Thames Estuary Harbour Porpoise Survey Report 2022

Prepared by:

Summary

The Zoological Society of London (ZSL), in partnership with Marine Conservation Research (MCR), conducted a visual and acoustic vessel-based survey for the presence and distribution of cetaceans within the Thames Estuary from 22nd to 28th April 2022. The survey incorporated 868 km of effort, of which 629 km included acoustic effort using a towed hydrophone array. There were 31 detections of porpoise groups and 16 sightings; of these encounters, seven were 'matched' (i.e. both seen and heard). In addition, five separate porpoise groups were detected at anchor using a hull-mounted array. Group sizes for the visual encounters were estimated to be between one and three individuals (mean 1.4); groups sizes estimated for the acoustic detections were slightly higher (1-10 individuals with a mean of 2.4). There were also 26 seal sightings, of which 10 were 'definite' grey seals and four were 'definite' common seals. An average encounter rate of 5.57 porpoise groups/100 km surveyed (variance = 1.8) was estimated. The variance inflation factor ($\hat{b}$) was above one (2.04), suggesting there was some clustering in the detections, with porpoise presence being highest in the outer Thames Estuary. When compared to a similar survey conducted in 2015, the 2022 survey resulted in more detections and sightings in the western part of the Thames Estuary and fewer in the northern areas of the study area. Overall encounter rates were lower in 2022 than those estimated in 2015 (mean = 8.13 porpoise groups/100 km; variance = 4.2); however, due to the relatively limited survey effort, this should not be interpreted as a significant decline in porpoise density.

This study confirms the Thames Estuary is an important habitat with significant densities of porpoises present in the area over multiple years. Acoustic encounter rates are comparable to those recorded in European protected sites for this species. It seems likely that the high encounter rate observed in the Thames is indicative of the importance of UK estuaries for harbour porpoises in general. As such we would recommend further survey work is conducted both in the Thames and in estuaries around the UK to fully understand their importance for this elusive cetacean and to ensure that this species continues to exist in our coastal waters into the future.

Introduction

The harbour porpoise (*Phocoena phocoena*) is the UK's most common and widely distributed cetacean. The species occurs throughout north-west European continental shelf seas, with the seas around the British Isles accounting for a high proportion of the European population. Harbour porpoise are a protected species in the UK under the Wildlife and Countryside Act, 1981, listed under CITES Appendix II and classified as a Priority Species under the UK Post-2010 Biodiversity Framework. In 2019, five Special Areas of Conservation (SACs) were designated as areas of importance for harbour porpoise in the UK, one of which, the Southern North Sea SAC is located to the east of England, stretching from the central North Sea (north of Dogger Bank) to the Straits of Dover in the south, covering an area of almost 37,000 km^2. Most of this site lies offshore, though some of it runs directly along the Norfolk and Suffolk coastline (Figure 1).

