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National Parks and Wildlife Service

Otter Survey of Ireland 2023-24

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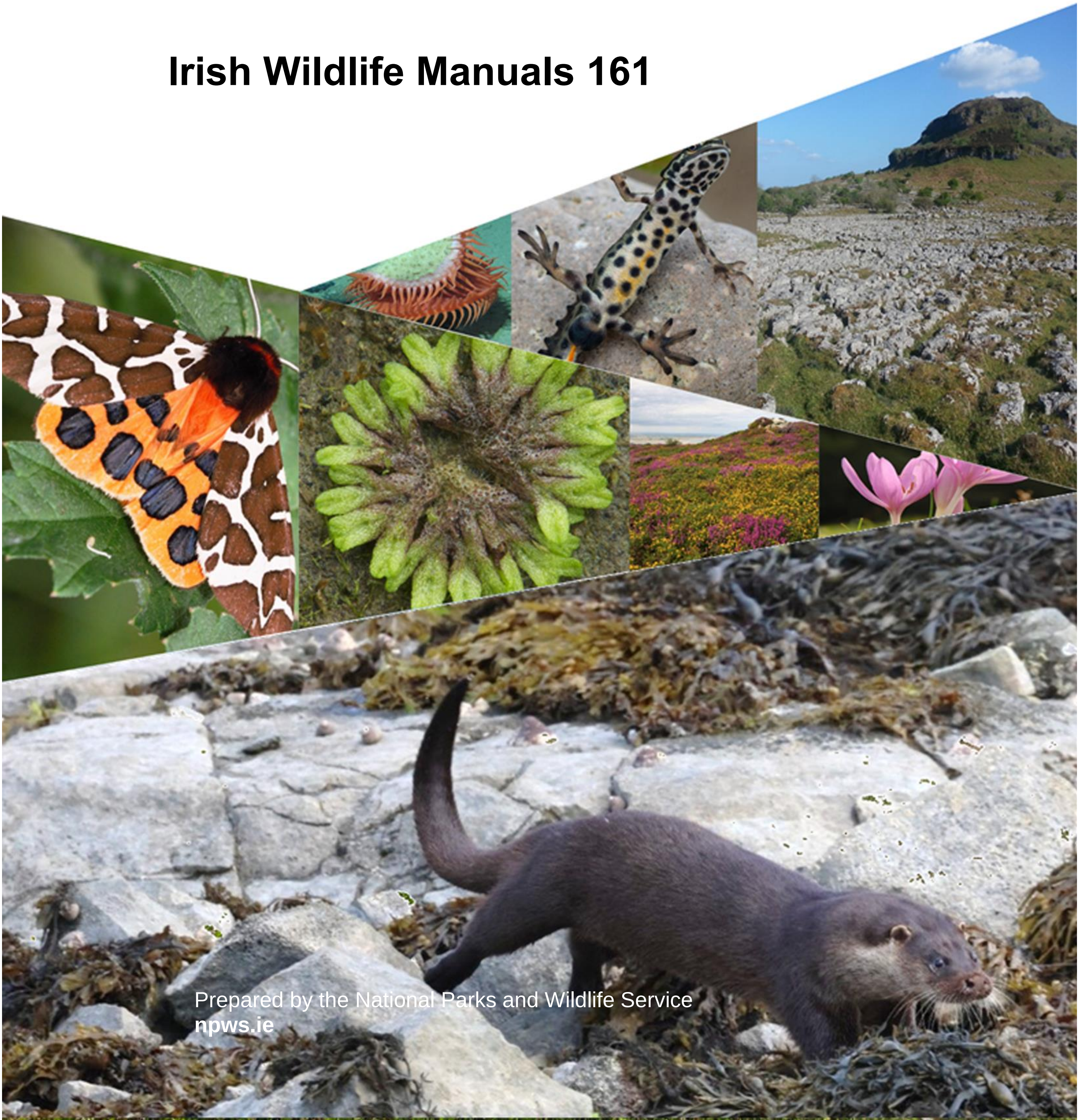

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Front cover, from left to right and top to bottom:

A deep water fly trap anemone *Phelliactis* sp., Yvonne Leahy; **Common Newt** *Lissotriton vulgaris,* Brian Nelson; **Limestone pavement**, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Garden Tiger** *Arctia caja,* Brian Nelson; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson; **Coastal heath**, Howth Head, Co. Dublin, Maurice Eakin; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott

Bottom photograph: **Eurasian Otter** *Lutra lutra*, Katie Grice

Otter Survey of Ireland 2023-24

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Contents

Executive Summary

It is a statutory responsibility of government to report regularly on the conservation status of designated species, such as the Eurasian Otter (*Lutra lutra*). Otter surveys were conducted throughout the Republic of Ireland (ROI) and Northern Ireland (NI) during 2023/24. The change in the status of otters throughout Ireland was assessed over the 40-year period from the 1980s to 2020s using data from four national surveys (n = 6,060 sites) plus species records from data repositories and citizen science appeals (n = 10,980 records).

During 2023-24, a total of 1,063 sites were surveyed with otters present at 65% [95%CI 62 - 68%] of sites in ROI and 66% [58 - 74%] of sites in NI. The otter remains widespread throughout Ireland yet site occupancy has likely declined since the 1980s. Most change appears to have occurred between the early 1990s and mid-2000s.

The Standard Otter Survey method is subject to various methodological biases including variation in detection between surveyors and survey teams and negative impact of flooding due to rainfall prior to surveys which washes away tracks and signs. Estimates of the otter population size (numbers of adult females) in ROI declined over the long-term since the 1980s (somewhere between the naive estimate, as observed in the field, of -27% and the estimate corrected for potential negative biases of -7% and more likely closer to the latter) yet showed no change since the last survey in 2010-11. In contrast, estimates of otter population size in NI declined similarly over the long-term (somewhere between the naive estimate of -24% and the corrected estimate of -18%, again more likely closer to the later) and also over the short-term (somewhere between the naive estimate of -27% and the corrected estimate of -26%). The divergence in trends between ROI and NI since the last survey seems likely accounted for by the combination of the experience, skill and expertise of the surveyor during the previous survey and an apparent significant decline in the Neagh-Bann River Basin District during the current survey coincident with a Harmful Algal Bloom in Lough Neagh.

Otter population density varied spatially being highest in the south and north-west, and, lowest in the more human-modified east and less suitable central peatlands. Nevertheless, otters remain ubiquitous throughout Ireland having been recorded in 95% of hectads (10 km squares) with no change in distribution or range since the 1980s.

Otters were more common at flowing freshwaters than at lakes or the coast and were associated with large, fast flowing rivers, rocky substrates, unmaintained (wild) river banks, riparian woodland (trees and shrubs) and areas with evidence of angling (likely reflecting salmonid prey availability) but negatively associated with peatlands.

Eleven candidate pressures were identified with otters negatively associated with disturbance, notably canalisation or resectioning. Siltation, pollution both agricultural and domestic, and water abstraction increased in prevalence since the 1980s being more widespread now than ever. While individual pressures were local in extent, and none was judged an existential threat to otters at the national scale, it seems likely the combination of pressures on water quality and freshwater and coastal ecosystems is implicated in population decline.

Ireland remains a stronghold for the otter despite an apparent decline since the 1980s with widespread suitable habitat despite apparent increases in pressures related to water quality.

Future work should focus on disaggregating detection from occupancy probability to account for negative methodological biases to more accurately capture the magnitude of any change, while future surveys should consider survey techniques less vulnerable to such biases *e.g*. environmental DNA detection in water samples.

Acknowledgements

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1 Introduction

Freshwater taxa show the steepest decline in the Living Planet Index, with aquatic animal populations declining by 81% from 1970 to 2020 (WWF, 2024). Key threats to freshwater ecosystems include water quality degradation from eutrophication due to agricultural runoff and wastewater discharge, siltation from soil erosion, pollution from agricultural, industrial, and domestic sources, overexploitation, invasive species, disease, and climate change (*e.g*. Albert *et al*., 2021; Dudgeon *et al.,* 2006; Heino *et al*., 2009; Strayer, 2010; Reid *et al*., 2019). Mammals are especially vulnerable, with 83% of wild mammalian biomass lost since the rise of humans (Greenspoon *et al*., 2023). Currently, 56% of mammal species are in decline (Finn *et al*., 2023), and up to 16% of their suitable habitat may be lost globally by 2050 (Baisero *et al*., 2020).

The Eurasian Otter (*Lutra lutra*), a semi-aquatic mustelid native to Europe and Asia, is IUCN-listed as Near Threatened, with a decreasing population trend (Loy *et al*., 2022). It inhabits rivers, streams, lakes, ponds, and coastal areas with freshwater access for grooming. Riparian vegetation provides cover and den sites, while rocky substrates offer hunting opportunities. Its diet is mainly fish but includes amphibians, crustaceans, bivalves, and terrestrial prey, reflecting an opportunistic feeding strategy (Reid *et al*., 2013a). Water pollution limits otter distribution (Prigioni *et al*., 2007), with their range influenced by prey availability and human-induced water quality degradation (Quiñónez *et al*., 2018).

Historically hunted (Schwenk, 1986), current pressures on otters include habitat loss and degradation due to development, urbanisation and river modification (Hui & Chan, 2023), and declining water quality. Pollutants like organochlorine insecticides and polychlorinated biphenyls (PCBs) bioaccumulate in otter tissue, causing population declines and sublethal effects on physiology and reproduction, often persisting in the environment for decades (Smit *et al*., 1998; Kean *et al*., 2021). Agricultural runoff, particularly siltation from poor tillage practices, reduces water clarity, increases Biological Oxygen Demand, and smothers substrates, degrading aquatic ecosystems and reducing prey availability (Rankinen *et al*., 2015; Skaalsveen *et al*., 2019; Johannsen & Armitage, 2010). Naturalised non-native American mink (*Neogale vison*), originally escaped from fur farms, are thought to negatively impact otters through competition, with their decline in recent decades potentially beneficial to otter in Great Britain (McDonald *et al*, 2007).

Otter populations across Europe have contracted due to multiple pressures. In Sweden, PCB-related declines occurred between the 1950s and 1980s, causing a genetic bottleneck in southern populations (Roos *et al*., 2001; Tison *et al*., 2015). In Italy, the species nearly vanished from central and northern regions by the late 20th century (Prigioni *et al*., 2007). In France, local extirpations left only two strongholds before recovery (Geboes *et al*., 2016). In Great Britain, hunting drove early declines in the 18th and 19th centuries, followed by population collapse from the 1950s due to pollution. Recovery began after the late 1970s (Jefferies, 1989), with full recolonisation of England by 2010 (Alastair Driver, Environment Agency *pers. comms.*).

Listed under the EU Habitats Directive (Council Directive 92/43/EEC), the otter is protected under Annex II (requiring Special Areas of Conservation) and Annex IV (strict protection). Article 17 mandates conservation status reporting on a six-year cycle. Post-Brexit, the UK adopted statutory monitoring responsibilities under the Habitats Regulations Reporting (HRR) framework. The Standard Otter Survey method involves searching 600 m of riverbank, lake, or coastline for tracks and signs (Lenton, 1980), with changes in occurrence indicating population trends (Mason & MacDonald, 1987). The first Otter Survey of Ireland (1980-81) reported the species at 92% of 2,177 sites (Chapman & Chapman, 1982). In the Republic of Ireland (ROI), incidence remained high at 90% of 268 sites in 1990-91 (Lunnon & Reynolds, 1992) but declined to 70% of 525 sites by 2004-05 (Bailey & Rochford, 2006), with an estimated population of 6,400 breeding females (95% CI 4,500 - 9,700; Marnell *et al*., 2011).

In Northern Ireland (NI), incidence fell to 78% in 2001-02 (Preston *et al*., 2006) but rebounded to 89% in 2010 (Preston & Reid, 2011) yet incidence declined further in ROI to 63% of 852 sites surveyed in 2010-11 (Reid *et al*., 2013b). Analyses suggested survey biases may have accounted for much of this apparent decline (Reid *et al*., 2013c). Despite this, the otter remained widespread in Ireland and was recolonising Great Britain during the last conservation assessment in 2019 and was judged in Favourable Conservation Status in both Ireland and the UK (NPWS, 2019; JNCC, 2019).

This study aimed to reassess the conservation status of the otter throughout the island of Ireland. The specific objectives included: 1) surveying tracks and signs to assess current occupancy rates to compare with previous surveys; 2) running a citizen science campaign for public records; 3) assessing changes in distribution and range; 4) estimating population trends; 5) analysing ecological and habitat associations; 6) evaluating pressures and threats; and 7) identifying candidate conservation measures. Findings informed the 2025 EU Habitats Directive Article 17 assessment in ROI and Habitats Regulations Reporting that contributed to the overall assessment of the species in the UK.

2 Methods

2.1 Funding

The National Otter Survey of Ireland 2023-24 was commissioned and funded by the National Parks and Wildlife Service (NPWS), Department of Housing, Local Government and Heritage (DHLGH), Republic of Ireland, while the Northern Ireland Otter Survey 2024 was commissioned and funded by the Northern Ireland Environment Agency (NIEA), Department of Agriculture, Environment and Rural Affairs (DAERA), Northern Ireland. Both contracts were delivered by Queen's University Belfast and both NPWS and NIEA agreed to share data reciprocally, enabling a biogeographically relevant analysis of the otter population across Ireland and providing context within- and between- regions over time.

2.2 Otter Survey of Ireland 2023-24

The Standard Otter Survey method was used to assess species occurrence along 600 m of riverbank, lake, or coast, searching for spraint (territorial scats) on boulders, rocks, or vegetation, and tracks in soft sediment. At rivers, surveys began at a bridge when available (known as the Spot-check method; Chanin & Smith, 2003), as otters preferentially mark concrete footings and prominent boulders under bridge arches where spraint is sheltered from weathering. Surveyors stopped upon detecting otter signs; otherwise, they completed the full 600 m transect. A total of 111 surveyors covered the ROI and seven covered NI. They received standardised training through written materials, video tutorials and field demonstrations. Surveys were avoided for two weeks after heavy rainfall affecting water levels (monitored in real-time using the Environmental Protection Agency surface water levels online portal https://epawebapp.epa.ie/hydronet/#Water%20Levels and Department of Infrastructure hydrometric water levels online viewer https://www.hydrometcloud.de/Rivers_Agency/index.jsp?menu=index) to minimise negative bias.

