Abundance and movement of wintering Eider at Belfast Lough

Booth Jones, K. A.[1], Leonard, K.[2], Allen, D.[3], Calbrade, N. A.[4], Austin, G.E.4, Humphreys, E. M.[5] & Burton, N. H. K.[4]

[1]British Trust for Ornithology Northern Ireland, Northern Ireland Environment Agency, Klondyke Building, Gasworks Business Park, Belfast, BT7 2JA;
[2]16 Birch Park, Bangor, Co. Down, BT19 1RZ;
[3]Allen & Mellon Environmental Ltd, 80 Ballynahatty Road, Belfast, BT8 8LE;
[4]British Trust for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU;
[5]British Trust for Ornithology Scotland, Beta Centre (Unit 15), Stirling University Innovation Park, Stirling, FK9 4NF;

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EXECUTIVE SUMMARY

1. The Marine Protected Areas Management and Monitoring (MarPAMM) project aims to inform future MPA management by supporting data collection for a range of marine bird species that make up an ecologically and culturally important element of the marine and coastal ecosystems of the Interreg VA region. While many seabird surveys focus on the breeding season, there is less known about populations of wintering sea duck. This study therefore aims to provide information on wintering Eider (*Somateria mollissima*) in Belfast Lough.
2. In this report, current knowledge of Eider numbers and distribution in the area of the Belfast Lough SPAs (coastal and Open Water) is summarised. In addition, the behaviour and movements of Eider through diurnal and tidal cycles are assessed, and potential sources of disturbance are identified and discussed.
3. Analysis of existing Wetland Bird Survey (WeBS) data highlighted that Eider numbers in Belfast Lough have increased at a greater rate than the Northern Irish population as a whole, and that this was driven by increased numbers along the northern shore of the lough, as demonstrated using trends in high tide counts at the sector-level.
4. Professionally conducted counts of the whole of Belfast Lough made in response to a suspension of normal WeBS counting due to the COVID-19 pandemic lockdown of January 2021 were within the usual five-year mean peak for the lough. A snapshot count of Eiders along points of the coastline between Larne Lough and Ballyquintin Point, representing the area covered by the proposed East Coast Marine SPA, revealed concentrations of Eider in Larne Lough and between Groomsport and the Copeland Island SPA.
5. Through-the-tide-counts (TTTCs) were carried out between November 2020 and March 2021 and consisted of three 30-minute count periods and three hour-long disturbance and flight watch periods. Eider abundance and flight activity in TTTC sectors peaked in November and declined through the winter, however abundance patterns were also shaped by tidal state. Numbers of Eider recorded were highest at low tide, likely reflecting easier foraging access to bottom-culture mussel beds in the area.
6. Three dawn watches were conducted from positions on the mouth of Belfast Lough to assess Eider morning movements into the lough. No significant movement into the lough was observed from the north, but Eiders passing into the lough along the southern shore accounted for approximately half of the total population of the lough. Therefore, when planning MPA management for Eider in Belfast Lough it will be important to consider the wider population external to the lough, particularly in the Groomsport-Copeland region.
7. Marine traffic was the main source of potential disturbance observed in the TTTC sectors. In 89% of cases, Eider did not respond to these by flying or swimming away, in contrast to a study made in Orkney, where Eider were observed to increase flight activity in relation to marine activity. However, rare cases of apparently deliberate disturbance of Eider flocks were observed on three separate days, resulting in Eider flocks being dispersed by boats.
8. Due to the disturbance and conflict observed between the growing and nationally important Eider population in Belfast Lough and the economically important bottom-culture mussel aquaculture industry, it is a recommendation of this report that stakeholder engagement work takes place to develop a better understanding of the issues involved and to find solutions to mitigate impacts.

9. This study was limited by the distance that Eider were observable from shore, and aerial surveys may provide a means to assessing numbers and distribution of Eider at a distance of over 3 km from shore. Additional study of movement into and out of the lough and between Eider populations would also be beneficial, particularly associations with the Groomsport-Copeland area.

1. INTRODUCTION

1.1. Background

The Marine Protected Areas Management and Monitoring project (MarPAMM) aims to inform future MPA management by supporting data collection for a range of marine bird species that make up an ecologically and culturally important element of the marine and coastal ecosystems of the Interreg VA region. This region spans the cross-border area between the Republic of Ireland, Northern Ireland and Scotland. For Marine Protected Areas (MPAs) to successfully preserve the species and ecosystems they are created to protect, there must be a solid evidence base from which to measure changes and develop management plans. While many seabird surveys focus on the breeding season, there is less known about populations of wintering sea duck, including their abundance, spatial distribution and movements. This report therefore aims to provide information on wintering Common Eider (hereafter 'Eider', *Somateria mollissima*) in Belfast Lough.

Belfast Lough is Northern Ireland's fourth most important site in terms of total wintering waterbird numbers, supporting approximately 16,000 individuals (five-year average of peak counts, Frost et al., 2021). The inner lough largely consists of tidal mudflats and lagoons, while its outer stretches are characterised by rocky shores and small sandy bays (DAERA, 2015a). Belfast Lough is designated as a Special Protection Area (SPA) under the EC Birds Directive (79/409/EEC) for its international importance for wintering Redshank (*Tringa totanus*), while a recent reassessment also identified the site's international importance for wintering Bar-tailed Godwit (*Limosa lapponica*) and breeding Common and Arctic Terns (*Sterna hirundo* and *S. paradisaea*; DAERA, 2015a). The Belfast Lough Open Water SPA qualifies for its international importance for Great Crested Grebe (*Podiceps cristatus*) in winter and also regularly supports nationally important numbers of Cormorant (*Phalacrocorax carbo*), Shelduck (*Tadorna tadorna*), Scaup (*Aythya marila*), Eider, Goldeneye (*Bucephala clangula*) and Red-breasted Merganser (*Mergus serrator*; DAERA, 2015b).

The Belfast Lough SPAs are in the process of being subsumed into a greater East Coast Marine SPA, in combination with the Larne Lough, Outer Ards, Copeland Islands and Strangford Lough SPAs. This large Marine SPA aims to safeguard breeding populations of Manx Shearwaters (*Puffinus puffinus*), Sandwich (*Sterna sandvicensis*), Common and Arctic Tern, and non-breeding populations of Red-throated Diver (*Gavia stellata*), Great Crested Grebe and Eider (DAERA, 2021a). In particular, the Eider population encompassed by the proposed SPA is the largest aggregation on the island of Ireland, representing approximately 77% of the Irish wintering population and 5% of the UK wintering population (Burke et al., 2018; Frost et al., 2021; Woodward et al., 2020) and consists of breeding birds from the County Antrim and Down coasts and may also host Eider dispersing from Scotland (DAERA, 2021a; Leonard, 2010).

The UK's internationally important non-breeding waterbirds are monitored through the Wetland Bird Survey (WeBS: https://www.bto.org/our-science/projects/wetland-bird-survey). Although the numbers of Eiders recorded by WeBS on Belfast Lough have increased in recent years (Frost et al., 2021), the species has recently moved from Amber to Red on the Birds of Conservation Concern list in Ireland (BoCCI; Gilbert et al., 2021), due the global conservation concern for the species as assessed by BirdLife International (2017). Eider are thought to be sensitive to disturbance (Jarrett et al., 2018; Merkel et al., 2006, 2009), and those using the lough have the potential to be affected by human developments and activities, for example by recreational use, shipping and boat traffic (Dehnhard et al., 2019; Merkel et al., 2009) and aquaculture (Cervencl et al., 2015; Žydelis et al., 2009). Aquaculture is a growing industry in Northern Ireland; in 2016 the shellfish aquaculture sector was valued at £4.3 million (DAERA, n.d.). In Belfast Lough there are 21 licenced bottom-culture mussel beds (both active and inactive) covering approximately 953 hectares (DAERA, 2021b; Ferriera et al., 2007). These beds may provide a food resource for Eider, while aquaculture activity may be a source of disturbance.

While WeBS data provide an overall assessment of population size and distribution of Eider in the lough, they do not reveal the variations that may occur in distribution through the tidal cycle as a whole or any tidal or daily movements to and from the SPA. In addition, nothing is yet known about Eider sensitivity to potential disturbance events in Belfast Lough, and because previous research has shown waterbird reactions to disturbance to be site-dependent (Jarrett et al., 2020), it is important that this information is collected locally. New data on these aspects will be vital to assess the pressures that Eider face in Belfast Lough and to inform appropriate mitigation measures.

1.2. Aims and objectives

The aim of this report is to provide the MarPAMM project with up-to-date distribution and abundance information on Eiders in Belfast Lough during the winter months, to identify potential disturbance pressures that Eider may be experiencing during this period and to use this information to identify potential mitigation measures. To meet these requirements the following objectives were set:

i) To ensure that current knowledge of Eider numbers and distribution in the area of the Belfast Lough and Belfast Lough Open Water SPAs is up to date and as complete as possible.

ii) To assess the numbers, behaviour and movements of Eiders at the four through-the-tide study sites.

iii) To record the disturbance activities typical of Belfast Lough and the responses of Eiders to these events in order to identify pressures and potential mitigation measures.

2. METHODS

In the original programme of work, objective (i) above was to be met through a review of existing WeBS Core and Low Tide scheme data and through additional gap-filling for these counts to ensure the best possible coverage of Eider numbers in the lough in winter 2020/21. Additional through-the-tide counts (TTTCs) aimed to deliver the data needed to address objectives (ii) and (iii). However, existing coverage of Belfast Lough WeBS sectors for both Core and Low Tide counts was comprehensive early in the season and from January 2021 tightening COVID-19 restrictions curtailed the WeBS surveys entirely. Consequently, objective (i) was reviewed, and a revised work programme agreed to provide additional data on WeBS trends, assessed following methods laid out in previous reports conducted for Natural England and the Northern Ireland Environment Agency (Austin et al., 2008; Booth Jones et al., 2021; Ross-Smith et al., 2013), WeBS gap-filling was dropped from the survey schedule, and TTTCs, dawn watches, counts of the proposed East Coast SPA extent and full Belfast Lough counts were carried out, as described below.

2.1. Assessment of WeBS Core Count and Low Tide Count Data (Objective i)

2.1.1. Collection of WeBS waterbird data

The WeBS Core Count scheme is a long-running survey that monitors waterbird numbers on sites throughout the UK via monthly site visits, when numbers of all waterbird species are recorded (Frost et al., 2020). The primary aim of the Core Count scheme is to provide abundance estimate for whole sites which then feed into population estimates, species indices and multispecies indicators. On coastal sites, WeBS Core Count visits are normally undertaken over high tide, the nominal date for survey visits chosen to correspond with spring high-tides when waterbirds are concentrated near the high-water mark or concentrated into high-tide roosts facilitating accurate counting. On large sites, such as Belfast Lough, where it is not feasible, or indeed desirable, to make a single count for the entire site, synchronous counts of smaller count sectors are undertaken by teams of volunteer counters. These sector counts are routinely summed to give the overall site total, and during this process the completeness of the overall count assessed. This is required because all sectors are not necessarily counted on all occasions. This completeness assessment is species specific because the absence of data from a given sector would not be expected to affect the overall total equally for all species. Furthermore, completeness is assessed on a month by month, year by year basis using algorithms that allow for both seasonal and long-term trends in site usage. Thus, a consolidated count for a site composed of multiple sectors is considered complete when those sectors counted on the month in question would be expected to hold at least 75% of the site total for the species in question for the season and year in question. Whilst the division of large sites into sectors has evolved principally in response to the practicality of undertaking counts, the divisions between sectors typically follow distinctive features of the environment. Thus, an analysis of trends on the individual sectors can inform in a biologically meaningful manner. Six constituent and extant WeBS Core Count sectors of Belfast Lough (Figure 1) were considered in this report.

The WeBS Low Tide Counts scheme has been running since the winter of 1992/93 and as the name indicates, counts are undertaken over low tide. The objective of the Low Tide Count scheme is to quantify the within-site distribution of species over the low-tide period as so identify important habitat/areas for feeding waterbirds. Counts are organised in a similar manner to those undertaken for the Core Count scheme other than monthly counts are restricted to the main winter period (November to February inclusive). Unlike Core Counts there is less emphasis on synchronicity of counts across a site as these counts are not typically summed to derive abundance estimates for the overall site. Indeed, if a given flock of waterbirds is recorded on several sectors during the course of a visit this does not compromise the principal aims of the Low Tide Counts, indicating, as it does, that all those sectors are important to the birds. It is not feasible to count all sites in all winters and typically the Low Tide Counts scheme aims to cover about 10 to 20 estuaries UK-wide each winter and ensure any given site is included at least once every five to ten years. Unfortunately, this means that Low Tide Counts cannot normally be used to derive sector level trends for the type of analysis being undertaken here, however exceptionally, through the efforts of the Northern Ireland Environment Agency (NIEA) and local volunteers, the Low Tide Counts scheme has run annually across the full time period in Belfast Lough. Consequently, for Belfast Lough, we are able to consider waterbird trends at the sector level for both high tide and low tide. Twenty-seven constituent and extant WeBS Low Tide Count sectors of Belfast Lough (Figure 1) were considered in this report.

Simple plots of the maximum number of Eider observed per year per Core Count and Low Tide sector were generated to illustrate sector-level abundance and change over time. For each Core Count sector between 21 and 28 years were surveyed (mean = 24.33, SD = 3.01) and between one and nine months were surveyed per year (mean = 5.08, SD = 2.14). For each Low Tide sector between one and 26 years were surveyed (mean = 14.7, SD = 7.93) and between one and three months were surveyed per year (mean = 2.13, SD = 0.79). For sectors with multiple counts per year (i.e. those counted in more than one month), the maximum count was taken to represent Eider usage of the sector in that year.

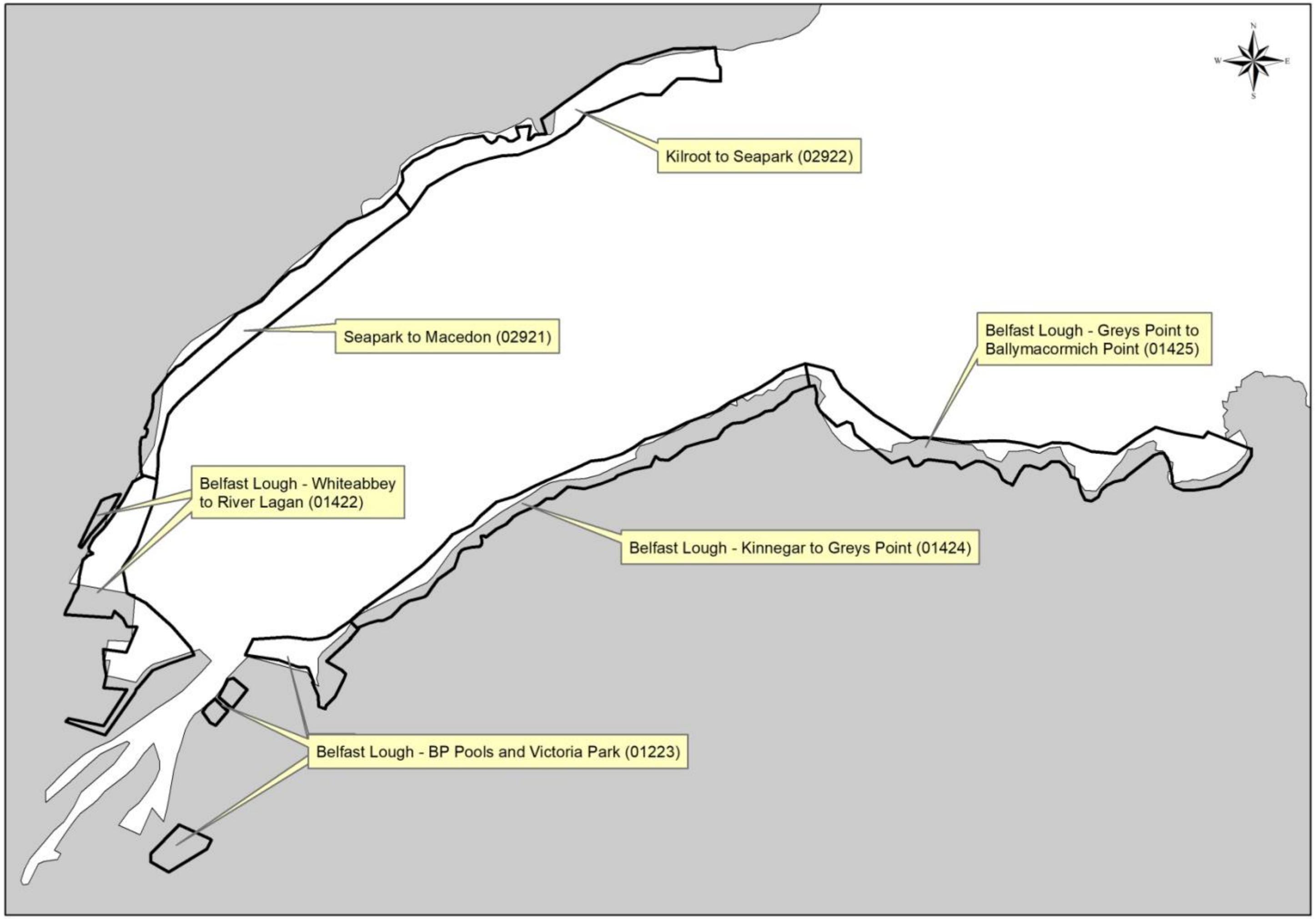

Figure 1: Locations of each Wetland Bird Survey (WeBS) Core Count sector in Belfast Lough. These WeBS sectors are the most recent subdivisions for WeBS counts in Belfast Lough, and represent the finest spatial scale over which data are collected.

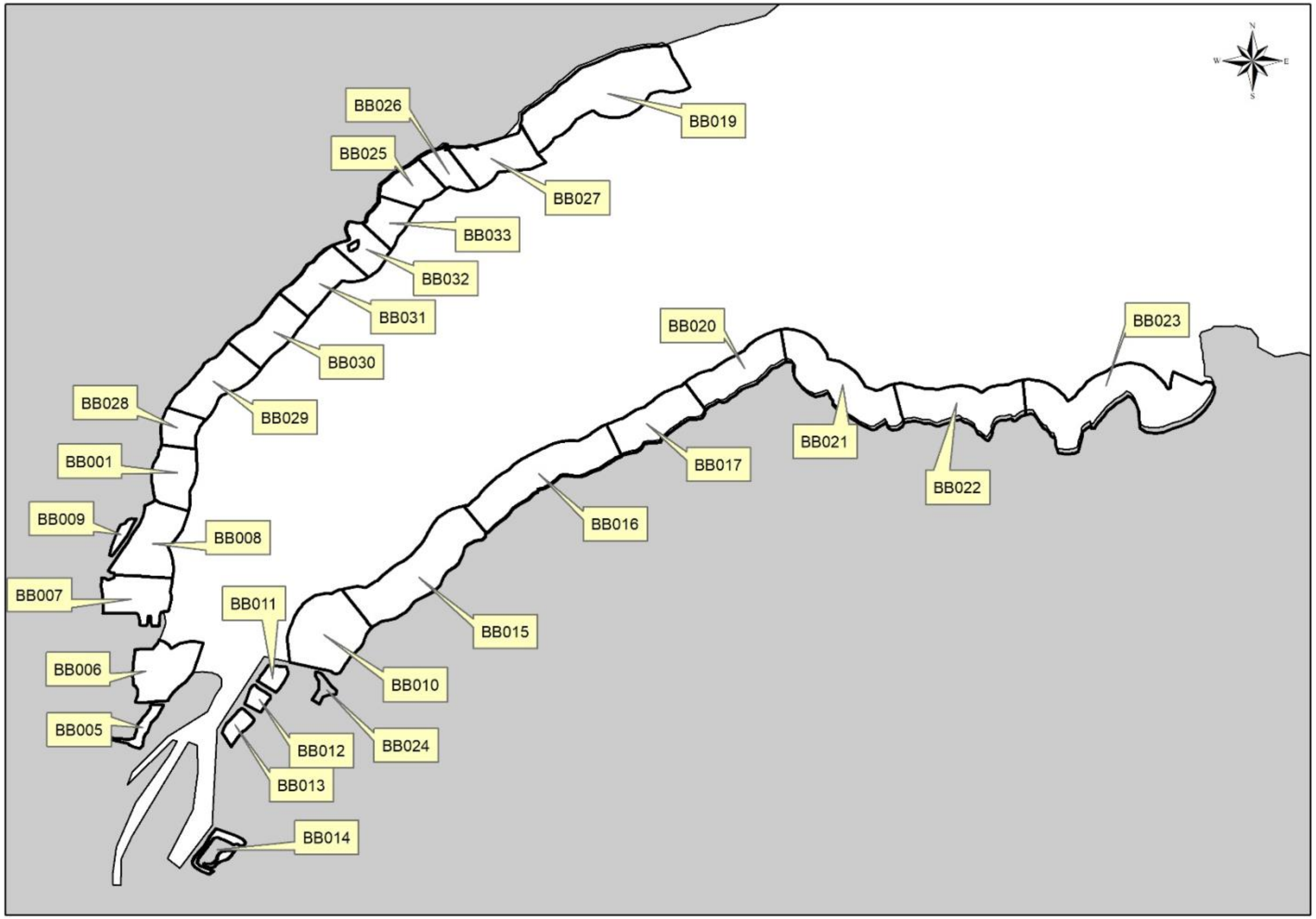

Figure 2: Locations of each Wetland Bird Survey (WeBS) Low Tide Count sector in Belfast Lough. These WeBS sectors are the most recent subdivisions for WeBS counts in Belfast Lough, and represent the finest spatial scale over which data are collected

2.1.2. Smoothed waterbird trends and percentage change

The methodology used to produce smoothed site, regional and national trends as reported by the WeBS 'Alerts' report (that is focused on trends on SPAs, Sites of Special Scientific Interest (SSSIs) and Areas of Special Scientific Interest (ASSIs): Woodward et al., 2019) can be usefully extended to generate trends on smaller areas of interest such as single or appropriately grouped WeBS count sectors. It is, however, important to recognise that the numbers of birds underlying the observed trend on sectors are generally much lower than those underlying site trends reported by WeBS Alerts which, by definition, are at least equal to the national qualifying threshold for the site as a whole. Consequently, individual trends should not be 'over-interpreted'. For example, a 50% decline from 30 birds to 15 birds would give much less cause for concern than a 50% decline from 1000 to 500 birds, the latter being much more likely to reflect a real and substantial loss of birds from an area than the former. However, whilst acknowledging this, a consistent pattern of decline across multiple species, even when the numbers involved for some of them are comparatively low, is strongly indicative of adverse factors affecting the sector in question, and the particular suite of species showing a decline in numbers can guide us in where to look for problems (for example, does the suite of species represent those known to be particularly sensitive to disturbance or those with similar ecological requirements).