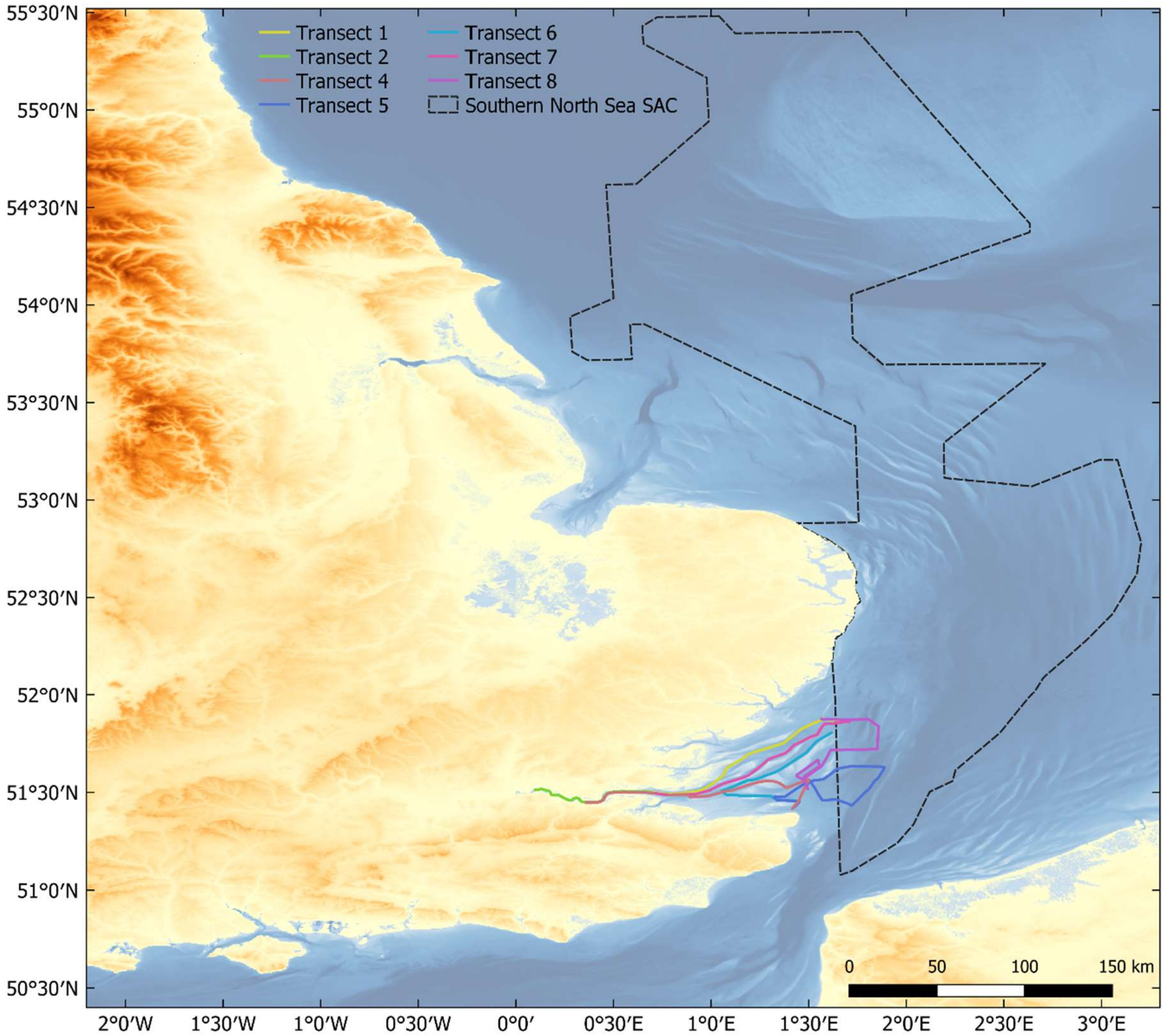

Figure 1. Transects surveyed in 2022 within the Thames Estuary. The Southern North Sea SAC is represented by a dashed polygon and shows some overlap with the survey transects.

In the 1980's porpoises were infrequently seen in the English Channel and southern North Sea. However offshore surveys for cetaceans in UK waters have shown an approximately similar harbour porpoise abundance over the last 30 years, but a southerly shift in distribution, with porpoises in 2005 and 2016 being found in higher densities in the southern North Sea and English Channel than recorded previously (Hammond *et al.*, 2017). In the North Sea harbour porpoises are believed to undertake seasonal movements, coming close to the coast to calve in summer, although porpoises are found in some coastal area's year around. Due to their small size porpoises need to feed continuously, with their prey being small fish, especially herring and sand eels.

The historical presence of harbour porpoises in the River Thames and Estuary, including central London, has been documented in literature and Victorian etchings (e.g., Kemsey, 1982, Plates

Illustrative of Natural History, S.P.C.K, ca.1845). In the last few decades, there has been an increase in the rate of incidental sightings made by the public, fishermen and shore-based groups (Castello y Tickell & Barker, 2015, Natural History Museum, 2018). Despite these reports, harbour porpoises received little dedicated research effort in the tidal Thames until a scientific survey undertaken by MCR and ZSL in March 2015 (Cucknell *et al.*, 2020). That survey represented the first systematic acoustic and visual survey of the tidal Thames for harbour porpoises and brought together previously disparate sighting and stranding data from interest groups working in the area to provide an update on harbour porpoise presence and distribution in the tidal Thames. During the 2015 survey, there were 17 sightings and 45 acoustic detections of porpoise groups. A conservative acoustic encounter rate of 4.2 animals/100 km [vâr(groups/100 km) = 5.4] was estimated based on the hull mounted elements alone, 8.13 porpoise groups/100 km [vâr(groups/100 km) = 4.2] when using the towed array. These results were comparable to results from acoustic surveys in other important European porpoise habitats. Information from opportunistic sightings and strandings suggest reports of porpoise presence peak in spring (with the highest number of reports in April) and late summer, although this finding is not corrected for effort and/or observer bias (Cucknell *et al*., 2020). The 2015 results supported the need for further studies in this significant habitat. The same collaborative team were able to repeat the 2015 survey in April 2022, seven years after the first, representing the second systematic acoustic and visual survey for harbour porpoises in the Thames Estuary. The survey was timed to take place at the same time of year to remove any seasonal effects on the presence/absence of porpoises.

