environmental quality standards (EQS) of 100 ng/L and 10 ng/L for freshwater and saltwater, respectively, have been proposed. Freshwater measured environmental concentrations were higher than this EQS for 31% of all samples taken in the catchment.

Overall, little is known about the occurrence, effects and toxicity of these CECs on human and environmental health. However, in England, pioneering steps are being taken by the Environment Agency to design and undertake semi-quantitative chemical monitoring across the country (Spurgeon *et al* 2022).

[5] Risk quotients are calculations based on an equation where the measured environmental concentration of a compound is divided by the lowest predicted no-effect concentration in freshwater of a compound sourced from the Norman Network Ecotoxicology Database as of December 2022.

RANKING	CECs	SUBSTANCE TYPE	RISK QUOTIENT (RQ)
1	Imidacloprid	Pesticides	High risk
2	Azithromycin	Antibiotics	High risk
3	Diclofenac	NSAI Drugs & analgesics	High risk
4	Acetamiprid	Pesticides	Medium risk
5	Clarithromycin	Antibiotics	Medium risk

Table 2: The five highest risk CECs in the Thames catchment area identified by Egli *et al* (2023) based on measured environmental concentrations from 390 water samples collected from 2019–21. High environmental risk was defined as RQ ≥10.0, medium risk as 1.0–10.0, low risk as 0.1–1.0, and insignificant risk as <0.1.

BIOTIC INDEX: INVERTEBRATES

Long-term trend: Data stable

Short-term trend: Data stable

Aquatic invertebrates have long been used in water quality monitoring as an indicator of 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: Green Drake Mayfly (*Ephemera danica*), a widespread Ephemera species in the UK.

BACKGROUND

The extent to which a water body has been impacted by pollution and habitat degradation is sometimes assessed using a biotic index, which measures water quality by using the presence or absence of certain species. These indices are often based on an invertebrate family's sensitivity to pollution and water conditions. 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 changes in habitat condition.

ANALYSIS

This analysis focuses on five Environment Agency sampling points in the Upper Tidal Thames, between Barnes and Teddington, where invertebrate communities have been consistently monitored since 2005. The data was 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 was obtained from the Environment Agency's Marine and Freshwater Invertebrates dataset.

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. 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 five freshwater-dominated sites in the Upper Thames.

FINDINGS

Throughout the sampling period (2005–2024), the most upstream sample site at Teddington recorded the highest average BMWP scores (72.9) of all five sites, while Barnes recorded the lowest (32.7). Both Teddington and Ham experienced a notable decline over the full survey period, while Kew showed a moderate improvement. Barnes and Isleworth remained relatively stable.

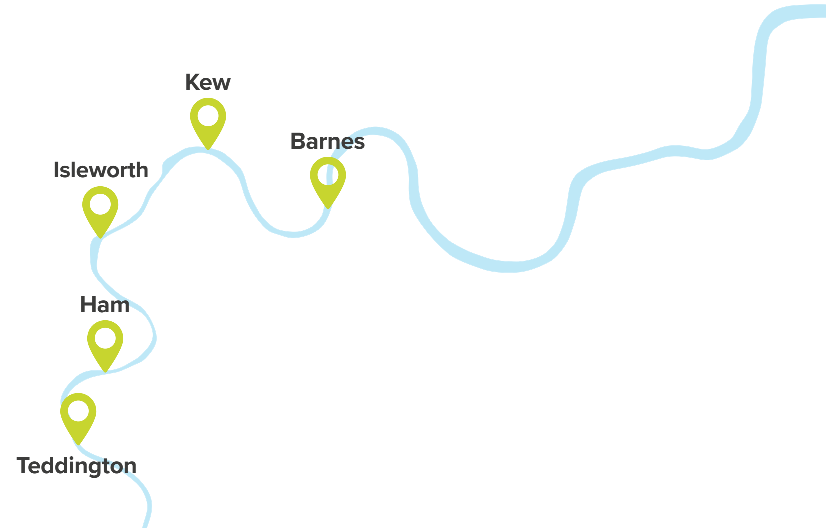
Comparing the mean scores from the recent five years (2020–2024) to the previous (2005–2019). Although Teddington remained the highest average score (57.8), its drop from “Good” to “Moderate” is concerning. Barnes again recorded the lowest average at 34.7, remaining in the 'Poor' band. Kew, however, showed modest progress, rising from 35.3 to 44.6 and moving up from 'Poor' to 'Moderate'.

A lower invertebrate BMWP score does not necessarily reflect a decline in water quality. For example, higher salinity may account for the lower scores at Barnes and Kew compared to Teddington, which lie closer to the saltwater-dominated reach of the estuary.

However, other factors, such as changes in freshwater flow and temperature, can influence dissolved oxygen and salinity, both of which affect invertebrate communities. Prolonged dry and warm summers, for example, can reduce river flow through both natural drought and increased abstraction, leading to lower dissolved oxygen and elevated salinity, particularly in the upper estuary. Attrill *et al*. (2000) found that declining river flows were closely associated with reductions in BMWP scores, suggesting that flow-related stressors, rather than direct pollution effects, may be a key driver of the observed declines in the upper estuary.

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

Table 3: BMWP score categories and descriptions (UKTAG WFD 2013).



BMWP scores at five sampling sites

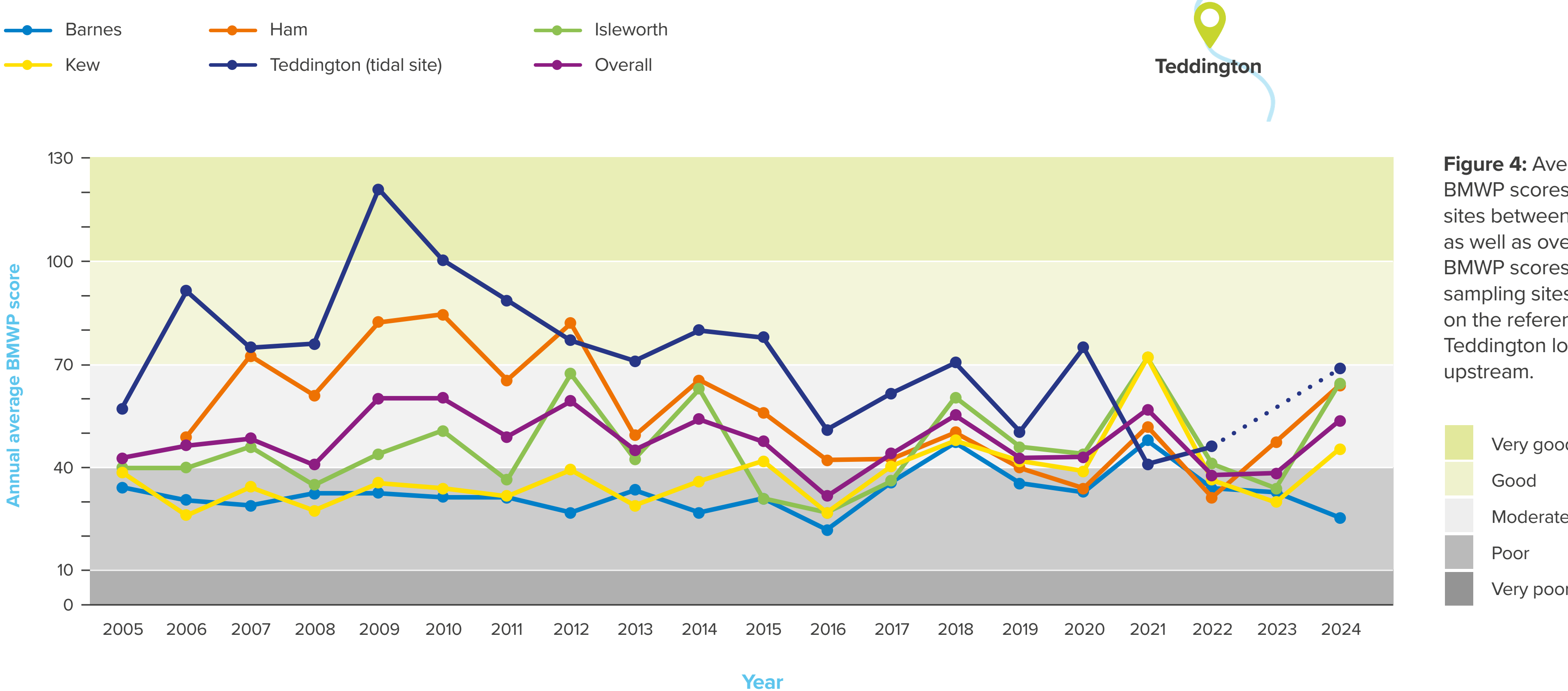


Figure 4: Average summer BMWP scores at five sampling sites between 2005 and 2024, as well as overall average BMWP scores. Locations of sampling sites can be seen on the reference map, with Teddington located furthest upstream.

Above: A common dolphin surfacing alongside a rowboat near Putney Peir on the Thames. **Image credit:** Simon Hunt.

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: Flooding at Tower Bridge, London in 2019.

WATER TEMPERATURE

Long-term trend: Deteriorating

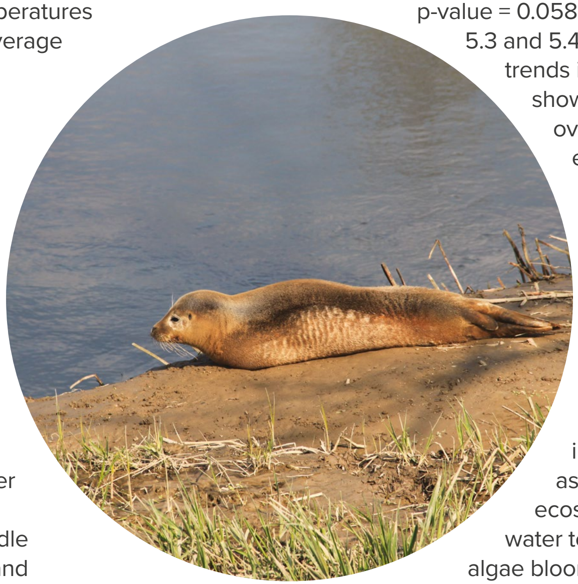
Short-term trend: Deteriorating

BACKGROUND

Global sea surface temperatures have increased by 0.6°C from 1980–2020, with the Atlantic Ocean warming slightly slower than the global average, according to the IPCC 5th Assessment Report (Fox-Kemper *et al* 2021). 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 dissolved oxygen 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. 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 was taken from the Environment Agency's Automated Quality Monitoring System. The data collected by these sensors for the 2007–2024 period was first manually cleaned, removing periods during which any sensors were not functioning properly. The data was 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, when temperatures reach their highest and lowest, average summer and winter temperatures for each year were calculated.[6] Annual data was then tested for statistically significant trends using linear regression models over two different time frames: long-term (2007–2024) and short-term (2020–2024).



FINDINGS

On average, summer and winter temperatures in the Upper Tidal Thames have been increasing by 0.13°C and 0.12°C per year respectively (this is a 1°C rise every eight years). Whilst the Middle Tidal Thames has seen summer and winter temperatures increase on average by 0.05°C and 0.07°C per year, respectively. The slower increase in temperatures in the Middle Tidal Thames can be attributed to deeper waters and more ocean exchange, causing greater variability in temperature. These temperature increases are all above the average warming of 0.037°C/yr found for estuaries in England (Hutchings *et al*. 2024).

Summer and winter temperatures in the Upper Tidal Thames (Figures 5.1 and 5.2) both saw a statistically significant long-term increasing trend (summer: p-value = 0.0031, winter: p-value = 0.007). As did winter temperatures in the Middle Tidal Thames, with summer temperatures in the Middle Tidal Thames approaching a significant increasing trend (summer: p-value = 0.058, winter: p-value = 0.035) (Figures 5.3 and 5.4). Middle Tidal Thames long-term trends in the previous report (2008–2020) showed a gradual temperature increase over time, but were not significant in either season. Therefore, the current significant increasing temperature trend, five years on, in the Middle Tidal Thames and approaching significant trend in the summer is of concern.

This indicator is identified as deteriorating in both the long and short-term because an increase in water temperature is associated with degradation to aquatic ecosystems. For instance, increasing water temperature can enhance harmful algae blooms, which reduce dissolved oxygen concentrations, and produce toxins that can be detrimental to wildlife.

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

Annual average summer water temperature **in the Upper Tidal Thames**

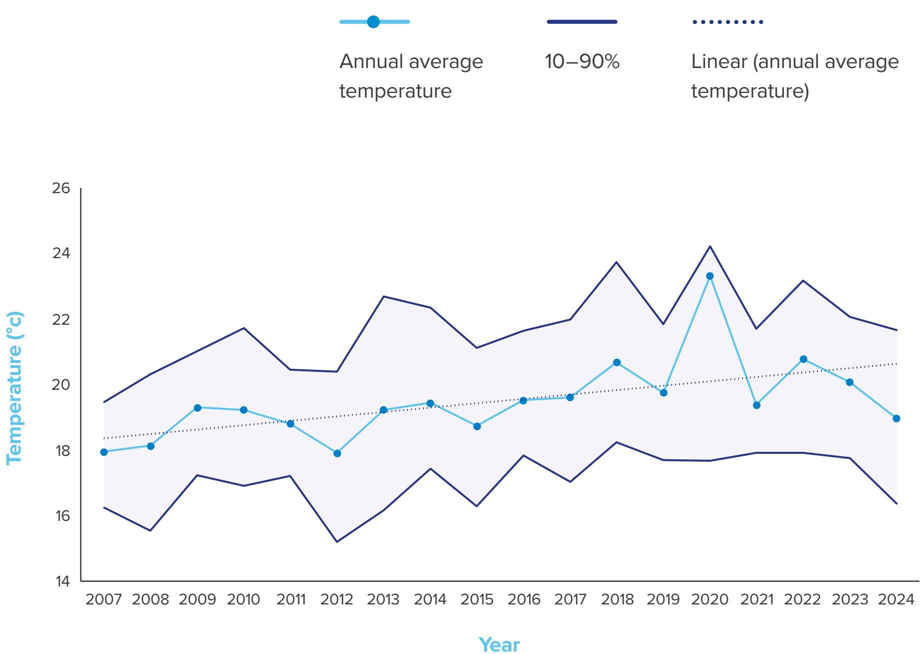


Figure 5.1: Average summer water temperature in the Upper Tidal Thames (between Battersea and Kew). The dotted line shows a linear model fitted to the data, the upper bound of the 10–90% blue area shows the 90% quantile (under which 90% of the data fall), and the lower bound of the 10–90% blue area shows the 10% quantile (above which 90% of the data fall).

Annual average winter water temperature **in the Upper Tidal Thames**

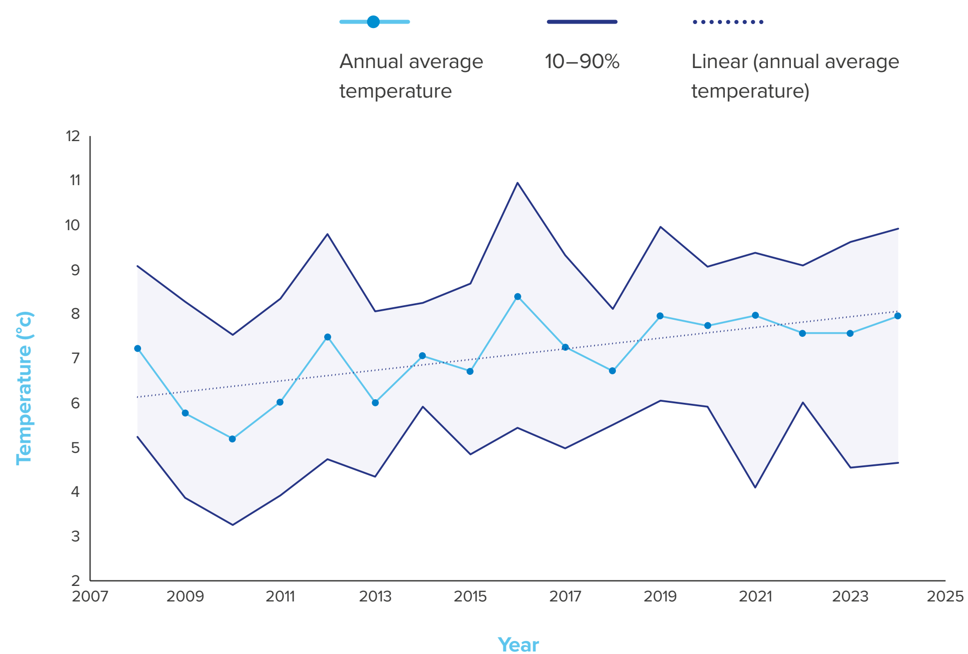


Figure 5.2: Average winter water temperature in the Upper Tidal Thames (between Battersea and Kew). The dotted line shows a linear model fitted to the data, the upper bound of the 10–90% blue area shows the 90% quantile (under which 90% of the data fall), and the lower bound of the 10–90% blue area shows the 10% quantile (above which 90% of the data fall).

Annual average summer water temperature in the Middle Tidal Thames

Figure 5.3: 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).

Annual average winter water temperature in the Middle Tidal Thames

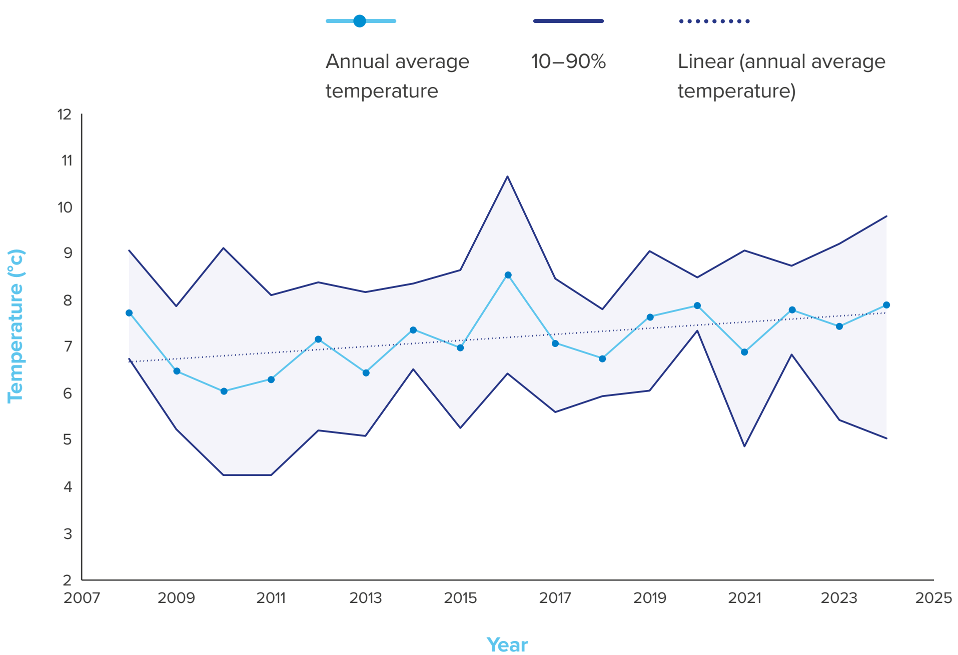


Figure 5.4: Average winter water temperature in the Middle Tidal Thames (between Dartford and Woolwich). The dotted line shows a linear model fitted to the data, the upper bound of the 10–90% blue area shows the 90% quantile (under which 90% of the data fall), and the lower bound of the 10–90% blue area shows the 10% quantile (above which 90% of the data fall).