Thus, using validated WeBS data to winter 2018/19 inclusive, smoothed trends following (Atkinson et al., 2000, 2006) were fitted using Generalized Additive Models (GAMs) for waterbirds in Belfast Lough (see Supplementary Materials: 'Section 3.1. Obj i - Belfast Lough Core Trends'). The smoothing is to ensure that year-specific factors, such as poor conditions on the breeding grounds or particularly harsh weather on the wintering grounds, that are not related to changes in the quality of the lough itself, do not contribute overly to the trend. Percentage change has been calculated for short- (5 year) medium- (10 year) and long-term (15 year) periods for waterbird species in Belfast Lough (see Supplementary Materials: 'Section 3.1. Obj i - Belfast Lough WeBS Core Result Matrices.xlsx' and 'Section 3.1. Obj i - Belfast Lough WeBS LowTide Result Matrices.xlsx'). To ensure statistical robustness, percentage change is calculated with reference to the penultimate winter in the time series available to avoid referring to the end points of the smoothed trend (which are less robust). Consequently, percentage change to winter 2017/18 is that reported. By way of analogy with the WeBS Alerts system, declines of at least 25% but below 50% are flagged as medium-declines (or moderate declines), and declines of 50% or greater are flagged as high-declines (or steep declines). We specifically do not use the terms medium- and high-Alerts because unlike the percentage change reported by WeBS Alerts, medium and high declines reported at the sector level do not constitute a formal WeBS Alert. The corresponding percentage change required to balance the numbers to their former level following a decline are likewise termed medium- or moderate (at least 33% but below 100%) and high- or sharp (100% or greater) increases.

2.1.3. Placing the smoothed waterbird indices into context

Once the smoothed sector indices have been produced the observed trends are placed in context of the site trends. Following (Banks & Austin, 2004), the standard WeBS methodology as used to compare site trends with regional and national trends when reporting WeBS Alerts (Woodward et al., 2019) is extended here to compare counts sector trends with site trends. Where waterbird numbers of a given species on a given count sector follow those of the species across the site as a whole then the proportion of site numbers on the sector will remain constant. Any significant deviation from this gradient of zero would indicate that the waterbird populations on the relevant count sector are doing either better or less well than would be expected from the site trend. Consequently:

- where a decline on a sector reflects a decline across the site as a whole it is unlikely that the observed site trend is being driven by factors affecting only that sector. If this is true of the majority of sectors, then this may indicate that the observed site decline in the species in question is due to factors external to the site and are thus not due to site management issues *per se*;

- where a decline on a sector is more pronounced than that across the site as a whole, this may suggest that factors affecting that sector could be contributing to the overall decline;

- where a decline on a sector is less pronounced than the decline across the site as a whole, this suggests that relatively favourable conditions on that sector are helping buffer site declines;

- where an increase on a sector is less pronounced than that across the site as a whole, this suggests that the sector is already at carrying capacity for the species in question or, if historically it supported greater numbers, that the quality of the sector to that species has diminished;

- where an increase on a sector is greater than that across the whole site, this suggests that trends on that sector are driving the increase across the site or that the sector in question is relatively attractive compared to the site as a whole when increased numbers arrive at the site due to external factors.

The comparisons between sectors and site are derived from a logistic regression model with a binomial error term. The resulting plots depict the percentage contribution of the sector to the site as a whole and the associated confidence limits represent both variation in this proportion between months in a given year and the underlying sample size (for example, we would be more confident of our estimate that a sector contributed 10% of the site total if 100 birds out of 1000 on the site were counted there than we would be if this was 10 out of 100). Analysis is based on the winter period as routinely used for all WeBS reporting (Sep-Mar for Eider). Only data from months where counts consolidated across the site as a whole had been assessed as complete were used – following standard WeBS protocols described above.

Having considered the trends on the sectors, each in the context of trends across the site as a whole, it is important to consider the site trends in a broader context – here the whole of Northern Ireland (following standard WeBS Alerts reporting), as this can modify our interpretation of the pattern of change across sectors. This is especially important where there has been an increase or decline at the broader scale. Consequently:

- where there has been an apparent re-distribution of a species within the site (that is, declines on some sectors appear to be balanced by increases on other sectors), but the proportional contribution of the site to increasing regional numbers is declining, then this implies that those sectors with static or declining numbers are actually of concern because we would expect them to be increasing in parallel with the other sectors. Thus, in such cases, the apparent redistribution within the site is misleading and the species in question may be facing problems on those sectors not supporting an increase in numbers;

- where a species is in decline at the broader scale we would expect declines on at least some of the sectors of the site regardless of whether birds are being affected by adverse factors locally. Thus, we would expect those sectors of least suitable habitat to a given species to be the first to show a decline in numbers.

2.2. Additional Count of the Salt Works Shoreline (Objective ii)

The north shore of Belfast Lough is an important area for Eider; however, the count sections for WeBS stop at the western edge of Kilroot Power station (J 43828 88371). The shoreline just east of this is restricted from public access and falls just outside the extend of the WeBS Core Count and Low Tide count sectors, therefore it was deemed appropriate to investigate this area for Eider as it had not previously been counted and was a potential route for Eider moving into the inner lough. Access to the Irish Salt Mining & Exploration Company (hereafter the 'Salt Works') shoreline was arranged and an informal exploratory survey of this area was carried out from two vantage points (J 45104 88790 and J 45250 88889, Figure 3) between 10:30 and 12:45 on 3rd December 2020.

Only 11 Eider were observed under good conditions during this pilot visit, and none moving through the count area. Discussions with staff at the Salt Works suggested that low numbers of Eider in this area were not unusual. As a result, it was concluded that this area could be discounted from further surveys.

Figure 3: Area of Salt Works shoreline (blue polygon) and count points (orange points) counted on the 3rd December 2020. The most north-easterly extent of the WeBS Low Tide count sector is drawn in orange.

2.3. Full Belfast Lough Counts (Objective i)

A full survey of Belfast Lough under ideal conditions during the second half of the season was deemed valuable in terms of obtaining a peak number for the winter on 2020/21, due to usual WeBS surveying being halted in January due to COVID-19. A caveat to this additional coverage was that due to the surveys being conducted by a smaller team, the asynchrony of counts may have increased the risk of totals being affected by undetected bird movements when compared to WeBS. However, while WeBS counts usually provide excellent coverage of Belfast Lough at both high and low tide throughout the winter period, these counts are made on fixed dates and therefore cannot take advantage of optimum count conditions. Therefore, ideal counting conditions were chosen for the dates of the full lough counts, and these were carried out on the 25th January and 5th March 2021. In choosing to survey on a very clear, settled day the aim was to maximise the likelihood of achieving a higher-accuracy count and highlight areas where Eider are too distant to count from shore under sub-optimal conditions. The methodology for this followed the standard WeBS methods, with the same count sectors also used, although due to the limitation of only having two surveyors available, a specific tidal state (for example, high tide) could not be targeted.

2.4. Counts of the Proposed East Coast SPA (Objective i)

Plans have been in place for some years to establish a marine SPA covering a large area of inshore waters off Northern Ireland's east coast. The proposed East Coast (NI) Marine SPA will subsume the existing Belfast Lough Open Water SPA and include waters adjacent to the Larne Lough, Outer Ards, Copeland Islands and Strangford Lough SPAs. DAERA are in the final stages of confirming this change and in steering group discussions around the redistribution of surveyor time from WeBS gap-filling it was agreed that surveys spanning the coastline outside the Belfast Lough boundaries would be beneficial. Point counts at regularly spaced intervals were undertaken for expediency, and took place on the 25th February 2021 from Carnlough Harbour, County Antrim (D 28787 18149) to Ballyquinton Point, County Down (J 62577 45973). As outlined in section 2.3, these were timed to make use of optimum counting conditions. The locations of these points are shown in Figure 7 and Figure 8 in section 3.1.4.

2.5. Through-the-tide counts (Objectives ii and iii)

2.5.1. Survey sites

The main area of interest for Eider in Belfast Lough is the north-west shoreline, between Kilroot (Kilroot Power Station, J440880) and Whiteabbey (Hazelbank Park, J355810). Recent analysis of WeBS Core Count data (Booth Jones et al. 2021, *unpublished report to NIEA,* also presented below in section 3.1.1) found that the highest five-year mean peaks of Eiders occurred in the 'Seapark to Macedon' and 'Kilroot to Seapark' sectors on the north-west shoreline (Figure 1). These both contained over 20% of the mean peak counts of the lough between the years of 2014/15 and 2018/19. At low tide, the sector which recorded the highest low tide mean peak counts over the last five winters was BB029 (Figure 2) at Loughshore Park (J366834). Therefore, four survey points were chosen to cover the north-west region of the lough as it hosts the majority of Eider present in the lough (Figure 4). Site location was constrained by access, since not all of the shore area of the lough on the north-west side can be viewed or reached easily by car. To ensure the greatest consistency between counts and to reduce the influence of observer bias, sites were allocated to individual surveyors, who surveyed the same sites in each month (Sterna Environmental: Loughshore Park, Castlerocklands, Hazelbank Park; Allen and Mellon: Fisherman's Quay, Figure 4). However, some flexibility was required to provide contingency against weather and daylight constraints (see section 2.5.2). In particular, daylight constraints were particularly narrow in December, therefore site allocation to each of the surveyors reflected the need for Allen and Mellon to survey a site usually allocated to Sterna Environmental (Hazelbank Park) to maximise the availability of survey opportunities in this month.

Figure 4: Map of Belfast Lough showing through-the-tide count (TTTC) study sites (orange points) and key Low Tide WeBS sectors, outlined in dark orange and labelled in the white boxes.

2.5.2. Time schedules

TTTCs were undertaken from November 2020 to March 2021. Due to limited daylight in midwinter, it was not feasible to survey sites through a whole tidal cycle in a single day. Consequently, each of the four study sites was counted twice per month, once on the flood tide and once on the ebb tide, each period spanning approximately 6 hours. However, during mid-winter where coverage of a full 6-hour ebb or flood period was not possible (due to weather conditions or daylight limitations), this was split into two 3-hour periods across two days, as closely placed as could be achieved around weather windows and surveyor schedules.

2.5.3. Counts

The counted area for the TTTCs were aligned to make use of existing WeBS Low Tide sectors (Figure 4, Appendix 1), allowing the TTTCs to be related to WeBS Low Tide data. The areas of these sectors reflected existing boundaries and marker such as buoys, pipelines, etc, thereby aiding counting. Counts of Eider and other waterbird species on the shore and on the water in each sector of each survey point were recorded every two hours through the tidal cycle (Table 1), between the boundaries of the sector and out in a straight line as far as could be observed, i.e. there was no seaward limit on observations. While other waterbirds were counted for completeness, data on these were not analysed for this report but are available in the Supplementary Materials ('Section 3.2. Obj ii and iii - TTTCs.csv').

For each count, surveyors also recorded wind direction (N, NE, E, SE, S, SW, W, NW), wind speed on the Beaufort Scale (0, 1, 2, 3, 4, 5), sea state on the Beaufort Scale (0, 1, 2, 3, 4, 5), weather (fair, rain, snow) and glare (none, moderate, strong), as these have a bearing on the accuracy of counts. Wind and sea state conditions of over a Beaufort Scale 4 and precipitation were avoided where possible. Conditions with poor visibility were also avoided (< 1 km).

Table 1: Structure of through-the-tide surveys, from the start of each high tide (ebb (falling) tide count) or low tide (flood (rising) tide count). The average length of a complete tidal cycle between November 2020 and March 2021 was 12:31 hours.

HOURS FROM LOW/HIGH TIDE	COUNT
0.0 - 0.5	**Count 1:** 30 mins
0.5 – 1.5	Record marine activity and target species' disturbance activity (60 minutes duration)
1.5 – 2.0	BREAK
2.0 – 2.5	**Count 2:** 30 mins
2.5 – 3.5	Record marine activity and target species' disturbance activity (60 minutes duration)
3.5 – 4.0	BREAK
4.0 – 4.5	**Count 3**: 30 mins
4.5 – 5.5	Record marine activity and target species' disturbance activity (60 minutes duration)

2.5.4. Recording disturbance

Between counts of Eider and other waterbirds, marine and shoreline activity was recorded in hour-long observations (Table 1). Sources of potential disturbance are listed in Table 2 and are derived from those used in Jarret et al. (2018) and the Non-Estuarine Waterbirds Survey (NEWS-III; Humphreys et al., 2021). During the first survey in the study period (November) it was decided not to record all potential land-based disturbances (largely of walkers and dog walkers, and dogs on and off lead) when Eider were not close to the shore (>100 m), as these were so common that they would have taken up all the study period in recording. Therefore, land-based human disturbances were only recorded if Eider were close to the shore (i.e. <100 m).

When a marine activity occurred, the category (Table 2) and its start and end time was recorded. The perceived response of any Eider in the sector to activity was recorded as follows: no response, running/swimming or flying, with the highest category of response recorded if these are combined (no response < running/swimming < flying) (Jarrett et al., 2020). Flights of Eider entering, leaving or flying past the sector during the hour-long observations were also recorded as secondary data.

Due to the low terrain surrounding the lough, survey points only provided a low height vantage (~<5 m) over the water, and therefore birds distant (> 2 km under ideal conditions) from the survey points were difficult to count and this is an important limitation of the methodology. Example recording sheets can be found in Appendix 2.

Table 2: Marine and shoreline activity categories to be recorded during the hour-long observation periods throughout the tidal cycle.

TYPE OF DISTURBANCE	CATEGORY
MARINE TRAFFIC	• Fishing boat/creel boat • Non-fishing industrial boat (e.g. tug, pilot boat, work boat) • Ferry • Lifeboat • Pleasure boat (e.g. yacht, sailing boat, powerboat) • Jet-skis • Unpowered boat (e.g. canoe, rowboat, kayak, paddleboard)
AIR	• Aeroplane • Helicopter • Drone
NATURAL	• Predator (e.g. bird of prey to species level)
LAND-BASED HUMAN	• Walkers • Joggers • Birdwatchers • Anglers • Shellfishers • Bait-diggers • Dogs on lead • Dogs off lead • Vehicles
OTHER	• Other disturbance – please specify.

2.5.5. Data analysis – counts

The influence of tidal state and month on counts of Eider made between November 2020 and March 2021 was analysed using generalized linear mixed models (GLMMs) in the R package glmmTMB (Brooks et al., 2017), which allows for fitting a covariance structure that deals with the temporal autocorrelation of counts.

Tidal state was calculated from the count observation number (1 - 3, each spaced two hours apart, starting from high or low tide) and the direction of the tide at the time of the count (ebb or flood). Four tidal states were thus identified and included in the model as categorical fixed effects: Low (zero hours from low tide), Intermediate Low (within two hours of low tide), Intermediate High (within two hours of high tide) and High (zero hours from high tide, Table 3). Month (November to March, inclusive) was also included as a five-level categorical fixed effect. Time of day (‘hour’, coded as a categorical effect with ten levels corresponding to the hours of 6 am to 3 pm, inclusive) was included in the covariance structure along with site to account for repeated measures at sites. In addition, time of day was also initially included as a fixed effect, however model comparisons using ANOVA testing and inspection of AIC suggested that this more complicated model did not provide a better fit for the data, and therefore time of day was only included in the temporal autocorrelation covariance structure of the final model. The site of the count was included as a four-level categorical random effect. The resulting residual degrees of freedom of the final model was 126.

Table 3: Structure of the tidal state effect as calculated from the count periods defined in Table 1.

Hours of the tide (from low)	0	1	2	3	4	5	6
Timing of low tide counts	Count 1		Count 2		Count 3		
Timing of high tide counts			Count 3		Count 2		Count 1
Level of model factor	Low		Inter-mediate Low		Inter-mediate High		High

Models were initially trialled with Poisson and negative binomial distributions appropriate to count data with the complimentary log link function, and rejected if the model did not converge or if the observed residuals deviated significantly from the expected residuals, a signal of overdispersion in the data (Hartig, 2020). Under these conditions, the negative binomial distribution was chosen over Poisson. Models were also tested with interaction terms, however these did not improve the model fit and did not aid an ecological interpretation of results.

2.5.6. Data analysis – disturbance

As in the above analysis, factors potentially influencing the disturbance of Eider – disturbance type, duration and tidal state – were analysed using a GLMM with a covariance structure that controlled for temporal autocorrelation. The dependent variable, disturbance of Eider, was coded as a two-level categorical response, of either 'yes' (Eider flew or swam in response to disturbance event) or 'no' (Eider did not react to disturbance event), and due to this a binomial model distribution with the complimentary logit link function was used. The disturbance type (limited to marine traffic, as other disturbance types were negligible; Table 2) was included as a seven-level categorical effect (Commercial Shipping, Ferry, Fishing Boat, Industrial, Lifeboat, Pleasure Boat and Unpowered Boat). The duration of the disturbance event was included as a continuous fixed effect, measured in minutes from the start of the disturbance event to its end. Tidal state was included in the model as above, while the site and the month of the observation were included as four-level and five-level categorical random effects, respectively. The time of the observation period was included in the temporal autocorrelation covariance structure of the final model, also as above. The resulting residual degrees of freedom of the final model was 307.

All data manipulation and analyses were carried out in the R programming environment (R version 4.0.3) and are detailed in the supplementary materials ('MarPAMM Lot2 Winter Eider Data Analysis - R Markdown.Rmd').

2.6. Dawn Watches (Objective ii)

In January, after discussion with the MarPAMM Lot 2 Steering Group, it was decided that spare surveyor time not required for gap-filling would be usefully deployed in ascertaining Eider movements into the lough. Based on observations during TTTCs and in the preliminary assessment of the Saltworks site, Eider were judged to be most active around dawn, therefore three dawn watches were carried out in January, starting around half an hour before dawn at three locations, one on the north shore (Whitehead, 18th January 2021, J 47957 92161) and two on the south shore

(Crawfordsburn, 18th January 2021, J 47189 82232; Groomsport, 22nd January, J 53804 83604). During these surveys, surveyors made three 1.5-hour watches, separated by a 30-minute break, and recorded:

1. Eider in flight, including the time of movement, an estimate of the number in the flock, and the direction of flight (e.g. from East or West).
2. Any disturbance to flocks during the watch time, however in practice no disturbances (e.g. from the sources listed in Table 4) were observed.

3. RESULTS

3.1. Eider numbers and distribution in Belfast Lough

3.1.1. WeBS Core Count Sector-level Trends

Eider in Belfast Lough have undergone a moderate (at least 33% but less than 100%) increase in numbers over the long-term (2002/03 - 2017/18; Table 4), and the population of the lough has increased in its importance in the Northern Irish context from supporting around 60% of the population to around 80%, while numbers over all in Northern Ireland have also increased during the same time period (Frost et al., 2021). The most important sectors in the lough in terms of both five-year mean peaks and mean winter peaks were Seapark to Macedon (02921) and Kilroot to Seapark (02922). Seapark to Macedon and Kilroot to Seapark both supported at least 20% of the total Belfast Lough mean peak counts over the most recent five winters and in the winter of 2018/19, while Belfast Lough - Whiteabbey to River Lagan (01422) contained between 10% and 20% of the total peak count for the lough in 2018/19. Trends were available for all sectors in the lough and were generally more positive in sectors on the north-west shore, and more negative on the south-east shore (Table 4). In particular, numbers in Kilroot to Seapark increased by at least 100% across all time periods, although the last two years of data show a decline (Figure 5 (a)). In contrast numbers of Eider in Belfast Lough - Whiteabbey to River Lagan declined by at least 50% across all time periods (Figure 5 (b)). Trend plots for Northern Ireland, Belfast Lough and each Core Count sector in Belfast Lough can be found in Appendix 3.

Table 4: Overview of population trends of Eider in Belfast Lough based on high tide counts over the long- (2002/03 - 2017/18) the medium- (2009/10 - 2017/18) and the short- (2012/13 - 2017/18) terms. Cells are coloured to indicate trend status as follows: Red – a decline in numbers of at least 50%; Orange – a decline in numbers of at least 25% but less than 50%; Grey – a decline in numbers of less than 25% or an increase of less than 33%; Pale Blue – an increase in numbers of at least 33% but less than 100%; Dark Blue – an increase in numbers of at least 100%; Cross hatched – insufficient data. These trends are mapped in Appendix 3: S3.1 - S3.3.

Sector Code	Sector Name	Shoreline	Eider		
			Short	Med	Long
01900	**Belfast Lough (site-level trend)**				
01425	Belfast Lough - Greys Point to Ballymacormich Point	South			
01424	Belfast Lough - Kinnegar to Greys Point	South			
01223	Belfast Lough - BP Pools and Victoria Park	South			
01422	Belfast Lough - Whiteabbey to River Lagan	North			
02921	Seapark to Macedon	North			
02922	Kilroot to Seapark	North			

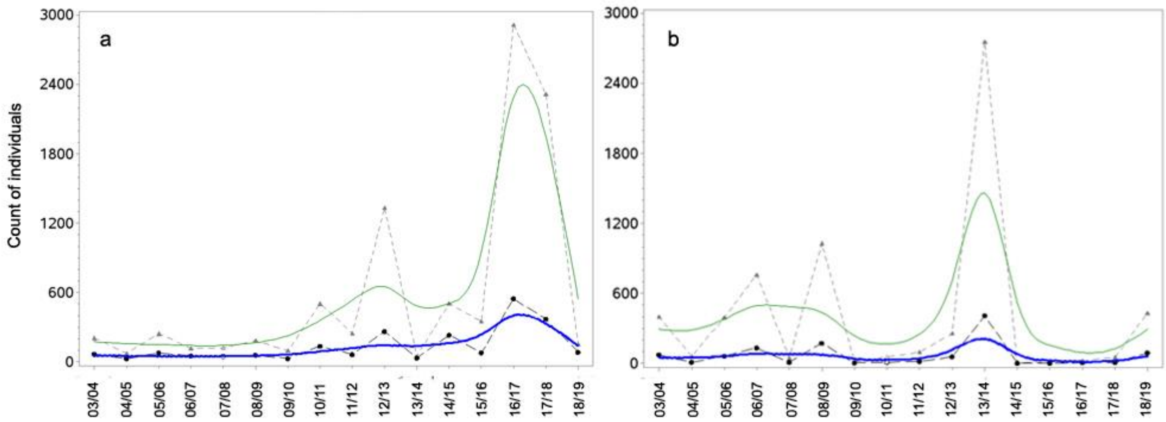

Figure 5: (a) The trend in the number of Eider on Kilroot to Seapark (02922), Belfast Lough. (b) The trend in the number of Eider on Belfast Lough - Whiteabbey to River Lagan (01422), Belfast Lough. The upper (green) trend line is fitted through the winter peak counts whilst the lower (blue) line is fitted through the winter mean counts.

3.1.2. WeBS Low Tide Count Sector-level Trends

Eider abundance has remained stable at low tide in Belfast Lough over all time periods, contrasting to the Core Counts, where a moderate long-term increase was observed. Numbers of Eider observed in low tide sectors around Belfast Lough varied hugely. The sector which recorded the highest low tide mean peak counts over the most recent five winters of available data was BB029, with neighbouring sectors on the north-west shore of the lough also containing the majority of the lough’s wintering Eider. Trends could be generated for seven sectors (Table 5), and these were mixed and did not appear to follow a spatial pattern. BB007, adjacent to Giant’s Park, saw strong increases of at least 100% across all time periods. Eider increased at BB012 and BB024 in the short-term, although in these sectors the short-term increases were preceded by declines. Steep declines were recorded in BB005 and BB009 over the long-term.