Methodology

A simultaneous acoustic and visual survey was conducted between Felixstowe and Tilbury Docks, London, from R/V *Song of the Whale*, between the 22^{nd} and 28^{th} April 2022. Due to significant navigational constraints, a randomised, even-coverage design was not possible; therefore survey lines were designed to cover every major channel within the Estuary (Figure 2). To facilitate inter-year comparison, the transects were the same as those surveyed in the 2015 survey (Cucknell *et al.*, 2020) with the exception of Transect 3 (Tilbury docks to Tower Bridge); this transect was not surveyed in 2022 due to restrictions preventing towing a hydrophone array along this stretch of water.

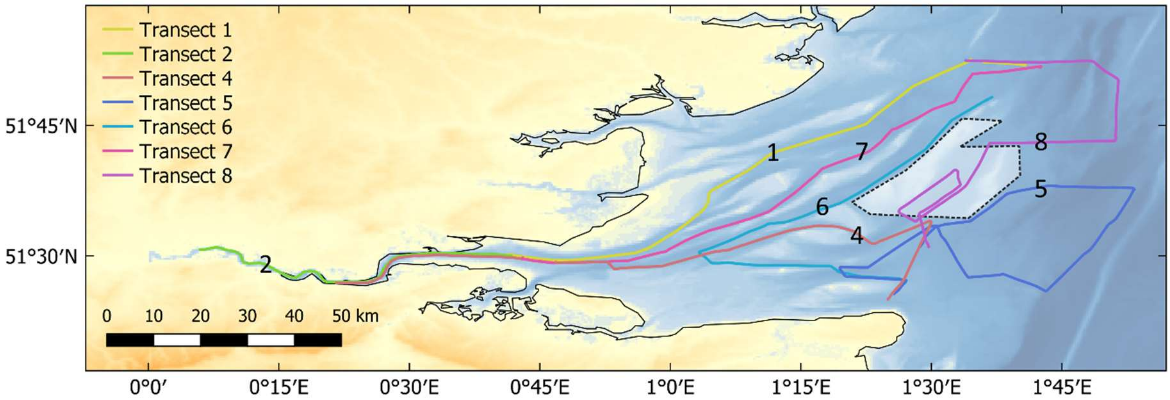

Figure 2. Realised acoustic survey effort made on seven transects during the 2022 survey. The location of the London Array offshore wind farm is shown as a pale polygon.

Acoustic sampling during the survey was conducted using a hydrophone array containing a pair of broadband elements with 2 kHz to 200 kHz bandwidth, towed 30 m behind the vessel. Stereo wav files were recorded continuously at a sample rate of 500 kHz using PAMGuard (Gillespie *et al.,* 2009). Surveys for harbour porpoises have been conducted using these methods on numerous previous surveys (Gillespie *et al.,* 2005; Boisseau *et al.*, 2007; Cucknell *et al.,* 2016a, 2016b, 2020). In addition, a hull-mounted array, consisting of two broadband elements (2 kHz to 200 kHz bandwidth) recorded continuously throughout the survey. This array, mounted ahead of the keel on the vessel's midline 1 m below the waterline, collected acoustic data when at anchor and when towing an array was not possible due to navigational or safety considerations. Signals passed to Sail DAQ data acquisition cards (St. Andrews Instrumentation Ltd.); for the bandwidths of interest for porpoises (115-160 kHz), the response of the system was approximately flat. A click detector module in PAMGuard was used to automatically detect harbour porpoise echolocation clicks in real-time throughout the survey.

In daylight hours and in sea states below four, two visual observers, on an elevated platform (eye height of 5.5 metres above sea level) recorded marine mammal sightings. Sightings, survey effort, environmental and GPS data were logged to a survey database using Logger software (www.marineconservationresearch.org). Observers scanned to 90 degrees either side of the trackline between the vessel and the horizon with naked eye, using binoculars for species confirmation. Estimated distances and relative angles (using an angle board) to sightings were recorded along with an estimate of group size.

