Dublin City Otter Survey

An Action of the Dublin City Biodiversity Action Plan 2015-2020

Prepared by Triturus Environmental Ltd. for Dublin City Council

August 2019

Please reference as:

Macklin, R., Brazier, B. & Sleeman, P. (2019). Dublin City otter survey. Report prepared by Triturus Environmental Ltd. for Dublin City Council as an action of the Dublin City Biodiversity Action Plan 2015-2020.

1. Introduction

1.1 Project background

Triturus Environmental Ltd. consultants were appointed by the Biodiversity Officer (Parks & Landscape Services) of Dublin City Council to undertake a Eurasian otter (*Lutra lutra*) survey, hereafter otter, of the fourteen major riverine watercourses within their jurisdiction. These watercourses included (listed from north to south) the River Mayne, Santry River, Naniken River, River Tolka, River Liffey, River Camac, River Poddle, River Dodder, Owendoher River, Whitechurch Stream, Little Dargle River, Wyckham Stream, Slang River and Elm Park Stream covering 83.8km. Additionally, the approximate 44.7km of coastal boundary of Dublin City Council was also surveyed. The M50 road network served as a working boundary and no reaches of any watercourses upstream of the motorway were surveyed.

The baseline otter surveys, conducted over 2018 and 2019, helped to identify the presence of otters within Dublin City boundaries by identifying the occurrence of otter field signs (i.e. holts, spraints, couches, prints & other signs – see Methodology section below). The distribution of these signs acted as an indicator regarding areas of channel and coastal habitat used by otters, inclusive of potential breeding areas (e.g. holts).

Areas of channel more intensively marked by otter (particularly holting areas) are typically considered to be more significant overall given that they are important breeding areas for the species. Otter communication via sprainting and or territorial marking may increase in areas with higher otter density and associated intraspecific competition with conspecifics (Macdonald & Mason, 1983).

This report will identify the most important areas for otters based on known lower areas of disturbance, characterised by better quality semi-natural river channel with good riparian cover and lower levels of encroachment and or associated disturbance. These areas typically have the highest concentration of otter sign marking and therefore may indicate preferential habitat use by the species. Where good-quality segments of channel are unfragmented, with well-intact riparian corridors, otter sign distribution and associated habitat use may be considered more optimal. In this respect, our survey results will help protect those higher quality areas of less disturbed habitat based on our total corridor otter (TCOS) survey approach (refer to methodology section).

This holistic methodology involves a continuous survey effort in order to comprehensively document otter usage at the river scale; details which can be lost within wider, macro-scale studies. Arguably, the finer-scale detail is more important as it helps rationalise otter marking preferences and consolidate our understanding of otter habitat usage in urban environments. For example, traditional otter survey methodologies involve inspecting rivers from bridges and other more readily accessible areas, whilst only surveying within ~500m upstream or downstream of these points (Bailey & Rochford, 2006; Gallant et al., 2008). Naturally, while surveys at bridges and accessible areas will detect otter, they will miss otherwise cryptic patterns of otter resource utilisation such as, for example, associations with trees such as crack willow and alder (pers. obs.). By surveying discontinuous blocks, such surveys may also fail to locate important otter signs such as holts, which may fall outside the boundaries of traditional survey reaches (e.g. poorly accessible reaches of river).

Furthermore, our holistic total corridor approach helps highlight where otter marking occurs in the context of the whole channel reach and riparian corridor, inclusive of bridge aprons and culverts, thus better informing otter sign marking associations with habitats in the context of disturbance and other attributes driving preferential habitat selection. Such conclusions on otter sign marking are not possible without total corridor surveys and are therefore essential to aid our understanding of urban otter ecology. Consequentially, the findings of the Dublin City otter survey will help focus conservation efforts on reaches of channel that may otherwise be pressurised in the future in the absence of comprehensive survey data. In a similar fashion to the EPA's approach to length of unpolluted channel, we can illustrate, longitudinally, the areas of optimal or degraded otter habitat and help identify where fragmentation has occurred or indeed where opportunities to preserve the most intact corridors exist.

Urban otter ecology

Otters have long been associated with urban river systems (including in Ireland, e.g. O'Sullivan et al., 1994; Sleeman et al., 2005; White et al., 2013) but also transitional and coastal habitats adjoining cities (Kruuk & Kruuk, 2006; Marcelli & Fusillo, 2009). The species is considered vulnerable given their reliance on fish prey sources and sensitivity to disturbance and pollution, in addition to their short life cycle (often <5 years) and small litter sizes (Chanin, 2003). Urban otter ecology will likely become a more important field of learning as cities expand and urbanisation results in further encroachment of otter habitat, meaning the species becomes increasingly visible to the public (should otter populations indeed remain stable within the riverine reaches of post-disturbance channel areas).

Peri-urbanisation has resulted in isolated villages and hamlets joining with urban centres causing unprecedented levels of human use and traffic not present historically (McCourt & Kelly, 2005). According to the most recent 2016 census of Dublin's population, Dublin City and suburbs had a population of 1,173,179 in April 2016 compared to 1,110,627 in April 2011 representing a 5.6% increase in population over this 5-year period. It is known that urbanisation and population increase can cause both direct and indirect disturbance to rivers (and therefore otters) via encroachment and physical change, or indirectly through pollution and other forms of indirect disturbance. With regard the effects of urbanisation and human population increases on otter, changes in habitat quality and associated fragmentation may be deemed an obvious threat.

Further research is required on the distribution of otters relative to pollution gradients on urban rivers, many of which decline in quality as they move longitudinally through cities. Otters were long thought to be useful bioindicators (Ruiz-Olmo et al. 1998) but more recent research suggests otherwise (cf. Reid et al., 2013) given their highly opportunistic diets (Kloskowski et al., 2013) and ability to adapt. It is more likely that the species is useful as a bio-indicator over extremities of water quality rather than at finer scales (pers. obs.). It is thus considered that changes in otter population and health status are likely to occur at the lower end of the WFD status e.g. Q1 and Q2 (i.e. Bad Status, seriously polluted rivers and streams), where salmonid populations are extirpated (Kelly et al. 2007). More research is required on urban and peri-urban otter populations, water quality and fish stocks to establish at what critical level(s) changes in otter populations become apparent, using these and other variables.

Unsurprisingly, it is clear that otter as a species can be affected by human disturbance including encroachment from urban sprawl, storm drain pollution (impacting water quality), physical barriers restricting movement and the removal of cover (e.g. riparian trees etc.). In this respect, studies such as the current Dublin City otter survey (focusing on the human disturbance attribute & river hydromorphological assessment technique) are crucial for the management of urban rivers in light of the expected pressures of urbanisation and human population growth. Otter may be considered a marker species for urban biodiversity given they are a charismatic and beautiful animal which the public can engage with to help improve or conserve urban aquatic environments (e.g. through citizens science initiatives & heritage events).

Summary of objectives

The Dublin City otter survey aims to fill some of the gaps in our understanding of otter ecology by collating both baseline otter sign distribution data and also novel findings on the interaction of human disturbance and otter sign distribution. In summary, the study's primary objectives are;

1. Provide a baseline study of otter sign distribution in Dublin City using a novel total corridor otter survey (TCOS) methodology. This approach will also better-identify existing and potential natal holting areas which typically (but not always) occur in areas of channel not readily accessible to humans.

2. Improve our knowledge of the role of human disturbance and its influence on urban and peri-urban otter sign distribution.

3. Highlight the most pristine areas of urban and peri-urban river channel for otter using indices such as RHAT (River Hydromorphological Assessment Technique).

4. Draw conclusions on where to focus conservation efforts to minimise encroachment and preserve core areas of otter habitat to prevent further fragmentation of habitat and preserve those areas under identified pressures.

1.2 Legislative protection

The Eurasian otter (*Lutra lutra*) is a species of conservation concern and high priority having suffered major declines in its range and population throughout Europe since the 1950s. It is classified as 'near threatened' by the IUCN Red List with a decreasing population trend and, as such, is listed in Appendix I of CITES, Appendix II of the Bern Convention (Council of Europe, 1979) and Annexes II and IV of the EC Habitats Directive (92/43/EEC).

Otters, along with their breeding and resting places, are also protected under provisions of the (Irish Wildlife Acts 1976 to 2012. Otters have additional protection because of their inclusion in Annex II and Annex IV of the Habitats Directive 92/43/EEC, which is transposed into Irish law by the European Union (Birds and Natural Habitats) Regulations 2011 to 2015.

The protection of otters is outlined in Article 51(1) and (2):

Protection of fauna referred to in the First Schedule;

51.(1) *The Minister shall take the requisite measures to establish a system of strict protection for the fauna consisting of the species referred to in Part 1 of the First Schedule.*

51.(2) *Notwithstanding any consent, statutory or otherwise, given to a person by a public authority or held by a person, except in accordance with a license granted by the Minister under Regulation 54, a person who in respect of the species referred to in Part 1 of the First Schedule (listed below). Items (b) and (d) may be considered most relevant to developments.*

- ***(a)*** *deliberately captures or kills any specimen of these species in the wild,*
- ***(b)*** *deliberately disturbs these species particularly during the period of breeding, rearing, hibernation and migration,*
- ***(c)*** *deliberately takes or destroys eggs of those species from the wild,*
- ***(d)*** *damages or destroys a breeding site or resting place of such an animal, or*
- ***(e)*** *keeps, transports, sells, exchanges, offers for sale or offers for exchange any specimen of these species taken in the wild, other than those taken legally as referred to in Article 12(2) of the Habitats Directive, shall be guilty of an offence.*

1.3 Biodiversity policies associated with Dublin City and County

The overarching aim of the draft Dublin City Biodiversity Action Plan 2015-2020 (DCC, 2015) is to conserve biodiversity within the city, including strengthening the knowledge base to inform policy, raising public and stakeholder awareness and enhancing opportunities for biodiversity conservation. This is achieved through adhering to four core themes, namely;

- **Theme 1:** Strengthen the knowledge base of decision-makers for the conservation and management of biodiversity, and protect species and habitats of conservation value within Dublin City

- **Theme 2:** Strengthen the effectiveness of collaboration between all stakeholders for the conservation of biodiversity in the greater Dublin region

- **Theme 3:** Enhance opportunities for biodiversity conservation through green infrastructure, and promote ecosystem services in appropriate locations throughout the City

- **Theme 4:** Develop greater awareness and understanding of biodiversity

The biodiversity action plan also outlines, as one of 28 key actions underpinning these four core themes, the need to collate additional baseline data for legally protected (e.g. Annex I & II) species within the city – including specific focus on otter populations of the Rivers Liffey, Camac, Santry, and Mayne (Action 1). Furthermore, Action 2 acknowledges the need to develop site-specific best management guidelines for legally protected species via key stakeholder consultation. Other actions also place importance on evaluating the biodiversity value of public parks (Action 9), collating and disseminating additional biodiversity data (Action 12 & 14) and generally managing overall biodiversity for the better of all throughout the city.

Therefore, by strengthening baseline data on otter populations within Dublin City Council bounds, this current report will help to compliment, support and achieve the following key objectives (among others) as set out in the draft Dublin City Biodiversity Action Plan 2015-2020;

- **Action 1:** Continue to map the distribution, and assess the abundance and conservation

- **Action 2:** Develop, in co-operation with the National Parks and Wildlife Service, the Dublin Naturalists' Field Club, Birdwatch Ireland, Inland Fisheries Ireland, Waterways Ireland, and other partners as appropriate, site-specific best management guidelines for legally protected species within Dublin City, and communicate with landowners and users.

- **Action 4:** Identify and map areas of conservation value within Dublin City, in conjunction with the National Parks and Wildlife Service, the Dublin Naturalists' Field Club, and other partners as appropriate.

- **Action 6:** Develop, in co-operation with the National Parks and Wildlife Service, the Dublin Naturalists' Field Club, Birdwatch Ireland, Inland Fisheries Ireland, and other partners as appropriate, site-specific best management guidelines for Areas identified under Action 4, and communicate with landowners and users.

- **Action 9:** Evaluate the biodiversity potential of public parks participating in the Green Flag Award Scheme

- **Action 12:** Continue to populate Dublin City Council's Geographical Information Systems with up-to-date biodiversity data, and ensure all departments and decision-makers have access to same

- **Action 14:** Work with the National Biodiversity Data Centre, Dublin Bay Biosphere Partnership, and others, to publish up-to-date maps and inventories of taxonomic groups within Dublin City

- **Action 20:** Prioritise the implementation of Actions 1, 2, 4, and 6 within Dublin City's Green Infrastructure Network

- **Action 23:** Communicate biodiversity messages set out in Table 4 through all available channels, and as a feature of all biodiversity initiatives within Dublin City

- **Action 24:** Prepare and implement an annual biodiversity awareness programme

- **Action 25:** Review all Dublin City biodiversity resources, update where appropriate, and develop a 'frequently asked questions' document for biodiversity matters in Dublin City

As otter records are often fragmented and catchment-wide studies in larger geographical areas are not routinely undertaken, the current study of otters in watercourses and habitats within DCC jurisdiction[1] will help consolidate a robust baseline that can be compared with any forthcoming studies. Future efforts in conservation can then be measured relative to repeated censuses of otter populations within the city, whilst information on otter can be more effectively communicated to key stakeholders and the general public alike.

[1] The Dublin City otter survey was focused within DCC jurisdiction but also extended outside the boundary to upstream river habitat extents as marked by the boundary of the M50 (i.e. Fingal County Council, South Dublin City Council and Dún Laoighre-Rathdown County Council jurisdictions)

2. Methodology

2.1 Study site description

Dublin City Council is one of four councils in the wider Dublin region and covers an area of approx. 115km^2. Numerous large, medium and small watercourses flow through the area and four Special Areas of Conservation (notably South Dublin Bay SAC) and two Special Protection Areas (notably South Dublin Bay and River Tolka Estuary SPA). A number of (proposed) National Heritage Areas (pNHA) are also contained within, or adjoin, the region.

Fourteen riverine watercourses were surveyed for otters in addition to approx. 44.7km of coastline. These are presented on Figure 2.1 and Table 2.1 below. Whilst none of the riverine watercourses in the survey area fall directly within any Natura 2000 designated sites, a number of rivers discharge into SAC sites – River Mayne (Baldoyle Bay SAC), River Santry and Naniken River (North Dublin Bay SAC) and Elm Park Stream (South Dublin Bay SAC). Additionally, several watercourses flow into SPA sites – River Mayne (Baldoyle Bay SPA), River Santry, Naniken River and River Tolka (North Bull Island SPA) and the Elm Park Stream (South Dublin Bay and River Tolka Estuary SPA).

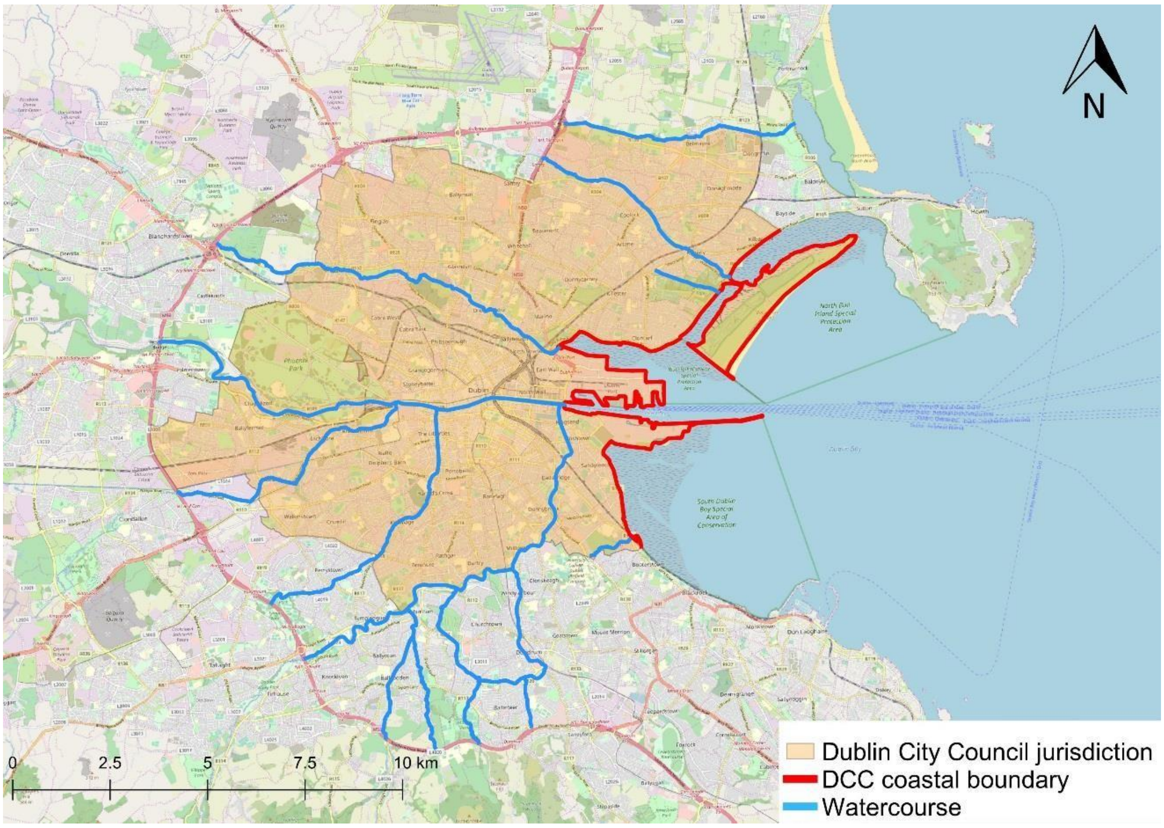

Figure 2.1 An overview map of the Dublin City Council study area, highlighting the watercourses surveyed for otters between April 2018 - April 2019

Table 2.1 List of watercourses surveyed as part of the Dublin City Council otter survey 2018-2019

Watercourse	Named tributaries	Length of channel surveyed (nearest 0.1km)
Coastal boundary	n/a	44.7
River Liffey	None	12.1
River Dodder	Owendoher River, Little Dargle River, Slang River	12.3
River Tolka	None	10.5
River Poddle	None	7.9
River Camac	None	7.3
River Mayne	None	6.3
Santry River	None	6.1
Little Dargle River	Ticknock Stream (culverted)	5.1
Slang River	Wyckham Stream	5.1
Owendoher River	Whitechurch Stream	3.8
Whitechurch Stream	None	3.2
Naniken River	None	1.7
Wyckham Stream	None	1.2
Elm Park Stream	None	1.2
Total length of channel surveyed (km)		**128.5**

2.2 Desktop review

A desktop survey of published and unpublished data (see References) for the River Mayne, Santry River, Naniken River, River Tolka, River Liffey, River Camac, River Poddle, River Dodder, Owendoher River, Whitechurch Stream, Little Dargle River, Wyckham Stream, Slang River and Elm Park Stream (plus associated smaller tributaries) within Dublin City Council jurisdiction was undertaken in respect of otter. Relevant data pertaining to otters held by the National Parks & Wildlife Service (NPWS) and National Biodiversity Data Centre (NBDC) was also reviewed. Our results are, however, presented independently of these records and thus are all contemporary and recorded in between April 2018 and April 2019. Detailed descriptions of each watercourse surveyed are presented in the section 3 below. Furthermore, the Environmental Protection Agency (EPA) biological water quality database was reviewed and water quality data was summarised for each watercourse where available.

2.3 Walkover surveys

Field surveys for the River Mayne, Santry River, Naniken River, River Tolka, River Liffey, River Camac, River Poddle, River Dodder, Owendoher River, Whitechurch Stream, Little Dargle River, Wyckham Stream, Slang River and Elm Park Stream, as well as along the DCC coastal boundary, were conducted between April 2018 and April 2019 during dry spells in mild, settled, bright conditions. This ensured that a good representation of habitat marked by otter could be recorded in the field including territorial marking or marking of feeding (fishing) areas. The survey was deliberately conducted during prolonged dry periods (≥72 hours of dry weather) to not only ensure that all habitat used by otter could be accessed safely but also that the extent of otter signs (spraint, smears etc.) washed away due to recent rainfall events was minimised.

Where practical and safe, watercourses were surveyed from within the channel (with appropriate PPE) as well as along both banks. Any nearby waterbodies (≤250m) such as park ponds or water reservoirs deemed to have otter potential were also included in the survey, regardless of water connectivity. This contemporary all-inclusive methodology is preferable, as infrastructure can cover large linear footprints and may overlap breeding or resting areas (e.g. holts), which may be missed by searching pockets of habitat rather than larger reaches of channel or intertidal areas. In this fashion, our survey methodology is preferred in the context of developments and built-up, urbanised areas as it is more descriptive and informative than traditional surveys.

2.4 Total corridor otter survey (TCOS)

The walkover surveys broadly followed the best practice survey methodology for otter as recommended by Lenton et al. (1980), Chanin (2003) and Bailey & Rochford (2006). However, our methodology differed in that the entire waterline was surveyed rather than the standard 500-600m sections from accessible points (e.g. bridges). In this respect, the novel survey technique is known as a **total corridor otter survey (TCOS)**, representing riparian zone and in channel surveys along both banks of an entire river or river section (the former representing disjunct sections of river channel within a catchment).

Total corridor survey methodology typically involves the use of two (or more) surveyors working independently in tandem along each respective bank of an individual watercourse (where applicable). This facilitates one to work from a more elevated position (e.g. bank top) with one surveying (with appropriate PPE such as a wet suit or chest waders) from within the channel, thus greatly increasing the likelihood of otter sign detection. This is especially true of more cryptic signs such as holts, which can be located in undercut banks, under tree root systems etc. out of the view of traditional surveys. The surveyors can alternate between the river and either bank depending on surveyor knowledge and experience of preferential areas of habitat likely to be used by otter. On smaller watercourses, or in coastal habitats, a single surveyor may be adequate although multiple personnel approach naturally facilitates a higher degree of detection when recording otter signs, and has added health and safety benefits. Where a reach of channel is not safely accessible on foot (e.g. section too deep or fast-flowing), we recommend the use of a small personal watercraft (e.g. kayak, boat).

Each watercourse or habitat is divided into equal 500m sections of channel to enable more effective data evaluation against other indices such as River Hydromorphological Assessment Technique (RHAT) and our newly formulated Human Disturbance Index (HDI) (see section 2.7 below).

2.5 Glossary of otter field signs

Collectively, otter field signs are found through careful observation and thus surveys require concentrated effort. A glossary of the definition of otter terms is presented below as prepared by the report authors. Each sign, where recorded, was logged by type, location (GPS), condition and age for later interpretation to distinguish differences in habitat use and activity.

To allow greater data resolution, spraints were categorised and aged as follows; fresh (very recent), old (spraint breaking down & not recently deposited) and mixed age (recent & older spraints together, typically indicative of a regular sprainting site). Photographic records were also taken for each sign. Furthermore, indicative counts of spraint (i.e. number of individual spraints) and the number of sprainting sites (often separate clusters in one area) were colle cted. This helped indicate the frequency of otter marking, which can also help infer higher levels of activity in particular parts of a catchment or river channel.

- **Holts** vary greatly from enlarged burrows created by other mammals to cavities within tree roots and rock piles. Adjoining rocks, soft substrata, grass and large woody debris are often marked with spraint or scratched (Triturus pers. obs.) to mark breeding territory. While some authors have speculated that natal (breeding) holts are not marked, this appears to simply be a function of the period when the females are underground (primarily February/March to July) and thus not actively marking breeding territory. Holts also tend to be located above normal river spate levels to avoid flooding (pers. obs.) with the alder (*Alnus glutinosa*) zone of riparian areas being an important area for holt situation.

- **Slides** can be ~200mm wide and variable in length depending on embankment height, sometimes pitted with prints in mud and occasionally with characteristic tail 'trail' marks in softer substrates such as estuarine mud. On grassy banks trails are often worn and always lead to or from the water. Wet slides help identify otters given the species' aquatic lifestyle.

- **Couches** (resting areas that are not subterranean) often occurring within a few meters of the bank near the bank top or on tree root systems. They often occur on grassy promontories were otters rest and consume prey or roll, muzzle wood and grass and mark such areas with latrines (either in mud or grass). They can also occur under bridges (near abutments) and are recognized by an area where the grasses or bank substrates have been flattened or intensively scent marked or sprainted (e.g. bridges) with frequent signs of activity. They differ from holts in that they are typically on exposed open banks but can also occur under tree roots, where physical burrowing has not been undertaken (i.e. thus distinguishing them from an excavated holt).

- **Spraints** (faeces, scat) are short, rounded segments, containing prey remains such as fish bones and or scales, bird/small mammal remains, crustacean/mollusc shell or carapace fragments (e.g. crayfish) etc. They are highly variable in colour and texture, ranging from black, green, brown and yellow in freshwater to lighter grey or whitish in estuaries. Spraints are most often found on banks of watercourses and typically positioned on prominent bankside features such as on logs, ledges, promontories or on rocks, grass, mud and sand above water level. They are routinely used by otters as a form of intra-species communication regarding breeding availability, territorial claims and fishing locations.

- **Smears and jellies** are a distinctive sub-type of spraint being completely gelatinous or with very little fragments, typically brown in colour (being less variable in colour form than spraints). They are, however, like spraints deposited strategically on boulders, rocks and ledges and appear to have a communicative function.

- **Latrines** are piles of spraint associated with scrapes and digs on substrates of grass, gravel, sand etc. and are often found on prominent, high points along the banks of streams, bays or along crossover trails between water bodies. The vegetation is usually flattened out, and the area may contain numerous piles of otter spraint, often comprised of fish scales or crustacean/molluscan parts. Latrines are associated with the digging behaviour of otter, thus distinguishing them from sprainting sites. In this respect, a small pit is dug with paws in grass or soft substrata (resulting in a twisted ball of grass or small heap in soft substrata) on which spraint is deposited. Latrines on grass have also been referred to as 'seats'. Latrines can also occur in gravel, sand and mud.