SEA LEVEL RISE

Long-term trend: Deteriorating

Short-term trend: Deteriorating

BACKGROUND

By 2100, the relative sea level along the UK coastline is projected to rise by up to 1.15 m, in line with global projections (Weeks *et al*., 2023, IPCC, 2021), although more cannot be ruled out (van de Wal *et al*., 2022). More recent records show sea levels rising at a rate of 3–5.2 mm per year around the coast of the UK (Kendon *et al*., 2022).

A recent study also highlights the risk of estuarine squeeze: the loss of upper-estuarine transitional zones as saline intrusion meets in-channel, human-made barriers (Little *et al*., 2022). As tidal saltwater influx increases with rising sea levels, habitats that were once freshwater or oligohaline shift towards more brackish conditions, placing tidal freshwater resources and their ecological communities at growing risk (Pietkiewicz *et al*., 2025). The Tidal Thames has one of the longest stretches of tidal freshwater in England, supporting important habitats, such as Syon Park SSSI and Old Deer Park in Richmond.

In recognition of the existing and future impacts of these threats on the Tidal Thames, the Environment Agency 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

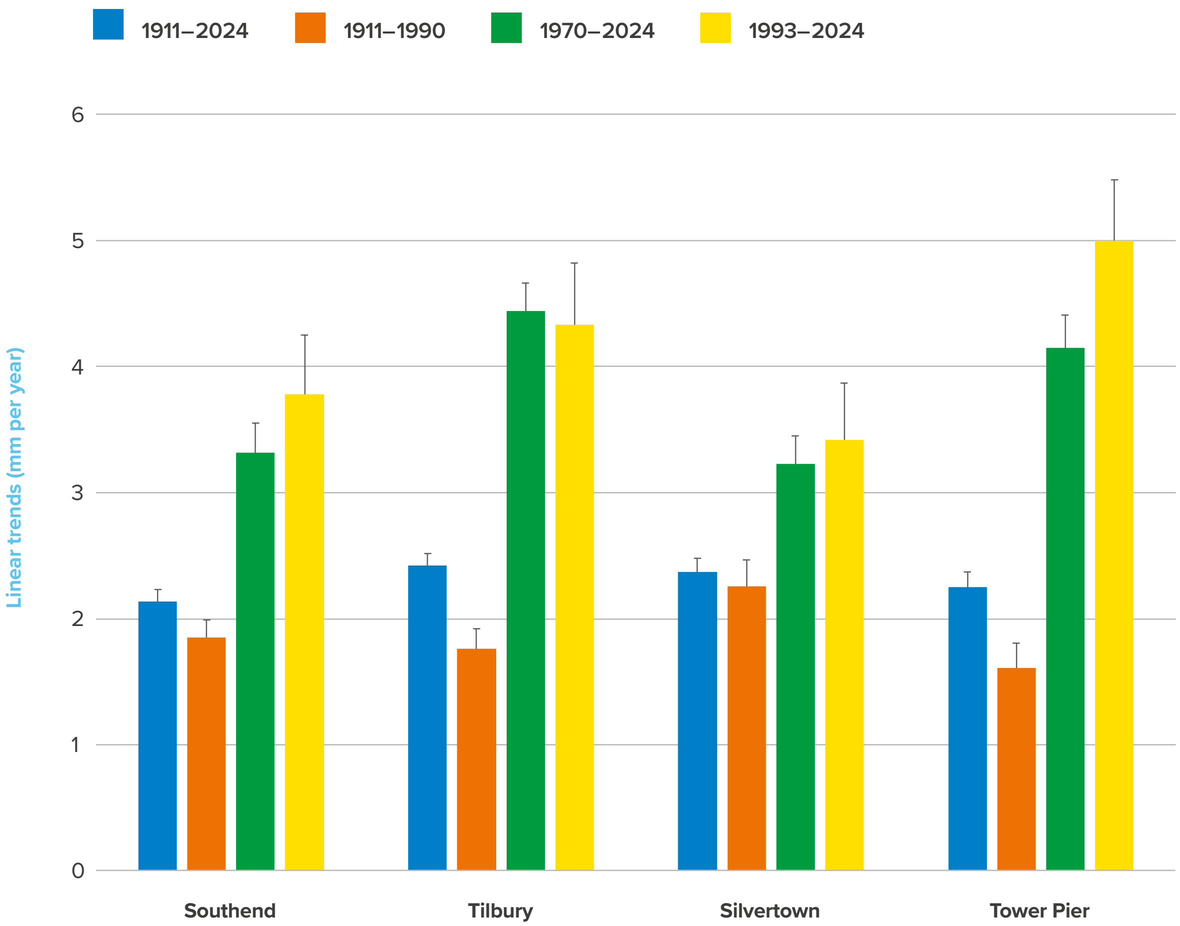
Sea level rise has been monitored at a number of fixed locations in the estuary since 1911 (and since 1832 at Sheerness). The data used for this analysis were provided by the Environment Agency, which had compiled historic tide gauge site records kept by the Port of London Authority (PLA). The Environment Agency and the University of Southampton conducted the analysis for the 15-Year Review of the Thames Estuary 2100 Plan (Haigh *et al* 2025). Trends were analysed over four timeframes: 1911–2024, 1911–1990, 1971–2024 and 1993–2024. These periods were chosen to approximately align with the global sea level rise trend timeframes in IPCC AR6 (Fox-Kemper *et al*., 2021). Linear models were fitted to mean sea level data at several gauging sites in the Tidal Thames across these three timeframes, allowing the average rate of change per year in mean sea level to be calculated for each timeframe.

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 5.5). Comparing linear trends over the full monitoring period (1911–2024) with linear trends in recent years (1970–2024, and 1993–2024), every gauging site showed there has been an increase in the average rate of mean sea level rise per year since monitoring began. Tilbury had the highest average rate of increase across the whole time period (1911–2024) at 2.42 mm/year (+/-0.1), however over the most recent time period (1993–2024) the average rate of change was highest at Tower Pier at 5 mm/year (+/-0.48).

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

Change in mean sea level in the Tidal Thames



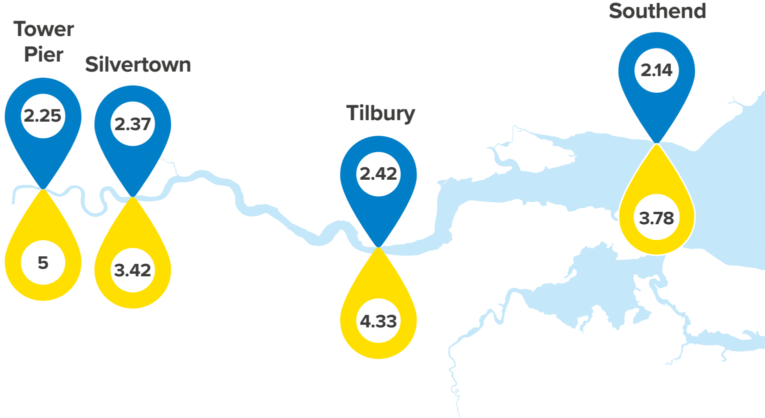


Figure 5.5: Change in mean sea level (mm per year) at four gauging stations in the Tidal Thames over four different time periods: 1911–2024, 1911–1990, 1971–2024, 1993–2024. The positive linear trends indicate increases in mean water level at all gauging stations. Negative values would indicate decreases in mean water level.

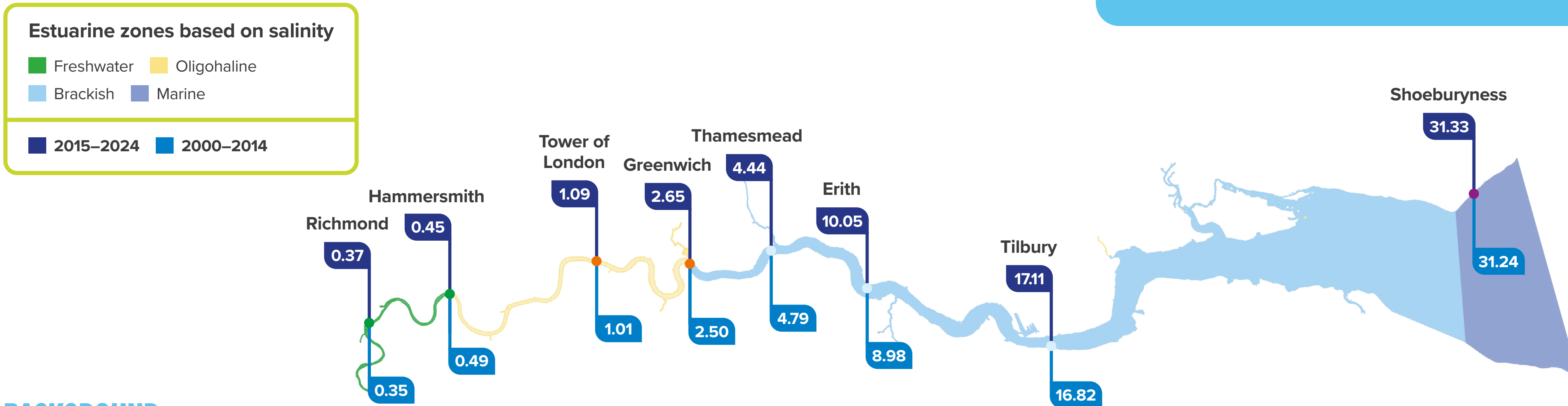
SALINITY

Long-term trend: **Data stable**

Short-term trend: **Data stable**

The gradient of salinity from freshwater to seawater is one of the defining features of an estuary, shaping its physical and biological characteristics. Salinity gradients in estuarine systems are commonly described in zones and measured in Practical Salinity Units, with salinity below 0.5 considered freshwater, between 0.5 and 5 as oligohaline, 5 to 30 as brackish, and above 30 as marine (Anon, 1958). These salinity zones separate communities with different tolerances to salinity, and ultimately have a large impact on the composition and distribution of flora and fauna along the estuary (Telesh and Khlebovich, 2010).

Right: Teddington Locks and Weir on the Thames Path from Teddington Lock Footbridge.



BACKGROUND

Sea level rise is one of the main drivers altering salinity patterns in estuaries. As sea levels increase, seawater intrudes further upstream, raising salinity and extending the saline influence deeper into the estuary (Haddout and Priya, 2021). For the Tidal Thames, changes in river flow can be equally significant in determining the extent of saline intrusion (Little *et al*., 2017). Reduced freshwater flow lessens the estuary resistance to tidal penetration. This is particularly relevant for the Thames, which is a vital water resource for southeast England, where drought events have been linked to pronounced shifts in salinity in the upper Thames estuary (Attrill *et al*., 1996).

The tidal Thames has one of the longest contiguous tidal freshwater and oligohaline reaches of all estuaries in mainland England and Wales, with around 24.4km of tidal freshwater zone and 36.9km of oligohaline zone, representing about 40% of the total tidal length (Pietkiewicz *et al*., 2025). These tidal freshwater and oligohaline zones provide critical nursery, feeding, and refuge areas for a wide range of fish and invertebrate species (Little *et al*., 2022). However, they remain poorly characterised and are particularly vulnerable to increases in salinity, which can alter community composition and reduce the extent of these low-salinity habitats (Little *et al*., 2017, Pietkiewicz *et al*., 2025a). Teddington Weir acts as an in-stream barrier to the inland propagation of the tide. As salinities increase due to sea level rise and reduced river flows, these important tidal freshwater and oligohaline zones will become squeezed out against this barrier, an issue recently defined as 'estuarine squeeze' (Little *et al*., 2022).

ANALYSIS

Data for this analysis were obtained from the Environment Agency's Water Quality Archive (EA, 2025), which includes salinity records dating back to 2000. Salinity is measured at 73 sites along the Tidal Thames, from Teddington to Shoeburyness. Summer (May to July) mean salinity for two periods, 2000–2014 and 2015–2024, was calculated for eight representative sites and are presented in Figure 6.1, together with the boundaries of the estuarine zones of Tidal Thames identified by Pietkiewicz *et al*. (2025). Annual mean salinity for five selected sites, located in the upper estuary, was plotted (Figure 6.2), and Mann–Kendall test was applied to assess temporal trends.

Figure 6.1: Change in mean salinity (PSU) in the Tidal Thames over two time periods: 2000–2014 and 2015–2024, and the estuarine zones of Tidal Thames from Pietkiewicz *et al*. (2025b) using data from the Environment Agency's Water Quality Archive. The boundaries between salinity zones are dynamic and vary depending on the data used for calculation. Pietkiewicz *et al*. incorporated additional datasets when mapping the estuarine zones, slightly altering the extent of the brackish zone.

FINDINGS

A clear geographical gradient in salinity is evident across sampling sites along the Tidal Thames, increasing from the tidal limit at Teddington toward the outer estuary (Figure 6.1). Comparison of mean summer salinity between the two periods (2000–2014 and 2015–2024) showed mixed salinity change across the estuary. Increases in salinity were observed at Richmond (+0.02), Tower of London (+0.08), Greenwich (+0.15), Erith (+1.07), and Tilbury (+0.28), while Hammersmith (−0.03) and Thamesmead (−0.34) showed modest decreases. The largest relative increases occurred in the upper estuary sites (Richmond +6%, Tower of London +8%, Greenwich +6%), consistent with greater saline influence during recent dry summers. Downstream sites (Shoeburyness and Tilbury) exhibited minimal change (<2%), indicating broadly stable salinity in the outer estuary.

Temporal trends in salinity over the last 25 years at Richmond, Hammersmith, Tower of London, Greenwich, and Thamesmead are shown in Figure 6.2, with Thamesmead showing the greatest variation in salinity. None of the sites showed a statistically significant trend, indicating no significant long-term change in summer salinity over the study period (Figure 6.2). However, elevated salinities observed in the upper estuary (Richmond, Hammersmith, Tower of London) in 2017 and 2022 coincided with major drought events in the UK, indicating that reduced freshwater inflows during such years may influence salinity levels in the upper estuary.

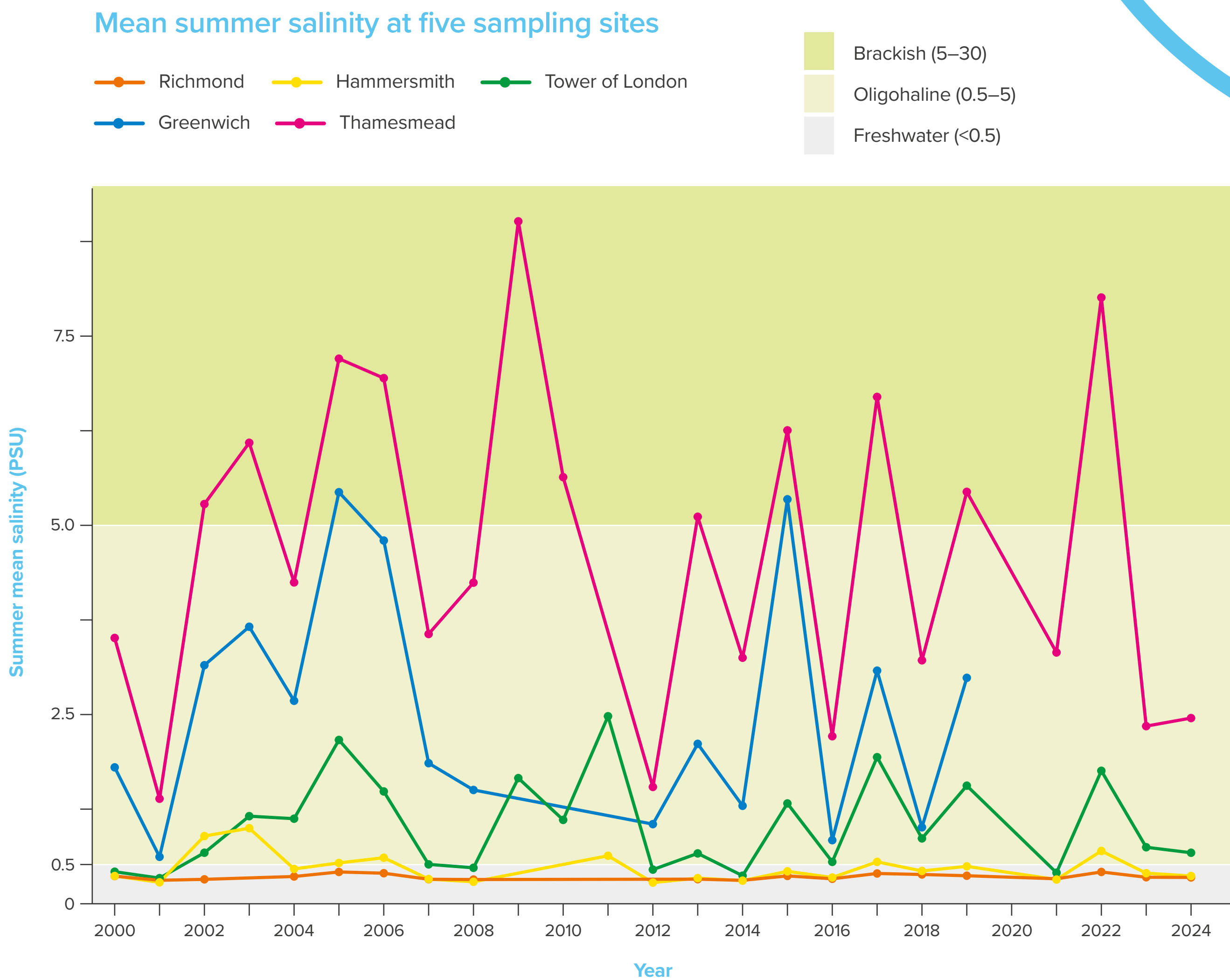


Figure 6.2: Summer mean salinity at five sampling sites in the Tidal Thames (2000–2024). Data for Greenwich was unavailable after 2019

PLASTIC POLLUTION

Long-term trend: Baseline

Short-term trend: Data stable

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. As concern over plastic pollution grows, long-term monitoring is essential for tracking trends in plastic pollution within the estuary.

Right: Plastic pollution in River Thames.

BACKGROUND

Each year, the UK sells approximately 2.5 billion litres of water in plastic bottles, which equates to roughly 3.5 billion bottles (BRITA, 2021). This has reduced substantially from 7.7 billion bottles per year (BRITA, 2016), but the new figure still equates to nearly 10 million every day, some of which eventually end up in the Tidal Thames. Other 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'. In a recent survey, more than half of the participants ranked the presence of litter as 'very important', the highest rating, as an indicator of water quality (Okumah *et al*., 2020).

Significant efforts have been made to remove litter from the Thames. Recent initiatives include #Clean Thames Challenge, launched by PLA in 2024, and the PLA's Clean Thames Plan, a broader initiative that builds on the Thames Litter Strategy to tackle all types of pollution affecting the Tidal Thames, including plastics, microplastics, litter, sewage, run-off and acidification of rain from emissions. These build on Thames 21's Thames River Watch programme among other initiatives such as Hubbub's 'plastic fishing' in the Docklands.