Data analysis

All harbour porpoise sightings and acoustic detections were mapped using QGIS (QGIS Development Team). In keeping with the previous analysis of the 2015 dataset, porpoise click trains comprising four clicks or more, and identified as 'certain', were included in subsequent analysis. Click trains were considered to represent a unique encounter (i.e. not a detection of an animal previously seen or detected acoustically) if there was no corresponding sighting or click train within 6 minutes and 15 seconds. This time threshold was estimated by projecting a hypothetical radial area of porpoise movement over the trackline, corrected for maximum acoustic detection distance for porpoises (400 m; Villadsgaard *et al.*, 2007). This was estimated using the average swimming speed of a porpoise (0.9 m sec^{-1}, Otani *et al.*, 2000) relative to the average survey speed of the vessel (5.9 knots).

The two separate hydrophone arrays provided independent detections of harbour porpoises. Due to hull vibrations and flow noise, the hull-mounted array had a lower detection range than the towed array. Combining the output from both arrays optimised the efficiency of surveying with challenging navigational constraints. To avoid duplication between arrays, any detections on the towed array within six minutes and 15 seconds of the hull-mounted array were removed from the dataset. Detections made with the towed hydrophone array were used to estimate a relative acoustic encounter rate throughout the survey; detections made with the hull-mounted array when not under way (i.e. at anchor) were used for presence/absence (rather than contributing to encounter rate).

The variance of the acoustic encounter rate *n*/100 km was calculated using transects as sampling units (Buckland *et al.*, 2001, pages 78-80). The variance in the total number of detections was calculated as follows:

$$\hat{\text{var}}(n) = L\sum_{i=1}^{k} l_i\left(\frac{n_i}{l_i}-\frac{n}{L}\right)^2 /(k-1)$$

where i is the transect number from 1 to k, l_i is the length of transect i and L is the sum of all transect lengths. The variance of the encounter rate was calculated by dividing $\hat{\text{var}}(n)$ by L^2. Encounter rates estimated from the towed hydrophone array were mapped across the survey area using a 0.05 degree grid in QGIS.

Results

The vessel survey comprised 868 km of effort between 22nd and 28th April 2022, of which 629 km included on-transect acoustic effort using the towed array. The survey mostly occurred in daylight hours and in sea states below four (sea state 1 = 3%, 2 = 8%, 3 = 46% and 4 = 41%). During the survey, there were 31 detections of porpoise groups, of which 7 were also confirmed. Therefore, of the 16 porpoise sightings, 9 were not detected acoustically (Table 1). In addition, five separate porpoise groups were detected at anchor using the hull-mounted array only. Group sizes for the visual encounters were estimated to be between one and three individuals (mean 1.4); groups sizes estimated for the acoustic detections were slightly higher (1-10 individuals with a mean of 2.4).

Table 1. Summary of acoustic detections and sightings of harbour porpoises on each transect.

Transect	Detection (towed array)	Static detection (hull-only)	Matched detection & sighting	Sighting without detection	Total
1	-	-	-	-	-
2	-	-	-	2	2
4	2	-	3	1	6
5	4	-	-	3	7
6	5	-	-	-	5
7	1	-	-	2	3
8	9	-	3	-	12
Off-transect	3	5	1	1	10
Total	24	5	7	9	45

As the transects used in 2022 were the same as those used in 2015, it is appropriate to compare results between the surveys (as transect 3 was not surveyed in 2022, it is not included in subsequent estimates of encounter rate for either survey). The acoustic detections and sightings for 2022 are shown in Figure 3, whereas those for 2015 are shown in Figure 4.