- **Prints & tail markings** typically showing only heel pad and claw marks. Otter toes fan out widely and are conspicuous, but inter-toe webbing rarely prints, except in mud. They are readily distinguishable from badger (wide pad and four toe prints), fox (two toes forward) and mink (star shape). Running stride or bounding paw prints are typically between 300-600mm apart. On soft mud, tail marks can also form behind prints where the tail drags in the soft substrate.

2.6 River Hydromorphological Assessment Technique (RHAT)

In order to evaluate and catalogue the degree of riverine habitat 'naturalness' along the *n*=14 watercourses (coastal habitat excluded due to unsuitability), in terms of their overall ecology and suitability for otter, the River Hydromorphological Assessment Technique (RHAT) was used (after NIEA, 2014).

RHAT expands on the previous standards for river surveys, such as the River Habitat Survey (RHS) methodology (EA, 2003). It is assumed that natural systems support ecology better than modified systems. Hence, the RHAT method classifies river hydromorphology based on a departure from naturalness and allows for the assignment of a morphological classification directly related to Water Framework Directive (WFD) status (Table 2.2), i.e. High, Good, Moderate, Poor or Bad.

Score calculation is based on eight semi-qualitative and quantitative hydromorphological criteria, namely:

- Channel morphology and flow types
- Channel vegetation
- Substrate diversity and condition
- Barriers to continuity
- Bank structure and stability
- Bank and bank top vegetation
- Riparian land use
- Floodplain interaction

The RHAT is designed to be a holistic visual assessment based on information from both desktop and field (walkover) studies incorporating GIS data, aerial (ortho) photography and historical data. The RHAT method was developed for WFD classification, but it also has other applications including assessing morphological pressures at a site and inferring the likelihood of otter usage (see Results, Discussion).

Following best practice (NIEA, 2014), RHAT walkover surveys were undertaken along the surveyed watercourses when instream and riparian vegetation growth was still visible and readily identifiable over the April 2018 to April 2019 period. Additionally, further walkover surveys were also conducted in the winter months to coincide with low riparian vegetation growth to better view river bank structure, which in summer can be heavily overgrown. This temporal, multi-seasonal approach facilitated a better overall assessment of the habitats and morphological features along the river corridors and was deemed beneficial to the overall RHAT data collation process. Each river was assessed in discrete 500m sections, along both banks (left and right, facing downstream).

For further detail please refer to the RHAT Training Manual (NIEA, 2014).

Table 2.2 RHAT hydromorph scores and their corresponding Water Framework Directive (WFD) classification

Hydromorph score	WFD Status
≥0.8	High Status
≥0.7 ≤0.8	Good Status
≥0.5 ≤0.6	Moderate Status
≥0.3 ≤0.4	Poor
≤0.2	Bad

2.7 Human Disturbance Index (HDI)

In order to assess the relative impact of human-related disturbance on otter distribution and habitat usage throughout the study area, the novel Human Disturbance Index (HDI) was formulated by the authors of this report.

In short, the HDI assesses a length of river channel in discreet 500m sections (to better correspond to RHAT, above) and scores both banks in terms of three broad yet key disturbance-related categories, namely;

- Human activity (category A)
- Land use (category B)
- Human accessibility & otter seclusion (category C) (not taken to be mutually exclusive)

Scores for each disturbance category are assigned to both banks of a given river section (left and right, facing downstream), ranging from a minimum of 0.2 (best, lowest disturbance) to a maximum of 1.0 (worst, highest disturbance) (see Table 2.3). This results in a total of six individual scores for any given 500m section of bank (left or right), which can be considered in isolation (total per bank score, as below) or simply added together and averaged between left and right banks to calculate an overall section mean score. The total per bank score for a particular 500m section is as follows, where;

A = human activity, B= land use & C= human accessibility and otter seclusion (X)

X_1 = 0-10m score (from channel edge),

X_2 = 10-25m score (from channel edge),

is calculated as follows (for each bank);

$$(A_1 \times A_2 \times B_1 \times B_2 \times C_1 \times C_2)^{(1\,/\,\text{number of scores})}$$

Owing to the inaccessibility to surveyors, those sections of channel culverted underground (common throughout Dublin City), regardless of length, were excluded from HDI analysis and not scored, even when contained within above-ground 500m sections. However, in this latter case, an objective assessment to the potential value of culvert entrances/exits to otter seclusion from human disturbance was factored into the overall scoring process for a given 500m section.

Table 2.3 Scoring system for each disturbance-related category of the Human Disturbance Index (Macklin & Brazier, manuscript in preparation)

HDI score	Disturbance class
0.8 -1.0	Very high disturbance
0.6 – 0.79	High disturbance
0.4 – 0.59	Moderate disturbance
0.2 – 0.39	Low disturbance

To allow for better resolution of data, scores for both banks are calculated in both 0-10m and 10-25m zones relative to the channel edge, i.e. within 10m of channel edge and 10-25m of channel edge. This allows an average score to be calculated for each bank in a given 500m section and the section overall (both banks combined) and accounts for common discrepancies between disturbance levels along and adjoining a river channel or corridor.

2.8 Biosecurity awareness

In keeping with standard best practice for environmental surveys, the clean-check-dry approach was employed. Furthermore, all equipment and PPE used during the survey (wellies, wading staffs, life jackets, gloves, waders etc.) was disinfected with Virkon® prior to and post-survey completion, and precautions were employed to prevent the potential spread of invasive species and water-borne pathogens, according to best practice biosecurity protocols. All surveys were conducted moving downstream to reduce the risk of introduction of invasives upstream.

3. Site descriptions

The following section briefly describes the hydro-morphology and habitats recorded along each watercourse, as surveyed between April 2018 and April 2019. Individual riverine watercourses are listed below in a north to south orientation and described in a downstream direction. Habitat codes, where provided, follow Fossitt (2000). Species' scientific names are provided (in parenthesis) at first mention only.

3.1 River Mayne

Emanating from lands near Dublin Airport, the River Mayne was a small watercourse approx. 6km in length flowing eastwards through Clonshagh, Belcamp, Balgriffin, Belmayne and Clongriffin before entering Baldoyle Bay at Mayne Bridge (where it intersects the R106 at Baldoyle). The River Mayne was located along the northern boundary of Dublin City Council jurisdiction and represented the northern most river in our study area (i.e. formed the boundary with Fingal County Council).

Shortly downstream of the M50 in the upper reaches of the study area, the River Mayne was culverted underground for some 0.7km under the Clonshaugh Road roundabout (R139) near the Clayton Airport Hotel, before then flowing through a semi-rural landscape, dominated by agricultural grasslands (GA1) and intensive tillage lands (BC3), north of the N32. Here, the river flowed in a deep V-shaped channel <1.5m wide that was heavily scrubbed over with bramble (*Rubus fructicosus* agg.) and bordered locally by riparian treelines comprising of ash (*Fraxinus excelsior*), sycamore (*Acer psuedoplatanus*) and willow (*Salix* spp.). Compacted soils associated with tillage land use evidently increased in-stream siltation via surface water run-off, although the river bed was dominated by moderate quality smaller cobble and coarse gravel substrata.

The river maintained a largely natural profile near Belcamp College, where it flowed through a large area of secluded, mature beech and sycamore-dominated woodland (WD1). The flow rates were low at the time of survey and this would have diminished the fisheries value of the upper reaches. An old artificial lake (FL8) associated with the College offered some good otter and fisheries habitat, although the lake was heavily silted and had been partially drained at the time of survey as a result of a new development in the area. Downstream of Belcamp (under the Malahide Road culvert), the Mayne became more heavily modified as it flowed through the largely residential areas of Belmayne and Clongriffin. The channel became more open and was bordered by amenity/maintained grassland areas (GA2) with little riparian cover. Historical straightening (but not deepening) was evident throughout these middle reaches and the reduced flow rates and slow-glide habitat greatly increased in-stream siltation. Substrata was invariably bedded. Numerous small culverts existed along the length of channel but in-stream barriers (e.g. weirs) were rare and the river maintained moderately good connectivity throughout much of the survey area.

Downstream of Belmayne, the river was again bordered by extensive agricultural lands, with the channel often heavily shaded due to dense riparian vegetation of bramble and willow. As with upstream reaches, the Mayne was typically shallow (<0.2m) and contained limited deeper pool areas, even in the lower reaches adjacent to Baldoyle racecourse. Livestock poaching, bank erosion and subsequent siltation was widespread in this area but some areas of gravel substrata were present locally, improving the fisheries value of the channel. The Mayne adjoined the Baldoyle Estuary at Mayne Bridge, south of Portmarnock, via a road (box) culvert, which was accessible to fish and otter.

The EPA collect biological water quality at one location on the River Mayne at Castlemoyne downstream of the Cuckoo Stream and River Mayne confluence. Biological water quality was recorded as Q2-3 (moderately polluted, poor status) at station (RS09M030500) during 2016 at the Hole-in-the-Wall Road Bridge.

Plate 3.1 The heavily scrubbed over upper V-shaped channel of the River Mayne (downstream of the M50 & N32) near Clonshagh Bridge

Plate 3.2 The open, heavily grazed banks of the lower River Mayne facing upstream towards Clongriffin (located on the Dublin City Council-Fingal County Council boundary)

3.2 Santry River

The Santry River rises in the peri-urban townland of Harristown at Dublin Airport and then flows south east through intensive agricultural lands at Merryfalls and Silloge. On approach to Junction 4 of the M50 it flows through Ballymun and then through Santry and Coolock to the south east entering Dublin Bay near Bettyglen, Raheny.

From the M50 downstream, this small watercourse often less than 1.5m wide was located in a heavily urbanised landscape, much of which had been modified as part of previous flood prevention works. Open grassy areas typically bordered the channel to serve as artificial flood buffers. Although numerous sections of channel were heavily altered (straightened) and bound by retaining walls (e.g. downstream of Malahide Road crossing), the Santry flowed through several open parkland areas where a greater degree of naturalness was present, e.g. Coolock Lane Park, Stardust Memorial Park. However, much of the Santry River was situated in a relatively steep V- or U-shaped channel with little in the way of riparian cover. The open banks were invariably colonised by low-lying herbaceous scrub only, such as nettle (*Urtica dioica*), alexanders (*Smyrnium olusatrum*), hemlock (*Conium maculatum*), hogweed (*Heracleum sphondylium*), willowherb (*Epilobium* spp.), broad-leaved dock (*Rumex obtusifolius*), winter heliotrope (*Petasites fragrans*) and rank grasses. In the more upper reaches, few areas of trees or dense scrub existed outside of the Woodlawn/Coolock Lane Park area, where narrow linear strips of mixed broadleaf woodland (WD1), dominated by alder, bordered the river.

Overall, the Santry was typically a shallow river (<0.2m on average) with slow-flowing glide dominating throughout. Deeper pools were localised and limited and often associated with culverts or small weirs. The lower reaches of the river featured more in the way of deeper pooling areas (>1m depth), where the channel retained a higher level of naturalness and meanders amidst residential housing areas. Public bankside access was possible along much of the survey area (e.g. cycle lanes, footpaths) and levels of disturbance were considered high but typically decreased downstream of the R105 Howth Road crossing. Riparian seclusion was higher in these lower reaches due to riverside fencing or residential (garden) walls preventing access, although such heavily-scrubbed areas were narrow and linear in nature.

A small artificial 0.25ha pond in Stardust Memorial Park was the only such feature along the surveyed area. The pond was shallow (<0.75m), heavily silted and supported a variety of wildfowl and three-spined stickleback (*Gasterosteus* aculeatus). Riparian cover was limited to several areas of willow-dominated vegetation and a large vegetated island. The very lower reaches of the Santry River downstream of the Watermill Apartments near Glenside Lodge and bordering the Watermill Road, flowed through an area of mixed broad-leaved woodland. It comprised predominantly sycamore with ivy ground layer and the river channel was semi-natural channel with gravels and cobbles that were bedded with evident siltation. Where the lower reaches of the Santry intersected the James Larkin Road, the river was culverted to its confluence with Dublin Bay near the Bull Island causeway. Here, a large plunge pool exceeding 1.8m in depth was associated with a large box culvert which was both otter and fish accessible, at least at larger hightides.

The EPA collects biological water quality on the Santry River at two locations, Clonshaugh and Raheny. The upriver sampling station at the Clonshaugh Road Bridge near the Northside Shopping Centre (station RS09S010300) has recorded biological water quality of Q3 (moderately polluted, WFD poor status) during 2016. The lowermost sampling site downstream at the Harmonstown Road near St. Joseph's Hospital (station RS09S010800) recorded a Q rating of 1 in 1988. Q1 biological water quality represents seriously polluted, WFD Bad status water quality. No more recent biological water quality is available. Overall the biological water quality can be summarised as between bad and poor status indicating very poor water quality on the Santry River.

Plate 3.3 Santry River downstream of the Watermill Apartments near Glenside Lodge

Plate 3.4 Santry River confluence with Dublin Bay near the Bull Island causeway

3.3 Naniken River

The Naniken River is a minor river on the north side of Dublin city and a central feature of Dublin's second largest municipal park, St. Anne's Park, Raheny. The river emanates from a culvert on the R105 (Howth Road) and flows eastwards south of the All Saints Road through St. Anne's Park, entering Dublin Bay south of the Bull Island causeway via one-way sluice flaps. The entire 96ha of St. Anne's Park is designated as part of the buffer zone of the Dublin Bay UNESCO Biosphere.

The Naniken River as stated was culverted underground upstream of the Howth Road (R105) and downstream of this point it had been extensively straightened historically through the parklands south of the St. Anne's Road beyond the Raheny Tennis Club. Within the park boundary the river was above ground and flowed for some 1.6km primarily through linear blocks of mature, semi-natural broadleaf woodland (WD1) in a parkland and amenity grassland (GA2) landscape. A range of tree species were present along the channel, including ash, sycamore, horse chestnut (*Aesculus hippocastanum*), elder (*Sambucus nigra*), alder (*Alnus glutinosa*) and beech (*Fagus sylvatica*), with yew (*Taxus baccata*) frequent especially in the eastern end of the park.

The river channel had been historically straightened through much of the park boundary and predominantly lay in a steep U-shaped channel with a bank height of 2-3m - riparian shading was often high as a result. The channel was 1.5m to 2m wide and less than 0.3m deep. The channel base contained bedded gravels with frequent beds of silt. It was not considered of fisheries value apart from perhaps eel or three-spined stickleback (the latter species being observed present). The banks were primarily colonised by low-lying scrub vegetation such as winter heliotrope (*Petasites fragras*), holly (*Ilex aquifolium*), lesser celandine (*Ficaria verna*), and ivy (*Hedera helix*) although some areas of extensive and less-accessible bramble-dominated scrub exist further upstream. In the lowers reaches of channel (e.g. St. Anne's Dog Park), the banks were mostly open and featured high levels of disturbance including bare muddy areas, with public footpaths regularly intersecting and adjoining the river both upstream and downstream of St. Anne's Pitch & Putt course.

Numerous small weirs existed along the lower reaches of the channel and many of the deeper pools within the channel were associated with these areas, but these were limited. Riffle and shallow glide habitat dominated throughout. Although much of the river bed retained a level of naturalness (cobble and coarse gravel dominated), some short sections had been canalised via retaining walls and concrete bases. Siltation was evident throughout the river.

The Naniken flowed alongside and fed a small (0.3ha), artificial park pond (FL8 habitat) in its lowermost reaches. The pond was shallow (<1m), heavily silted and supported extensive populations of wildfowl, with complete public access around its perimeter. Three small, heavily vegetated islands were present. The Naniken adjoined Dublin Bay near Bull Island on a shingle shore via two sluice flaps which likely presented access issues for otters and migratory fish.

No biological water quality data was available for the Naniken River according to the EPA database.

Plate 3.5 The Naniken River flowing through St. Anne's Park, showing open banks and well worn walkaways (i.e. higher human-related disturbance levels)

3.4 River Tolka

The River Tolka was the major river surveyed on Dublin City's north side, with approximately half of its 22km course flowing through urban areas such as Mullhuddart, Ashtown and Glasnevin, before entering Dublin Bay at Clontarf. In the vicinity of the M50 crossing, the river existed in a semi-rural landscape, flowing through extensive areas of dense mixed broad-leaved woodland (WD1) and riparian woodland (WD5) composed of tree species such as alder, crack willow (*Salix fragilis*), sycamore and occasional ash. The river was largely natural in profile in these reaches, with abundant large woody debris (LWD) in stream and generally good fisheries habitat, especially for salmonids. The channel was up to 10m wide and varied between 0.5m and 1.5m deep. Large areas of low-lying ground dominated by reed canary grass (*Phalaris arundinacea*) adjoined the channel upstream of Ashtown (north bank) and served as natural floodplains. Some fields of agricultural grassland (GA1) adjoined the river but overall the level of naturalness was high overall.

Downstream of Dunisea Lane bridge the Tolka flowed through Tolka Valley Park and became exposed to high levels of human-related disturbance throughout. The channel maintained a largely natural profile, with more deeper pools and faster glides than upstream but the riparian zones, largely due to unmitigated livestock access, were largely open and offered poor seclusion for otter throughout the parkland. Some fragmented mature bankside treelines were present but typically the banks were maintained, modified and open. Bankside boulder revetments (flood defences) were frequent throughout Tolka Valley Park and the channel was historically modified, with multiple adjoining storm drains and evidence of straightening in certain sections. Nevertheless, some natural profile remained and good fisheries habitat was present although widespread siltation of instream hard substrata was evident. A series of three small, heavily-vegetated artificial ponds (FL8) near Cardiff's Bridge, lined with common reed beds, supported wildfowl populations and showed potential for otter usage but levels of human disturbance were high.

Downstream of Tolka Valley Park, the river became deeper (mostly >1.0m) and slower and flowed through the National Botanical Gardens and Griffith Park, both high-use amenity areas with high levels of human-related disturbance. Although the river maintained a good natural profile throughout the Botanical Gardens, retaining walls were frequent and the quality and cover of riparian zones became lower. Throughout Griffith Park the river was evidently historically straightened and bound by retaining walls with a concrete base and open banks. A number of major and minor weirs were present on the Tolka throughout the study area but few offered significant barriers to otter passage.

High retaining walls were characteristic of the Tolka in its lower reaches, with few sections retaining natural banks downstream of the N135 road crossing. This offered seclusion for otter despite the close proximity of human disturbance. The Tolka supported some good cobble and gravel substrata throughout the study area and fisheries habitat was often good, especially for brown trout (both wild and stocked fish).

Below Drumcondra, the Tolka was subject to tidal influences and, like many lower reaches of rivers, was bound by retaining (quay) walls in a 20-30m heavily modified, canalised channel. It flowed under the M50 Port Tunnel crossing and joined Dublin Bay at East Point business park.

Plate 3.6 The upper reaches of the River Tolka survey reaches near the M50 showing a low-disturbance, semi-natural channel

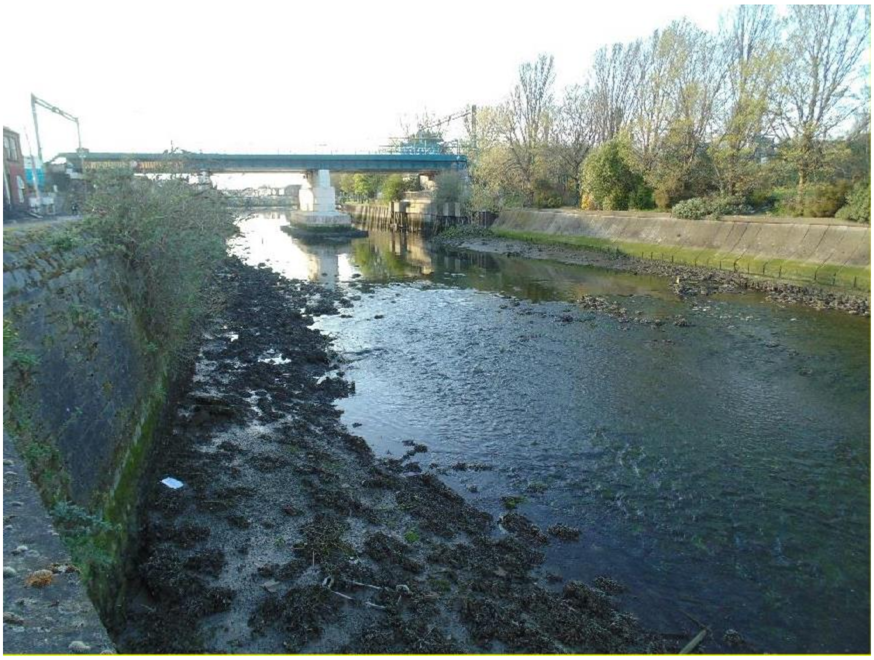

Plate 3.7 The River Tolka in the lower tidal reaches showing modification and retaining quay walls

3.5 River Liffey

Dublin's major watercourse, the River Liffey, was surveyed between the M50 at Waterstown Park (Palmerstown), through Chapelizod, Islandbridge and Dublin City centre as far as the East Link Toll Bridge (Tom Clarke Bridge) at Ringsend. The River between Palmerstown and Chapelizod was characterized by primarily deeper water (1-2m) with moderate flows of water subject to fluctuations from upstream hydroelectric operations. In this area the riparian zone was largely continuous, with mature tree species including crack willow, grey willow, sycamore, beech, elder and ash.

The river continued in a deep channel with localised faster runs between Chapelizod and Islandbridge, the Islandbridge area being notably slower moving behind the large weir. This area is well known as popular area for canoeing and walking in the adjoining parklands. In the river between Chapelizod and Islandbridge a number of river islands existed, the most extensive being downstream of the Islandbridge Weir with some smaller islands upstream at Laurence Brook. These islands were predominantly of willow and alder with ground indicator species of low disturbance and perhaps more ancient woodland, such as ramsons (*Alium ursinum*), wood anemone (*Anemone nemorosa*) and toothwort (*Lathraea squamaria*). Downstream of Islandbridge the river was tidal and contained between quayside walls and often rocky revetments. Often the banks were heavily scrubbed over and very steep, particularly in the area adjoining Heuston Station. The River Camac also formed a confluence with the River Liffey via an underground culvert near Heuston Station.

As the Liffey progressed further through the city centre there were few accessible areas of bankside to otter with the exception of a small number of quayside steps between St. James Gate and Custom House Quay. Downstream of Samuel Beckett Bridge, the MV Cill Airne floating restaurant, offered an accessible floating platform to otter, which was heavily marked with spraint. Opposite this area the numerous steps and floating platforms of Grand Canal Harbour and the mouth of the River Dodder were also marked by otter. Indeed, otter sign marking density increased at the mouth of the River Liffey and extended to the Poolbeg lighthouse area where spraints were recorded on quayside steps.

Biological water quality data is available from three locations on the River Liffey, at Palmerstown, Chapelizod and Islandbridge. The biological water quality data recorded near the Mill Lane Studio, Palamerstown at EPA station (RS09L012327) during 2002 was Q3 (moderately polluted water). Downstream at EPA station (RS09L012330) 1km upstream of Chapelizod Bridge the biological water quality was recorded at Q3 (moderately polluted) during 2005. The lowermost EPA station (RS09L012400) at Islandbridge near the UCD Boat Club recorded a Q rating of Q3 in 1991 (moderately polluted, WFD poor status water quality). In summary, water quality at all stations from historical water quality data indicates WFD poor status, moderately polluted water quality on the lower River Liffey.

Plate 3.8 The River Liffey at Waterstown Park, Liffey Valley Park in the upper survey reaches

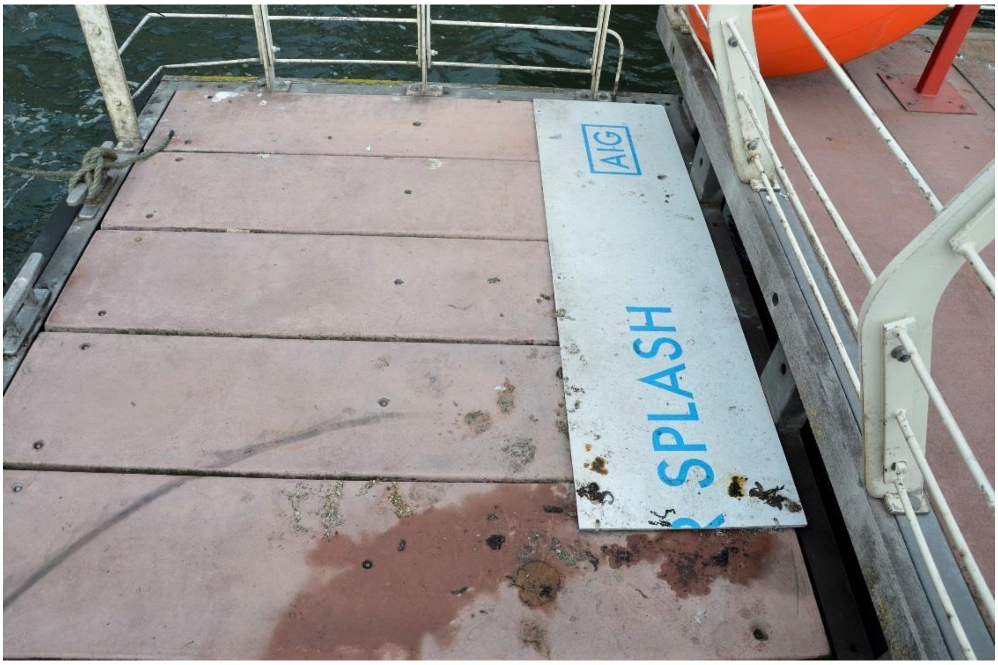

Plate 3.9 A very regular sprainting site (showing fresh otter prints) on the River Liffey at the MV Cill Airne floating restaurant in Dublin City Centre. An active holt was also present alongside this pontoon in a quay wall.

3.6 River Camac

The River Camac rises on the western slopes of Mount Seskin and then flows westward into Brittas Lake. After flowing out of the lake it continues north through Saggart and then north east through Clondalkin, Gallanstown, Bluebell, Inchicore and then forms a confluence with the Liffey at Kilmainham upstream of Sean Heuston Bridge (Heuston Station). The Camac has a catchment length of 24km and approximately 6.5km within our study area between the M50 and the River Liffey.