2.3 Previous surveys

Data from previous surveys (Chapman & Chapman, 1982; Preston *et al*., 2006; Bailey & Rochford, 2006; Preston & Reid, 2011; Reid *et al*., 2013b) were obtained with permission from NPWS (ROI) and NIEA (NI). However, original data sheets and electronic copies of Lunnon & Reynolds (1992), which covered ROI only, were unavailable and excluded from reanalysis (though their overall reported occupancy rate is cited for context). Datasets were standardised by aligning (stacking) variables and recoding to a common format, with minor category amalgamations where necessary. Chapman & Chapman (1982) revisited some otter-negative sites for a second survey, inflating site occupancy compared to later surveys, where each site was visited only once. To ensure comparability, all second visits from the 1980s dataset were removed. Thus, otter occupancy rates reported here for the 1980s vary slightly from those reported originally by Chapman & Chapman (1982).

2.4 Spatial variation

ArcGIS Pro (ESRI, California, USA) mapped survey sites, assigning them to one of eight River Basin Districts (Eastern, Neagh-Bann, North Eastern, North Western, Shannon, South Eastern, South Western, Western) to capture spatial variation in otter occurrence. Sites were classified as either wider countryside sites (outside protected areas) or within 600 m (survey transect length) of a Special Area of Conservation (SAC) designated for otters, including 44 SACs in ROI (www.npws.ie/protected-sites/sac) and six in NI (www.daera-ni.gov.uk/articles/special-areas-conservation). Though SACs were designated in 1994, sites surveyed by Chapman & Chapman (1982) were retrospectively assigned to those later included in SACs.

2.5 Bias correction

The Standard Otter Survey method is subject to methodological negative biases (Reid *et al*., 2013c). Analysis of the last national otter survey, suggested otter detection varied substantially between survey teams, with a *c*. -16% difference between the best and the average surveyor. Rainfall in the preceding week lowered detection by *c*. -6%, while the absence of bridges (representing availability of suitable sprainting sites where spraints persist and are easily found) reduced detection by *c*. -5%. Taken together, all three sources accounted for a -30% bias in ROI and -5% bias in NI during the last survey suggesting true otter occurrence may be significantly higher than naive incidence suggests (Reid *et al*., 2013c). For comparability, otter incidence during 2023-24 was, therefore, corrected assuming the same magnitude of negative bias as quantified during the last national survey to provide an estimate of possible upper values.

2.6 Environmental data

The same variables and survey recording sheet used since the 1980s were digitised into a Survey123 Form (ESRI, California, USA) for smartphone-based georeferenced data collection. Habitat type was recorded as flowing freshwater (streams, rivers), static freshwater (lakes), or coastal (high tide mark). River width categories were <2, 2-5, 5-10, 10-20, 20-40, >40 m, depth categories were <0.5, 0.5-1, 1-2, >2 m, and current was recorded as static, sluggish, slow, fast, rapid. Substrate types (boulders, cobbles, gravel, sand, silt), bank/shore trees and shrubs, and surrounding habitats (grassland, arable, broad-leaved woodland, conifer plantation, peat/heathlands, urban, saltmarsh) were recorded as present or absent. Elevation was extracted from UK and Ireland Digital Elevation Models (https://diva-gis.org).

2.7 Pressures and threats

Surveyors recorded potential pressures on otter populations, including pollution from agriculture (*e.g*. visible runoff, siltation, agro-chemical barrels, dead livestock *etc*.), domestic waste (*e.g*. household dumping *etc*.) and industrial sources (*e.g*. factory discharge *etc*.). Water abstraction was identified by signs of water removal, such as slurry tankers at bridge access points with pipes left *in situ*. Boating included manual (rowing), wind (sail), and powered (motor) vessels of any size. Angling and coarse fishing (possibly with fish (re)stocking) were indicated by observing anglers, fishing pontoons, or proximity of fish farms. Surveyors were trained to identify non-native American mink tracks and signs which were recorded as present or absent. Surveyors recorded a subjective disturbance score for each site from 0 to 5 (0 = none, 5 = highest), based on the total pressures observed and their perceived intensity. During analysis, risks were mapped to EU Habitat Directive pressure and threat codes and linked to corresponding conservation measures (https://cdr.eionet.europa.eu/help/habitats_art17).

2.8 Species records

The National Biodiversity Data Centre (NBDC), Waterford, and the Centre for Environmental Data and Recording (CEDaR), Belfast, are the primary biodiversity repositories for ROI and NI, respectively. Both provided exports of all otter records in their databases. During 2023-24, NBDC hosted the National Otter Survey webpage (https://biodiversityireland.ie), and CEDaR hosted the Northern Ireland Otter Survey webpage (https://www2.habitas.org.uk), each with a data submission portal for public georeferenced sightings and photo uploads for validation. Press releases (one in ROI, one in NI) generated local print, radio, and TV coverage, encouraging public participation. All records were validated from images, videos, or camera trap footage. False positives were recorded as a percentage of validated records. All otter-positive records from the survey in 2023-24 were added to the sources above to create a master otter database containing all species records available.

2.9 Population estimation

Ó Néill (2008) and Marnell *et al*., (2011) outlined a method for estimating otter population size, focusing on adult females due to their stable home ranges (Kruuk, 1995, 2006). The model incorporates aquatic habitat, river width, landscape productivity and geology. The total length of streams, rivers, lake edges and coastline was calculated using ArcGIS Pro with line shapefiles from Ordnance Survey NI (OSNI) and Ordnance Survey Ireland (OSI). NI rivers were classified by width (<2, 2-5, 5-10, 10-20, 20-40, >40 m), while ROI rivers were grouped into streams (4.2 m average) and rivers (12.9 m average) due to dataset resolution. Since otters rarely forage >80 m from the bank (Kruuk & Moorhouse, 1991), rivers >80 m wide were treated as two banks, while lakes and coasts were mapped at 80 m resolution, merging habitats <80 m apart to reflect shared foraging areas. Streams, rivers, and lakes were classified by trophic status, based on phosphate levels: low (0.00-0.02 mg/L), intermediate (0.02-0.04 mg/L), and high (>0.04 mg/L). Phosphate data were obtained from the Environmental Protection Agency, ROI (https://gis.epa.ie/EPAMaps) and Water Management Unit, NIEA (https://gis.daera-ni.gov.uk/arcgis/apps/webappviewer/index.html?id=7e234827aa7a405d990359aa92c7c287).Spatial interpolation of georeferenced values using Kriging in ArcGIS Pro generated a landscape productivity heatmap (following Reid *et al*., 2013b). Ó Néill (2008) estimated average otter densities using data from: Green *et al*., 1984; Kruuk, 1995; Kruuk *et al*., 1993; Durbin, 1996; Kruuk, 2006; Ó Néill, 2008, and Yoxon 1999. Coastal densities were classified by geology, based on the All-Ireland Bedrock Map from the Geological Survey of Ireland (https://www.gsi.ie/en-ie/data-and-maps/Pages/Bedrock.aspx). Assumed densities for population estimation are listed in Appendix 1, with spatial variation in habitat and productivity in Appendix 2. A multiplicative model estimated adult female density (per km²) within River Basin Districts, using otter percentage occurrence summed within River Basin Districts to generate absolute abundances (for details see Ó Néill, 2008 and Marnell *et al*., 2011). To account for potential negative bias, a second population estimate was produced assuming the values for corrected species incidence (see Section 2.5 Bias correction above) to provide an estimate of possible upper values.

2.10 Statistical analysis

Descriptive statistics (percentage occurrence ± 95% Confidence Intervals, percentage change) captured patterns in otter incidence across countries, habitats, site designation, and River Basin Districts. Chi-squared tests assessed changes in percentage occurrence between pre-designation and the current survey (1980s vs. 2020s) and the last and current survey (2010s vs. 2020s). Spatial analyses mapped and enumerated species records, occupied monads (1 km²), and hectads (10 km²) within EU Habitats Directive Article 17 reporting periods: 1905-1994 (first species record to pre-designation *i.e*. the first assessment), 1994-2006 (second assessment), 2007-2012 (third), 2013-2018 (fourth), 2019-2024 (fifth and current assessment) and 1905-2024 (all records to date). Otter occurrence (0/1) was spatially interpolated within each assessment period as a proxy for population density, using Kriging with 12 neighbouring points and a Gaussian distribution. Logistic regressions tested the effects of country, habitat type, designation, and pressures/threats on otter occurrence. Each variable was fitted in a separate model within each habitat, as well as within countries. Significant effects were visualised using Sigmaplot 15.

3 Results

3.1 Otter Survey 2023-24 and change over time

Between June 2023 and October 2024, a total of 1,063 sites were surveyed across Ireland: 886 flowing freshwater, 40 static freshwater, and 137 coastal. A total of 690 otter records were generated (595 in ROI, 95 in NI). Otter occurrence did not differ between ROI (65% [95% CI: 62–68%], n=919) and NI (66% [58–74%], n=144) ($Wald_{df=1}$ = 0.082, p=0.774; Table 1). Otters were widespread with no clear spatial pattern (Fig. 1).

Otter occurrence varied significantly between habitats ($Wald_{df=2}$ = 8.370, p=0.015), with the highest incidence in flowing freshwater (67%), followed by static freshwater (63%), and coastal sites (54%; Table 1, Fig. 2a). In NI, otter occurrence was +38% higher in SACs (84% occurrence) than in the wider countryside (61% occurrence; $Wald_{df=1}$ = 5.212, p=0.022), but in ROI, there was little difference between SACs (68%) and the wider countryside (63%; $Wald_{df=1}$ = 2.298, p=0.130; Fig. 2b, Appendix 3).

Otter occurrence varied spatially between River Basin Districts ($Wald_{df=7}$ = 22.315, p=0.002), showing similar trends in ROI and NI (Fig. 2c; Appendix 4). Highest occurrence was in the South Western district in ROI (77%, mainly County Cork) and the North Western district in NI (74%, mainly Tyrone and Fermanagh), while the lowest was in Neagh-Bann (55%), Eastern (56%), and Shannon (59%) districts (Fig. 2d, Appendix 4). Harmful Algal Blooms in Lough Neagh coincided with the otter survey (Reid & Emmerson 2023; Reid et al. 2024) with the probability of otter detection within the Neagh-Bann district significantly lower in close proximity (within ~13km) of the lake itself ($Wald_{df=1}$ = 7.053, p=0.008, pseudo-R^2=0.334; Appendix 5).

In ROI, otter occurrence declined from 91% in the 1980s to 63% in the 2010s, yet remained stable since with 65% occurrence in the 2020s (Table 1). In NI, otter occurrence fell from 83% in the 1980s to 68% in the 2000s, increased to 88% in the 2010s, then declined to 66% in the 2020s. These values suggested a long-term decline of -28% (-29% in ROI and -20% in NI) between the 1980s and 2020s and a short-term decline of -8% (+3 in ROI and -25% in NI) between the 2010s and 2020s (Table 1; Fig. 3). In both countries, trends in otter occurrence where largely consistent across habitats (Fig. 3b-d) and River Basin Districts (Appendix 6).

Declines were similar in SACs and wider countryside sites (*ca*. -28%). In ROI, declines were similar between SACs and wider countryside sites (*ca*. -30%) yet in NI, SACs declined by -16%, substantially less than the -27% decline at wider countryside sites (Appendix 3; Figs. 3e-g).

In summary, the survey suggested a modest decline in otter occurrence since the 1980s, with most of this decline occurring between the early 1990s (Lunnon and Reynolds 1992) and mid-2000s (Bailey and Rochford 2006), with stability in ROI but a decline in NI since the last survey in 2010-11. Otters were most common in flowing freshwater but remained widespread across all habitats. Occurrence was lowest in the east with higher human populations, central peatlands, and the Neagh-Bann River Basin District. Forty-four SACs in ROI had only marginally higher otter occurrence than the wider countryside with no protective effect of designation in offsetting decline, while six SACs in NI had higher otter occurrence, though they are concentrated in the west (Tyrone and Fermanagh) where otter occurrence was highest.

Table 1 Number of sites surveyed (*n*) and the percentage occurrence of otter tracks and signs [with the 95% Confidence Interval] within aquatic habitats throughout Ireland from the 1980s to 2020s (*this survey*). Percentage change (%Δ) in species occurrence over the long-term (1980s-2020s) and short-term (2010s-2020s) was assessed using chi-squared tests.

Region / Habitat	1980s (Chapman & Chapman 1981)		2000s (Bailey & Rochford, 2006; Preston et al. 2004)		2010s (Reid & Preston, 2010; Reid et al. 2013)		2020s (*this study*)		Δ1980s-2020s (long-term)			Δ2010s-2020s (short-term)		
	n	**% [95%CI]**	***n***	**% [95%CI]**	***n***	**% [95%CI]**	***n***	**% [95%CI]**	**%Δ**	$\chi^2_{df=1}$	***p***	**%Δ**	$\chi^2_{df=1}$	***p***
Ireland														
Flowing freshwater	1,856	91 [90 - 93]	1,012	68 [66 - 71]	995	72 [69 - 74]	886	67 [64 - 70]	-26	259.01	<0.001	-7	5.41	0.020
Static freshwater	364	89 [86 - 92]	162	78 [71 - 84]	59	76 [65 - 87]	40	63 [47 - 78]	-29	21.54	<0.001	-17	2.18	0.140
Coastal	286	83 [78 - 87]	92	57 [46 - 67]	171	65 [58 - 72]	137	54 [46 - 62]	-35	38.44	<0.001	-17	3.77	0.052
Total / average	**2,506**	**90 [89 - 91]**	**1,266**	**69 [66 - 71]**	**1,225**	**71 [68 - 73]**	**1,063**	**65 [62 - 68]**	**-28**	**322.37**	**<0.001**	**-8**	**9.53**	**0.002**
Republic of Ireland														
Flowing freshwater	1,573	92 [91 - 93]	461	71 [67 - 75]	694	65 [61 - 68]	775	66 [63 - 70]	-28	254.00	<0.001	+2	0.30	0.586
Static freshwater	324	89 [86 - 93]	27	67 [49 - 85]	24	54 [34 - 75]	22	73 [54 - 92]	-18	5.35	0.021	+35	1.70	0.193
Coastal	232	87 [82 - 91]	36	67 [51 - 82]	134	57 [48 - 65]	122	54 [45 - 63]	-38	45.67	<0.001	-5	0.18	0.674
Sub-total / average	**2,129**	**91 [90 - 92]**	**524**	**70 [67 - 74]**	**852**	**63 [60 - 67]**	**919**	**65 [62 - 68]**	**-29**	**317.46**	**<0.001**	**+3**	**0.42**	**0.516**
Northern Ireland														
Flowing freshwater	283	86 [82 - 90]	551	66 [62 - 70]	301	87 [84 - 91]	111	70 [62 - 79]	-19	13.58	<0.001	-20	16.64	<0.001
Static freshwater	40	88 [77 - 98]	135	80 [73 - 87]	35	91 [82 - 100]	18	50 [26 - 74]	-43	9.53	0.002	-45	11.65	<0.001
Coastal	54	65 [52 - 78]	56	50 [37 - 63]	37	95 [87 - 100]	15	53 [27 - 79]	-18	0.66	0.417	-44	12.70	<0.001
Sub-total / average	**377**	**83 [80 - 87]**	**742**	**68 [64 - 71]**	**373**	**88 [85 - 92]**	**144**	**66 [58 - 74]**	**-20**	**18.52**	**<0.001**	**-25**	**35.95**	**<0.001**