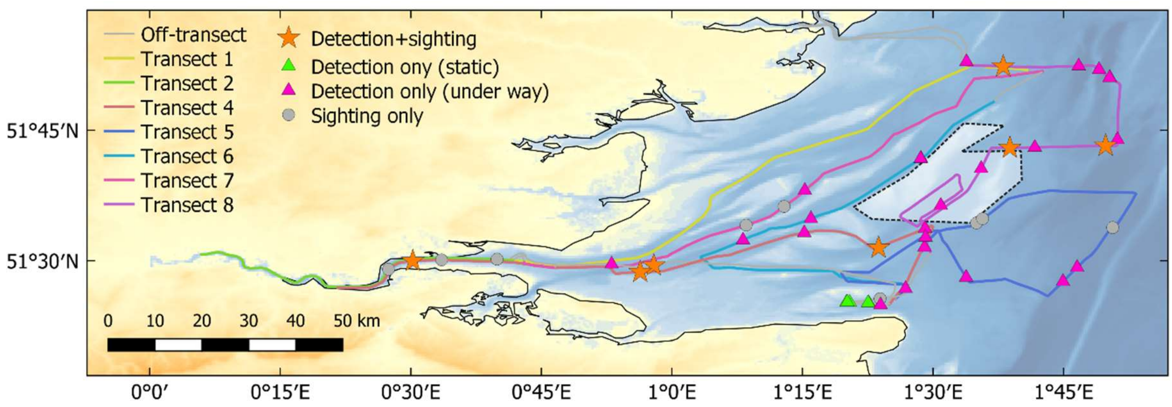

Figure 3. Summary of all acoustic detections of harbour porpoises made during the 2022 survey. The location of the London Array offshore wind farm is shown as a pale polygon.

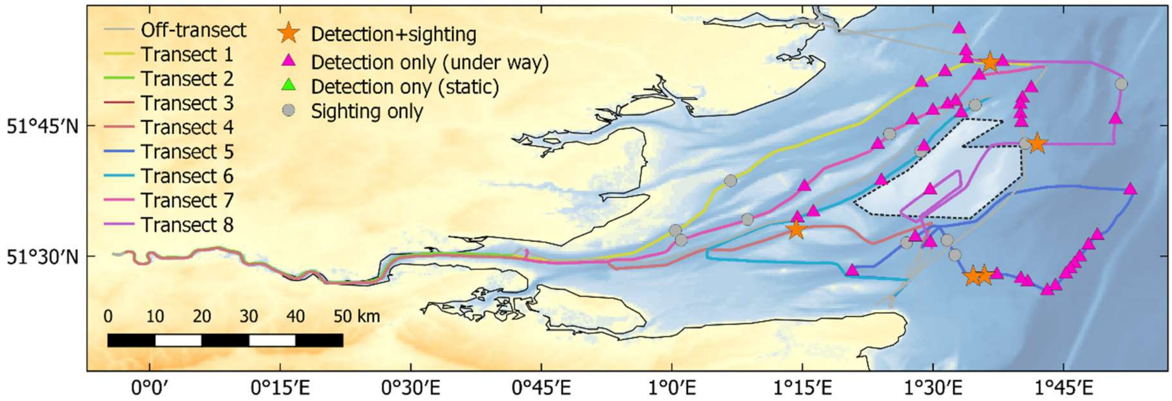

Figure 4. Summary of all acoustic detections of harbour porpoises made during the 2015 survey. The location of the London Array offshore wind farm is shown as a pale polygon.

There were also 26 seal sightings, of which 10 encounters were ‘definite’ grey seals and four encounters were ‘definite’ common seals (Figure 5).

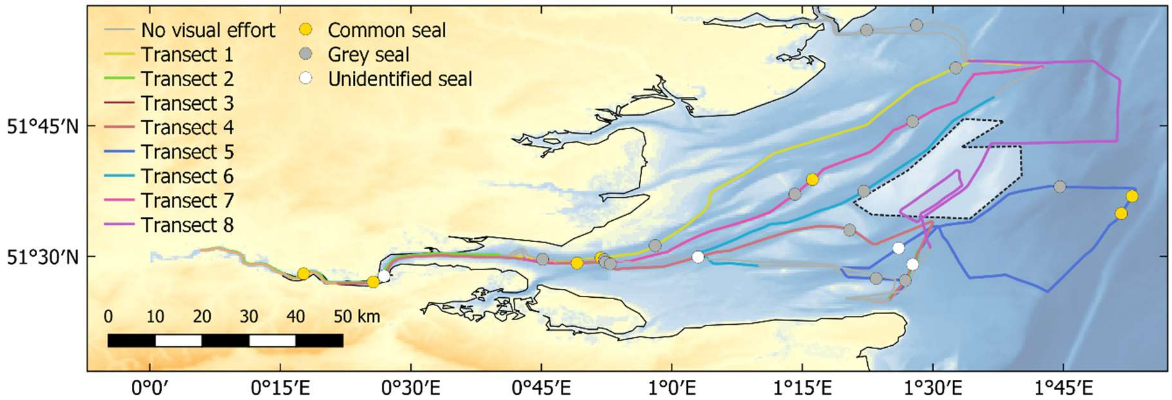

Figure 5. Summary of all sightings of seals made during the 2022 survey. The location of the London Array offshore wind farm is shown as a pale polygon.