The River Camac becomes increasingly modified downstream of Clondalkin and the M50 at Gallanstown at the start of the survey area. In this respect the river is characterised by a U-shaped channel that had been historically dredged and straightened, often held within retaining walls. For example, where the River Camac emerges from a box culvert under the M50 at the Riverview Business Park, the channel was held in a channel with gabion matressing and or retaining walls and was heavily scrubbed over with bramble. The channel averaged 4-5m wide at this point and 0.4m deep on a bed of cobble and gravel that was bedded and suffering from moderate to heavy siltation. Incidentally, no crayfish were observed present downstream of the M50, while evident extant populations exist upstream at Clondalkin (pers. obs.).

Downstream of Park West Avenue, the Camac bordering Nangor House had a more well-developed riparian zone with mature sycamore and willow with good riffle and glide sequences. The habitat improved for otter but downstream at the Toyota material handling plant the river became more open with modifications such as box culverts, weirs and heavily managed banks, characteristic of industrial sites. Indeed, the heavily industrialised area of Bluebell resulted in 1km of the River Camac being culverted underground downstream of the Toyota plant as far as the City Link Business Park. The river was again accessed via the Sheldon Park Hotel where steep retaining walls bound the channel. Despite limited opportunity for riparian vegetation, fringes of willow trees growing on alternate margins (north and south bank) of the channel provided cover for otter and locally merged with extensive banks of bramble. There was no access for people or dogs by virtue of the impounded channel shape meaning cover existed for otter. Here, the river often comprised deeper glide but locally faster riffle and glide runs were present also.

The River Camac channel again became culverted at Bluebell House only to emerge circa. 1km to the south east at the Landsdowne Gate apartments at Landsdowne Valley before taking a northerly course towards Inhicore. The Landsdowne Valley area had open parkland on the eastern bank with frequent access by people and dogs with more restricted access in the mixed broad-leaved woodland on the western bank. The channel of the Camac in this area was V-shaped with mixtures of pool, riffle and glide habitat and a bed of boulders, cobble and gravels. Water quality was moderate at best but certainly had potential to support a low-density salmonid population.

Between the Goldenbridge Industrial Estate on the Tyrconnell Road and South Circular Road near the Kilmainham Jail Museum the River Camac had a good semi-natural profile with relatively good riparian cover for a river heavily encroached by urbanisation. Riffle and glide sequences provided for some moderate quality brown trout habitat with trout observed in pools providing food for otter. Minnow (*Phoxinus phoxinus*) and stickleback were also observed present locally. Downstream of South Circular Road as far as Dr. Steven's Hospital near Heuston Station (where the Camac becomes culverted before entering the Liffey), the River Camac was heavily straightened and modified. It was characterised by retaining walls with properties engulfing the entire riparian zone with many sections of the bed concreted, although the riparian zone improved between Old Kilmainham Village and St. Patrick's Hospital.

EPA water quality was recorded at two stations on the River Camac at Bluebell and Inchicore. Water quality at Kylemore Road Bridge (Bluebell) was recorded as Q3 (moderately polluted, poor WFD status water quality) in 1998 with no more recent biological water quality data available (EPA webmapper accessed April 2019). Further downstream at the second EPA station on the River Camac near Emmet Road at Inchicore (station RS09C020500), a Q rating of 3 was recorded in 2016 (moderate status, poor WFD status water quality).

Plate 3.10 Ross Macklin examining otter prey remains on a crack willow trunk on the upper survey reaches of the River Camac, where the river retained some semi-natural characteristics compared to downstream

Plate 3.11 The lower River Camac at Kilmainham, heavily modified and bound by retaining walls

3.7 River Poddle

The River Poddle was a major tributary of the River Liffey, which it joined at Ushers Quay in Dublin City centre following extensive underground culverting (approx. 3km) from Mount Argus Park, Kimmage. The Poddle was culverted below ground for almost half of its short length.

Downstream of the M50 box culvert (no otter ledges), the Poddle fed a series of three small lakes in Tymon Park, a large area of amenity grassland (GA2). The lakes (0.25ha, 0.15ha and 1.5ha) were all shallow in depth (<1.5m) with a silt base and supported extensive wildfowl populations as well as limited fish stocks (e.g. three-spined stickleback and European eel (*Anguilla anguilla*)). Some fragmented but dense areas of common reed (FS1) and willow scrub (WS1) habitat existed in the vicinity of the two smaller ponds, which provided seclusion for otter from the general public.

Downstream of Tymon Park, the river was historically straightened and modified throughout, typically narrow (<2m) and shallow (<0.25m), with a silted bed (over gravels). In-stream macrophytes were limited but beds of fool's watercress (*Apium nodiflorum*) and the non-native Nuttall's pondweed (*Elodea nuttallii*) were present locally. The channel became more heavily scrubbed downstream of the park boundary, with often steep V-shaped banks, but as it flowed through extensive residential areas of Kimmage the river was frequently open and U-shaped in profile with a general lack of riparian cover and a low-lying herbaceous layer. Culverts and associated trash screens (many limiting access to otter) were increasingly common moving downstream, as were retaining walls (e.g. Poddle Park). River hydro-morphology was typically uniform, with slow-flowing glides, limited pools and silted substrata. Storm drains also adjoined the Poddle at regular intervals and were evidently impacting water quality.

In Mount Argus Park, a small, shallow (0.3m) artificial pond (FL8) existed with a concrete base and banks. Retaining walls directed the river over a fish-impassable weir at the pond outflow and underground for the rest of its course as far as the River Liffey at Ushers Quay.

The EPA have collected historical biological river water quality data on the River Poddle upstream of the Kimmage Manor, Kimmage during 2007 at station (RS09P030400). The biological water quality was recorded as Q3 (moderately polluted, poor status).

Plate 3.12 The River Poddle at the upstream extent of the survey area in Tymon North Park near the M50

Plate 3.13 The River Poddle at Poddle Park showing heavy modification prior to underground culverting at Mount Argus Park

3.8 River Dodder

One of Dublin's major watercourses, the River Dodder rises at Kippure Mountain in the Wicklow Mountains and flows in an arc to the sea over a course of circa 29km. It takes a north-easterly course through various suburbs of Dublin City - Templeogue, Terenure, Rathfarnham, Rathmines, Clonskeagh, Donnybrook and Ballsbridge - and enters the River Liffey near the Grand Canal Harbour at Ringsend.

Although the River Dodder flowed through an increasingly urbanised landscape downstream of the M50 crossing (near Junction 11), the river maintained a relatively high degree of naturalness in form and profile. Typically for a lowland depositing watercourse (FW2), the Dodder averaged 10-15m in width and was dominated by slow, relatively deep glide habitat, often over 1.5m in depth. The substrate throughout was dominated by cobble and boulder with high fractions of coarse and medium gravels. Historical straightening was evident in certain areas but this was largely confined to the lower reaches (e.g. Herbert Park and tidal sections), where retaining walls were more common (typically both banks) and often restricted access for otter to the riparian zone. The river became tidal near Lansdowne Road.

The Dodder was bisected by many pedestrian and road bridges given its urban location but, unlike the majority of the smaller rivers within the city, was not culverted underground. A characteristic of the Dodder was the high number of in-stream barriers in the form of man-made weirs. Some of these were considerable barriers to otter and fish passage due to their scale and design (e.g. Beaver Row and Orwell Row weirs), although the weir pools associated with these structures often provided optimal foraging habitat for otters (good salmonid and eel habitat).

The Dodder flowed alongside various public parks and high-value amenity areas, such as Herbert Park and Bushy Park, the latter of which supported some of the most extensive woodland remaining in Dublin City. Public accessibility was high along the river (footpaths, cycleways, roads), but the riparian zone was usually well-developed in more upper sections with many mature and continuous treelines (WL2) dominated by sycamore, alder, elder and ash on steeply sloping banks. Such habitats were often present on both banks of the river and prevented or reduced human access to many areas. Further downstream, in more urbanised or populated areas (e.g. Patrick Doyle Road), high, walled banks often prevented human access to the river channel and thus provided valuable seclusion for otter.

The EPA collect biological water quality data from 6 stations on the River Dodder between the M50 and its confluence with the River Liffey. We have summarised three locations at Templeogue, Terenure and Ballsbridge to provide an even, longitudinal spread of water quality records. The furthest upstream site, downstream of M50 Junction 11, in Dodder Valley Park (EPA station RS09D010430) recorded biological water quality of Q3 in 2002 (moderately polluted, WFD poor status water quality). Downstream at Terenure on the Lower Dodder Road (station RS09D010700), the EPA recorded biological water quality of Q2-3 in 1991 (moderately polluted, poor status). The lowermost EPA biological water quality monitoring station (RS09D011000) is located at Ballsbridge near the Pembroke Place. Biological water quality was recorded at Q2-3 (moderately polluted, WFD poor status water quality) in 1984. In summary, biological water quality can be considered as moderately polluted, WFD poor status on the River Dodder.

Plate 3.14 The River Dodder at the M50 crossing

Plate 3.15 The River Dodder at Dodder Road showing one of many major weirs along the middle and lower reaches of the river

3.9 Owendoher River

The Owendoher was the largest tributary of the River Dodder, which it joined opposite Bushy Park near Rathfarnham. The Owendoher may be an English derivation from the gaeilge 'Abhainn an Dobhair' or river of the otter. Near the M50 crossing of the Owendoher (111m elevation), the river flowed down a steep natural gradient over a large man-made chute block spillway (to prevent flow erosion). Although the river has a long history of modification (once supported some 22 mills; McEntee & Corcoran, 2016), the upper survey reaches (Edmondstown) displayed a high level of naturalness, flowing over a moderate gradient through a good example of sloping, semi-natural broad-leaved woodland (WD1), dominated by beech, sycamore, willow and occasional cherry laurel (*Prunus laurocerasus*). The river here represented an upland eroding watercourse (FW1), with plentiful large woody debris (LWD) in-stream and well-represented characteristic cascading riffle-pool sequences in a V-shaped valley. The river, often flowing over bedrock, meandered through the woodland and natural bank erosion (scouring) was evident in many areas. Salmonid fisheries value was considered very good, with good spawning and nursery habitat throughout, with ample deeper pools. Seclusion levels for otter, given the steep, sloping banks, well-developed riparian zones and lack of direct access for humans, were high.

Moving downstream, the Owendoher River continued to flow alongside the R115 road and entered the more urbanised, residential area of Ballyboden. However, despite this and the increasing number of bridges, road crossings and minor culverts, the river maintained a relatively high seclusion from direct bankside disturbance given dense riparian vegetation and high walled or fenced-off banks. Again, the river retained much of its natural profile and form, flowing over a coarse gravel, cobble and boulder-dominated bed with high riparian shading from mature vegetation. Tunnelling was high in certain areas due to heavy canopies of species such as rhododendron (*Rhododendron ponticum*), which likely reduced fisheries potential. Several weirs were present along the survey area and some present access issues to otter and migratory fish alike, e.g. weir at Ballyboden Bridge.

Downstream of the Whitechurch Stream confluence (at Fairbrook Lawn), the Owendoher became wider (10m average) with higher flows, leading to more a cobble-dominated habitat. Fisheries value remained high, as did seclusion for otters given the increasingly scrubbed-up banks not accessible from adjacent residential areas or roads. In its lower reaches, the river again flowed through linear tracts of broad-leaved woodland before joining the River Dodder via a short underground culvert under the R112 road, which was reasonably accessible to otter.

Plate 3.16 The upper survey extent of the Owendoher River near Edmondstown Road showing a highly natural river channel with high otter potential

Plate 3.17 The lower survey reaches of the Owendoher River, downstream of the Whitechurch Stream confluence, showing an increased level of modification but a still well-developed riparian zone

3.10 Whitechurch Stream

The primary tributary of the Owendoher River, the Whitechurch Stream was a medium-sized watercourse displaying a relatively high degree of naturalness throughout the survey area. From the M50 downstream, the channel flowed for approx. 3km before its confluence with the larger Owendoher.

The upper survey reaches of the Whitechurch bordered Marlay Park and the Whitechurch Road, flowing through a semi-natural landscape bordered by small pockets of mature broadleaved woodland (WD1) and, later, landscaped residential gardens (GA2). The stream represented an upland eroding watercourse (FW1) in this area, cascading over a cobble-boulder substratum and several, steep man-made weirs along the Whitechurch Road. The Whitechurch also flowed through two golf courses (Edmondstown and Grange golf clubs) before meandering through St. Enda's Park in mature mixed broadleaf woodland.

Downstream of St. Enda's Park the stream flowed alongside the Whitechurch Road through increasingly urbanised areas. Similar to the neighbouring Owendoher, the channel retained relatively high seclusion levels owing to the lack of human access to the stream due to retaining walls, fences and well-developed riparian zones, i.e. dense scrub and some mature treelines. The stream averaged 3-4m in width in its lower reaches, <0.3m deep and was composed of riffle and glide-dominated habitat over cobble and boulder substrata. Some deeper pools were present locally in a deep U-shaped channel which retained many semi-natural characteristics and good salmonid and eel fisheries value. Adjoining storm drains increased in frequency moving downstream. Both large woody debris and natural bank erosion were frequent, often leading to channel blockages but this presented some good fisheries habitat and otter foraging opportunities. Several weirs limited access for otters and (especially) upstream fish migration in the lower reaches and much of the stream was (box) culverted underground downstream of the Rathfarnham Ford dealership. Overall, connectivity with the Owendoher was reasonably good, however.

The EPA collect biological water quality at one site on the Whitechurch Stream at Whitechurch downstream of the M50. Biological water quality at EPA station RS09K060600 near Willowbrook Grove (Whitechurch) was recorded as Q3 (moderately polluted, WFD poor status water quality) in 1991. No more recent biological water quality was available for the river.

Plate 3.18 The middle survey reaches of the Whitechurch Stream near Willbrook showing a semi-natural channel amidst residential areas

3.11 Little Dargle River

The Little Dargle was a small tributary of the Dodder, flowing in a south-north direction for approx. 4.5km downstream of the M50 crossing. At the upper point of survey, having been culverted under the M50, the river was <1.5m wide, heavily modified (retaining walls, boulder revetments, straightened historically) and culverted under the R113 College Road. From there, the river flowed in a braided fashion through Marlay Park, an extensive 121ha 18th century landscaped park supporting mature beech woodlands, ornamental lakes and public walkways.

Upstream of the Upper and Lower Ponds (0.75ha and 0.2ha, respectively), the river was sinuous and narrow in nature, often <1.5m in width. Various footbridges bisected the channel and the throughout the park the river (and ponds) featured a high number of small weirs and sills as it flowed over a moderate gradient towards Dublin City. Human disturbance, given the popularity of this public amenity, was high along most of the river channel within the park. However, downstream of the ponds the channel braided into multiple shallow, narrow channels and flowed through dense, often inaccessible scrub and woodland habitat, providing some seclusion for otter. Much of the river featured good finer and medium gravel substrata but the general lack of deeper pools and glides reduced its fisheries value considerably. Many areas of channel in the northern end of the park were heavily silted and contained large amounts of instream woody debris. The pipe culvert leading from Marlay Park under the R822 road was blocked with such debris at the time of survey and was largely inaccessible to otters.

Reappearing above ground again at Broadford Rovers FC (Grangewood), the river took a meandering course through several areas of amenity parkland. The river had a semi-natural profile consisting of riffle-pool-glide sequences which likely supported salmonids (brown trout). However, the river became straightened and more heavily modified through Dargle Valley where it flowed through more parkland, complete with several minor weirs. Banks were invariably open and maintained to the bank top with little in the way of riparian cover (GA2).

The river was culverted underground at Loreto Park for approx. 0.75km before emanating from a culvert in Castle Golf Club. The river was diverted through several small artificial ponds (FL8) within the golf course. Downstream of this, the channel flowed through a heavily scrubbed channel. Water quality observably decreased moving downstream, with multiple storm drains adjoining the river. The channel was invariably narrow (<2m), shallow, heavily silted and situated in a steep V-shaped valley. Human access was difficult and the river was increasingly modified and historically straightened in an urban landscape. The majority of the Little Dargle was culverted underground downstream of the golf course before joining the Dodder near Ely's Arch. Connectivity was poor at this point and accessibility for otter from the Dodder to the Little Dargle was low.

Plate 3.19 The Little Dargle River flowing through the upper extent of Marlay Park

3.12 Wyckham Stream

The Wyckham Stream was a small, short, minor watercourse and tributary of both the Little Dargle and Slang Rivers (depending on water levels). The channel was heavily modified and straightened and largely represented a drainage ditch (FW4) habitat for much of its length. The Wyckham flowed through public parkland represented by amenity grassland (GA2) and scattered trees and parkland (WD5) habitat and was culverted underground in several areas (e.g. Dundrum Football Club). The banks were invariably open and maintained with high levels of human access and disturbance throughout although security fences and sections of treeline habitat supporting ash, willow, hawthorn and occasional yew with associated bramble and herbaceous scrub prevented access locally. The watercourse also flanked by various residential areas on the north bank.

The stream was narrow (<2m) and shallow (<0.2m) on average and, at the time of survey, only contained standing water in isolated pockets mostly towards the eastern end of the watercourse (near the Slang River). Connectivity to the Slang was good and the channel likely served as a flood relief channel for the Slang in periods of higher water.

Plate 3.20 The Wyckham Stream upstream of the River Slang confluence along the Wyckham Way walkway

3.13 Slang River

The Slang River (also known locally as the Dundrum River) was a short watercourse which rose on Three Rock Mountain and flowed through Ticknock, Ballinteer, Dundrum and Windy Arbour before joining the River Dodder at Milltown, near the Nine Arches viaduct. The upper survey reaches, near the M50, were culverted with the river appearing above ground at Wesley College for a short distance (approx. 100m). Here, the channel was <1m wide, <0.3m deep and heavily modified having been historically straightened. It was often retained by boulder revetments, encroached by low-lying scrub vegetation and silted with gabion mattressing on the riverbed. The river was culverted underground again downstream of the school grounds.

The channel became open again near Ardglass, approx. 500m downstream of Wesley College, at the confluence with the Wyckham Stream. Here, the Slang was bordered by the Wyckham Way cycle route in a residential, urbanised landscape. The river was situated in a historically straightened and deepened steep U-shaped channel, with largely open, maintained banks (GA2) featuring a deliberately-unmaintained (un-cut) low-lying herbaceous riparian layer composed primarily of nettle, broad-leaved dock, alexanders, winter heliotrope, cleavers, ivy and hemlock. Some fragmented mature treelines of ash, hawthorn, elder, sycamore and alder with bramble scrub also bordered the river on the south bank. The channel was often silted, with some localised bedded cobbles, and supported beds of Canadian pondweed (*Elodea canadensis*) in-stream due to low flow rates. Fisheries value as considered low and human disturbance levels were high.

From Dundrum downstream, the Slang became more urbanised and modified, with frequent retaining walls and culverts (e.g. downstream of St. Columbanus's Road). Some sections retained a good degree of seclusion given the direct inaccessibility to humans but overall the channel appeared degraded, with multiple adjoining storm drains and frequent instream trash accumulations. Flow rates were moderate at best and siltation was often high throughout, although some limited cobble and gravel substrata existed in higher flow areas. Three-spined stickleback were often abundant, especially where localised marginal beds of fool's watercress existed.

The lower reaches of the Slang bordered residential areas but were largely secluded from human activity through mature treeline, walls and fences. Downstream of Farranboley Park the river flowed through a small, dense block of mixed broad-leaved woodland (WD1) in an increasingly steep V-shaped valley. Here, the river and its banks retained a greater degree of naturalness and seclusion, and both otter and fisheries habitat was much improved over many upstream areas, with a wider channel featuring greater substrata variation, i.e. boulder, cobble, gravels. The Slang was diverted underground for the final 200m of its course before joining the Dodder near Windy Arbour Playground via a box culvert, which was accessible to otter.

Plate 3.21 The Slang River at Ardglass showing evident modification and largely open banks open to human-related disturbance

3.14 Elm Park Stream

The Elm Park Stream was a short, modified watercourse running for approx. 2km in open or fragmented channel lengths from the UCD Belfield Campus to its confluence with Dublin Bay at Blackrock. Located near to the Dún Laoghaire–Rathdown County Council boundary, the Elm Park emanated from two small, shallow, densely vegetated wildlife ponds on the UCD campus. The stream was heavily culverted throughout, including under the R138 Stillorgan Road.

Above ground, much of the stream was situated within a golf course at Elm Park Golf and Sports club. Here, the channel opened into a small, shallow and meandering channel (<1.5m wide). Here the channel was modified and straightened and largely bound by retaining walls/revetments through the golf course. Maintained grasslands (GA2) typically extended to the bank top throughout this section with very little riparian cover. The stream was predominantly very shallow (<0.1m deep) and featured often bedded gravel and cobble substrata. Some limited areas of cleaner finer gravels existed although fisheries potential was considered poor, with only isolated deeper pools (<0.6m). Various storm drains entered the stream along its course and surface run-off (associated with nearby roads, developments and the golf course) was considered a likely issue affecting water quality.

Downstream of the golf course, the stream was straightened and bound by high retaining walls before again becoming culverted under apartment complexes prior to discharging to Dublin Bay (South Dublin Bay SAC) along Merrion Road. A large trash screen was located upstream of the R118 road culvert and this presented a major barrier to otter passage. Upstream fish passage from Merrion Road was not possible given the high fall-out from the culvert.

Plate 3.22 The Elm Park Stream flowing through Elm Park Golf and Sports club

4. Results

4.1 Otter records

A total of *n*=196 otter signs were recorded during the survey over the April 2018 to April 2019 period across fourteen riverine watercourses (83.8km) in addition to 44.7km of coastal habitat. These encompassed spraints, smears (jellies), holts, slides, prints, couches and latrines. Spraints were the predominant sign recorded (*n*=121), accounting for 61% of total records. Holts were the second most encountered otter sign, with a total of *n*=25 holt sites recorded - many showed signs of recent activity. Latrine (*n*=18) and prints (*n*=17) and couches (*n*=8) were next numerous in terms of abundance, with low numbers of jellies (smears), slides and prey remains also recorded (Table 4.1).

Otter records are further summarised in the sections below relative to each watercourse. Please also refer to each associated map for otter sign locations. Watercourses are presented in a north to south orientation.

Table 4.1 Summary of the total number of otter signs recorded across all watercourses and coastal habitat during this study

Otter sign	Number of total signs
Spraints	121
Holts	25
Latrines	18
Prints	17
Couch	8
Jelly (smear)	3
Slide	3
Prey remains	1
Total otter signs	**196**

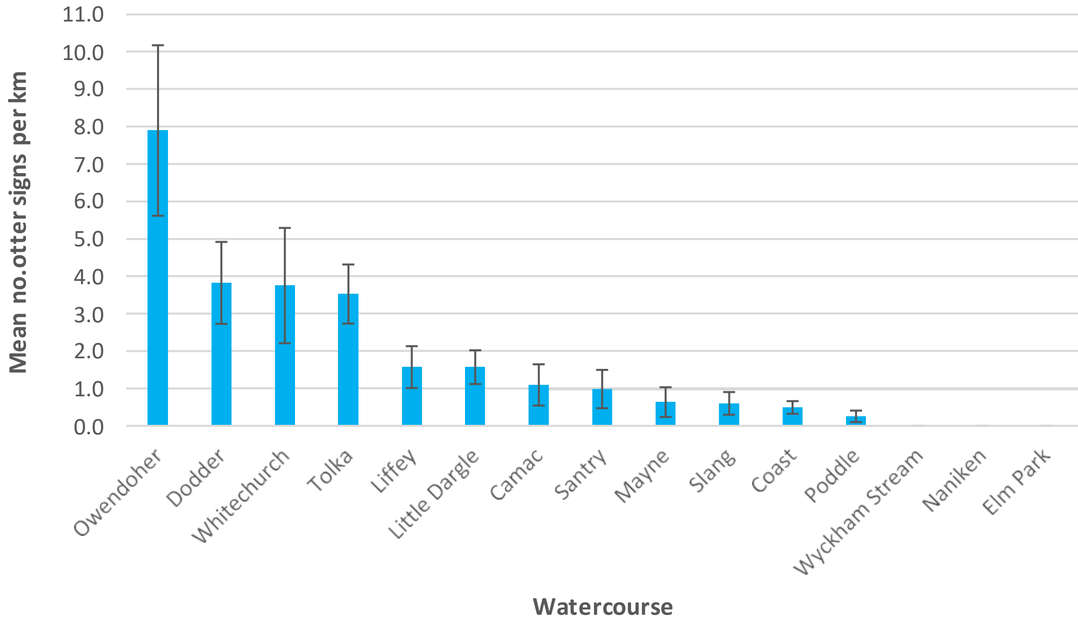

Figure 4.1 Plot showing the mean number (±SE) of otter records (all signs) per kilometre along all watercourses surveyed (positively ranked in order of abundance)

River Mayne

A total of *n*=4 otter records were recorded along the approx. 6.3km of River Mayne channel surveyed. This corresponded to 0.6 otter signs per kilometre of river, among the lowest of any river surveyed (Figure 4.1). The majority of the signs were recorded in the lower reaches of the river (section MAY11), with two spraint sites (under the same farm access bridge) and a latrine. A single (disused) holt was also recorded in the upper catchment, in the steep banks of beech-dominated woodland adjacent to a drained lake at Belcamp House (Figure 4.2).

Santry River

A total of *n*=6 otter signs were recorded along approx. 6.1km of surveyed River Santry channel, corresponding to 0.98 signs per kilometre of river. In contrast to the Mayne, the majority (five) of otter signs were located in the upper survey reaches, with <1.5km of M50. These were mostly represented by spraint sites associated with footbridges or culverts although a single (potential) holt was located under a crack willow amongst a large raft of in-stream debris approx. 450m downstream of the M50. Much of the heavily-modified river channel featured zero otter signs, even under bridges and within culverts although a single (old) spraint was recorded on a retaining wall in the lower reaches of the river near Raheny (Figure 4.2).