ANALYSIS

The data used in this analysis was 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. Data collected by citizen scientists through the programme also feeds into the Tidal Thames Live Litter Map, which presents the quantity, types and distribution of plastic contamination in the Thames Estuary.

Citizen scientists collect data using systematic transect sampling. This process involves counting the number of litter items found within a 1 m^2 area at different sampling points along the foreshore. Once all litter items have been counted and categorised, the items are responsibly disposed of (and recycled where possible). To analyse change over time in the amount of plastic, the average number of the four most common plastic items per 1 m^2 area across all sample sites was calculated for each sample year (2015–2024, excluding 2021).

FINDINGS

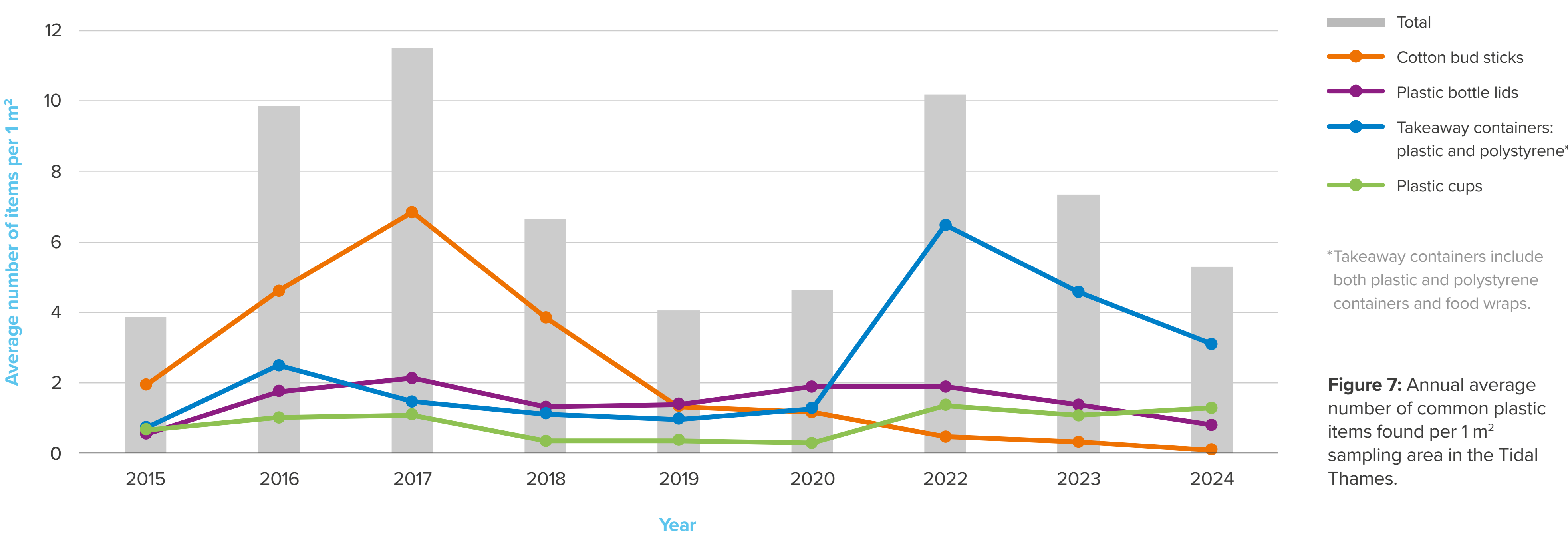
The most commonly found plastic-based items were cotton bud sticks, bottle lids, takeaway containers (plastic and polystyrene), plastic cups and wrappers. A significant finding from this period was that cotton bud sticks, which enter through sewage discharge and were the most frequently found item until 2019, have reduced to almost zero. This is likely to be due to the UK Government's 2020 ban on the sale of plastic cotton buds and is a good example of how legislation and regulation can have a direct, rapid and positive impact. Takeaway containers, on the other hand, increased sixfold within two years from 2020 to 2022 and have since become the most common single-use plastic items found.

The flow dynamics of the river mean that these items are deposited in particular areas of foreshore with two main types noticed: sites that collect lightweight items which float on the surface of the water (such as food wrappers and drink bottles) and those that collect sinking items (such as wet wipes). The 2020 Thames 21 Plastic Pollution in the Tidal Thames Report found that 65% of the single use bottles were found in saltmarsh and reedbed habitats outside the city, compared to 33% from slipways and beaches in London (Thames21, 2020).

Wet wipes are by far the most common items at these sink sites. Many of these wipes contain plastic and are physically altering the Thames foreshore by forming large mounds of densely compacted sediment. In West London, where water moves more slowly, wet wipe products are changing the shape and sediment type of the riverbed, creating large mounds of sediment densely bound together.

Above: A seahorse grasping a plastic cotton bud with it's tail, to ride the ocean currents. **Image credit**: Justin Hofman.

Plastics in the Tidal Thames



*Takeaway containers include both plastic and polystyrene containers and food wraps.

Figure 7: Annual average number of common plastic items found per 1 m^2 sampling area in the Tidal Thames.

WET WIPE ISLAND

In August 2025, the PLA, in collaboration with Thames Water, completed a three-week project to clear up London's 'wet-wipe island.' One hundred and fourteen tonnes of wet wipes (equivalent of ten double decker buses) that had congealed into a 250 m island on the south side foreshore of the River Thames, near Hammersmith Bridge, were removed. The island had changed the course of the river, potentially harming the aquatic wildlife and ecology in the area.

To remove the polluting mess, workers developed an innovative 'rake and shake' method. It used two eight-tonne excavators to sift through the island, separating wet wipes and waste from the natural sediment and riverbed, to minimise the environmental impact.

Thames21 and its volunteers have been monitoring the island since 2017. Their data and research have played a vital role in raising awareness of how wet wipes containing plastic can degrade the environment and harm wildlife.

In November 2025, the Government announced that wet wipes containing plastic will be banned across the UK to reduce long-lasting pollution. The ban is expected to come into force in Spring 2027.

Left: An aerial view of wet-wipe Island. **Image credit:** PLA.

REDUCING SEWAGE-DERIVED LITTER

The Thames Tideway Tunnel (TTT), also known as the 'super sewer', is a major infrastructure project designed to intercept combined sewer overflows during storm events. It connects to the Lee Tunnel at Abbey Mills Pumping Station and significantly reduces the amount of pollution, including sewage-derived litter, that would otherwise enter the River Thames.

Abbey Mills Pumping Station, located in East London, plays a key role in this system. During dry weather, it lifts sewage from incoming sewers and transfers it to Beckton Sewage Treatment Works (STW). In storm conditions, the station diverts excess stormwater into the Lee Tunnel, which is later pumped out and treated at Beckton STW once the storm has passed.

At Abbey Mills, storm flow pumped to the tunnel is screened. This allows Thames Water to estimate how much sewage-derived litter is being captured by the TTT and prevented from reaching the river. Between 2020 and 2023, data were collected on both the volume of stormwater entering the Lee Tunnel and the weight of litter captured. On average, 16.59kg of sewage-derived litter was screened for every 1,000m^3 of stormwater.

This capture rate is used as a proxy to estimate the environmental benefit of the TTT. It is expected to prevent over 250 tonnes of sewage-derived litter from entering the River Thames each year.

Above: Abbey Mills Pumping Station.

YEAR	SCREENINGS (KG)	FLOW TO LEE TUNNEL (M^3)	CAPTURE RATE (KG / 1000 M^3)
2020	105,340	4,347,732	24.23
2021	86,340	8,056,268	10.72
2022	50,560	3,868,244	13.07
2023	131,680	6,272,346	20.99
Total	373,920	22,544,590	69.01

Table 4: Annual amount of sewage-derived litter captured by screens at Abbey Mills Pumping Station, total annual flow to the Lee Tunnel, and corresponding capture rate.

STATE OF NATURE

"Successful coexistence between wildlife and people depends upon conserving remaining habitats, improving connections between habitats and innovating new ways to maximise opportunities for wildlife in the urban environment."

Estuaries are among some of the most productive ecosystems on the planet. Rich in nutrients from both the freshwater river and ocean tide, they are made up of connected wetland habitats that support a wide range of globally important plant and animal species.

For centuries, estuaries have been centres of human settlement, trade and industry, and the Tidal Thames reflects this long history of use and modification. While far removed from its natural state, the Tidal Thames still supports this interconnected mosaic of valuable habitats that are essential for the feeding, breeding and life cycle needs of migratory and resident wildlife. Furthermore, they provide essential ecosystem services such as water quality regulation, food production, natural flood defence and carbon sequestration. The future of coexistence between wildlife and people depends upon conserving remaining habitats, improving connections between habitats and innovating new ways to maximise opportunities for wildlife in the urban environment.

This section describes the current state of nature in the Tidal Thames.

Right: Seagrass (*Zostera marina*) meadows growing beneath the water surface in the Outer Thames Estuary.

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, it is oligohaline, and it becomes brackish downstream of Greenwich to Shoeburyness before being considered fully 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.

Wet woodlands

Comprising specially adapted trees that can extract oxygen from water saturated substrates, wet woodland supports many species including mosses, invertebrates and mammals such as otters.

Habitat of Principle Importance (Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 (England))

Tidal freshwater

A nationally scarce habitat found at the top of estuaries with a rich diversity of plants, invertebrates, fish and birds.

Islands

Several islands, including Glovers at Isleworth and Oliver's Island at Strand on the Green, provide roosting areas for wildfowl and wading birds, and important invertebrate habitat. Largely undisturbed areas for both amphibious and terrestrial wildlife.

Local Nature Reserves

Foreshore

The intertidal zone between high water and low water is an important feeding habitat for fish and birds. It also is the mechanism for how fish move up and down the estuary using selective tidal transport.

Natural riverbank

Only 1% of the Tidal Thames natural riverbank remains and it is found at Syon House, Isleworth. The riverbank provides important feeding grounds for fish, invertebrates and waterbirds.

Site of Special Scientific Interest (SSSI)

Reedbeds

Wetlands dominated by the common reed (*Phragmites australis*), are found in transitional areas between river and land where the water table is at ground level for most of the year. They act as an important habitat for aquatic invertebrates, fish and water birds.

Habitat of Principle Importance

Subtidal sands and gravels

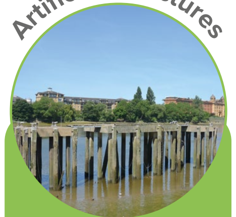
Underwater habitat for invertebrates, providing important foraging and spawning substrate for fish.

Habitat of Principle Importance

Tidal creeks

A productive habitat where the freshwater tributaries meet the Tidal Thames. Rich in organic matter, the soft muds provide food and shelter for fish, invertebrates and birds.

Artificial structures



Redundant or low disturbance structures exposed at high tide, providing roost sites for wildfowl, with some also serving as nest sites for oystercatchers and gulls.

Saline lagoons

Saline lagoons are essentially saltwater habitats that are separated from the main sea or estuary. The saline lagoons at Cliffe represent 10% of the English resource of this habitat, supporting nationally important numbers of invertebrates and are also important for feeding and roosting waterfowl.

Priority habitat under the EU Habitats Directive. Habitat of Principle Importance. SPA. Site of Special Scientific Interest (SSSI).

Saltmarsh

Upper vegetated portion of intertidal mudflats that are flooded at high tide and characterised by vegetation that is tolerant of saltwater. Important nursery habitat for fish, and a feeding and refuge area for wading birds and wildfowl.

Habitat of Principle Importance. SSSI. National Nature Reserve.

Main river channel

The main river channel provides an important habitat for fish to metamorphosise, feed and grow. It provides a critical fish migratory corridor.

Estuary edges

Man-made structures, such as river defences, that have space for nature designed into them to encourage the growth of vegetation to support fish and invertebrates.

Intertidal and subtidal mudflats

Important for coastal protection, mudflats comprise of soft sediments rich in organic matter, which play an important role in nutrient chemistry. Mudflats are highly productive, supporting an abundance of invertebrates, including the tentacled lagoon worm (*Alkmaria romijni*). They provide feeding and resting areas for the internationally important wading birds and wildfowl, and foraging areas for fish (especially flatfish).

Habitat of Principle Importance. SPA. Ramsar. SSSI.

Seagrass beds

Seagrass beds in the Tidal Thames develop mainly on the intertidal muds and sands, and provide important seabed stabilisation. They support many invertebrates, are spawning grounds for fish and provide an important food source for wildfowl.

Habitat of Principle Importance

Image credit: Courtesy of Essex Wildlife Trust.

Oyster habitat

A complex habitat where large numbers of live oysters and dead shells form a structure which provide habitat and refuge for a diversity of organisms, such as juvenile fish, crabs, molluscs and sponges.

Habitat of Principle Importance

Image credit: Jim Pullen.

HABITAT: PROTECTED AREAS

Long-term trend: Baseline

Short-term trend: Insufficient data

BACKGROUND

The Tidal Thames comprises a highly diverse mosaic of critical estuarine wetland habitat that supports a wide range of key species, including large populations of globally important wintering birds. Strengthening the resilience of this ecosystem relies in part on conserving the extent of existing habitats but also improving condition and, where possible, expanding them. A key mechanism for achieving this is the use of legal protection to guard against development pressures and other potentially detrimental activities. Protected areas are designated to conserve and restore rare, threatened and ecologically valuable marine and estuarine ecosystems, habitats and species that are vulnerable to human impacts.

Conservation designations in the Thames Estuary include Sites of Importance for Nature Conservation (SINCs), Sites of Special Scientific Interest (SSSIs), Special Protection Areas (SPAs), Marine Conservation Zones (MCZs), and Special Areas of Conservation (SACs). Within the Tidal Thames itself, there are approximately 13,700 ha of SSSIs, SPAs covering around 21,500 ha, and one MCZ, 300 ha, in addition to many Local Nature Reserves (LNRs). Beyond the immediate boundary of the Tidal Thames of this report, there are an additional two SACs (Margate and Long Sands, Essex Estuaries), one MCZ (Medway Estuary) and one SPA (Medway Estuary & Marshes). Although technically outside the tidal boundary, these neighbouring sites are ecologically linked with the estuary, which form part of the wider ecological network of the Greater Thames Estuary.

ANALYSIS

Condition assessments of protected areas are undertaken to evaluate whether conservation objectives are being met and to build an evidence base that informs ongoing site management. Information on the condition of marine features is also required for statutory reporting obligations, e.g. Marine and Coastal Access Act (Marine Act) or the Environment Improvement Plan reporting.

Table 5 compiles publicly available information on the condition assessments, including the type of protected zone, the most recent condition status and key habitat characteristics.

In the first *State of the Thames* report, saltmarsh extent was used as an indicator of the extent of natural habitat in the Thames. No new data are available, so for current extent, please refer to the Environment Agency Saltmarsh Extent and Zonation Summary.

FINDINGS

Of the 13 protected areas assessed within the Tidal Thames, seven were last assessed as being in favourable condition.[7] Three were in mixed condition, with some features favourable and others either recovering or destroyed. Two were classed as unfavourable. One site had 70% of its features unassessed. The Swanscombe MCZ, as the only MCZ in the Tidal Thames, was established in 2019 and has yet to receive a condition assessment.

Monitoring MPAs and SSSIs, which often cover vast areas and encompass a wide variety of species, features and habitats, can pose significant challenges and involve great costs. For four of the sites, the most recent condition assessments are now more than a decade old, and seven sites have not been assessed in the past five years, leaving significant gaps in the monitoring of protected habitats. Regular condition assessments are essential to understand current site status, identify conservation needs, and guide appropriate management action.

[7] Definition of favourable condition: The (sub) feature is adequately conserved, as all evidence analysed through attribute assessments result in the principal attributes for the (sub) feature meeting their targets. Unfavourable condition: Where the criteria for favourability have not been met, the (sub) feature is considered in part or whole to be unfavourable. Recovering: progress made towards the recovery of the condition. Declining: no management is in place to reverse or improve the condition.

TYPE	NAME	YEAR DESIGNATED	FEATURE	CONDITION *	YEAR OF LAST ASSESSMENT
MCZ	Swanscombe	2019	Intertidal mud, tentacled lagoon worm (*Alkmaria romijni*)	**Favourable**	**2019**
SSSI	Syon Park	1984	Tall grass washland	**Favourable**	**2017**
SSSI	South Thames Estuary and Marshes	1984	Saltmarsh, mudflat, grazing marsh and shingle	**Favourable: 19%** **Unfavourable – Declining: 10%** **Not Recorded: 71%**	**2021**
SSSI	Inner Thames Marshes	1986	Saltmarsh, freshwater lagoons	**Favourable: 60%** **Partially destroyed: 40%**	**2024**
SSSI	Vange and Fobbing Marshes	1987	Intertidal mudflats and saltmarsh	**Unfavourable – Recovering: 100%**	**2022**
SSSI/SPA/ Ramsar**	Benfleet and Southend Marshes	1987 (SSSI) 1994 (SPA) 1994 (Ramsar)	Saltmarsh, mudflat and grassland habitats	**Favourable: 50%** **Unfavourable – Recovering: 33%** **Unfavourable – No change: 17%**	**2025**
SSSI/SPA/ Ramsar	Mucking Flats and Marshes	1991 (SSSI)	Mudflats and saltmarsh	**Favourable: 70%** **Unfavourable – Recovering: 30%**	**2016**
SSSI	West Thurrock Lagoon & Marshes	1991	Brackish lagoons and grazing marsh	**Unfavourable – Declining: 100%**	**2010**
SPA/ Ramsar	Thames Estuary and Marshes (comprises of South Thames Estuary & Marshes, and Mucking Flats & Marshes SSSIs)	2000	Saltmarsh, mudflat, grazing marsh and shingle	**Favourable**	**2009**
SSSI	Barn Elms Wetland Centre	2002	Wetland	**Favourable**	**2022**
SSSI	Swanscombe Peninsula	2021	Chalk pits, grazing marsh, mudflats and saltmarsh	**Favourable: 92%** **Unfavourable – No change: 8%**	**2021**
SSSI	Holehaven Creek	2003	Intertidal mudflats and saltmarsh	**Favourable**	**2024**
SSSI	Canvey Wick	2005	Brownfield, grassland and scrub habitat	**Favourable**	**2009**

Table 5: Condition of designated nature conservation sites in the Tidal Thames.

*Percentages indicate the proportion of assessed features in each condition category. For example, 60% means that three out of five assessed features are in favourable condition.
**A Ramsar site is the land listed as a Wetland of International Importance under the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (the Ramsar Convention) 1973.

TRANSFORMING THE THAMES

INTRODUCTION

The Greater Thames Estuary is one of Europe's most significant wildlife sites, featuring a unique blend of freshwater, coastal and marine habitats that include mudflats and sand banks, coastal grazing marsh, saltmarshes, seagrass meadows and shellfish reefs. However, through centuries of development, pollution and overfishing these habitats have now been left in a fragmented and degraded state which has dire implications for nature, people and our resilience to climate change.