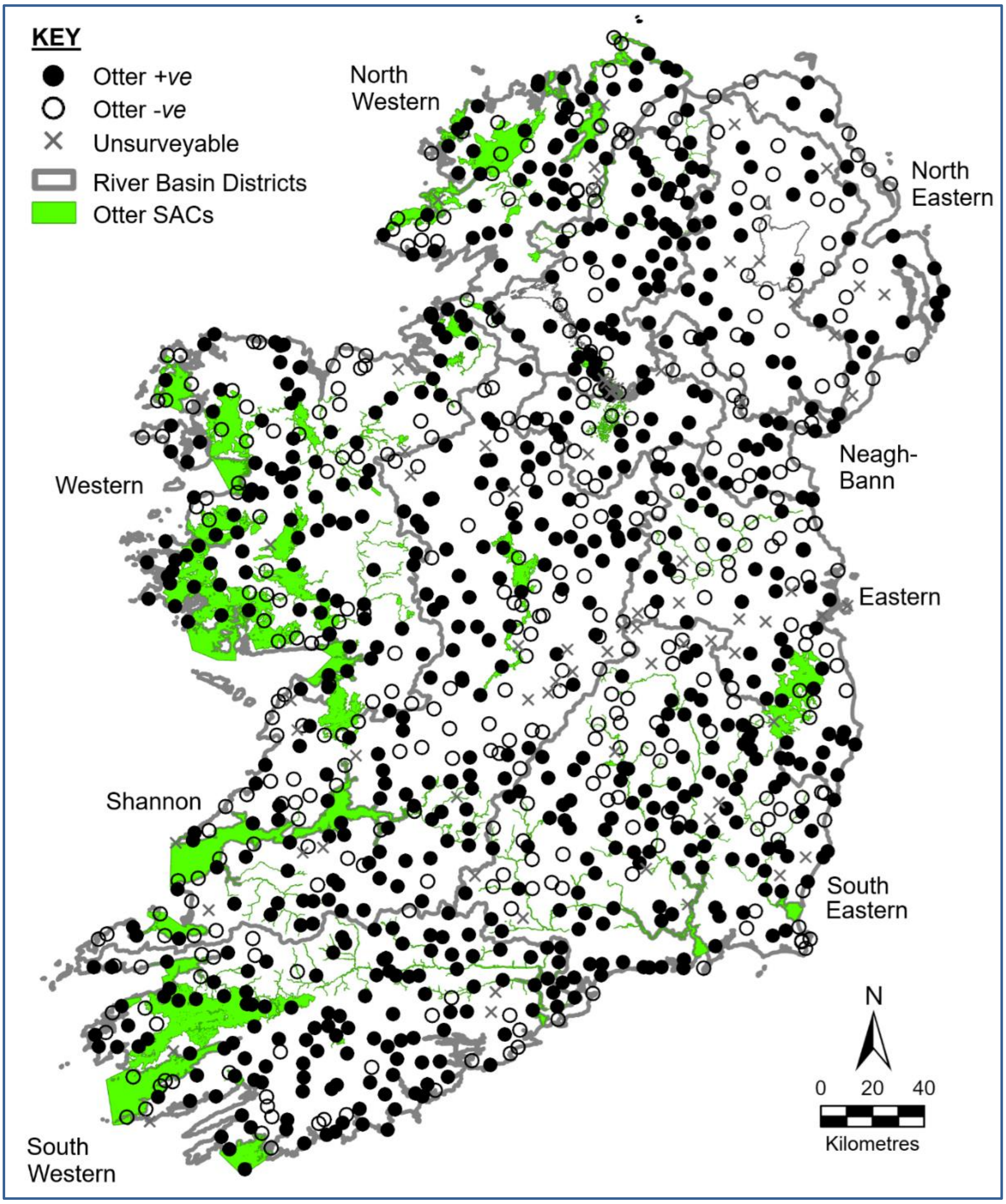

Figure 1 Sites surveyed for otter tracks and signs throughout Ireland (*n*=1,063) where the Republic of Ireland was surveyed from June 2023 to August 2024 (*n*=919) and Northern Ireland was surveyed from May to August 2024 (*n*=144). River Basin District outlines and Special Areas of Conservation (SACs) where the otter is a feature of interest are shown.

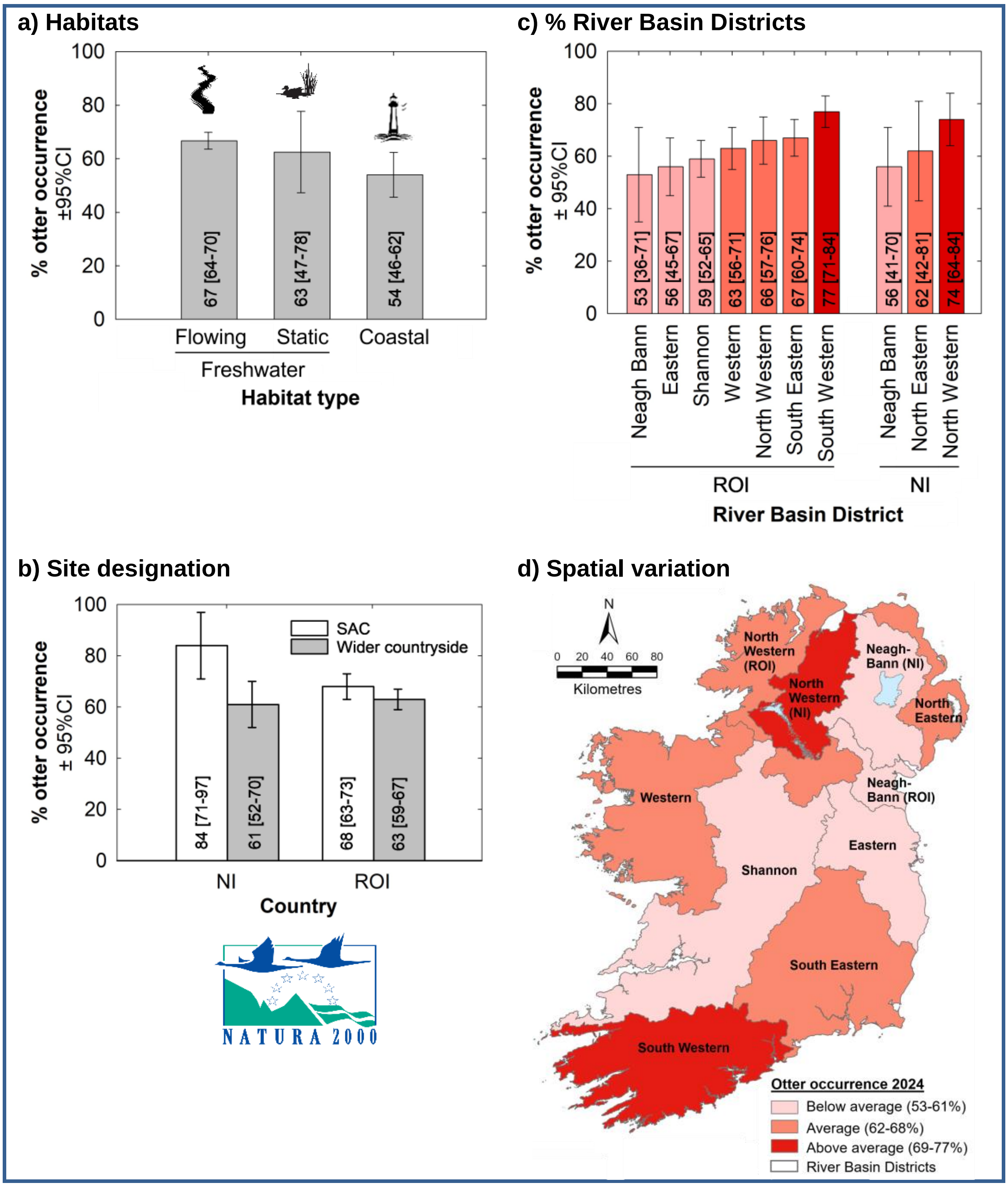

Figure 2 Mean percentage occurrence of otters at survey sites ± 95%CIs between **a)** habitat types, **b)** site designation status per country and **c)** River Basin Districts showing **d)** spatial variation in average occurrence.

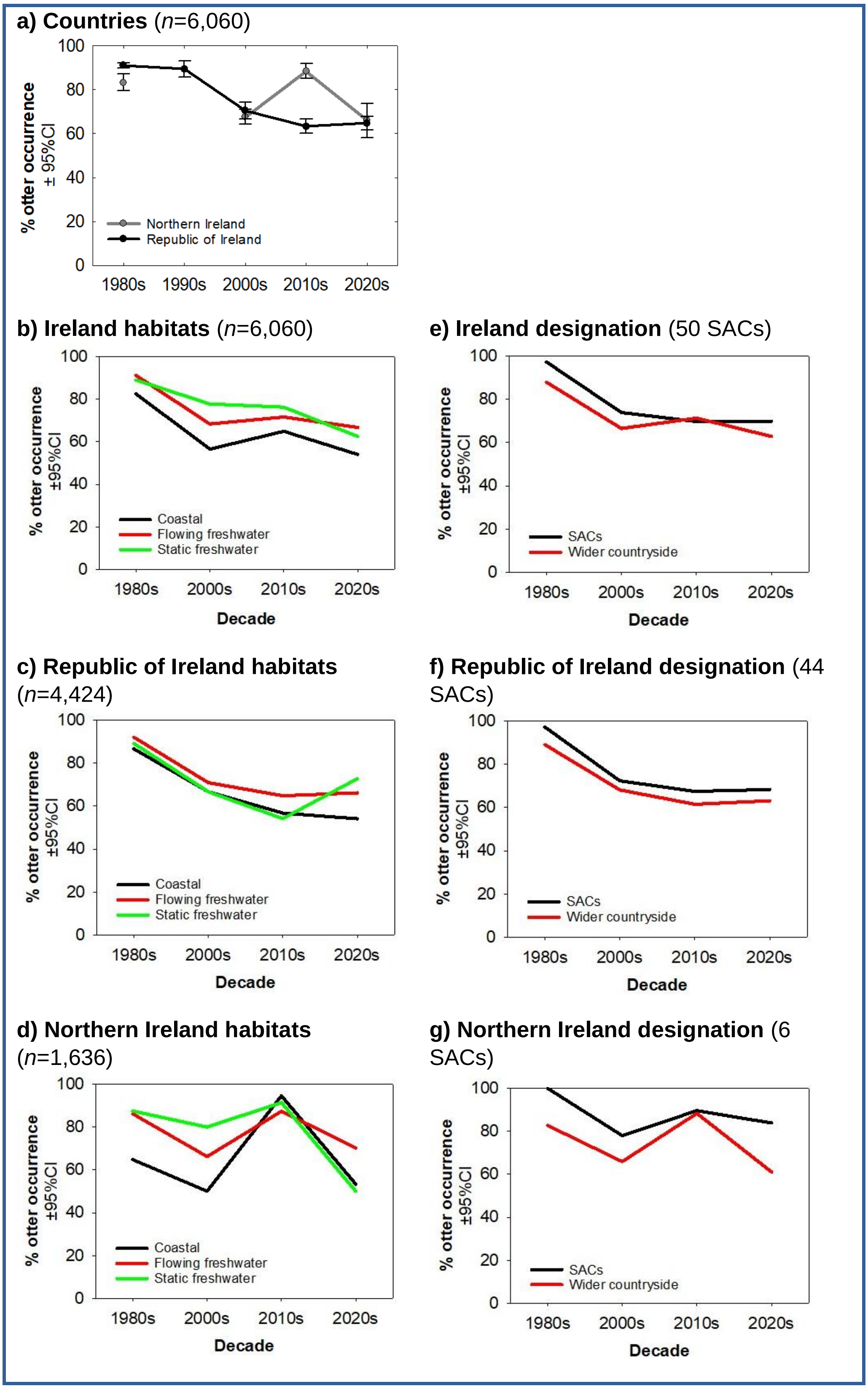

Figure 3 Percentage occurrence of otters in **a)** the Republic of Ireland (ROI) and Northern Ireland (NI) from the 1980s to the 2020s, **b)** throughout Ireland, **c)** ROI and **d)** NI split between habitats and **e-g)** the same split by site designation. Note: the national average figure for ROI taken from Lunnon & Reynolds (1993) is shown in a) but the absence of the raw data for re-analysis means it was excluded from all subsequent plots.

3.2 Range

The 2023-24 survey records (*n*=690) were added to existing databases. The National Biodiversity Data Centre (NBDC), Waterford held 7,035 otter records, mostly from ROI, while the Centre for Environmental Data and Recording (CEDaR), Belfast held 2,784 records, mostly from NI. NBDC also had 559 unvalidated records from the 2023-24 Citizen Science appeal, of which 191 included photographic evidence. After removing six duplicate images, 185 photographs remained, with 181 validated as otter: 77 photographs, 3 videos, 11 camera trap images, 1 sighting from NPWS staff, 22 carcasses (mostly roadkill), 62 spraints and 5 tracks. One image was identified as a stoat (*Mustela erminea*), while three were too poor in quality to confirm. This resulted in a 2% false positive rate (4/185). Among 348 records without photographic evidence, 13 duplicates (same date and grid reference) were removed, leaving 355 unique unvalidated records. Assuming a 2% false positive rate, only ~7 records were likely erroneous. Given the ubiquity of the otter, rejecting all 355 records to avoid ≤7 errors was deemed excessive, so all Citizen Science records were accepted and mapped. After merging all data sources and removing 104 duplicate entries, a master database of *n*=10,980 otter records (1905-2024) was created.

From 1905 to 2024, otter records occurred in 960 hectads (10km squares), covering 95% of the squares in Ireland (95% in ROI, 96% in NI; Table 2, Fig. 4a). Gaps were primarily coastal areas with little land or inaccessible sites. Given this widespread presence, the Favourable Reference Range should include all hectads with land (1,014 hectads throughout Ireland; 869 in ROI; 188 in NI; Table 2, Fig. 4a). There was no clear temporal trend in distribution or range, with 631 occupied hectads at designation and 684 in the current assessment period 2019-24) (Table 2). Fluctuations in record numbers and occupied monads likely reflected variation in survey effort, including National Otter Surveys and mammal atlases. Otters remain widespread and ubiquitous throughout ROI and NI (Fig. 4b–f).