Naniken River

There were no otter signs recorded along the 1.7km of Naniken River channel and corridor surveyed throughout St. Anne's Park and surrounds. As outlined in the preceding section (site descriptions), the Naniken was a heavily modified watercourse with limited connectivity for otter to/from the sea due to a storm valve on seaward side of the R807culvert. Fisheries value as well as naturalness (see RHAT scores, section 4.2) was low and human disturbance (see section 4.3) within St. Anne's Park and adjoining pitch & putt club was high. As such, it offered poor potential for otter.

No historical records were available for otter along the Naniken River (NBDC, 2019, NPWS, 2019).

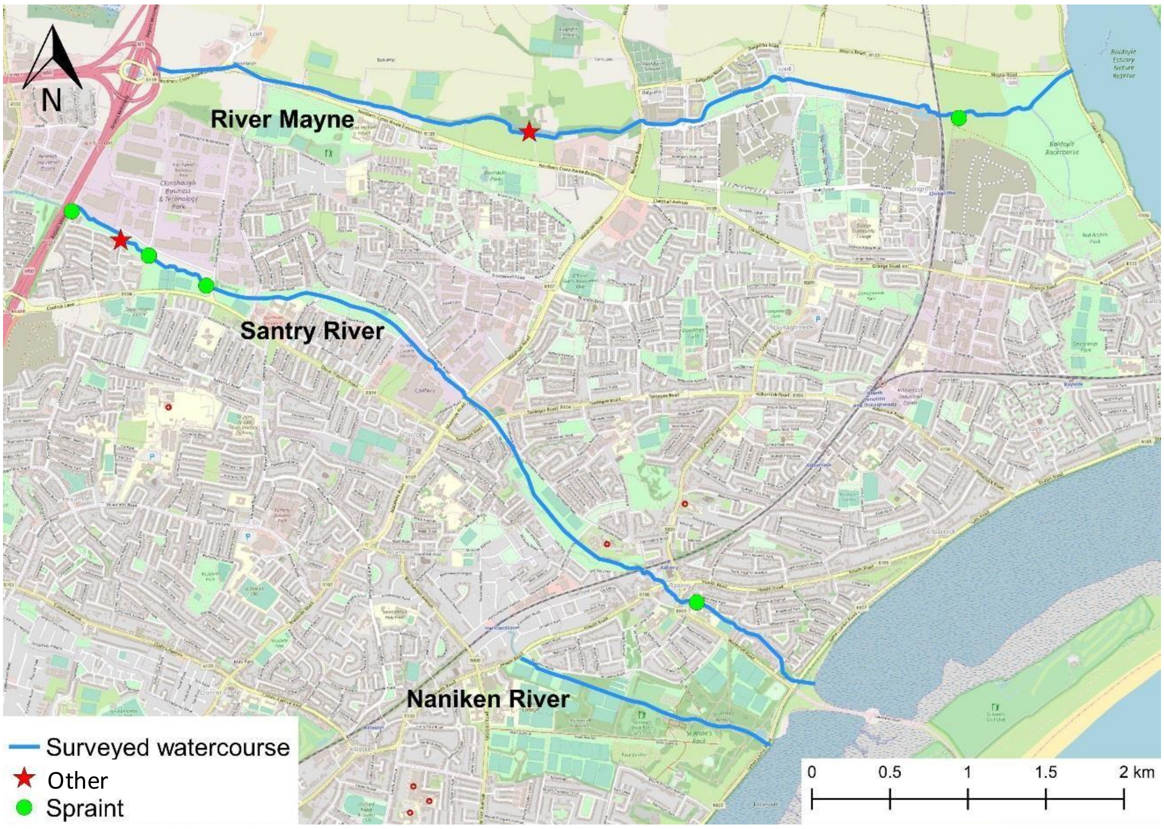

Figure 4.2 Otter sign distribution on the surveyed reaches of the Rivers Mayne, Santry and Naniken, Co. Dublin as surveyed April 2018-April 2019

River Tolka

A total of *n*=35 otter signs were recorded the River Tolka, the second highest of any river in this study (Figure 4.1 above). Given that 10.5km of channel was surveyed, this equated to 3.5 otter signs per kilometre of river, among the highest density recorded. The majority of recorded signs (*n*=21) were spraint sites, with a low number of couches, latrines and prints also recorded. Three holts were recorded in the uppermost survey reaches (TOL1 & TOL3).

Whilst signs were well distributed throughout the river, approx. half of the records were located in the upper survey sections (Figure 4.3). These sections (especially TOL1 to TOL4, inclusive) featured a high level of naturalness (see RHAT scores) and a largely natural profile, which evidently supported a healthy otter population. In contrast to other Dublin City watercourses (e.g. the Liffey), the Tolka maintained a relatively natural profile well into urban areas. The frequency of otter signs typically decreased within the more urbanised, modified lower reaches.

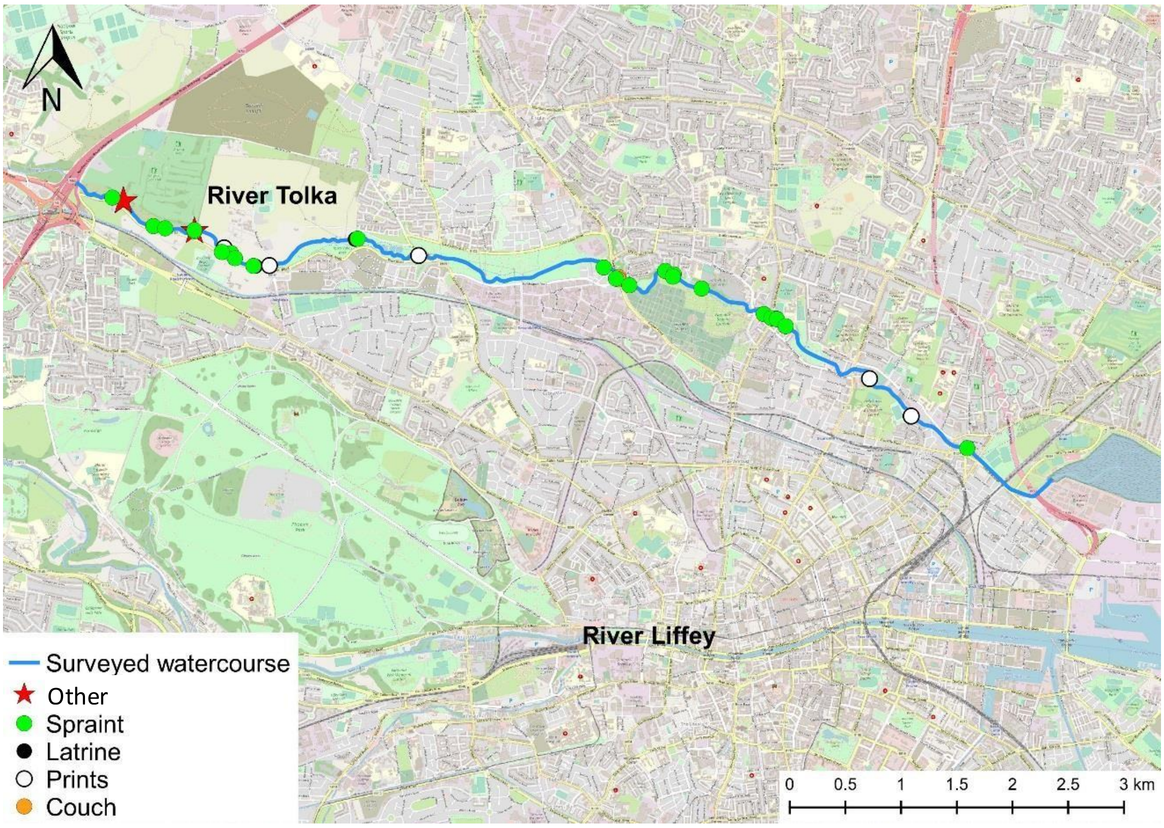

Figure 4.3 Otter sign distribution on the surveyed reaches of the River Tolka, Co. Dublin as surveyed April 2018-April 2019

River Liffey

A total of *n*=19 otter signs were recorded along 12.1km of the River Liffey, a moderate average of 1.6 signs per 1km of channel (Figure 4.1 & Figure 4.4). Otter signs were poorly distributed along the survey sections, with several extended reaches of channel failing to record any signs (e.g. sections LIF14 to LIF19 inclusive). As with most other watercourses surveyed, spraints made up the majority of signs (*n*=11 or 58%), with low numbers of latrines and slides recorded throughout the middle and upper survey reaches. A low number of holts was also recorded (*n*=2); one disused holt was present under a mature sycamore on 'The Island' upstream of Chapelizod (LIF7) whereas one was located in a quay wall in Dublin City centre at the MV Cill Airne floating restaurant (Figure 4.4).

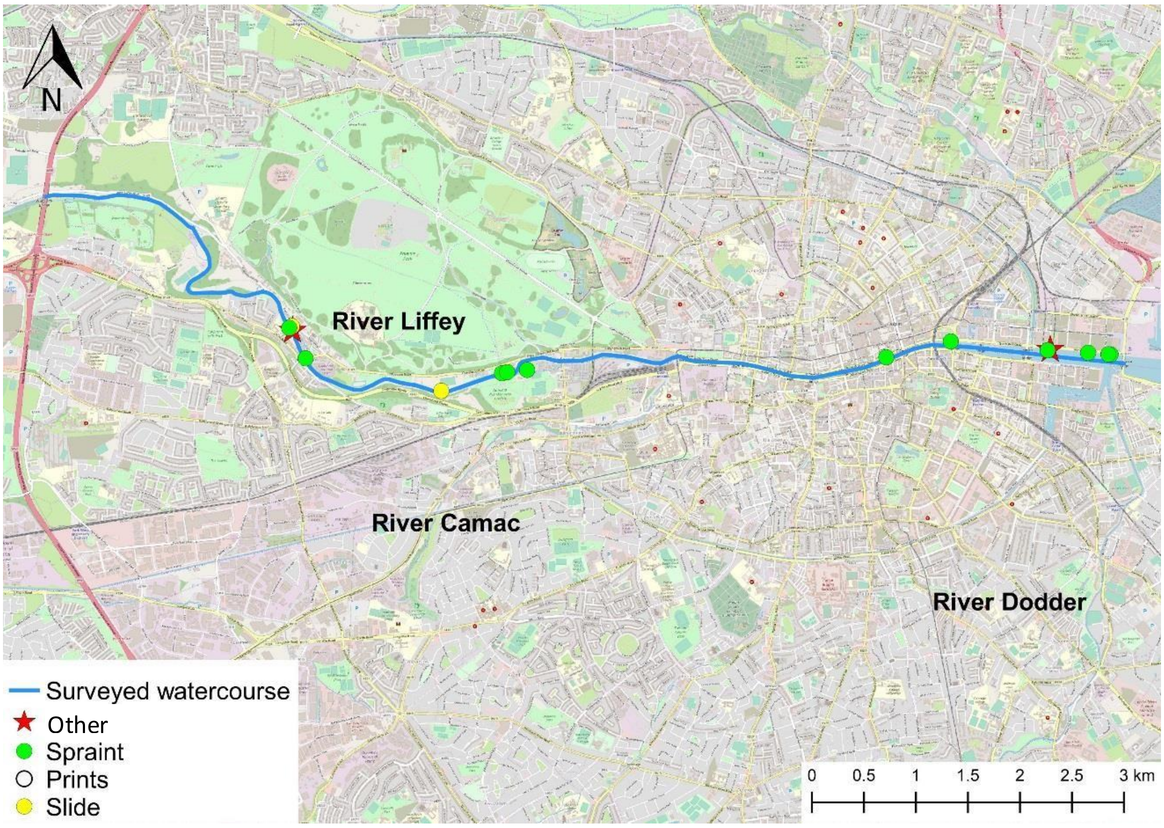

Figure 4.4 Otter sign distribution on the surveyed reaches of the River Liffey, Co. Dublin as surveyed April 2018-April 2019

River Camac

A total of *n*=8 otter signs were recorded along the 7.3km of surveyed River Camac channel, equating to a moderate 1.1 signs per kilometre of channel (Figures 4.1 & 4.5). Half of these signs (i.e. *n*=4) were represented by spraints, with single examples of a couch and latrine also recorded. A single holt was located in section CAM6 (Bluebell) and, given fresh spraint at the entrance, appeared to be active. The holt was excavated in a steep embankment under crack willow, some 0.6m above the low-flow water level, with one entrance. A single example of prey remains (unidentified waterfowl, recently predated) was also recorded on a mid-channel crack willow trunk.

The distribution of otter signs along the Camac was very much clustered in three areas within the upper and middle and reaches, namely Nangor Road, Bluebell and Inchicore – see Figure 4.5). Extensive reaches of the river were either open to high levels of disturbance, thus discouraging otter from marking (see Human Disturbance Index results) or, as with the lower reaches, were culverted underground and not open for survey.

River Poddle

Just *n*=2 otter signs were recorded along the River Poddle (Figure 4.5). Given that approx. 7.9km of channel existed downstream of the M50, this resulted in one of the lowest number of signs per kilometre of channel (0.25 km^{-1}). Evidently, otter usage of this heavily modified (straightened, deepened, multiple stressors) river was low. However, approximately half of the river was culverted underground, from Mount Argus Park to its confluence with the River Liffey and was thus not accessible to surveyors.

A single spraint site was recorded underneath a small footbridge in Tymon North Park adjacent to the M50 (POD1) with a single set of prints noted on a gravel margin under Wellington Court Bridge (POD3).

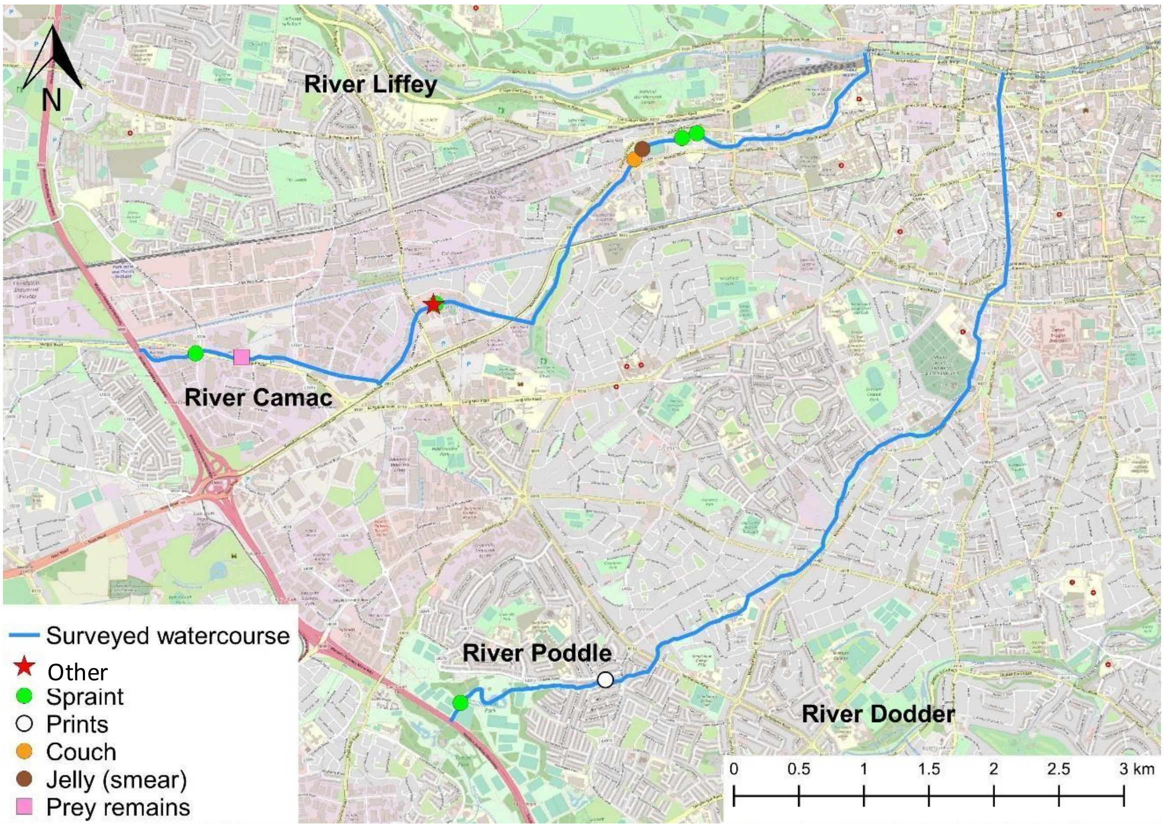

Figure 4.5 Otter sign distribution on the surveyed reaches of the Rivers Camac and Poddle, Co. Dublin as surveyed April 2018-April 2019

River Dodder

A total of *n*=47 otter signs were recorded along the River Dodder, the highest of any watercourse surveyed by a considerable margin. In fact, the Dodder alone accounted for 24% of all otter signs recorded in this study. In terms of channel length surveyed, 12.3km of the Dodder was searched for otter signs, which equated to an average of 3.8 signs per kilometre of river (see Figure 4.1). This was the joint second highest of all watercourses survey.

Unlike other Dublin rivers (e.g. Camac), otter signs were well distributed along the length of the Dodder. The majority (*n*=30) of records were accounted for by spraints, with most either located on in-stream or marginal boulders and under bridges. Low numbers of other signs including latrines, prints and couches were also recorded. A total of *n*=6 holts were located along the Dodder, the highest of any watercourse surveyed. Like other signs, these were well spread along the surveyed sections (Figure 4.6).

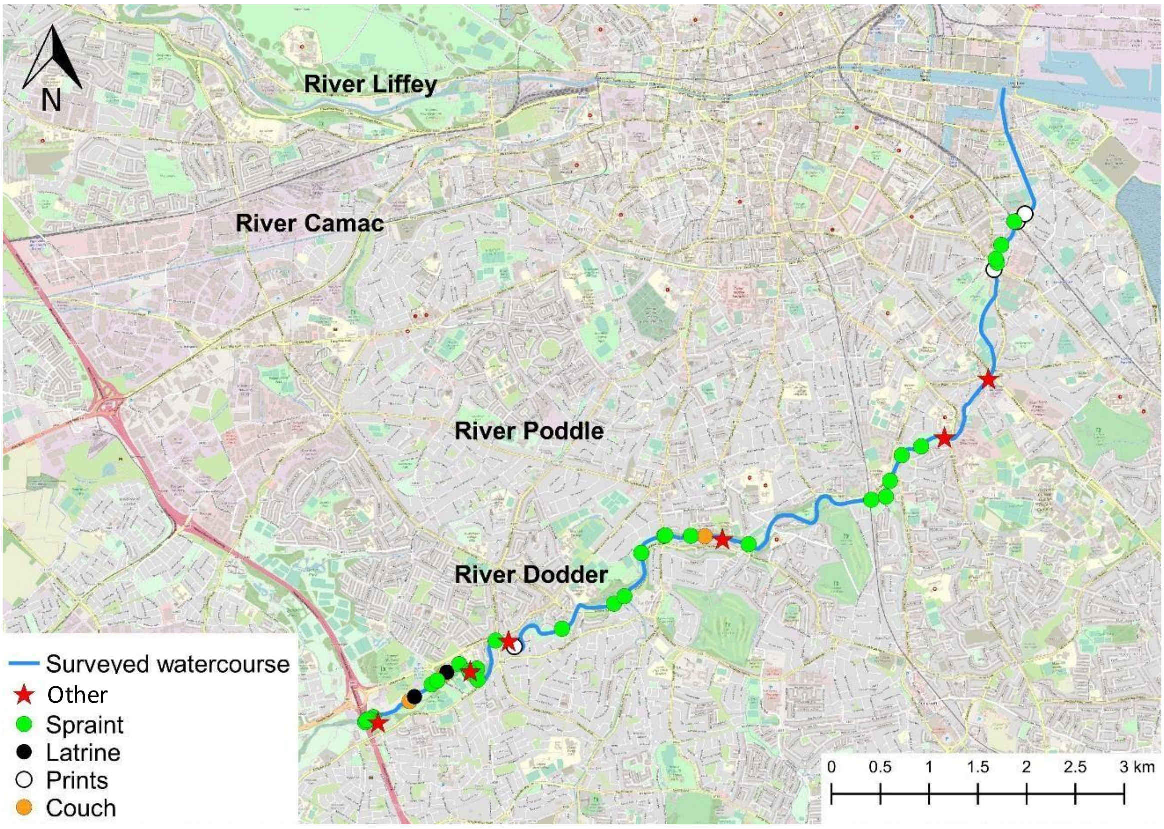

Figure 4.6 Otter sign distribution on the surveyed reaches of the River Dodder, Co. Dublin as surveyed April 2018-April 2019

Owendoher River

A total of *n*=30 otter signs were recorded along the 3.8km of Owendoher River channel surveyed (Figure 4.7). This was the third highest total of any watercourse in the study (Figure 4.1) but the highest in terms of average number of signs per kilometre (7.9 signs km^{-1}). Evidently, otter usage along the Owendoher downstream of the M50 was high.

Spraints were the most frequent sign recorded along the Owendoher (*n*=18, 60% of river total), being located along almost all 500m sections surveyed (except sections OWN7 & the culverted OWN8). Low numbers of prints, couches, latrines and slides were present along with a particularly high number of holts (*n*=4) given the short length of channel surveyed. Two of the four holt sites appeared inactive at the time of survey.

Whitechurch Stream

A moderately number of otter signs (*n*=12) were recorded along 3.2km of the Whitechurch Stream channel surveyed downstream of the M50. The river ranked as joint second (with the Dodder) in terms of the average number of otter signs per kilometre (3.8 signs km^{-1}) and otter usage was evidently relatively high along the surveyed reaches (Figure 4.1).

Otter sign distribution was clustered in both the upper and lower reaches of the survey sections (Figure 4.7), which may be partly explained by higher human disturbance levels in the middle reaches (WHI4 and much of WHI5 contained no signs, see Discussion). Again, spraints were the dominant sign, accounting for 58% of total Whitechurch signs. Two latrines and two active holts were identified, respectively. The majority of signs (spraint, latrine, couch, prints) were in association with bridges and culverts.

Little Dargle River

A total of *n*=8 otter signs were recorded along the 5.1km of surveyed Little Dargle River channel (Figure 4.7), equating to an average of 1.6 otter signs per kilometre (Figure 4.1). This moderate frequency was also the same as that recorded along the River Liffey.

Again, as with other watercourses, spraints were the dominant sign although a single set of prints was recorded along with a jelly smear on a culvert ledge in Loretto Park. No holts, active or inactive, were located during the survey although the presence of such areas in the extensive woodlands of Marlay Park was considered likely. The Little Dargle was heavily modified and culverted throughout much of the survey area and most signs were in association with culverts or bridges. There were no signs recorded in the lowermost c. 1.8km of channel (again, mostly culverted underground or heavily disturbed, see Discussion).

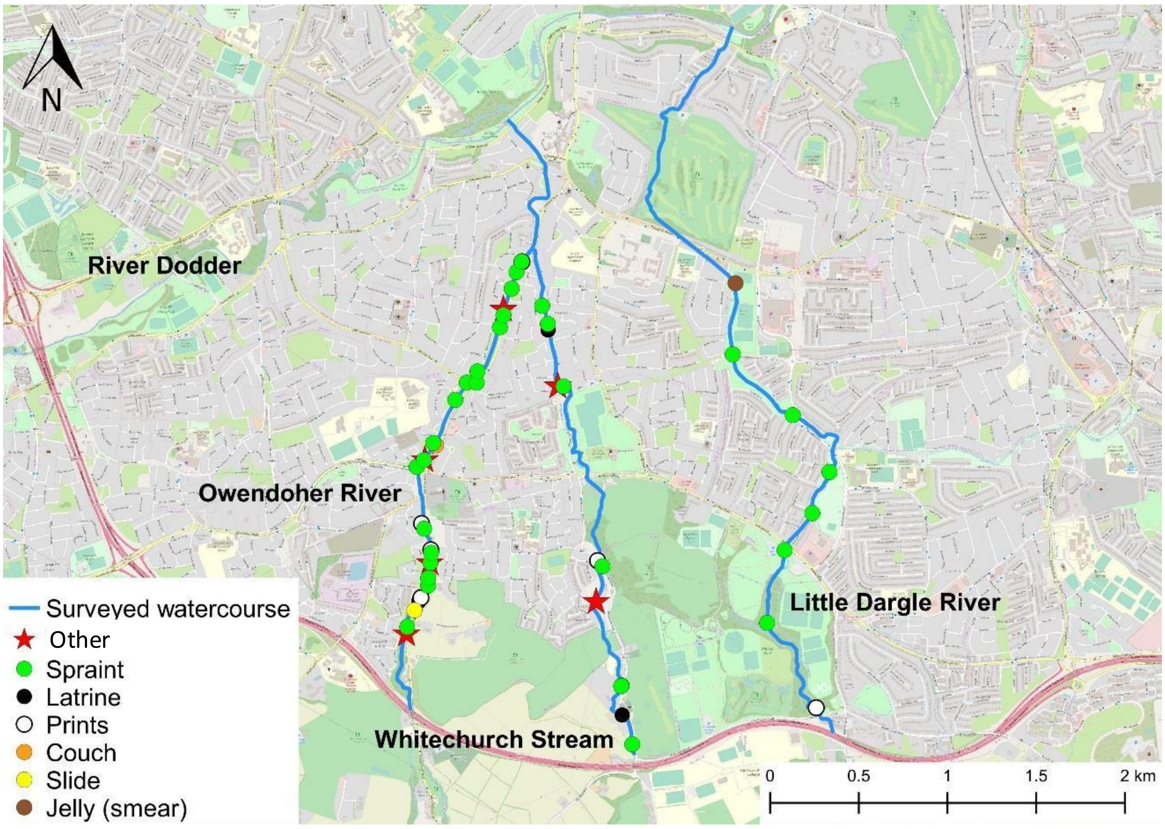

Figure 4.7 Otter sign distribution on the surveyed reaches of the Rivers Owendoher, Whitechurch and Little Dargle, Co. Dublin as surveyed April 2018-April 2019

Wyckham Stream

There were no otter signs recorded along the Wyckham Stream (Figure 4.8). All 1.2km of the channel was surveyed. Otter potential was noted as being very low given the heavily modified, open and disturbed nature of the channel (see proceeding sections and Discussion).

