BTO RESEARCH REPORT 759

Analysis of waterbird population trends for Northern Ireland's sea loughs: assessing the potential impacts of aquaculture and disturbance.

Part 3 – Larne Lough, Killough Harbour and Dundrum Inner Bay

Booth Jones, K., O'Connell, P., Calbrade, N. & Austin, G.

BTO Birds Science People

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Authors

Katherine Booth Jones, Peadar O'Connell, Neil Calbrade and Graham Austin

Report of work carried out by the British Trust for Ornithology
on behalf of NIEA and the DAERA Marine and Fisheries Division

28th March 2023

British Trust for Ornithology

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CONTENTS

Page No.

Page No.

Page No.

LIST OF TABLES

Page No.

LIST OF FIGURES

Page No.

EXECUTIVE SUMMARY

1. Larne Lough, Killough Harbour and Dundrum Inner Bay are sea loughs on the east coast of Northern Ireland. They hold Special Protection Area (SPA) and Area of Special Scientific Interest (ASSI) designations for their importance to wetland biodiversity and host nationally and internationally important populations of waterbirds. In particular, Larne Lough and Killough Harbour SPAs are internationally important for Light-bellied Brent Goose, and the Larne Lough, Killough Harbour and Dundrum Inner Bay (Murlough) ASSIs are important for a suite of other wintering waterbirds.

2. In addition to their importance to wintering waterbirds, Northern Ireland's coastal loughs and bays are also important sites in terms of human use. Recreational activities such as boating, wildfowling and dog-walking do cause disturbance, particularly to winter birds feeding or roosting, the severity of which is often location-specific. Some activities may also modify the habitat or ecosystem, such as shellfish or seaweed harvesting and gravel extraction. In recent decades an increasingly commercially important use of sheltered sea loughs and bays is aquaculture, the impacts of which on important populations of wintering waterbirds has not been well documented in Northern Ireland.

3. The Wetland Bird Survey (WeBS) is a long-running survey recording numbers of all waterbird species on wetland sites throughout the UK. WeBS 'Core Counts' record waterbird numbers monthly throughout the year at high tide. For large sites, such as estuaries and sea loughs, sites may be divided into sectors, across which within-site trends can be assessed. This study examined wintering waterbird trends for the seven sectors that make up Dundrum Inner Bay, and two in Larne Lough. There were no sub-divisions of Killough Harbour due to its small size, but WeBS trends were examined at the site-level.

4. This study is Part 3 of a series of sector-level analysis reports on sea-lough WeBS data in Northern Ireland, previously documenting Carlingford Lough, Strangford Lough, Belfast Lough, and Lough Foyle, which were chosen as sites that host aquaculture activities. These reports aim to improve understanding of the fluctuations in numbers of waterbirds within the sites and inform the consenting of operations and assessment of development plans on these protected areas. Part 3 (this report) aims to provide an initial insight into the potential impact of intertidal oyster aquaculture on trends in Larne Lough, Killough Harbour and Dundrum Inner Bay.

5. Due to the length of time each site had been surveyed for, analyses for each site covered slightly different time periods. Smoothed population trends were generated using data from 2001/02 – 2016/17 for Dundrum Inner Bay, 2004/05 - 2019/20 for Larne Lough and from 2000/01 - 2015/16 to Killough Harbour, for a suite of species that matched Parts 1 and 2 of this report series, including species for which the SPAs and ASSIs were nationally and internationally important for. For most species there were sufficient numbers recorded on at least some sectors to assess sector trends, relative importance in relation to the loughs' populations and whether the proportion of the entire loughs' populations supported by each sector had increased or decreased significantly.

6. To examine the potential impact of intertidal oyster cultivation on waterbird populations in the featured sites, waterbird population trends in sectors that overlapped with active licensed oyster trestle areas were examined. Potential changes in population trends over time in relation to the presence of these areas and divergence from the trend of the overall lough were used to investigate potential impact of aquaculture on bird trends in the relevant sectors.

7. The relative importance in the site-level context of different sectors was not relevant for Killough Harbour or Larne Lough, which only consisted of a single and two sectors respectively. However, for Dundrum Inner Bay, areas in the north and south arms of the lagoon, including Green Island, Ardilea and Blackstaff and South Inner Bay, which are characterised by sand and mud flats covered only at high tide, were generally the most important sectors of the site. Given that the count data analysed here are recorded at high tide, these sectors are likely important to birds for roosting between low tides.

8. For the 15 species for which sector-level trends in Dundrum Inner Bay were generated, these appeared to be more commonly in decline than trends for Larne Lough or Killough Harbour. While Killough Harbour consisted of a single sector, the nine species for which trends could be created were largely increasing or stable, with only Golden Plover in steep decline. Overall, it appeared that conditions in Killough Harbour were favourable relative to other sites, with trends generally more positive than the regional trend during this time period. Larne Lough in contrast was more mixed, with some species groups declining (diving ducks and grebes, waders) and some increasing or remaining largely stable (geese, seaducks, dabbling ducks). However, with the exception of diving ducks and grebes which appeared to be buffered slightly from regional declines, trends across groups tended to follow the regional trend.

9. In the sites covered by this report, only three intertidal oyster farms were recorded as active in the latest available data (2018/19). Because Killough Harbour did not have sector divisions in which to compare trends between sectors with and without active aquaculture, and both sector divisions in Larne Lough were spanned by the same active aquaculture area, sub-site level patterns in trends could not be related to the presence of aquaculture for these sites. While there did not appear to be a signal in the high tide WeBS trends of the influence of oyster aquaculture on wintering waterbird abundance in Dundrum Inner Bay, this would be better assessed using low tide data, or a more bespoke study of abundance throughout the tidal cycle, focused on the active area itself.

10. To build on the findings of this report we recommend continuing to develop more targeted field-based studies to assess the potential impact of disturbance associated with aquaculture activity on waterbirds, including data on specific bird behaviours, building working relationships with aquaculture businesses in areas of ornithological importance to better understand husbandry activity and promote environmental awareness, and to continue to upskill and grow the volunteer surveyor base in Northern Ireland to ensure long-term, high quality low tide data collection at sites of national and international significance to wintering waterbirds.

1. INTRODUCTION

1.1. Background

Larne Lough and Killough Bay hold Special Protection Area (SPA) and Ramsar Convention designations for their importance to wetland biodiversity, and in addition to Murlough (Dundrum) Bay, also contain Areas of Special Scientific Interest (ASSIs), protected areas that aim to preserve the best of Northern Ireland's wildlife and geology, and are safeguarded under The Environment (Northern Ireland) Order 2002 (Part IV). Larne Lough hosts a busy port and a power station to the north at the mouth of the lough leading to the North Channel, the surrounding land further south is primarily agricultural. It has a single SPA designation that stretches right around the lough. In winter it is an internationally important area for Light-bellied Brent Geese (*Branta bernicla hrota*) which roost and feed here. It is also nationally important for wintering populations of Goldeneye (*Bucephala clangula*), Great Crested Grebe (*Podiceps cristatus*), Red-breasted Merganser (*Mergus serrator*), Shelduck (*Tadorna tadorna*) and Redshank (*Tringa totanus*). Killough Bay is a protected bay adjacent to the small town of Killough. It hosts a single SPA which consists of inter-tidal habitat with important mudflat, sandy beach and rocky shore habitats. It covers Killough Harbour and Coney Island Bay. In winter it is internationally important for Light-bellied Brent Geese. Murlough Bay is part of an ASSI that stretches along the coast south to Newcastle and north beyond Ballykinler and includes Dundrum Inner Bay, a tidal estuary lagoon. It hosts large numbers of wintering waterbirds which feed and roost within and adjacent to the site. Upon designation the site was internationally important for Light-bellied Brent Goose and nationally important for Red-breasted Merganser and Common Scoter (*Melanitta nigra*), which were located on the seaward side of the ASSI.

In addition to their importance to wintering waterbirds, Northern Ireland's coastal loughs and bays are also important sites in terms of human use. Recreational activities such as boating, wildfowling and dog-walking do cause disturbance, particularly to winter birds feeding or roosting, the severity of which is often site-specific. Some activities may also modify the habitat or ecosystem, such as shellfish or seaweed harvesting and gravel extraction. In recent decades an increasingly commercially important use of sheltered sea loughs and bays is aquaculture, the impacts of which on important populations of wintering waterbirds has not been well documented in Northern Ireland.

Aquaculture is a growing industry in Northern Ireland; in 2018 the two key shellfish species (Blue Mussel *Mytilus edulis*, and Pacific Oysters *Crassostrea gigas*) were valued at over £4 million (DAERA, 2020). Sea loughs in Northern Ireland host aquaculture activities as do a number of enclosed bays, cultivating predominantly mussels, but also oysters, scallops and clams. Each of the three sites in this report contains licenced blocks for shellfish aquaculture, a mixture of bottom-cultured mussels and oysters, and oyster trestles (see Table 2). The key responsibility of the Department of Agriculture, Environment and Rural Affairs' (DAERA's) Marine and Fisheries Division is to ensure the protection of Northern Ireland's marine and coastal areas while promoting their sustainable use in industries such as shellfish aquaculture.

The BTO have been requested to provide DAERA with an analysis of sector-level WeBS data for sea loughs in Northern Ireland. Work on this began in 2019 with Carlingford and Strangford Loughs (Booth Jones et al., 2019, Part 1), for Belfast Lough and Lough Foyle (Booth Jones et al., 2022, Part 2) and continues here for Larne Lough, Killough Harbour and Dundrum Inner Bay (Part 3). The aim of these reports is to reveal how key species of waterbirds in the largest sea loughs and important enclosed bays are distributed within the SPAs, or in the case of Dundrum Inner Bay an ASSI, and to identity whether the populations are increasing or decreasing in the sectors relative to the site as a whole. The methodology for this follows similar reports for Natural England for estuaries in Britain (Austin et al., 2008; Ross-Smith et al., 2013, 2015). Across the report series, we also examine the

evidence for impacts of aquaculture in these sites by comparing waterbird population trends in sectors with aquaculture to trends at the site level where possible. This will enable DAERA to better assess the potential impact of existing and future aquaculture (and other developments) on SPA features and other protected populations.