The Tidal Thames forms the upper reach of the Greater Thames Estuary. Saltmarshes offer essential habitat for birds and rare plants, while also helping to reduce flood risks by absorbing storm energy (UKCEH Saltmarsh, 2023). Similarly, seagrass meadows serve as important nursery grounds for juvenile fish, crustaceans and shellfish, and help stabilise sediments to prevent coastal erosion (Unsworth *et al.*, 2023). Saltmarshes and seagrass are also effective habitats for capturing and storing carbon dioxide (CO_2). The estuary is also home to the native oyster (*Ostrea edulis*). Native oysters act as natural water filters, improving water clarity and quality. When left undisturbed, they form complex reef structures that provide habitat and refuge for a diverse array of marine life, including juvenile fish, crabs, sea snails and sponges (zu Ermgassen *et al.*, 2023).

TRANSFORMING THE THAMES

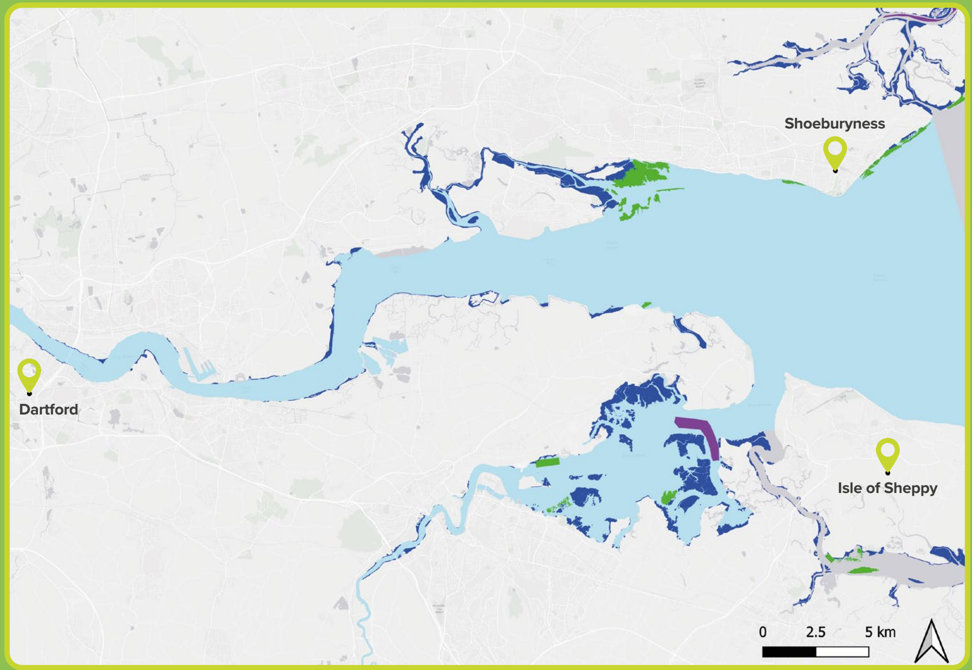
Transforming the Thames is a ZSL-led partnership programme with a 100-year vision for a recovered, connected and resilient Greater Thames Estuary – an outstanding coastal wetland for nature and communities. The partnership unites diverse organisations including NGOs, government agencies, landowners and academic institutions who are working together to restore the habitats of the Thames Estuary, enabling coordinated and strategic decisions that maximise ecological connectivity and function. Primarily funded by the Endangered Landscape and Seascape Programme (ELSP) for the first 5 years of delivery, the partnership aims to **restore** 320 ha of coastal habitat (including saltmarsh, seagrass meadows, native oyster beds, saline lagoons, coastal grazing marsh, and sand and shingle bird-nesting habitat), **protect** existing coastal habitats through further understanding pressures such as water quality, and **build capacity** through knowledge exchange, site visits and volunteering.

HABITAT POTENTIAL MODELLING

Modelling habitat potential provides a way of identifying where coastal and estuarine restoration could be most effective, offering a strategic overview before more detailed local site assessments take place. As an example of this, the map (Figure 8.1) provides an overview of the current extent of seagrass, native oyster beds and saltmarshes in the tidal Thames, as well as the potential areas of restoration. The current extent of existing seagrass habitat is based on datasets collected collaboratively by Natural England and the Environment Agency, while saltmarsh extent is derived from aerial imagery surveys conducted by the Environment Agency. The models for potential habitat draw on national-scale datasets – such as Environment Agency floodplain mapping, environmental condition layers, and sediment, hydrodynamic and elevation data – applying exclusion rules to filter out unsuitable areas and highlight zones with favourable conditions for habitat restoration.

Above: ZSL's Thames team collect seagrass samples.

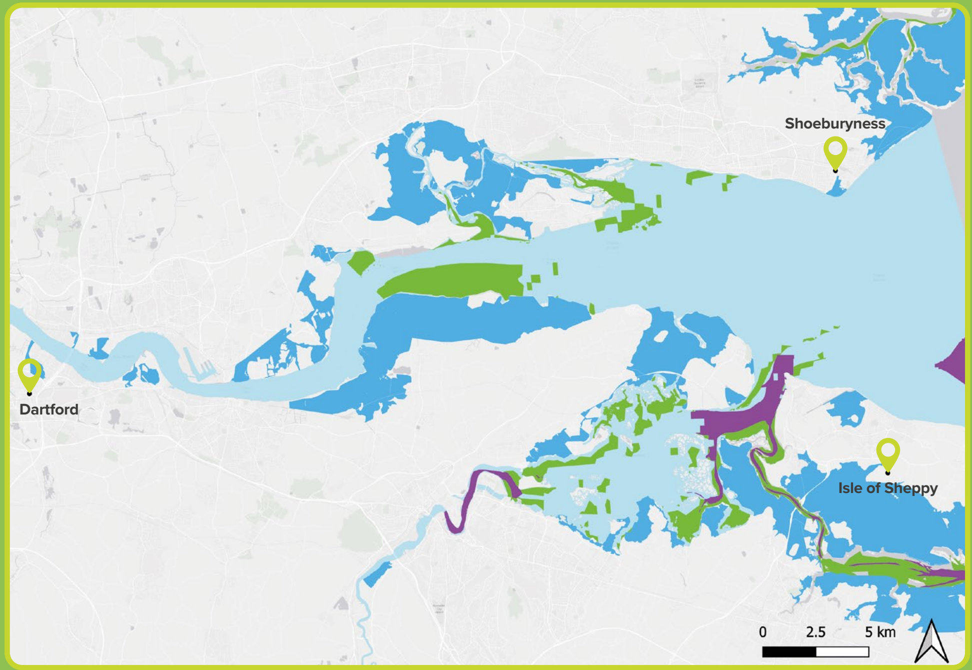
Existing habitat



Native oysters | Saltmarsh | Seagrass meadows | WFD transitional water bodies

Figure 8.1: Current extent of existing seagrass, saltmarsh and native oyster habitat in the Tidal Thames, including parts of the Medway Estuary.

Restoration potential



Native oysters | Saltmarsh | Seagrass meadows | WFD transitional water bodies

Figure 8.2: Potential extent of existing seagrass, saltmarsh and native oyster habitat in the Tidal Thames, including parts of the Medway Estuary.

HABITAT CREATION

Long-term trend: Baseline

Short-term trend: Improving

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 man-made 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: RAINHAM MARSHES

The Rainham Marshes habitat creation scheme is located on the north bank of the Tidal Thames in the London Borough of Havering, within the Inner Thames Marshes SSSI. Approved in late 2018, it represents the largest habitat creation project inside the M25 motorway, covering approximately 110 hectares when fully completed. The scheme makes use of over six million tonnes of wet and dry spoil, including clay and chalk from the Thames Tideway 'super sewer' project, to re-engineer former dredging lagoons into functioning freshwater wetland habitats. Key features of the habitat design included an impermeable base to retain water in new lakes, sandy uplands and damp swales (channels) that passively feed the permanent wetlands.

This project aims to enhance and extend nationally important wetland habitats within the Inner Thames Marshes SSSI, while creating new wildlife havens that support birds, plants and invertebrates, and improve ecological connectivity along the Thames corridor. It also reuses dredged sediments and soils from infrastructure projects, contributing to a disposal policy of less than 10%.

Above: Rainham marshes, London Borough of Havering.

Below: Picture of Battersea Reach Terrace. This site was constructed in 2005, featuring gabion basket structures with implanted vegetation. Fish species recorded at this site include common goby, common roach, common bream, common dace, flounder, European sea bass, and European eel. **Image credit:** Wanda Bodnar.

HABITAT CREATION: ESTUARY EDGES

Intertidal zones are foreshores that are exposed at low tide and submerged at high tide. They are among the world's most biologically productive ecosystems, serving as vital nursery habitats (Vasconcelos *et al*., 2011; Bodnar *et al*., 2024). The intertidal zone of the Tidal Thames includes a mosaic of habitats that support diverse invertebrate communities and provide spawning, nursery and feeding grounds for fish. However, these important natural areas have been heavily reduced by historic and ongoing development along the river. Today, only about 1% of its banks retain a natural 'soft' profile (Colclough *et al*., 2005). The loss of intertidal habitat is believed to negatively affect fish populations by reducing available foraging grounds and, through the narrowing of the river (coastal squeeze), potentially increasing the speed of the tidal currents, which makes swimming more difficult for fish (*The State of the Thames 1st Edition*).

Riverside developers are increasingly encouraged to incorporate bioengineered solutions to mimic natural foreshore habitat and promote vegetation growth. These approaches can be applied to both new developments and existing Thameside infrastructure, to help create 'stepping stones' for migrating wildlife along the Tidal Thames. These efforts have been led by organisations including the Thames Estuary Partnership (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. There are now 34 estuary edge sites along the Tidal Thames which take different forms. For example, terraces (see small image opposite) are long stretches of soft ground built in front of the concrete riverbank to allow vegetation to establish, and 'set backs', which extend intertidal habitat inland (e.g. at Barking Creek, Creekmouth). Other designs include vertipools at Duke Shore Wharf and simple additions such as bolted-on timbers, all of which aim to create habitat and ecological benefits within an urban river setting.

Some of these sites have been monitored for vegetation cover and wildlife use. Findings from Bodnar *et al*. (2024), based on surveys conducted between 2017 and 2023, indicate that these sites can support native plant colonisation and provide favourable habitat for fish by serving as nursery areas for fish species such as common goby, European seabass, and the Critically Endangered European eel.

Figure 8.3: Estuary Edges sites along the Tidal Thames.

CONNECTIVITY

Long-term trend: **Baseline**

Short-term trend: **Improving**

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. There are 13 tributaries that flow into the Tidal Thames and many adjacent wetlands stretch along its length. This section assesses the extent to which connectivity within the river system of the Tidal Thames has been disrupted.

Right: Fish pass at River Crane, which came into operation in 2024.
Image credit: Crane Valley Partnership.

BACKGROUND

Longitudinal connectivity allows fish to move along the length of a river system, from upstream to downstream and vice versa, while lateral connectivity refers to a fish's ability to access connected habitats like floodplains, side channels and wetlands from the main river. These forms of connectivity are vital for fish to access feeding, spawning and rearing areas, and are crucial for the overall health and biological integrity of a river ecosystem.

Many fish species found in the Tidal Thames migrate long distances to complete their life cycle. For example, the European smelt (*Osmerus epilanus*) is anadromous, which means it migrates from coastal waters into the freshwater Thames to spawn. The European eel is described as catadromous, which means it matures in freshwater or brackish habitats before emigrating across the Atlantic ocean to reproduce.

The Tidal Thames and its associated tributaries and wetlands are characterised by heavy river engineering, comprising many instream structures, largely to provide flood management and enable navigation. These can impede fish movements. To mitigate this, fish passes have been retrofitted to weirs and sluices.

There are morphological differences between eels and round fish, so fish passes must be designed to accommodate the different modes of fish movement. For example, eel passes require a crawling medium. 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 i) eel migration and ii) 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 Thames Estuary Partnership (TEP) Greater Thames Estuary Fish Migration Roadmap database were used, as well as additional information from local conservation organisations including SERT, the Environment Agency and Thames21.

FINDINGS

Twenty-nine passes have now been installed in the tributaries of the Tidal Thames to facilitate fish movement, primarily targeting the Critically Endangered eel. The results for eel connectivity indicate that approximately 170 km of tributaries are now connected to the Tidal Thames allowing eel migration. This is up from 145 km in 2020, as a result of the construction of an eel pass at Loughton on the River Roding, and a barrier completely removed on the River Darrent at Central Park in Dartford in 2021. Of the 13 tributaries of the Tidal Thames, five still have barriers at the confluence of the main Thames river channel that are impassable to eels (Figure 9.1).

Three new multispecies fish passes have been built since 2020. These are located on the River Crane, Roding and Quaggy. The new Mereway Fish Pass, constructed by the Environment Agency on the River Crane, became operational in June 2024. For the first time in several hundred years, this installation has successfully restored the movement of fish between the Lower Crane and its upstream catchment area. However, the repopulation of the upper Crane by many species, such as trout, is expected to be limited by several remaining barriers located further downstream (Figure 9.2).

Results for multispecies fish connectivity show analysis that 72 km of unrestricted tributary length is open to migration of other species of fish from the Tidal Thames. While six tributaries still have impassable barriers for fish at, or very near, the confluence with the Thames (Figure 9.2).

The identification, mapping and passing of barriers to fish movement continues. This includes the lateral connectivity to the important floodplain wetlands, especially in the freshwater tidal section of the Thames and in the outer estuary of Kent and Essex.

Above: European eels.

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

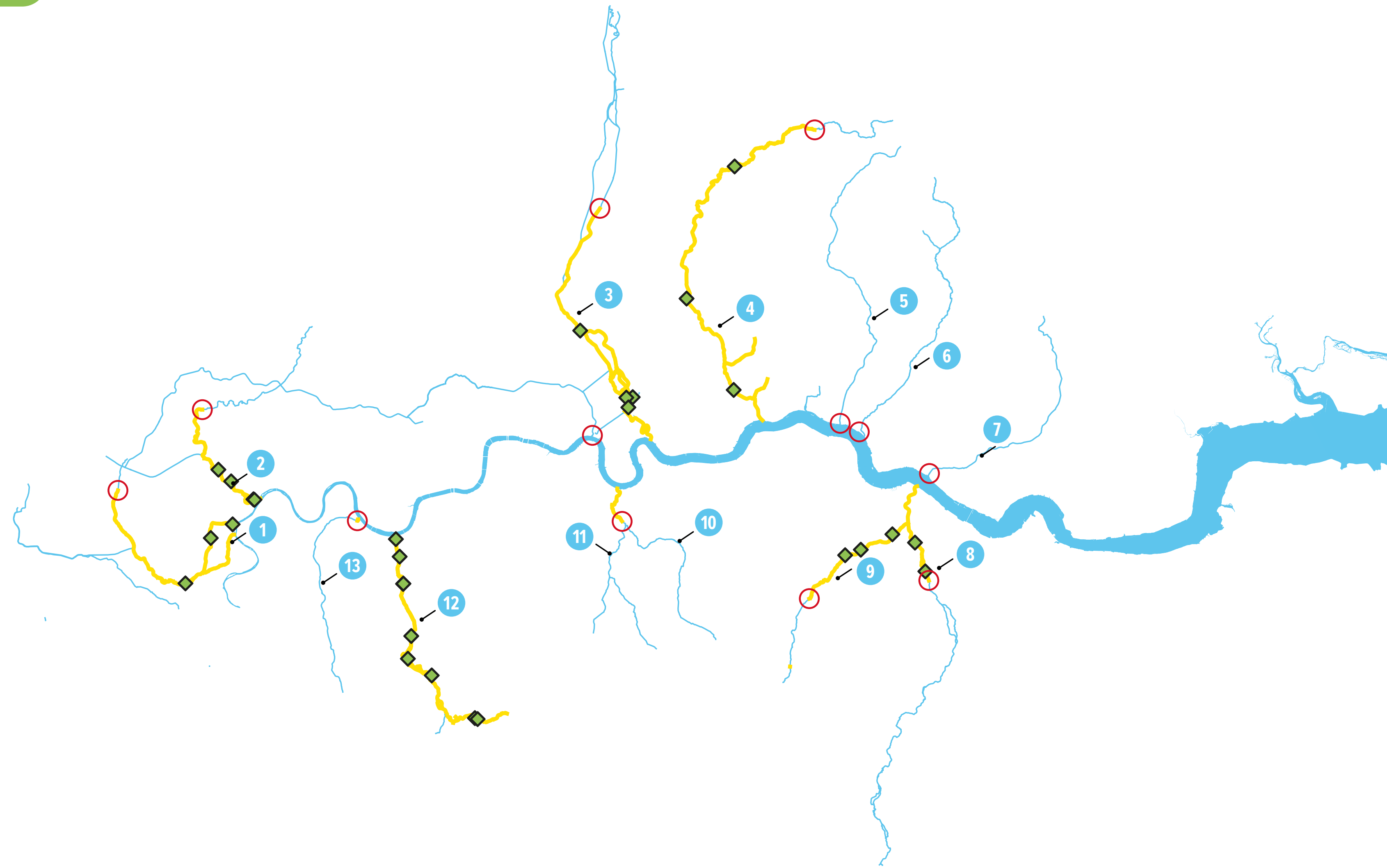


Figure 9.1: Connectivity of the Tidal Thames tributaries to eel migration.

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

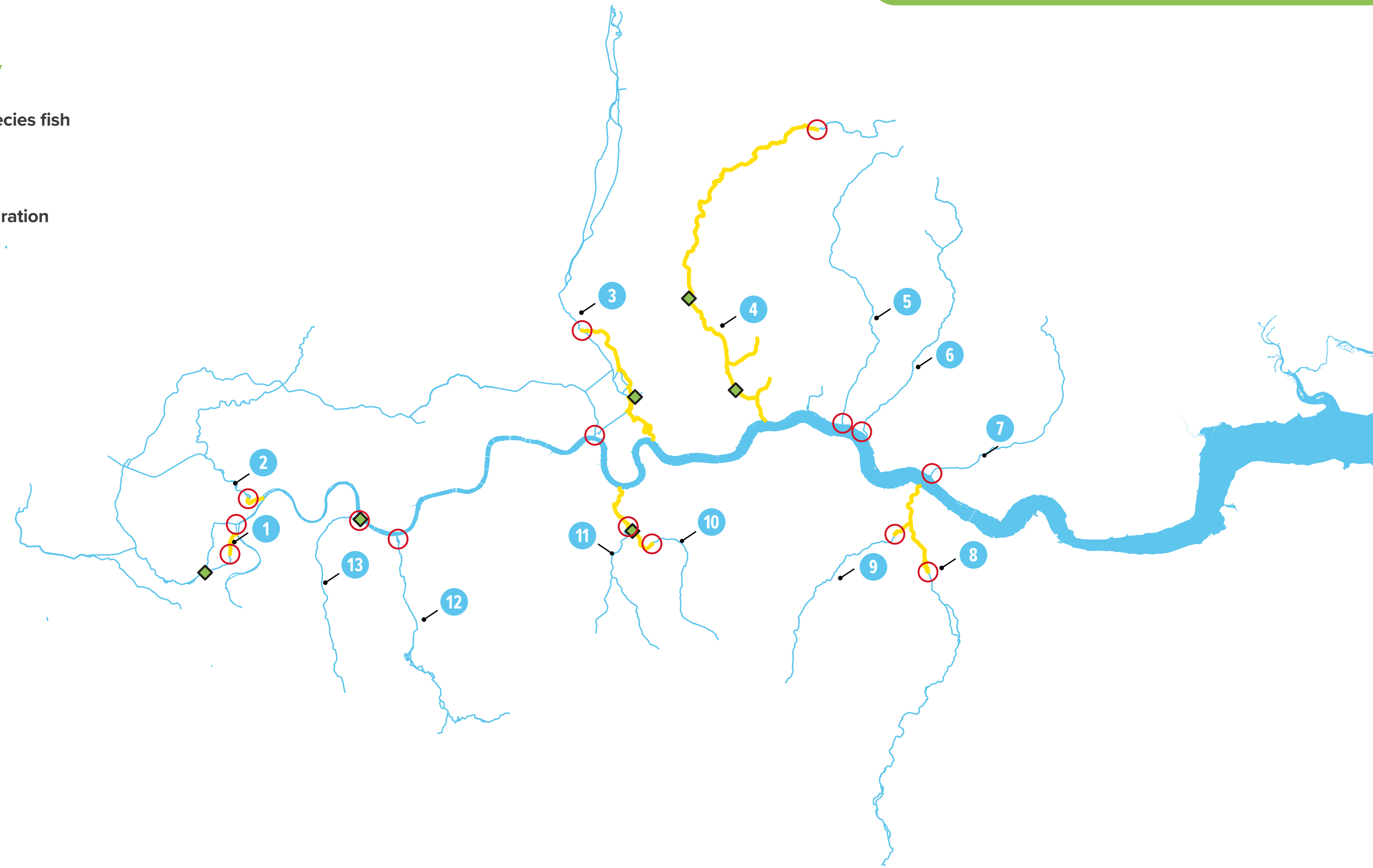


Figure 9.2: Connectivity of the Tidal Thames tributaries to multispecies fish migration.