Table 5: Overview of population trends of Eider in Belfast Lough based on low tide counts over the long- (2002/03 - 2017/18) the medium- (2009/10 - 2017/18) and the short- (2012/13 - 2017/18) terms. Cells are coloured to indicate trend status as follows: Red – a decline in numbers of at least 50%; Orange – a decline in numbers of at least 25% but less than 50%; Grey – a decline in numbers of less than 25% or an increase of less than 33%; Pale Blue – an increase in numbers of at least 33% but less than 100%; Dark Blue – an increase in numbers of at least 100%; %; Cross hatched – insufficient data. These trends are mapped in Appendix 3: S3.4 - S3.6.

Sector Code	Sector Name	Shoreline	Eider		
			Short	Med	Long
BB000	**Belfast Lough (site-level trend)**				
BB001	Belfast Lough LTC 1.1	North			
BB002	Belfast Lough LTC 1.2	North			
BB003	Belfast Lough LTC 1.3	North			
BB004	Belfast Lough LTC 1.4	North			
BB005	Belfast Lough LTC 2.1	North			
BB006	Belfast Lough LTC 2.2	North			
BB007	Belfast Lough LTC 2.3	North			
BB008	Belfast Lough LTC 2.4	North			
BB009	Belfast Lough LTC 2.5	North			
BB010	Belfast Lough LTC 3.1	South			
BB011	Belfast Lough LTC 3.2	South			
BB012	Belfast Lough LTC 3.3	South			
BB013	Belfast Lough LTC 3.4	South			
BB014	Belfast Lough LTC 3.5	South			
BB015	Belfast Lough LTC 4.1	South			
BB016	Belfast Lough LTC 4.2	South			
BB017	Belfast Lough LTC 4.3	South			
BB018	Belfast Lough LTC 5.1	North			
BB019	Belfast Lough LTC 5.2	North			
BB020	Belfast Lough LTC 6.1	South			
BB021	Belfast Lough LTC 6.2	South			
BB022	Belfast Lough LTC 6.3	South			
BB023	Belfast Lough LTC 6.4	South			
BB024	Belfast Lough LTC 3.6	South			
BB025	Belfast Lough LTC 5.1a	North			
BB026	Belfast Lough LTC 5.1b	North			
BB027	Belfast Lough LTC 5.1c	North			
BB028	Belfast Lough LTC 1.2d	North			
BB029	Belfast Lough LTC 1.2c	North			
BB030	Belfast Lough LTC 1.2b	North			
BB031	Belfast Lough LTC 1.2a	North			
BB032	Belfast Lough LTC 1.3	North			
BB033	Belfast Lough LTC 1.4	North			

While WeBS Low Tide count data do not usually lend themselves well to between-year comparisons of numbers due to the periodical recording usually attained for sites, Belfast Lough is exceptional because it receives annual Low Tide Counts (see section 2.1.1). Not all sectors received counts in all years since records began, and some sectors have been split or merged to form new sectors, however it was possible to plot maximum annual counts per sector for visual inspection (Appendix 4). Of particular interest to this report were sectors BB001, BB018, BB019 and BB029 (Figure 2), which were chosen as key sites for TTTCs due to their overlap with important sectors for Eider during Core Counts (see section 2.5.1.).

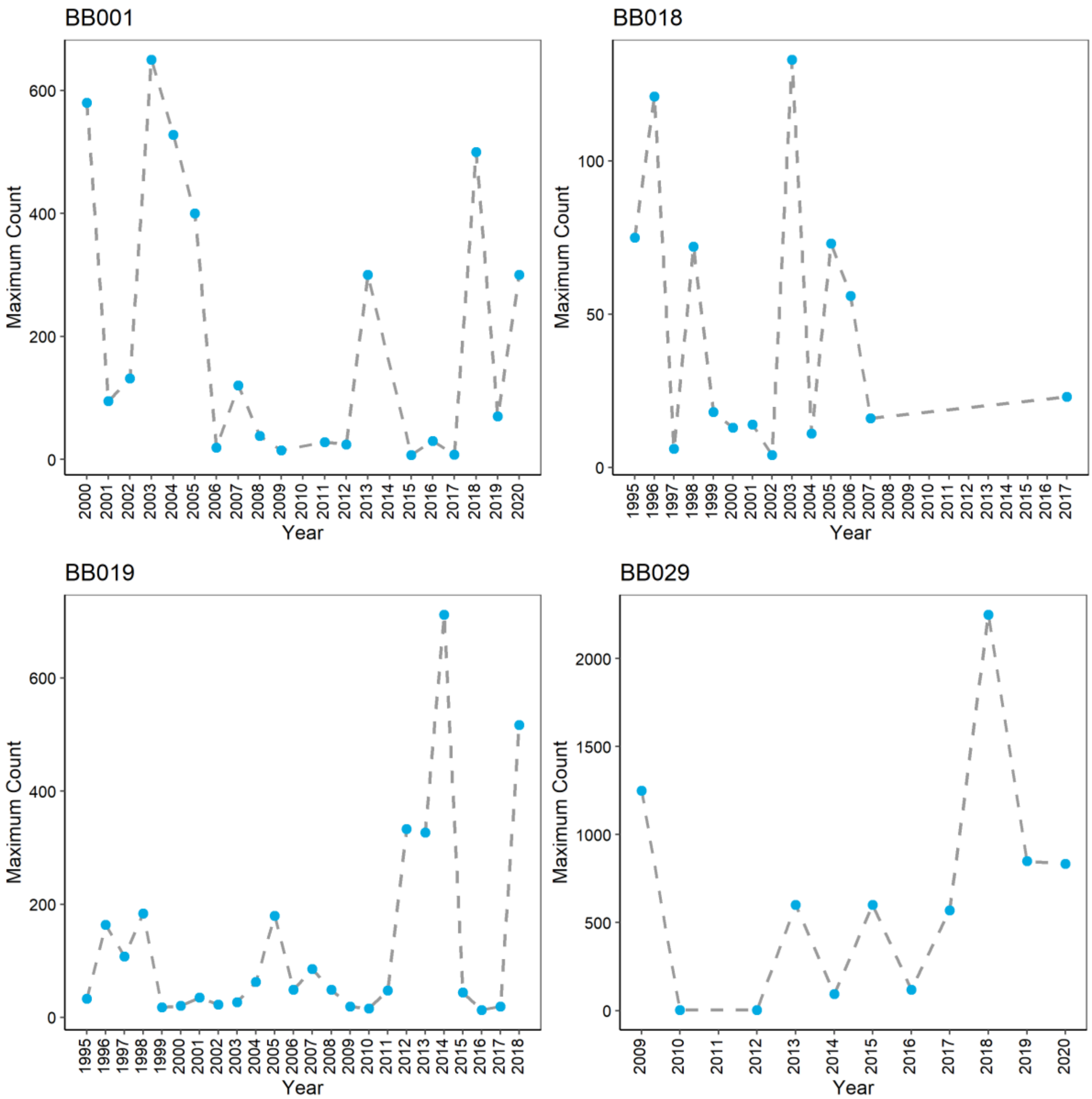

Figure 6: Maximum counts of Eider per year for four focal sectors in Belfast Lough: BB001, BB018, BB019 and BB029. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

The most extensively surveyed sector of this selection was BB019, which was surveyed between one and three times per year for 24 years between 1995 and 2018. The sector with the highest maximum count of Eider was BB029, which recorded a count of 2,250 Eider on 17th December in 2018.

However, this sector has received a shorter duration of surveillance, with records spanning from 2009 to 2020. Trends could not be generated for the sectors (Table 5), and visual inspection of the plots in Figure 6 suggests that this is because the number of Eider present in these sectors was very variable between years.

3.1.3. Full lough counts

Full lough counts were conducted in Belfast Lough on the 25th January and 5th March 2021 under optimal counting conditions. During the 25th January count one surveyor (Allen, *pers. comm.*) noted that glare and chop in the outer lough reduced visibility to around 1.5 km at times on the north shore. Low vantage points and the distance of birds from the count points was also a factor on the south shore (Leonard, *pers. comm.*), with some uncountable flocks seen towards the centre of the lough (Table 6). Otherwise conditions were fine, visibility was good and the sea state was calm.

Table 6 Counts made of Eider under near-optimal weather conditions (sea calm, low wind, good visibility, no precipitation) in Belfast Lough on the 25th January and 5th March 2021. *Small numbers seen in flight but otherwise invisible.

	Count of Eider	
Count area	**25th January**	**5th March**
Saltworks	4	8
Fisherman's Quay	29	22
Carrick Marina	62	182
Castlerocklands	69	0
Loughshore Park	415*	38
Hazelbank	1,782*	262
Macedon Point	183	36
Dargan Bay	66	6
Airport road west	178	38
Holywood	12	64
Seapark	88	18
Seafront Road	10	4
Station Road	8	12
Seahill Shore	7	10
Grey Point area	209	145
Crawfordsburn shore	85	4
Carnalea area	70	10
Stricklands area and shore	20	0
Brompton area	2	6
Pickie Bangor	0	6
Long Hole Bangor	12	2
Seacliff Road Bangor	8	18
Seacliff Road Outer Ballyholme	8	20
Seacliff Road Inner Ballyholme	2	0
Total count	**3,329**	**991**

The total count of 3,329 Eider made in January falls within the range of the WeBS Core Count moving five-year (2015/16 – 2019/20) average of 3,558 (Frost et al., 2021). In the last five winters, the highest record was in 2016/17 (4,542) but WeBS totals in the most recent two years have declined somewhat (2018/19 = 2,987; 2019/20 = 2,225). However, it is clear that by March many Eider had left the lough, with only approximately 30% (N =991) of the January total counted in the same areas in the spring.

3.1.4. Proposed East Coast Marine SPA counts

Coastline external to Belfast Lough but included in the proposed East Coast Marine SPA was surveyed on the 25th February 2021. Point counts were undertaken from the locations illustrated in Figure 7 and Figure 8. A table of these counts can be found in Appendix 5. Across the 66 sites visited between Carnlough and Ballyquinton, 550 Eider were observed. Thirty-one points had zero counts of Eider, and a further 23 had fewer than 10 Eider present. The majority of Eider were counted in the County Down stretch between and Ballymacormick (J 51299 82793) and Ballyquinton (370), while the largest count (105) for this section of coastline was found off Groomsport (J 53798 83588. The counts from points between Ballymacormick and Warren Road South (J 57835 81429) on the north-east County Down coast represented 67% of the Eider observed in the County Down surveys. However, the point with the largest count of Eider (164) was Glynn Station within Larne Lough, County Antrim (J 40962 99885). Only 16 additional Eider were observed at other County Antrim points.

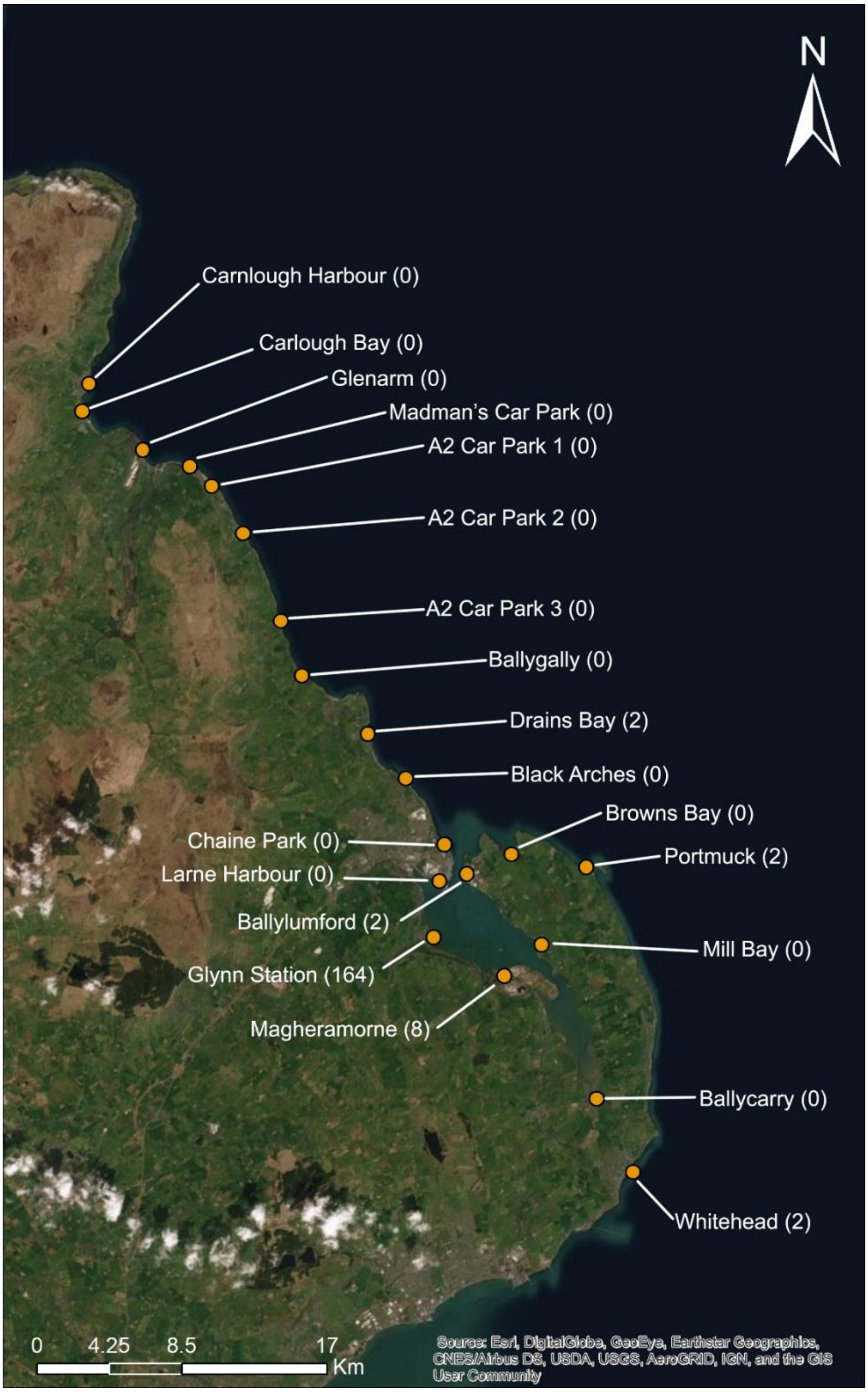

Figure 7: Point count locations in County Antrim, surveyed on 25th February 2021. Number of Eider at each site is included in brackets.

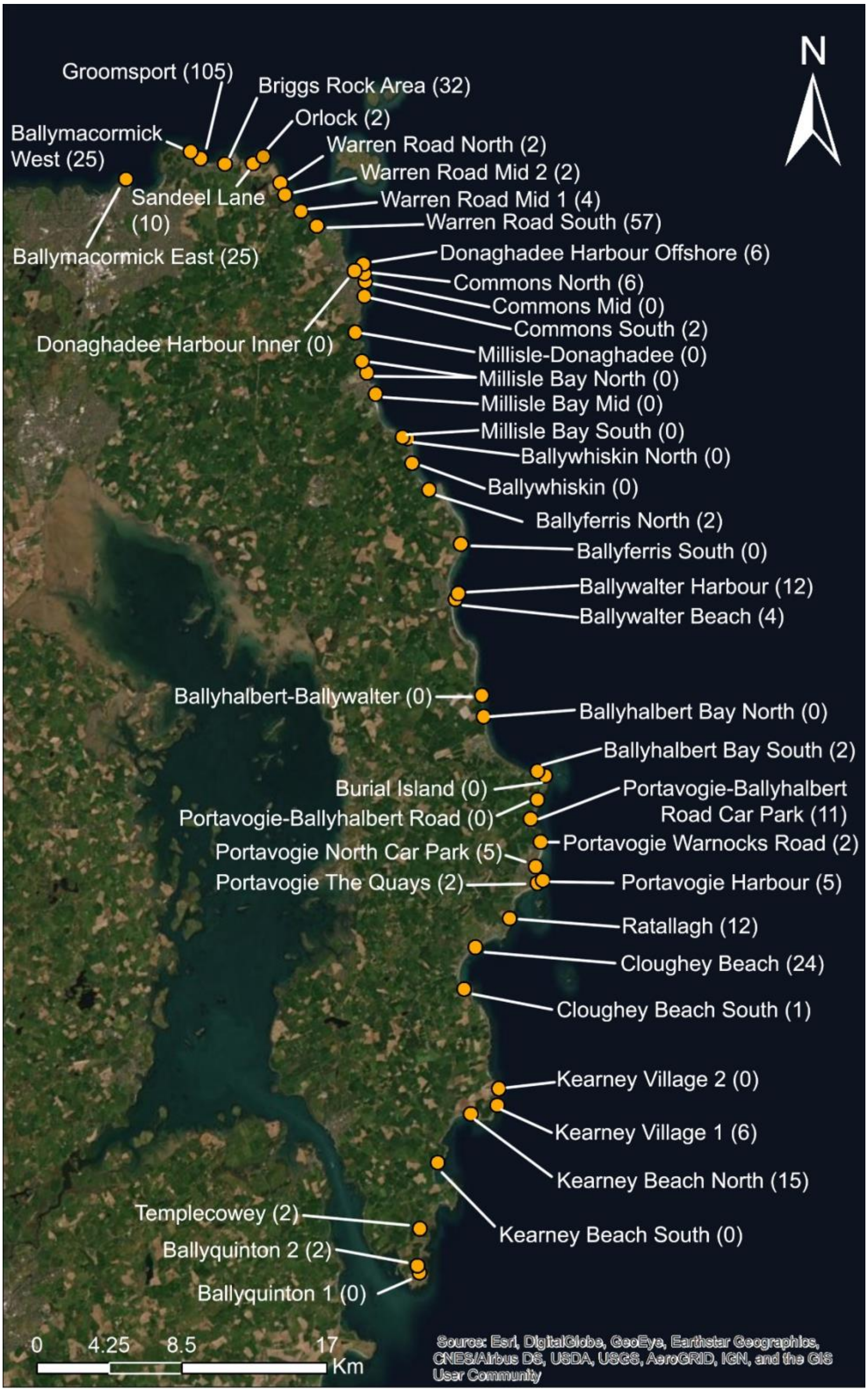

Figure 8: Point count locations in County Down, surveyed on 25th February 2021. Number of Eider at each site is included in brackets.

3.2. Eider movement and behaviour in Belfast Lough

3.2.1. Summary of through-the-tide-counts

Across the 138 TTTCs made throughout the winter, flocks of up to a maximum of 4,480 Eider were observed (mean 549, 95% CI: 407 – 690). The four sites surveyed, Fisherman's Quay, Castlerocklands, Hazelbank and Loughshore, all received at least one survey (consisting of three counts at two-hour intervals) during the ebb tide, and one during the flood tide each month. However, during January, Castlerocklands, Hazelbank and Loughshore received a repeat ebb survey and during February these same sites received a repeat flood survey.

In addition to Eider, 33 species of waterbird were recorded in Castlerocklands, 25 in Fisherman's Quay, 37 in Hazelbank and 41 in Loughshore. The most commonly encountered species were Herring Gull (*Larus argentatus*), Great Crested Grebe, Eider, Shag (*Gulosus aristotelis*), Common Gull (*Larus canus*), Black Guillemot (*Cepphus grylle*) and Black-headed Gull (*Chroicocephalus ridibundus*). The species with the highest average count for all sites was Eider (Hazelbank: 1,192, Loughshore: 669, Castlerocklands: 152 and Fisherman's Quay: 109), but Herring Gull, Black-headed Gull, Dunlin (*Calidris alpina*), Great Crested Grebe, Turnstone (*Arenaria interpres*), Redshank, Oystercatcher (*Haematopus ostralegus*) and Light-bellied Brent Goose (*Branta bernicla*) also had high average counts (for average counts per site, see Appendix 6, Table S6.1 and data contained in the Supplementary Materials: 'Section 3.2. Obj ii and iii - TTTCs.csv').

3.2.2. Effect of tidal state and month on Eider numbers

Tidal state and the month of the count both had a significant effect on the count of Eider at the study sites (Table 7). Counts made earlier in the winter and closer to low tide were higher, on average (Appendix 6, Figure 9). Counts were particularly low in March, when the majority of Eider were presumed to have moved outside the count areas.

Table 7: Summary of GLMM outputs for the effect of tidal state (High, Intermediate High, Intermediate Low and Low) and Month (November to March) on counts of Eider made at four sites on the northern shore of Belfast Lough. Coefficients for the 'High' tidal state and for January are subsumed into the intercept.

	Count Total		
Predictors	*Incidence Rate Ratios*	*CI*	*p*
(Intercept)	214.48	77.12 – 596.51	**<0.001**
Tidal State [Intermediate High]	1.26	0.75 – 2.12	0.380
Tidal State [Intermediate Low]	1.61	0.97 – 2.67	0.063
Tidal State [Low]	2.21	1.28 – 3.83	**0.005**
Month [November]	2.08	1.21 – 3.57	**0.008**
Month [December]	1.32	0.80 – 2.19	0.283
Month [February]	0.46	0.29 – 0.74	**0.001**
Month [March]	0.15	0.09 – 0.26	**<0.001**
N_{Site}	4		
Observations	138		

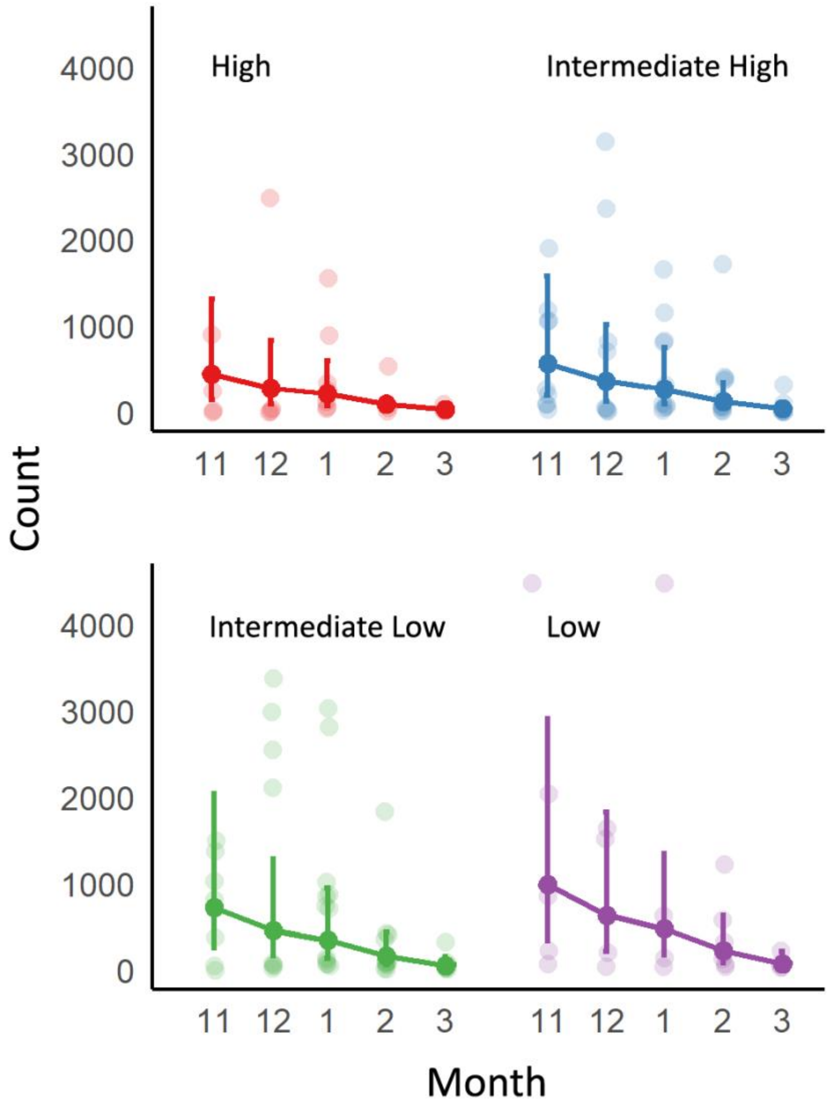

Figure 9: Plot of estimated marginal mean counts (dark points) and 95% confidence intervals (vertical bars) of Eider per month, faceted by tidal state and adjusted for the population level across all sites surveyed, as predicted using the GLMM described in section 2.5.4. Light points represent raw data used in the model.