1.2. Objectives

The aim of this project is to produce a sector-level analysis of WeBS data in Northern Ireland, for Larne Lough, Dundrum Inner Bay and Killough Harbour. This will improve understanding of the fluctuations in numbers of waterbirds within the sites and inform the consenting of operations and assessment of development plans on designated sites. The four main objectives of this work are to:

- Identify the abundance trends for the short (5 years), medium (10 years) and long (15 years) term for up to 36 waterbird species (based on species already analysed as in Parts 1 and 2 of this reporting series), including the internationally important Light-bellied Brent Goose populations that are features of the Larne Lough and Killough Harbour SPAs (Table 1). Trends will be calculated from high-tide counts. Sector-level trends will be compared with trends for the respective sites as a whole where possible (Larne Lough and Dundrum Inner Bay). Where possible the work will identify those WeBS sectors where large numbers of species are declining or increasing contrary to or more rapidly than on the site as a whole.
- Identify WeBS sectors that support important proportions of the species on the site.
- Where possible, identify potential drivers of change in the sectors where changes in waterbirds population are observed, such as changes in food supply/suitable roosting/feeding habitats.
- Identify sectors where changes in waterbird numbers overlap with shellfish aquaculture farms to infer whether there might be short, medium- or long-term impacts of aquaculture disturbance on waterbird trends.

Table 1 The sector-level analysis will be carried out, where data allow, on a species list that matches that of Part 1 of this report, based upon the internationally or nationally important waterbird species that are features of the SPAs covered in Parts 1 and 2 of this reporting series (Strangford Lough, Carlingford Lough, Belfast Lough and Lough Foyle), plus any additional species that are features of Larne Lough, Killough Harbour and Dundrum Inner Bay, totalling a potential 36 species. Blue ticks = internationally important populations, green ticks = populations important in all-Ireland context.

	Larne Lough			Killough Harbour			Dundrum Inner Bay	
Species	**SPA***	**ASSI***	**Number of sectors for which Core sector-level analysis is available**	**SPA***	**ASSI***	**Number of sectors for which Core sector-level analysis is available**	**ASSI** **	**Number of sectors for which Core sector-level analysis is available**
Mute Swan			0			0 (site not sub-divided)	✓	1
Whooper Swan			0			"		0
Bewick's Swan			0			"		0
Greylag Goose			1			"		0
Light-bellied Brent Goose	✓	✓	2	✓	✓	"	✓	1
Shelduck		✓	1			"	✓	2
Wigeon			2			"		2
Teal			2			"		0
Mallard			2			"		2
Pintail			0			"		0
Pochard			0			"		0
Eider			1			"		0
Red-breasted Merganser		✓	2			"	✓	0
Scaup			0			"		0
Goldeneye		✓	1			"		0
Common Scoter			0			"	✓	0
Great Crested Grebe		✓	1			"	✓	0
Coot			0			"		0
Cormorant			1			"		2
Oystercatcher			0			"	✓	5
Ringed Plover			0			"		1
Golden Plover			0			"		1
Purple Sandpiper			0			"		0

	Larne Lough			Killough Harbour			Dundrum Inner Bay	
Species	**SPA***	**ASSI***	**Number of sectors for which Core sector-level analysis is available**	**SPA***	**ASSI***	**Number of sectors for which Core sector-level analysis is available**	**ASSI** **	**Number of sectors for which Core sector-level analysis is available**
Grey Plover			0			"		0
Lapwing			2			"	✓	4
Dunlin			1			"	✓	5
Sanderling			0			"		0
Knot			0			"	✓	2
Black-tailed Godwit			0			"		0
Bar-tailed Godwit			0			"		0
Turnstone			1			"		1
Curlew			2			"		4
Greenshank			0			"	✓	0
Redshank		✓	2			"	✓	5
Slavonian Grebe			0			"		0
Red-throated Diver			0			"		0

* 'All ornithological SPA features_finalised_Oct 2014.xslx' obtained from NIEA, 10th February 2020.

** Based on Murlough ASSI.

2. METHODOLOGY

2.1. Waterbird Data

WeBS is responsible for a number of monthly or periodic monitoring schemes including the WeBS Core Counts, the WeBS LowTide Counts and the Non-Estuarine Waterbird Survey. This report is based on data collected by the Core Count surveys.

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., 2021). 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, 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 waterbird trends on the individual sectors can inform in a biologically meaningful manner.

Two constituent and extant WeBS Core Count sectors of Larne Lough (Figures 2.1.i and 2.1.ii), one of Killough Harbour (Figures 2.1.iii & 2.1.iv) and six sectors of Dundrum Inner Bay (Figures 2.1.v & 2.1.vi) were considered in this report.

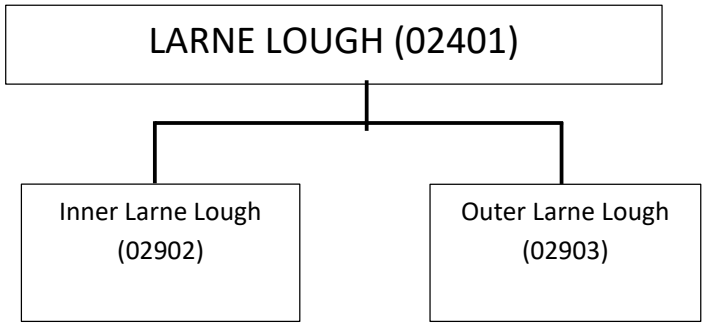

Figure 2.1i Structural hierarchy of WeBS Core Count sectors in Larne Lough.

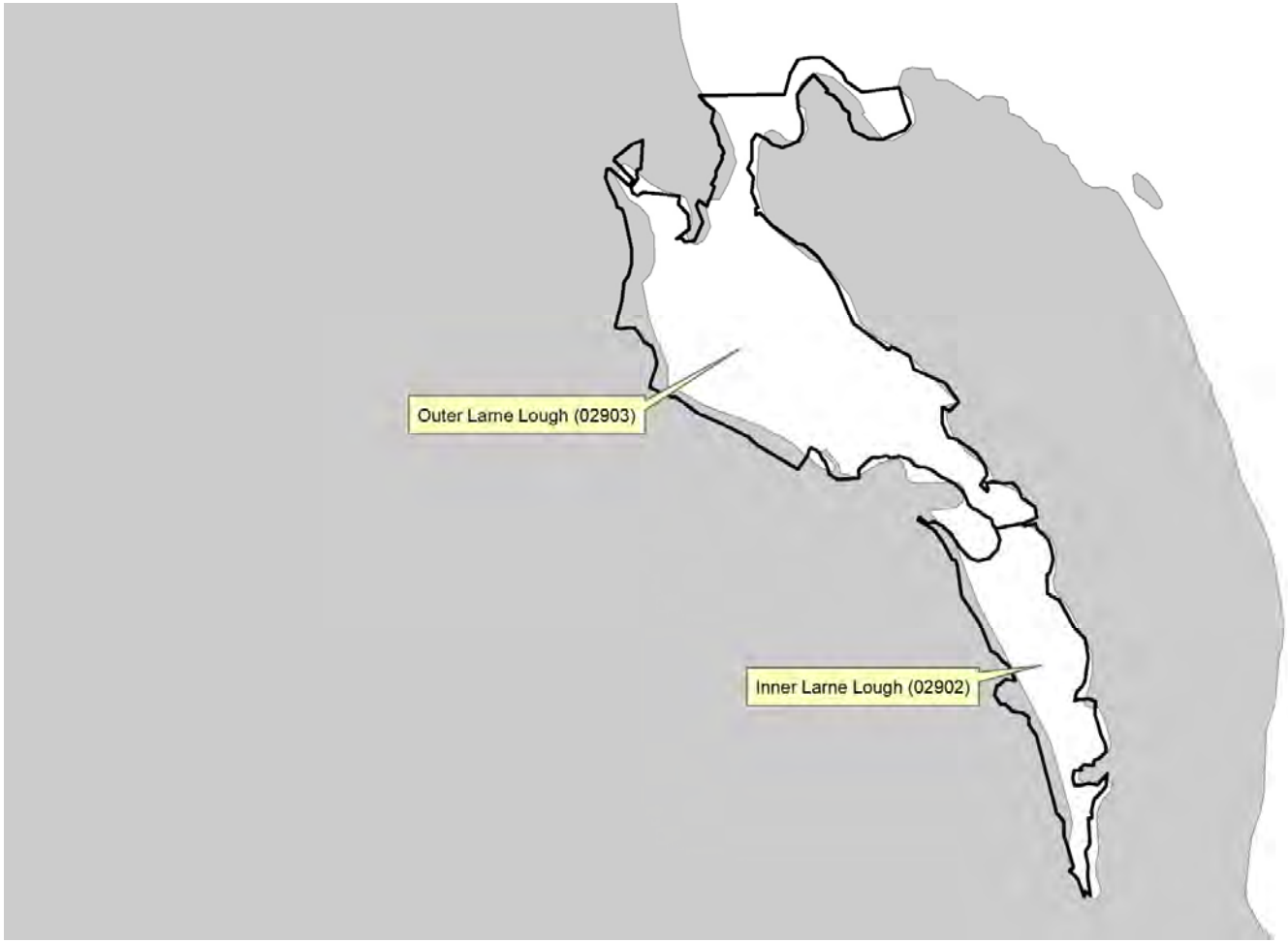

Figure 2.1.ii Locations of the Core Count sectors in Larne Lough. These WeBS sectors are the most recent subdivisions for WeBS counts in Larne Lough, and represent the finest spatial scale over which data are collected (see Figure 2.1 i).

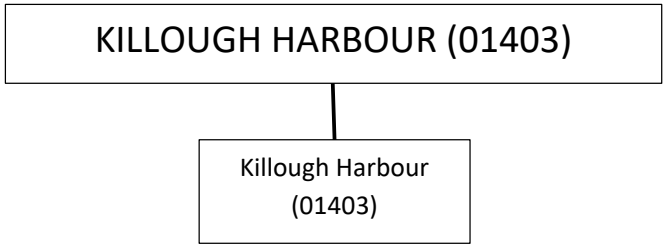

Figure 2.1.iii Structural hierarchy of WeBS Core Count sectors in Killough Harbour.