FISH

Long-term trend: Deteriorating

Short-term trend: Data stable

Estuarine environments, such as the Tidal Thames, play a critical role in the lifecycles of many fish species. For some species, estuaries provide a nursery habitat with plenty of food and protection during early life stages. Other species 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 dynamic estuarine environments. 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.

While the data analysed for this section showed a deteriorating long-term trend, it is important to note that the number of fish species has increased from zero in 1957, when the Tidal Thames was declared biologically dead, to over 115 fish species in the 2000s.

Right: The Environment Agency monitoring fish populations in the Tidal Thames.

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, allowing them to once again utilise the Thames' critical habitats.

ANALYSIS

The Environment Agency has been monitoring fish in the Tidal Thames since the 1970s using mixed sampling methods. The associated data was 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 netting is a sampling method where a long rectangular net is anchored at one end on the riverbank and pulled from the other, forming an enclosed semicircle that captures fish. 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 10.1) experienced different trends over time, each area was analysed separately.

FINDINGS

Annual average species richness per sample are plotted for the Middle and Upper Tidal Thames (Figures 10.2 and 10.3). The overall average number of species per sample across all years was 4.53 in the Lower Tidal Thames, 5.77 in the Middle, and 5.14 in the Upper. However it should be noted that seine net samples in the Lower Tidal Thames had only been taken for the 2011–2018 period from one site.

Therefore, data was combined for the Upper and Middle Thames only, and a Mann-Kendall test indicated a significant long-term declining trend in species richness between 1992–2023 ($p = 0.002$). In contrast, the shorter recent period (2014–2023) showed no statistically significant trend, suggesting that values have stabilised in recent years.

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. Since then, there have been over 115 fish species recorded in the Tidal Thames, which is a promising indication of ecosystem recovery.

Right: European seabass caught in the Thames Estuary during a seine netting survey.

SEINE NET SAMPLING LOCATIONS

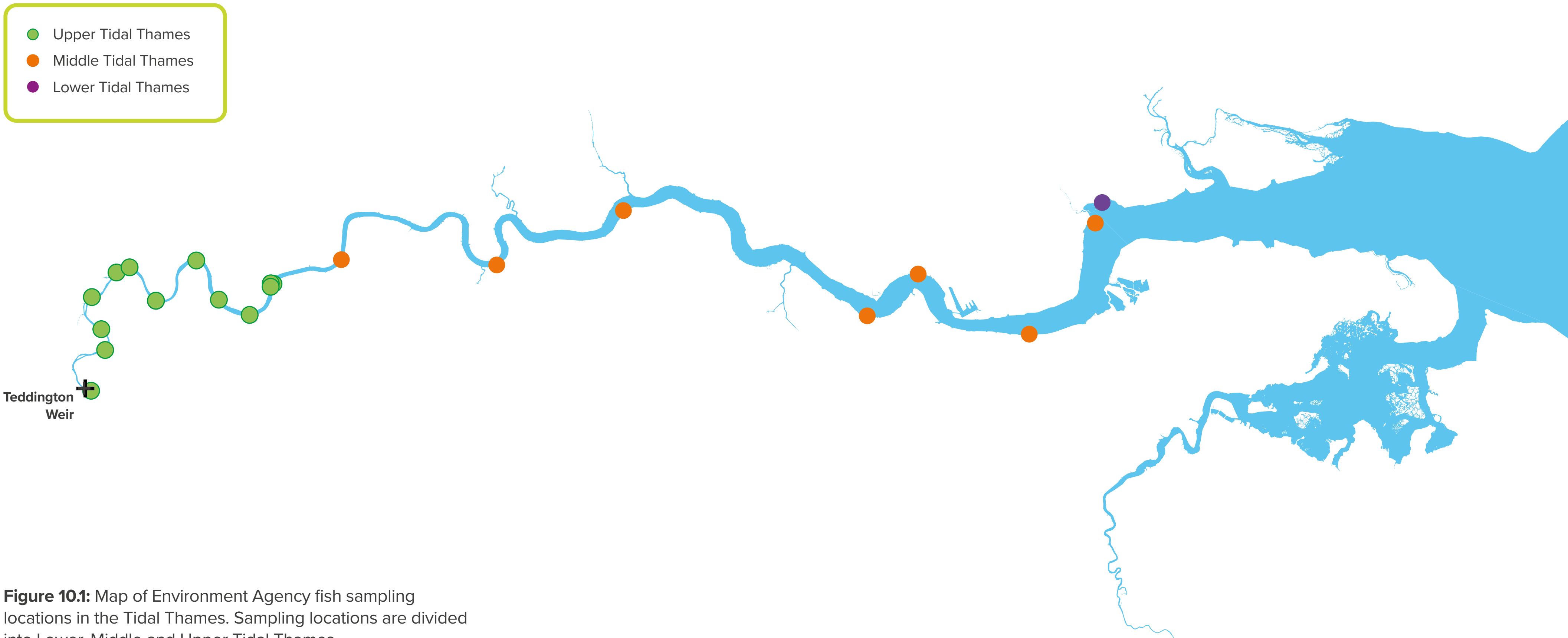


Figure 10.1: Map of Environment Agency fish sampling locations in the Tidal Thames. Sampling locations are divided into Lower, Middle and Upper Tidal Thames.

Species richness per sample – Middle Thames

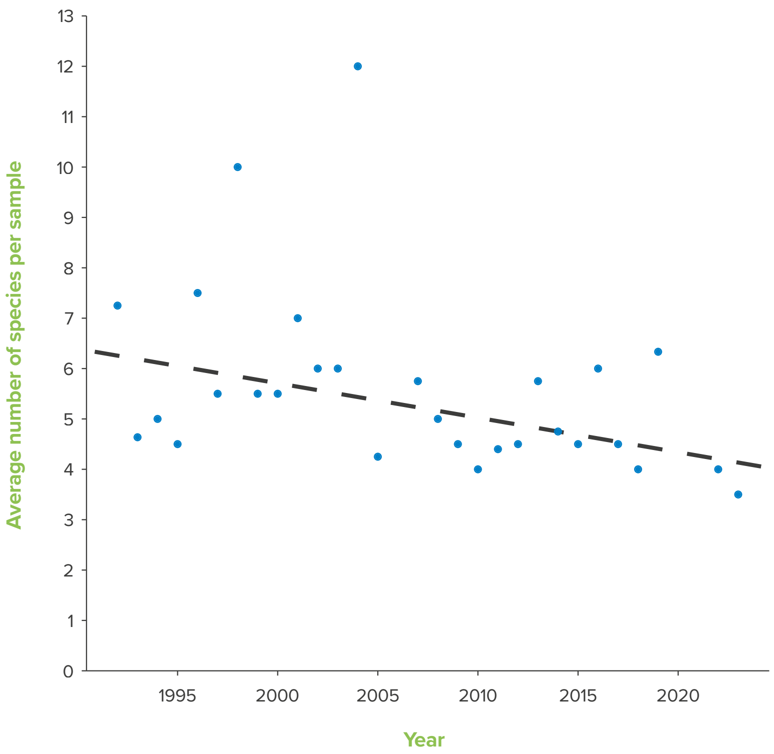


Figure 10.2: Annual average number of species per sample found in the Middle Tidal Thames between 1992–2023. Points show the annual averages, and the dotted line shows the trend estimated using a Theil–Sen robust linear model.

Species richness per sample – Upper Thames

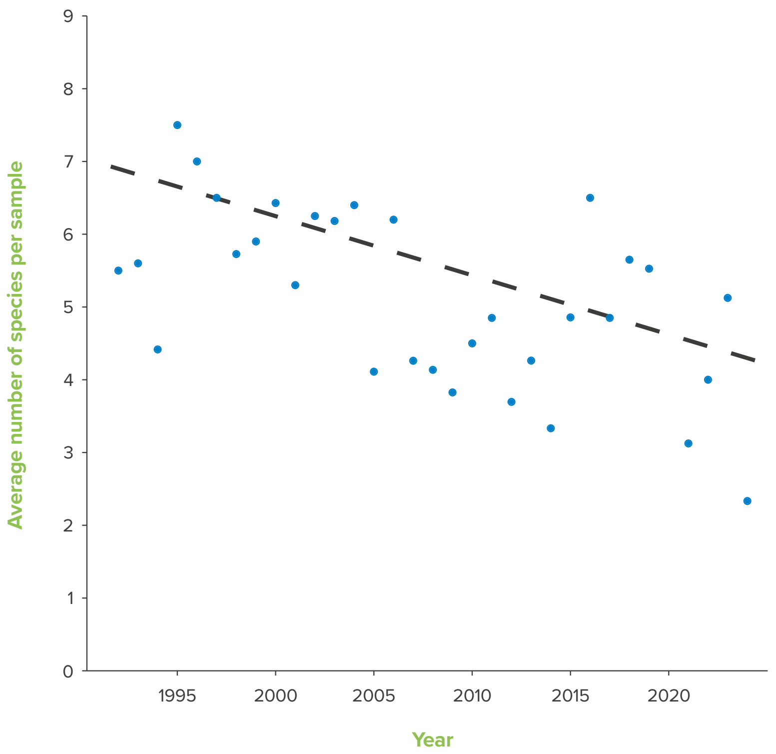


Figure 10.3: Annual average number of species per sample found in the Upper Tidal Thames between 1992–2023. Points show the annual averages, and the dotted line shows the trend estimated using a Theil–Sen robust linear model.

FISH: PRESENCE AND ABSENCE

Species occurrence in the Middle and Upper Thames from seine net surveys were compiled to provide a visual overview of fish species recorded presence and absence in the Tidal Thames over time (Figure 10.4). Each dot indicates that a species was recorded in at least one survey during that year. However, it is important to note that this analysis is based solely on seine netting survey data. The exclusion of otter trawl records (another method used by the Environment Agency to sample deeper waters) means that certain species, particularly midwater and demersal/pelagic fish such as smelt and common sole, are likely to be under-represented due to the limitations of the survey method.[8] As a result, the final years in which a species appears on the chart should not be interpreted as its disappearance from the Tidal Thames as a whole.

Some resident species of the Tidal Thames include common bream, dace, flounder, roach, goby, perch, European eel and European sea bass. Although European sea bass is primarily a marine species, its presence shows the importance of the Thames Estuary as a habitat supporting the wider North Sea population. The European eel is an iconic migratory (catadromous) species, spawning in the Sargasso Sea before migrating over 5000 km to rivers such as the Tidal Thames and its tributaries to mature. Its continued presence highlights the importance of maintaining both habitat quality and connectivity within the Thames system.

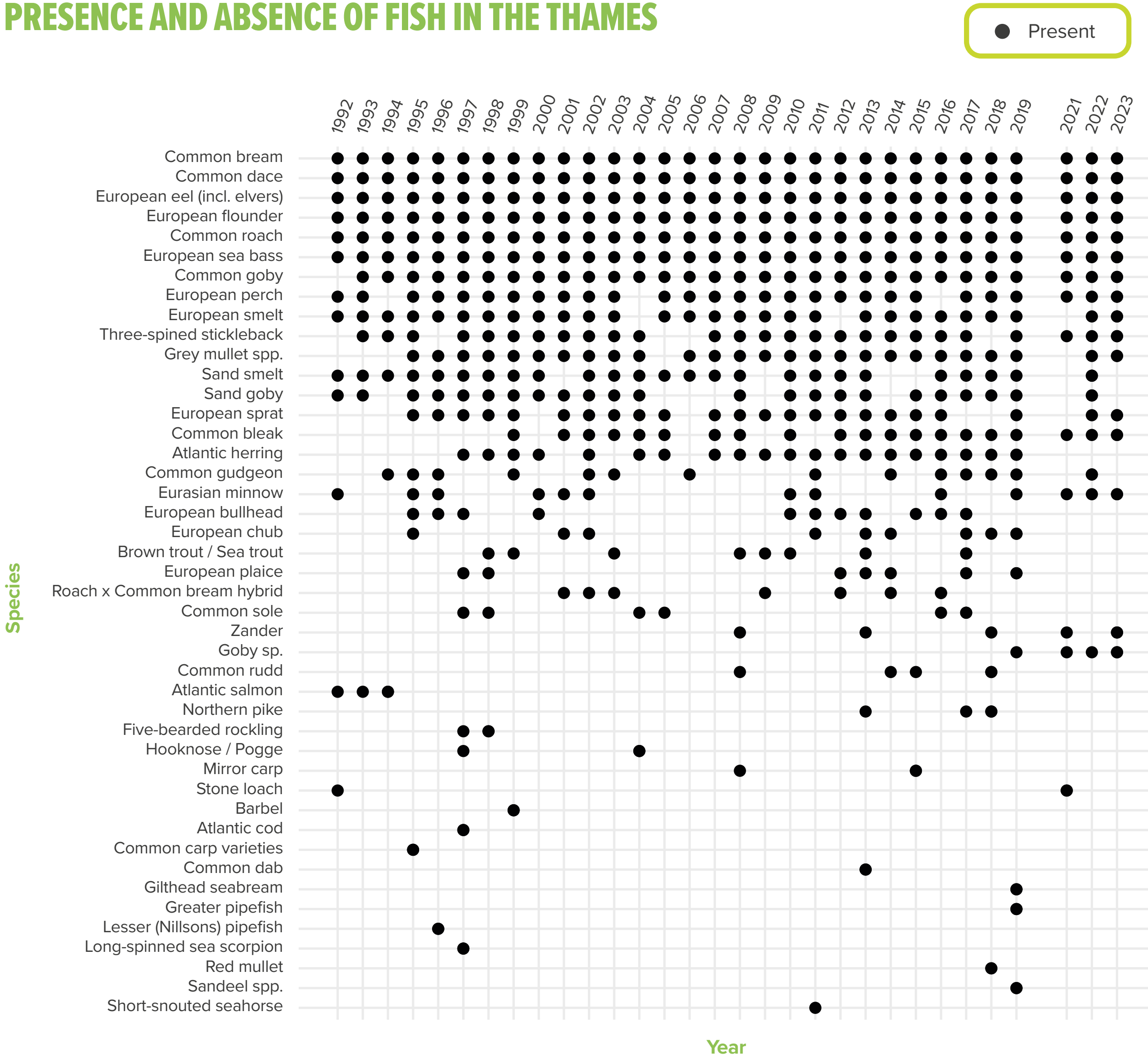
Atlantic salmon has not been recorded in surveys since 1994, despite intensive restocking efforts since the 1970s. While other surveys have confirmed the presence of occasional strays, no hatchery-reared salmon have been caught since 2005, highlighting the futility of long-term stocking without corresponding improvements in habitat and water quality (Griffiths *et al*., 2011) and reducing mortality at sea. The emerging presence of non-native species such as zander and mirror carp signals the spread of introduced species within the estuary.

Nevertheless, the persistent presence of nationally important species of significant conservation concern, including European smelt, sea trout and European eel, underlines the estuary's value for threatened species recovery (Threatened Species Recovery Actions (TSRA) 2025).

[8] **Limitations of seine net sampling:** Estuarine fish occupy different zones of the water column, for example, open water (pelagic), near the bottom (demersal), and along the margins. Representative sampling of estuarine fish communities typically requires multiple gear types (Rotherham and Gray, 2005). This analysis for fish diversity is limited to seine net survey data, which would only offer a partial view of the estuaries' fish communities, primarily focused on i) freshly spawned and juvenile fish less than a year old during spring, and ii) demersal and small shoaling pelagic species that use marginal habitats, such as flounder, smelt, dace and seabass (NECR271 Natural England, 2020).

Left: Seine netting survey, typically conducted by pulling a net from one point on the bank to another to form an enclosed semicircle.

PRESENCE AND ABSENCE OF FISH IN THE THAMES



Above: European flounder (*Platichthys flesus*), a migratory demersal flatfish commonly found in the Thames Estuary.

Figure 10.4: Presence/absence plot showing fish species recorded across sampling years in the Tidal Thames. Black dots indicate species presence, while empty cells indicate absence. The figure shows temporal patterns in species occurrence from seine netting surveys, with species arranged according to their overall frequency of occurrence.

EUROPEAN SEABASS

The European seabass (*Dicentrarchus labrax*) is a demersal finfish found throughout the Northeast Atlantic and Mediterranean Sea (Wright *et al*., 2024). It occurs mainly in inshore coastal and estuarine waters in summer, moving to deeper offshore waters in winter. Coastal bays and estuaries serve as key nursery habitats (Pickett & Pawson, 1996).

The Thames Estuary and its tributaries provide essential nursery habitat for a wide range of fish species. Smelt utilise the mid-channel throughout their development, while flounder, sea bass and eels use the margins and deeper waters for selective tidal stream transport and feeding (ZSL, 2019). Sea bass enter the estuary between June and August to spawn, with juveniles migrating as far upstream as Richmond and making use of nursery habitats within the sub-tidal and intertidal zone, such as saltmarshes and smaller tributary estuaries (Hyder *et al*., 2018). Present year-round, bass contribute to making the Thames Estuary one of the main production areas of the southern North Sea. Owning to its importance as a nursery area, the Thames Estuary has been proposed as a new Bass Nursery Area (BNA) by the Centre for Environment Fisheries & Aquaculture Science (Cefas) but has not been enacted in legislation (Hyder *et al*., 2018).

Sea bass is economically important in the UK, supporting commercial fisheries, a valued recreational fishery, and a major aquaculture industry (Dawson *et al*., 2024). However, in 2010, the International Council for the Exploration of the Sea (ICES) reported a sharp decline in Northeast Atlantic stocks (ICES, 2022), falling below 'safe biological limits' by 2016. Although the stock rose above the safe limits in 2019, it remains depleted relative to historical levels and below the maximum sustainable yield threshold.