Slang River

A total of *n*=3 otter signs were recorded along the Slang River (Figure 4.8), with a very low average compared to other watercourses of 0.4 signs per kilometre(Figure 4.1). A single spraint was recorded during the survey, under a road bridge approx. 150m downstream of the Wyckham Stream confluence. Two holts were located, both in the lower reaches of the channel in largely inaccessible steep banks. One, upstream of Highfield Park, had not been recently used although the holt approx. 300m upstream of the River Dodder confluence appeared active.

Elm Park Stream

There were no otter signs recorded along the 1.2km reach of the Elm Park Stream accessible for survey (most of the watercourse was culverted underground). Otter potential along the channel was notable as being particularly low given the highly modified and disturbed nature of the channel. Incidentally, a spraint and jelly site was located at the seaward side of the Bray-Dublin rail line but the stream was not accessible to otter due to an impassable culvert and screen (see coastal section below; not shown on riverine map).

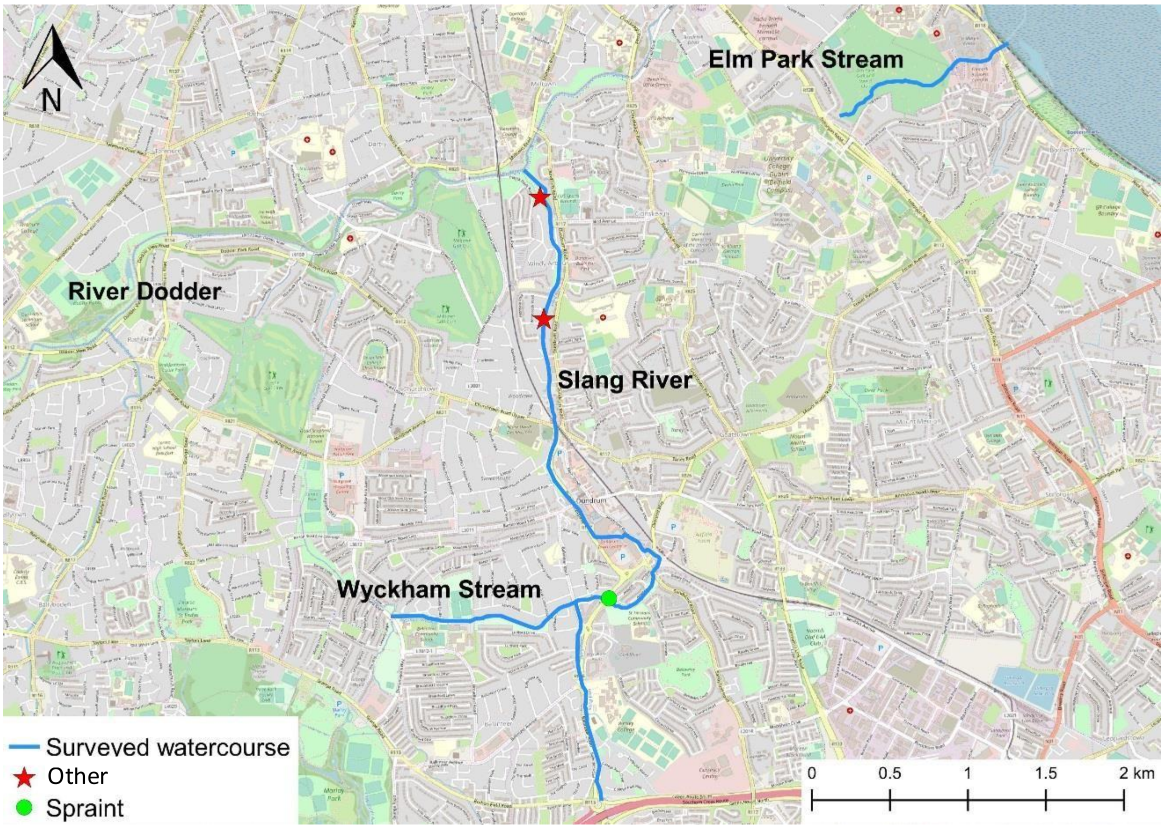

Figure 4.8 Otter sign distribution on the surveyed reaches of the Wyckham Stream, Slang River and Elm Park Stream, Co. Dublin as surveyed April 2018-April 2019

Coastal boundary

In total, *n*=22 otter signs were recorded along the 44.7km of coastal habitat surveyed, i.e. boundary of Dublin City Council jurisdiction with both Fingal County Council and Dún Laoghaire–Rathdown County Council (Figure 4.9). This equated to an average of 0.5 signs per kilometre of coastline, ranking near the bottom of areas surveyed for this study (Figure 4.1).

Spraints accounted for over half (*n*=14) of all signs recorded along the coast, including two regular sites on quay steps near Poolbeg Lighthouse. Surveys failed to identify any otter signs on North Bull Island and throughout much of Dublin Port and Merrion Strand. A low number of latrines (*n*=3) and holts (*n*=3) were logged. All three holts recorded (two active, one inactive) were located in largely inaccessible areas of habitat on the north side of Dublin Port (Figure 4.9). This can be considered the most important area of the coastal boundary for otter. A set of fresh prints was located at the culvert-associated plunge pool of the River Santry outfall, with a single jelly smear located on the aforementioned seaward-side culvert of the Elm Park Stream.

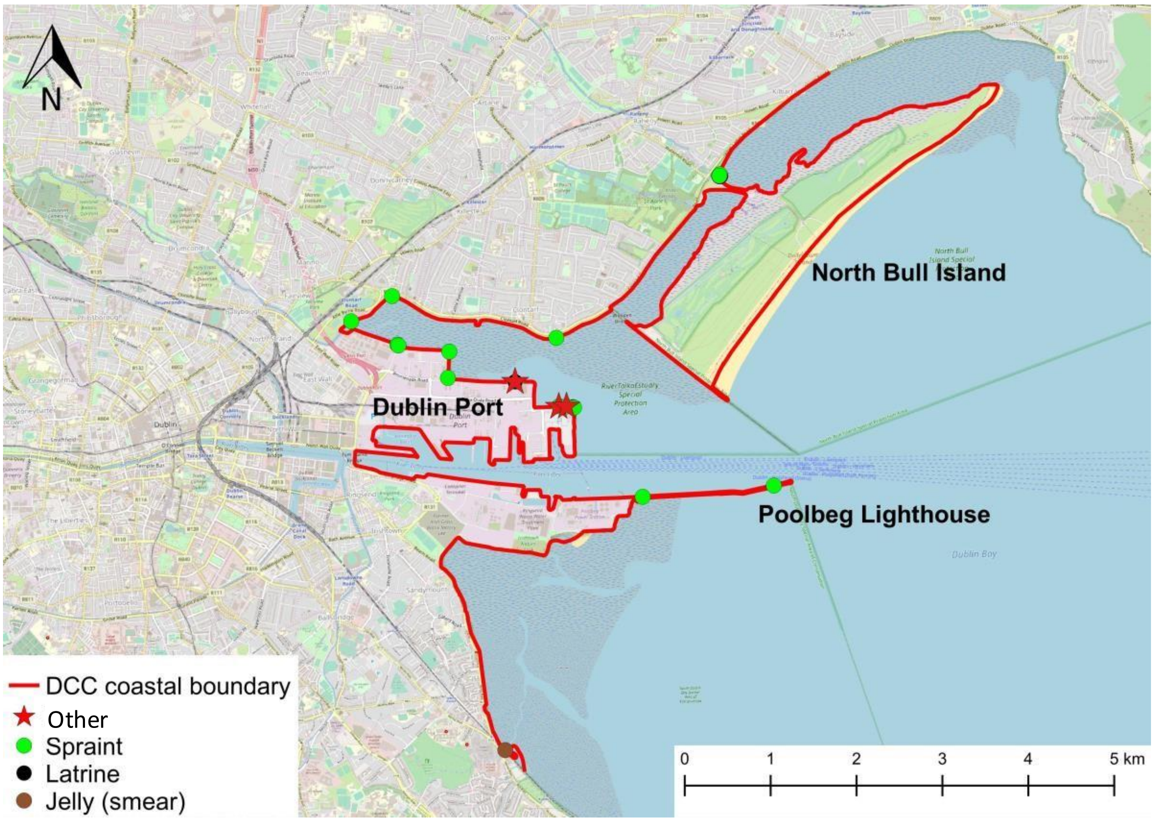

Figure 4.9 Otter sign distribution along the 44.7km of coastal habitat surveyed along Dublin City Council boundaries, April 2018-April 2019

4.2 River Habitat Assessment Technique (RHAT) scores

The following sections describe the River Habitat Assessment Technique (RHAT) scores for each 500m section of river assessed across *n*=14 watercourses during the April 2018 to April 2019 period. The RHAT methodology does not apply to coastal, non-riverine habitats. Results per river are presented in a north to south orientation (in a downstream direction) and are discussed in the context of both riverbanks (where applicable) and are displayed below in Figures 4.10 through 4.16 and summarised in both Figure 4.17.

River Mayne

In terms of degree of naturalness (which the RHAT assesses), the River Mayne achieved, at best, 'poor' scores throughout the survey area (Figure 4.10). The river was heavily modified and or urbanised throughout much of its course, with poor channel morphology, substrate diversity, in-stream vegetation, floodplain interactions and frequent barriers to migration, e.g. culverts. Riparian land use was invariably heavily modified throughout. Although the river retained a more natural profile in its lower reaches, away from much human activity and interference, the Mayne achieved a mean hydromorph score of 0.1 within the study area, corresponding to a 'poor' status under WFD classification.

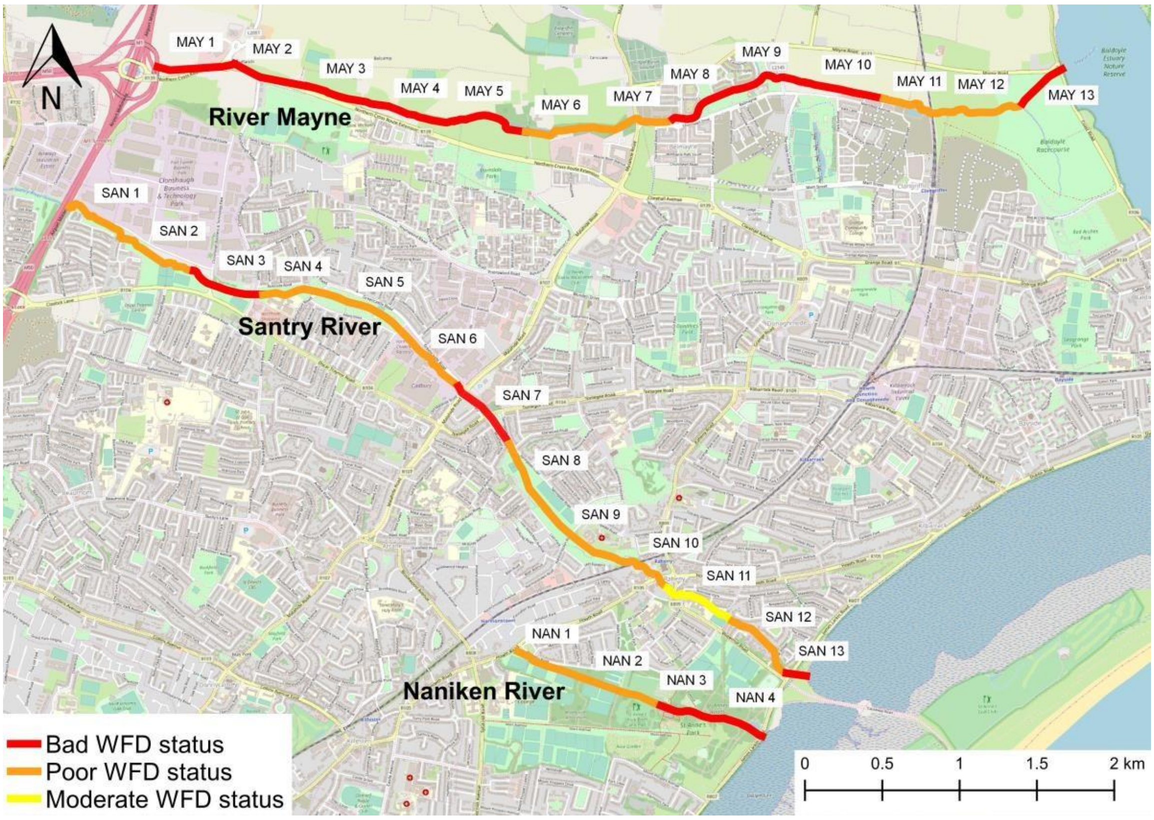

Figure 4.10 RHAT scores (equivalent to WFD status) along the River Mayne, River Santry and Naniken River surveyed in Dublin City boundaries, April 2018-April 2019

Santry River

The Santry River achieved the equivalent of 'poor WFD status' scores throughout the majority (69%) of surveyed sections (Figure 4.10), with a mean river hydromorph score of 0.2. A low number of sections also graded as 'bad' status. The river was heavily modified and or urbanised throughout much of its course, with poor channel morphology, substrate diversity, in-stream vegetation, floodplain interactions and frequent barriers to migration, e.g. culverts. Riparian land use was invariably heavily modified throughout. Some more natural river habitat was present in the lower reaches of the Santry (sections SAN9, SAN10 & SAN11) where river form, riparian land use, substrate condition and floodplain interactions were somewhat improved.

Naniken River

A total of *n*=4 sections were assessed in terms of RHAT on the Naniken River; two achieved 'poor status' scores, with the two lowermost sections grading as 'bad status'. This reflected the heavily modified nature of the channel in the survey area (St. Anne's Park) – the river had been extensively deepened and straightened historically and featured a lack of natural profile and substrate diversity with multiple barriers to continuity throughout, e.g. open culverts. The last section (NAN4) also contained a small weir in addition to an under-road culvert and associated storm valve which effectively blocked the channel in terms of continuity. This section received the lowest hydromorph score (4) of any section surveyed (Figure 4.10).

River Tolka

The River Tolka featured a range of RHAT scores throughout the survey area, typically decreasing in levels of naturalness along the length of channel surveyed (Figure 4.11). Overall, the Tolka river hydromorph score (average of all sections) was 0.4, equating to moderate WFD status. The uppermost four sections achieved very high scores (all 'High' status), with a largely natural, unmodified profile in the vicinity of the M50. However, downstream of Dunisea Lane bridge (section TOL4 onwards), the Tolka flowed through Tolka Valley Park and became increasingly modified, urbanised and less natural. RHAT scores fell substantially given the poor channel morphology (straightened, deepened), channel vegetation, substrata diversity & condition, modified riparian land use and low floodplain interactions. Those sections within more urban areas of Dublin City typically received poor or even bad status scores.

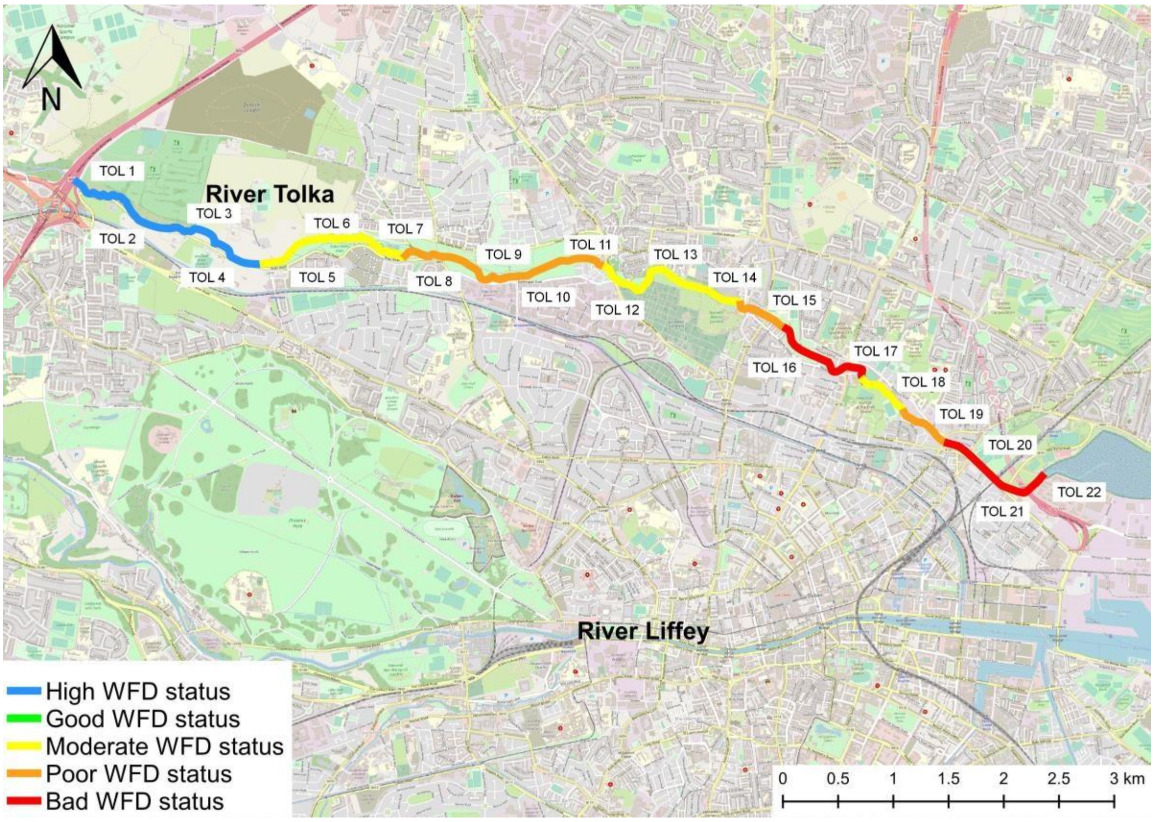

Figure 4.11 RHAT scores (equivalent to WFD status) along the River Tolka surveyed in Dublin City boundaries, April 2018-April 2019

River Liffey

The River Liffey demonstrated a similar pattern of RHAT scores to that of the Tolka, typically decreasing gradually moving in a downstream direction due to urbanisation pressures and increased modifications (Figure 4.12). The upper sections of the Liffey survey area (LIF1 to LIF6) represented a more natural river form with 'good status' scores. However, the presence of multiple barriers to continuity (artificial weirs) along with the regulated nature of the river (hydroelectricity generation) decreased these RHAT scores. Much of the middle survey reaches retained some good levels of naturalness (moderate scores) as far downstream as Heuston Station where the river (in Dublin City centre) became bound by retaining walls and bordered by

100% built land. From this point on RHAT scores were appreciably low. Overall, the Liffey achieved a mean hydromorph score of 0.3 due to urban influences.

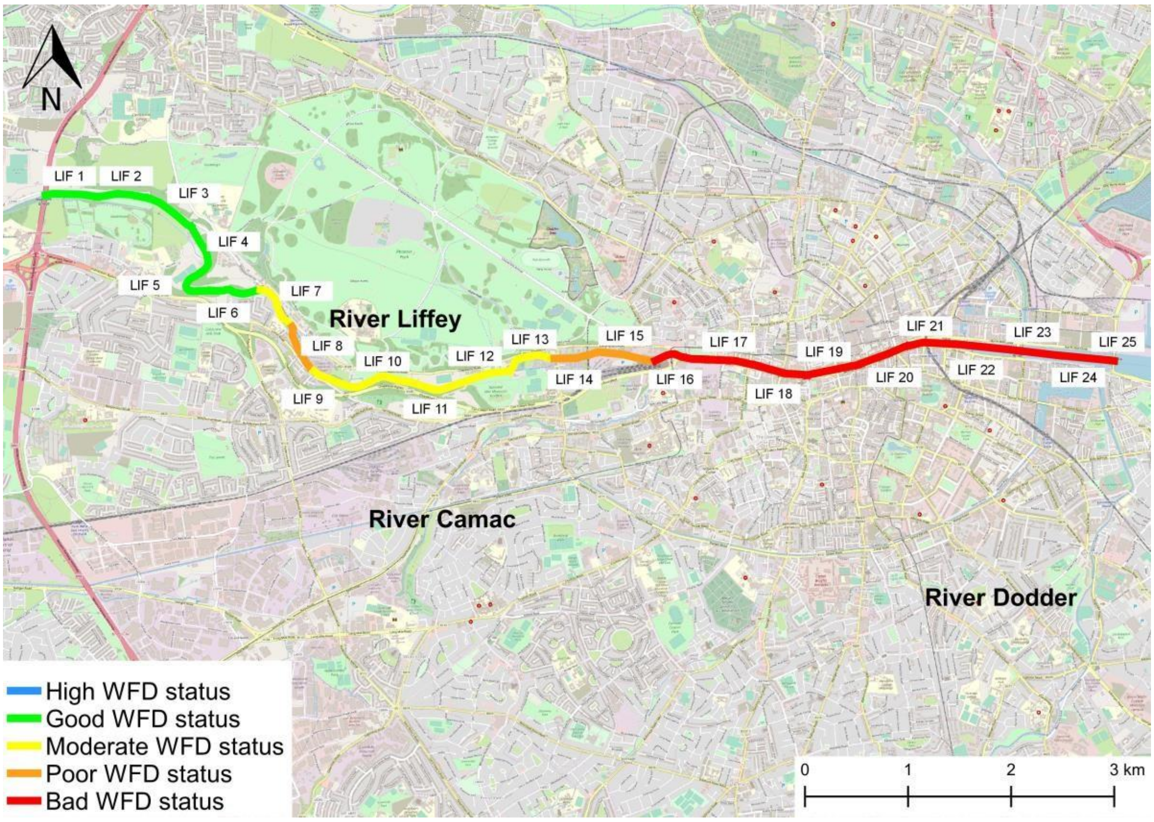

Figure 4.12 RHAT scores (equivalent to WFD status) along the River Liffey surveyed in Dublin City boundaries, April 2018-April 2019

River Camac

Downstream of the M50, the River Camac represented a heavily modified channel although localised semi-natural areas were present, especially in the upper survey sections (e.g. section CAM2). Overall, approximately half of the sections were of 'bad status' in terms of RHAT scores, owing largely to the urbanised location of river banks, historical straightening, lack of floodplain connectivity and barriers to continuity (e.g. culverts, artificial weirs). The remaining sections all achieved either poor or, at best, moderate RHAT scores although, again, some localised sections achieved relatively high scores given their better developed riparian zones and overall profile (e.g. CAM8, CAM11) (Figure 4.13).

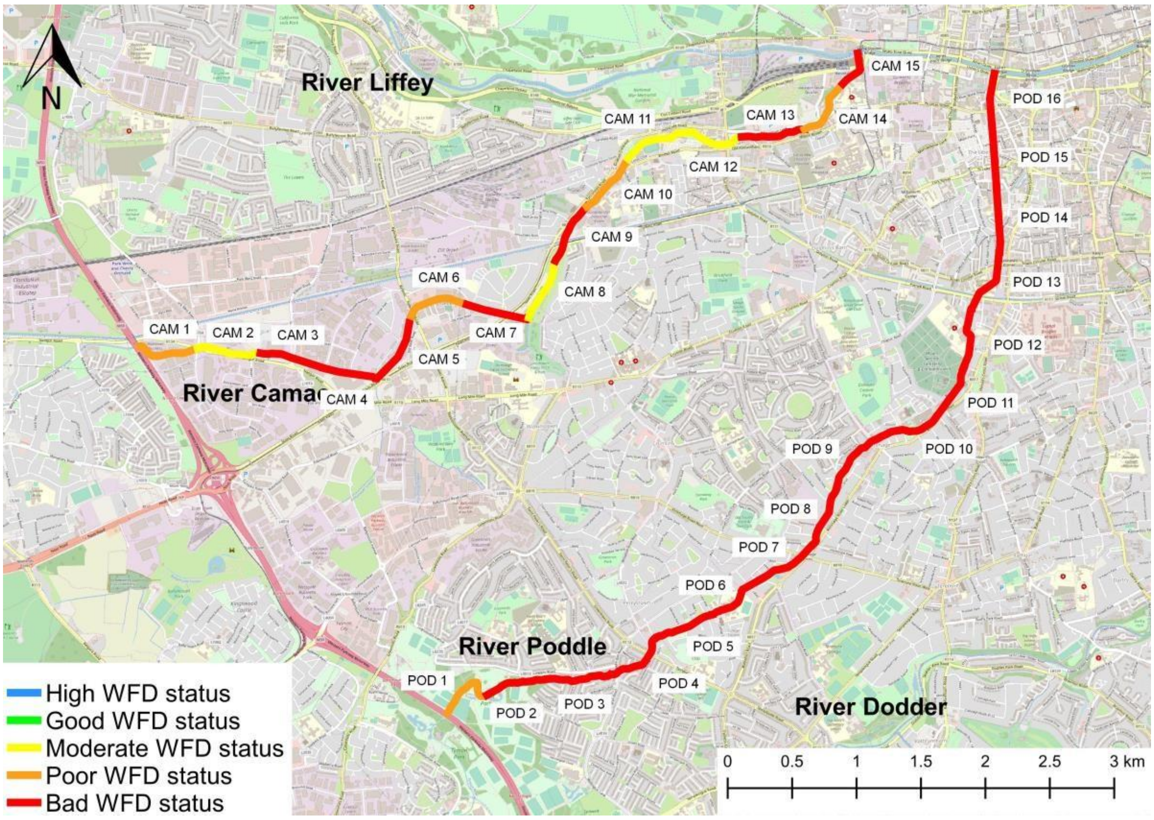

Figure 4.13 RHAT scores (equivalent to WFD status) along the River Camac and River Poddle surveyed in Dublin City boundaries, April 2018-April 2019

River Poddle

The River Poddle was a very heavily modified urban watercourse, with almost half of the survey reaches culverted underground. Those sections above ground (POD1 to POD9) all achieved a 'bad status' score, with the exception of the uppermost section which graded as poor (Figure 4.13). The Poddle has been modified and straightened throughout with poor levels of naturalness remaining. The channel was extensively culverted (barriers to continuity) with essentially no floodplain interaction and multiple urban pressures. In keeping with the pattern of RHAT scores seen in other Dublin City watercourses, scores typically decreased moving downstream. Downstream of Mount Argus Park, sections POD10 to POD16, achieved the lowest possible RHAT scores (i.e. 0) by virtue of their culverted nature.