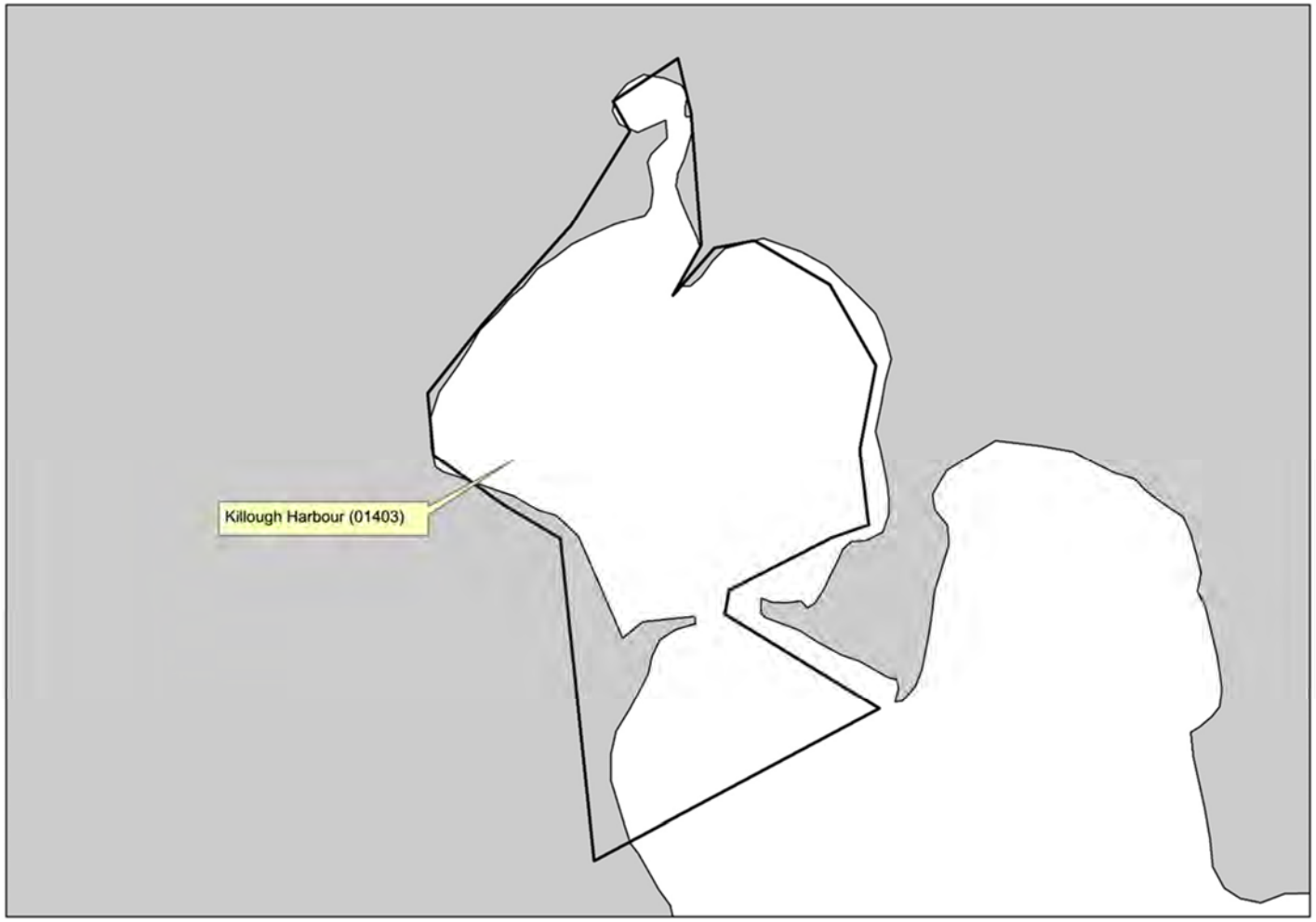

Figure 2.1.iv Location of Killough Harbour (no Core Count sector division within this site, see Figure 2.1 iii).

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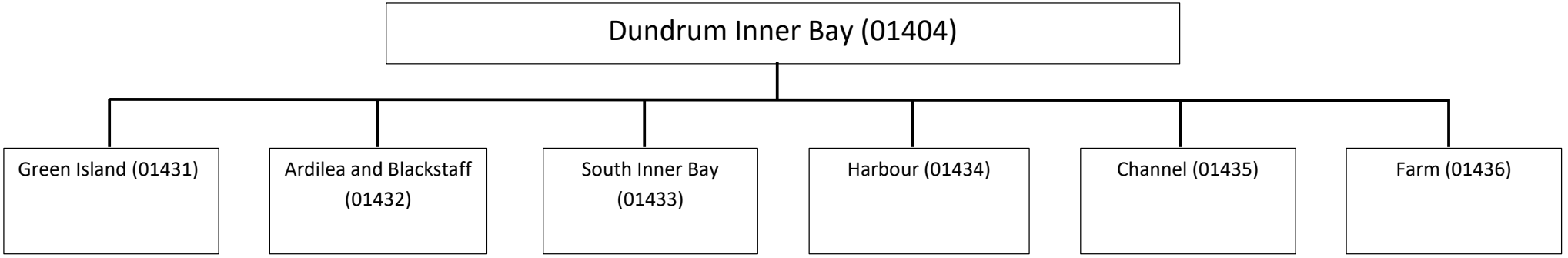

Figure 2.1.v Structural hierarchy of WeBS Core Count sectors on Dundrum Inner Bay

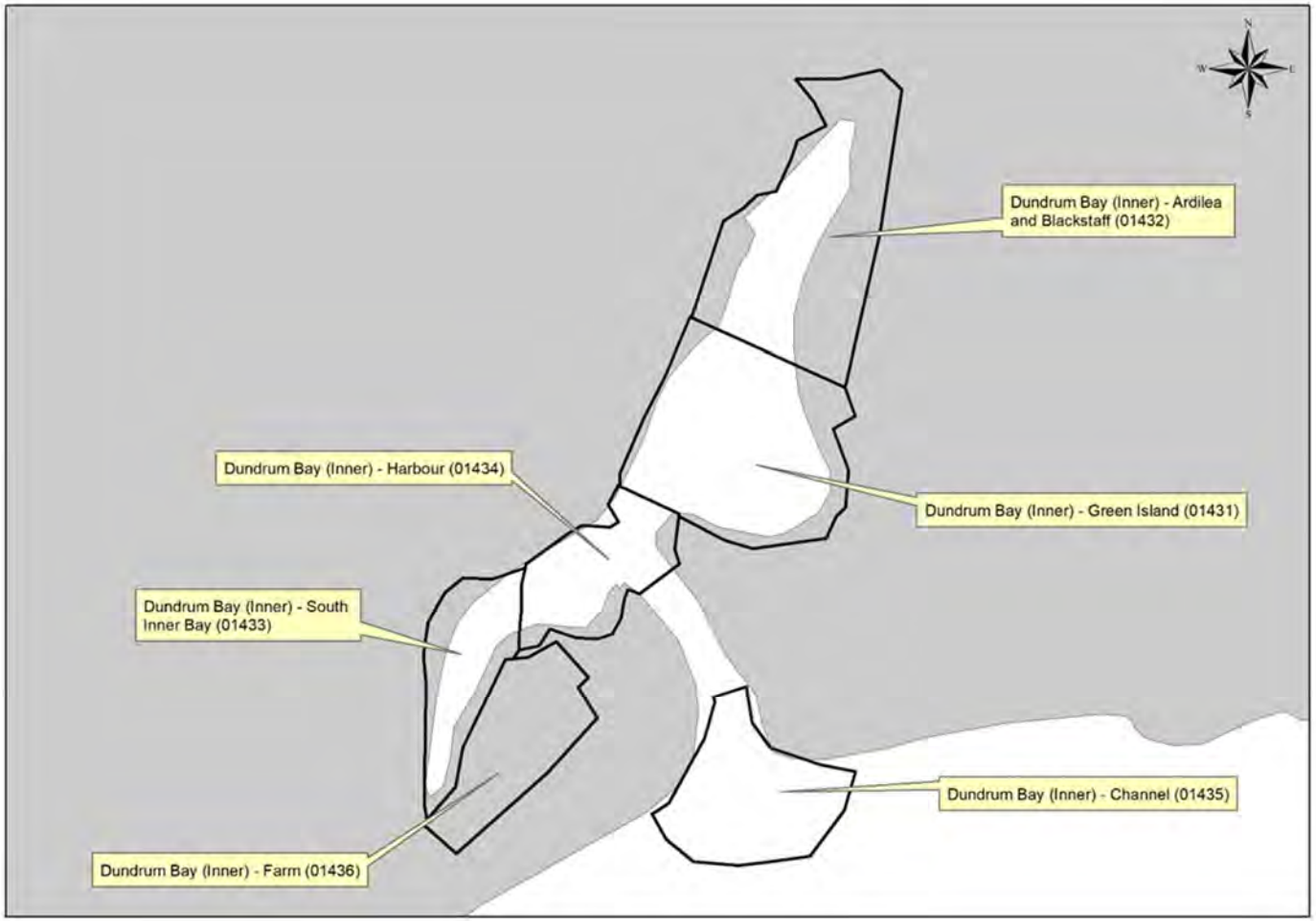

Figure 2.1 vi Locations of each Core Count (high tide) count sector in Dundrum Inner Bay. These WeBS sectors are the most recent subdivisions for WeBS counts in Dundrum Inner Bay, and represent the finest spatial scale over which data are collected (see Figure 2.1 v)

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2.1.1. Smoothed waterbird trends and percentage change

The methodology used to produce smoothed site, regional and national trends as reported by WeBS Alerts (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 1,000 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 the latest available validated WeBS data for each site (Larne Lough from 2004/05 to 2019/20, Killough Harbour from 2000/01 to 2015/16 and Dundrum Inner Bay from 2001/02 to 2016/17), following (Atkinson et al., 2000, 2006), smoothed trends were fitted using Generalized Additive Models (GAMs) for the relevant species. 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 loughs themselves, do not contribute overly to the trend. Percentage change has been calculated for short- (5 year) medium- (10 year) and long-term (15 year). 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). 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.

Trends can only be produced for species where sufficient data exist across the years being considered, and cannot be produced for species which are recorded irregularly and/or in very low numbers in any of the sites in winter (Larne Lough: Whooper Swan, Pintail, Pochard, Slavonian Grebe, Ringed Plover, Golden Plover, Grey Plover, Sanderling, Knot, Black-tailed Godwit, Bar-tailed Godwit, Greenshank; Killough Harbour: Mute Swan, Whooper Swan, Light-bellied Brent Goose, Shelduck, Mallard, Pintail, Pochard, Red-breasted Merganser, Goldeneye, Great Crested Grebe, Cormorant, Ringed Plover, Grey Plover, Knot, Black-tailed Godwit, Bar-tailed Godwit, Greenshank; Dundrum Bay: Whooper Swan, Bewick's Swan, Greylag Goose, Pintail, Pochard, Red-breasted Merganser, Goldeneye, Great Crested Grebe, Slavonian Grebe, Sanderling, Bar-tailed Godwit, Greenshank). In addition, trends are for the winter period only, and robust WeBS trends cannot be produced for species which are almost entirely recorded on passage (Greenshank). Wintering trends rely on the assumption that the number of individuals present at a site usually remains relatively stable for several weeks at a time (or longer) and hence monthly WeBS counts are representative of the wintering population. This is not the case during passage months: numbers can fluctuate on a daily basis as birds arrive and depart, so counts may vary by chance from year to year according to whether or not the count date happens to coincide with a peak in passage. In addition, passage birds

are present for a relatively short but unknown length of time, which may also vary from year to year. For both these reasons, numbers counted during passage months cannot be considered representative of the passage population in a particular year, and hence trends are not produced.