Encounter rates

The acoustic encounter rate for the survey was 5.57 porpoise groups/100 km surveyed (variance = 1.80). The variance inflation factor ($\hat{b}$) was above unity (2.04), suggesting there was some clustering in the detections, with porpoise presence being highest in the outer Thames Estuary (Figure 6). The encounter rate in 2022 was lower than for the 2015 survey (mean = 8.13 porpoise groups/100 km; variance = 4.23). The variance inflation factor ($\hat{b}$) was higher in 2015 (3.58), suggesting there was more clustering (Figure 7), with porpoises only being seen or detected east of 01°00’E. For the 2022 survey, there was a greater longitudinal dispersion of porpoises, with the most westerly detection being 00°27’E. Encounter rates are compared between the two surveys in Table 2.

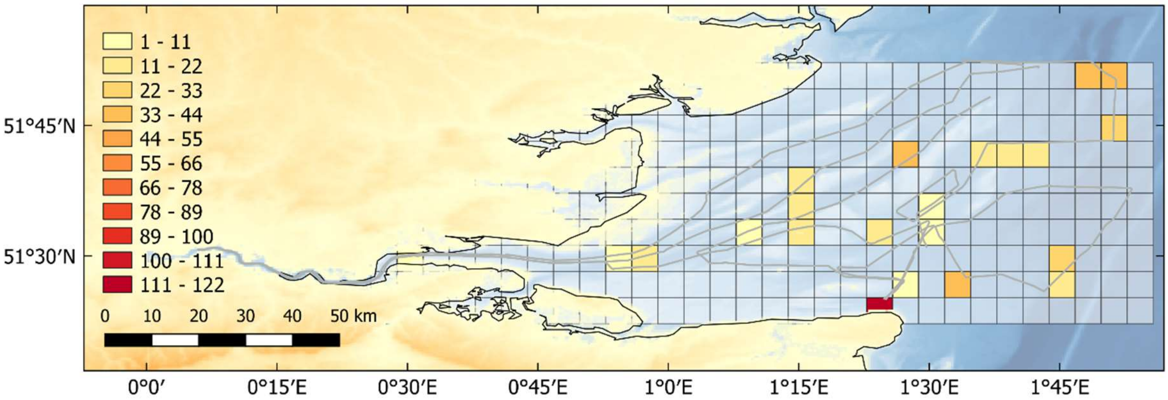

Figure 6. Relative acoustic encounter rates (unique detections per 100 km from the towed array only) for 2022 presented in a 0.05° grid. The vessel's track is marked as a grey line.

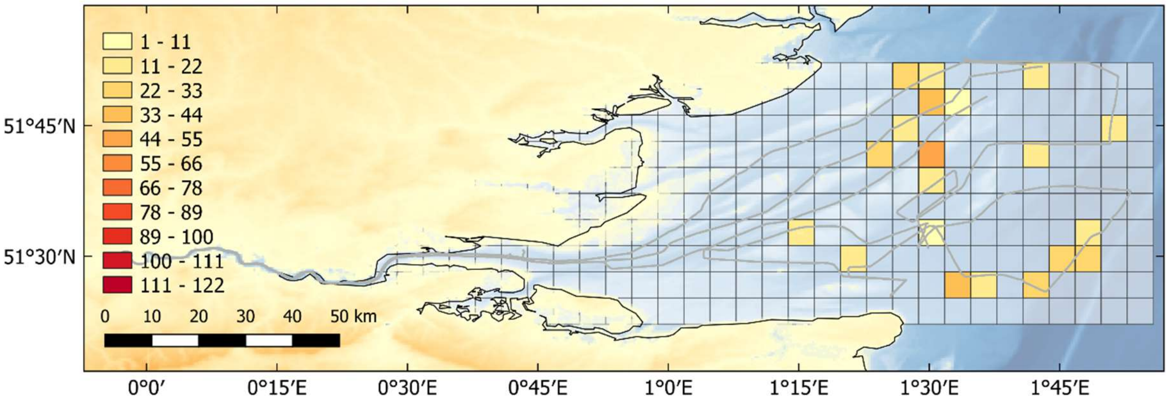

Figure 7. Relative acoustic encounter rates (unique detections per 100 km from the towed array only) for 2015 presented in a 0.05° grid. The vessel's track is marked as a grey line.