River Dodder

The majority of the River Dodder RHAT scores downstream of the M50 were either poor or moderate (Figure 4.14) Similar to other Dublin City watercourses, the uppermost sections achieved the best scores (DOD1 to DOD3 were 'good status') whilst the lower reaches, within Dublin City centre, achieved the worst scores. This pattern was due to an increasingly modified, urbanised and less natural river profile moving downstream. Invariably, it was channel morphology, barriers to continuity (artificial weirs), substrate diversity & condition and a lack of floodplain interaction which reduced scores across the Dodder sections. However, it should be noted that the RHAT scores for sections of the Dodder within heavily urbanised areas were typically higher than for other watercourses in this study (e.g. Liffey, Camac).

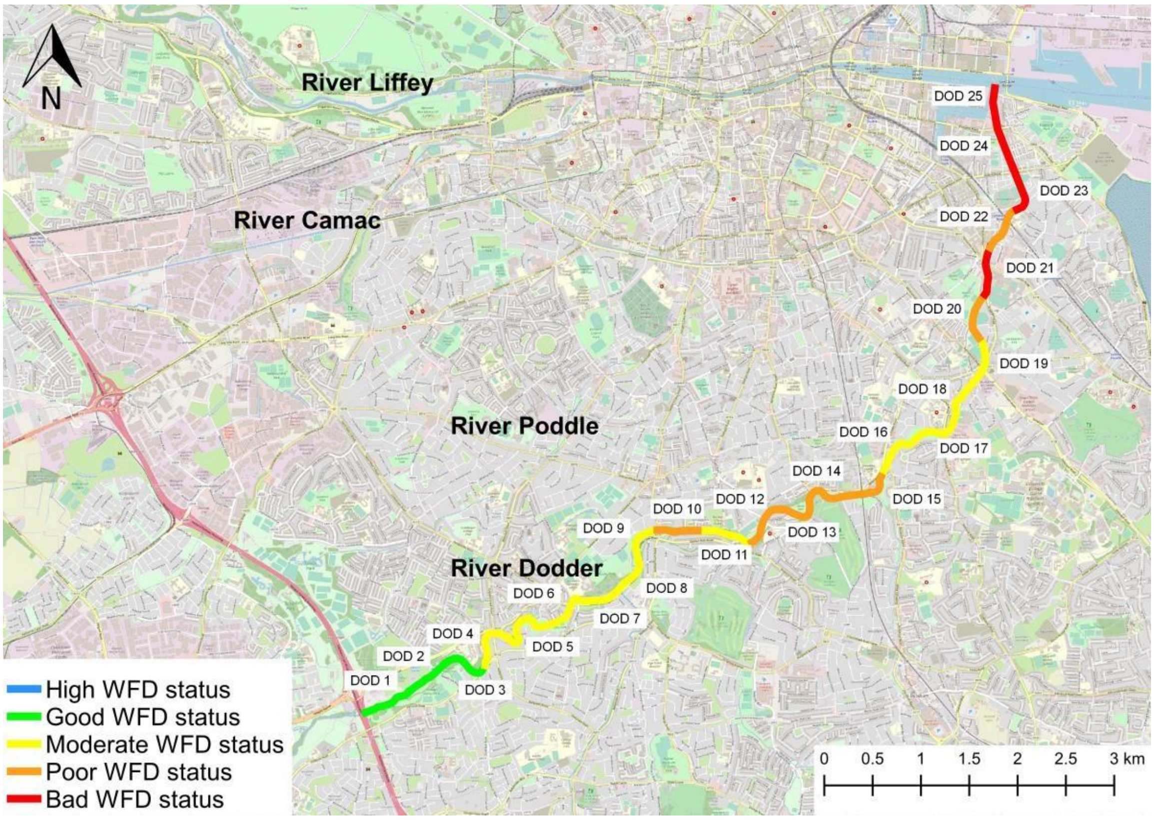

Figure 4.14 RHAT scores (equivalent to WFD status) along the River Dodder surveyed in Dublin City boundaries, April 2018-April 2019

Owendoher River

The mean hydromorph (RHAT) score for the Owendoher River sections was 0.6 (moderate WFD status equivalent), the highest of any of the *n*=14 watercourses surveyed within Dublin City boundaries. Whilst the Owendoher demonstrated a similar RHAT score pattern to most other watercourses, i.e. decreasing in a downstream direction, the river consistently maintained a high average score throughout (≥14; Figure 4.15). The uppermost survey sections were represented by a largely unmodified upland, eroding river flowing through a natural river valley (good to high scores), whilst the majority of sections flowing through more urbanised areas achieved moderate RHAT scores. This was due largely to the degree of separation and isolation of the river channel from surrounding pressures and modified land usages (see proceeding Human Disturbance Index section for more explanation). Overall, the Owendoher channel retained good levels of naturalness throughout despite adjacent urbanisation, with a good semi-natural profile, diverse substrata, well developed riparian vegetation and semi-natural riparian land use. A number of channel modifications such as culverts and artificial weirs, as well as prevention of floodplain interaction, reduced the scores.

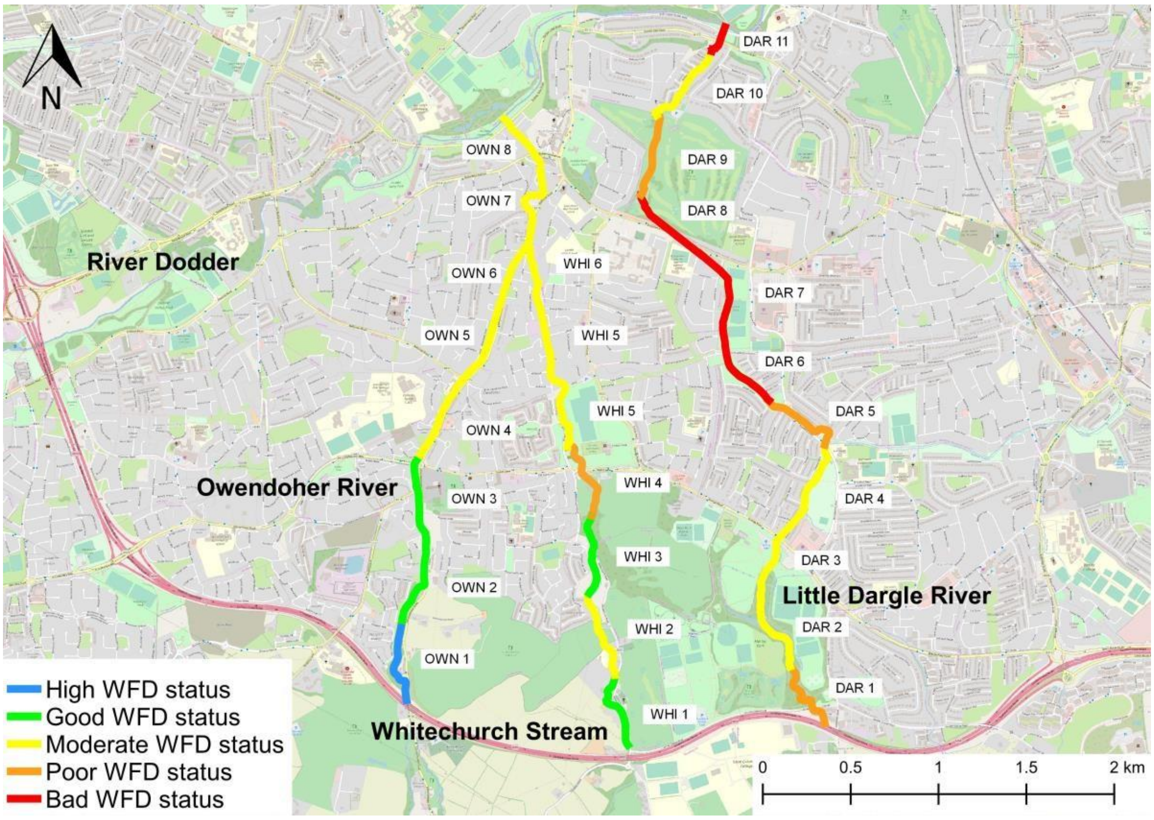

Figure 4.15 RHAT scores (equivalent to WFD status) along the Owendoher River, Whitechurch Stream and Little Dargle River surveyed in Dublin City boundaries, April 2018-April 2019

Whitechurch Stream

Hydromorph scores along the Whitechurch Stream (an Owendoher tributary) were typically the equivalent of moderate or good WFD status, with an overall mean score of 0.5 across the seven sections surveyed (Figure 4.15). The stream retained some good levels of naturalness, particularly in the upper survey reaches nearer the M50 (i.e. sections WHI1 & WHI3), with well-developed riparian zones, good channel morphology (despite some historical straightening) and varied substrate diversity. As with most other watercourses in this study, RHAT scores generally decreasing traveling downstream. Only a single section (WHI4) received a 'poor status' score, owing to the presence of a major weir and associated culverts which presented a significant barrier to continuity, in addition to increasingly urbanised land use adjacent to the channel. However, overall levels of naturalness were relatively high for a watercourse situated in such urbanised surrounds.

Little Dargle River

The Little Dargle was a heavily modified channel for much of the survey length, with a mean hydromorph score of 0.3 corresponding to 'poor WFD status' overall. However, some moderate levels of naturalness were present in the upper survey reaches within Marlay Park (sections DAR2 to DAR4) (Figure 4.15). Typically for the watercourses in this study, RHAT scores typically decreased (worsened) moving downstream although section DAR10, near the confluence with the River Dodder, retained some moderate levels of naturalness amidst an urban location (well-developed riparian zone, channel largely sectioned off from development, no barriers to continuity etc.). Overall, scores were invariably bad to poor given channel modifications (straightening), poor substrata diversity (siltation), multiple barriers to continuity (culverts), urbanised riparian land use and poor or no floodplain connectivity.

Wyckham Stream

In terms of levels of naturalness, the Wyckham Stream, was a heavily modified channel which achieved very low RHAT scores across the short survey reach (three sections only, 1.2km total length). All sections graded as 'bad' WFD status with hydromorph scores of ≤0.2 in all sections (Figure 4.16). The channel was represented by a heavily modified drainage channel with universally poor channel morphology, channel vegetation and substrate diversity with frequent barriers to continuity (culverts), no floodplain connectivity and heavily modified riparian land use adjoining the channel.

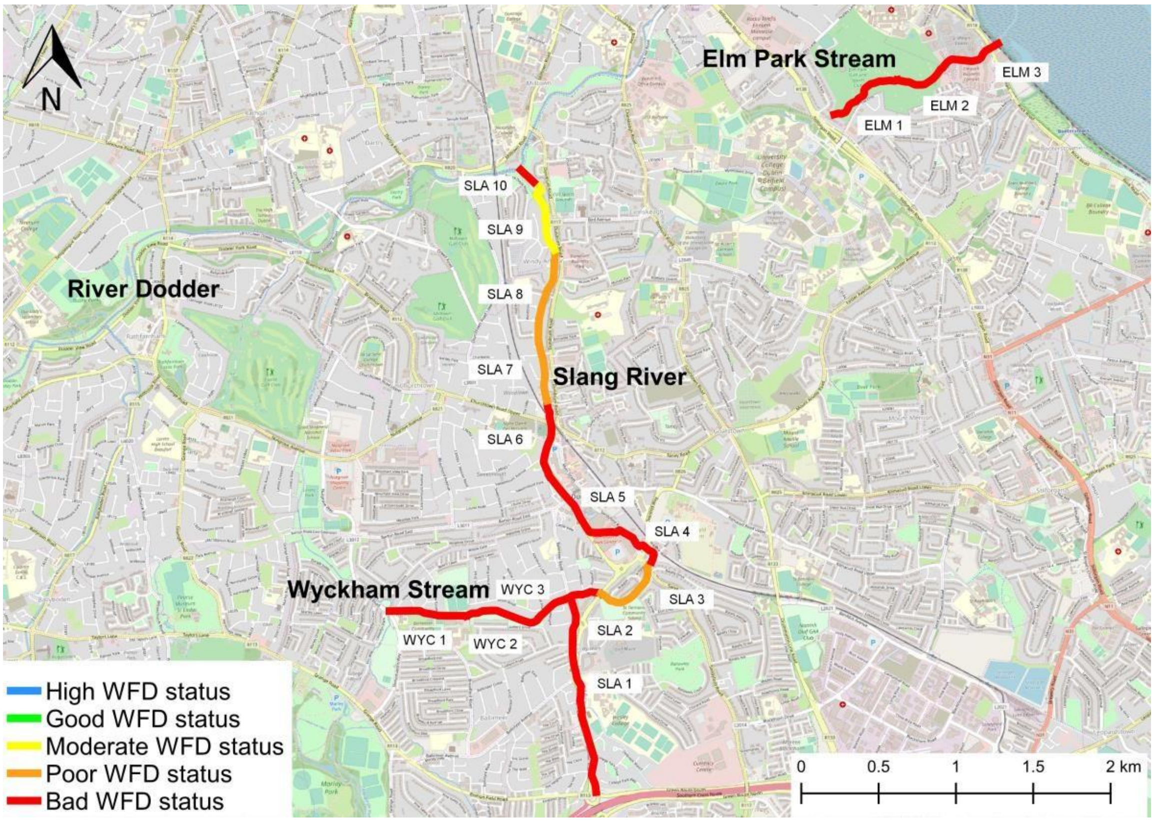

Figure 4.16 RHAT scores (equivalent to WFD status) along the Wyckham Stream, Slang River and Elm Park Stream surveyed in Dublin City boundaries, April 2018-April 2019

Slang River

The Slang River was a heavily modified, heavily urbanised watercourse with poor levels of naturalness overall. The majority of sections achieved a hydromorph score corresponding to 'bad' WFD status (Figure 4.16). The mean total river RHAT score was very low at 0.1, owing to the poor channel morphology, channel vegetation, substrate condition, modified land use and frequent barriers to continuity (e.g. culverts).

In contrast to most other watercourses, the better RHAT scores on the Slang were attained in the lower reaches (SLA8, SLA9 & SLA10). Here, the river retained more semi-natural characteristics and a more well-developed, less modified riparian zone.

Elm Park Stream

The Elm Park Stream was a heavily modified channel which achieved very low RHAT scores across the short survey reach (three sections only, 1.2km total length). All sections graded as 'bad' WFD status with hydromorph scores of ≤0.1 in all sections (Figure 4.16). The channel was heavily modified throughout, having been historically straightened. All of the upper reaches of the original stream had been culverted underground, with above-ground sections flowing through a golf course before, again, being diverted underground as far as sea confluence. Channel morphology, channel vegetation, substrate diversity & condition, bank top vegetation and floodplain interactions were all very poor, alongside modified riparian land use, no floodplain interactions and multiple barriers to continuity throughout.

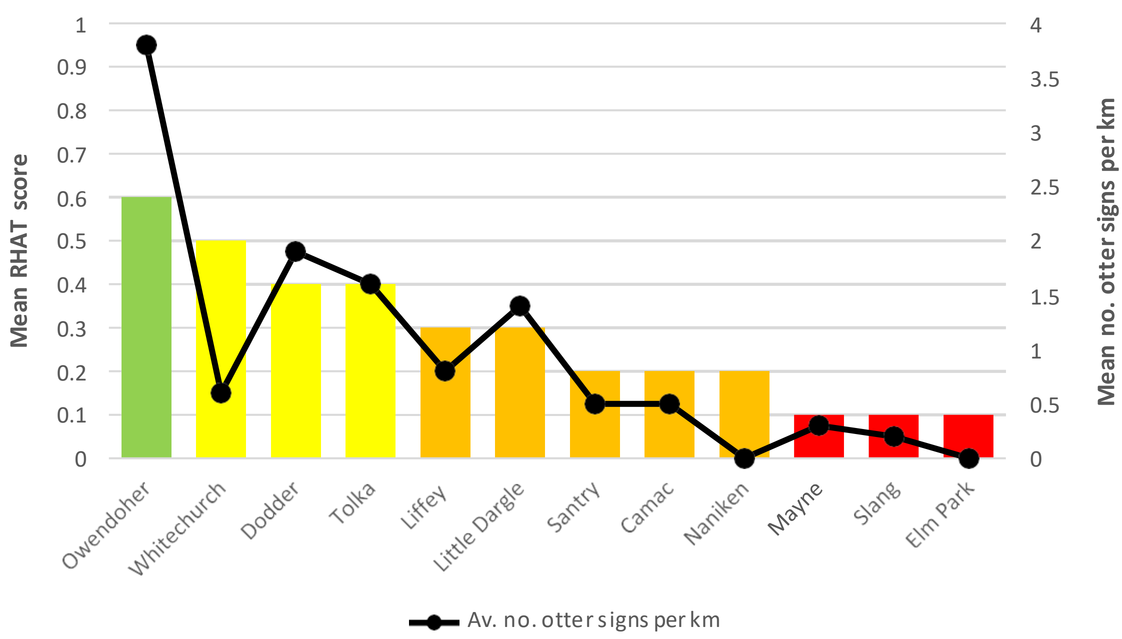

Figure 4.17 Mean RHAT scores (equivalent to WFD status) for the watercourses and habitats surveyed within Dublin City Council boundaries, April 2018-April 2019. Green = good WFD status; yellow – moderate status; orange = poor status; red = bad status.

4.3 Human Disturbance Index (HDI) scores

The following sections describe the Human Disturbance Index (HDI) scores for each 500m section of river surveyed across *n*=14 watercourses during the April 2018 to April 2019 period, in addition to each 500m of coastal habitat surveyed. Scores range from a minimum of 0.2 (low disturbance) to a maximum of 1.0 (very high disturbance). Sections of channel located in underground culverts were not assessed or scored (as outlined in the Methodology). Results are discussed in the context of both riverbanks (where applicable) and are summarised below in Figure 4.18.

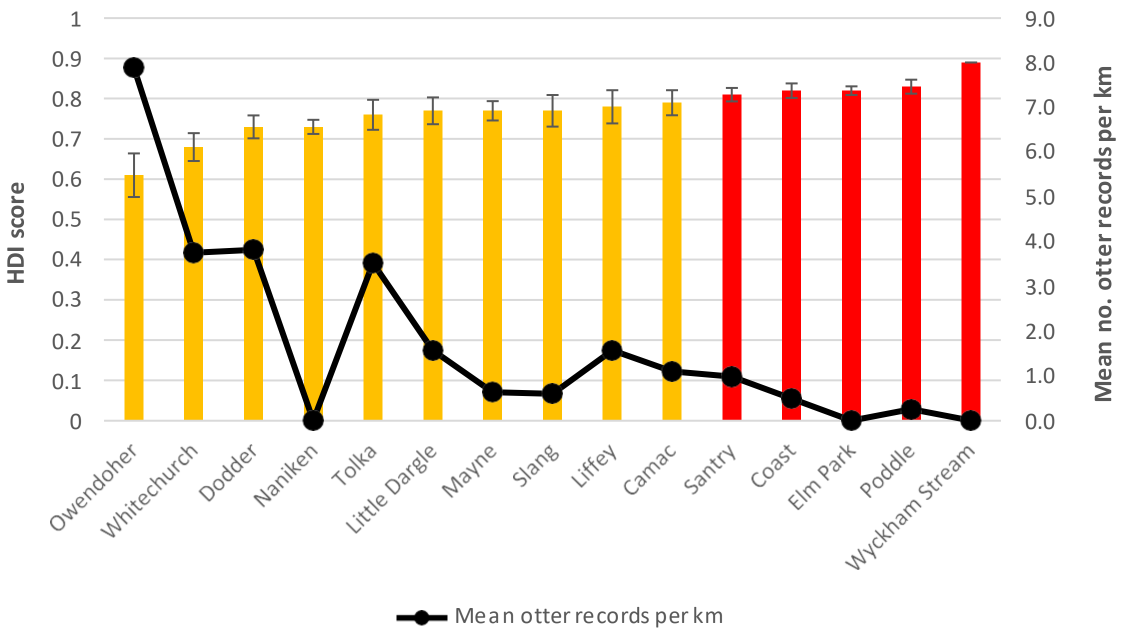

Figure 4.18 Mean Human Disturbance Index (HDI) scores per watercourse (±SE) with mean number of otter signs recorded per kilometre of channel (watercourses ranked from lowest (least disturbed) to highest (most disturbed).

*Note the Naniken River was not accessible to otter from the sea and this may explain the absence of signs recorded.

River Mayne

Levels of relative human disturbance along the River Mayne were invariably high (Figure 4.19), with an average HDI score of 0.77 across all section surveyed (Figure 4.18). Typically, the high scores recorded were due to a combination of both heavily modified land use adjacent to the channel and a lack of seclusion for otter within and adjacent to the channel. Actual human activity along the Mayne channel (within 10m) was usually low to moderate, although this was greater in the wider context of the river corridor (10-25m buffer) due to the urban location of many sections. Two sections (MAY5 & MAY6) achieved moderate disturbance scores thanks to some improved localised seclusion for otter. The entirety of section MAY2 was culverted underground and was therefore not assessed for human disturbance.

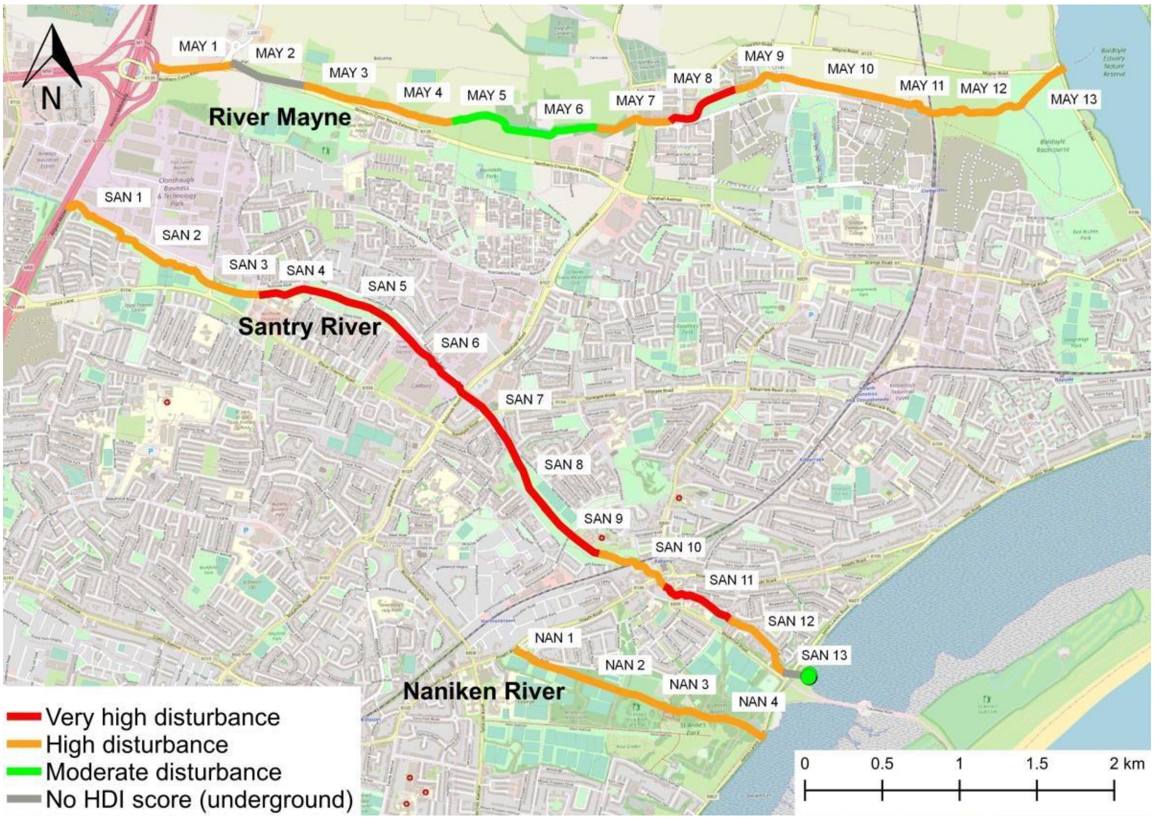

Figure 4.19 Human Disturbance Index scores (colour coded) along the River Mayne, Santry River and Naniken River surveyed in Dublin City boundaries, April 2018-April 2019

Santry River

All sections surveyed along the Santry River were subject to either high or very high levels of human related disturbance (Figure 4.19) with an average HDI score of 0.81 (very high disturbance) for the river overall (Figure 4.18). This was among the highest (most disturbed) score recorded from all the watercourses surveyed across Dublin City. A total of seven sections (58% of the total assessed for human disturbance) featured very high levels of disturbance. This was related to both frequent levels of human activity and modified land usage near the channel, in addition to a distinct lack of otter seclusion by way of riparian vegetation, dense treelines, large woody debris in-stream etc. throughout most sections. Otter signs were scarce along the Santry (*n*=6, see section 4.1) with all but one record associated with areas of lower relative disturbance along the river. 66% of these records were associated with bridges.

Naniken River

The four sections surveyed along the Naniken River all achieved HDI scores of ≥0.67 (averaged across both banks), equating to high disturbance (Figure 4.18). While land use was semi-natural along much of the survey reaches, human activity was moderate to frequent along the channel given the location within St. Anne's Park. Otter seclusion was also poor throughout due to the heavily modified nature of the river and largely open, historically deepened banks. No otter signs were recorded along the Naniken River (see section 4.1). This may be explained by the absence of access to the stream from the sea given a storm sluice valve system that is in operation and high quayside walls.