2.1.2. 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 and 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, without that sector being disproportionately important to the site-level numbers of that species, it is unlikely that the observed site trend is being driven by factors affecting 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). This is based on the winter period as routinely used for all WeBS reporting (Nov-Mar for waders and Sep-Mar for other species). Only data from months where counts consolidated across the site as a whole had been assessed as complete were used - following standard WeBS protocol 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.

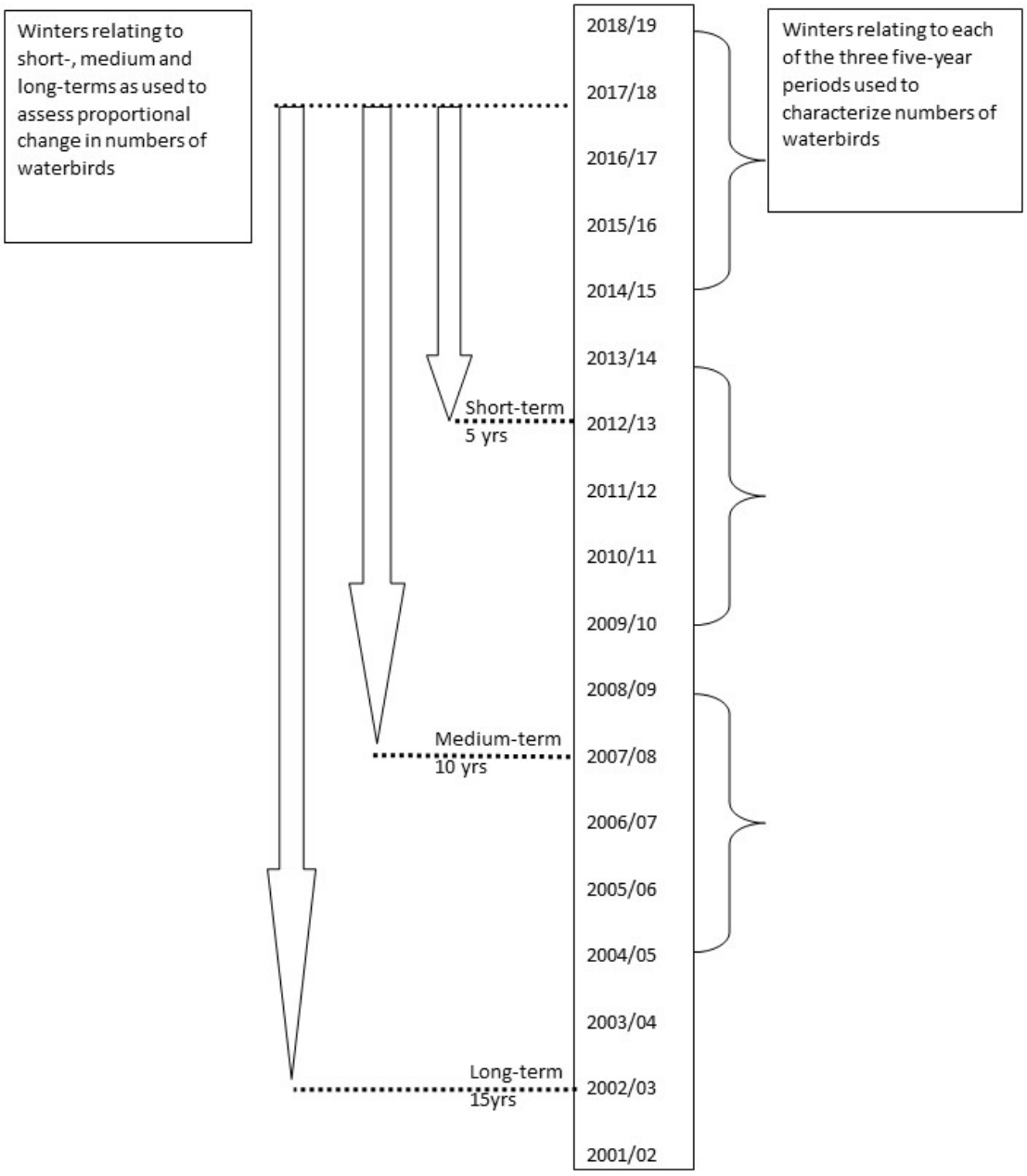


Figure 2.1.2.v An example schematic of reference winters used for reported waterbird numbers and change. In this report (as opposed to Parts 1 and 2) time frames vary per site depending on WeBS coverage. Larne Lough was covered from 2004/05 to 2019/20, Killough Harbour from 2000/01 to 2015/16 and Dundrum Inner Bay from 2001/02 – 2016/17.

2.1.3. Comparing figures and tables with previous reports

The BTO has prepared a guidance document 'Guidance to interpretation of Wetland Bird Survey within-site trends' (Austin and Ross-Smith, 2014) to aid the interpretation of WeBS sector trend analyses. This document is also provided in the supplementary material accompanying this report. These guidelines give full details of analyses included in this report and the rationale behind them as

an aid to the interpretations of numbers and trends on WeBS count sectors. In summary these include:

- proportional change in the numbers of each species assessed over the long-, medium- and short-terms (Overview: Tables 3, 6, and 7 for underlying values see sheet 'TableOfChange' in 'Larne Lough Core Result Matrices.xls', 'Killough Harbour Result Matrices.xls' and 'Dundrum Bay Result Matrices.xls').
- underlying linear trend across the 15-winter period and the significance of this trend from zero (see sheet 'TableOfProportions' in 'Larne Lough Core Result Matrices.xls', 'Killough Harbour Result Matrices.xls' and 'Dundrum Bay Result Matrices.xls').
- means of peak counts of each species for the most recent five-winter period (Overview: Tables 4 and 8 for underlying values together with equivalent values for the previous two five-winter periods and the peak value in the most recent winter, see sheets 'TableOf5yrPeaks' in 'Larne Lough Core Result Matrices.xls', 'Killough Harbour Result Matrices.xls' and 'Dundrum Bay Result Matrices.xls').
- Peak counts of each species for the most recent winter period available (for Larne Lough: 2019/20, Killough Harbour: 2015/16 & Dundrum Bay: 2016/17) (Overview: Tables 5 and 9 for underlying values see sheet 'TableOfPeaks' in 'Larne Lough Core Result Matrices.xls', 'Killough Harbour Result Matrices.xls' and 'Dundrum Bay Result Matrices.xls').
- the proportion of species assessed as falling into each of the five categories from high decline through to high increase (mapped pie-charts: Figures 3.1.i to 3.1.iii).
- for each species for each sector, graphs depicting both annual mean and annual peak numbers together with, where there is sufficient data, the smoothed trends through each. Accompanying each of these is a graph showing the proportional contribution of each sector to the overall numbers across the whole site. The equivalent graphs are also available for the whole sites relative to Northern Ireland (supplied digitally).
- density plots for each species across all sectors which focus attention on the most important areas for each species (supplied digitally).

2.2. Relating Trends to Aquaculture Activity

Larne Lough had four licenced shellfish aquaculture sites (Table 2, Figure 2.2.i), three trestle oyster beds and one bottom-culture mussel bed. The mussel bed (L6) and two oyster trestles (L3 and L5) were found in Outer Lough Larne (02903). One of these oyster trestles (L3) extends by about 100 m into Inner Lough Larne (02902), which also coincides with another licenced area for trestle culture oysters (L1). All of these licenced sites were located near the narrowing of the lough at the mid-way point. However, of these sites, only L3 was recorded as active in the latest available data (2018/19), and therefore was the only site to be considered in the analysis. There was a single licenced area for oyster trestles in the centre of Killough Harbour (01403, Table 2, Figure 2.2.ii), which was recorded as active in 2018/19. There were two licenced areas in Inner Dundrum Bay (Table 2, Figure 2.2.iii), one for oyster trestles in Green Island (01431), overlapping slightly into Harbour (01434), and a bottom culture mussel bed in Harbour (01434). Only the oyster trestle, DB1, was active in 2018/19, and therefore the mussel bed was not included in the analysis. To provide an initial indication of whether these licensed areas were influencing wintering waterbirds in their respective locations, the trends of sectors overlapping the licensed areas were investigated in relation to the overall site and regional trends.

However, there are a few important caveats to consider when assessing potential impacts of licensed aquaculture in this method. Firstly, no information was available on the length of time licensed areas may have been worked for, and it is possible that some were never active during the period of assessment. It is also important to note that the aquaculture polygons shown in Figures 2.2.i, ii and iii represent the total licenced area of each operator, which is not necessarily concurrent with the total active area, nor an indicator of the yield or activity of the area. Husbandry activity, such as thinning or predator control, is not measured (NIEA staff, *pers. comm.*) and therefore the quantity of disturbance potentially caused by shellfish aquaculture in these sites can only be estimated by examining yield per area (tonnage) per year as a proxy for activity, as in Parts 1 and 2 of this report series . However, tonnage data were not available for the sites covered by this this report (Part 3), and therefore this context was not incorporated in the interpretation of the results.

Table 2 Active oyster trestle licenced areas in Larne Lough, Killough Harbour and Inner Dundrum Bay and the WeBS sectors they overlap with.