3.2.3. Flight watches

During observation periods between counts, flights of Eider were also recorded to provide information when and where might be sensitive in the lough in terms of Eider travelling to foraging locations. Eider were observed in flocks of a maximum of 53 birds moving in the lough. Movements were most commonly observed in Loughshore Park (a total of 562 flights observed), and this site also had the highest mean number of Eider moving per flight (22 birds, 95% CI 20-23, Table 8), while Fisherman's Quay recorded the fewest flights. March was the quietest month for movement of Eider in the lough, with the total flights of Eider and flock size dropping steadily throughout the winter from November (Table 8). The earliest hour-long observations were made from 07:07 and the latest from 15:56, while the earliest flight of Eider was recorded at 7:15 and the latest at 16:40. Observations of flights were restricted by daylight hours in the winter, and observations were timed to take advantage of the first full ebb or flood tide of the day, meaning that the majority of observations were made in the morning (Figure 10a). Between these times, flights of Eider were most commonly recorded between 10:00 and 11:00 (Figure 10b), when 24% of the total number of flights were recorded. After midday, Eider were observed moving less in the lough, with only 30% of the total flights recorded between 12:00 and 17:00. Surveyors also recorded whether Eider were flying into the count sector ('Entering'), flying out of the sector ('Leaving') or passing by in the lough ('Passing). The majority of records were of Eider passing by during counts (Figure 10b).

Table 8: Summary of flights of Eider observed across four sites and between November 2020 and March 2021.

	Number of flights observed	**Mean count of flock size**	**Lower 95% Confidence Interval**	**Upper 95% Confidence Interval**	**Minimum flock size**	**Maximum flock size**
Site						
Castlerocklands	318	17.75	16.07	19.43	1	50
Fisherman's Quay	182	18.66	16.38	20.95	1	52
Hazelbank Park	292	17.41	15.64	19.18	1	52
Loughshore Park	562	21.60	20.22	22.97	1	53
Month						
11	446	22.34	20.75	23.92	1	52
12	307	20.86	19.06	22.67	1	53
1	268	15.63	13.95	17.32	1	53
2	240	18.60	16.69	20.52	1	52
3	93	13.31	10.39	16.24	1	50

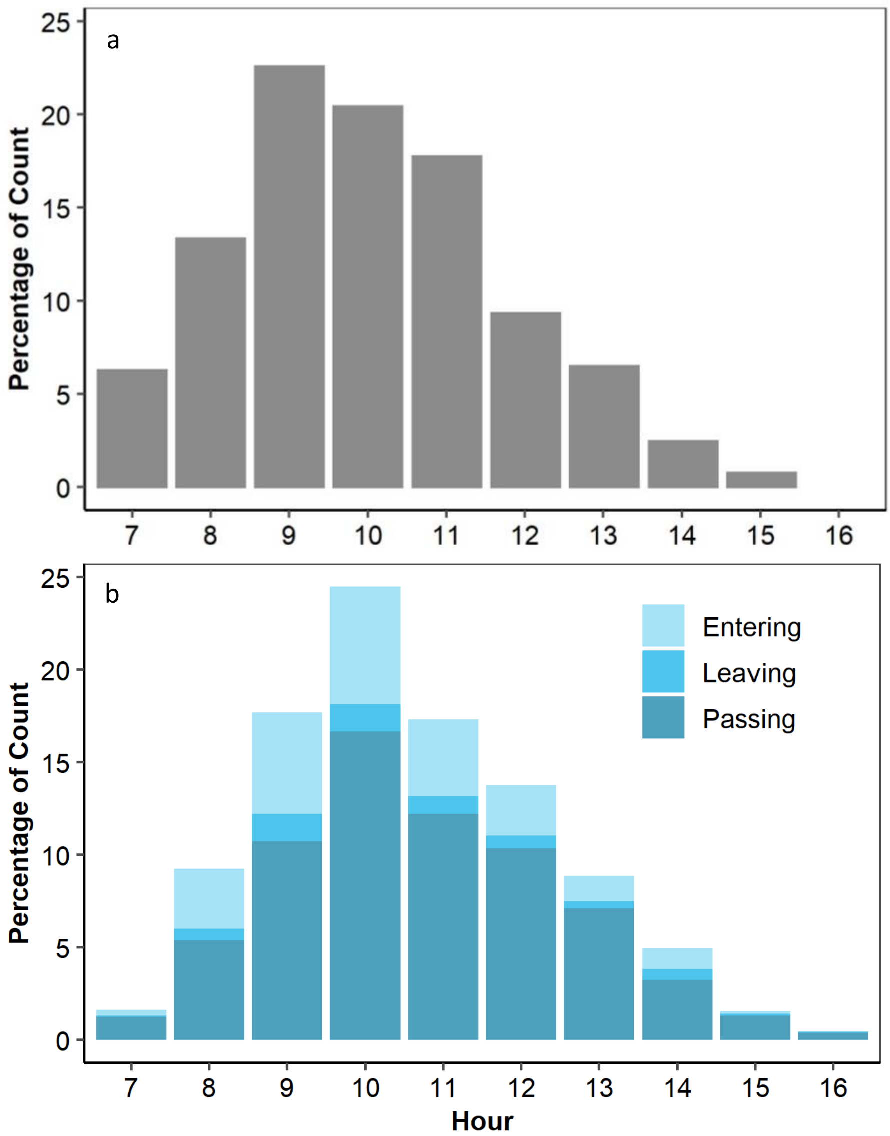

Figure 10: a: The proportion of the total number of flight observations per hour in Belfast Lough. b: The proportion of Eider flights recorded per hour. Bars are coloured to show the proportion of each bar attributed to Eider entering (light blue), leaving (medium blue) or passing the count sector (dark blue). Both plots represent observations across all sites (Loughshore Park, Castlerocklands, Hazelbank Park and Fisherman's Quay) and across all months (November to March).

3.2.4. Dawn watches

Three exploratory dawn watches were carried out in January 2021. One took place on the north shore at Whitehead and two on the south shore at Crawfordsburn and Groomsport. These locations were chosen as viewpoints to watch Eider entering the lough from roosting locations overnight. Only two Eider were observed flying past Whitehead on the 18th January, however, there were 109 counts of Eider moving east to west (i.e. into Belfast Lough) from Crawfordsburn on the same date, and 67 from Groomsport on the 22nd January, also heading into the lough (Table 9). Throughout the morning, the majority of birds were observed during the first watch, which began approximately 30 mins prior to sunrise (Figure 11), and numbers moving peaked approximately 30 minutes after dawn.

Table 9: Eider observed in flight during dawn counts at three locations on the shore of Belfast Lough.

Site	Number of flights counted	Mean flock size	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Total Eider counted
Crawfordsburn	109	13.32	9.20	17.44	1452
Groomsport	67	20.70	10.19	31.22	1387
Whitehead	2	1	1	1	2

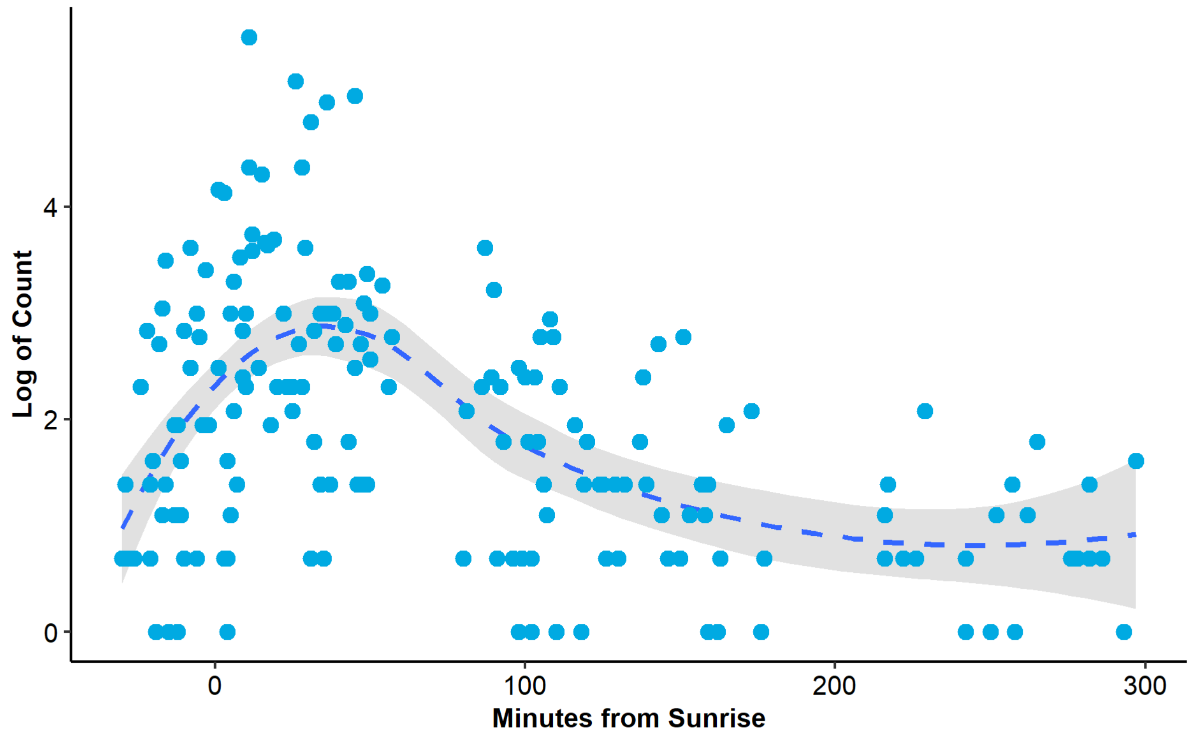

Figure 11: Log-transformed counts of Eider in flight recorded at Crawfordsburn, Groomsport and Whitehead in January 2021 in relation to the time from sunrise. The dashed line represents the Locally Weighted Least Squares Regression trend in counts over time. The shaded region represents the 95% confidence interval around the trend.

3.3. Disturbance

During 414 hour-long observation periods, surveyors recorded potential disturbance events and Eider reactions to these. Out of the 346 records of potential disturbance events, 93% of these were to do with marine traffic. Ferries, commercial shipping, industrial boats and fishing vessels (79% of which were mussel boats) represented the majority of the potential disturbance events observed during the winter (32%, 24%, 21% and 17% of the total observations of marine traffic, respectively). On average, disturbances lasted 10 minutes (95% CI: 8.91 – 11.50 minutes). Of the land-based disturbances (N = 8), three recorded Eider reacting to the presence of people and in one case a dog by flying and swimming away, and the other five showed no reaction. In two of the cases with no reaction, Eider were on the water. No air-based disturbances (e.g. aeroplanes, helicopters, or drones) were recorded. Only three incidences of natural disturbance events were recorded – one incidence each of the presence of Buzzard (*Buteo buteo*), Peregrine (*Falco peregrinus*) and a Sparrowhawk (*Accipiter nisus*), to which no Eiders present responded.

In most cases, Eider were not observed to react to disturbance events (Figure 12), and analysis of the reaction of Eider to disturbance suggested that there was no measurable influence of disturbance type, duration or tidal state (Table 10).

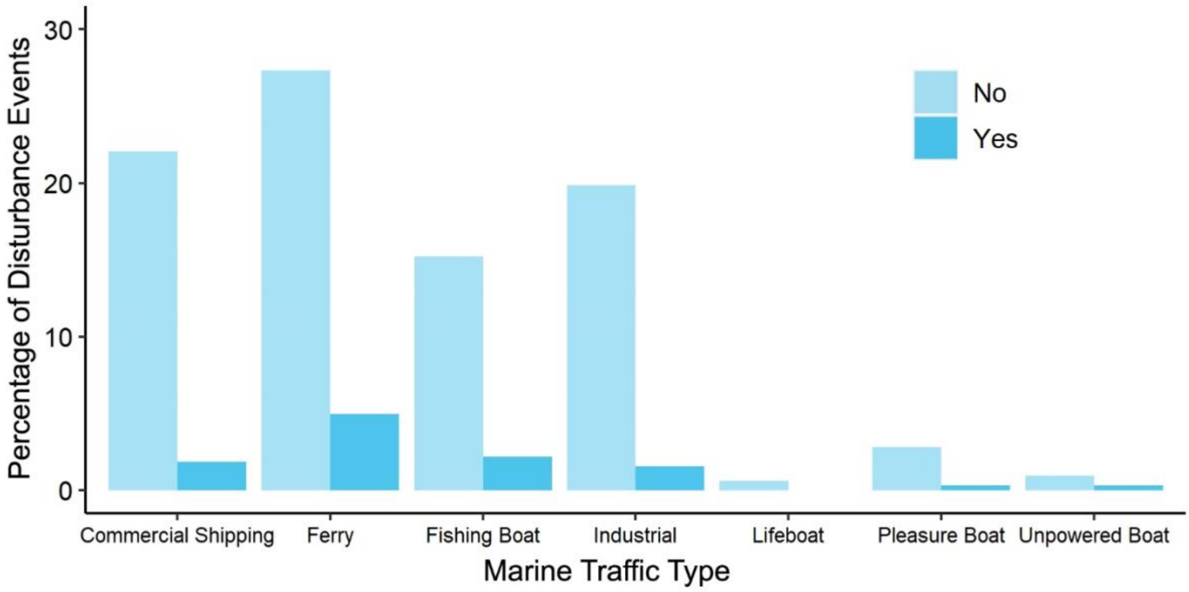

Figure 12: The percentage of disturbance events attributed to different marine traffic types. Light blue bars represent events where no avoidance behaviour was elicited from the Eider, while dark blue bars represent events where Eider either swam or flew in reaction to the disturbance.

Table 10: Summary of GLMM outputs for the effect of disturbance duration (minutes), disturbance type (Ferry, Commercial Shipping, Industrial, Fishing Boat, Pleasure Boat, Lifeboat and Unpowered Boat) and tidal state (High, Intermediate High, Intermediate Low and Low) on counts of Eider made at four sites on the northern shore of Belfast Lough. Coefficients for the 'High' tidal state and for the 'Commercial Shipping' disturbance type are subsumed into the intercept.

	Disturbed		
Predictors	*Odds Ratios*	*CI*	*p*
(Intercept)	0.05	0.00 – 0.59	**0.017**
Disturbance Duration	1.00	0.95 – 1.04	0.823
Tidal State [Intermediate High]	0.78	0.25 – 2.49	0.679
Tidal State [Intermediate Low]	0.34	0.08 – 1.37	0.128
Tidal State [Low]	1.00	0.25 – 4.07	0.998
Disturbance Type [Ferry]	1.78	0.57 – 5.53	0.321
Disturbance Type [Fishing Boat]	2.75	0.61 – 12.32	0.187
Disturbance Type [Industrial]	0.82	0.20 – 3.29	0.776
Disturbance Type [Lifeboat]	0.00	0.00 – Inf	0.999
Disturbance Type [Pleasure Boat]	0.22	0.02 – 3.16	0.266
Disturbance Type [Unpowered Boat]	0.57	0.03 – 11.27	0.712
N_{Site}	4		
N_{Month}	5		
Observations	322		

4. DISCUSSION

4.1. Eider numbers and distribution in Belfast Lough and the surrounding area

Analysis of existing WeBS data revealed that Eider numbers had increased in Belfast Lough over the last 15 years, and the lough's relative importance in a Northern Ireland context had increased from supporting around 60% of the population to around 80%, despite numbers of wintering Eider in Northern Ireland increasing at a regional level over this time period (Frost et al., 2021). Therefore, it is likely that increases in the number of Eider present in Belfast Lough are due to local conditions, rather than a general regional increase. The long-term growth in Eider observed during Core Counts (at high tide) appeared to be driven by increases in the two large sectors along the north shore of Belfast Lough between Macedon Point and Kilroot. These increases contrasted with but were not negated at a site level by declines observed in other sectors, notably between Whiteabbey and the River Lagan. Site level trends at low tide were stable over the long term, but within-site trends varied, with no strong spatial pattern evident. In particular, the low tide sectors which overlapped key areas at high tide and that formed the basis of the TTTC sectors were very variable in the peak number of Eider present between years, and no formal trend over time could be generated for these sectors.

One possible explanation for the difference in trends between high and low tide in sectors is that due to the low-lying nature of the shoreline of Belfast Lough and the distance over which counting is required at low tide, observers find making an accurate count of distant birds difficult, particularly when weather conditions are less than ideal (Allen and Leonard, *pers. comm.*). In contrast, during high tides, Eider move closer to the shore, where their numbers are more easily estimated. However, although this is likely to produce some variation between high tide and low tide counts, it is also likely that due to the large area of mussel beds in Belfast Lough, and because Eider are highly mobile and often aggregated into large groups, that there is a lot of natural variation in where they might occur at low tide. The entire area of Belfast Lough inshore of the harbour limit between Kilroot and Grey Point is shallow (maximum depth of 9 m) and therefore well within the comfortable dive depth of Eider, which has been recorded as 42 m (Guillemette et al., 1993). Guillemette et al. (1993) also demonstrated that the preferred foraging dive depth of Eider is within 0 – 6 m. The licenced bottom-culture mussel beds in Belfast Lough, a preferred foraging habitat for Eider (Cervencl et al., 2015; Kirk et al., 2007; Player, 1971) are all, with one exception off the eastern shore, within this depth envelope. The combined area of the 21 licenced bottom-culture mussel beds (both active and inactive) in Belfast Lough is 953 hectares (DAERA, 2021b; Ferriera et al., 2007) and therefore Eider have a very large area of potential foraging habitat available, which may contribute to the lack of consistent aggregations at low tide in particular areas.

The winter of 2020/21 was unusual in terms of WeBS survey effort due to the impacts of the COVID-19 pandemic, which curtailed the volunteer- and NIEA-led counts of WeBS Core Count and Low Tide count sectors in Belfast Lough. In response to this, professional effort was put towards gaining a full-lough population estimate based on surveys conducted under weather conditions as close to ideal as could be managed during the winter. The aim of this was both to provide a snapshot count for the lough to gap-fill for missing volunteer counts, and to compare a count made under optimum weather conditions to those made on fixed dates, as is customary for WeBS Core Counts. Due to the timing of the January 2021 COVID-19 lockdown, counts were carried out in the latter half of the winter, on 25th January and 5th March 2021. Across all years of available WeBS Core Count data (1993 - 2020), the average Eider count per sector between November and March was highest in January (273, 95% CI: 183 – 363), therefore the January 2021 count of 3,329 is likely to be closer to the usual annual peak reported by WeBS than the lower count made in March 2021 (991). Indeed, despite the lack of synchrony in counts due to the limitation of only two surveyors, the January figure is close to the five-year moving average for the site (3,558; 2015/16 – 2019/20) and higher than the most recent year's annual peak count (2,225; 2019/20) (Frost et al., 2021). However, although best efforts were made to count under ideal weather conditions, surveyors still noted that views were restricted to 2-3 km from shore and this reduced to 1.5 km when the sea state deteriorated (Allen and Leonard, *pers. comm.*). It is important to note therefore that counts from shore will likely miss aggregations in the mouth of the lough, particularly in the north channel area. This is an issue that is discussed later under recommendations in section 4.4.1.

While the focus of this report is primarily restricted to within Belfast Lough, counts made externally to the core WeBS area of Belfast Lough were made to help inform the future management of the proposed East Coast Marine SPA. The aim of these point counts was to make counts concurrently with other surveying conducted during winter 2020/21 to provide information on the Eider distribution outside Belfast Lough. While it was deemed unlikely that large aggregations of Eider would be found externally along Belfast Lough and also acknowledged that due to the time constraints involved this count would only be a snapshot, the data from this preliminary survey was useful for determining whether more intensive survey efforts might be required in the future. Concentrations of Eider outside of Belfast Lough along the east coast of Northern Ireland predominantly were found in Larne Lough, County Antrim and in the region of Groomsport, Outer Ards, County Down. The number of Eiders counted in the Outer Ards section totalled 370 individuals, which was more than the WeBS five-year moving average count for this site (319) and greater than the numbers counted in the winters between 2016/17 and 2019/20 (Frost et al., 2021). It was also more than the last total count during the 2015/16 NEWS-III (count of 237), but within the confidence intervals for the population estimate for this region (255, CI: 93-507; Austin et al., 2017). The WeBS five-year moving average count of Eider within Larne Lough between 2015/16 and 2019/20 was 112, and in each winter between 2015/16 and 2019/20 counts did not exceed 128 individuals (Frost et al., 2021), so the count made on the 25th February 2021 (a total of 174 in Ballylumford, Glynn Station and Magheramorne) represents a higher than usual count for this area.

While Larne Lough and Outer Ards are generally well covered by WeBS and Outer Ards is covered periodically by the NEWS there is more to be learned about the numbers and movement of Eider in the region of the north-east coast of County Down and how associated these flocks are with the Copeland Island SPA. It was the opinion of the authors that the Copelands should be a focus of future surveillance of Eider in the Belfast Lough area (Leonard, *pers. comm*). As observed during WeBS counts and between the two full lough counts conducted in January and March of 2021 (see section 3.1.3), numbers of Eider in Belfast Lough begin to fall in the late winter, therefore it is possible that larger aggregations of Eider would have been observed if the point counts along the shore of the proposed East Coast Marine SPA had been conducted earlier in the season than late February, as was the case in 2021.

4.2. Assessment of the behaviours and movements of Eider in Belfast Lough

An assessment of the variation in Eider numbers through the tide was made at four sites along the north shore of Belfast Lough – as shown by WeBS data, a key area for Eider in a Northern Ireland context (see section 3.1.1). Results from these TTTCs, conducted between 5th November 2020 and 17th March 2021, showed that Eider occurred in the largest numbers in the Hazelbank Park count sector closest to the head of the lough (on average 1,192) and that average counts were lower on sectors further out towards the mouth of the lough. While not specifically investigated here, it is possible that the higher density of licenced mussel aquaculture plots in the inner lough provide attractive foraging areas for Eider, as has been found elsewhere for Eider and other sea ducks (Cervencl et al., 2015; Kirk et al., 2007; Žydelis et al., 2009). Eider abundance across all sectors was influenced by both tidal state and the month of the count. Analysis using a GLMM predicted that higher numbers of Eider would be present in the count sectors at low tide and earlier in the winter (predicted mean count for low tide in November across all sites: 986, 95% CI: 335 – 2,904). Eider numbers were predicted to be 2.21 times higher at low tide than at high tide, with other variables held constant, and this is consistent with the hypothesis that foraging energy expenditure increases with dive depth (Lovvorn & Jones, 1991), because low tide presents an opportunity for Eider to maximise their foraging efficiency within the TTTC sectors. Movements away from wintering foraging grounds are to be expected as the spring progresses towards the start of the breeding season in April. Many of the Eider that breed along the southern shore of Belfast Lough and around the Copeland-Groomsport area probably winter in the lough (Leonard, 2010), but the majority of the wintering flock are likely to breed elsewhere in Northern Ireland or beyond.