The figure shows the annual average abundance of sea bass sampled in seine netting surveys in the Tidal Thames. The data indicates no long-term increase or decrease, but rather interannual fluctuations, suggesting that sea bass abundance in the Thames has remained relatively stable. This highlights the continuing importance of the Thames Estuary as a nursery ground supporting the wider North Sea population, despite overall North Sea stocks declining.

Abundance of sea bass in the Tidal Thames

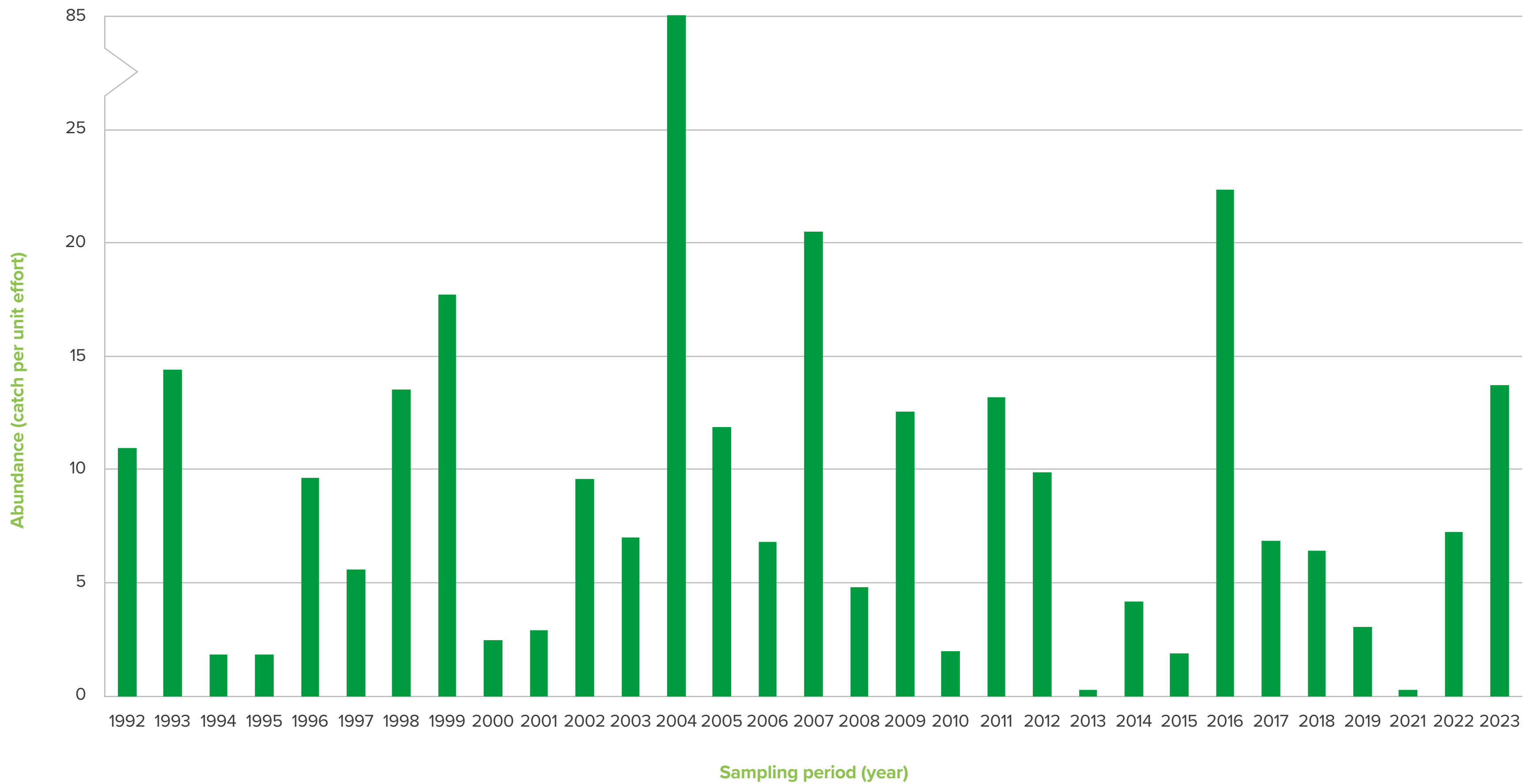


Figure 10.5: Interannual trends in abundance (catch per unit effort) from seine netting survey for sea bass (*Dicentrarchus labrax*) in the Tidal Thames.

BIRDS

Long-term trend – waders: Improving

Short-term trend – waders: Deteriorating

Long-term trend – wildfowl: Deteriorating

Short-term trend – wildfowl: Deteriorating

While some birds spend all year in UK habitats, others are migratory and spend only part of the year here. Because of its mild winter temperatures compared with northern Europe, the UK serves 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: Ringed plover (*Charadrius hiaticula*).

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 was designated because of the frequent presence of protected species including the avocet (*Recurvirostra avosetta*) and the hen harrier (*Circus cyaneus*). The area is part of a coastal network of wetlands along the east coast of England, which in 2023 was added to the UK's tentative list for World Heritage sites status. Inclusion on this exclusive list is the first stage towards joining UNESCO's (United National Educational, Scientific and Cultural Organisation) World Heritage List. These wetlands are extremely important for the role they play in supporting migratory birds along the East Atlantic Flyway migratory route.

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 four decades.

ANALYSIS

The data used for the current analysis was counts from the BTO/Royal Society for the Protection of Birds (RSPB)/ Joint Nature Conservation Committee (JNCC) Wetland Bird Survey.[9] The dataset was reduced to include only survey sites in the Tidal Thames. Following the Living Planet Index methodology (Collen *et al*. 2009), a Living Thames Index (LTI) value for each year was calculated for both wildfowl and waders, representing average changes in relative population abundance.[10] The LTI was calculated by modelling trends from population-count time-series data, covering different species per location. These population trends were then aggregated to the species level with each population carrying equal weight within a species. Annual index values were then calculated by setting the baseline year to one and multiplying the mean value of the species trends per year to calculate each subsequent index value.[11] 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 the LTI for waders in the Tidal Thames has gradually increased from 1993 to 2022, peaking at an index value of 1.6 in 2022, though the confidence intervals are large and straddle the baseline (Figure 11.1). In contrast, 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 State of the Thames 1st Edition report p.67 for more information).

The LTI for wildfowl shows the opposite trend, with a gradual decline continuing up to and including 2023, with temporary recoveries in certain years across this timespan; most notably in 2011 and 2016–2018. However, the confidence intervals are wide and straddle the baseline, meaning that there is a large amount of variation in the underlying species trends (Figure 11.2). This average decline generally aligns with the gradual declining trends seen nationally. The underlying causes of these population trends are species specific, but habitat loss and pollution in both wintering and breeding grounds are two primary threats to wildfowl populations.

[9] 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.

[10] Full lists of species can be found in Appendix I.

[11] 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.

Above: Red knot (*Calidris canutus*).

Living Thames Index – Wading Birds

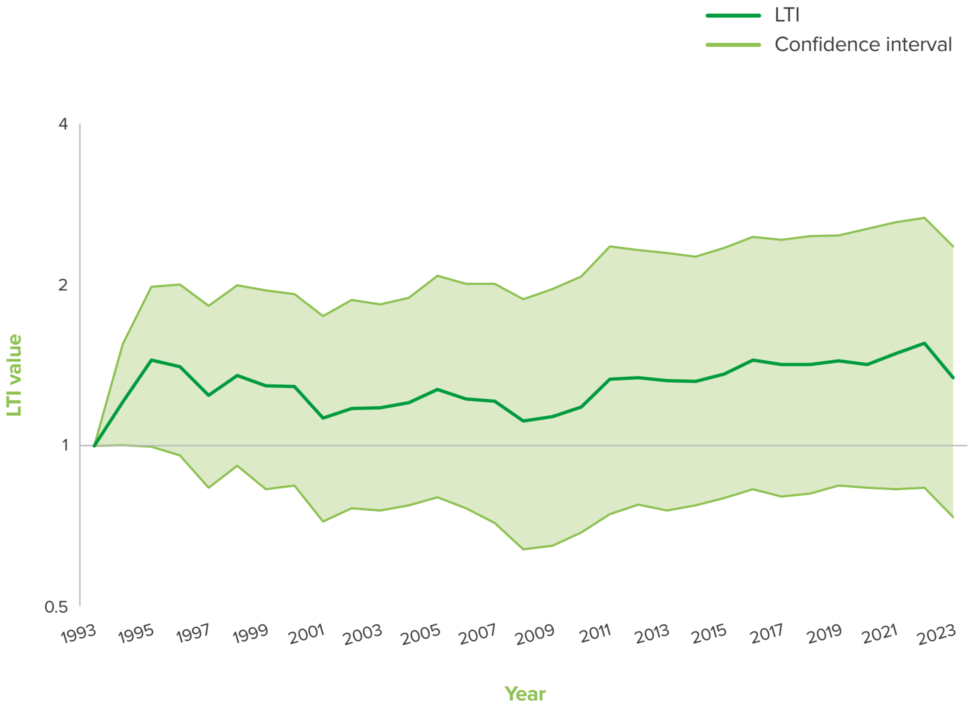


Figure 11.1: Change in LTI values for waders, 1993–2023. Results are displayed at log scale. The dark green line shows calculated LTI values, while the shaded areas shows 95% confidence interval.

Living Thames Index – Wildfowl

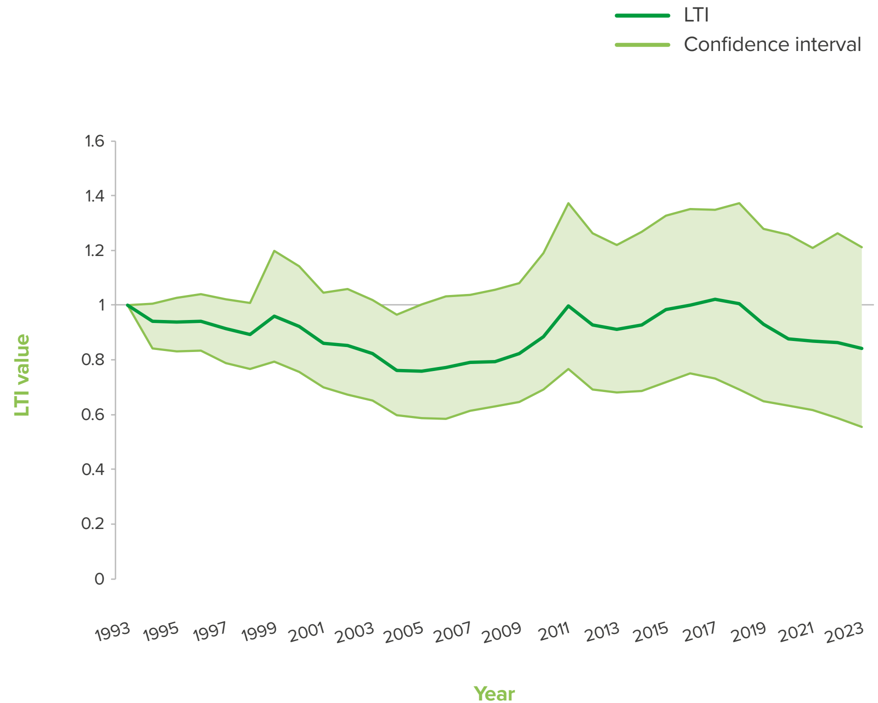


Figure 11.2: Change in LTI values for wildfowl, 1993–2023. The dark green line shows calculated LTI values, while the shaded areas shows 95% confidence interval.

THE THAMES ESTUARY AND MARSHES SPA

The Thames Estuary and Marshes Special Protected Area (SPA) wildfowl and wader populations have recently been assessed by the Wetland Bird Survey Alerts (WeBS) report (Caulfield *et al.* 2025). This report is published every five or six years and assesses the status of designated feature species on SPAs and SSSIs, as well as presenting trend graphs for non-feature species, using the established Underhill Index methodology.

The Thames Estuary and Marshes SPA, for the purposes of the WeBS Alerts, is defined as the coast between the Rivers Medway and Crouch. The intertidal habitat is mainly muddy in character with extensive areas of saltmarsh around Canvey Island. Land claim has removed about 12% of the estuary, mostly before the 19th century, and today much of the coastline is heavily industrialised with major ports, chemical works and extensive areas of housing, apart from the north Kent coastline which is more rural.

The Thames Estuary and Marshes SPA assessment shows long-term declines (last 25 years) for some species, with four of the seven designated wader species prompting 'alerts'. The declining species include the ringed plover, grey plover, knot and redshank, with the avocet and black-tailed godwit showing increasing population trends, and the dunlin population remaining stable in the SPA. Redshanks have had the steepest long-term decline (-70%) of all the featured species, echoing regional and British trends and suggesting that broadscale changes are affecting this species. However, numbers in the SPA are declining more rapidly, suggesting that site-specific pressures may be worsening the site decline in this species. In contrast, the avocet is the only featured species whose over-wintering numbers in the SPA are increasing in the short, medium and long-term. This reflects the regional and British avocet trends, suggesting that environmental conditions remain relatively favourable and that this site is becoming increasingly important for this species. Overall the waterbird assemblage over-wintering on the SPA is showing a slight short-term decline of -18%, but despite this, numbers continue to slightly increase long-term (17%).

Right: Red shank (left) next to a green shank (right).

MARINE MAMMALS

Long-term trend – grey seal: Improving

Short-term trend – grey seal: Improving

Long-term trend – harbour seal: Data stable

Short-term trend – harbour seal: Deteriorating

The Thames Estuary supports a diverse assemblage of marine mammals, providing a critical habitat for several species. Two resident pinniped species occur within the estuary: the grey seal (*Halichoerus grypus*) and the harbour seal (*Phoca vitulina*), the latter of which is known to pup in this area. Recent research has confirmed a significant, year-round presence of harbour porpoises (*Phocoena phocoena*) within the Thames (Cucknell *et al*., 2020). In addition, common bottlenose dolphins (*Tursiops truncatus*) are recorded as transient visitors to the estuary. The shallow bathymetry of the Thames limits regular use by larger cetaceans such as whales; however, occasional sightings of species, including the common minke whale (*Balaenoptera acutorostrata*), have been documented, indicating sporadic use of the estuary by these animals.

Image: Aerial photograph captured from a helicopter during the Thames seal survey.

BACKGROUND

Both harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*) are widely distributed throughout the Greater Thames Estuary. These species regularly haul out along river margins, muddy coastal areas and sandbanks. As generalist feeders, they consume a broad range of fish species and some crustaceans, adjusting their diet according to seasonal changes and prey availability.

Until the early 2000s, little was known about the abundance and distribution of seals within the Tidal Thames (Cox *et al*., 2020). Systematic population monitoring began in 2003, led by the Sea Mammal Research Unit (SMRU), the Zoological Society of London (ZSL) and Bramley Associates. Annual surveys now encompass the area from Gravesend in the west to Felixstowe in the north and Deal in the south, and sandbanks offshore.

ANALYSIS

Seal surveys in the Thames use a nationally recognised approach, ensuring consistency with accepted monitoring standards across the UK. 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). Images of haul-out sites are taken either from fixed-wing aircraft or helicopters, or from boats in areas with flying restrictions. Images were later analysed, and seals in the photographs counted. Population estimates were 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

Figures 12.1 and 12.2 present counts of hauled-out harbour and grey seals, along with population estimates derived from these counts between 2013 and 2024. Based on the 2024 survey, the estimated Thames population was approximately 599 harbour seals and 2,987 grey seals.

Following the 2002 outbreak of phocine distemper virus (PVD), which caused the death of approximately 30,000 harbour seals, the population demonstrated a strong recovery. Numbers increased steadily from the start of monitoring in 2013, reaching a peak of 796 individuals in 2017. However, this upward trend reversed after 2017, and by 2024 the population had declined to 599 individuals, falling below 2013 levels.

Grey seal numbers have shown a consistent upward trend since monitoring began in 2013. By 2024, counts were approximately 3.5 times higher than 2013 levels. Despite their relative abundance in the Thames Estuary, grey seals remain globally scarce. The UK is of exceptional importance for this species, supporting around 40% of the global population and 95% of the EU population. The continued increase in grey seal numbers within the estuary highlights its role as a habitat of both national and international significance (JNCC, 2025).

Although the increase in grey seal numbers represents a positive conservation trend, it is increasingly recognised as a potential threat to harbour seals. Key concerns include competition for haul-out sites and prey resources, as well as the risk of PDV transmission. Harbour seals are highly susceptible to PDV and often develop severe infections, whereas grey seals are generally resistant but may act as asymptomatic carriers (Hall *et al*., 2006; Jensen *et al*., 2002).

Another growing challenge in the Thames Estuary is the interaction between seals and coastal fisheries. Rising seal numbers have led to economic impacts on local fishers, including loss or damage to gear and catch in nearshore waters.

The precise drivers of changes in seal populations remain uncertain. However, pressures such as heavy shipping traffic, noise pollution and coastal development are known risks to seals and other marine mammals in the Thames Estuary. Some yearly variation in counts is expected and does not necessarily indicate a decline, for example, the dip observed in grey seal numbers in 2024. Continued monitoring is important for measuring the seal population's health and understanding their responses to these impacts.