Table 2. Summary of acoustic detections and encounter rates (groups per 100 km) for each transect surveyed in 2015 and 2022 (using the towed array data only). Transect 3 was not surveyed in 2022 and is not included in either the 2015 or the 2022 estimates of encounter rate, variance or variance inflation factor.

	2015			2022		
Transect	Detections	Effort	Enc. rate	Detections	Effort	Enc. rate
1	4	89	4.47	0	85	0.00
2	7	68	10.34	2	49	4.06
3	0	44	0.00	-	-	-
4	1	134	0.75	6	106	5.68
5	19	113	16.79	7	113	6.22
6	8	87	9.19	5	85	5.90
7	8	90	8.86	3	86	3.48
8	9	107	8.41	12	105	11.44
Off-transect	12	322	3.72	5	240	2.09
Total (on-transect)	56	689	8.13	35	629	5.57
Enc. rate variance			4.23			1.80
Var. inflation factor			3.58			2.04

Discussion

This study confirms the Thames Estuary is an important habitat with significant densities of porpoises present in the area over multiple years.

The acoustic encounter rates from the Thames surveys, of 5.6 harbour porpoise detections/100 km recorded in April 2022 and 8.13 porpoise groups/100 km in March 2015 are noteworthy, particularly when compared to studies of two Special Areas of Conservation (SAC) in Ireland reporting 4 detections/100 km and 2 detections/100 km (Rockabill to Dalkey Island SAC and Roaringwater Bay SAC respectively) (Berrow and O'Brian, 2013), and an acoustic/visual survey in the German and Dutch Dogger Bank zones reporting an encounter rate of 4.8 animals/100 km surveyed (Gilles *et al.*, 2011). These sites are designated as protected areas with porpoises as a qualifying feature. Acoustic encounter rates from a winter survey (November) over and around the Dogger Bank in the southern North Sea showed higher acoustic encounter rates than those recorded in the Thames Estuary, between 8.1 and 17.8 animals / 100 km surveyed (Cucknell *et al.*, 2016b). These high acoustic detection rates may be a reflection their seasonal migrations into offshore waters in winter months, however more seasonal research effort is needed.

The overall number of detections and mean encounter rate were lower in 2022, than 2015, however there is not enough evidence that this represents a significant decrease in numbers. During the 2022 survey, the highest encounter rates were recorded in the outer Estuary (i.e. east of 01°20'), which was further west than in 2015. However, as survey effort was relatively low for both surveys, this shouldn't be taken as evidence of a westwards shift in distribution.

Repeated studies of the same region using matching protocols are extremely rare (e.g. Hammond *et al.*, 2013) and therefore these surveys, provide an extremely useful comparisons (although it is noted that the length of the tow-cable for the towed array varied slightly between surveys due to logistical considerations). The effective detection range of the array was uniform in 2022, whereas it was more variable in 2015 which could have caused variable detection rates in 2015. For example, when the tow cable was 10 m long in 2015, the array would have been closer to the vessel' propeller, for example, which would have increased background noise levels. This could be problematic, as the detection of porpoise clicks involves comparing the frequency band of interest for porpoises (115-160 kHz) with lower frequency bands, and any increase of noise in that lower band could reduce the likelihood of detection. However, the proportional increase in noise when reducing the array from 100 m to 10 m would largely effect only the lowest frequency bands (<2 kHz) which were not used by the click detection module in Pamguard for porpoise detections. Therefore, given the paucity of data available, comparing the outputs from the towed arrays between years is justified, even if not completely equivalent.

The hull-mounted array was previously used for the estimation of acoustic encounter rates in 2015 (Cucknell *et al.*, 2020). This type of array has a greatly reduced range when compared to a traditional towed array. Likewise, in 2022, the same hull-mounted array did not perform as well as the towed array. Of all 31 acoustic detections made with the towed array, only 18 were also detected using the hull-mounted array. Despite these limitations, this study provides additional evidence of the efficacy of a hull-mounted hydrophone array if required for confined waters.

Of the 31 encounters logged when there was consecutive acoustic and visual effort, nine were seen but not detected. All of these sightings were of animals within 100 m of the survey vessel (range 38-97 m; mean = 70 m) and were thus certainly within the typical detection range of the hydrophone elements. As harbour porpoises are known to be silent for periods of time (Linnenschmidt *et al.*, 2013), these 'missed' acoustic detections may relate to these silent periods. However, it is perhaps more likely that as porpoise clicks are highly directional (Wisniewska *et al.*, 2015), a proportion of clicks and buzzes may not have been detected by the hydrophone elements at those times when individuals were orientated away from the research vessel.