Core Count Sector	Overlapping aquaculture licence areas
Larne Lough	
Outer Larne Lough (02903)	L3
Inner Larne Lough (02902)	L3
Killough Harbour	
Killough Harbour (01403)	K1
Dundrum Bay	
Harbour (01434)	DB1
Green Island (01431)	DB1

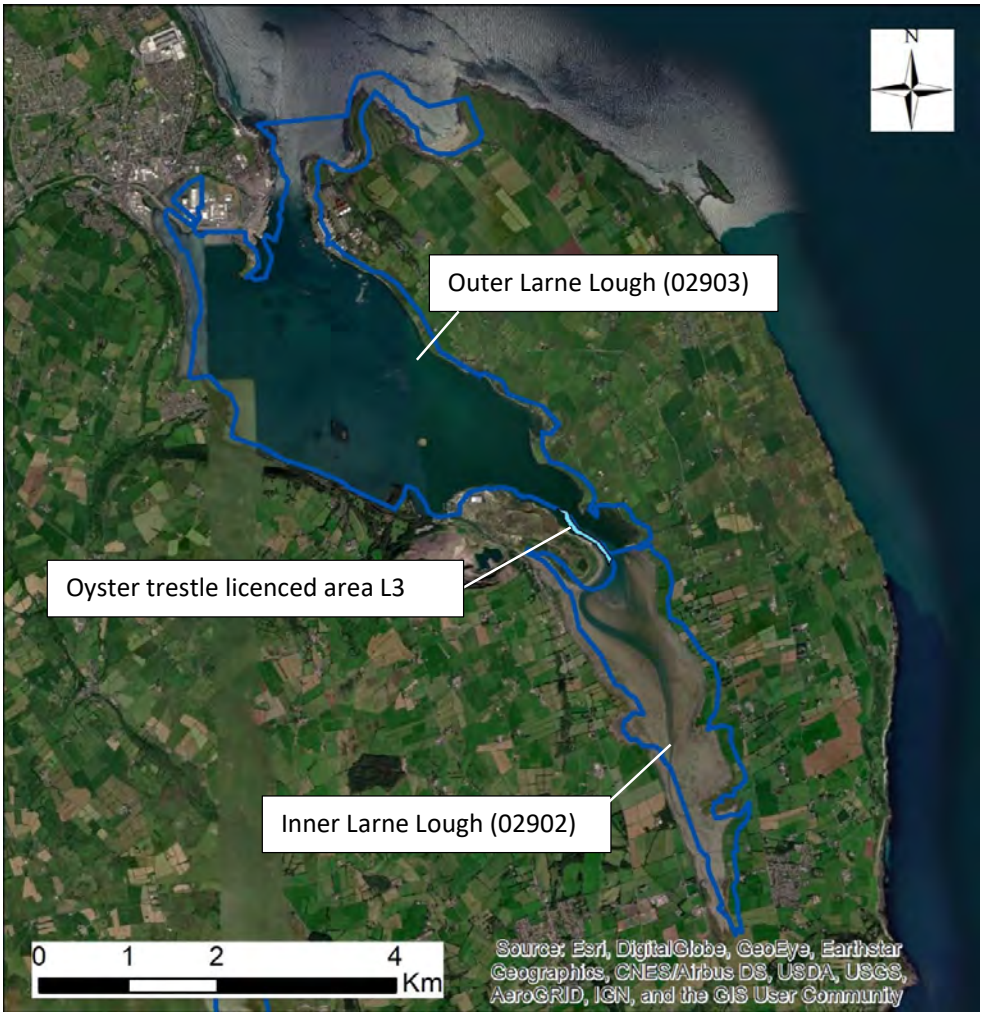


Figure 2.2.i Map of the active licenced aquaculture site (blue polygon) in Larne Lough. WeBS sectors are outlined in blue.

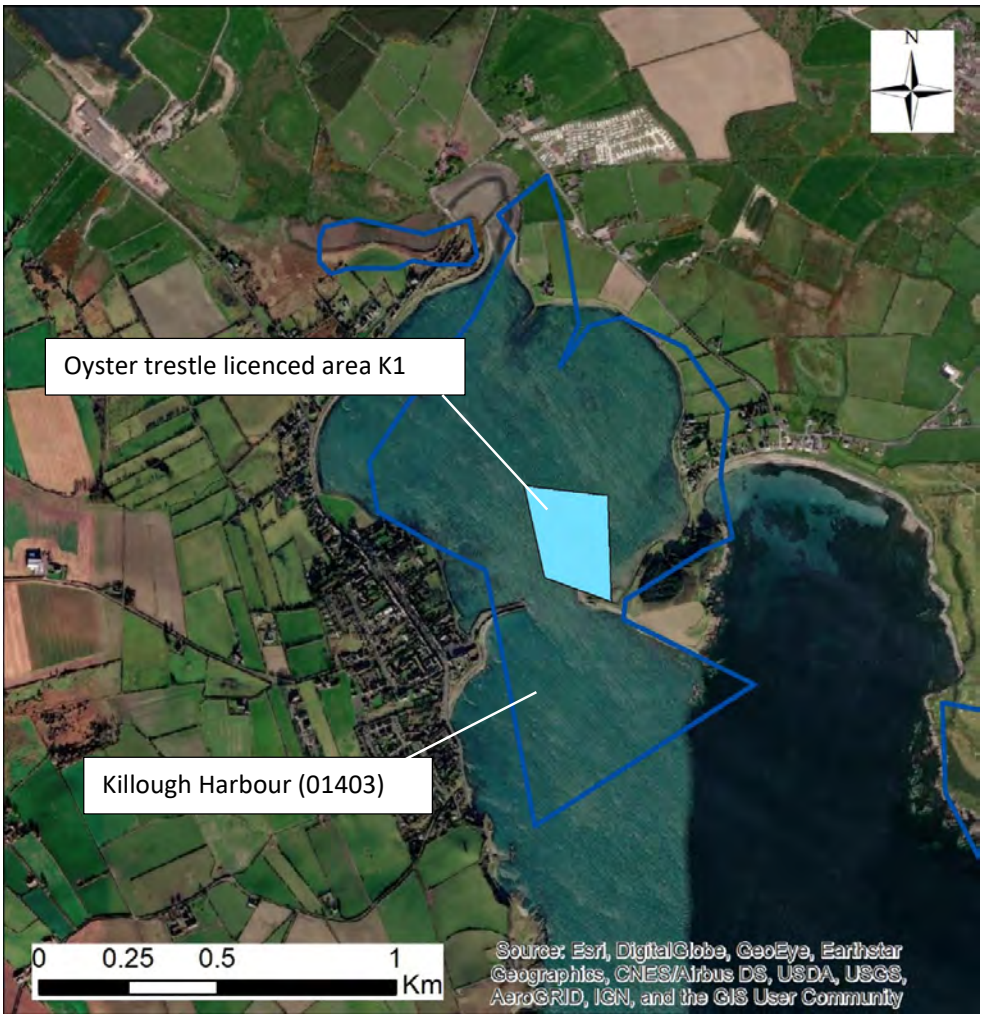


Figure 2.2.ii Map of the active licenced aquaculture site (blue polygon) in Killough Harbour. The single WeBS sector is outlined in blue.

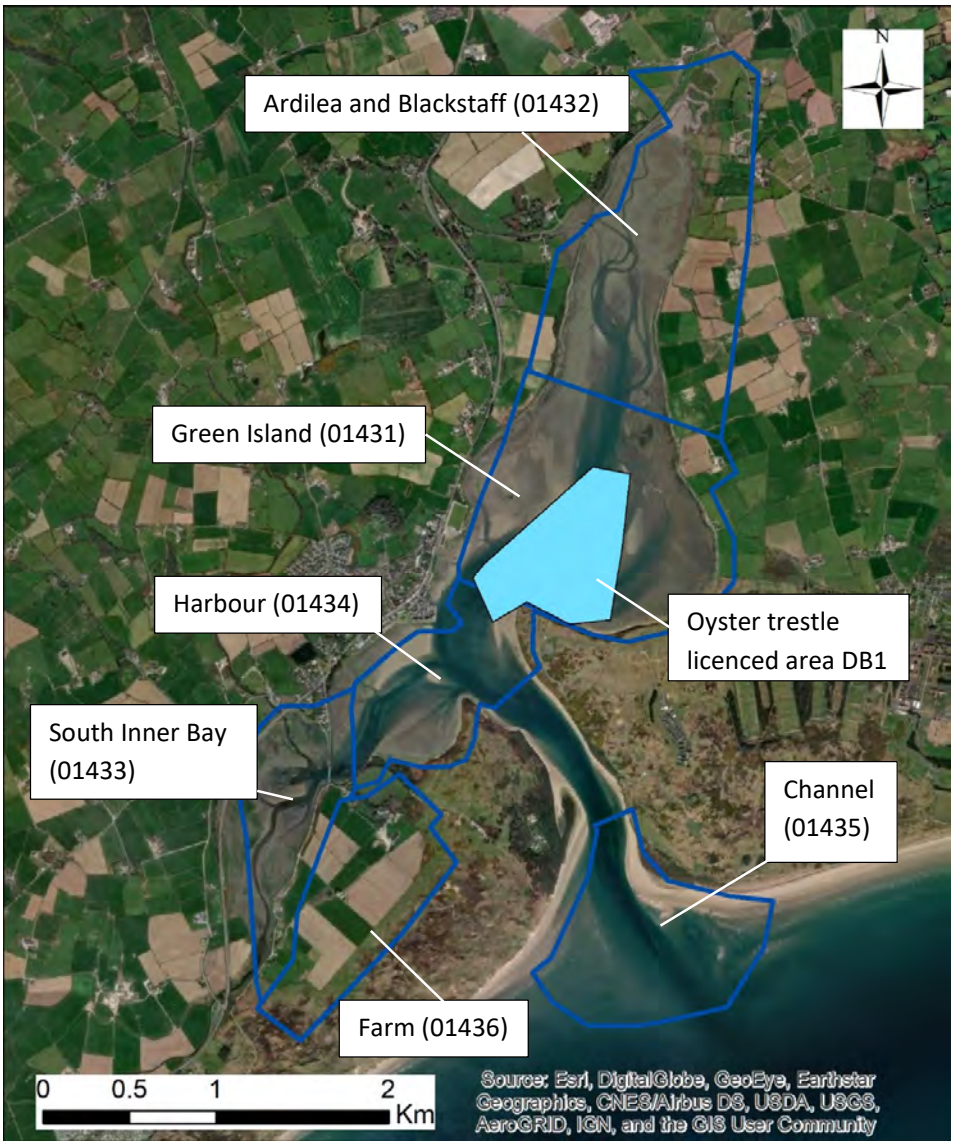


Figure 2.2.iii Map of the active licenced aquaculture site in Inner Dundrum Bay (blue polygon). WeBS sectors are outlined in blue.