Eider flight activity was recorded in observation periods between TTTCs. The highest level of flight activity in terms of number of recorded flights and flock size took place in November and this declined throughout the winter, following the pattern observed in Eider abundance. Similarly to patterns described by previous observational studies (Campbell, 1978; Merkel et al., 2009) and inferred through analysis of energy expenditure data by Pelletier et al. (2007), the majority of Eider flight moving into the lough were observed close to dawn. However, the timings of the flight observational periods in the TTTCs were biased towards the morning since surveys were mostly conducted on ebb tides (thus with high tide occurring in the morning) or flood tides (thus with low tide occurring in the morning). Therefore, caution is required in how representative these results may be for other periods within the fortnightly tidal cycle. However, in January, additional observational surveys were carried out specifically to gather more information about the timing and direction of the morning Eider influx into Belfast Lough. While these were limited in number and locations (two locations on the northern and southern shore surveyed on the 18th January, one location on the southern shore on the 22nd January), it was clear that Eider movement into the lough peaked at around 30 minutes after sunrise and tailed off at around 150 minutes (2.5 hours) after sunrise. Interestingly only two Eider were observed entering the lough via the north shore, whilst 1,452 and 1,387 Eider were observed passing the Crawfordsburn and Groomsport vantages, respectively. In particular it was noted that many Eider were originating from the Copeland Islands region but given that the total number observed entering the lough from the southern shore on both days was far short of the lough total (~3,300), it is possible that unobserved birds were entering from the middle of the lough between Groomsport and Blackhead on the opposite shore (Leonard, *pers. comm.*) or that birds were roosting overnight in the lough. In this study, no time was available to conduct an assessment of evening movements, and the findings of other studies show variable movement behaviour prior to roosting, with some populations appearing to depart offshore at night (Mudge & Allen, 1980) while others move to sheltered bays inshore (Merkel et al., 2006). The results of this study highlight that there is still much to be understood about the seasonal and diurnal movements of Eider both within and externally to Belfast Lough, and possibilities for improving this are discussed in section 4.4.2.

4.3. Assessment of disturbance of Eider and their responses

Wintering Eider are thought to be vulnerable to disturbance (Jarrett et al., 2018; Merkel et al., 2006, 2009), especially while foraging, due to their need to restore body reserves post-breeding and to enable them to survive harsh winter conditions (Merkel et al., 2006, 2009). Between TTTC, hour-long observations were made of disturbance activities and the Eiders' response to these, with the aim of identifying pressures and potential mitigation measures. Although not formally quantified due to the constraints of the survey methodology, surveyors reported that there were hundreds of people and dog walkers on the shoreline at Hazelbank Park and Loughshore Park during observation periods, and therefore it is possible that the presence of human activity on the beach deters Eider from approaching the shore and that the true impact of land-based disturbance is greater than can be measured here. Only three natural disturbance sources were recorded, all native avian predators, and the lack of reaction of Eider to these is understandable given that the species observed (Peregrine, Sparrowhawk and Buzzard) are unlikely to take prey as large as an adult Eider. Marine traffic was the primary source of potential disturbance activity across the four focal sectors, but there was no detectable impact of boat type or tidal state on the probability of disturbance. In 88% of the boat-based disturbance activities, the Eider were not seen to react by flying or swimming away.

However, on the 7th, 9th and 14th November 2020, boats were observed deliberately disturbing flocks of waterbirds. From the Hazelbank Park vantage point on the 7th November a mussel boat was observed to travel away from a dredge line to aim through multiple flocks of Eider, sounding its horn as it did so. It was observed to have disturbed approximately 1,000 Eider, in addition to Great Crested Grebes amongst the Eider flocks. On the 9th November, a volunteer WeBS counter observed a similar event associated with mussel dredger in the same vicinity, however on this occasion a Rigid-hull Inflatable Boat was observed making obviously deliberate transects through two large Eider flocks of a total of approximately 2,200 individuals at a speed the observer judged to be at risk of striking birds, before moving on to disturb other smaller flocks in the area. The volunteer returned an hour later to check on Eider numbers in the area and found that these had been reduced to around 1,300 individuals. On the 14th November, another volunteer WeBS counter observed mussel dredgers displacing Eider between Hazelbank Park and Green Island. It is not certain what aspect of mussel aquaculture these boats were engaged in at this time of year. These three incidences were reported to DAERA's Marine and Fisheries Division at the time, as the licencing body for aquaculture in Northern Ireland, and no further disturbances of this kind were observed throughout the rest of the study period. It was noted by one of the WeBS volunteers who had been counting this area of Belfast Lough for over 30 years that this was the only incidence of this deliberate disturbance behaviour that they had seen during this time.

In this study, disturbance to Eider was only measured as a fleeing response, therefore in most cases it might be deduced that ship- and boat-traffic cause little issue for Eider in Belfast Lough, with the exception of seemingly rare incidences such as the those described above. This contrasts with the findings of a previous study in Orkney, which found that Eider significantly increased their flight behaviour following disturbance by marine traffic (Jarrett et al., 2018). Movement in response to disturbance has the potential to negatively impact individual Eider fitness by increasing their energy expenditure (Pelletier et al., 2008) and stress levels. However, it has also been demonstrated elsewhere that disturbance from boats can lead to a reduction in Eider feeding activity (Merkel et al., 2009). Since body condition in female Eiders is linked to breeding success (Lehikoinen et al., 2006; Meijer & Drent, 1999), disturbance resulting in movement or reduced foraging rate may have population-level effects. Therefore, while the lack of response recorded here may be due to a habituation of Eider to traffic in the lough, a more detailed study on the impacts of the common disturbance events described here on Eider foraging rate in Belfast Lough would be beneficial to ascertain whether mitigation measures are required.

It has been shown for other sea duck species that cultivated mussels provide a more profitable source of prey than naturally occurring intertidal mussels (Kirk et al., 2007), and that in turn this can lead to an increase in local densities of sea duck (Žydelis et al., 2009). Predation of mussels by Eider has the potential to impact the profits of mussel fisheries businesses (Dionne et al., 2006; Ross & Furness, 2000; Varennes et al., 2013), while mussel fishery activity may also reduce Eider body condition by directly disturbing foraging birds either incidentally or intentionally, and by removing prey biomass from foraging habitats (Laursen et al., 2009). There is therefore a clear source of conflict between the SPA's goals of supporting Belfast Lough's Eider population, and the productivity of the mussel aquaculture businesses in the lough. Environmental decision-making around Eider and aquaculture in Belfast Lough is likely to benefit from diverse stakeholder engagement and the integration of scientific and local knowledge of the issue, as discussed in Ainsworth et al., (2020).

4.4. Recommendations

4.4.1. Numbers and distribution of offshore Eider

While this study adds considerably to the understanding of Eider distribution and movement within Belfast Lough, observations of the numbers and their distribution in the lough were limited by the large size of the lough area, the distance between surveyors and flocks, and the low-lying nature of the surrounding land, providing little vantage over the water. All these elements contributed to a difficulty in surveying Eider at distance in the mouth of the lough, and therefore questions still remain on how many may forage or roost out of view from the shore. In addition to unviewable areas in the mouth of the Belfast Lough between Groomsport and Blackhead, the investigative point counts of the extent of the East Coast Marine SPA demonstrated the value of making a stronger focus of the area between Groomsport and the Copeland Islands.

More detailed information of this kind may be provided by aerial survey. Win et al., (2016) performed four aerial surveys of Belfast Lough between the winters of 2006/07 and 2008/09, primarily with the aim assessing whether the inshore region of Belfast Lough supported sufficient numbers of waterbirds outside the breeding season to meet UK SPA Selection Guidelines, particularly with a focus on Red-throated Diver. Although Eider were the most commonly recorded species during the aerial surveys, the raw counts (maximum recorded: 753) and population estimates using distance sampling (mean of peak estimate: 198) were well below the numbers of Eider recorded by WeBS. No information was provided on the state of the tide during the aerial transects of this study, and therefore it is possible that sub-optimal tidal states were surveyed (i.e. high tide), which may have reduced the efficacy of counts. However, aerial surveys are useful for assessing distribution and have been used in the Dutch Wadden Sea to assess the locations of wintering Eider flocks in relation to mussel culture plots (Cervencl et al., 2015), and have the potential to provide information on Eider distribution in areas not viewable from the shore and in areas not routinely covered by WeBS, for example around the Copeland Islands.

The key concentrations of Eider in the wider East Coast Marine SPA area identified in this report are regularly surveyed as part of WeBS (Larne Lough SPA and Outer Ards SPA, Groomsport; Frost et al., 2021) and periodically as part of the NEWS (Outer Ards SPA and Copeland Islands SPA; Austin et al., 2017; Humphreys et al., 2021), although analysis of these data was outside the scope of this report. A continuation of the survey effort for these areas will be important for maintaining up-to-date information on Eider trends and distribution in the East Coast Marine SPA to inform MPA management plans in the future.

4.4.2. Diurnal and seasonal movements of Eider

While this study reports some initial findings of the movements of Eider within Belfast Lough, it was limited by the observational distances involved. In particular questions remain about where Eiders not viewable from the shore go, whether these areas are tide-, season- and time-specific and how important these areas might be in terms of Eider behaviour, for example, for safe roosting. Additionally, little is known about the connectivity of nearby breeding populations of Eider and how this relates to the population in Belfast Lough during the winter.

Understanding the diurnal and seasonal movements of Eider in Belfast Lough, and their habitat associations, would benefit hugely from tracking studies. However, Eider are a problematic species to attach tags to. Their diving behaviour and marine lifestyle prohibit harness-mounted attachments, and due to the strength of their bills it is unlikely that they would tolerate a glue- or tape-mounted tag. In North America, satellite tracking Eiders has required surgically implanting tags (Beuth et al., 2017; De La Cruz et al., 2014; Mallory et al., 2020; Merkel et al., 2006; Petersen & Flint, 2002), but such studies require veterinary oversight and have not yet occurred in the UK; all deployment of tags on birds in the UK is subject to licencing, through the independent Special Methods Technical Panel of the BTO ringing scheme and the Home Office.

While methods for non-surgical tagging of Eider are yet to be developed, colour-ringing may provide some information on the movement of individuals between breeding areas and wintering grounds, and within wintering grounds themselves, as is being trialled in Morecambe Bay, Cumbria (Booth Jones, *pers. obs.*). In particular information on the movement of individuals within Northern Irish populations, for example the association between Belfast Lough and Copeland Eider populations, and between these and Scotland, for example Eider from the Firth of Clyde, may be important. This information may be particularly valuable in the future if wind farm developments are proposed in the Irish Sea close to Belfast Lough's significant Eider population, as previous studies have shown that Eider are vulnerable to collision (Larsen & Guillemette, 2007) and potentially to avoidance costs (Masden et al., 2009).

4.4.3. Mitigating and addressing disturbance issues

Although there were notable exceptions of extreme disturbance activity observed during the study period, it was found that marine traffic-based disturbance did not often cause Eider to flee. However, a more detailed study of Eider foraging rate may be beneficial to assess the true impact of human activity on Eider energy budgets during critical winter foraging in the lough. It was noted by surveyors that land-based human activity was predominantly of walkers and dog walkers, and that while Eider were mostly over 100 m offshore from this source of disturbance, many species of shorebirds were seen to be disturbed (Leonard, *pers. comm*). It has been shown that signage explaining the impacts of disturbance on birds can reduce human nuisance behaviours (Allbrook & Quinn, 2020), and therefore this may be an option on busy shoreline areas to help reduce human impacts on Belfast Lough's waterbirds.

Disturbance of Eider by mussel dredgers and the economic impact of Eider on mussel beds may become more of a problem in Belfast Lough if Eider populations increase further. Conflict between Eider conservation interests and mussel aquaculture farms in Belfast Lough would benefit from stakeholder engagement work to develop a better understanding of the issues involved and to collaboratively seek mitigation measures for the impacts of predation pressure on mussel beds whilst preserving the health of Belfast Lough's nationally important Eider population.

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APPENDIX 1

Figure S1: Site map of Fisherman's Quay. Orange boundary line indicates WeBS Low Tide Sector, dashed line indicates continuation of sector boundaries out into Belfast Lough, between which counting should occur up to the constraints of visibility. Orange point indicates counting point location.

Figure S2: Site map of Castlerocklands. Orange boundary line indicates WeBS Low Tide Sector, dashed line indicates continuation of sector boundaries out into Belfast Lough, between which counting should occur up to the constraints of visibility. Orange point indicates counting point location.

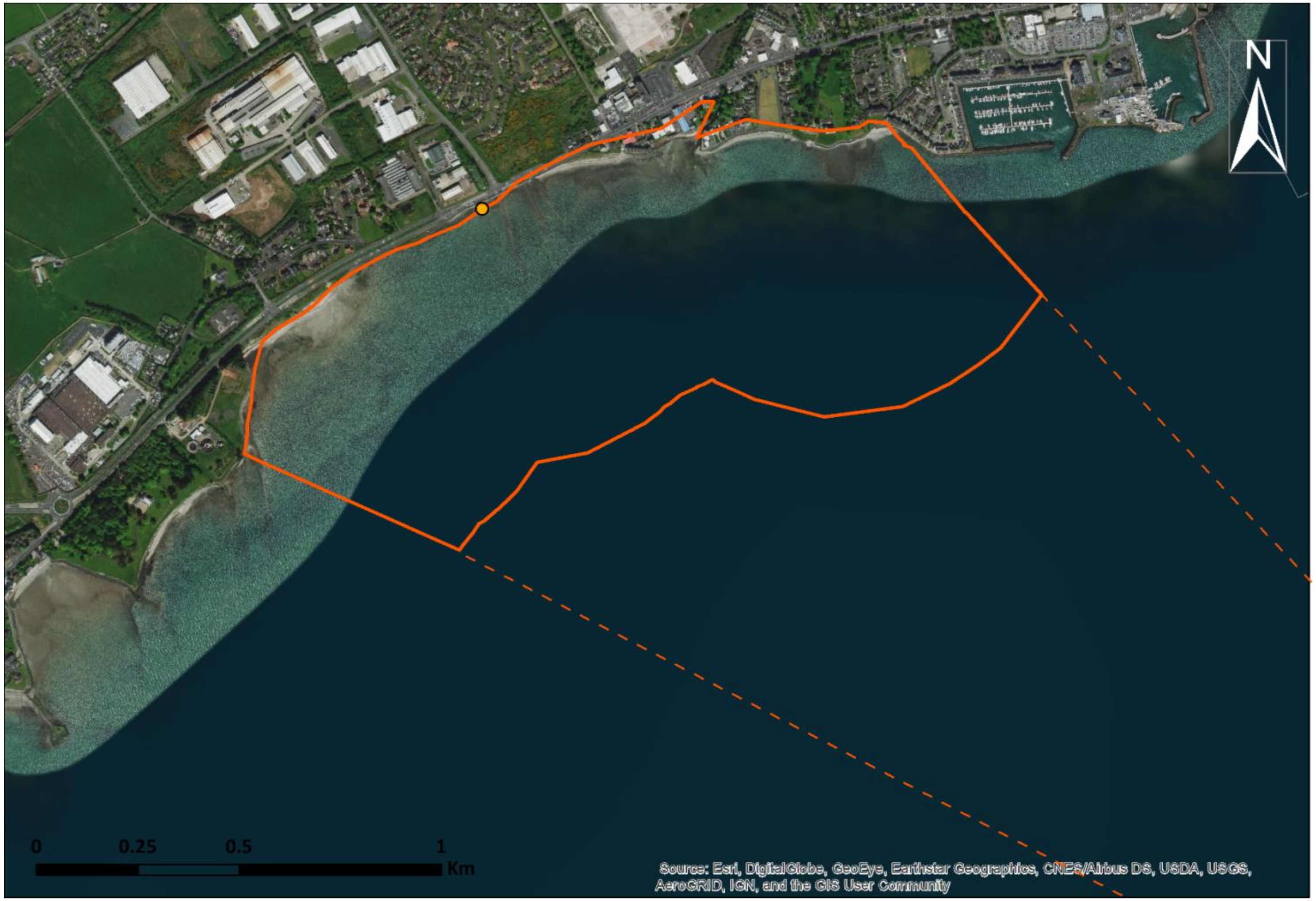

Figure S3: Site map of Loughshore Park. Orange boundary line indicates WeBS Low Tide Sector, dashed line indicates continuation of sector boundaries out into Belfast Lough, between which counting should occur up to the constraints of visibility. Orange point indicates counting point location. Grey boundary line represents outline of a neighbouring Low Tide sector (Hazelbank Park, Figure S4).

Figure S4: Site map of Hazelbank Park. Orange boundary line indicates WeBS Low Tide Sector, dashed line indicates continuation of sector boundaries out into Belfast Lough, between which counting should occur up to the constraints of visibility. Orange point indicates counting point location.

APPENDIX 2

Instructions and field sheet: through the tide counts

Recording schedule

HOURS FROM LOW/HIGH TIDE	COUNT STAGE
0.0 - 0.5	Count 1: 30 mins
0.5 – 1.5	Observation of marine activity 1: 60 mins
1.5 – 2.0	BREAK
2.0 – 2.5	Count 2: 30 mins
2.5 – 3.5	Observation of marine activity 2: 60 mins
3.5 – 4.0	BREAK
4.0 – 4.5	Count 3: 30 mins
4.5 – 5.5	Observation of marine activity 3: 60 mins

One complete set of recording sheets (this document) will be required per survey. It is recommended that this document is printed double-sided and stapled to ensure counts/observations remain associated with the correct time/location.

Counts

There are three 30-minute counts in each survey schedule, occurring every 2 hours. During the 30-minute counts, count all waterbirds on the shore or on the water within the WeBS sector specified in the map, and out to sea from the shore in a straight line from the boundaries of the sector to the best of your approximation and as far as can be perceived. If there are too many birds to be counted within 30 minutes, concentrate on Eider.

Counts should be recorded in RECORDING SHEET 1. Each count in the schedule has a separate count table in which to make records (Count 1, Count 2, Count 3). Please record weather conditions at the start of each count as specified in the recording sheet.

Observations

Following each 30-minute count, a 60-minute observation will take place from the specified survey point on the site map to record marine activity and Eider responses to disturbance (RECORDING SHEET 2). Flights of Eider entering, leaving or flying past the sector during the hour-long observations will also be recorded (RECORDING SHEET 3).

Within the WeBS sector and out to sea from the shore in a straight line from the boundaries of the sector please record occurrences of marine activity and other potential sources of disturbance, using categories from the table below. For each instance of activity, please record the category, the time the activity started, the time it finished, and the reaction of any Eider present that could be perceived. In the case of a mixed response from Eider please record the highest level of response observed, where flying is a stronger response than swimming or running away, which are stronger responses than no response (flying > swimming/running > no response). While the recording of activity and responses to activity are the primary goal of the 60-minute observations, any movements of Eider into, out of, or past the sector should be noted in RECORDING SHEET 3. Please record whether the Eider were observed entering, leaving or passing, when this was observed and how many Eider were involved.

Each observation in the schedule has separate tables (one for marine activity - RECORDING SHEET 2, one for Eider movement - RECORDING SHEET 3) in which to make records (Observation 1, Observation 2, Observation 3).

Categories of disturbance to record in RECORDING SHEET 2

TYPE OF DISTURBANCE	CATEGORY
BOAT	• Fishing boat/creel boat • Non-fishing industrial boat (e.g. tug, pilot boat, work boat) • Ferry • Lifeboat • Pleasure boat (e.g. yacht, sailing boat, powerboat) • Jet-skis • Unpowered boat (e.g. canoe, rowboat, kayak, paddleboard)
AIR	• Aeroplane • Helicopter • Drone
NATURAL	• Predator (e.g. bird of prey)
LAND-BASED HUMAN	• Walkers • Joggers • Birdwatchers • Anglers • Shellfishers • Bait-diggers • Dogs on lead • Dogs off lead • Vehicles
OTHER	• Other disturbance – please specify.

RECORDING SHEET 1: Count (30 mins every 2 hours)

Site name: Date: Surveyor name:

Tide at start of survey period: High □ Low □ Tidal phase: Flood □ Ebb □

Start time: End time:

Count 1
Hours from HIGH/LOW (delete as appropriate) tide: 0.0 – 0.5

Weather conditions (circle choices)

Wind direction	N	NE	E	SE	S	SW	W	NW
Wind speed (Beaufort)	1	2	3	4	5 (avoid > 4 if possible)			
Sea state (Beaufort)	1	2	3	4	5 (avoid > 4 if possible)			
Glare	None	Moderate		Strong				
Precipitation	None	Rain	Hail/Sleet		Snow (avoid precipitation if possible)			

Species	**Count**	**Total**
e.g. Eider	*1,2,17, 3,7*	*30*

RECORDING SHEET 2: Observation of marine activity and Eider disturbance activity (60 mins every 2 hours)

Site name: Date: Surveyor name:

Tide at start of survey period: High □ Low □ Tidal phase: Flood □ Ebb □

Start time: End time:

Observation 1			
Hours from HIGH/LOW (delete as appropriate) tide: 0.5 -1.5			
Category of disturbance	**Start time**	**Finish time**	**Response of Eider (no response < running/swimming < flying, recording highest response of any mixed response)**
e.g. fishing boat	*e.g. 11:45*	*e.g. 11:55*	*e.g. Flying*

RECORDING SHEET 3: Observation (60 mins every 2 hours): flights of Eider entering, leaving or flying past the sector

Site name: Date: Surveyor name:

Tide at start of survey period: High □ Low □ Tidal phase: Flood □ Ebb □

Start time: End time:

Observation 1		
Hours from HIGH/LOW (delete as appropriate) tide: 0.5 -1.5		
Flight type (entering sector/leaving sector/passing sector)	**Time**	**Count of Eider**
e.g. entering	*e.g. 08:30*	*7*

APPENDIX 3

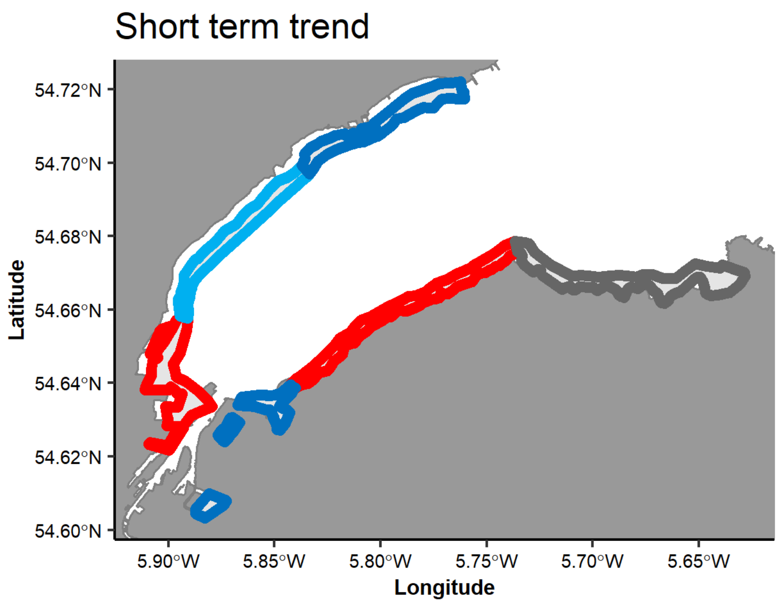

Figure S3.1. Population trends of Eider in Belfast Lough based on high tide counts over the short- (2012/13 - 2017/18) term. Sectors are coloured to indicate trend status as follows: Red – a decline in numbers of at least 50%; Orange – a decline in numbers of at least 25% but less than 50%; Grey – a decline in numbers of less than 25% or an increase of less than 33%; Pale Blue – an increase in numbers of at least 33% but less than 100%; Dark Blue – an increase in numbers of at least 100%. NB: position of sectors relative to basemap are approximate, there is a slight south-east shift to sectors in relation to the basemap.