Due to harbour porpoise's small size, living in cold temperate water gives rise to a high relative heat loss and limits the amount of energy it can store with respect to its metabolic rate (Kastelein *et al.*, 1997). Harbour porpoises are therefore hypothesized to feed at high rates year-round, capturing up to 10% of their body weight in fish per day to support their metabolic requirements (Kastelein *et al.*, 1997; Wisniewska *et al*. 2016). Estuaries are essential fish nursery areas, and between March and July fish such as seabass and flounder come into estuaries to spawn every year. It seems likely that this is one of the reasons harbour porpoises are found in high numbers in the Thames. Stalder *et al*. (2020) found areas where saltwater and freshwater interact demonstrated higher foraging activity by harbour porpoise. Furthermore, there is some indication that porpoises come into more protected coastal waters, such as bays and estuaries, to calve. Using this rationale, it seems likely that the relatively high encounter rate observed in the Thames could be indicative of the importance of UK estuaries for harbour porpoises in general.

Approximately every decade, since 1994, large scale surveys are undertaken in August to assess cetacean density and abundance around the coast of the UK (Hammond *et al*., 2017). Although these surveys are essential to understand long term UK-wide fluctuations in cetacean density and distribution, they have many limitations. Due to the large size of the survey area, inshore coastal regions and estuaries are not surveyed in a high enough resolution to understand important porpoise habitat in these regions, and variations in seasonality cannot be picked up. As such, more regular, localised survey effort is needed in coastal regions and estuaries, including the Thames, across different times of year, to provide more fine scale detail on the presence and distribution of coastal species such as the harbour porpoise.

Harbour porpoise are considered a sentinel species i.e. animals which indicate the health of an ecosystem and point to potential risks. Over the last decade, there has been significant development within the Thames Estuary, including construction for the new Tideway Tunnel, offshore windfarms and the London Gateway "super port", in addition to increased levels of shipping. Harbour porpoises are threatened throughout their range by incidental bycatch in fishing gear (Donovan and Bjørge, 1995), disturbance from anthropogenic noise from shipping (Hermannsen *et al.*, 2014; Dyndo *et al.*, 2015) and pile-driving during construction, including for wind farms (Dähne *et al.*, 2013; Brandt *et al.*, 2011; Tougaard *et al.*, 2009). The continued rapid development in the Thames may be a cause for concern, given the declines in densities of harbour porpoise documented in other Southern North Sea studies, possibly in relation to anthropogenic pressures (Nachtsheim *et al*., 2021). It is hoped that by confirming significant densities of porpoises are present in the Thames over multiple years, this study will help inform future actions required to ensure the conservation of this cryptic British marine mammal and its coastal habitat.

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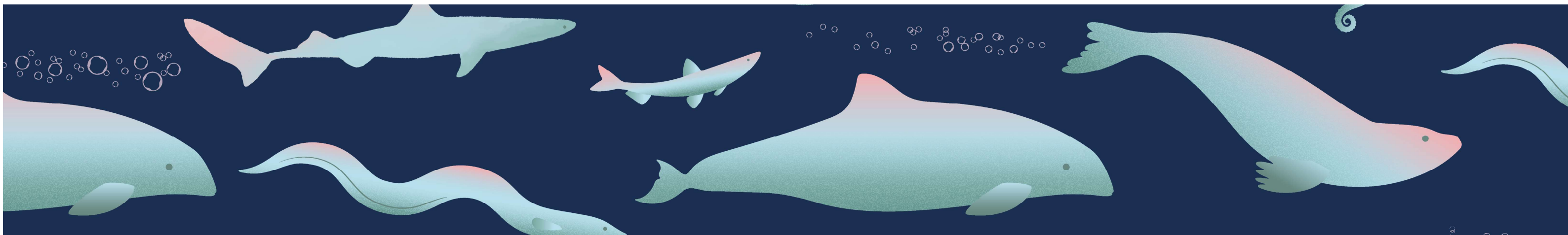

permissions. The survey team included Anna Cucknell (ZSL), Alison Debney (ZSL), Celine Gamble (ZSL), Edd Hewitt (MCR), Jonny Reid (MCR), Lucy Green (ZSL), Oliver Boisseau (MCR) and Richard McLanaghan (MCR).

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