Grey seal in the Thames Estuary

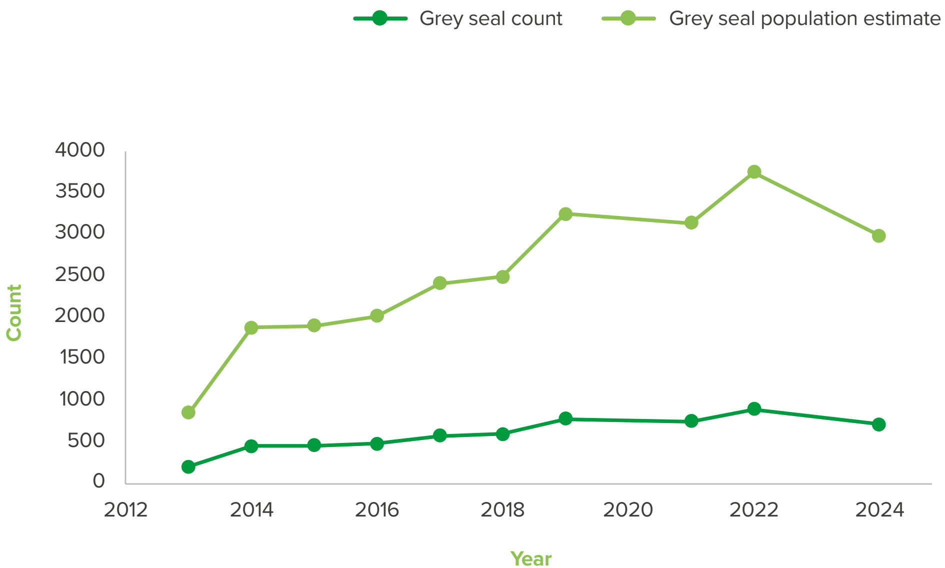


Figure 12.1: Harbour seal counts and population estimates* in the Greater Thames Estuary from 2013–2024**

Harbour seal in the Thames Estuary

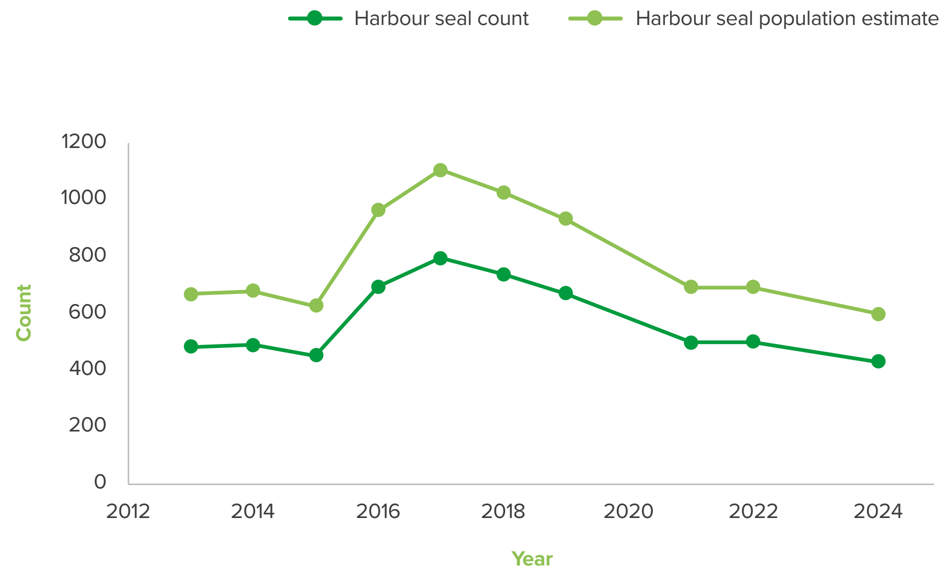


Figure 12.2: Grey seal counts and population estimates in the Greater Thames Estuary from 2013–2024

*These population estimates are calculated by adjusting the observed counts to account for the proportion of seals likely to be in the water at the time of the survey. For harbour seals, it is assumed that 72% are hauled out during the survey period (95% confidence interval [CI]: 0.54–0.88), while for grey seals, the assumed haul-out proportion is 23.9% (95% CI: 0.192–0.286) (Lonergan *et al.*, 2013; SCOS-BP-16/03).

**Count not completed in 2020 due to COVID-19 restrictions, and in 2023 due to unavailability of pilot.

HARBOUR PORPOISE

Harbour porpoises are found globally across the northern hemisphere's coastal and offshore waters, and are known to swim up rivers. They are active hunters that feed on schooling fish. Harbour porpoise is considered a sentinel species, i.e. animals which indicate the health of an ecosystem and point to potential threats.

The Thames Estuary is an important habitat for the harbour porpoise. However the Thames also holds industries and ports which can create stressors such as noise pollution and vessel traffic, both of which are known to potentially have negative impact on porpoises and other cetaceans (Pigeault *et al*., 2024, Gomez *et al*., 2016). Additionally, harbour porpoises face ongoing threats throughout their range from bycatch in fishing gear and water pollution.

In 2015 and 2022, ZSL and Marine Conservation Research (MCR) conducted surveys on the presence and distribution of harbour porpoise throughout the Thames Estuary using combined visual and acoustic methods (towed hydrophone and hull-mounted arrays). Surveys confirmed the Thames Estuary is nationally important habitat for harbour porpoise, with 5.6 porpoise groups per 100 km (var = 1.80) recorded in April 2022, compared to 8.13 groups per 100 km (var = 4.23) in March 2015. Due to insufficient evidence, this is currently considered a natural fluctuation and not a decline in population.

Interestingly, the detection rates in the Thames Estuary remain higher than those reported from two Special Areas of Conservation (SAC) sites designated for harbour porpoise in Ireland (two and four detections per 100 km, respectively) and are comparable to Dogger Bank in the North Sea (4.8 detections per 100 km) (ZSL & MCR, 2022). The Thames Estuary is not currently one of the seven UK SACs designated for harbour porpoise, but these results underscore the importance of the estuary's habitats for this species and therefore considering the species in the planning and operation of infrastructure in the estuary.

Right: A harbour porpoise surfacing with its dorsal fin cutting through the water surface.

STATE OF PLAY

> "Recognising cultural ecosystem services is crucial for promoting environmental protection, informing urban planning and policymaking, and understanding the full value of natural spaces to society."

Cultural ecosystem services are the non-material, non-consumptive benefits that people receive from their relationships with nature, such as a sense of place, spiritual enrichment, aesthetic enjoyment and opportunities for recreation and learning. These services encompass a wide range of experiences, from quiet walks along a towpath to cultural traditions tied to specific landscapes, such as a sacred river. They contribute significantly to human wellbeing and quality of life.

The Tidal Thames serves as a geographical, economic and cultural hub for millions of people. It provides many cultural ecosystem services to residents and visitors alike. The River Thames, for example, is central to spiritual festivals such as Ganesh Chaturthi Festival. It also provides a window into the past through archaeological finds that can be found on the foreshore and are sometimes explored through mudlarking.[12] It must be observed that some cultural services are dependent on having a good quality environment. For example, the river must be clean enough to allow people to enjoy water-based sports safely.

Understanding the full value of natural spaces to society, and recognising the cultural ecosystem services they provide, is crucial to promote environmental protection and should inform local and regional planning policy. The following section describes how the Tidal Thames is being used for physical and cogitative benefits.

[12] 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

Long-term trend: Baseline

Short-term trend: Baseline

Across the Tidal Thames, over 130 organisations deliver sport that contributes to participation in water-based activities. London Sport Consultancy conducted a survey in 2017 of these organisations to capture a snapshot of river use, highlighting the most popular activities enjoyed by the public on the river.

Right: A group of kayakers on the Thames passing under London Bridge in central London.

ON THE RIVER

With responses from participants, administrators and coaches, the results showed that rowing is the most popular sport activity undertaken on the river, with 54% of the 76 responding administrators indicating that they offer this activity (London Sport Consultancy, 2021). The second most popular activity was kayaking (33%), followed by powerboating/cruising (29%), sailing (28%), paddleboarding (24%) and canoeing (23%) (London Sport Consultancy, 2021).

Out of the 751 participants who responded to the survey, 70% were members of a water sports club. Among the three sections of the tidal Thames, the Upper Thames was used by the largest proportion of participants (64%), followed by the Central Thames (37%) and the Lower Thames and Estuary (27%). The number of sporting events on the river has increased since 2021, with 719 major events taking place (PLA, 2024). Participation in organised sport on the river was estimated to be around 19,000 individuals (London Sport Consultancy, 2021) . These included the colourful Great River Race, which attracts crews from across Europe; and the iconic Oxford and Cambridge University Boat Race. Angling is another popular activity on the Thames. The Tidefest Angling Championship, organised annually by the Angling Trust, is London's biggest angling competition. The championship is part of the Thames Tidefest community festival that celebrates the recreational importance of the Thames tideway, drawing anglers and visitors to enjoy competitions and river-based activities.

The 2024 PLA annual report estimated that there were 9 million passenger journeys (leisure, commuter and tourist) on the River Thames, the same as recorded in 2023. The London River Bus service, operated by Uber Boat by Thames Clippers, carried 4.6 million passengers across all routes in 2022/23 (Uber Boat by Thames Clippers, 2023).

ROWING

is the most popular activity on the river.

KAYAKING AND POWER BOATING

are the second and third most popular activities.

19,000

individuals are estimated to have taken part in organised sport events.

719

major sporting events took place on the river in 2024.

9 MILLION

passenger journeys took place on river in 2024.

BY THE RIVER

From the Upper Tidal Thames at Teddington to the study boundary at Southend, the river is bordered by 121 km of public footpaths, 6.4 km^2 of parks and gardens, 12 beaches, and 5.8 km^2 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 294 km 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.

ORVal is a tool that estimates visits to existing and new greenspaces using a sophisticated model of recreational demand in England and Wales. ORVal identifies four categories of outdoor recreation areas: paths, parks, beaches and nature reserves. The model, combined with data from the Monitor of Engagement with the Natural Environment (MENE) survey, calculated that, in 2018, riverside outdoor areas along the Tidal Thames received 39.1 million recreational visits per year. Of these, 43% (16.8 million) were to riverside paths, 31.2% (12.2 million) to parks, 21% (8.2 million) to beaches, and 4.9% (1.9 million) to nature reserves. These findings underline the Thames' importance as a recreational resource. The ORVal tool is no longer in operation, and the MENE survey ended in 2019, continuing thereafter as the People and Nature Survey for England (PaNS).

RIVERSIDE SPACE

Public open spaces along the Thames provide vital opportunities for people to access and connect with the river. The Tideway project is enhancing this connection by creating three acres of new public realm sites along the riverbank, adding to the existing network of riverside spaces. Four sites, Putney Embankment, Chelsea Quay, Heathwall Quay (Heathwall Pumping Station) and Isle of Effra & Effra Quay, have already been completed, with further sites at Tyburn Quay (Victoria), Bazelgette Embankment and King Edward Memorial Park currently under construction.

The new designs create new welcoming spaces and open walkways where residents and visitors can enjoy expansive views up and down the Thames, helping to reconnect London with its river. At the Chelsea Embankment Riverside Space, the riverbank has been extended and enhanced to create a new public area with vibrant colours and integrated lighting. The newly opened space is designed to be 'floodable' at high tide, giving Londoners the chance to dip their toes in the Thames while enjoying views of the city. The site also promotes biodiversity through intertidal terraces planted with native species, partially replacing the intertidal foreshore lost in construction.

Above: Chelsea Quay at Chelsea Embankment site.

LEARNING AND VOLUNTEERING

Long-term trend: **Baseline**

Short-term trend: **Baseline**

The Tidal Thames is a living classroom and a place to get involved. From school sessions and guided walks to citizen science and practical volunteering, people can learn new skills, deepen their understanding of the river and help look after it by supporting habitat restoration, wildlife monitoring and river stewardship. People also gain numerous cognitive benefits from nature, including knowledge about the environment, scientific discovery and engineering advancements inspired by nature's designs.

Right: Volunteers planting seagrass.

CULTURAL SIGNIFICANCE

The Thames is more than an ecological or transport corridor, it's a civic stage and cultural spine. From public artworks and festivals to annual river blessings, communities along the Thames use the water as both venue and participant, binding daily activities including work, leisure and even spiritual life to its tides.

Illuminated River is a long-term light artwork that unifies nine Central London bridges along a ~3.2-mile stretch of the Thames, using slow-moving, energy-efficient LED sequences that respond to each bridge's history and architecture. It transforms the river at night and has spawned guided walks and official boat tours, creating regular cultural activity on and alongside the river. The project also embedded environmental considerations, by minimising light spill with focused LEDs and shielding, enforcing a 2 am lights-off curfew, and timing operations around sensitive fish periods, with input from ecological advisors including ZSL and London Wildlife Trust.

Thames Festival Trust curates Totally Thames each September, a month-long programme of arts, heritage and environmental events staged on, under and alongside the river including installations, performances, guided walks, boat races and clean-ups. Alongside the festival, the Trust runs year-round education and heritage projects. Examples include, Rivers of the World (in partnership with the British Council) and River of Hope, which link schools locally and internationally through the study of rivers, creative work and environmental learning, plus initiatives like Kids' Choir and art competitions like the Thames Lens community events.

Some people regard the Thames as a sacred river; London's Hindu communities celebrate Ganeshotsav with public prayers, music and processions. Small clay statues of Ganesha are immersed in the Thames at designated locations under Port of London Authority and council permits, with safeguards to protect the river (clay-only statues, supervised sites, or purpose-built immersion tanks).

Each January, on the Sunday after Epiphany (the Baptism of Christ), Blessing of the River takes place on London Bridge. It is an annual Church of England ceremony, held jointly by Southwark Cathedral and St Magnus-the-Martyr. Clergy and congregations process from opposite banks, meet mid-span for prayers, and cast a wooden cross into the Thames in blessing and in honour of those who live and work on the river and those lost to it. The service is public and free to attend.

VOLUNTEERING

Volunteering can be a way to learn about and connect with nature. There are many different organisations that hold events and provide opportunities for volunteers across the Tidal Thames. In 2024, Thames21 engaged with 12,392 volunteers to achieve a variety of goals, including clearing litter from waterways, creating habitats and controlling problematic introduced non-native species. In addition to this, the Port of London Authority supported over 400 foreshore clean-ups in 2024 through its 'Cleaning the Thames' initiative, contributing significantly to the health of the tidal river. Since 2019, the organisation Hubbub has also taken more than 10,000 volunteers on 'Plastic Fishing' trips in the London Docklands, engaging everyone from school groups to international businesses. Beyond organised projects, many informal volunteers also act as everyday stewards of the Thames, whose contributions to the river's care and upkeep deserve recognition.

Image credit: The Boy and the River, Lichena Bertinato. Thames Lens Winner 2025. Courtesy of Thames Festival Trust.

YOUTH ENGAGEMENT

In 2025, a ZSL-led campaign 'Nature For Every Child' highlighted the importance of connecting children with nature, following survey findings that 56% of secondary schools offer no regular outdoor learning, and 70% of UK teachers report having received no training in biodiversity or climate education (Schools for Nature report, WWF, 2022; Teach the Future, Students organising for sustainability, 2021).

One way to strengthen young people's connection with the Tidal Thames is by incorporating it into the London school curriculum, thereby helping students build a deeper understanding of the world around them and develop stronger connections to their local environment. The Thames Explorer Trust has tailored trips for schools to visit the foreshores of the Tidal Thames. It offers students the opportunity to learn about the ecology of the Thames through fieldwork and to explore the heritage and history of London. In 2024, 11,032 children under 18 years of age took part in the Thames Explorer Trust's foreshore programmes to learn about the ecology of the Thames through fieldwork and to explore the heritage and history of London. The Thames Explorer Trust also makes this Thames-focused learning available to schools in the form of outreach, with 8,220 children (7–11 years) reached through 76 school visits and 14 assemblies related to Thames-focused learning in 2024. In addition to school children, the Thames Explorer Trust also provides opportunities for adults to learn about the Tidal Thames. In 2024, they engaged with 4,850 adults (aged 18 and over) at events and tours.

COMMUNITY SCIENCE

Community science (otherwise known as citizen science) involves public participation in scientific research, empowering volunteers to contribute to data collection, analysis and other aspects of a research project to increase scientific knowledge – typically as part of a collaborative project with professional scientists. Citizen science projects take place in and around the Tidal Thames and its tributaries, providing opportunities for community members to receive training and learn more about the importance of this habitat and its associated species. Citizen science is known to enhance conservation science and support environmental protection (McKinley *et al*., 2017).

The British Trust for Ornithology (BTO) works with researchers and over 3,000 volunteers to collect population data. The WeBS (Wetland Bird Survey) is one of BTO's long-running volunteer surveys. It monitors UK's internationally important non-breeding waterbirds on wetlands, estuaries, rivers, lakes and coastal sites across the UK, including the Tidal Thames. The data helps track migration, breeding, survival, distribution of birds and how they respond to environmental change.

ZSL conducts numerous citizen science projects in the Tidal Thames and its tributaries, all of which improve understanding of the ecosystem and supported species. As part of Transforming the Thames, ZSL is restoring seagrass in the Thames Estuary with help from citizen scientists and volunteers. Trained volunteers help to collect seeds and monitor the health of the seagrass bed. Another example is ZSL's Thames Marine Mammal Sightings Survey. Numbers of seal sightings submitted have increased over the years, and in 2024, the 21st year of the survey, there were over 800 sightings.

The Thames Catchment Community Eels Project trained 97 volunteers to carry out ObstacEELS surveys on targeted rivers to identify barriers to fish migration. Of the 457 barriers recorded and mapped over seven months by citizen scientists, 278 were 'new' (not present in existing baseline data).

Above: Citizen scientists trained by ZSL using a new invertebrate monitoring method (adapted from the Riverfly Partnership's Riverfly Monitoring Initiative) to assess the function and health of a London wetland.

LOOKING FORWARD

The findings of this second report highlight the continued 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 wellbeing. These results are testimony to the collaborative hard work of many people and organisations. With the Tideway Tunnel having come into operation in 2025, we look forward to collating the evidence on how this significant investment in water management will contribute to the continued improvement in water quality, ultimately benefiting public health and wildlife.

As well as the positive trends, this report also identifies those pressures that the Tidal Thames still faces. Climate change, increasing nutrient levels, plastics and forever chemicals are among the issues demanding our attention and will continue to increase if London's population grows as forecasted. Significant attention has been given to the way our wastewater management system fails rivers, but it is also important to follow the pathway of harm and look at the other sources of pollution, such as the significant risk that comes from road runoff and land management in adjacent river corridors.

The most effective way to combat these pressures and improve the environmental health of the Tidal Thames is through collaboration, particularly between the quadruple helix of civil society, public sector, private sector and knowledge institutions. With new national legislation, such as the Environmental Improvement Plan, Biodiversity Net Gain (BNG) and Local Nature Recovery Strategies coming into effect, in addition to the regional Mayor's Clean and Healthy Waterway Strategy, there is cautious optimism that they will underpin the agenda for change. Confidence will grow in high integrity financing mechanisms, be it Blue Carbon or biodiversity credits, and hopefully this will drive investment into nature recovery.

Finally, this report communicates the shared ambition to achieve the 100-year vision to restore and reconnect a resilient Greater Thames Estuary seascape, which encompasses the Tidal Thames, for both wildlife and people. Across the globe, people look to the Thames as an inspirational story of recovery. It is our shared responsibility that we continue to drive the Thames' journey to being that global exemplar of a thriving ecosystem at the heart of a world-renowned capital city.

ACRONYMS

BMWP: Biological Monitoring Working Party

BNA: Bass Nursery Area

BTO: British Trust for Ornithology

CECs: Chemicals of emerging concern

Cefas: Centre for Environment Fisheries & Aquaculture Science

CPUE: Catch Per Unit Effort

CSO: combined sewer overflow

DO: dissolved oxygen

EA: Environment Agency

EFH: essential fish habitat

ICES: International Council for the Exploration of the Sea

IPCC: Intergovernmental Panel on Climate Change

JNCC: Joint Nature Conservation Committee

KEIFCA: Kent and Essex Inshore Fisheries and Conservation Authority

LNR: Local Nature Reserve

LTI: Living Thames Index

MCR: Marine Conservation Research

MCZ: Marine Conservation Zone

MENE: Monitor of Engagement with the Natural Environment

ORVal: Outdoor Recreation Valuation Tool

OSPAR: The Convention for the Protection of the Marine Environment of the North-East Atlantic

PaNS: People and Nature Survey for England

PDC: passive debris collector

PLA: Port of London Authority

RSPB: Royal Society for the Protection of Birds

SAC: Special Area of Conservation

SDL: Sewage-derived Litter

SERT: South East Rivers Trust

SINC: Site of Importance for Nature Conservation

SMRU: Sea Mammal Research Unit

SPA: Special Protection Area

SSSI: Site of Special Scientific Interest

SST: sea surface temperature

STW: sewage treatment works

TEP: Thames Estuary Partnership

TLS: Thames Landscape Strategy

TTT: Thames Tideway Tunnel

UKCEH: UK Centre for Ecology & Hydrology

UKCP18: UK Climate Projections 2018

UKTAG: UK Technical Advisory Group (UKTAG)

WeBS: Wetland Bird Survey Alerts

WFD: Water Framework Directive

WIMS: Environment Agency's Water Quality Archive

WINEP: Water Industry National Environment Programme

ZSL: Zoological Society of London

GLOSSARY

Algal bloom: a rapid increase or accumulation of algae in freshwater or marine water systems.