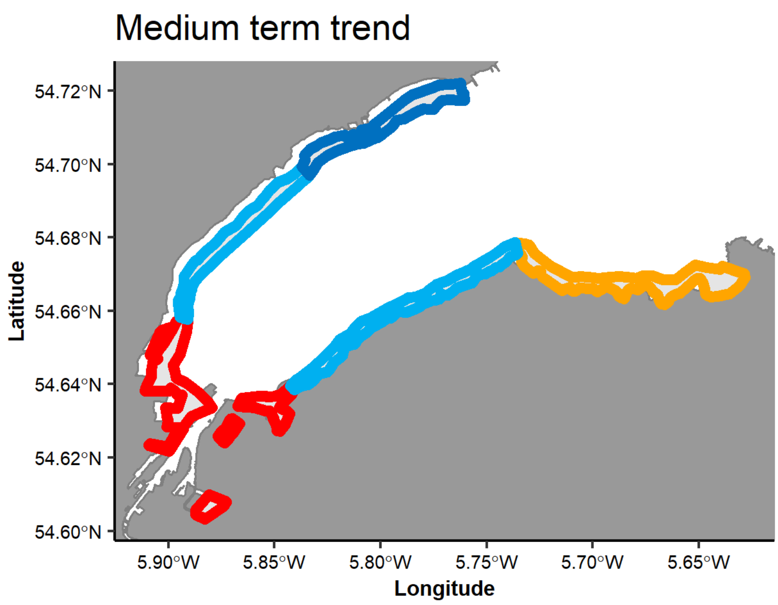

Figure S3.2. Population trends of Eider in Belfast Lough based on high tide counts over the medium- (2009/10 - 2017/18) term. Sectors are coloured to indicate trend status as follows: Red – a decline in numbers of at least 50%; Orange – a decline in numbers of at least 25% but less than 50%; Grey – a decline in numbers of less than 25% or an increase of less than 33%; Pale Blue – an increase in numbers of at least 33% but less than 100%; Dark Blue – an increase in numbers of at least 100%. NB: position of sectors relative to basemap are approximate, there is a slight south-east shift to sectors in relation to the basemap.

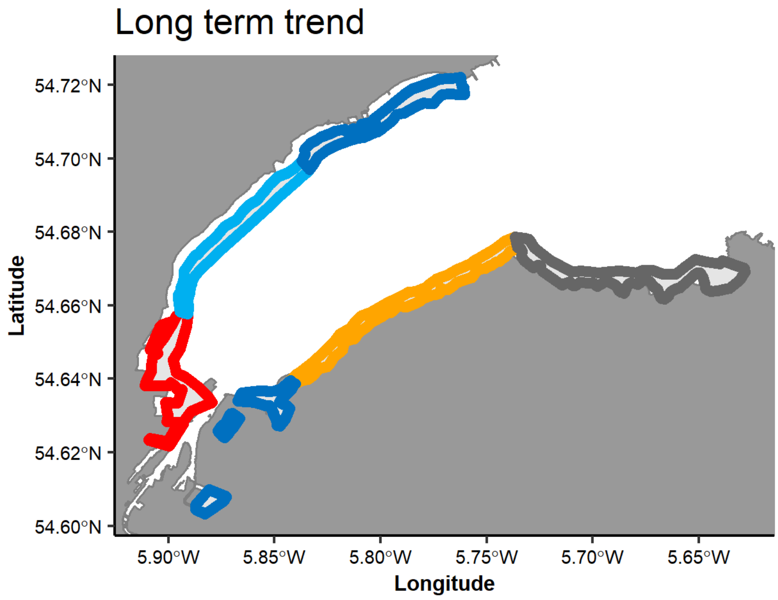

Figure S3.3. Population trends of Eider in Belfast Lough based on high tide counts over the long- (2002/03 - 2017/18) term. Sectors are coloured to indicate trend status as follows: Red – a decline in numbers of at least 50%; Orange – a decline in numbers of at least 25% but less than 50%; Grey – a decline in numbers of less than 25% or an increase of less than 33%; Pale Blue – an increase in numbers of at least 33% but less than 100%; Dark Blue – an increase in numbers of at least 100%. NB: position of sectors relative to basemap are approximate, there is a slight south-east shift to sectors in relation to the basemap.

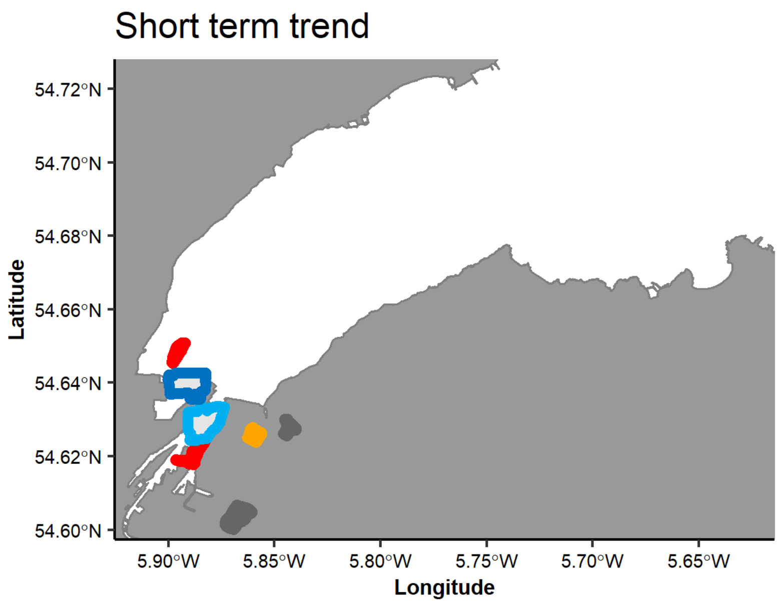

Figure S3.4. Population trends of Eider in Belfast Lough based on low tide counts over the short- (2012/13 - 2017/18) term. Sectors are coloured to indicate trend status as follows: Red – a decline in numbers of at least 50%; Orange – a decline in numbers of at least 25% but less than 50%; Grey – a decline in numbers of less than 25% or an increase of less than 33%; Pale Blue – an increase in numbers of at least 33% but less than 100%; Dark Blue – an increase in numbers of at least 100%. NB: position of sectors relative to basemap are approximate, there is a south-east shift to sectors in relation to the basemap.

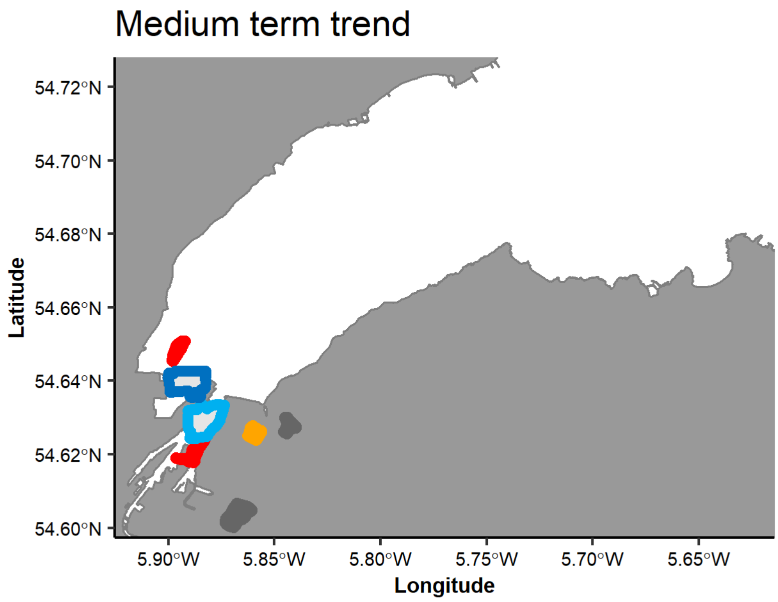

Figure S3.5. Population trends of Eider in Belfast Lough based on low tide counts over the medium- (2009/10 - 2017/18) term. Sectors are coloured to indicate trend status as follows: Red – a decline in numbers of at least 50%; Orange – a decline in numbers of at least 25% but less than 50%; Grey – a decline in numbers of less than 25% or an increase of less than 33%; Pale Blue – an increase in numbers of at least 33% but less than 100%; Dark Blue – an increase in numbers of at least 100%. NB: position of sectors relative to basemap are approximate, there is a south-east shift to sectors in relation to the basemap.

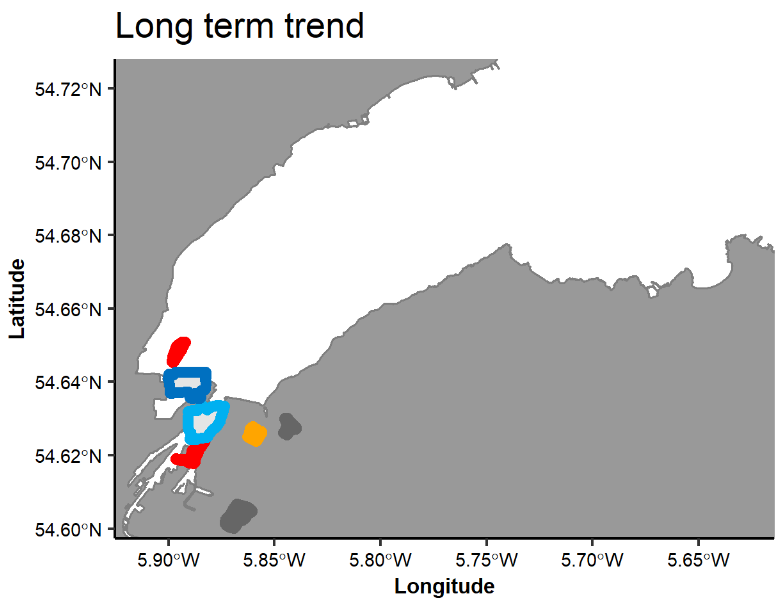

Figure S3.6. Population trends of Eider in Belfast Lough based on low tide counts over the long- (2002/03 - 2017/18) term. Sectors are coloured to indicate trend status as follows: Red – a decline in numbers of at least 50%; Orange – a decline in numbers of at least 25% but less than 50%; Grey – a decline in numbers of less than 25% or an increase of less than 33%; Pale Blue – an increase in numbers of at least 33% but less than 100%; Dark Blue – an increase in numbers of at least 100%. NB: position of sectors relative to basemap are approximate, there is a south-east shift to sectors in relation to the basemap.

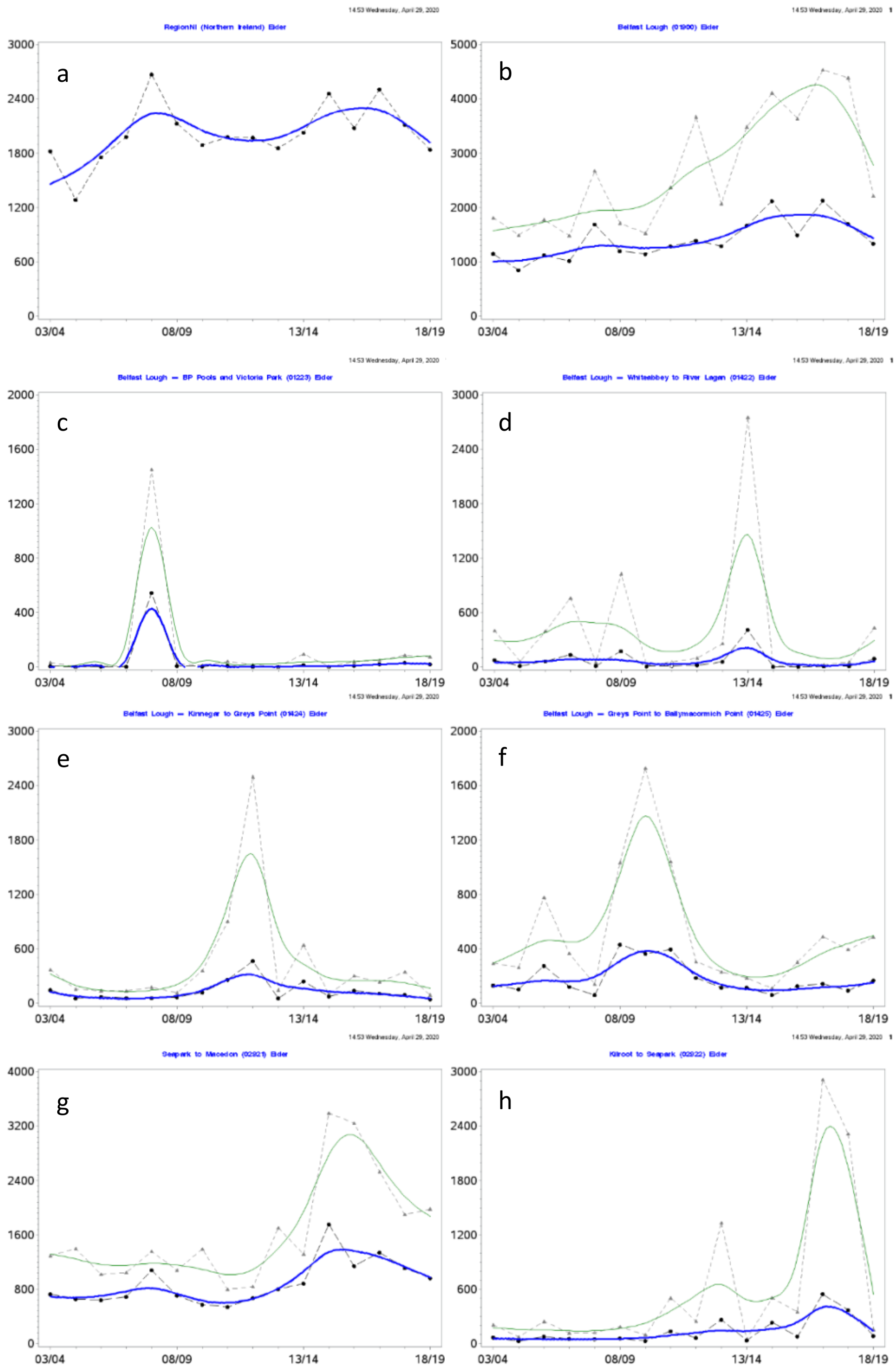

Figure S3.7: Trend plots for Eider at the country, site and WeBS Core Count sector levels. The upper (green) trend line is fitted through the winter peak counts whilst the lower (blue) line is fitted through the winter mean counts. (a) Northern Ireland. (b) Belfast Lough. (c) Belfast Lough - BP Pools and Victoria Park. (d) Belfast Lough - Whiteabbey to River Lagan. (e) Belfast Lough - Kinnegar to Greys Point. (f) Belfast Lough - Greys Point to Ballymacormich Point. (g) Seapark to Macedon. (h) Kilroot to Seapark.

APPENDIX 4

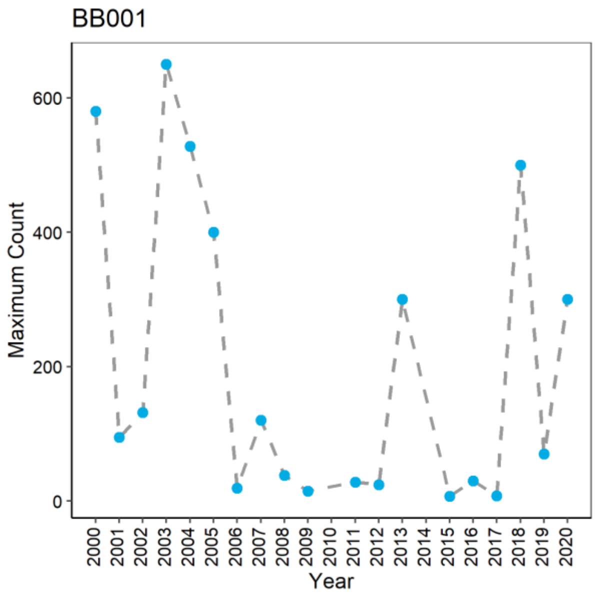

Figure S4.1: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB001. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

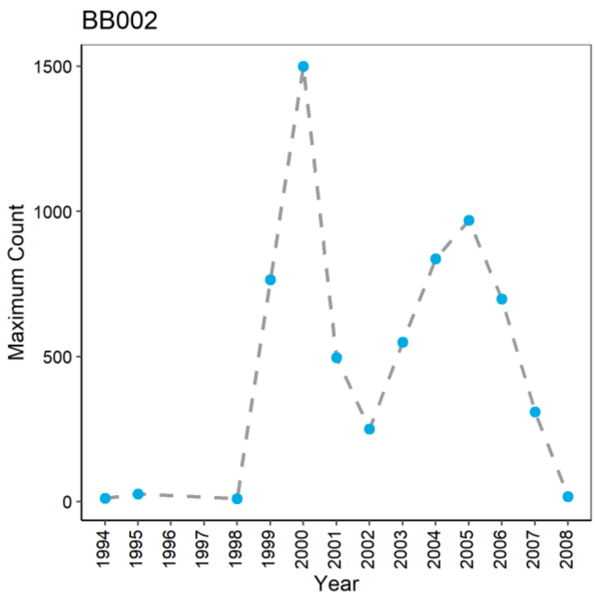

Figure S4.2: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB002. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

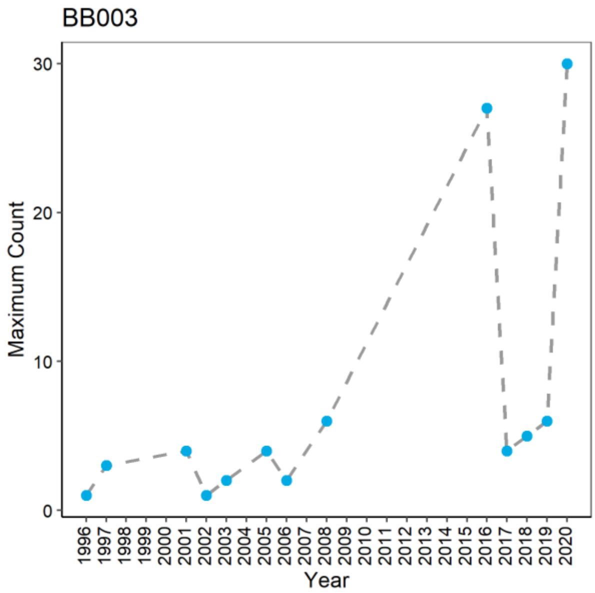

Figure S4.3: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB003. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

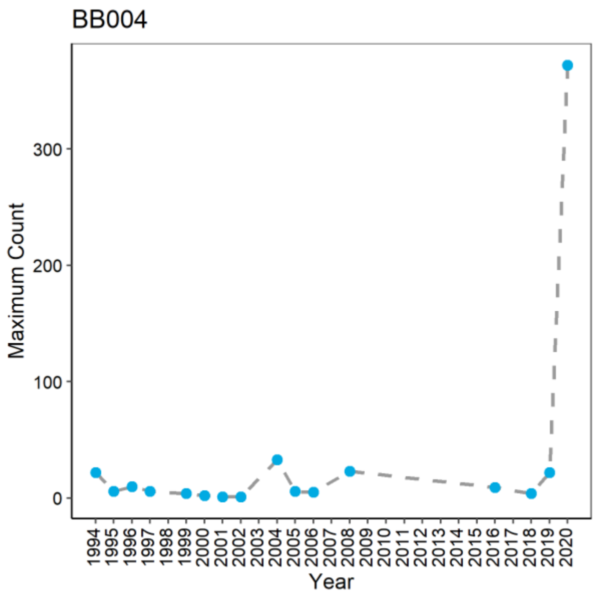

Figure S4.4: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB004. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

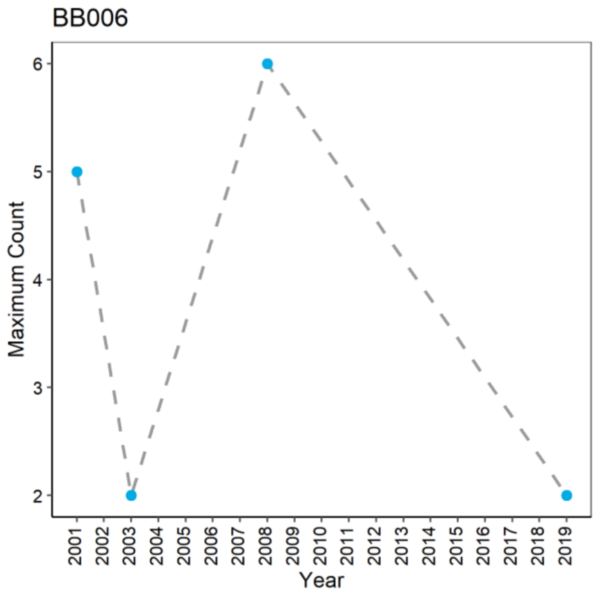

Figure S4.5: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB006. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

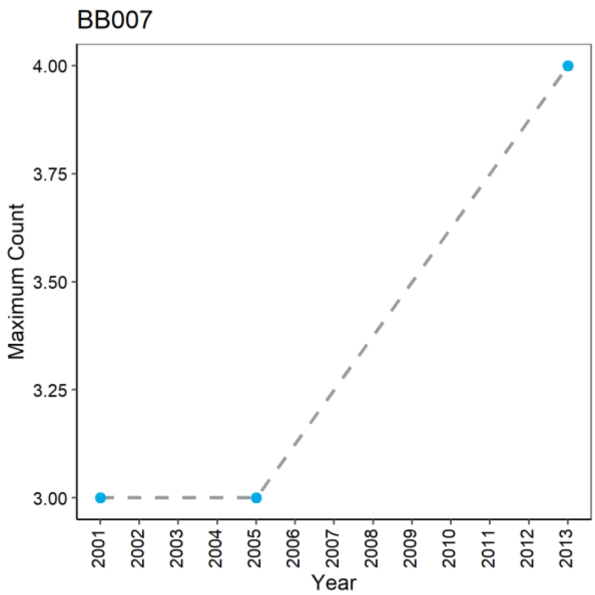

Figure S4.6: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB007. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