Table 2 Counts of otter records and occupied hectads and monads during assessment periods. FRR = Favourable Reference Range. Distribution = occupied cells. First assessment was pre-designation.

				10km sqs (hectads)			1km sqs (monads)			Records		
				All Ireland	ROI	NI	All Ireland	ROI	NI	All Ireland	ROI	NI
FRR												
All 10km squares				1014	869	188						
Distribution	**Start**	**End**	**Yrs**									
All records	1905	2024	119	960	822	180	6649	5082	1608	10980	8017	8017
First assessment	1905	1993	88	631	521	129	2595	2146	451	2736	2189	2189
Second assessment	1994	2006	12	514	384	167	1310	614	719	1454	618	618
Third assessment	2007	2012	5	747	622	160	1947	1312	657	2936	2096	2096
Fourth assessment	2013	2018	5	605	502	134	1760	1415	359	2310	1807	1807
Fifth assessment	2019	2024	5	684	586	125	1257	1022	238	1520	1248	1248

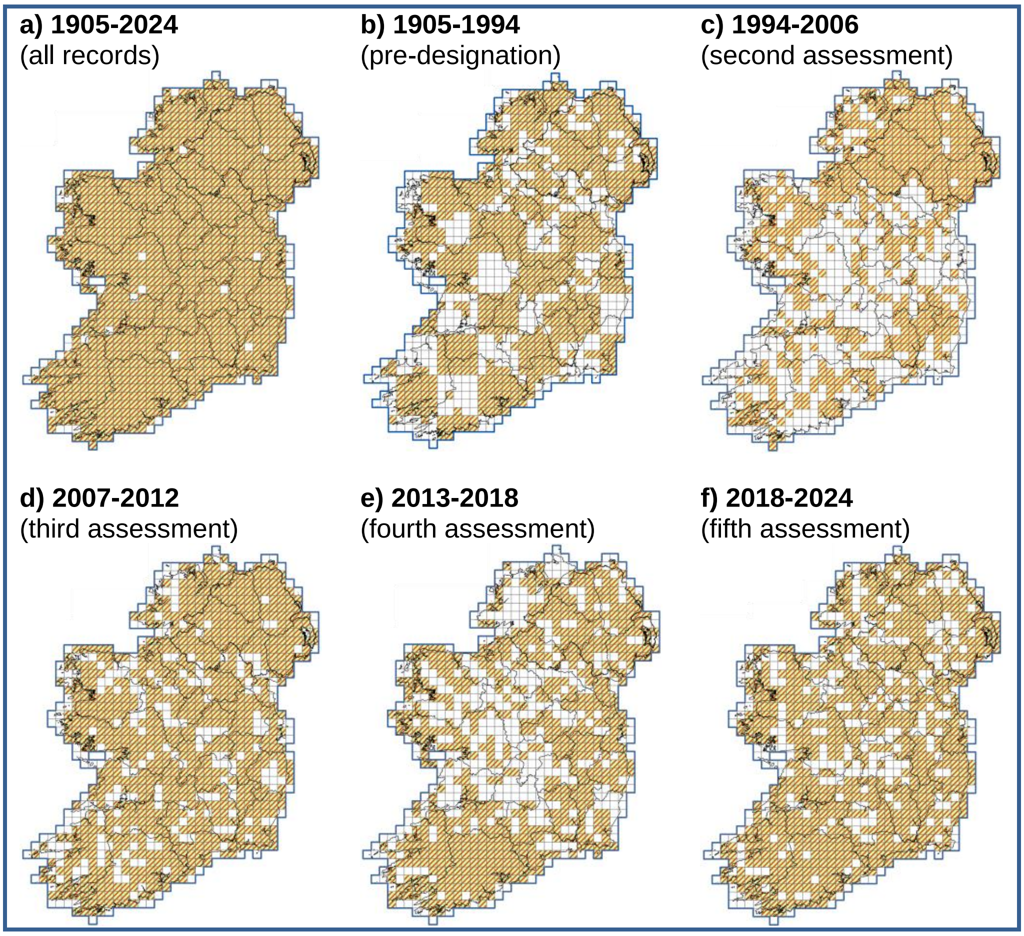

Figure 4 Otter distribution (hatched hectads) **a)** throughout Ireland since records began; and during assessment periods since designation: **b)** 1905-1994, **c)** 1994-2006, **d)** 2007-2012, **e)** 2013-2018 and **f)** 2018-2024. All hectads with land were taken as within the species Favourable Reference Range (bold blue line). Counts are shown in Table 2.

3.3 Population

The 2023-24 otter population was estimated at 5,774 [95% 5,005 - 6,560] adult females: 4,949 [4,362 - 5,561] in ROI and 825 [643 - 999] in NI (Appendix 7). The population estimate declined by -27% long-term from the 1980s to 2020s (-27% in ROI, -24% in NI), with consistent declines across River Basin Districts (Appendix 7). Over the short-term from the 2010s to 2020s, the population declined -3% overall (+2% in ROI, -27% in NI), with regional variation; notably increasing in the South Western district (+13%) but declining sharply by -40% in the Neagh-Bann district (Appendix 7a). The estimated decline in otter numbers was more notable in the wider countryside of NI than within SACs, both in the long- and short-term, yet trends in ROI were similar between SACs and the wider countryside (Appendix 7b).

Kriging analysis of otter occurrence suggested fairly uniform density across the island, with localized low spots but no clear spatial pattern (Appendix 8a). Most density fluctuations over time occurred in eastern and central regions (Appendix 8b-e). The highest densities in 2023-24 were in the south and north-west, while the lowest were in the east, Neagh-Bann district, central and Mayo peatlands and the Burren, County Clare (Appendix 8e).

3.4 Bias correction

Applying the same correction factor for potential negative biases following Reid et al. (2013c), the corrected species incidence during 2023-24 was estimated at 87% [84 - 90%] in ROI and 71% [63 - 76%] in NI (Appendix 9). Correspondingly, the corrected population estimate for 2023-24 may have been as high as 7,524 (6,758 - 8,234) adult females: 6,635 (6,050 - 7,171) in ROI and 889 (708 - 1,063; Appendix 9). Comparing estimates of corrected population size suggested the long-term decline may have been as low as -5% (-3% in ROI and -18% in NI) and short-term declines as low as -10% (-7 in ROI and -26% in NI; Appendix 9) with no real change in ROI but apparent decline in NI. These changes are of notably lower magnitude than that suggested by naive species incidence whilst the high degree of overlap in the 95% Confidence Intervals of the corrected population estimates for the 1980s, 2010s and 2020s suggest considerable uncertainty in any trend (Appendix 9).

3.5 Habitats

Otter occurrence increased significantly with river width, rising from ~55% at 1-2m wide rivers to 85% in >40m wide rivers (Appendix 10, Fig. 5a). It also varied with water current (Appendix 10), being lowest (~32-43%) at static or sluggish sites and highest (~67-70%) in slow, fast, and rapid-flowing waters (Fig. 5b). Otters were more likely to occur at sites with rocky substrates such as boulders, cobbles, gravel (Appendix 10; Figs. 5c–e) but were negatively associated with peat/heathland (Appendix 10, Fig. 5f) with no effect of elevation (Appendix 10). Otters were positively associated with broad-leaved woodland (Appendix 10, Fig. 5g) and bank-side trees (Appendix 10, Fig. 5h) and shrubs (Appendix 10, Fig. 5i). They preferred wild, unmaintained riverbanks, avoiding sites with bank maintenance including vegetation trimming or cutting (Appendix 10, Fig. 5j). Patterns were similar between ROI and NI, though relationships at the All-Ireland and ROI scale were more numerous and had stronger effects than in NI, likely due to larger sample sizes (Appendix 11).

3.6 Pressures and threats

Otter occurrence declined significantly with site disturbance score, especially at flowing freshwaters (Appendix 10). Occurrence was highest (71%) at undisturbed sites (score =1) but dropped to 41% at the most disturbed sites (score =5; Fig. 5k). Canalization or resectioning reduced occurrence to 53% (Appendix 10, Fig. 5l). In 2023-24, key threats reached their highest recorded prevalence since the 1980s (Appendix 12), including: siltation (at 53% of sites), pollution (at 36% of sites, mostly agricultural at 22% and domestic at 19%), water abstraction (at 13% of sites) and conifer plantations (adjacent to 13% of sites). Siltation and water abstraction showed significant linear increases over time ($Wald_{df=1}$ = 127.53, p<0.001; $Wald_{df=1}$ = 2591.51, p<0.001; Fig. 6). Other threats were less prevalent or showed no clear trend. The prevalence of pressures was similar between ROI and NI (Appendix 8). Otters were more frequent at sites with evidence of angling (74% occurrence) compared to sites without (62% occurrence; Fig. 5m), making it the only positive pressure at rivers and lakes. Bank maintenance and angling were recorded at twice frequency at survey sites in the 1980s than afterwards (Appendix 10; Fig. 6a-b) suggesting either a decline in such activities or a difference in how surveyors subsequently defined and recorded the data. Pressures and threats were classified under EU Habitats Directive Article 17, identifying eleven candidate pressures and associated conservation measures (Table 5). It seems likely that otter populations have faced pressures from agriculture including habitat loss (riparian corridor loss) as well as development, and water quality degradation from siltation and pollution. Should conservation measures be deemed necessary at the local level, they should focus on protecting semi-natural habitat along riparian corridors while mitigating pollution, disturbance and development.

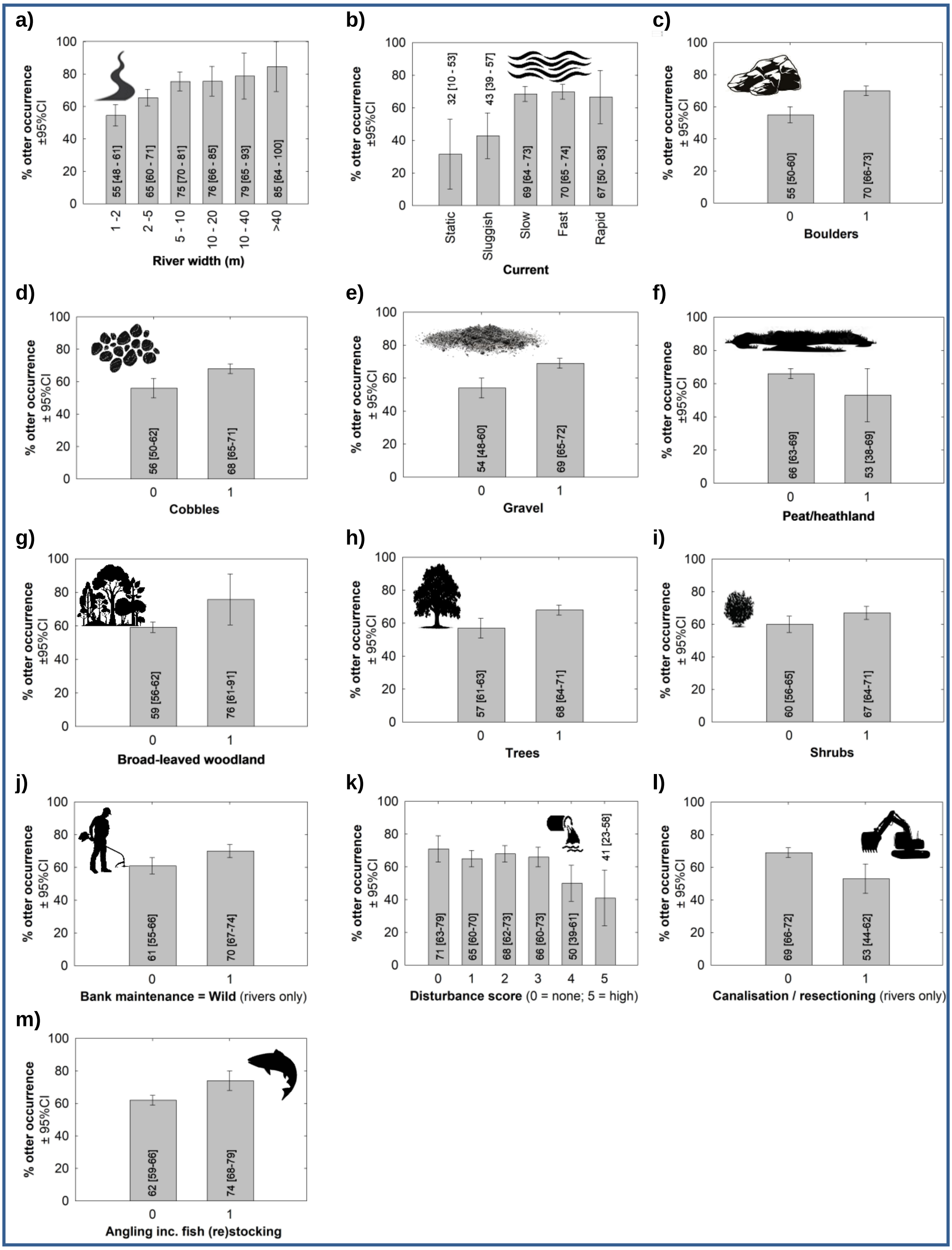

Figure 5 Variation in percentage occurrence of otters ± 95%CIs with **a)** river width, **b)** water current, **c)** boulders, **d)** cobbles, **e)** gravel, **f)** peat/heathland, **g)** broad-leaved woodland, **h)** trees, **i)** shrubs, **j)** bank maintenance, **k)** disturbance score, **l)** canalisation/resectioning, **m)** angling including fish (re)stocking.