River Tolka

Whilst the levels of relative human disturbance were low to moderate in the upper survey reaches of the River Tolka (Figure 4.20), HDI scores increased (worsened) considerably downstream of section TOL4 (from Tolka Valley Park onwards), in parallel with RHAT scores (see section 4.2). Hereafter, HDI scores were either 'high' or 'very high', with over 70% of the remaining sections featuring very high levels of human disturbance. Despite this, otter signs were widespread along the river, including in areas of very high human disturbance (e.g. sections TOL11, TOL15). This was typically due to high retaining walls, fences or dense vegetation preventing direct human access to the channel, even in heavily urbanised areas. Areas with direct human access to the channel edge contained few or no otter signs. All holts recorded on the Tolka (*n*=3) were located in lower disturbance areas. Otter signs within the more urbanised sections of river were typically associated with bridges.

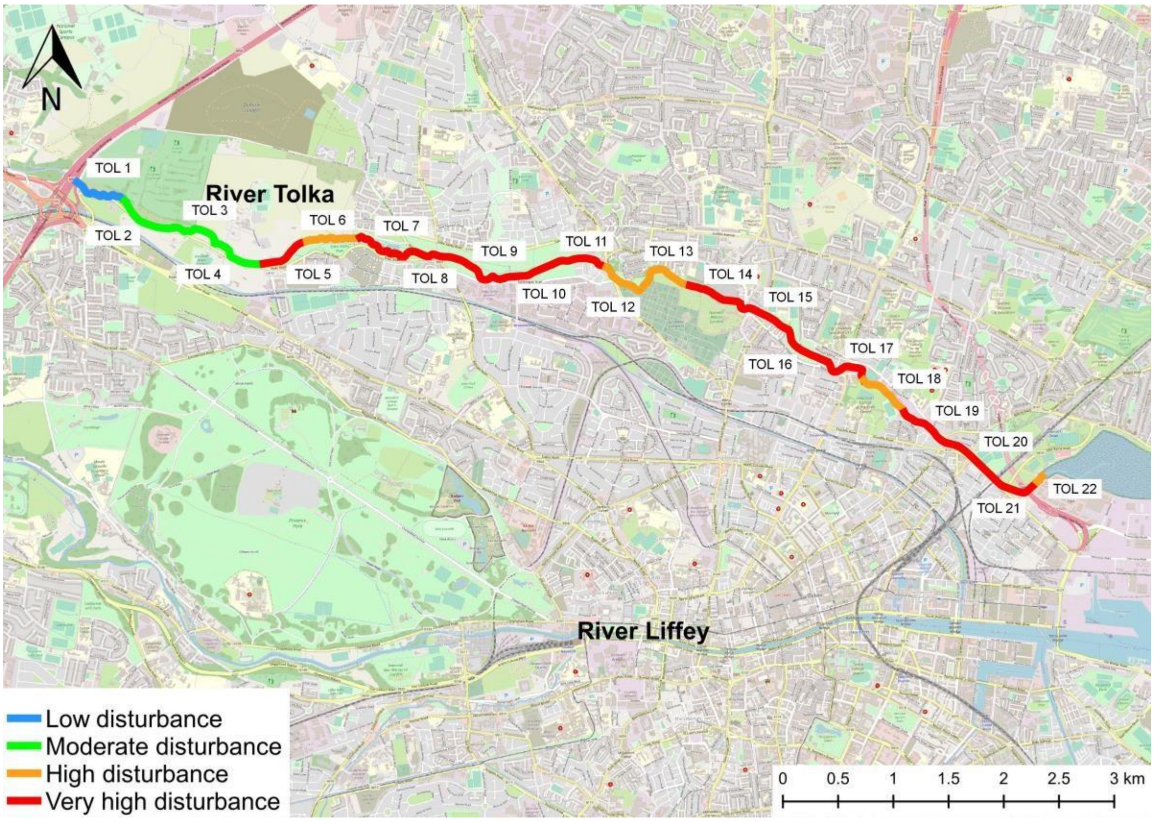

Figure 4.20 Human Disturbance Index scores (colour coded) along the River Tolka surveyed in Dublin City boundaries, April 2018-April 2019

River Liffey

The distribution of HDI scores along the River Liffey showed a similar pattern to the Tolka; lower disturbance levels in the upper survey reaches with increasing levels of disturbance downstream (Figure 4.21). Despite this, no otter signs were recorded from the uppermost six sections, which achieved low to moderate HDI scores (all ≤0.52). Both banks of the Liffey featured relatively high (sometimes very high) levels of human disturbance in terms of human activity, modified land use and or a lack of otter seclusion. In the middle survey reaches, most otter signs were associated with instream islands, away from direct human disturbance pressures. Several otter signs were recorded from very high HDI-scoring sections in Dublin City centre and both *n*=2 otter holts recorded along the Liffey were also present within 'very high' disturbance areas. Human activity and land use considerations aside, seclusion levels were invariably poor for otter throughout the Liffey sections due to open, modified banks (e.g. parklands).

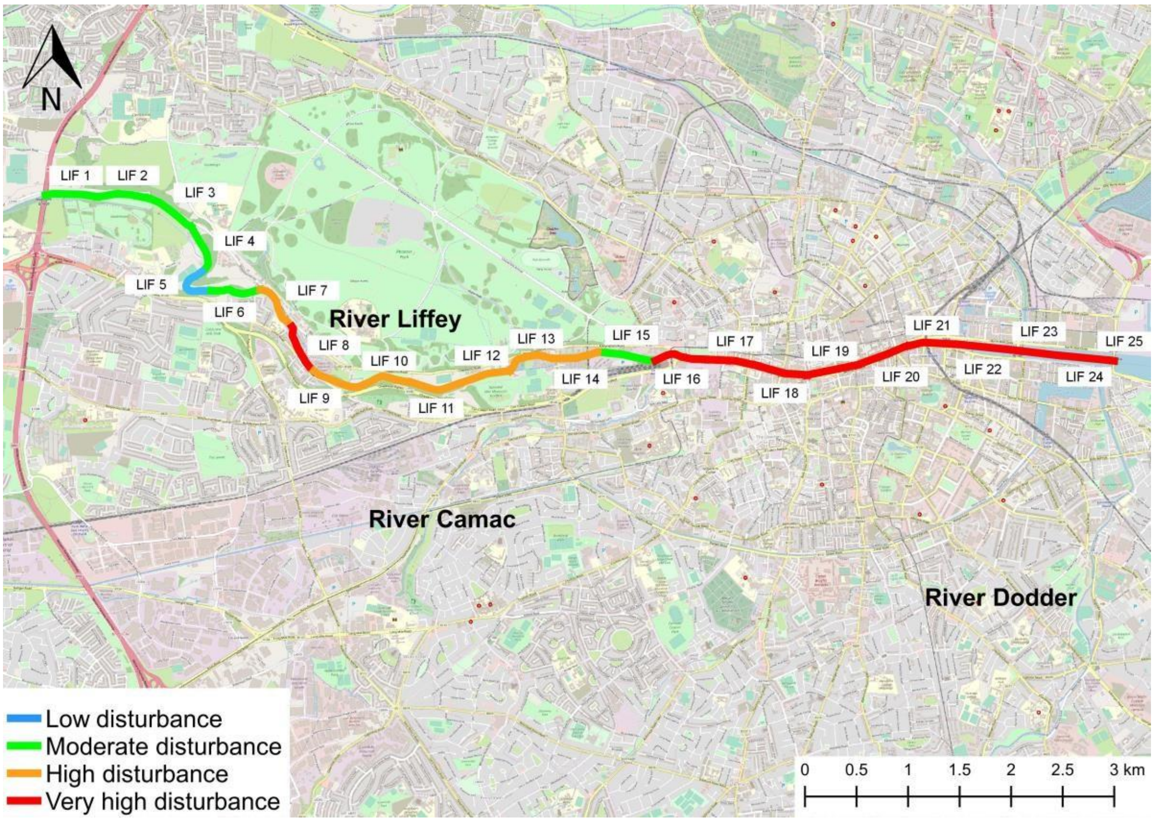

Figure 4.21 Human Disturbance Index scores (colour coded) along the River Liffey surveyed in Dublin City boundaries, April 2018-April 2019

River Camac

The average HDI score for the River Camac sections surveyed was 0.79, corresponding to high levels of human disturbance (Figure 4.18). All sections achieved either 'high' or 'very high' human disturbance ratings (Figure 4.22). Three sections (i.e. CAM4, CAM5 & CAM7) were culverted underground for their entirety and were thus not scored. The majority of otter signs recorded (*n*=8, see section 4.1) were from sections with 'high' as opposed to very high disturbance scores. Human activity along the channel and corridor was typically moderate to frequent, with modified land use widespread throughout. Otter seclusion was generally poor across all sections although some local moderate levels of seclusion was present in the upper and middle survey reaches. The single holt identified along the Camac was present in the section with the lowest level of relative disturbance (i.e. section CAM6, HDI score 0.60).

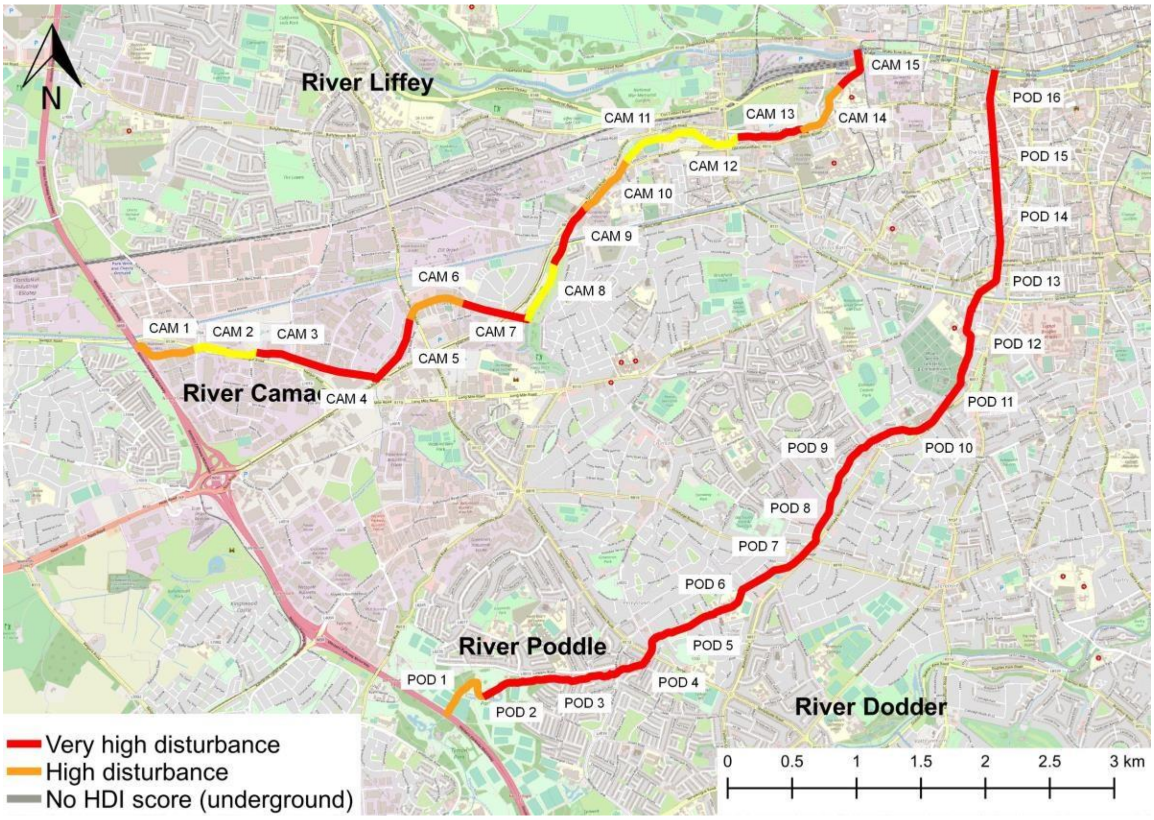

Figure 4.22 Human Disturbance Index scores (colour coded) along the River Camac and River Poddle surveyed in Dublin City boundaries, April 2018-April 2019

River Poddle

Of all the above-ground sections surveyed along the River Poddle, 60% (i.e. six of ten) achieved HDI scores corresponding to 'very high disturbance' (Figure 4.22). The remaining sections scored as high disturbance. Six sections (POD11 through POD16) of the Poddle were culverted underground as were not scored in terms of human disturbance. As outlined in section 4.2 above, the Poddle was a heavily modified river and levels of human activity in the vicinity of the channel were at least moderate if not frequent. Modified land usage including artificial surfaces, open culverts and managed parklands was widespread and offered poor seclusion for otter. Only *n*=2 otter signs (one spraint, one set of prints) were recorded along the Poddle, both from bridge sites.

River Dodder

Although the uppermost survey sections (DOD1 through DOD5, near Dodder Valley Park) of the River Dodder featured moderate levels of human disturbance (all HDI scores ≤0.57) and some good overall otter habitat, much of the river was wither high or very high in terms of human related disturbance (Figure 4.23). In keeping with the pattern observed in most other Dublin City rivers, levels of disturbance gradually increased moving downstream, with the most heavily disturbed areas located in the lowermost reaches. However, otter signs were well distributed throughout, although these were clumped into the upper, middle and lower survey sections (see section 4.1). The Dodder flowed through various managed parklands and urbanised areas and, thus, human activity adjacent to the channel was invariably frequent. Otter seclusion, although typically poor, was locally present, particularly under bridges and in areas not readily accessible to humans such as those sectioned off via high retaining walls, steep banks and scrub/treelines. Regardless of observed disturbance levels, the number of otter signs along the Dodder was appreciably high; one of highest of all rivers surveyed when averaged over the entire survey reach. Of the *n*=5 holts recorded along the Dodder, three were located in sections with low human disturbance scores. The remaining holts were situated on banks in markedly lower disturbance areas within high and very high human disturbance sections, respectively.

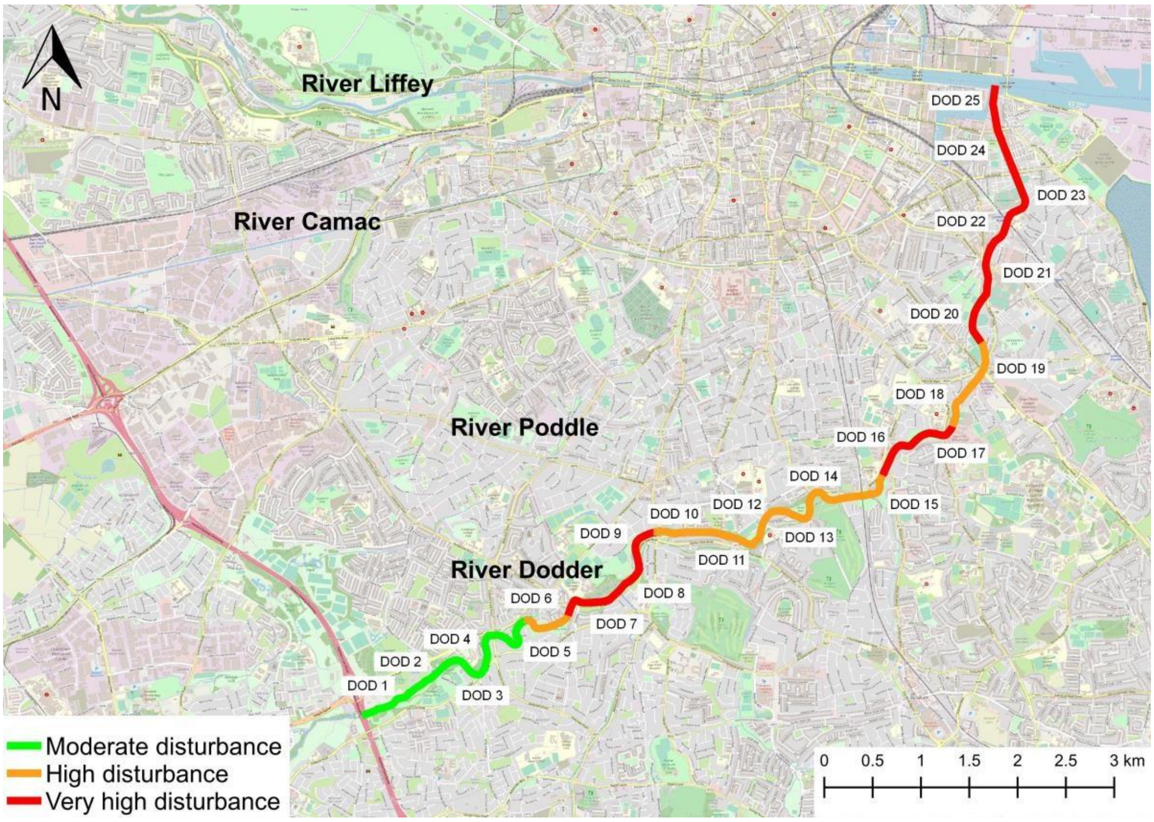

Figure 4.23 Human Disturbance Index scores (colour coded) along the River Dodder surveyed in Dublin City boundaries, April 2018-April 2019

Owendoher River

The majority (62%) of survey sections assessed along the Owendoher River featured high levels of human related disturbance (Figure 4.24), with an average river-wide HDI score of 0.61 (>0.6, therefore high disturbance) (Figure 4.18). No sections graded as very high disturbance. As per other rivers in the study area, the less-disturbed sections of the river were located in the upper survey reaches (i.e. OWN1, OWN3) where human activity along the channel was lower and overall otter seclusion rates were higher. However, otter signs were well distributed throughout the Owendoher (highest number of records per kilometre of any river surveyed, see section 4.1). In higher disturbance areas (adjacent to busy roads, residential areas, footpaths etc. with more modified land usage), otter records were often associated with bridges and culverts which offered seclusion locally. Despite flowing though heavily urbanised, higher disturbance areas, the Owendoher typically retained good levels of seclusion in the immediate riparian zone (≤10m from channel edge) by way of mature treelines, scrub, steep banks and barriers, therefore limiting human access to much of the river. As with rivers like the Dodder, otter holts along the

Owendoher (*n*=4) were located in areas of banks with lower levels of disturbance, even within high disturbance sections.

Whitechurch Stream

The average HDI score across all Whitechurch Stream sections was 0.68, corresponding to high disturbance level (Figure 4.18). The majority (71%, five of seven) of sections achieved a ‘high’ disturbance score (Figure 4.25), with sections WHI1 and WHI3 featuring moderate levels of disturbance owing to less human activity near the channel and less accessible, more secluded riparian zones. Again, as with most other watercourses surveyed, the lesser disturbed areas (lower HDI scores) were located in the uppermost reaches, nearer the M50. Overall, seclusion levels were lower than the adjacent Owendoher to which the Whitechurch joined, and land usage was more heavily modified. Otter signs (total of *n*=12) along the Whitechurch were typically associated with bridges and culverts. Two holts were located along the Whitechurch and, similar to other channels, both were situated under tree root systems in less accessible (to humans), low disturbance areas within sections of high human related disturbance.

Little Dargle River

All *n*=11 sections surveyed along the Little Dargle River achieved either high or very high HDI scores, with the sections of least disturbance located in the uppermost survey reaches (Marlay Park) (Figure 4.24). Although there was some localised otter seclusion and areas of low to moderate human activity along the semi-natural river channel within Marlay Park, overall human disturbance increased markedly downstream. Flowing through managed lands (parkland, gold course) and residential areas, the Little Dargle offered poor seclusion for otter throughout much of the channel, with limited riparian zone cover and a heavily modified channel form. As seen elsewhere in heavily modified channels (e.g. Whitechurch), the majority of otter signs (total *n*=8) were recorded in association with bridges and culverts. No holts were recorded along the Little Dargle.

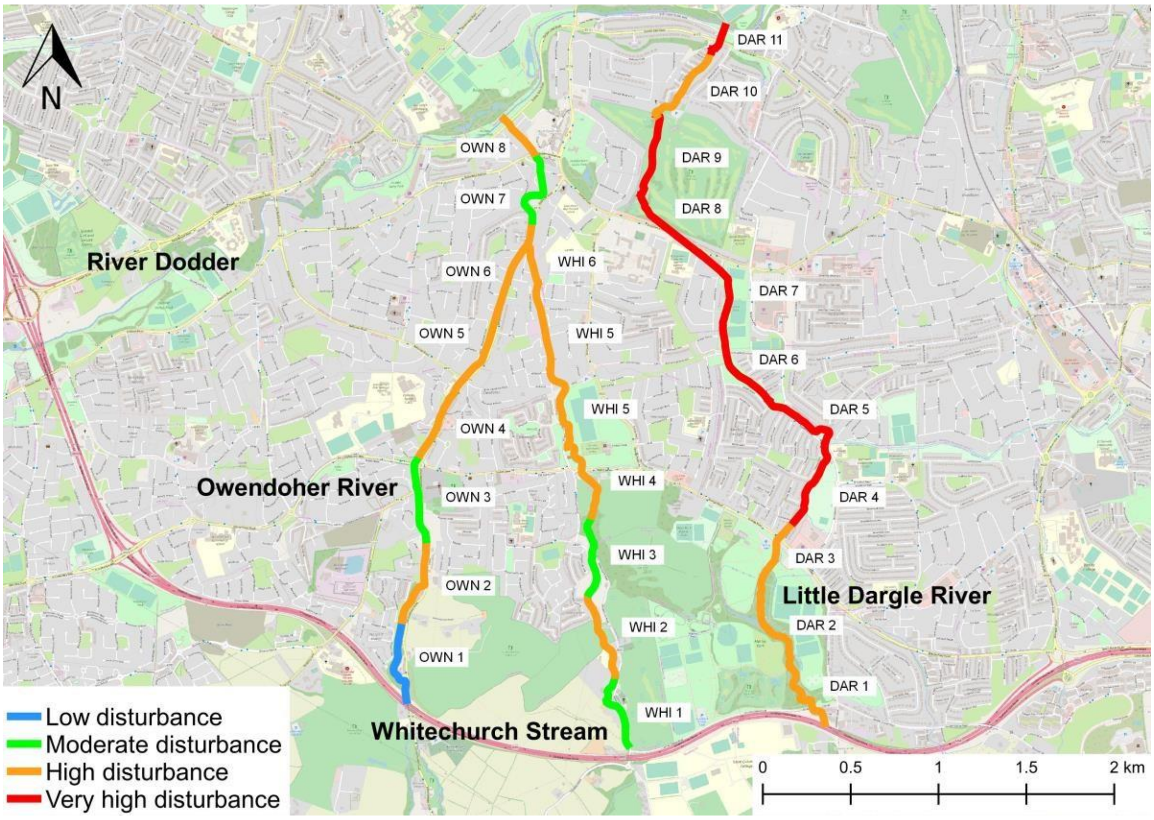

Figure 4.24 Human Disturbance Index scores (colour coded) along the Owendoher River, Whitechurch Stream and Little Dargle River surveyed in Dublin City boundaries, April 2018-April 2019

Wyckham Stream

The Wyckham Stream, a short heavily modified drainage channel, achieved the highest (worst) HDI score of all watercourses surveyed, with an average HDI score of 0.89 per section (i.e. very high disturbance) (Figure 4.18). All three sections surveyed featured very high levels of human related disturbance (Figure 4.25). The channel was readily accessible to humans throughout its length (often on both banks), flowed through managed parkland, was heavily modified and offered little to no seclusion for otter throughout. No otter signs were recorded along the Wyckham Stream (see section 4.1).

Slang River

In contrast to most other watercourses surveyed, the levels of disturbance typically decreased moving downstream along the Slang River (Figure 4.25). However, most sections featured with high or very high levels of human-related disturbance, with an average section HDI score of 0.77 (high disturbance, Figure 4.18). Typically, the river was heavily modified (frequently culverted), flowed through high disturbance urban areas and offered poor seclusion to otter (except often in culverts). The lowermost above-ground section (SLA10) achieved a moderate HDI score, owing to the well-developed riparian zone, low human accessibility and much improved otter seclusion along the channel compared to the rest of the river. Section SLA10 contained one of two holts recorded along the river, the other being located in an area of locally low disturbance (steep vegetated embankment) within a high disturbance section (SLA9). The final survey section was culverted underground (to the River Dodder confluence) and was not scored (Figure 4.21).

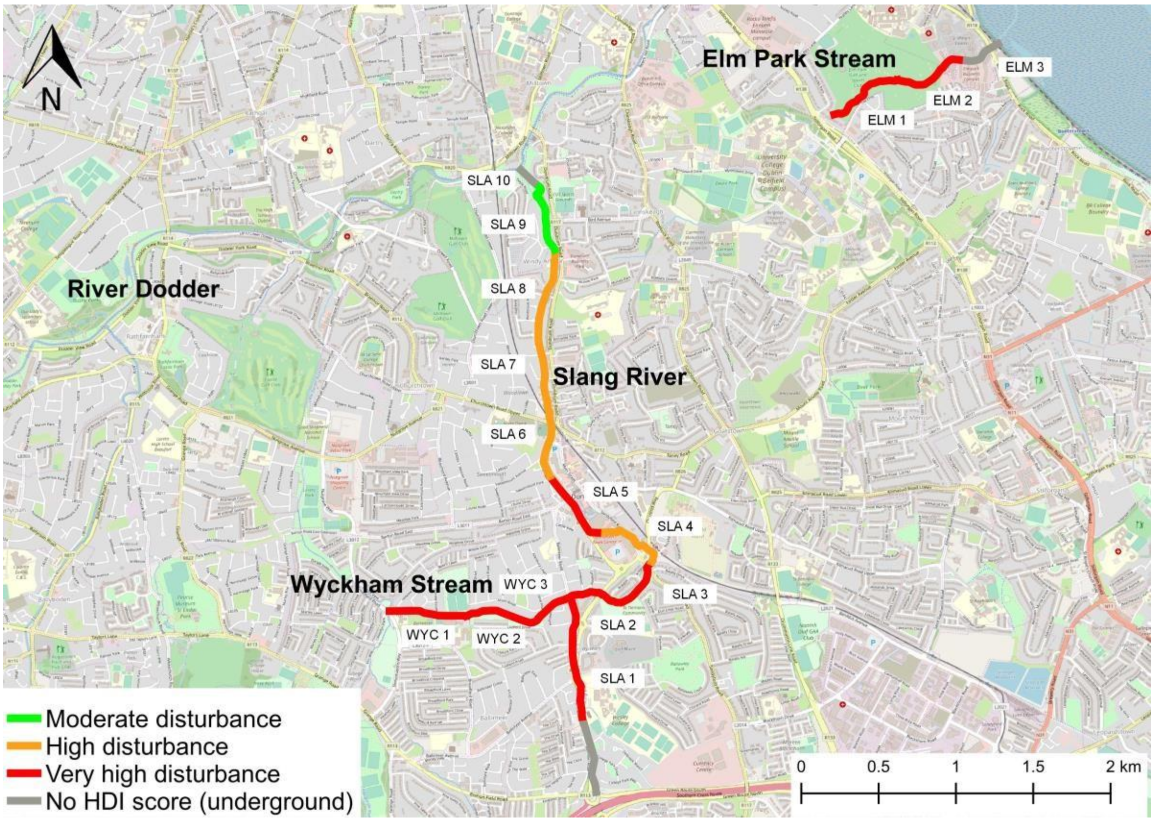

Figure 4.25 Human Disturbance Index scores (colour coded) along the Owendoher River, Whitechurch Stream and Little Dargle River surveyed in Dublin City boundaries, April 2018-April 2019

Elm Park Stream

The short course of the Elm Park Stream received one of the highest HDI scores of all watercourses surveyed, with an average of 0.82 per section (Figure 4.18). Of the three sections assessed, two featured very high levels of human disturbance whilst section ELM3 was entirely underground and not scored (Figure 4.22). The stream was heavily modified and flowed through a golf course, resulting in frequent human activity to the channel edge, heavily modified land use and little to no otter seclusion. No otter signs were recorded along the Elm Park Stream.