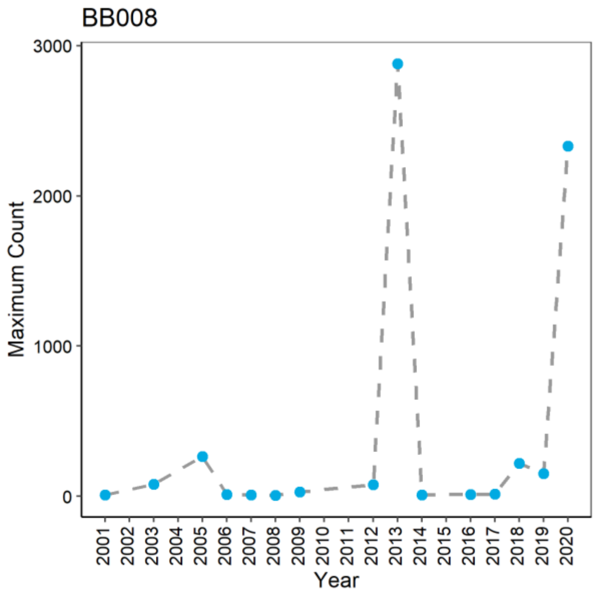

Figure S4.7: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB008. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

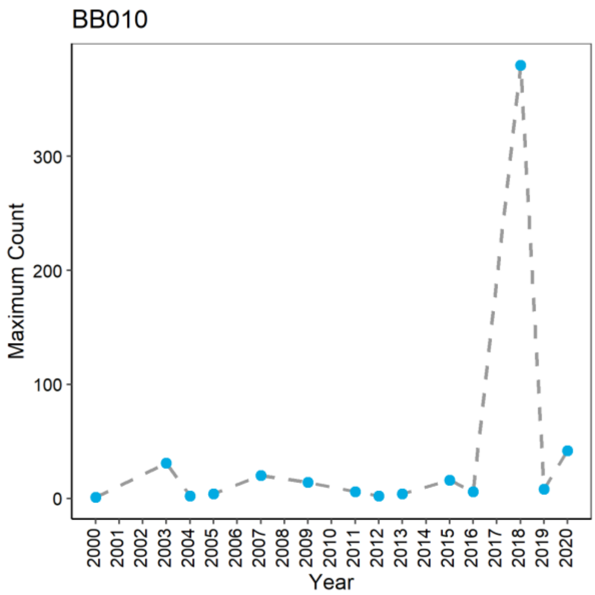

Figure S4.8: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB010. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

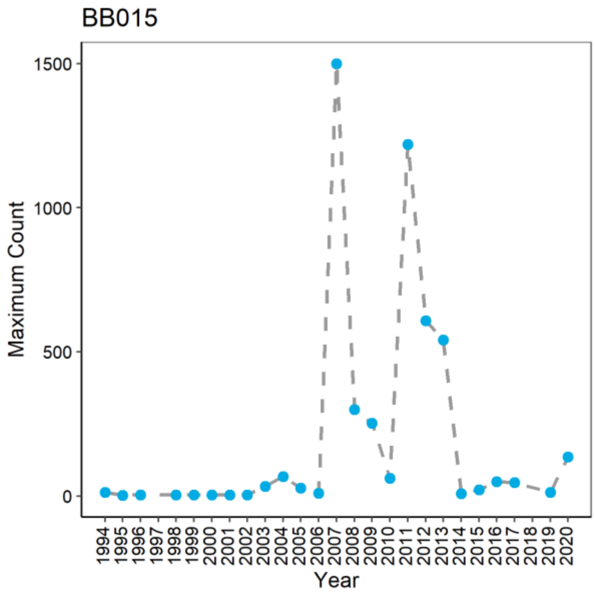

Figure S4.9: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB015. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

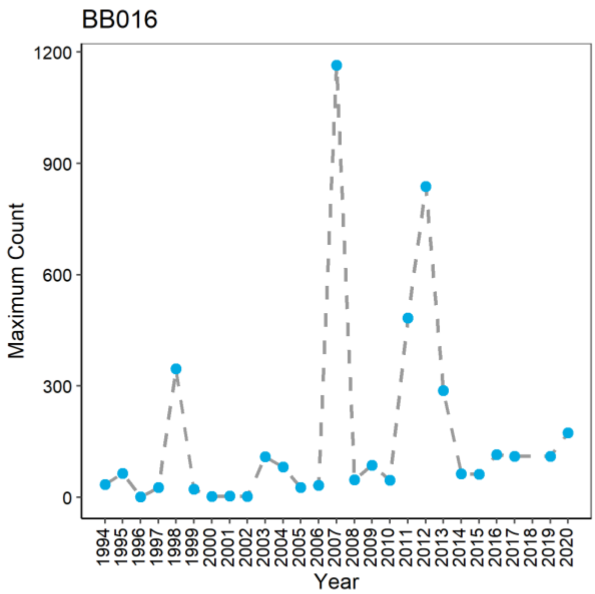

Figure S4.10: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB016. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

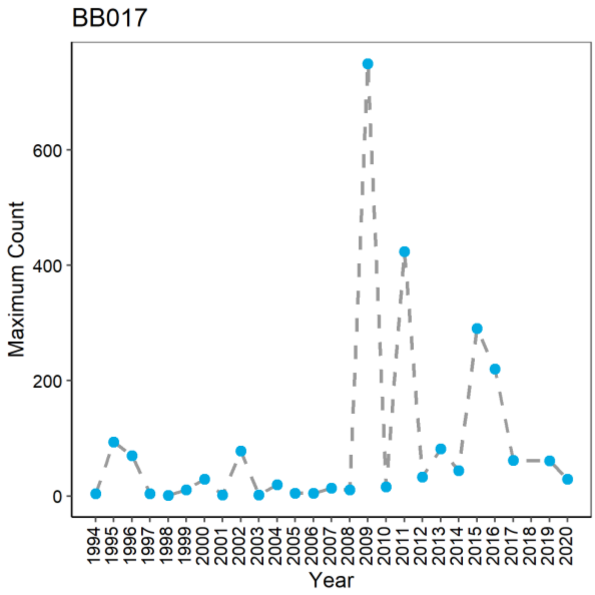

Figure S4.11: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB017. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

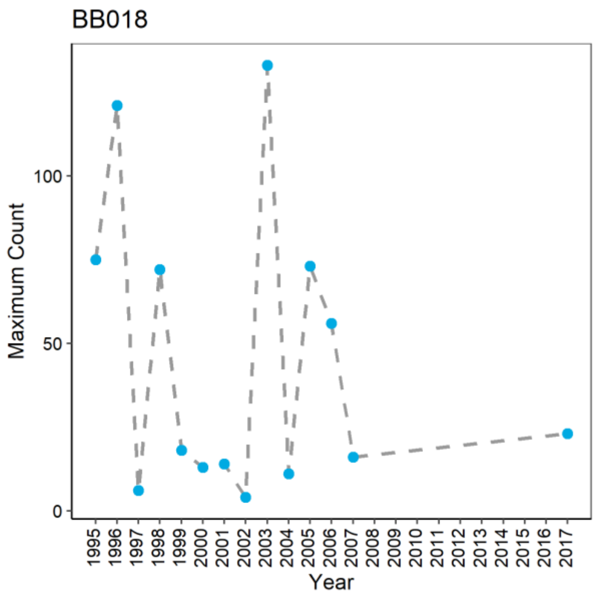

Figure S4.12: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB018. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

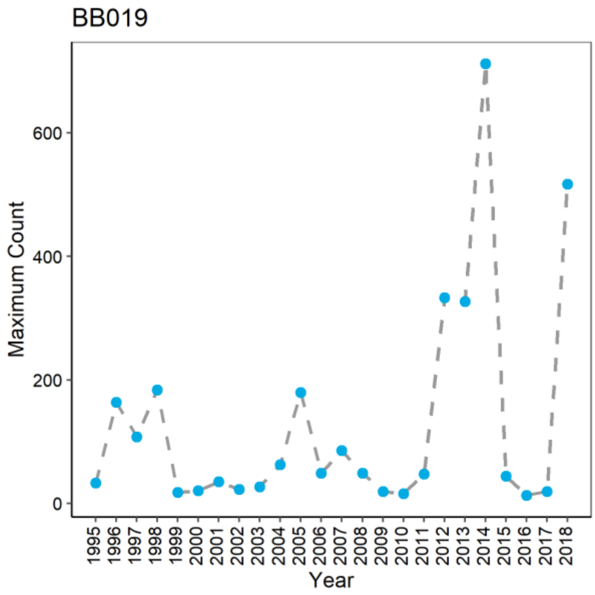

Figure S4.13: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB019. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

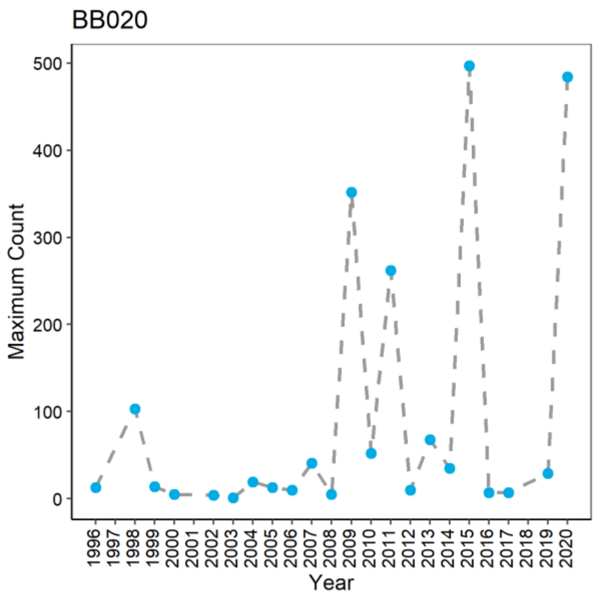

Figure S4.14: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB020. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

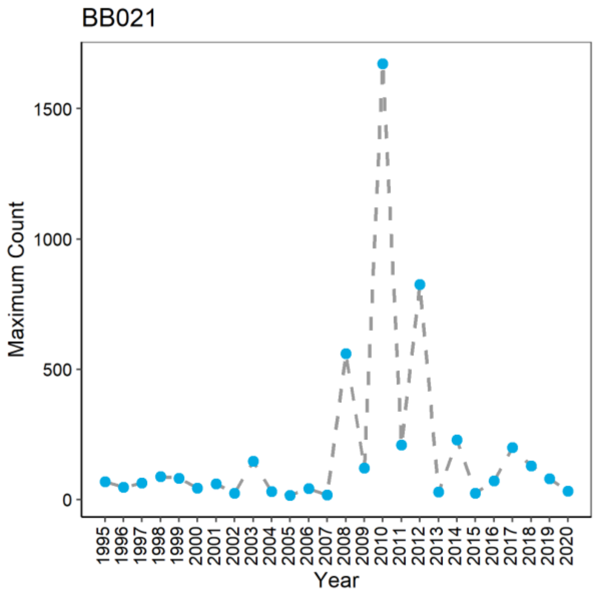

Figure S4.15: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB021. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

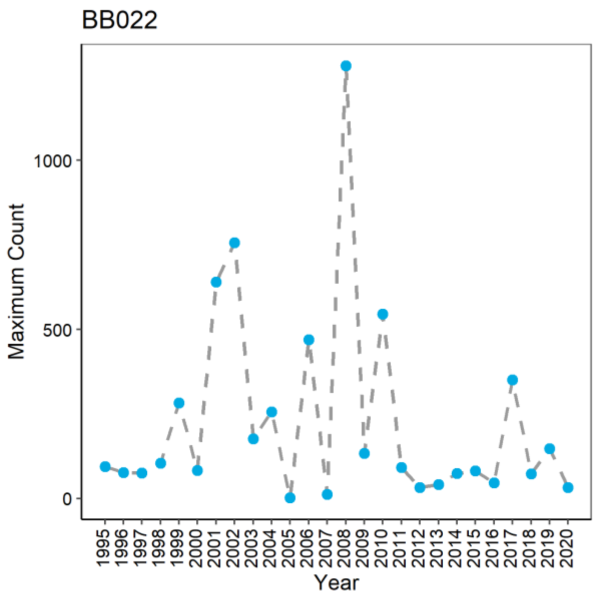

Figure S4.16: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB022. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

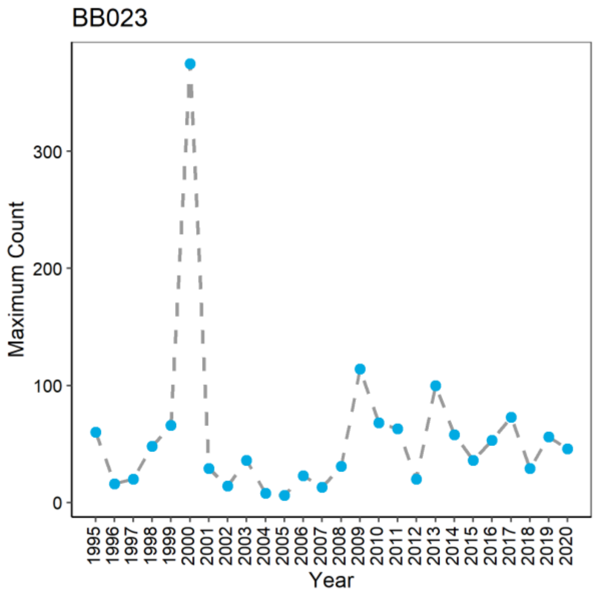

Figure S4.17: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB023. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

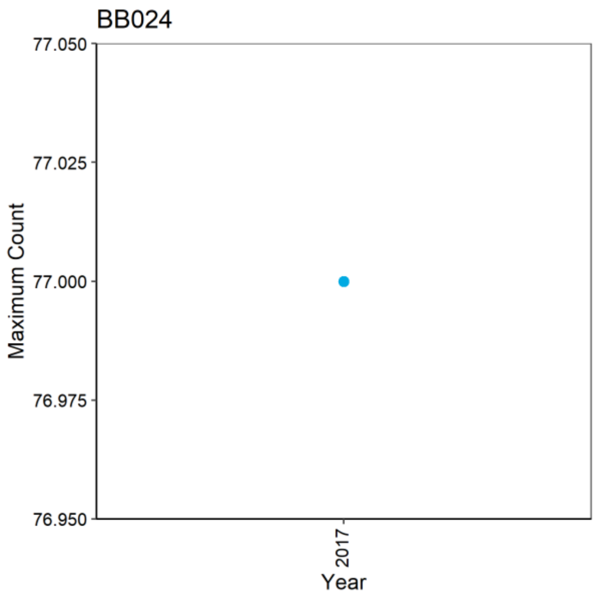

Figure S4.18: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB024. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

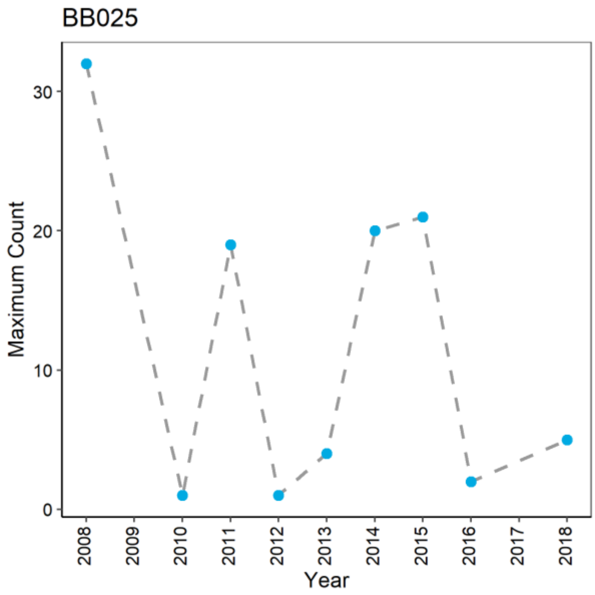

Figure S4.19: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB025. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

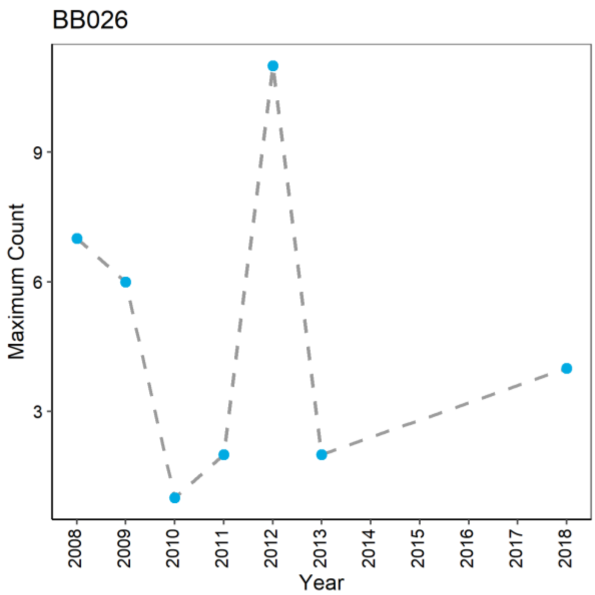

Figure S4.20: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB026. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

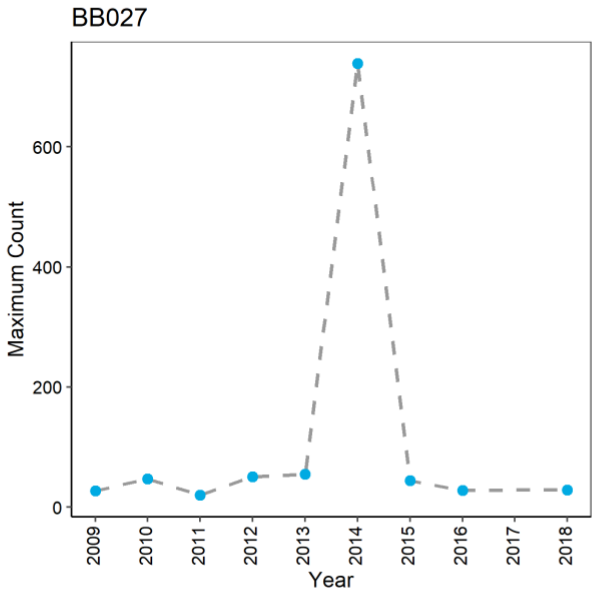

Figure S4.21: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB027. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

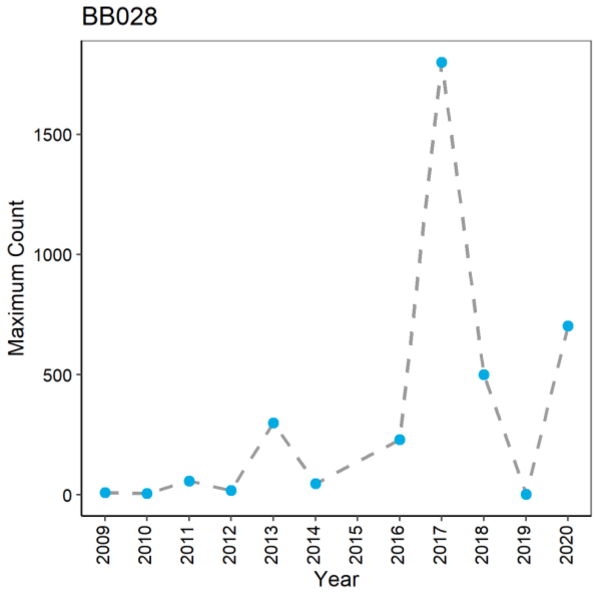

Figure S4.22: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB028. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

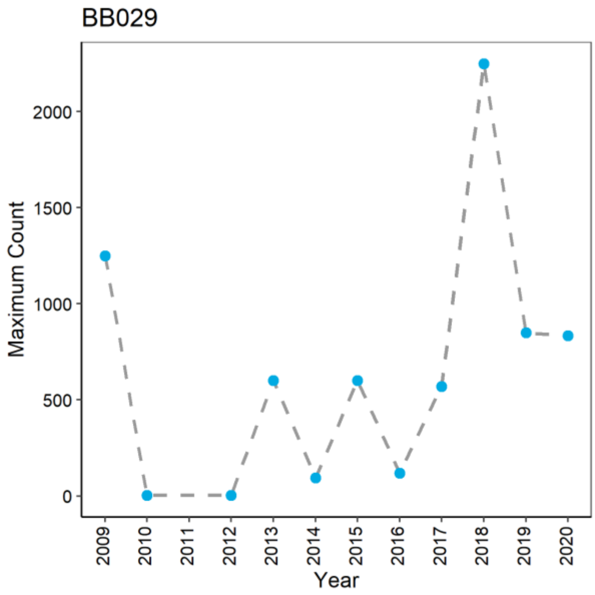

Figure S4.23: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB029. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

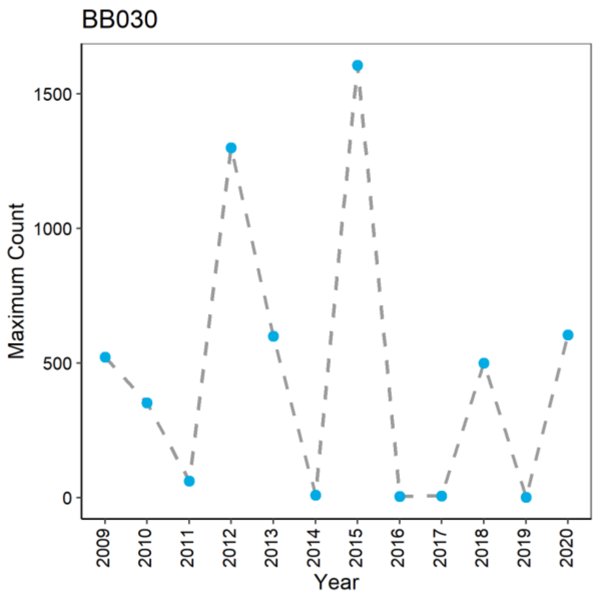

Figure S4.24: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB030. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

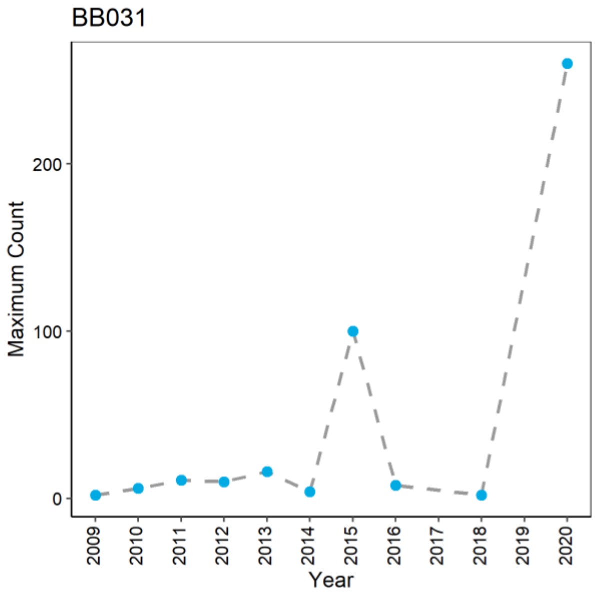

Figure S4.25: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB031. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