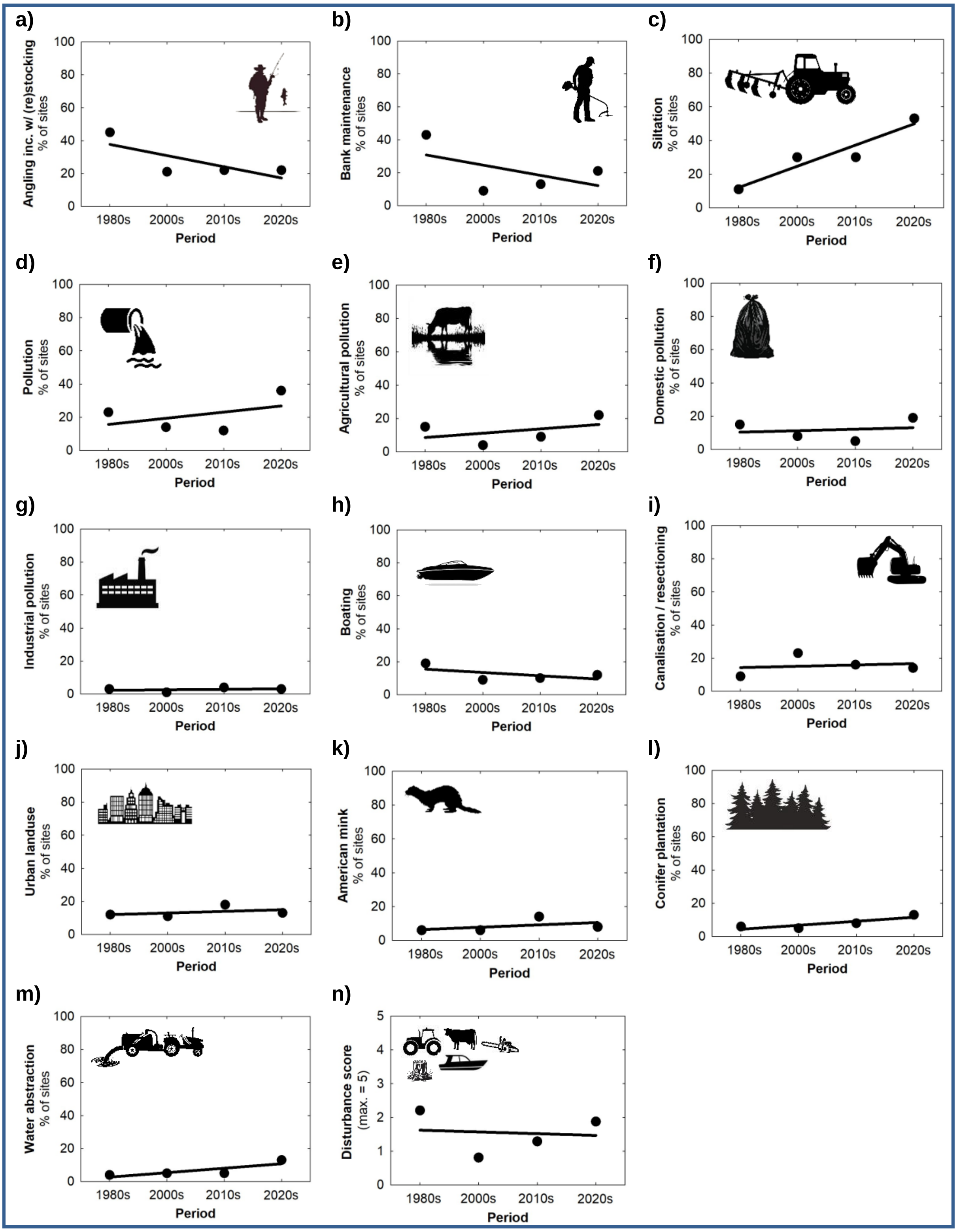

Figure 6 Temporal trends in prevalence of perceived environmental pressures at otter survey sites throughout Ireland from the 1980s to 2020s (see Table S6).

Table 5 A list of eleven identified pressures or threats to otter populations mapped across to the 2019-24 EU Habitats Directive Article 17 nomenclature (updated 05/02/2024) and corresponding candidate conservation measures.

#	Pressure or threat	Likely impact	Candidate conservation measure (if deemed necessary)
1	PA02: Conversion from one type of agricultural land use to another	Destruction and degradation of e.g. riparian corridor vegetation inc. trees or shrubs	MA01: Prevent conversion of natural and semi-natural habitats, and habitats of the species, into agricultural land
2	PA17: Agricultural activities generating pollution to surface waters	Negative impact on water quality	MA10: Reduce/eliminate point or diffuse source pollution to surface waters from agricultural activities
3	PA11: Soil management practices in agriculture (e.g. ploughing)	Negative impact on water quality	MA08: Adapt soil management practices in agriculture
4	PA13: Application of natural or synthetic fertilisers on agricultural land	Negative impact on water quality	MA09: Manage the use of natural and synthetic fertilisers, as well as chemicals, in agriculture
5	PK01: Mixed source pollution to surface waters (limnic and terrestrial)	Negative impact on water quality	MK01: Reduce impact of mixed source pollution
6	PF07: Residential and commercial activities and structures generating pollution to surface waters	Negative impact on water quality	MF04: Reduce/eliminate pollution to surface waters from commercial, residential and recreational areas and activities, and from industrial activities and structures
7	PF08: Industrial activities and structures generating pollution to surface waters	Negative impact on water quality	MF04: Reduce/eliminate pollution to surface waters from commercial, residential and recreational areas and activities, and from industrial activities and structures
8	PE05: Land, water and air transport activities generating pollution to surface waters	Negative impact on water quality e.g. oil/fuel	ME02: Manage/reduce/eliminate pollution to surface water from transport
9	PE01: Roads, paths, railroads and related infrastructure	Otters are common roadkill with unknown demographic impacts	ME01: Reduce impact of transport operation and infrastructure
10	PI02: Other invasive alien species (other than species of Union concern)	Negative impact of American mink *Mustela vision*; potential competition for space and resources	MI03: Management, control or eradication of other invasive alien species
11	PG09: Management of fishing stocks and game	A positive impact; unknown demographic impact of salmonid availability	MG03: Reducing the impact of (re)stocking for fishing

4 Discussion

This study confirms the ubiquity of the otter throughout Ireland yet re-analysis of past surveys suggested a likely decline in occupancy and population size since the 1980s. National surveys and citizen science campaigns produced a large number of species records, with photographic evidence suggesting that false positives *i.e*. misidentified records wrongly submitted as otter to data repositories, are rare. Over 95% of hectads in the ROI and NI had otter records, with no significant change across five conservation assessment periods from pre-designation to the present. Any apparent fluctuations likely reflect variations in recording effort.

Otters were more frequently detected along rivers than lakes and the coast, where lower connectivity and fewer obvious sprainting sites make detection more challenging. Their use of dispersed latrine sites along large water bodies further complicates identification at lakes and coastal areas (Balestrieri *et al*., 2010). Larger rivers and streams offer greater hydrodynamic stability than small watercourses, with abundant large fish prey, and enhanced connectivity facilitating movement and dispersal (*e.g.* Madsen & Prang, 2001). Otters prefer fast-flowing, oxygenated waters that support richer and more diverse invertebrate and fish populations (*e.g*. Gurung, 2023). Rivers with rocky substrates, such as boulders and cobble, not only provide these optimal conditions but also create structurally complex habitats that serve as refuges for prey like crayfish and bivalves, while exposed rocks offer conspicuous sprainting sites for territorial marking (Shin *et al*., 2020). Rivers with muddy substrates or an absence of rocks on otherwise vegetated banks provide less obvious locations to search for otter tracks and signs (Jeffress *et al*., 2011). Riparian vegetation, particularly broad-leaved woodland or bankside trees and shrubs in non-wooded areas, provides shelter, denning sites (holts) among roots, and stabilises banks while contributing organic input that enhances aquatic productivity (Hong *et al*., 2018). Otters were negatively associated with peatland and heathland habitats and were recorded less frequently in ROI's central lowland raised bogs, where acidic, nutrient-poor conditions likely support lower invertebrate and fish densities (Sokolova *et al*., 2022; Nakonechny & Nakonechna, 2023).

During 2023-24, otter occupancy was higher in the south and northwest but lowest in the human-dominated east. Otters were negatively affected by river modifications, including canalisation, resectioning, bank maintenance and disturbance with pressures likely more prevalent in densely populated eastern regions. Otter incidence varied spatially across River Basin Districts, with the Neagh-Bann district showing a notable decline in occupancy since the last survey. Harmful Algal Blooms in Lough Neagh during the survey period (see Reid *et al*., 2024) led some to describe the lake as "dying in plain sight" (Reid & Emmerson, 2023). Otter occupancy within the Neagh-Bann district was significantly lower at sites closer to Lough Neagh itself, suggesting a possible localised impact. While it is unlikely that the bloom affected otters across the entire catchment, their large home ranges allow wide-ranging movements. In Ireland, adult females typically range *c*. 7 km and males *c*. 13 km, with one male known to have expanded its range from 10 km to 20 km within days following a territorial neighbour's death (Ó Néill *et al*., 2009). Given their high mobility, otters can redistribute rapidly in response to environmental change, making it possible that the observed decline in the Neagh-Bann district in NI reflects a temporary response to the algal blooms. Future surveys are needed to determine if this decline is temporary. Despite spatial variation, otter occurrence was strikingly similar north and south, with 65% occupancy in ROI and 66% in NI during 2023-24.

Otter detection is subject to various methodological biases including variation in detection between surveyors or survey teams reflecting experience, skill or even visual acuity (which are typically confounded by space as teams worked regionally); recent rainfall which washes tracks and signs away; and, the availability of prominent sprainting sites, such as bridge footings, where spraint are preserved from weathering, accumulate and are easily found (Reid *et al*., 2013c). The first survey in 1980-81 was conducted in both ROI and NI by a highly experienced husband and wife team (P.J. and L.L. Chapman) who surveyed 2,785 sites (of which 2,506 first site visits were re-analysed here; though curiously they report only 2,177 sites in their report) while all 373 sites during the 2010 survey in NI were assessed by a single highly experienced aquatic consultant (S.J. Preston), who specialises in otter surveys as a professional environmental consultant. In both cases, otter occupancy was high (90% and 88% respectively) while it might be assumed variation in detection was likely fairly consistent within each survey. In contrast, all other surveys (where occupancy varied from 60-74%) were conducted by a large range of individuals (for example, 118 surveyors during 2023-24) although all received the same standardised guidance including online video tutorials and in-field training sessions. The consistency in otter occurrence between ROI and NI within the 1980s, 2000s, and 2020s suggests NI's 2010 estimate, and the variation in occupancy within the other surveys, may reflect, to some degree, surveyor expertise rather than a real population change.

Estimates of the otter population size in ROI declined over the long-term since the 1980s (somewhere between the naive estimate of -27% and an estimate that corrected for negative biases of -7%; more likely closer to the lower bound) yet showed no change since the last survey in 2010-11. Most of that decline seems likely to have occurred between the early 1990s (Lunnon & Reynolds, 1992) and mid-2000s (Bailey & Rochford, 2006). In contrast, estimates of the otter population size in NI declined similarly over the long-term (somewhere between the naive estimate of -24% and a corrected estimate of -18%; again more likely closer to the lower bound) and over the short-term (somewhere between the naive estimate of -27% and a corrected estimate of -26%). The divergence in trends between ROI and NI seems likely accounted for by the combination of the experience, skill and expertise of the surveyor during the last NI survey and the apparent significant decline in the Neagh-Bann River Basin District during the current survey.

Otter occurrence was higher within and near SACs where the species was a designated feature, though the effect was marginal in ROI due to SACs being widely distributed across the species' range. In NI, the effect appeared more substantial, as SACs are concentrated in the west, specifically in the Sperrin Mountains and Fermanagh Lakelands, which were otter hotspots. Despite these spatial differences, the temporal trend in otter occurrence was consistent across rivers, lakes, and the coast, as well as between SACs and the wider countryside, providing further evidence of a decline. As observed in other studies, this decline was only marginally offset by the Natura2000 protected area network (Abellán & Sánchez-Fernández, 2015).

In common with freshwater biodiversity generally, otters face increased pressures from habitat modification and declining water quality. River modifications such as canalisation and resectioning negatively impacted otter occurrence likely fragmenting habitats, altering water flow and reducing fish abundance (Elosegi & Sabater, 2013). These modifications straighten rivers, increasing velocity in some areas while slowing flow in others, disrupting ecological integrity and lowering productivity of invertebrate and fish prey populations (Kubheka *et al*., 2013; Bain *et al*., 1988; Fette *et al*., 2007). Loss of riparian vegetation through bank maintenance, such as cutting or strimming, reduces denning and resting sites, exposes otters to more disturbance, alters shading and affects river productivity (Naiman *et al*., 1993). Siltation, mainly from agriculture and forest felling, decreases water clarity and oxygen levels, harming invertebrates and fish (Ojha, 2021). The expansion of non-native conifer plantations, driven by afforestation efforts (Teagasc, 2024), further threatens freshwater systems by increasing acidification and altering hydrological regimes (Riipinen *et al*., 2009; Feeley *et al*., 2011). Siltation risk is highest immediately after forest felling when exposed soils are vulnerable to runoff (Stott *et al*., 2020). Pollution from agriculture (fertilisers, pesticides) and domestic waste further degrades water quality and habitat suitability for otters and their prey. Water abstraction, mainly for agriculture, disrupts flow and can introduce pollutants, particularly when extracted via slurry tankers prone to backflow contamination. Water quality across Europe has shown little improvement since the mid-2010s (Haase *et al*., 2023), with only 39% of ROI rivers achieving good or high biological status, 17% classified as poor or bad, and nearly 70% of NI rivers failing to meet good ecological status (Rivers Trust, 2024). Our analysis indicates siltation (now present at over half of sites), pollution (at over a third of sites, including agricultural pollution at over a fifth of sites), water abstraction, and conifer plantations have reached their highest recorded levels since otter surveys began over four decades ago.

Significant linear increases in siltation and water abstraction suggest deteriorating water quality is coincident with otter declines.

Otters were positively associated with evidence of angling, coarse fishing, including sites with fish re(stocking) indicating the importance of food availability. In Ireland, fish (re)stocking, invariably with salmonids, is not particularly common, yet in parts of Europe where it is more widespread, a reduction in natural prey from habitat degradation may drive otters toward artificially stocked sites (Kranz, 2000; Weinberger *et al*., 2016) creating a potential human-wildlife conflict.

Otters have shown resilience in modified landscapes, but ongoing human disturbance and water quality deterioration may threaten their long-term stability and may explain, to some extent, the apparent population decline in recent decades. Nevertheless, the pressures identified here were mostly local in extent, with none posing an existential threat at the national scale, with otters remaining widespread, and their habitat largely intact, throughout Ireland. Where conservation efforts are merited, they should prioritise restoring natural river dynamics, preserving riparian vegetation, improving water quality and reducing human disturbance (Weinberger *et al*., 2016).