3. RESULTS

3.1. Sector Trend Plots

The trends of each species on each WeBS sector are supplied digitally, together with plots comparing the count sector trends with the site trends for Larne Lough, Killough Harbour and Dundrum Bay. This series of plots puts each sector into the context of trends of each of the Loughs as a whole. Plots are grouped by sector and species presented in taxonomic order. This information is summarised below (Table 3, 6 and 7) and the underlying values representing percentage change to Larne Lough, Killough Harbour and Dundrum Bay are available in the accompanying Excel™ Workbooks ('Larne Lough Result Matrices.xls', 'Killough Harbour Core Result Matrices.xls' and 'Dundrum Bay Result Matrices.xls'). Colour coding is used to represent declines or increases; species are listed in taxonomic order and sectors have been listed to represent their geographical proximity to each other. Caution is advisable in interpreting individual cells in these tables at face value. For example, a 50% decline (shown in red) could represent a decline from 10,000 to 5,000 birds or could be a decline from 20 to 10. Consequently, it is important to be aware of the numbers of birds involved (obtainable from the plots supplied digitally or the mean of peak numbers in the Excel Worksheet). However, consistency between adjacent cells would suggest that either a group of species or a group of adjacent sectors have similar trends even when numbers of individuals involved are relatively low. Where this is the case, this may suggest that the trends represent real ecological changes. Note that trend graphs have not been presented for some species in Table 1 where trends could not be calculated due to the very low numbers or intermittent occurrence during the winter on the loughs. This information is further summarised in map format, which better facilitates a geographic interpretation of the trends (Figure 3.1.i and 3.1.ii) (see also digital supplementary materials).

The importance of individual sectors for given species can be determined by considering the five-year mean of peak counts (Table 4 and 8) and underlying values are available in the supporting material ('Larne Lough Result Matrices.xls', and 'Dundrum Bay Result Matrices.xls'); the importance of individual sectors to particular species clearly influences the level of concern regarding the characteristics of the trends. Peak counts from the most recent available winter (Larne Lough (2004/05-2019/20) and Dundrum (2001/02 – 2016/17)) are also provided in separate tables (Table 5 and 9) and supporting material). However, caution is advisable in interpreting these tables of peak counts to identify important sectors for given species rather than Table 4 and 8, as peaks from a single year are less robust against missing data or abnormal counts (e.g. caused by disturbance in an adjacent sector on the day of a count).

Table 3 Overview of population trends of waterbirds in Larne Lough based on high-tide counts over the long- (2004/05 - 2019/20) the medium- (2009/10 - 2019/20) and the short- (2014/15 - 2019/20) 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%; White – 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%; Grey – insufficient data.

Table 3 i Waterfowl

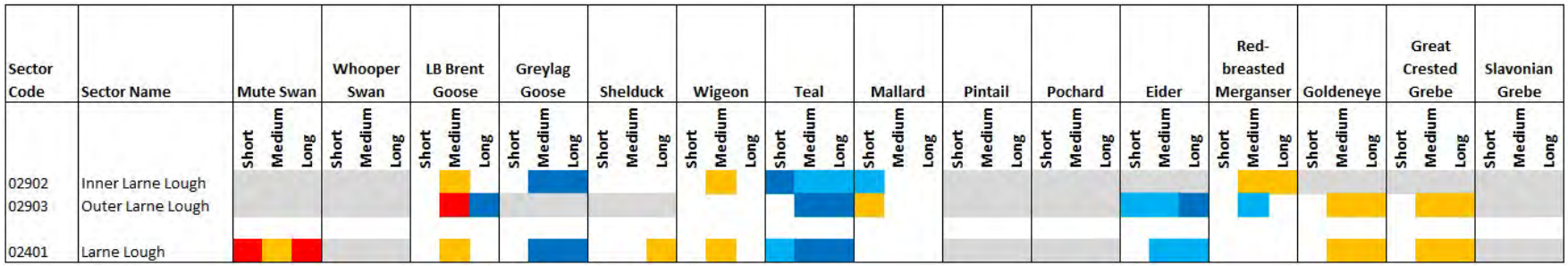


Table 3 ii Waders and Cormorant

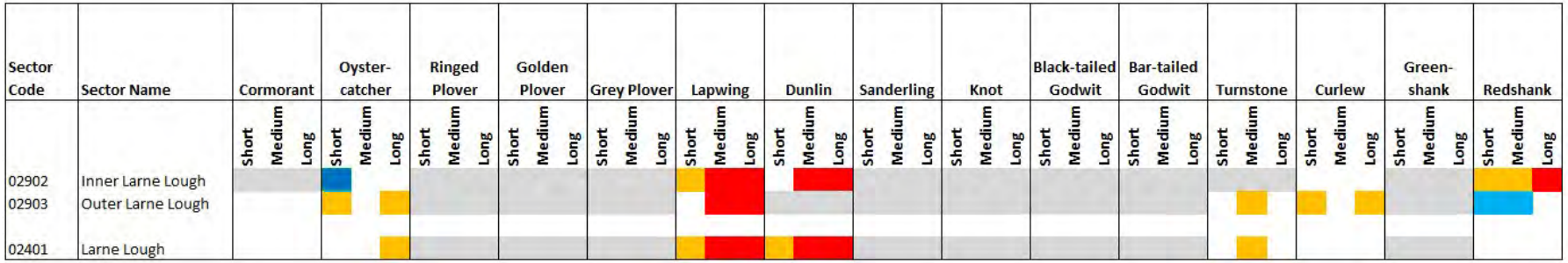


Table 4 The most important sectors for waterbirds in Larne Lough shown by colour: Dark Blue- sectors with a mean peak count over the last five winters (2014/15 – 2019/20) that is at least 20% of the total mean peak counts for Larne Lough over the same period; Light Blue – sites with a mean peak count over the last five winters that is between 10% and 20% of the total mean of peak count for Larne Lough over the same period.

Sector	Sector Name	Mute Swan	Whooper Swan	Light-bellied Brent Goose	Greylag Goose	Shelduck	Wigeon	Teal	Mallard	Pintail	Pochard	Eider	Red-breasted Merganser	Goldeneye	Great Crested Grebe	Slavonian Grebe	Cormorant	Oystercatcher	Ringed Plover	Golden Plover	Grey Plover	Lapwing	Dunlin	Sanderling	Knot	Black-tailed Godwit	Bar-tailed Godwit	Turnstone	Curlew	Greenshank	Redshank
02902	Inner Larne Lough																														
02903	Outer Larne Lough																														

Table 5 The most important sectors in the latest year (2019/20 for waterbirds in Larne Lough shown by colour: Dark Green – Sites with a peak count in the latest year that is at least 20% of the total peak count for Larne Lough in the same year; Light Green – sectors with a peak count in the latest year that is between 10% and 20% of the total peak count for Larne Lough in the same year.

Sector	SectorHandle	Mute Swan	Whooper Swan	Light-bellied Brent Goose	Greylag Goose	Shelduck	Wigeon	Teal	Mallard	Pintail	Pochard	Eider	Red-breasted Merganser	Goldeneye	Great Crested Grebe	Slavonian Grebe	Cormorant	Oystercatcher	Ringed Plover	Golden Plover	Grey Plover	Lapwing	Dunlin	Sanderling	Knot	Black-tailed Godwit	Bar-tailed Godwit	Turnstone	Curlew	Greenshank	Redshank
02902	Inner Larne Lough																														
02903	Outer Larne Lough																														

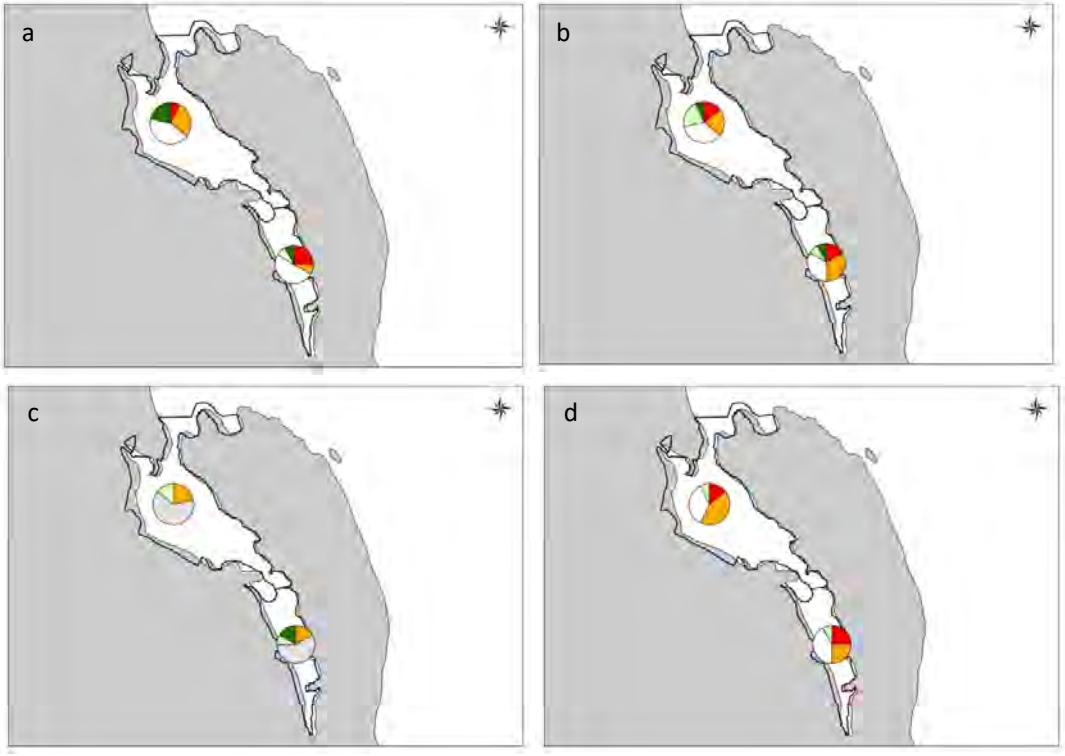


Figure 3.1.i Population trends of waterbirds within Larne Lough over (a) the long-term (2004/05 - 2019/20) (b) the medium-term (2009/10 - 2019/20); (c) the short-term (2014/15 - 2019/20) and (d) the "worst case" scenario of the three terms. The area of each pie chart relates to the number of species for which trends could be determined on the WeBS count sector in question and within each pie chart the proportions of those species that have undergone a substantial decline (red), a moderate decline (orange), "no" change (white), moderate increase (pale green) and sharp increase (dark green).

Table 6 Overview of population trends of waterbirds in Killough Harbour based on high-tide counts over the long- (2000/01 - 2015/16) the medium- (2005/06 - 2015/16) and the short- (2010/11 - 2015/16) 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%; White – 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%; Grey – insufficient data.