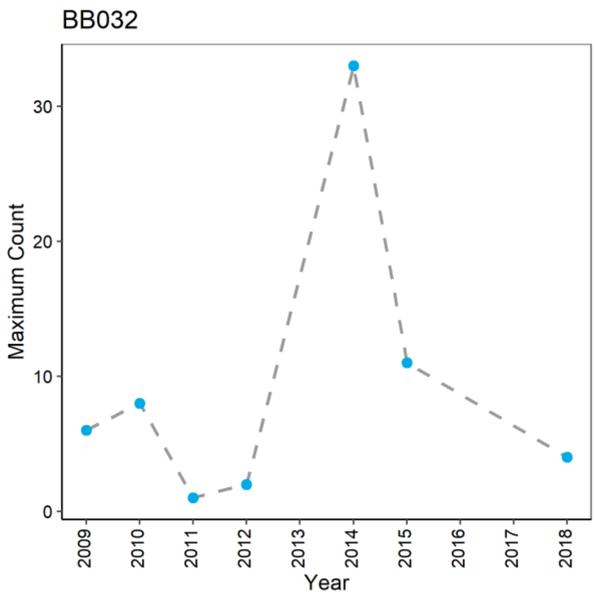

Figure S4.26: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB032. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

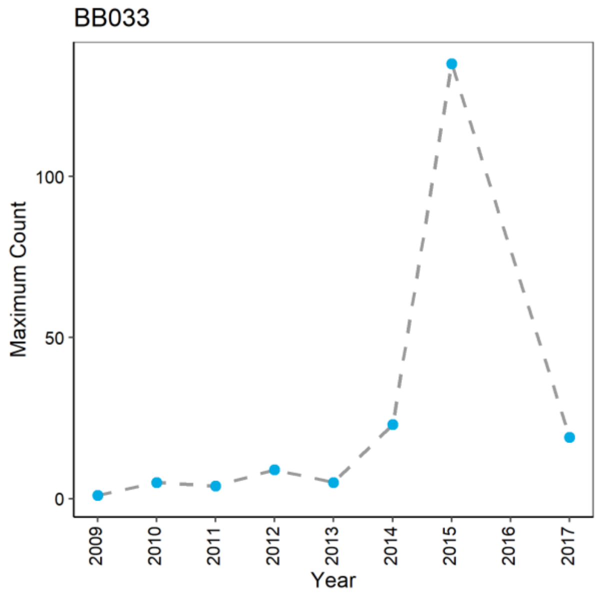

Figure S4.27: Maximum counts of Eider per year for Belfast Lough WeBS Low Tide sector BB033. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

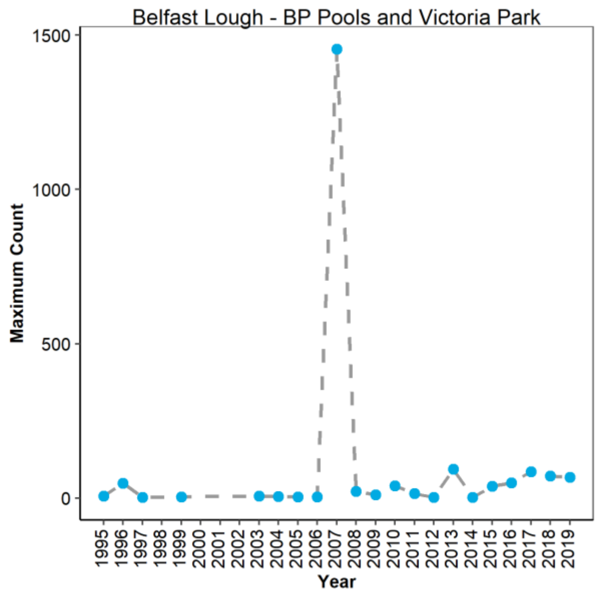

Figure S4.28: Maximum counts of Eider per year for Belfast Lough WeBS Core Count sector BP Pools and Victoria Park. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

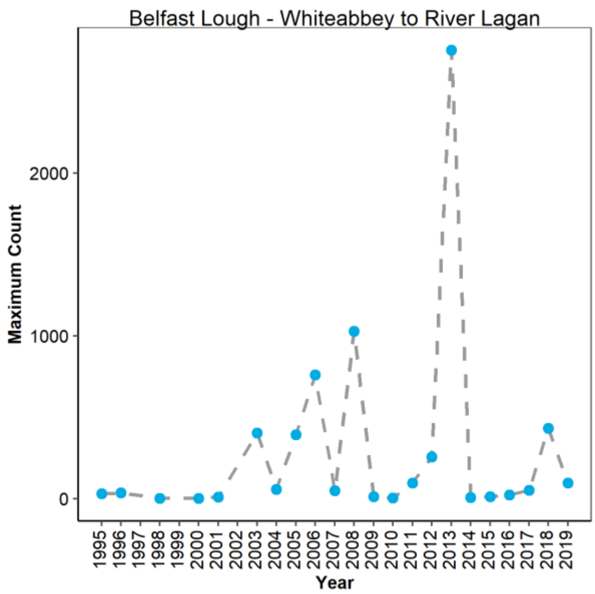

Figure S4.29: Maximum counts of Eider per year for Belfast Lough WeBS Core Count Whiteabbey to Rover Lagan. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

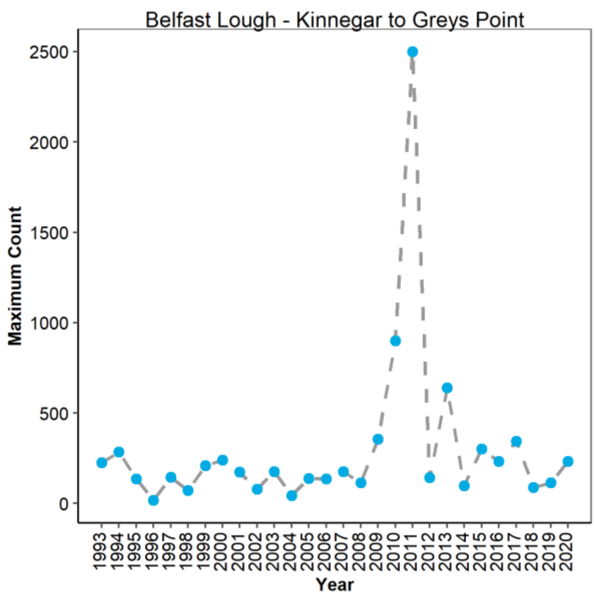

Figure S4.30: Maximum counts of Eider per year for Belfast Lough WeBS Core Count sector Kinnegar to Grey Point. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

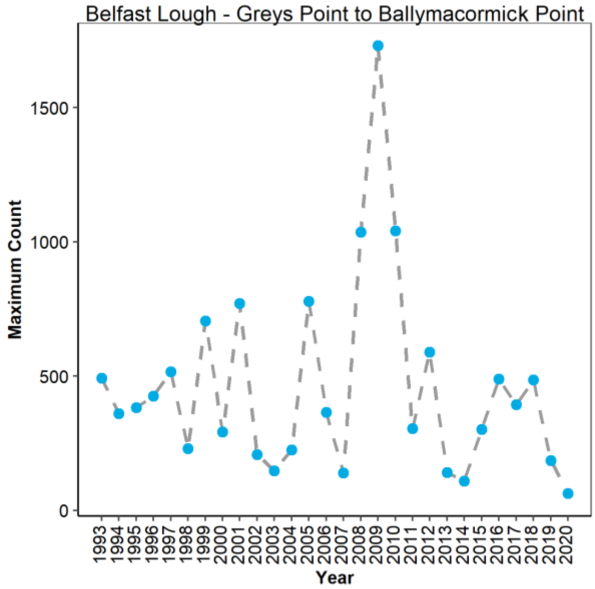

Figure S4.31: Maximum counts of Eider per year for Belfast Lough WeBS Core Count sector Greys Point to Ballymacormick Point. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

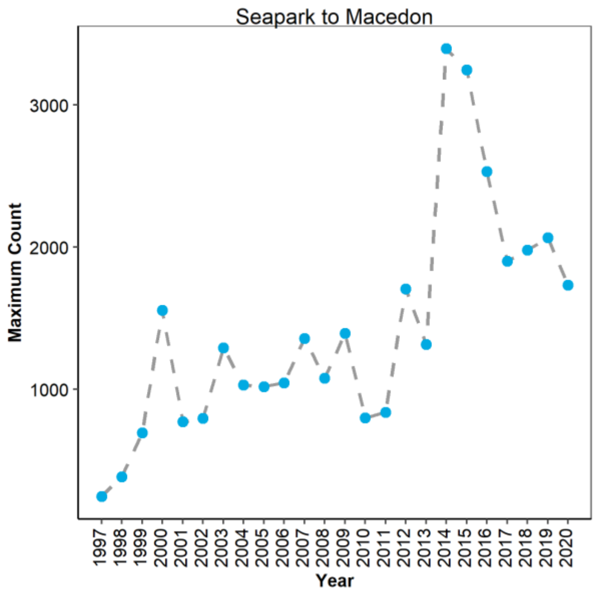

Figure S4.32: Maximum counts of Eider per year for Belfast Lough WeBS Core Count sector Seapark to Macedon. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

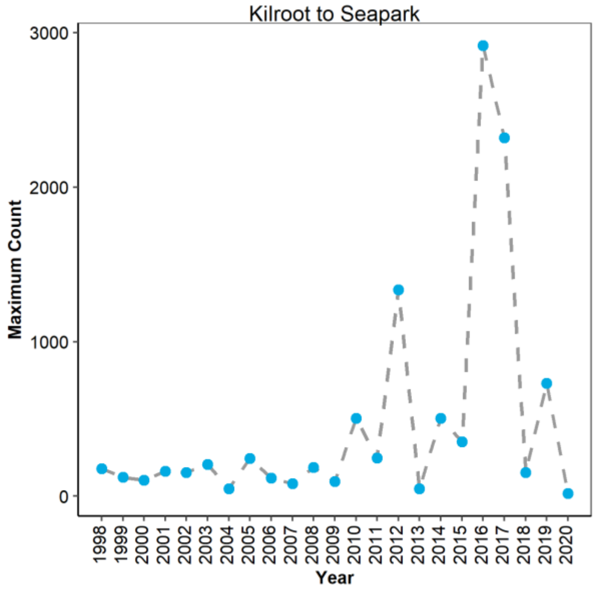

Figure S4.33: Maximum counts of Eider per year for Belfast Lough WeBS Core Count sector Kilroot to Seapark. For years surveyed in multiple months, the largest count was taken to represent Eider use of the sector in that year.

APPENDIX 5

Table S5: Counts of Eider at points along the extent of the proposed East Coast Marine SPA.

Location	Latitude	Longitude	Count
County Antrim			
Carnlough Harbour	54.994349	-5.988221	0
Carnlough Bay	54.986208	-5.991755	0
Glenarm	54.974504	-5.959847	0
Madman's Car Park	54.969498	-5.935149	0
A2 Car Park 1	54.963573	-5.923476	0
A2 Car Park 2	54.949231	-5.90704	0
A2 Car Park 3	54.922709	-5.887363	0
Ballygally	54.906299	-5.876184	0
Drains Bay	54.888716	-5.841347	2
Black Arches	54.875113	-5.821526	0
Chaine Park	54.855219	-5.801232	0
Larne Harbour	54.843952	-5.803785	0
Glynn Station	54.827102	-5.807063	164
Magheramorne	54.815302	-5.769861	8
Ballycarry	54.778019	-5.72113	0
Mill Bay	54.824797	-5.75027	0
Ballylumford	54.8463	-5.789452	2
Browns Bay	54.852155	-5.765805	0
Portmuck	54.8484	-5.726581	2
Whitehead	54.755712	-5.702076	2
County Down			
Ballymacormick East	54.670661	-5.6552178	25
Ballymacormick West	54.679191	-5.6212342	10
Groomsport	54.677044	-5.6160897	105
Briggs Rocks Area	54.675369	-5.6032205	32
Sandeel Lane	54.675463	-5.5884603	10
Orlock	54.666017	-5.5714336	2
Warren Road North	54.669649	-5.5740756	2
Warren Road Mid 2	54.666017	-5.5714336	2
Warren Road Mid 1	54.660993	-5.5630356	4
Warren Road South	54.65642	-5.5547369	57
Donaghadee Harbour Inner	54.642875	-5.5348885	0
Donaghadee Harbour Offshore	54.644893	-5.5303985	6
Commons North	54.641962	-5.5298191	6
Commons Mid	54.639578	-5.5292183	0
Commons South	54.635039	-5.5297601	2
Millisle-Donaghadee	54.624171	-5.5344701	0
Millisle Bay N1	54.615323	-5.5311053	0
Millisle Bay N1	54.611808	-5.5283198	0

Millisle Bay Mid	54.605355	-5.5238137	0
Millisle Bay South	54.592198	-5.5097696	0
Ballywhiskin North	54.591697	-5.5071598	0
Ballywhiskin	54.584187	-5.5045983	0
Ballyferris North (Road)	54.576104	-5.4957014	2
Ballyferris S (Road)	54.559659	-5.4790288	0
Ballywalter Harbour	54.544563	-5.4804289	12
Ballywalter Beach	54.542771	-5.4817808	4
Ballyhalbert-Ballywalter	54.513459	-5.4679942	0
Ballyhalbert Bay North	54.506919	-5.466916	0
Ballyhalbert Bay South	54.490233	-5.438624	2
Burial Island	54.488788	-5.4345471	0
Portavogie-Ballyhalbert Road	54.48146	-5.4386361	0
Portavogie-Ballyhalbert Road Car Park	54.475658	-5.442473	11
Portavogie Warnocks Road	54.468663	-5.4370496	2
Portavogie North Car Park	54.461105	-5.4395333	5
Portavogie Harbour	54.456874	-5.4360303	5
Portavogie The Quays	54.455969	-5.4386187	2
Ratallagh	54.445122	-5.4532045	12
Cloughey Beach	54.436368	-5.4712826	24
Cloughey Beach South	54.423487	-5.4773015	1
Kearney Village 2	54.393152	-5.4591322	0
Kearney Village 1	54.387986	-5.4599932	6
Kearney Beach North	54.385243	-5.4739273	15
Kearney Beach South	54.370334	-5.491206	0
Templecowey	54.350241	-5.5004919	2
Ballyquinton 2	54.338746	-5.5018008	2
Ballyquinton 1	54.33667	-5.5008137	0
Total			**550**

APPENDIX 6

Table S6.1: Waterbird counts made during through-the-tide-counts (TTTCs) between November 2020 and March 2021.

Site	Species	Number of counts	Mean Count	Lower 95% Confidence Interval	Upper 95% Confidence Interval
Castlerocklands	Bar-tailed Godwit	5	1.40	0.29	2.51
	Black-headed Gull	36	35.19	26.94	43.45
	Black-throated Diver	1	1.00		
	Black Guillemot	36	6.19	4.86	7.53
	Brent Goose	28	12.36	9.74	14.97
	Common Gull	36	19.72	13.06	26.38
	Common Scoter	9	1.11	0.85	1.37
	Cormorant	34	4.50	1.19	7.81
	Curlew	15	3.00	0.85	5.15
	Dunlin	11	29.73	11.21	48.24
	Eider	36	151.56	27.13	275.99
	Goldeneye	20	1.30	0.96	1.64
	Great Black-backed Gull	34	2.09	1.66	2.52
	Great Crested Grebe	36	6.08	4.01	8.16
	Great Northern Diver	9	1.11	0.85	1.37
	Grey Heron	9	1.11	0.85	1.37
	Guillemot	7	1.00	1.00	1.00
	Herring Gull	39	54.59	43.96	65.22
	Kittiwake	4	1.50	-0.09	3.09
	Knot	2	1.50	-4.85	7.85
	Lesser Black-backed Gull	5	2.40	-0.17	4.97
	Long-tailed Duck	5	2.80	1.44	4.16
	Mallard	3	1.67	0.23	3.10
	Mute Swan	2	2.00	2.00	2.00
	Oystercatcher	19	29.47	22.66	36.29
	Razorbill	16	1.25	1.01	1.49
	Red-breasted Merganser	34	9.44	8.20	10.68
	Red-throated Diver	30	2.23	1.58	2.89
	Redshank	15	5.33	3.35	7.32
	Ringed Plover	13	19.62	10.81	28.42
	Scaup	1	3.00		
	Shag	36	5.94	4.49	7.40
	Shelduck	5	1.60	0.92	2.28
	Turnstone	14	21.50	15.37	27.63
Fisherman's Quay	Bar-tailed Godwit	2	2.50	-16.56	21.56
	Black-tailed Godwit	3	4.67	-3.32	12.65
	Black Guillemot	27	3.30	2.71	3.89
	Brent Goose	13	9.54	6.84	12.24

	Common Scoter	4	1.50	-0.09	3.09
	Cormorant	30	9.47	7.04	11.90
	Curlew	10	2.20	1.39	3.01
	Dunlin	29	24.52	14.96	34.08
	Eider	30	108.97	26.49	191.45
	Gannet	1	1.00		
	Goldeneye	3	1.00	1.00	1.00
	Great Crested Grebe	15	1.80	1.17	2.43
	Great Northern Diver	14	1.14	0.93	1.35
	Grey Heron	8	1.38	0.94	1.81
	Guillemot	1	1.00		
	Long-tailed Duck	3	1.33	-0.10	2.77
	Mediterranean Gull	1	1.00		
	Oystercatcher	27	27.15	20.52	33.77
	Razorbill	14	1.64	1.21	2.07
	Red-breasted Merganser	28	7.36	4.22	10.50
	Red-throated Diver	23	1.65	1.17	2.13
	Redshank	28	27.21	9.65	44.78
	Ringed Plover	23	18.13	13.07	23.19
	Shag	30	12.77	10.60	14.93
	Shelduck	11	2.27	1.67	2.88
	Turnstone	30	38.07	20.83	55.31
Hazelbank Park	Bar-tailed Godwit	10	2.70	1.19	4.21
	Black-headed Gull	26	26.81	12.51	41.10
	Black-tailed Godwit	5	10.20	1.40	19.00
	Black-throated Diver	4	1.75	0.23	3.27
	Black Guillemot	35	9.74	7.66	11.82
	Brent Goose	24	12.83	9.18	16.48
	Common Gull	15	4.07	2.79	5.35
	Common Scoter	14	3.71	1.88	5.55
	Cormorant	34	10.21	6.27	14.14
	Curlew	15	2.00	1.14	2.86
	Dunlin	8	11.75	2.76	20.74
	Eider	36	1192.06	835.55	1548.56
	Goldeneye	27	1.96	1.50	2.42
	Great Black-backed Gull	22	2.36	1.74	2.98
	Great Crested Grebe	36	61.03	45.06	77.00
	Great Northern Diver	11	2.27	1.11	3.44
	Greenshank	1	2.00		
	Grey Heron	3	1.33	-0.10	2.77
	Greylag Goose	1	1.00		
	Guillemot	5	2.00	0.24	3.76
	Herring Gull	27	27.15	21.77	32.52
	Knot	1	1.00		
	Lesser Black-backed Gull	2	1.50	-4.85	7.85
	Little Egret	4	1.50	-0.09	3.09

	Long-tailed Duck	3	3.67	2.23	5.10
	Mallard	1	2.00		
	Oystercatcher	29	10.93	7.09	14.77
	Razorbill	15	2.67	1.15	4.19
	Red-breasted Merganser	32	6.81	5.25	8.37
	Red-throated Diver	28	2.36	1.15	3.57
	Redshank	22	4.64	3.35	5.92
	Ringed Plover	6	2.17	1.13	3.20
	Scaup	12	6.50	2.59	10.41
	Shag	35	2.80	2.19	3.41
	Shelduck	6	1.67	0.40	2.94
	Slavonian Grebe	2	1.00	1.00	1.00
	Turnstone	21	6.67	4.53	8.80
	Wigeon	4	1.75	0.95	2.55
Loughshore Park	Bar-tailed Godwit	6	2.33	0.27	4.40
	Black-headed Gull	35	88.71	72.91	104.52
	Black-tailed Godwit	5	13.60	-19.31	46.51
	Black-throated Diver	1	1.00		
	Black Guillemot	35	8.43	5.49	11.37
	Brent Goose	31	19.13	11.72	26.54
	Common Gull	35	16.09	3.74	28.43
	Common Scoter	19	3.63	2.45	4.81
	Cormorant	34	7.18	2.82	11.54
	Curlew	17	3.00	1.74	4.26
	Dunlin	15	126.87	52.88	200.86
	Eider	36	668.69	381.91	955.48
	Gadwall	1	1.00		
	Goldeneye	23	2.17	1.51	2.83
	Great Black-backed Gull	32	3.22	2.60	3.84
	Great Crested Grebe	36	30.94	20.46	41.43
	Great Northern Diver	4	1.00	1.00	1.00
	Greenshank	1	1.00		
	Grey Heron	14	1.57	1.08	2.06
	Greylag Goose	1	1.00		
	Guillemot	10	1.20	0.90	1.50
	Herring Gull	37	76.78	60.30	93.27
	Kittiwake	1	14.00		
	Knot	2	17.50	-166.74	201.74
	Lesser Black-backed Gull	4	1.25	0.45	2.05
	Little Egret	3	2.33	-1.46	6.13
	Mallard	3	2.67	-0.20	5.54
	Mediterranean Gull	17	1.18	0.97	1.38
	Oystercatcher	22	31.00	19.06	42.94
	Razorbill	16	1.63	0.90	2.35
	Red-breasted Merganser	35	8.09	6.05	10.12
	Red-throated Diver	27	1.78	1.28	2.27

	Redshank	20	8.75	6.08	11.42
	Ringed Plover	9	10.78	2.51	19.05
	Scaup	1	4.00		
	Shag	35	3.91	2.89	4.94
	Shelduck	2	2.00	2.00	2.00
	Slavonian Grebe	5	1.00	1.00	1.00
	Snipe	2	1.00	1.00	1.00
	Turnstone	22	21.27	15.21	27.34
	Whimbrel	1	1.00		
	White-fronted Goose	1	1.00		

Table S6.2: Estimated marginal mean counts of Eider, adjusted for the population level across all sites surveyed, as predicted using the GLMM described in section 2.5.4.

Month and tidal state	Predicted value	Standard Error	95% Confidence Interval (low)	95% Confidence Interval (high)
November				
High	445.42	0.55	150.97	1314.18
Intermediate High	562.13	0.52	200.95	1572.50
Intermediate Low	718.22	0.53	253.21	2037.22
Low	985.83	0.55	334.63	2904.30
December				
High	283.31	0.55	96.56	831.24
Intermediate High	357.54	0.53	125.88	1015.52
Intermediate Low	456.82	0.53	162.58	1283.61
Low	627.04	0.54	215.48	1824.65
January				
High	214.48	0.52	77.12	596.51
Intermediate High	270.68	0.52	97.41	752.15
Intermediate Low	345.84	0.52	125.88	950.13
Low	474.70	0.53	167.38	1346.31
February				
High	99.08	0.54	34.63	283.48
Intermediate High	125.04	0.51	45.80	341.40
Intermediate Low	159.76	0.51	58.39	437.14
Low	219.29	0.54	76.38	629.58
March				
High	32.86	0.54	11.38	94.82
Intermediate High	41.47	0.53	14.80	116.19
Intermediate Low	52.98	0.52	19.17	146.43
Low	72.72	0.54	25.23	209.62

Project partners

AGRI-FOOD & BIOSCIENCES INSTITUTE · Ulster University · NatureScot · SAMS Scottish Association for Marine Science · UCC University College Cork, Ireland · Scottish Government marine scotland · BirdWatch Ireland

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For more information on the MarPAMM project please visit the project website:

www.mpa-management.eu

MarPAMM Marine Protected Area Management and Monitoring