5 Recommendations

- Future studies should focus on quantifying the prevalence and magnitude of potential negative biases in otter survey methodology, focusing on inter-surveyor variability in detection rates and the impact of flooding *i.e*. water levels as the direct consequence of prior rainfall. This may provide greater accuracy in any statistical correction. More generally, future work should refine detection and occupancy estimates by generating detection histories for each site or hectad, allowing, for example, a Bayesian hierarchical occupancy modelling approach to separate detection probability from true changes in occupancy probability (*e.g*. see Twinning *et al*., 2023; Twinning *et al*., 2024a, b). Thus, without explicitly testing all possible negative biases, such an approach would allow unbiased occupancy probabilities to be generated, more accurately capturing the magnitude of any population change.
- Future surveys should consider moving to methods that minimise negative biases, in particular, consideration should be given to water sampling and environmental or eDNA detection recently developed for otters (*e.g*. see Broadhurst *et al*., 2021; Harper *et al*., 2019; Jamwal *et al*., 2023). Water sampling may be less vulnerable to variation in collector skill whilst detection should not be biased negatively so long as a minimum volume of water necessary for DNA presence to be detected is filtered.
- Advances in both survey methodologies and statistical analyses may go some way in resolving uncertainty in otter population trends.

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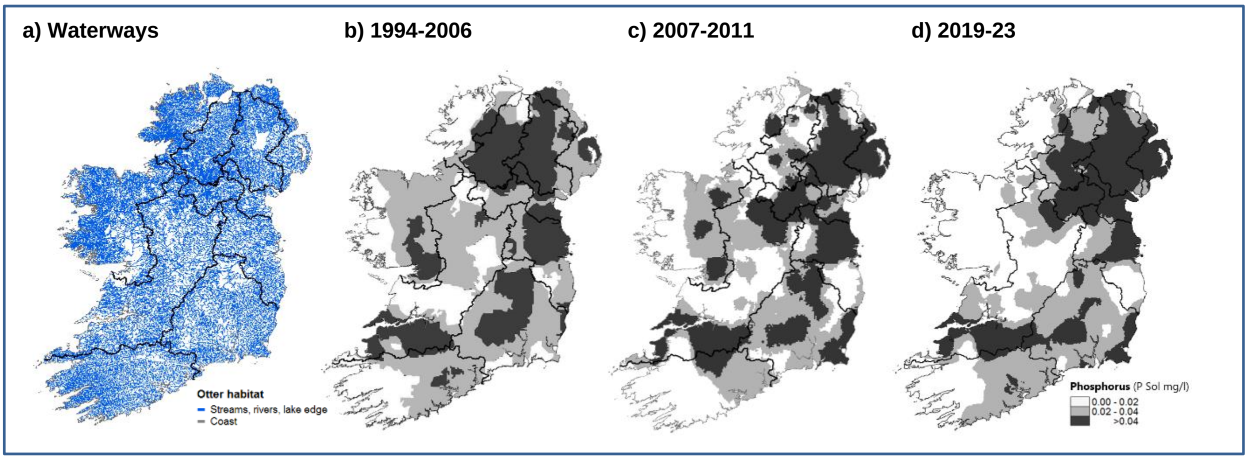
7 Appendices

Appendix 1 Adult female otter density (individuals.km^{-1}) with 95% confidence intervals in brackets for various habitats throughout Ireland at three levels of agricultural intensity.

Country (source)	**Habitat category**	**Phosphorus (agricultural intensity)**		
		Low[I] (0.00 - 0.02 mg.l^{-1})	**Intermediate**[†] (0.02 - 0.04 mg.l^{-1})	**High**[II] (>0.04 mg.l^{-1})
Republic of Ireland	Streams ~ 4.2m	0.05 [0.05 - 0.06]	0.06 [0.05 - 0.10]	0.07 [0.05 - 0.10]
(OSI)	Rivers ~ 12.9m	0.05 [0.05 - 0.06]	0.08 [0.05 - 0.14]	0.12 [0.11 - 0.14]
	Lakes	0.05 [0.05 - 0.06]	0.09 [0.05 - 0.21]	0.17 [0.15 - 0.21]
Northern Ireland	Streams <2m	0.05 [0.05 - 0.05]	0.05 [0.05 - 0.05]	0.05 [0.05 - 0.05]
(OSNI)	Streams 2-5m	0.06 [0.05 - 0.08]	0.07 [0.05 - 0.10]	0.08 [0.05 - 0.12]
	Rivers 5-10m	0.08 [0.05 - 0.12]	0.09 [0.07 - 0.12]	0.10 [0.08 - 0.14]
	Rivers 10-20m	0.10 [0.08 - 0.14]	0.11 [0.09 - 0.14]	0.12 [0.11 - 0.15]
	Rivers 20-40m	0.12 [0.11 - 0.15]	0.13 [0.11 - 0.15]	0.13 [0.11 - 0.16]
	Rivers >40m	0.13 [0.11 - 0.16]	0.14 [0.12 - 0.16]	0.15 [0.13 - 0.17]
	Lakes	0.05 [0.05 - 0.06]	0.09 [0.05 - 0.21]	0.17 [0.15 - 0.21]
Coastlines	Paleozoic[III]		0.43 [0.38 - 0.49]	
(Geological Survey	Carboniferous[††]		0.43 [0.38 - 0.49]	
of Ireland)	Devonian[‡]		0.10 [0.09 - 0.11]	
	Igneous[III]		0.10 [0.09 - 0.11]	
	Mesozoic[III]		0.66 [0.58 - 0.75]	
	Pre-Cambrian[III]		0.18 [0.16 - 0.20]	

Density estimates were derived from [I]Green *et al.* 1984, Kruuk *et al.* 1993, Durbin 1996, Kruuk 2006; [II]O'Néill, 2008; [†]intermediate between low and high trophic status with most extreme confidence intervals; [III]Yoxon 1999; [††]Carboniferous limestone was assumed to be similar to Cambrian rock (Yoxon 1999) and [‡]otter density on Devonian rock was assumed similar to that on Igneous rock (Kruuk 1995, Yoxon 1999, H. Kruuk *pers. comms*.). Note the effect of geology was assumed independent of nutrient status (Ó Néill, 2008).



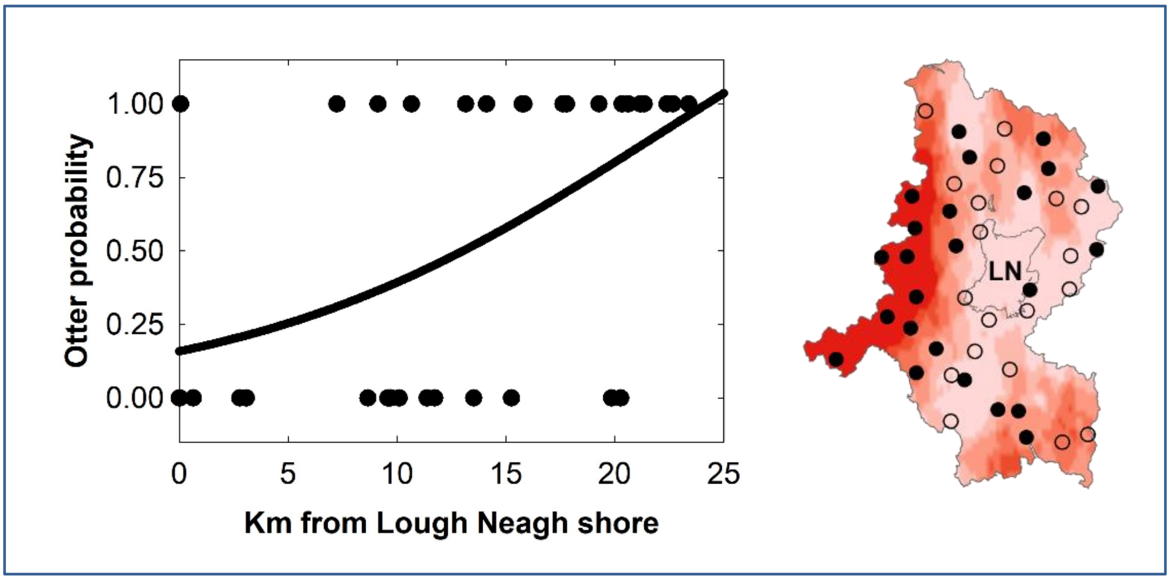
Appendix 2 a) Waterways that are suitable otter habitat i.e. streams, rivers, lake edge and the coast; and isoclines of phosphorus levels in Irish freshwaters (reflecting agricultural intensity) during **b)** 1993-2006 [extracted from Ó Néill 2008] and used for the 1980 population estimate, **c)** 2007-2011 used for the 2010s population estimate and **d)** 2019-23 used for the 2020s population estimate. Phosphate data were obtained from the Environmental Protection Agency, ROI (https://gis.epa.ie/EPAMaps) and Water Management Unit, NIEA (https://gis.daera-ni.gov.uk/arcgis/apps/webappviewer/index.html?id=7e234827aa7a405d990359aa92c7c287) with details of spatial interpolation in Methods section 4.9. Bold black lines represent River Basin District boundaries.

Appendix 3 Number of sites surveyed (*n*) and the percentage occurrence of otter tracks and signs [with the 95% Confidence Interval] with site designation i.e. sites within 600m of an Special Area of Conservation (SAC) where the otter is a feature of interest throughout Ireland from the 1980s to the 2020s (*this survey*). Site declaration was 1996, thus those surveyed in the 1980s were attributed to later being included within a future SAC. Percentage change (%Δ) in species occurrence over the long-term (1980s-2020s) and short-term (2010s-2020s) was assessed using chi-squared tests.

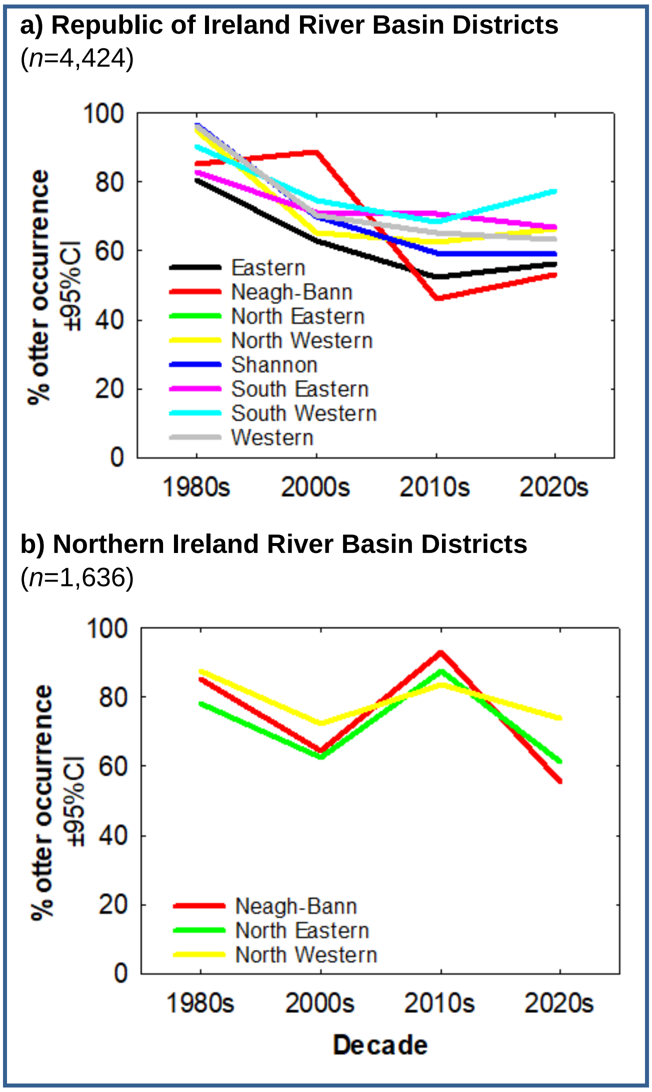
Country Designation	**1980s** (Chapman & Chapman 1981)		**2000s** (Bailey & Rochford, 2006; Preston et al. 2006)		**2010s** (Preston & Reid, 2011; Reid et al. 2013b)		**2020s** (*this study*)		**Δ1980s-2020s** (long-term)			**Δ2010s-2020s** (short-term)		
	Sites	**% occurrence [95%CI]**	**Sites**	**% occurrence [95%CI]**	**Sites**	**% occurrence [95%CI]**	**Sites**	**% occurrence [95%CI]**	**%Δ**	**$\chi^2_{df=1}$**	***p***	**%Δ**	**$\chi^2_{df=1}$**	***p***
All-Ireland														
SAC (*n*=50)	523	97 [96 - 99]	379	74 [69 - 78]	281	70 [64 - 75]	318	70 [65 - 75]	-28	131.66	<0.001	0	0.00	0.987
Wider countryside	1,983	88 [87 - 89]	887	67 [63 - 70]	944	71 [68 - 74]	745	63 [59 - 66]	-28	222.96	<0.001	-11	13.64	<0.001
Total / average	**2,506**	**90 [89 - 91]**	**1,266**	**69 [66 - 71]**	**1,225**	**71 [68 - 73]**	**1,063**	**65 [62 - 68]**	**-28**	**322.37**	**<0.001**	**-8**	**9.53**	**0.002**
Republic of Ireland														
SAC (*n*=44)	512	97 [96 - 99]	279	72 [67 - 78]	252	67 [62 - 73]	287	68 [63 - 74]	-30	135.25	<0.001	+1	0.04	0.836
Wider countryside	1,617	89 [88 - 91]	245	68 [62 - 74]	600	62 [58 - 65]	632	63 [59 - 67]	-29	206.18	<0.001	+1	0.35	0.554
Sub-total / average	**2,129**	**91 [90 - 92]**	**524**	**70 [67 - 74]**	**852**	**63 [60 - 67]**	**919**	**65 [62 - 68]**	**-29**	**317.46**	**<0.001**	**+3**	**0.42**	**0.516**
Northern Ireland														
SAC (*n*=6)	11	100 [100 - 100]	100	78 [70 - 86]	29	90 [78 - 100]	31	84 [71 - 97]	-16	*na*	*na*	-7	0.43	0.510
Wider countryside	366	83 [79 - 87]	642	66 [62 - 70]	344	88 [85 - 92]	113	61 [52 - 70]	-27	23.49	<0.001	-31	42.29	<0.001
Sub-total / average	**377**	**83 [80 - 87]**	**742**	**68 [64 - 71]**	**373**	**88 [85 - 92]**	**144**	**66 [58 - 74]**	**-20**	**18.52**	**<0.001**	**-25**	**35.95**	**<0.001**

Appendix 4 Number of sites surveyed (*n*) and the percentage occurrence of otter tracks and signs [with the 95% Confidence Interval] within River Basin Districts throughout Ireland from the 1980s to the 2020s (*this survey*). Percentage change (%Δ) in species occurrence over the long-term (1980s-2020s) and short-term (2010s-2020s) was assessed using chi-squared tests.