Anadromous: migrating upriver from the sea to spawn.

Anthropogenic: caused by humans or their activities.

Blue space: places on or by water bodies.

Brackish: water that has a salinity level between freshwater and seawater.

Carbon sequestration: a natural or artificial process by which carbon dioxide is removed from the atmosphere.

Catadromous: migrating downstream to the sea to spawn.

Chlorophyll: a green pigment responsible for absorbing light to provide energy for photosynthesis.

Citizen science: the collection and analysis of scientific data by members of the public, typically as part of a collaborative project with professional scientists.

Coastal squeeze: the loss of intertidal habitat in front of sea defences.

Cognitive benefits: the learning and understanding we derive from the natural world.

Confluence: the point where two rivers meet.

Ecosystem services: contributions of ecosystem structure and function to human well-being.

Estuary: the tidal mouth of a river, where freshwater and saltwater mix.

Eutrophication: the process by which a body of water gradually becomes enriched with minerals and nutrients.

Invasive species: an organism that causes ecological/economic harm in an environment where it is not native.

Macrophyte: an aquatic plant that grows in or near water.

Macroplastic: plastic items ≥ five millimetres in size.

Managed realignment: removal of part or all existing coastal defence structures to allow coastal flooding, creating new intertidal zones.

Microplastic: plastic particles < five millimetres in size.

Mudlarking: searching for historic or valuable items hidden in mud.

Oligohaline: brackish water with a salinity of 0.5 to 3.0 parts per thousand from ocean-derived salts.

PP: polypropylene plastic

p-value: a number describing the likelihood that the trend in the data could have occurred by random chance.

Ramsar Sites: wetlands of international importance designated under the Convention on Wetlands.

Recruitment: the process by which new individuals are added to a population.

Spawn: to produce or deposit eggs in water.

Strand line: a line on the foreshore resulting from a water level that is higher than the present.

Sublittoral: the seashore zone lying immediately below the intertidal zone and extending to about 200 m depth or to the edge of the continental shelf.

Transitional water body: bodies of surface water in the vicinity of river mouths which are partly saline in character as a result of their proximity to coastal waters but are substantially influenced by freshwater flows.

Tributary: a river or stream flowing into a larger river or lake.

REFERENCES

Anon, 1958. The Venice system for the classification of marine waters according to salinity. Limnology and Oceanography 3, 346–347.

Attrill, M.J. (Ed.). 1998. A Rehabilitated Estuarine Ecosystem: The environment and ecology of the Thames Estuary. Kluwer Academic Publishers, London.

Attrill, M.J., Power, M., 2000. Modelling the effect of drought on estuarine water quality. Water Research 34, 1584–1594. https://doi.org/10.1016/S0043-1354(99)00305-X

Attrill, M.J., Rundle, S.D., & Thomas, R.M. (1996) The influence of drought-induced low freshwater flow on an upper-estuarine macroinvertebrate community. Water Research, 30, 261–268.

Bodnar, W., Colclough, S. and Pryor, A. 2024. Fish utilisation of bioengineered intertidal habitats in the Thames Estuary. Thames Estuary Partnership, University College London, London.

Caulfield, E.B., Feather, A., Smith, J.A., Frost, T.M. & Woodward, I.D. 2025. Wetland Bird Survey Alerts 2021/2022: Changes in numbers of wintering waterbirds in the Constituent Countries of the United Kingdom, Special Protection Areas (SPAs), Sites of Special Scientific Interest (SSSIs) and Areas of Special Scientific interest (ASSIs). BTO Research Report 786. BTO, Thetford. www.bto.org/webs-alerts

Centre for Environment, Fisheries and Aquaculture Science (Cefas), 2025. Threatened Species Recovery Actions 2025 baseline (JP065). URL: https://publications.naturalengland.org.uk/publication/6106216194113536 (Accessed: October 2025).

Colclough, S.R, Fonseca, L., Astley, T., Thomas, K. & Watts, W. 2005. Fish utilisation of managed realignments. Fisheries Management and Ecology 12: 351–360.

Collen *et al*. 2009. "Monitoring change in vertebrate abundance: the Living Planet Index." Conservation Biology 23.2: 317–327.

Cox, T., Barker, J., Bramley, J., Debney, A., Thompson, D. and Cucknell, A-C. 2020. Population trends of harbour and grey seals in the Greater Thames Estuary. Mammal Communications 6:42–51.

Cucknell, A.C., Moscrop, A., Boisseau, O. and McLanaghan, R. 2020. Confirmation of the presence of harbour porpoise (Phocoena phocoena) within the tidal Thames and Thames Estuary. Mammal Communications 6:21–28.

D'Cruz, L. 2020. London's Plastic Pandemic: Investigating the Extent and Abundance of Macro-plastic Pollution in the Tidal River Thames. Undergraduate Dissertation (unpublished).

Dawson, J., Lincoln, H., Sturrock, A.M., Martinho, F., McCarthy, I.D. 2024. Recruitment of European sea bass (Dicentrarchus labrax) in northerly UK estuaries indicates a mismatch between spawning and fisheries closure periods. Journal of Fish Biology 105, 564–576. https://doi.org/10.1111/jfb.15843

DEFRA. 2006. Flood and Coastal Defence Appraisal Guidance, 2006.

Egli M., Rapp-Wright H., Oloyede O., Francis W., Preston-Allen R., Friedman S., Woodward G, Piel F.B., Barron L.P., 2023. A One-Health environmental risk assessment of contaminants of emerging concern in London's waterways throughout the SARS-CoV-2 pandemic. Environment International. 180. https://doi.org/10.1016/j.envint.2023.108210

Environment Agency, 2012a. Lower Tidal River Arun Strategy Environmental Report. Worthing, West Sussex. (Accessed: 18 November 2024).

Environment Agency. 2019a. Phosphorus and Freshwater Eutrophication Pressure Narrative. London. Available from https://consult.environment-agency.gov.uk/environment-and-business/challenges-and-choices/user_uploads/phosphorus-pressure-rbmp-2021.pdf

Environment Agency. 2019b. 2021 River Basin Management Plan. London. Available from https://consult.environment-agency.gov.uk/environment-and-business/challenges-and-choices/user_uploads/pollution-from-abandoned-mines-challenge-rbmp-2021-1.pdf

Environment Agency. 2021. Thames Estuary 2100: 10-Year Review – Technical monitoring report.

Environment Agency. 1997. The Water Quality of the Tidal Thames.

Environment Agency, 2012b. Water Framework Directive (WFD) Classification Scheme for Marine Benthic Invertebrates: Infaunal Quality Index (IQI) – Associated Salinity Data. UK Government Open Data Portal, pp. 2004–2012.

Environment Agency, 2025. Water quality data [online]. UK government open data portal. Available at: https://www.data.gov.uk/dataset/a0e6f23e-d631-4584-9ea2-7053620e4af2/water-quality-archive. (Accessed: 15 November 2024).

Fox-Kemper, B., H.T. Hewitt, C. Xiao, G. Aðalgeirsdóttir, S.S. Drijfhout, T.L. Edwards, N.R. Golledge, M. Hemer, R.E. Kopp, G. Krinner, A. Mix, D. Notz, S. Nowicki, I.S. Nurhati, L. Ruiz, J.-B. Sallée, A.B.A. Slangen, and Y. Yu, 2021: Ocean, Cryosphere and Sea Level Change. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R.

Gomez, C., Lawson, J.W., Wright, A.J., Buren, A.D., Tollit, D., Lesage, V., 2016. A systematic review on the behavioural responses of wild marine mammals to noise: the disparity between science and policy. Can. J. Zool. 94, 801–819. https://doi.org/10.1139/cjz-2016-0098

Griffiths, A.M., Ellis, J.S., Clifton-Dey, D., Machado-Schiaffino, G., Bright, D., Garcia-Vazquez, E., Stevens, J.R., 2011. Restoration versus recolonisation: The origin of Atlantic salmon (Salmo salar L.) currently in the River Thames. Biological Conservation 144, 2733–2738. https://doi.org/10.1016/j.biocon.2011.07.017

Haddout, S., Priya, K.L., 2021. Preparing for the future: The impact of sea-level rise on salinity gradient energy in estuaries. Energy and Climate Change 2, 100041. https://doi.org/10.1016/j.egycc.2021.100041

Haigh, I.D., Hogarth, P., Clarke, L., 2025. Sea level rise and extreme water level analysis to inform the Thames Estuary 2100 Plan 15-Year Review. University of Southampton Report.

Haigh, I.D., Inayatillah, A. and Radtke H. 2020. Sea Level Analysis to Inform the Thames Estuary 2100 Plan – 10-Year Review. Southampton.

Hall, A.J., Jepson, P.D., Goodman, S.J., Härkönen, T. 2006. Phocine distemper virus in the North and European Seas – Data and models, nature and nurture. Biological Conservation 131, 221–229. https://doi.org/10.1016/j.biocon.2006.04.008

Hutchings M.A, de Vries C.S, Hayes N.R, Orr H.G. 2024. Temperature and dissolved oxygen trends in English estuaries over the past 30 years. Estuarine, Coastal and Shelf Science. https://doi.org/10.1016/j.ecss.2024.108892

Hyder, K., Scougal, C., Couce, E., Fronkova, L., Waugh, A., Brown, M., Paltriguera, L., Readdy, L., Townhill, B. and Armstrong, M. 2018. Presence of European sea bass (Dicentrarchus labrax) and other species in proposed bass nursery areas. Centre for Environment, Fisheries and Aquaculture Science (Cefas), 27 April. Available at: https://www.gov.uk/government/publications (Accessed: September 2025)

ICES. 2022. Sea bass (Dicentrarchus labrax) in divisions 4.b–c, 7.a, and 7.d–h (central and southern North Sea, Irish Sea, English Channel, Bristol Channel, and Celtic Sea) (report). ICES Advice: Recurrent Advice. https://doi.org/10.17895/ices.advice.19447796.v1

IPCC. 2021. In: Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S.L., Pe´an, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J.B.R., Maycock, T.K., Waterfield, T., Yelekçi, O., Yu, R., Zhou, B. (Eds.), Climate Change 2021: the Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, p. 2391.

Jensen, T., Van De Bildt, M., Dietz, H.H., Andersen, Ths.H., Hammer, A.S., Kuiken, T., Osterhaus, A. 2002. Another Phocine Distemper Outbreak in Europe. Science 297, 209–209. https://doi.org/10.1126/science.1075343

JNCC Annex II Species Types List: 1364 Grey seal Halichoerus grypus. URL: https://sac.jncc.gov.uk/species/S1364/ (Accessed: October 2025)

Johnson A, C. *et al*. 2025. Zinc and Copper have the greatest relative importance for river macroinvertebrate richness at a national scale. Environ. Sci. Technol. https://doi.org/10.1021/acs.est.4c06849

Kendon, M., McCarthy, M., Jevrejeva, S., Matthews, A., Sparks, T., Garforth, J., Kennedy, J. 2022. State of the UK Climate 2021. International Journal of Climatology 42, 1–80. https://doi.org/10.1002/joc.7787

Little, S., Lewis, J.P., Pietkiewicz, H. 2022. Defining estuarine squeeze: the loss of upper estuarine transitional zones against in-channel barriers through saline intrusion. Estuar. Coast Shelf Sci. 278, 108107.

Martín-Llanes, G., López-Ruiz, A., 2024. The role of estuarine convergence on the salinity distribution and the estuary response to short river discharge pulses. Estuarine, Coastal and Shelf Science 306, 108893. https://doi.org/10.1016/j.ecss.2024.108893

Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1211–1362, doi: 10.1017/9781009157896.011.

McKinley, D.C., Miller-Rushing, A.J., Ballard, H.L., Bonney, R., Brown, H., Cook-Patton, S.C., Evans, D.M., French, R.A., Parrish, J.K., Phillips, T.B., Ryan, S.F., Shanley, L.A., Shirk, J.L., Stepenuck, K.F., Weltzin, J.F., Wiggins, A., Boyle, O.D., Briggs, R.D., Chapin, S.F., Hewitt, D.A., Preuss, P.W., Soukup, M.A. 2017. Citizen science can improve conservation science, natural resource management, and environmental protection. Biological Conservation, The role of citizen science in biological conservation 208, 15–28. https://doi.org/10.1016/j.energy.2021.122428

Morris, C.D., Duck, C.D. and Thompson, D. 2021. Aerial surveys of seals in Scotland during the harbour seal moult, 2016–2019. NatureScot Research Report 1256.

Natural England. 2025. Designated Sites View: Site Search. Available at: https://designatedsites.naturalengland.org.uk/SiteSearch.aspx (Accessed: September 2025).

Okumah, M., Yeboah, A.S., Bonyah, S.K. 2020. What matters most? Stakeholders' perceptions of river water quality. Land Use Policy 99, 104824. https://doi.org/10.1016/j.landusepol.2020.104824

Pawson M, Pickett G.1996. The annual pattern of condition and maturity in bass, Dicentrarchus labrax, in waters around England and Wales. Journal of the Marine Biological Association of the United Kingdom 76: 107–125.

Philine S.E. zu Ermgassen, Hannah McCormick, Alison Debney, José FariñasFranco, Celine Gamble, Chris Gillies, Boze Hancock, Ane T. Laugen, Stéphane Pouvreau, Joanne Preston, William G. Sanderson, Asa Strand, Ruth H. Thurstan. 2023. European native oyster reef ecosystems are universally Collapsed.

Pietkiewicz, H., Mortimer, R.J.G., Hirst, A.G., Lewis, J.P., Clarke, L., Little, S. 2025. Artificial barriers and estuarine squeeze: A novel assessment of estuarine vulnerability to climate change and sea level rise. Estuarine, Coastal and Shelf Science 320, 109299. https://doi.org/10.1016/j.ecss.2025.109299

Pigeault, R., Ruser, A., Ramírez-Martínez, N.C., Geelhoed, S.C.V., Haelters, J., Nachtsheim, D.A., Schaffeld, T., Sveegaard, S., Siebert, U., Gilles, A. 2024. Maritime traffic alters distribution of the harbour porpoise in the North Sea. Marine Pollution Bulletin 208, 116925. https://doi.org/10.1016/j.marpolbul.2024.116925

Plastic Pollution in the River Thames, 2020. Thames21. URL https://www.thames21.org.uk/thames-river-watch__trashed/report-plastic-pollution-in-the-tidal-thames/ (Accessed: July 2025).

Port of London Authority, 2021. Active Thames Participation and Workforce Study, August 2021: Summary and Full Report.

Port of London Authority, 2024. Annual Report and Accounts 2024. Available at: https://pla.co.uk/annual-report-and-accounts-2024 (Accessed: 12 October 2025).

Port of London Authority. 2020. Litter Rapid Appraisal Methodology.

Smith, M.T., and Brown, M., 2009. Preliminary review of potential new nursery areas. Cefas, Lowestoft, UK. 50pp.

Spurgeon D., Wilkinson H., Civil W., Hutt L., Armenise E., Kieboom N., Sims K., Besien T.., 2022. Worst-case ranking of organic chemicals detected in groundwaters and surface waters in England. Science of The Total Environment. 835. https://doi.org/10.1016/j.scitotenv.2022.155101

Stamp, T. 2021. The Ecology and Distribution of European Bass (Dicentrarchus labrax) in inshore and coastal waters of the U.K. https://doi.org/10.24382/993

Telesh, I.V., Khlebovich, V.V., 2010. Principal processes within the estuarine salinity gradient: A review. Marine Pollution Bulletin, Estuarine Ecosystems: Structure, Function and Management (ECSA-42 Symposium in Russia) 61, 149–155. https://doi.org/10.1016/j.marpolbul.2010.02.008

Thames Estuary Partnership Biodiversity Action Group, 2001. Tidal Thames Habitat Action Plan.

The State of the Thames 1st Edition: Environmental trends of the Tidal Thames, 2021. Zoological Society of London.

Tideway. 2025. London's Super Sewer. Available from: https://www.tideway.london/

Tysall, D. 2016. An assessment of floating macro-litter on the tidal Thames and recommendations for future monitoring. MSc Thesis (unpublished).

Uber Boat by Thames Clippers 2023. Neighbourhood Edit magazine unveils its latest volume in print and digital. Thames Clippers. Accessed: October 2025, from https://www.thamesclippers.com/news/neighbourhood-edit-magazine-unveils-its-latest-volume-in-print-and-digital

UK Technical Advisory Group on the Water Framework Directive. 2013. Final recommendations on new and updated biological standards (Annex 4).

UKCEH Saltmarsh fact sheet. 2023.

Unsworth et al. 2021. The ecosystem service role of UK Seagrass meadows Project Seagrass.

van de Wal, R. S. W., Nicholls, R. J., Behar, D., McInnes, K., Stammer, D., Lowe, J. A., et al. (2022). A high-end estimate of sea level rise for practitioners. Earth's Future, 10, e2022EF002751. https://doi.org/10.1029/2022EF002751

Vasconcelos, R.P., Reis-santos, P., Costa, M.J. & cabral, H.N. 2011. Connectivity between estuaries and marine environment: Integrating metrics to assess estuarine nursery function. Ecological Indicators 11: 1123–1133.

Weeks, J.H., Fung, F., Harrison, B.J., Palmer, M.D. 2023. The evolution of UK sea-level projections. Environ. Res. Commun. 5, 032001. https://doi.org/10.1088/2515-7620/acc020

White D., Lapworth D.J., Civil W., Williams P., 2019. Tracking changes in the occurrence and source of pharmaceuticals within the River Thames, UK; from source to sea. Environmental Pollution. 249: 257-266. https://doi.org/10.1016/j.envpol.2019.03.015

Wright, S., Griffiths, C.A., Bendall, V., Righton, D., Hyder, K., Hunter, E. 2024. Seasonal migrations of the European sea bass (Dicentrarchus labrax L.) in UK and surrounding waters. Mov Ecol 12, 45. https://doi.org/10.1186/s40462-024-00482-w

Zoological Society of London. 2019. Larval and juvenile fish in the Thames: Investigating early life history stages (ELHS) to understand ecological function of the tidal Thames and the impact of improved water quality.

Zoological Society of London. 2025. Working with nature to improve water quality in London. Witcombe, E., Facey, S., Glover, A., Pecorelli, J. (Eds). ZSL, Regents Park, London, UK.

Zoological Society of London. Marine Conservation Research. 2022. Thames Estuary Harbour Porpoise Survey Report 2022. Available at: https://cms.zsl.org/sites/default/files/2022-11/ZSL%20MCR%20Thames%20Estuary%20Harbour%20Porpoise%20survey%20report.pdf (Accessed: September 2025).

APPENDICES

Appendices can be viewed and downloaded from zsl.org/stateofthethames

We're ZSL, a science-driven conservation charity, working to restore wildlife in the UK and around the world.

@OFFICIALZSL

OFFICIALZSL

ZSL