Table 6 i Waterfowl

Sector Code	Sector Name	Mute Swan			Whooper Swan			LB Brent Goose			Shelduck			Wigeon			Teal			Mallard			Pintail			Pochard			Red-breasted Merganser			Goldeneye			Great Crested Grebe		
		Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long
01403	Killough Harbour																																			

Table 6 ii Waders and Cormorant

Sector Code	Sector Name	Cormorant			Oyster-catcher			Ringed Plover			Golden Plover			Grey Plover			Lapwing			Dunlin			Knot			Black-tailed Godwit			Bar-tailed Godwit			Turnstone			Curlew			Green-shank			Redshank		
		Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long
01403	Killough Harbour																																								

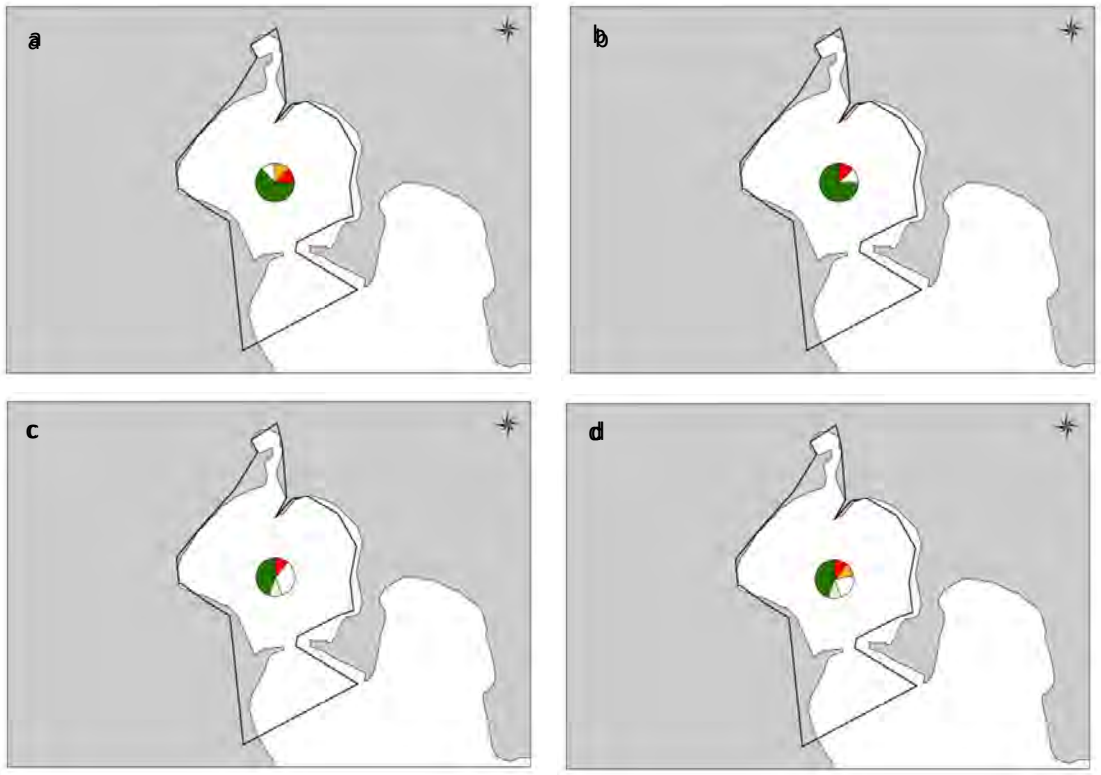


Figure 3.1.ii Population trends of waterbirds within Killough Harbour over (a) the long-term (2000/01 - 2015/16) (b) the medium-term (2005/06 - 2015/16); (c) the short-term (2010/11 - 2015/16) and (d) the "worst case" scenario of the three terms. The area of each pie chart relates to the number of species for which trends could be determined on the WeBS count sector in question and within each pie chart the proportions of those species that have undergone a substantial decline (red), a moderate decline (orange), "no" change (white), moderate increase (pale green) and sharp increase (dark green).

Table 7 Overview of population trends of waterbirds in Dundrum Inner Bay based on high-tide counts over the long- (2001/02 - 2016/17) the medium- (2006/07 - 2016/17) and the short- (2011/12 - 2016/17) 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%; White – 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%; Grey – insufficient data.

Table 7 i Waterfowl

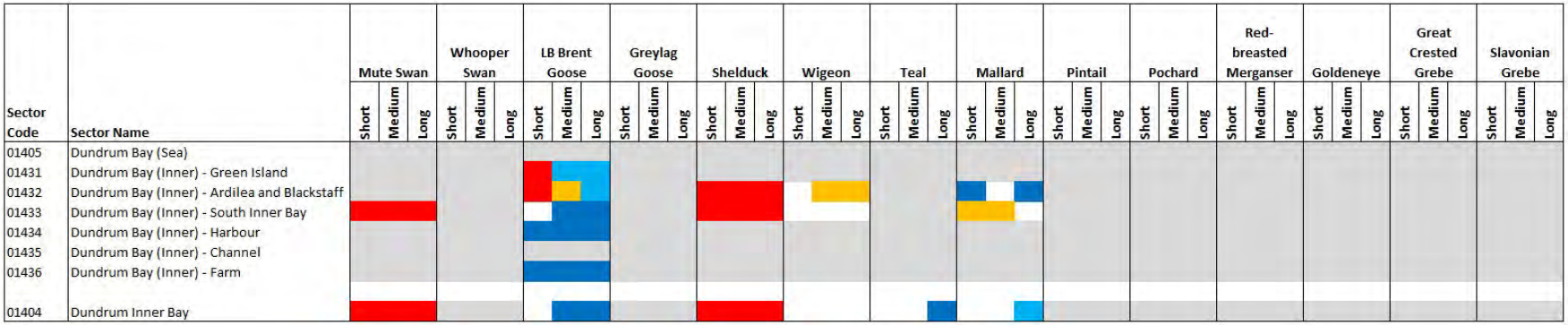


Table 7 ii Waders and Cormorant

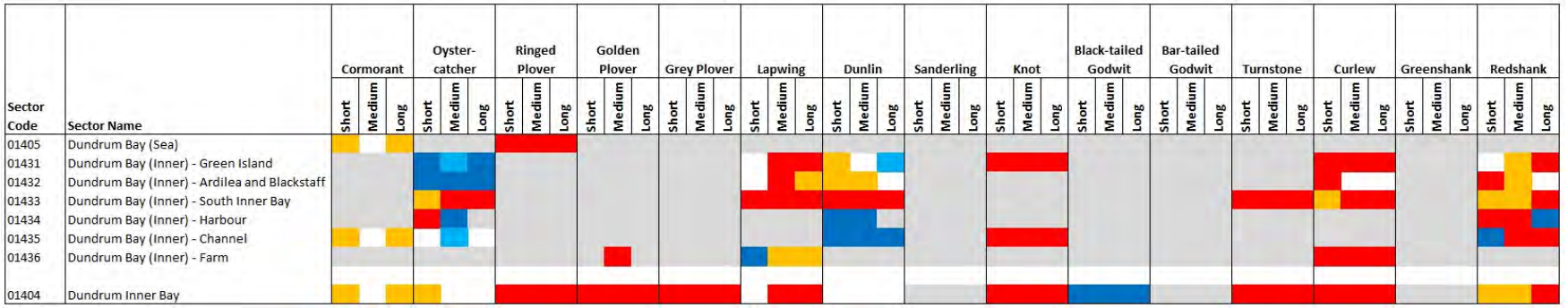
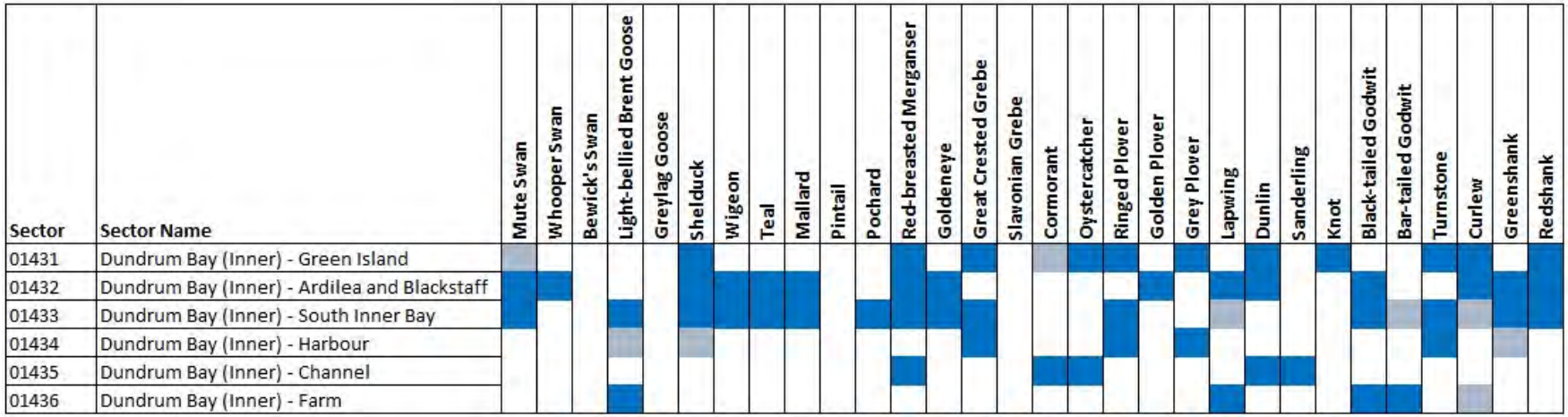


Table 8 The most important sectors for waterbirds in Dundrum Inner Bay shown by colour: Dark Blue- sectors with a mean peak count over the last five winters (2011/12 - 2016/17) that is at least 20% of the total mean peak counts for Dundrum Inner Bay over the same period; Light Blue – sites with a mean peak count over the last five winters that is between 10% and 20% of the total mean of peak count for Dundrum Inner Bay over the same period.



Sector	Sector Name	Mute Swan	Whooper Swan	Bewick's Swan	Light-bellied Brent Goose	Greylag Goose	Shelduck	Wigeon	Teal	Mallard	Pintail	Pochard	Red-breasted Merganser	Goldeneye	Great Crested Grebe	Slavonian Grebe	Cormorant	Oystercatcher	Ringed Plover	Golden Plover	Grey Plover	Lapwing	Dunlin	Sanderling	Knot	Black-tailed Godwit	Bar-tailed Godwit	Turnstone	Curlew	Greenshank	Redshank
01431	Dundrum Bay (Inner) - Green Island																														
01432	Dundrum Bay (Inner) - Ardilea and Blackstaff																														
01433	Dundrum Bay (Inner) - South Inner Bay																														
01434	Dundrum Bay (Inner) - Harbour																														
01435	Dundrum Bay (Inner) - Channel																														
01436	Dundrum Bay (Inner) - Farm																														

Table 9 The most important sectors in the latest year (2016/17) for waterbirds in Inner Dundrum Bay shown by colour: Dark Green – Sites with a peak count in the latest year that is at least 20% of the total peak count for Larne Lough in the same year; Light Green – sectors with a peak count in the latest year that is between 10% and 20% of the total peak count for Larne Lough in the same year.