Country River Basin District	**1980s** (Chapman & Chapman 1981)		**2000s** (Bailey & Rochford, 2006; Preston et al. 2004)		**2010s** (Reid & Preston, 2010; Reid et al. 2013)		**2020s** (*this study*)		**Δ1980s-2020s** (long-term)			**Δ2010s-2020s** (short-term)		
	Sites	**% occurrence [95%CI]**	**Sites**	**% occurrence [95%CI]**	**Sites**	**% occurrence [95%CI]**	**Sites**	**% occurrence [95%CI]**	**%Δ**	$\chi^2_{df=1}$	***p***	**%Δ**	$\chi^2_{df=1}$	***p***
All-Ireland														
Eastern	199	80 [75 - 86]	35	63 [47 - 79]	65	52 [40 - 65]	78	56 [45 - 67]	-30	16.62	<0.001	+8	0.24	0.624
Neagh Bann	210	85 [80 - 90]	291	65 [60 - 71]	184	86 [81 - 91]	77	55 [43 - 66]	-35	29.97	<0.001	-36	31.14	<0.001
North Eastern	129	78 [71 - 85]	142	63 [55 - 71]	80	88 [80 - 95]	26	62 [42 - 81]	-21	3.28	0.070	-30	8.64	0.003
North Western	289	93 [90 - 96]	384	71 [67 - 76]	236	75 [69 - 80]	174	70 [63 - 76]	-25	45.31	<0.001	-7	1.27	0.259
Shannon	550	97 [95 - 98]	100	70 [61 - 79]	216	59 [53 - 66]	221	59 [52 - 65]	-39	186.59	<0.001	0	<0.01	0.926
South Eastern	378	83 [79 - 87]	107	71 [62 - 80]	130	71 [63 - 79]	168	67 [60 - 74]	-19	18.25	<0.001	-6	0.57	0.450
South Western	418	90 [87 - 93]	95	75 [66 - 84]	161	68 [61 - 76]	163	77 [71 - 84]	-14	16.77	<0.001	+13	3.30	0.069
Western	333	96 [94 - 98]	112	71 [62 - 79]	153	65 [58 - 73]	156	63 [56 - 71]	-34	95.08	<0.001	-3	0.12	0.728
Total / average	**2,506**	**90 [89 - 91]**	**1,266**	**69 [66 - 71]**	**1225**	**71 [68 - 73]**	**1,063**	**65 [62 - 68]**	-28	**322.37**	**<0.001**	-8	**9.53**	**0.002**
Republic of Ireland														
Eastern	199	80 [75 - 86]	35	63 [47 - 79]	65	52 [40 - 65]	78	56 [45 - 67]	-30	16.62	<0.001	+8	0.24	0.624
Neagh Bann	34	85 [73 - 97]	9	89 [67 -	26	46 [27 - 66]	32	53 [36 - 71]	-38	8.08	0.004	+15	0.28	0.597
North Western	217	95 [92 - 98]	66	65 [54 - 77]	101	62 [53 - 72]	101	66 [57 - 76]	-31	46.39	<0.001	+6	0.35	0.557
Shannon	550	97 [95 - 98]	100	70 [61 - 79]	216	59 [53 - 66]	221	59 [52 - 65]	-39	186.59	<0.001	0	<0.01	0.926
South Eastern	378	83 [79 - 87]	107	71 [62 - 80]	130	71 [63 - 79]	168	67 [60 - 74]	-19	18.25	<0.001	-6	0.57	0.450
South Western	418	90 [87 - 93]	95	75 [66 - 84]	161	68 [61 - 76]	163	77 [71 - 84]	-14	16.77	<0.001	+13	3.30	0.069
Western	333	96 [94 - 98]	112	71 [62 - 79]	153	65 [58 - 73]	156	63 [56 - 71]	-34	95.08	<0.001	-3	0.12	0.728
Sub-total / average	**2,129**	**91 [90 - 92]**	**524**	**70 [67 - 74]**	**852**	**63 [60 - 67]**	**919**	**65 [62 - 68]**	-29	**317.46**	**<0.001**	+3	**0.42**	**0.516**
Northern Ireland														
Neagh Bann	176	85 [80 - 90]	282	65 [59 - 70]	158	93 [89 - 97]	45	56 [41 - 70]	-34	19.14	<0.001	-40	38.03	<0.001
North Eastern	129	78 [71 - 85]	142	63 [55 - 71]	80	88 [80 - 95]	26	62 [42 - 81]	-21	3.28	0.070	-30	8.64	0.003
North Western	72	88 [80 - 95]	318	72 [67 - 77]	135	84 [77 - 90]	73	74 [64 - 84]	-16	4.26	0.039	-12	2.83	0.092
Sub-total / average	**377**	**83 [80 - 87]**	**742**	**68 [64 - 71]**	**373**	**88 [85 - 92]**	**144**	**66 [58 - 74]**	-20	**18.52**	**<0.001**	-25	**35.95**	**<0.001**



Appendix 5 Probability of otter occupancy of sites within the Neagh-Bann River Basin District with distance from the Lough Neagh shoreline during the NI Otter Survey 2024 and heatmap of the interpolated probability of otter detection (absent = pale, present = red).

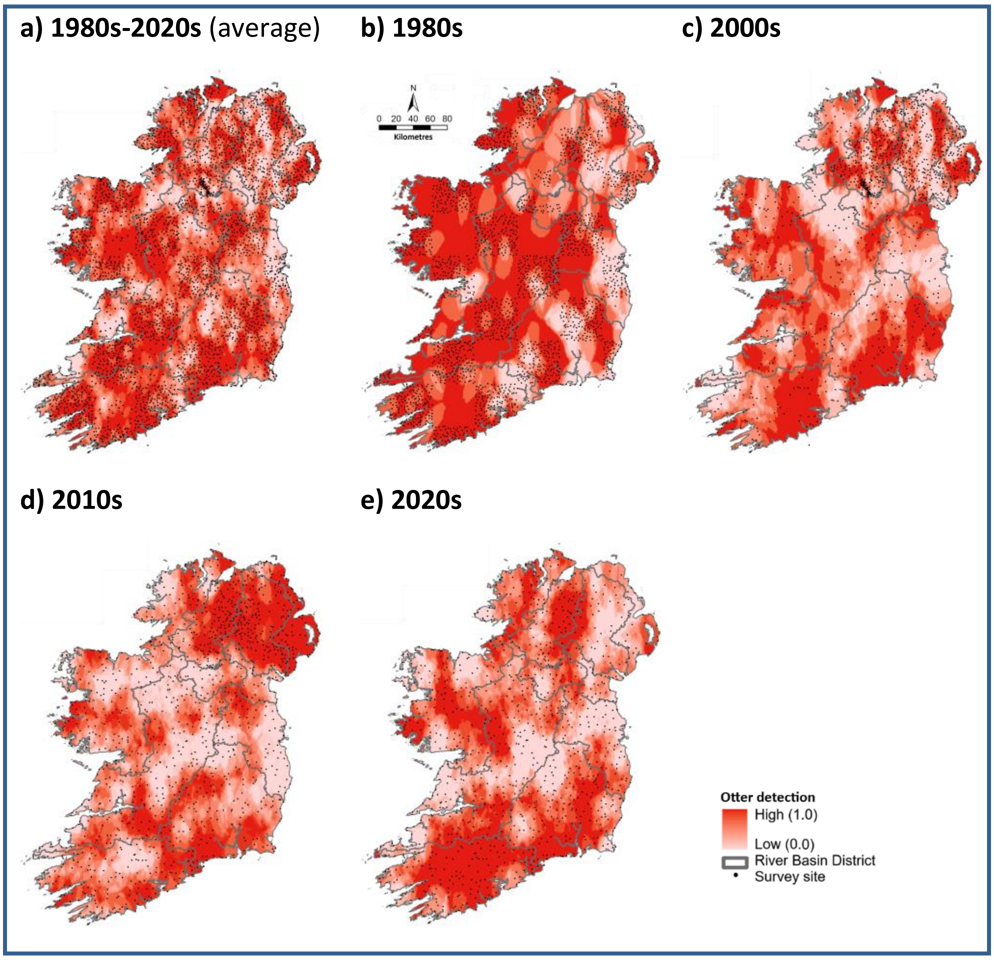


Appendix 6 Percentage occurrence of otters within River Basin Districts throughout **a)** Ireland, **b)** the Republic of Ireland and **c)** Northern Ireland from the 1980s to the 2020s.

Appendix 7 Population estimates (adult females) derived from naive **UNCORRECTED** species incidence in the 1980s (first survey), 2010s (last survey) and 2020s (this survey) by which to evaluate percentage change within a) River Basin Districts and b) designated sites.

Region	**Naive (UNCORRECTED) estimates**						**Population trend**	
RBD / Designation	**1980s** (first survey)		**2010s** (last survey)		**2020s** (current survey)		**%Δ1980s -2020s** (long-term)	**%Δ2010s -2020s** (long-term)
	% occurrence* [95%CI]	**Population estimate** [95%CI]	**% occurrence** [95%CI]	**Population estimate** [95%CI]	**% occurrence** [95%CI]	**Population estimate** [95%CI]		
a) RIVER BASIN DISTRICTS								
Ireland	**90 (89 - 91)**	**7905 (7817 - 7993)**	**71 (68 - 73)**	**5970 (5287 - 6711)**	**65 (62 - 68)**	**5774 (5005 - 6560)**	**-27**	**-3**
Republic of Ireland	**91 (90 - 92)**	**6824 (6749 - 6899)**	**63 (60 - 67)**	**4835 (4229 - 5506)**	**65 (62 - 68)**	**4949 (4362 - 5561)**	**-27**	**+2**
Eastern	80 (75 - 86)	605 (567 - 650)	52 (40 - 65)	393 (302 - 491)	56 (45 - 67)	424 (340 - 506)	-30	+8
Neagh Bann	85 (73 - 97)	121 (104 - 138)	46 (27 - 66)	65 (38 - 94)	53 (36 - 71)	75 (51 - 101)	-38	+15
North Western	95 (92 - 98)	927 (898 - 956)	62 (53 - 72)	605 (517 - 702)	66 (57 - 76)	644 (556 - 741)	-31	+6
Shannon	97 (95 - 98)	1515 (1484 - 1531)	59 (53 - 66)	921 (828 - 1031)	59 (52 - 65)	921 (812 - 1015)	-39	0
South Eastern	83 (79 - 87)	932 (887 - 977)	71 (63 - 79)	797 (707 - 887)	67 (60 - 74)	752 (674 - 831)	-19	-6
South Western	90 (87 - 93)	1152 (1114 - 1190)	68 (61 - 76)	870 (781 - 972)	77 (71 - 84)	986 (909 - 1075)	-14	+13
Western	96 (94 - 98)	1748 (1712 - 1784)	65 (58 - 73)	1184 (1056 - 1329)	63 (56 - 71)	1147 (1020 - 1292)	-34	-3
Northern Ireland	**83 (80 - 87)**	**1081 (1042 - 1133)**	**88 (85 - 92)**	**1135 (1058 - 1205)**	**66 (58 - 74)**	**825 (643 - 999)**	**-24**	**-27**
Neagh Bann	85 (80 - 90)	434 (408 - 460)	93 (89 - 97)	475 (454 - 496)	56 (41 - 70)	286 (209 - 358)	-34	-40
North Eastern	78 (71 - 85)	214 (195 - 233)	88 (80 - 95)	241 (220 - 260)	62 (42 - 81)	170 (115 - 222)	-21	-29
North Western	88 (80 - 95)	439 (399 - 474)	84 (77 - 90)	419 (384 - 449)	74 (64 - 84)	369 (319 - 419)	-16	-12
b) DESIGNATED STATUS								
Ireland	**90 (89 - 91)**	**7905 (7817 - 7993)**	**71 (68 - 73)**	**5970 (5287 - 6711)**	**65 (62 - 68)**	**5774 (5005 - 6560)**	**-27**	**-3**
SACs	97 (96 - 99)	1675 (1665 - 1670)	70 (64 - 75)	1216 (1053 - 1395)	70 (65 - 75)	1228 (1058 - 1402)	-27	+1
Wider countryside	88 (87 - 89)	6230 (6152 - 6323)	71 (68 - 74)	4754 (4234 - 5316)	63 (59 - 66)	4546 (3947 - 5158)	-27	-4
Republic of Ireland	**91 (90 - 92)**	**6824 (6749 - 6899)**	**63 (60 - 67)**	**4835 (4229 - 5506)**	**65 (62 - 68)**	**4949 (4362 - 5561)**	**-27**	**+2**
SACs	97 (96 - 99)	1501 (1485 - 1518)	67 (62 - 73)	1057 (916 - 1241)	68 (63 - 74)	1080 (944 - 1238)	-28	+2
Wider countryside	89 (88 - 91)	5323 (5264 - 5381)	62 (58 - 65)	3778 (3313 - 4265)	63 (59 - 67)	3869 (3418 - 4323)	-27	+2
Northern Ireland	**83 (80 - 87)**	**1081 (1042 - 1133)**	**88 (85 - 92)**	**1135 (1058 - 1205)**	**66 (58 - 74)**	**825 (643 - 999)**	**-24**	**-27**
SACs	100 (100 - 100)	174 (174 - 160)	90 (78 - 100)	159 (134 - 162)	84 (71 - 97)	148 (115 - 165)	-15	-7
Wider countryside	83 (79 - 87)	907 (868 - 973)	88 (85 - 92)	976 (924 - 1043)	61 (52 - 70)	677 (528 - 834)	-25	-31

* Note that these figures differ from those reported by Ó Néill (2008) due to the correction of a minor totalling error in the original calculations.



Appendix 8 Spatially interpolated presence and absence using Kriging as a proxy of population density. Regions with fewer survey sites (black dots) have greater uncertainty.

Appendix 9 Population estimates (adult females) derived from **CORRECTED** species incidence (accounting for likely negative bias) in the 1980s (first survey), 2010s (last survey) and 2020s (this survey) by which to evaluate percentage change within a) River Basin Districts and b) designated sites.