Coastal boundary

Of the 44.7km of Dublin City Council coastal boundary surveyed, approx. 63% of sections featured very high levels of human disturbance, whilst 31% featured high disturbance (Figure 4.26). Just six sections surveyed achieved either low and moderate HDI scores, respectively. These six sections (COAST44 through 49) were located on the north side of Dublin Port where all three holts recorded along the coast were found, i.e. lower disturbance areas. Typically, the coastal boundary featured high or very high levels of human activity (roads, paths, cycleways, beaches, industrial areas) with modified land usage (roads, industrial areas etc.) and low levels of otter seclusion. North Bull Island, for example (sections COAST5 – COAST31, approx. 13km of coastline) offered almost no otter seclusion given the beach and sand dune habitats present (no vegetation) and high levels of human (and dog) activity. The same can be said of other recreationally important areas such as Merrion Strand, as well as much of the open coastline. Most of Dublin Port featured very high levels of human activity (industrial zone) and was largely unsuitable for otter marking. The causeway to Poolbeg lighthouse, whilst featuring very high overall levels of human disturbance, supported two regular otter spraint sites at the top of concrete steps.

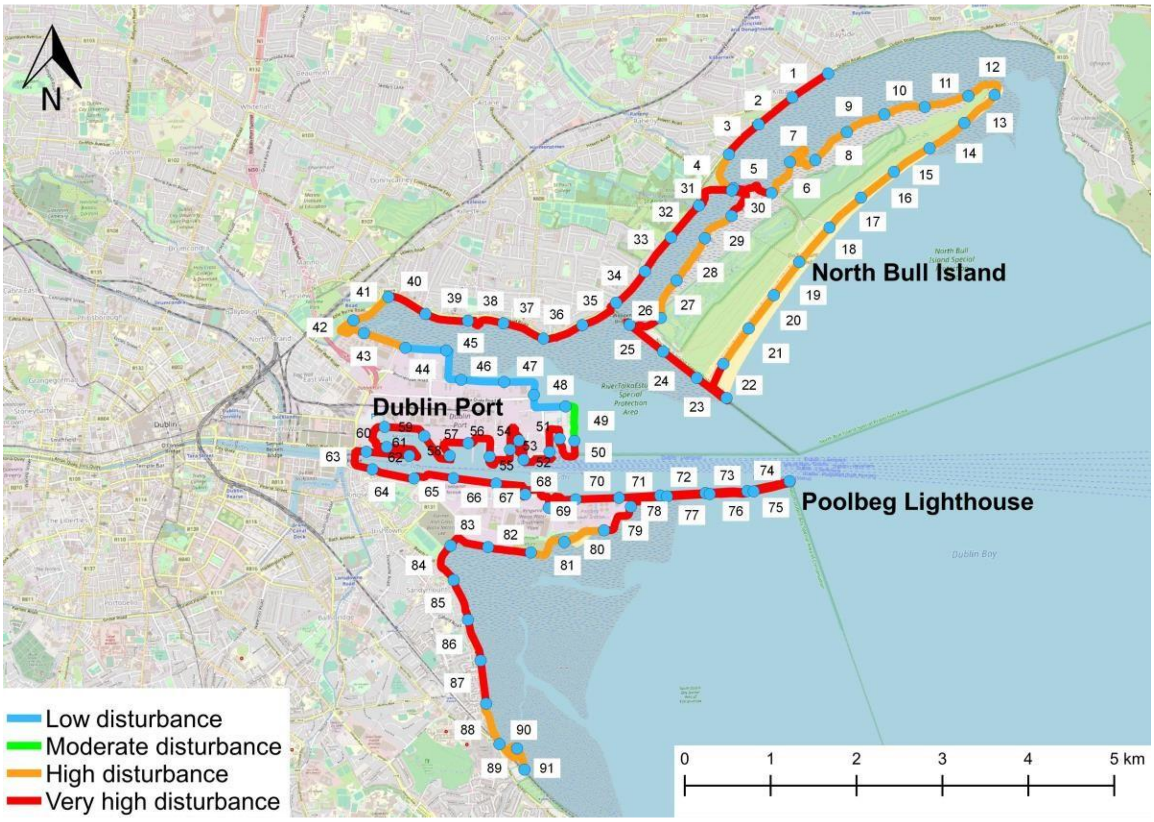

Figure 4.26 Human Disturbance Index scores (colour coded) along the coastal boundary surveyed in Dublin City, April 2018-April 2019

5. Discussion

A baseline of otter sign distribution along riverine watercourses and coastline within the Dublin City Council boundary have been collated and summarised in this report. By mapping otter distribution (through sign marking) and identifying the optimal areas of otter habitat (refer to introduction section), this data also helps to meet some of the requirements of the Draft Dublin City Biodiversity Action Plan 2015-2020. This report, therefore, provides a useful comparative baseline database for future studies both within the city as well as the adjoining jurisdictions of Fingal, Dún Laoghaire-Rathdown and South Dublin County Councils.

As both the breeding and resting places of otter are protected under the Habitats Directive, the Dublin City Otter survey remains essential in helping determine the most important areas for such habitat in our survey areas to assign protection. It is important to define these reaches of otter habitat clearly as they are often isolated and or fragmented blocks which can be easily overlooked given their poorly accessible locations.

Our approach to surveying involved three core indicators of otter habitat quality, namely RHAT, the HDI index and otter field signs. RHAT essentially described how natural each 500m section of river was in terms of profile, substrata quality, fish passage, riparian quality and other variables. The second component was the Human Disturbance Index which helped to evaluate how much human activity, accessibility to riparian areas and associated seclusion were present within each respective river segment. The intention was that the third category, otter sign record distribution, would correlate with lower levels of human disturbance and perhaps more natural areas of channel as defined by RHAT (as they would be congenial to otter). These sections of river channel could be prioritised as areas of especially high importance to otter over other significantly altered sections of channel with low levels of seclusion, high human disturbance and associated absent or very low levels of otter sign marking. These three key components of our study were also facilitated using our novel total corridor otter survey (TCOS) approach, which ensured that all physically accessible areas of channel were observed. This ensured a very high degree of coverage within each survey reach (128.5km of channel in total) and thus higher detection rates of otter signs, alongside better interpretation of the nature of physical habitats in the field. The following sections provide a synopsis of the survey areas and their value to urban otter.

5.2 Areas and rivers with the highest density of otter records (highest importance)

A total of *n*=196 otter signs, consisting of spraints, holts, couches, prints, jellies (smears) and prey remains, were recorded across fourteen watercourses and the coastal habitat fringe across Dublin City Council jurisdiction. Many signs constituted new location records for Dublin City and these results have significantly expanded the baseline knowledge of otter populations within the city boundary.

The Rivers Dodder, Tolka, Owendoher, Liffey and Whitechurch accounted for the majority (73%) of the otter signs in this study area and also supported the highest marking frequencies and number of holts per kilometre of channel (Figure 4.1). Other watercourses such as the Little Dargle, Camac, Santry, Mayne, Slang and Poddle appeared to support far fewer otters, with broadly poorer quality habitat (see preceding sections) and number of otter signs.

However, there has long been much trepidation held regarding the use of otter sign marking as a proxy for otter distribution, or even presence (Mason & Macdonald, 1996). A paucity of records, even discerned through the Total Corridor Otter surveys (TCOS) such as ours, does not necessarily imply an absence of otter from a particular habitat (Hutchings & White, 2000; Guter et al., 2008). Otter marking is influenced by many temporal, climatic, demographic and (as suggested in this study) disturbance-related factors. In particular, the availability of marking sites evidently plays a key role in sign marking. Although the nuances are not fully understood, marking serves a variety of territorial and communicative functions in otter populations (Kruuk, 1982; MacDonald & Mason, 1987; Remonti et al., 2001) and are routinely associated with prominent features such as large boulders and holts, as well as at typical key foraging sites such as weirs and pools. Rationally, without such sites or features to mark in a given habitat, otter signs may be present at cryptically low levels or even absent entirely. A good example would be the rivers Camac, Slang, Santry, Mayne and even Liffey where, despite known otter usage throughout the channel (based on historical and our contemporary data), long tracts existed with evidently few or no conspicuous features, nor otter signs. The same can be said of the coastal habitat surveyed. This common fragmented pattern of otter sign distribution further reinforces the value of total corridor surveys.

However, a lack of signs in a given habitat does not imply the absence of otter, rather habitat less appropriate to otter marking; animals may regularly use such areas for commuting between other areas, as suggested by our spatial results. This can be concluded as site specific locations (e.g. bridge abutments & culvert ledges) within larger reaches of channel barren of otter signs are often heavily marked. The deposition of signs by otter (e.g. spraint, smears and jellies) appears to be non-random and deliberately placed, often where human access (including that of dogs) is restricted. The juxtaposition of the presence of heavy spraint sites and sites devoid of spraints suggest preferential marking behaviour. Our hypothesis is that is relates at least in part to lower levels of human-related disturbance.

Nevertheless, overall habitat quality in terms of potential foraging opportunities, water quality and holting opportunities (as well as disturbance, see preceding section), appears to play a large role in otter distribution across Dublin City environs. Although contemporary data on fish stocks (major prey resource) and water quality were largely unavailable or not comprehensive enough for this study (see 'Further study' section), their importance in supporting otter populations are well known. Superficially, those rivers and areas of habitat with healthier fish stocks and or less anthropogenic pressures than other rivers in Dublin City (e.g. Dodder, Tolka, Owendoher) appeared to support more regular otter usage, as inferred from sign marking.

In the proceeding paragraphs we discuss how RHAT and HDI classification of 500m reaches of channel have influenced otter sign marking based on channel form (i.e. naturalness) and human disturbance respectively.

5.3 The influence of RHAT on otter sign distribution

Here, for the first time, we have used RHAT to broadly quantify the naturalness of watercourses within Dublin City whilst also concurrently inferring the relationship between overall river hydromorphology and overlapping otter sign distribution. RHAT scores were calculated for each 500m section of all watercourses (except coastal habitat, given the system is for rivers only) and quantified the degree of departure from naturalness of a given river section. To an extent, RHAT also assesses several elements of human-related disturbance although our novel HDI methodology allows a greater level of detail in this regard (see proceeding section, 5.4).

A moderate positive correlation (R^2 = 0.59, data not shown) was observed between mean river-wide RHAT scores and the density of otter marking (Figure 4.18). Rivers with higher RHAT scores (i.e. greater levels of naturalness) typically featured more total otter signs, such as the Owendoher River, for example (see Table 5.1). However, correlation between RHAT scores and sign marking at the finer-scale (i.e. per riverbank or per 500m section) was not as apparent with some 'poor status' and 'bad status' sections supporting relatively high densities of otter signs. Likewise, certain apparently 'good status' scoring sections of river channel were found to contain relatively few (or sometimes no) otter marking signs. This would indicate that other factors may be at play locally including availability of spraint sites, prey resources and human disturbance.

Nonetheless, as is evident from the data summarised in Figure 4.17, when accompanied by total corridor surveys and assessments of disturbance, RHAT can be very useful in identifying and prioritising better areas of habitat at the river-scale for otters, thus facilitating more effective management and conservation efforts. This is especially true for urban environments where better quality otter habitat may be localised, more fragmented and rarer overall, as observed during this study.

5.4 The influence of human disturbance on otter sign distribution

As is evident from our data, human-related disturbance does appear to influence distribution of otter signs in habitats within and adjoining Dublin City. In general, areas of river channel or coastline exposed to higher disturbance (categorised under human activity, land use and human accessibility/otter seclusion) contained fewer otter signs although there are, of course, often exceptions depending on other factors such as prey resources, water quality and local hydromorphology (also indicated in our observations associated with RHAT). However, other variables such as prey resource studies, sprainting site availability and water quality analysis were beyond the scope of the current study. Nonetheless, by quantifying the level of human-related disturbance via the Human Disturbance Index, it facilitated the identification of the most undisturbed areas of river channel and coastline that were often associated with higher density marking (Figure 5.1, Table 5.1). Accordingly, these areas could then be earmarked as priority areas for otter management and conservation.

This is particularly true with regards the location of otter holts and breeding sites, which are widely accepted as being especially sensitive to direct human disturbance (Mason & Macdonald, 2009). When examined on a per riverbank basis (0-10m buffer only), there was a clear relationship between the location of otter holting areas and lower levels of human disturbance, i.e. HDI scores (Figures 5.1 & Table 5.1 below). Out of a total of *n*=25 otter holts recorded throughout the study area, 72% of all holts were located in areas of low (28%) or moderate (44%) human disturbance (HDI ≤0.59), with 20% contained within high disturbance areas of river or coastal bank. This same pattern was also evident when HDI scores were considered for both 0-10m and 10-25m buffers combined, although not to same extent (data not shown).

Only 8% of holts (*n*=2) were located in very high disturbance areas (0-10m buffer HDI score ≥0.8). One was situated on the River Dodder (upstream Clonskeagh Bridge) and one in Dublin City centre on the River Liffey. Both of these holts were evidently active and were situated in the lowest-disturbance areas within their respective sections. These holts were situated in areas which were close to high levels of disturbance but were, nevertheless, largely inaccessible to humans. This same pattern was observed with the majority of other holts recorded, i.e. irrespective of adjoining disturbance levels, holts were invariably located within the least-disturbed areas of a given 500m river section. This may be explained by observations of otter reproductive success being higher in less disturbed habitat and apparent preferential fidelity for low disturbance areas of channel (Loy et at., 2009; Ruiz-Olmo et al., 2011).

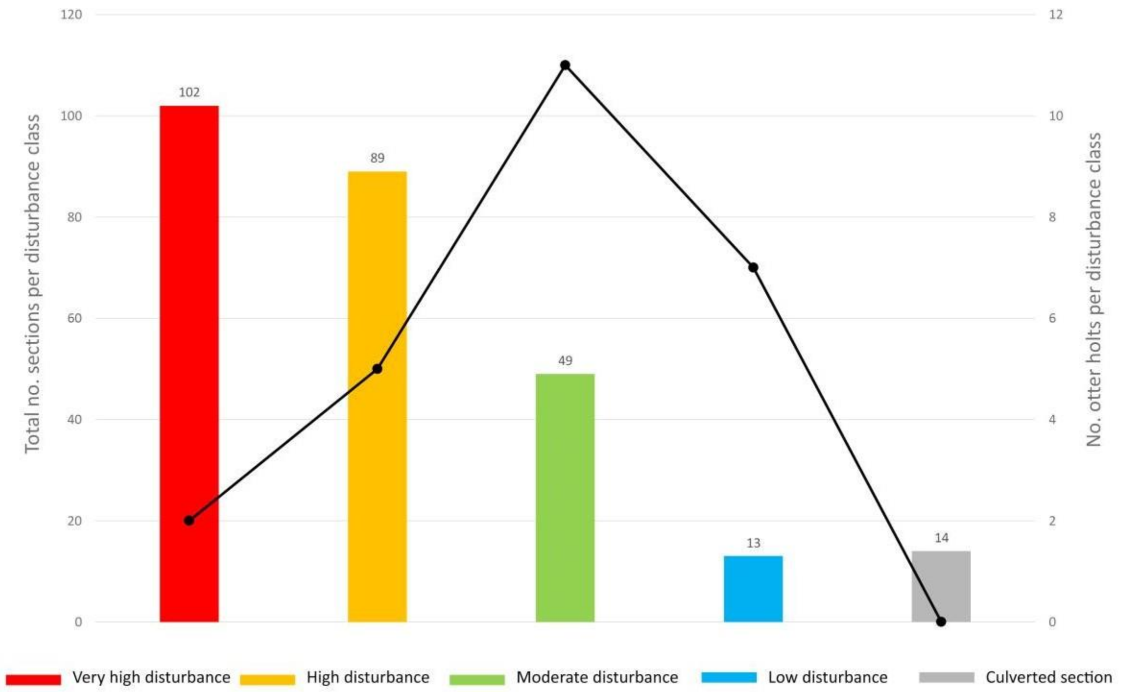

Figure 5.1 Total number of 500m survey sections falling within each Human Disturbance Index class showing comparative density of otter holts per class (0-10m riparian buffer only).

*Note: sections culverted underground were not scorable under the HDI and were omitted.

Table 5.1 Summary of the better-quality areas for otters per watercourse based on RHAT scores, HDI scores (0-10m + 10-25m buffers combined) and overall otter marking sign density. Please refer to Figures 4.10 through 4.16 for the location of each coded section.

Watercourse	Moderate to high RHAT score	Low to moderate HDI score	≥3 otter signs per section	Holt presence
River Mayne	None	MAY6, MAY7	None	1 located
Santry River	SAN11	None	None	1 located
Naniken River	None	None	None	None
River Tolka	TOL1, TOL2, TOL3, TOL4, TOL5, TOL6, TOL7, TOL12, TOL13, TOL14, TOL18	TOL1, TOL2, TOL3, TOL4	TOL4, TOL13, TOL15	2 located
River Liffey	LIF1, LIF2, LIF3, LIF4, LIF5, LIF6, LIF7, LIF9, LIF10, LIF11, LIF12, LIF13	LIF1, LIF2, LIF3, LIF4, LIF5, LIF6, LIF15	LIF24	2 located
River Camac	CAM2, CAM8, CAM11, CAM12	None	None	1 located
River Poddle	None	None	None	None
River Dodder	DOD1, DOD2, DO3, DOD4, DOD5, DOD6, DOD7, DOD8, DOD9, DOD11, DOD16, DOD17, DOD18, DOD19	DOD1, DOD2, DOD3, DOD4, DOD5	DOD1, DOD3, DOD10, DOD15	6 located
Owendoher River	OWN1, OWN2, OWN3, OWN4, OWN5, OWN6, OWN7, OWN8	OWN1, OWN3, OWN7	OWN2, OWN3, OWN5, OWN6	4 located
Whitechurch Stream	WHI1, WHI2, WHI3, WHI4, WHI5, WHI6, WHI7, WHI8	WHI1, WHI3	WHI1	2 located

Watercourse	Moderate to high RHAT score	Low to moderate HDI score	≥3 otter signs per section	Holt presence
Little Dargle River	DAR2, DAR3, DAR4, DAR10	None	None	None
Wyckham Stream	None	None	None	None
Slang River	SLA10	SLA10	None	2 located
Elm Park Stream	None	None	None	None
Coastal boundary	n/a	COAST44, COAST45, COAST46, COAST47, COAST48, COAST49	None	3 located

6. Implications of findings

The findings of the Dublin City otter survey illustrate the importance in the preservation of the remaining areas of good to high quality otter habitat within DCC boundaries, as inferred by River Hydromorphology Assessment Technique (RHAT) and Human Disturbance Index (HDI) analysis.

Areas of higher seclusion and lower levels of relative human disturbance appear to strongly influence the location of otter holts in both coastal and riverine environments. Similarly, with respect to RHAT scores - which illustrate how a river conforms to or deviates from naturalness - those watercourses which score highly and correspond to a more natural channel form appear to be of greater importance for otter marking. As marking (spraints, jellies, latrines, couches etc.) is a known prerequisite for the occurrence and usage of a channel by otter (Mason & Macdonald, 1986) higher incidences of marking would suggest a more important overall habitat for the species (Prenda & Granado-Lorencio, 1996), despite some known exceptions.

In light of our findings, the application of both RHAT and HDI methodologies are useful habitat management tools in respect of identifying priority areas for otter when used in conjunction with otter sign field surveys. This approach works most effectively when combined with our novel total corridor otter survey methodology (TCOS), which inspects and analyses entire reaches of river as opposed to only localised strategic point surveys at bridges, for example. The HDI approach demonstrates that higher levels of relative human disturbance appear to be negatively correlated with otter holt positioning. Equally, higher RHAT scores indicate rivers conforming to good or high WFD status appear to be more heavily utilised by otter (i.e. higher numbers of otter signs). Therefore, both metrices could be used as predictors of more optimal otter habitat, in both rural and more urbanised settings throughout the wider Dublin area.

Crucially, in respect of strategic planning for development along watercourses including greenways, blueways and other linear infrastructural developments, our study and inherent methodologies will help protect those identified reaches of river channel and coastal habitat of higher importance for otter as a species. This will help to realise the objectives of the Dublin City Biodiversity Action Plan 2015-2020 and help to meet the conservation requirements under the EU Habitats Directive 92/43/EEC for otter as an Annex II and Annex IV species.

7. Further study

It is recommended that a follow-up total corridor otter survey (TCOS) and associated reporting be repeated every 3 to 5 years to ensure that otter populations within Dublin City remain stable over time, through comparison with the current findings. In this respect, this report provides a good baseline through which to relate future survey efforts.

As water quality status remains a very important marker of ecosystem quality, otter health and population status will improve in watercourses with cleaner water and a more diverse prey resource, including a healthy fish population (Triturus pers. obs.). While otters may still mark areas in polluted rivers and streams (i.e. Q2 and Q2-3 water quality), signs appear to be more frequent in less polluted rivers, particularly those with viable salmonid populations (i.e. Q3 and above; Kelly et al. 2007). Overall, while otters are not as good a bio-indicator as riverine aquatic invertebrates (e.g. EPA Q-ratings), sign marking occurrence does appear to be reduced in smaller, more polluted watercourses. Therefore, based on preliminary observations, otter marking is less intense on Q2 and Q2-3 watercourses and, as such, they may be useful bio-indicators at the lower end of the biological water quality scale. However, catchment-wide biological water quality analysis would help validate this observation, with fully empirical data.

Unfortunately, the EPA does not monitor many of the smaller urban rivers and streams, given that resources are required to be concentrated on larger river sites. Consequentially, biological Q-ratings are not readily available for some of the watercourses in the Dublin City area. As such, it is recommended that water quality monitoring be undertaken in the upper, middle and lower reaches of the watercourses surveyed for otter in DCC jurisdiction to establish a contemporary water quality baseline longitudinally in rivers to calculate the length of polluted or unpolluted channel. This would help to identify where pollution threats are originating and would also help target efforts to reduce, for example, storm drain pollution and alleviate other point sources. EPA Q-ratings would be most useful in that they would establish definitive water quality status (i.e. good, moderate, poor etc.), whereas a Small Streams Risk Score (SSRS) assessment would only establish risk. Otter sign distribution could also be compared with the distribution of biological water quality (i.e. length of unpolluted channel versus density of otter records per kilometre) to establish whether water quality status is affecting otter distribution or not. Such a holistic approach would also fully compliment the wider biodiversity objectives set out under the Dublin City Biodiversity Action Plan 2015-2020.

Further monitoring could also include fish population data through catchment-wide electro-fishing (CWEF) which would serve to provide a baseline of the fish resources, again in the upper, middle and lower reaches of each system. This is considered especially important and informative as fish have long been known as the most important prey resource for otter (Erlinge, 1968; Mason & Macdonald, 1986; Ruiz-Olmo et al., 2001; Krawczyk et al., 2016 but cf. Wise et al., 1981; Kloskowski et al., 2013; Reid et al., 2013). Baseline electro-fishing surveys would help identify which riverine channels support the healthiest fish populations and whether a correlation exists between areas with the healthiest fish stocks and those most frequently marked by otters (as suggested by several authors, e.g. Weinberger et al., 2016). Such data collation would also help to substantiate water quality analysis for the same channels.

While DNA fingerprinting of otter populations through genetic sampling from fresh spraint may be beyond the scope of council resources, a collaborative effort between Dublin City Council and University College Dublin (national leaders in genetic studies) would help evaluate otter population status (population size and sex demographics) for the most important otter rivers (e.g. Dodder, Tolka, Whitechurch, Owendoher). As molecular techniques are becoming more cost effective and results more rapidly interpreted with the advent of SNP (single nucleotide polymorphisms) analysis, robust estimates of otter numbers within specific catchments are becoming more attainable. This report presents the distribution of otter marking sites along fourteen watercourses (83km) and 44km of coastline which can subsequently be used to help collect DNA samples, as otter often use the same sites to spraint interannually (Triturus unpublished data; Balaestrieri et al., 2011).

8. Acknowledgements

This study was commissioned by Dublin City Council and we would like to particularly thank Shane Casey (Dublin City Biodiversity Officer) for his continued support throughout. We also extend our gratitude to Dr. Paddy Sleeman (UCC), Dr. David Kelleghan (UCD) and Sinead Hurson for their advice and assistance during the project.

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