Region RBD / Designation	CORRECTED estimates						Population trend	
	1980s (first survey)		**2010s** (last survey)		**2020s** (current survey)			
	% occurrence* [95%CI]	**Population estimate** [95%CI]	**% occurrence** [95%CI]	**Population estimate** [95%CI]	**% occurrence** [95%CI]	**Population estimate** [95%CI]	**%Δ1980s -2020s** (long-term)	**%Δ2010s -2020s** (long-term)
a) RIVER BASIN DISTRICTS								
Ireland	**90 (89 - 91)**	**7905 (7817 - 7993)**	**94 (78 - 97)**	**8374 (7011 - 8677)**	**83 (80 - 88)**	**7524 (6758 - 8234)**	**-5**	**-10**
Republic of Ireland	**91 (90 - 92)**	**6824 (6749 - 6899)**	**94 (79 - 97)**	**7172 (6027 - 7428)**	**87 (84 - 90)**	**6635 (6050 - 7171)**	**-3**	**-7**
Eastern	80 (75 - 86)	605 (567 - 650)	94 (84 - 97)	711 (635 - 733)	78 (67 - 89)	590 (507 - 673)	-2	-17
Neagh Bann	85 (73 - 97)	121 (104 - 138)	94 (81 - 97)	134 (115 - 138)	75 (58 - 93)	107 (83 - 132)	-12	-20
North Western	95 (92 - 98)	927 (898 - 956)	93 (76 - 97)	907 (742 - 946)	88 (79 - 98)	859 (771 - 956)	-7	-5
Shannon	97 (95 - 98)	1515 (1484 - 1531)	94 (81 - 97)	1468 (1265 - 1515)	81 (74 - 87)	1265 (1156 - 1359)	-17	-14
South Eastern	83 (79 - 87)	932 (887 - 977)	94 (85 - 97)	1056 (954 - 1089)	89 (82 - 96)	999 (921 - 1078)	+7	-5
South Western	90 (87 - 93)	1152 (1114 - 1190)	94 (77 - 97)	1203 (986 - 1241)	99 (93 - 100)	1267 (1191 - 1280)	10	+5
Western	96 (94 - 98)	1748 (1712 - 1784)	93 (73 - 97)	1693 (1330 - 1766)	85 (78 - 93)	1548 (1421 - 1693)	-11	-9
Northern Ireland	**83 (80 - 87)**	**1081 (1042 - 1133)**	**94 (77 - 97)**	**1202 (984 - 1249)**	**71 (63 - 79)**	**889 (708 - 1063)**	**-18**	**-26**
Neagh Bann	85 (80 - 90)	434 (408 - 460)	94 (80 - 97)	480 (408 - 496)	61 (46 - 75)	311 (235 - 383)	-28	-35
North Eastern	78 (71 - 85)	214 (195 - 233)	94 (68 - 98)	258 (187 - 269)	67 (47 - 86)	184 (129 - 236)	-14	-29
North Western	88 (80 - 95)	439 (399 - 474)	93 (78 - 97)	464 (389 - 484)	79 (69 - 89)	394 (344 - 444)	-10	-15
b) DESIGNATED STATUS								
Ireland	**90 (89 - 91)**	**7905 (7817 - 7993)**	**94 (78 - 100)**	**8374 (7011 - 8677)**	**84 (81 - 87)**	**7524 (6758 - 8234)**	**-5**	**-10**
SACs	97 (96 - 99)	1675 (1665 - 1670)	96 (80 - 100)	1694 (1428 - 1684)	90 (85 - 96)	1584 (1414 - 1738)	-5	-6
Wider countryside	88 (87 - 89)	6230 (6152 - 6323)	92 (76 - 100)	6680 (5583 - 6993)	82 (78 - 86)	5940 (5344 - 6496)	-5	-11
Republic of Ireland	**91 (90 - 92)**	**6824 (6749 - 6899)**	**94 (79 - 100)**	**7172 (6027 - 7428)**	**87 (84 - 90)**	**6635 (6050 - 7171)**	**-3**	**-7**
SACs	97 (96 - 99)	1501 (1485 - 1518)	97 (82 - 100)	1537 (1301 - 1529)	90 (85 - 96)	1427 (1292 - 1567)	-5	-7
Wider countryside	89 (88 - 91)	5323 (5264 - 5381)	92 (77 - 100)	5635 (4726 - 5899)	85 (81 - 89)	5208 (4758 - 5604)	-2	-8
Northern Ireland	**83 (80 - 87)**	**1081 (1042 - 1133)**	**94 (77 - 100)**	**1202 (984 - 1249)**	**71 (63 - 79)**	**889 (708 - 1063)**	**-18**	**-26**
SACs	100 (100 - 100)	174 (174 - 160)	89 (73 - 100)	158 (128 - 156)	89 (76 - 100)	157 (123 - 170)	-10	-1
Wider countryside	83 (79 - 87)	907 (868 - 973)	94 (77 - 100)	1044 (856 - 1093)	66 (57 - 75)	732 (585 - 893)	-19	-30

Appendix 10 Logistic regressions where the dependent variable was otter presence/absence during 2023-24 with separate models for each independent variable run for **a)** all, **b)** flowing freshwater, **b)** static freshwater and **c)** coastal sites.

	a) All sites (*n*=1,063)			**b) Flowing freshwater** (*n*=886)			**c) Static freshwater** (*n*=40)			**d) Coastal** (*n*=137)		
Independent variables	**Wald**	***df***	***p***	**Wald**	***df***	***p***	**Wald**	***df***	***p***	**Wald**	***df***	***p***
Administrative												
Country	0.082	1	0.774	*na*	*na*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
Habitat type (river, lake, coast)	8.370	2	**0.015**	*na*	*na*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
River Basin District	22.315	7	**0.002**	25.071	7	**<0.001**	5.249	5	0.386	3.098	7	0.876
Designation	4.767	1	**0.029**	8.656	1	**0.003**	0.027	1	0.870	1.348	1	0.246
Ecology												
Elevation	1.987	1	0.159	0.494	1	0.482	1.326	1	0.250	*na*	*na*	*na*
Grassland	0.027	1	0.870	2.336	1	0.126	0.655	1	0.418	0.134	1	0.714
Arable	2.545	1	0.111	2.061	1	0.151	0.000	1	0.999	0.424	1	0.515
Broad-leaved woodland	28.304	1	**<0.001**	20.579	1	**<0.001**	5.504	1	**0.019**	0.009	1	0.924
Conifer plantation	1.661	1	0.197	0.842	1	0.359	0.288	1	0.591	0.000	1	1.000
Peatland/Heathland	7.082	1	**0.008**	3.878	1	**0.049**	2.043	1	0.153	0.541	1	0.462
Urban	2.302	1	0.129	2.061	1	0.151	0.000	1	0.999	0.424	1	0.515
Saltmarsh	0.767	1	0.381	*na*	*na*	*na*	*na*	*na*	*na*	0.767	1	0.381
Park/Garden	0.436	1	0.509	0.666	1	0.414	0.462	1	0.497	0.084	1	0.772
River width	24.587	1	**<0.001**	25.426	1	**<0.001**	*na*	*na*	*na*	*na*	*na*	*na*
River depth	0.221	1	0.638	0.225	1	0.635	*na*	*na*	*na*	*na*	*na*	*na*
River current	12.179	1	**<0.001**	12.273	1	**<0.001**	*na*	*na*	*na*	*na*	*na*	*na*
Boulders	22.714	1	**<0.001**	27.580	1	**<0.001**	0.817	1	0.366	0.392	1	0.531
Gravel	17.457	1	**<0.001**	8.658	1	**0.003**	0.064	1	0.800	4.304	1	**0.038**
Cobbles	12.527	1	**<0.001**	7.425	1	0.006	0.008	1	0.931	2.054	1	0.152
Sand	0.325	1	0.569	2.142	1	0.143	3.956	1	**0.047**	0.205	1	0.651
Silt	0.135	1	0.714	3.667	1	0.055	2.492	1	0.114	0.041	1	0.840
Trees	10.231	1	**0.001**	10.231	1	**0.001**	*na*	*na*	*na*	*na*	*na*	*na*
Shrubs	5.316	1	**0.021**	5.316	1	**0.021**	*na*	*na*	*na*	*na*	*na*	*na*
Wild unmaintained banks	8.280	1	**0.004**	8.280	1	**0.004**	*na*	*na*	*na*	*na*	*na*	*na*
Angling (~ fish)	9.877	1	**0.002**	7.500	1	**0.006**	3.956	1	**0.047**	0.371	1	0.542
American mink	0.529	1	0.467	0.440	1	0.507	1.054	1	0.305	0.498	1	0.480
Pressures and threats												
Pollution	0.125	1	0.723	0.053	1	0.818	3.398	1	0.065	1.508	1	0.219
Agricultural pollution	0.092	1	0.762	0.164	1	0.686	3.627	1	0.057	0.242	1	0.623
Domestic pollution	0.267	1	0.605	0.003	1	0.958	0.064	1	0.800	2.970	1	0.085
Industrial pollution	0.212	1	0.645	0.021	1	0.941	2.446	1	0.118	1.992	1	0.158
Water abstraction	0.000	1	0.997	0.048	1	0.826	0.610	1	0.435	0.680	1	0.410
Boating	0.771	1	0.380	0.011	1	0.916	2.586	1	0.108	0.038	1	0.845
Canalisation/resectioning	12.383	1	**<0.001**	12.383	1	**<0.001**	*na*	*na*	*na*	*na*	*na*	*na*
Bank maintenance	0.132	1	0.716	0.132	1	0.716	*na*	*na*	*na*	*na*	*na*	*na*
Disturbance score	10.425	1	**0.001**	11.668	5	**0.040**	2.053	5	0.842	5.279	5	0.383

Appendix 11 Logistic regressions where the dependent variable was otter presence/absence (0/1) during 2023-24 with separate models for each independent variable run for **a)** All-Ireland, **b)** Republic of Ireland and **c)** Northern Ireland.

	a) All-Ireland (*n*=1,063)			**b) ROI** (*n*=919)			**c) NI** (*n*=144)		
Independent variables	**Wald**	**df**	***p***	**Wald**	**df**	***p***	**Wald**	**df**	***p***
Administrative									
Country (ROI, NI)	0.082	1	0.774	-	-	-	-	-	-
River Basin District	22.315	7	**0.002**	18.923	6	**0.004**	4.409	2	0.110
Designation	4.767	1	**0.029**	2.298	1	0.130	5.212	1	**0.022**
Ecology									
Type (River, lake, coast)	8.370	2	**0.015**	7.277	2	**0.026**	3.922	2	0.141
Elevation	1.987	1	0.159	1.748	1	0.186	0.207	1	0.649
Grassland	0.027	1	0.870	0.057	1	0.811	0.032	1	0.858
Arable	2.545	1	0.111	2.820	1	0.093	0.319	1	0.572
Broad-leaved woodland	28.304	1	**<0.001**	21.884	1	**<0.001**	6.741	1	**0.009**
Conifer plantation	1.661	1	0.197	1.489	1	0.222	0.205	1	0.651
Peatland/Heathland	7.082	1	**0.008**	6.208	1	**0.013**	1.422	1	0.233
Urban	2.302	1	0.129	1.292	1	0.256	1.485	1	0.223
Saltmarsh	3.124	1	0.077	2.367	1	0.124	0.000	1	1.000
Park/Garden	0.436	1	0.509	0.273	1	0.601	0.324	1	0.569
River width	24.587	1	**<0.001**	14.307	1	**<0.001**	14.582	1	**<0.001**
River depth	0.221	1	0.638	0.002	1	0.966	1.468	1	0.226
River current	12.179	1	**<0.001**	9.814	1	**0.002**	3.646	1	0.056
Boulders	22.714	1	**<0.001**	17.238	1	**<0.001**	6.108	1	**0.013**
Gravel	17.457	1	**<0.001**	18.188	1	**<0.001**	0.847	1	0.357
Cobbles	12.527	1	**<0.001**	9.781	1	**0.002**	2.965	1	0.085
Sand	0.325	1	0.569	0.274	1	0.600	0.047	1	0.828
Silt	0.135	1	0.714	0.013	1	0.911	1.555	1	0.212
Trees	10.231	1	**0.001**	8.375	1	**0.004**	2.319	1	0.128
Shrubs	5.316	1	**0.021**	6.070	1	**0.014**	0.076	1	0.783
Wild banks (no maintenance)	8.280	1	**0.004**	6.874	1	**0.009**	1.333	1	0.248
Angling (~ fish)	9.877	1	**0.002**	7.991	1	**0.005**	2.568	1	0.109
American mink	0.529	1	0.467	0.981	1	0.322	0.205	1	0.651
Pressures and threats									
Pollution	0.125	1	0.723	0.166	1	0.684	0.026	1	0.871
Agricultural pollution	0.092	1	0.762	0.205	1	0.651	0.058	1	0.810
Domestic pollution	0.267	1	0.605	1.495	1	0.221	1.941	1	0.164
Industrial pollution	0.212	1	0.645	0.003	1	0.959	1.150	1	0.283
Canalisation/resectioning	12.383	1	**<0.001**	12.757	1	**<0.001**	0.296	1	0.586
Water abstraction	0.000	1	0.997	0.412	1	0.521	1.488	1	0.223
Boating	0.771	1	0.380	0.670	1	0.413	0.097	1	0.756
Disturbance score	10.425	1	**0.001**	4.688	1	**0.030**	9.894	1	**0.002**

Appendix 12 Percentage (%) prevalence of perceived potential impacts at otter survey sites (listed in descending order of prevalence from most common to rarest across all sites; see right hand column) split by country. *na* = variable unavailable (not recorded in database).

Pressure or threat	**Ireland**					**ROI**					**NI**				
	1980s	**2000s**	**2010s**	**2020s**	**Average**	**1980s**	**2000s**	**2010s**	**2020s**	**Average**	**1980s**	**2000s**	**2010s**	**2020s**	**Average**
Angling inc. w/ (re)stocking	45	21	22	22	**31**	44	27	22	24	**34**	49	17	20	13	**25**
Bank maintenance	43	9	13	21	**26**	42	13	15	22	**29**	47	5	9	16	**17**
Siltation	11	30	30	53	**26**	12	30	30	54	**26**	5	30	30	46	**26**
Pollution	23	14	12	36	**22**	20	*na*	11	33	**21**	39	14	14	54	**23**
Agricultural pollution	15	4	9	22	**13**	12	*na*	10	21	**14**	32	4	5	28	**13**
Domestic pollution	15	8	5	19	**12**	12	*na*	3	17	**11**	31	8	9	31	**16**
Industrial pollution	3	1	4	3	**11**	2	*na*	6	3	**15**	3	1	1	5	**2**
Boating	19	9	10	12	**14**	19	7	10	12	**15**	19	10	9	11	**12**
Canalisation/resectioning	9	23	16	14	**14**	9	34	15	14	**14**	8	15	19	15	**14**
Urban land use	12	11	18	13	**13**	12	6	18	13	**12**	16	15	17	15	**16**
American mink	6	6	14	8	**8**	6	15	14	8	**9**	8	0	*na*	10	**3**
Conifer plantation land use	6	5	8	13	**7**	6	4	9	14	**8**	7	6	5	10	**6**
Water abstraction	4	5	5	13	**6**	5	7	5	10	**6**	3	4	5	26	**6**
Disturbance score (0-5)	2.2	0.8	1.3	1.8	**1.8**	2.1	*na*	1.5	1.9	**2.0**	2.3	0.8	0.9	1.9	**1.3**

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