Sector	Sector Name	Mute Swan	Whooper Swan	Bewick's Swan	Light-bellied Brent Goose	Greylag Goose	Shelduck	Wigeon	Teal	Mallard	Pintail	Pochard	Red-breasted Merganser	Goldeneye	Great Crested Grebe	Slavonian Grebe	Cormorant	Oystercatcher	Ringed Plover	Golden Plover	Grey Plover	Lapwing	Dunlin	Sanderling	Knot	Black-tailed Godwit	Bar-tailed Godwit	Turnstone	Curlew	Greenshank	Redshank
01431	Dundrum Bay (Inner) - Green Island																														
01432	Dundrum Bay (Inner) - Ardilea and Blackstaff																														
01433	Dundrum Bay (Inner) - South Inner Bay																														
01434	Dundrum Bay (Inner) - Harbour																														
01435	Dundrum Bay (Inner) - Channel																														
01436	Dundrum Bay (Inner) - Farm																														

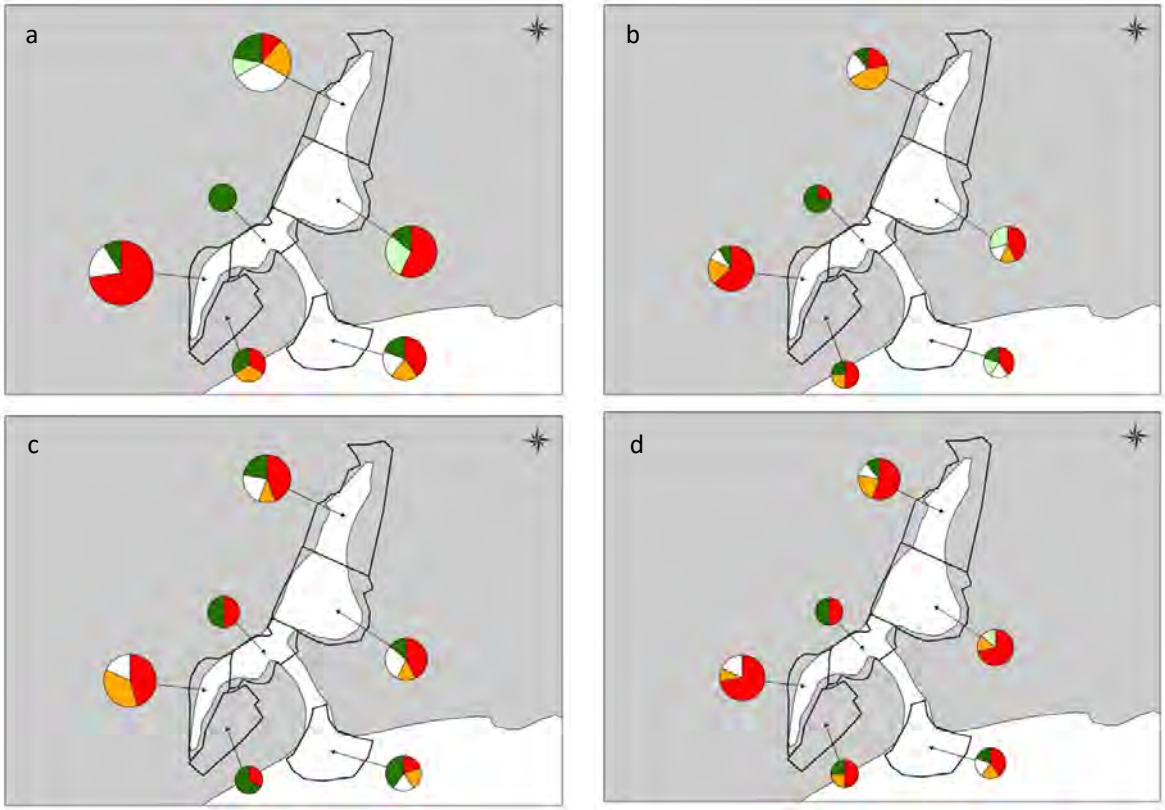


Figure 3.1.iii Population trends of waterbirds within Dundrum Bay over (a) the long-term (2001/02-2016/17) (b) the medium-term (2006/07 - 2016/17); (c) the short-term (2011/12-2016/17) and (d) the "worst case" scenario of the three terms. The area of each pie chart relates to the number of species for which trends could be determined on the WeBS count sector in question and within each pie chart the proportions of those species that have undergone a substantial decline (red), a moderate decline (orange), "no" change (white), moderate increase (pale green) and sharp increase (dark green).

4. DISCUSSION

4.1. Species Trends – Larne Lough Core Counts (high tide): 2013/14 - 2018/19

4.1.1. Mute Swan (*Cygnus olor*)

The Northern Irish Mute Swan population dipped in the mid to late 2000's but has since recovered. Larne Lough has a very small proportion of the national population and this has declined significantly on the lough in the long- and short-terms, and moderately in the medium-term. Therefore, it is difficult to infer if the declines are related to site specific issues or if they are simply an artefact of natural fluctuations of the small numbers using the site. There were insufficient data to distinguish between trends in Inner Larne Lough (02902) and Outer Larne Lough (02903).

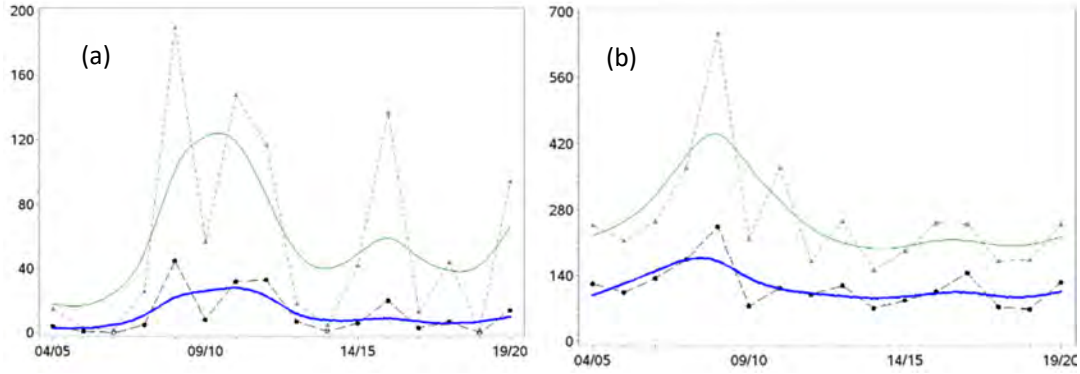


Figure 4.1.1(a) The trend in the number of Mute Swan on Outer Larne Lough (02903). (b) The trend in the number of Mute Swan on Inner Larne Lough (02902). The upper (green) trend line is fitted through the winter peak counts whilst the lower (blue) line is fitted through the winter mean counts.

4.1.2. Whooper Swan (*Cygnus cygnus*)

There were insufficient Whooper Swan recorded at high-tide in Larne Lough to generate trends at the sector- or site-level.

4.1.3. Light-bellied Brent Goose (*Branta bernicla hrota*)

There was a steady increase in the population of Light-bellied Brent Geese in Northern Ireland between 2004/05 and 2019/20. During the study period Larne Lough contained <5% of the Northern Irish wintering population. The population remained largely stable over the reporting period although there was a moderate decline in the medium-term following a small increase in the late 2000s/early 2010s. Inner Lough Larne (02902) is by far the most important sector, consistently possessing >75% of the population. The population of about 140 birds in Inner Lough Larne (02902) follows the trend for the lough as a whole. Outer Lough Larne (02903) with a much smaller population underwent a moderate decline in the medium-term followed by a significant increase (up to six birds) in the long term.

4.1.4. Greylag Goose (*Anser anser*)

Greylag Geese have increased in Northern Ireland since 2010/11 and their importance in Larne Lough has consistently been between 10-30% of the Northern Irish population. Greylag Geese are mostly found in Inner Larne Lough (02902). They increased significantly in the long- and medium-terms while stabilising in the short-term, perhaps reaching carrying capacity as the importance of this population dropped in its national context in 2019/20.

4.1.5. Shelduck (*Tadorna tadorna*)

Shelduck have undergone a large decline in Northern Ireland since 2004/05, a trend partially echoed in Larne Lough. The moderate long-term decline in the site as a whole highlighted by the analysis is likely associated with a high count in Outer Larne Lough (02903) in 2004/05 but there was not enough data for this sector subsequently to generate trends. The lough consistently holds about 10% of the Northern Irish population of Shelduck, mostly recorded in Inner Larne Lough (02902) (>90%), whose population has remained stable in the long-, medium- and short-terms.

4.1.6. Wigeon (*Anas penelope*)

Northern Ireland's Wigeon population underwent a steep decline between 2003/04 and 2012/13, but has been variable but increasing since. A far smaller decline can be seen for Larne Lough and the subsite Inner Larne Lough (02902). This equated to modest decline occurring in the medium-term bookended by stable trends in the long- and short-terms. Outer Lough Larne (02903) in comparison has shown a stable trend since 2004/05. As suggested by these results Larne Lough has increased in its importance for Wigeon in a Northern Irish context, although it is still below 10%.

4.1.7. Teal (*Anas crecca*)

There has been a slight increase in the Teal population between 2004/05 and 2019/20 in Northern Ireland. The importance of Larne Lough has also increased steadily in this time but remains below 10%. Larne Lough as a whole has shown a moderate increase in the short-term but a strong increase in the medium- and long-terms. Inner Larne Lough (02902) has the larger proportion of the site's Teal, generally >70% except for an apparent shift in 2013/14 when this fell to under 40%. There has been a significant increase in the short-term but only moderate increases in the medium- and long-terms. In Outer Larne Lough (02903) the short-term trend was stable while the medium- and long-term trends showed a significant increase. In 2019/20 Inner Larne Lough (02902) held about 300 birds whereas Outer Larne Lough (02903) held about 50.

4.1.8. Mallard (*Anas platyrhynchos*)

The Northern Irish population of Mallard has remained largely stable since 2004/05. Larne Lough only possesses small numbers of Mallard, less than 5% of the Northern Irish population. Most of these are located in Outer Larne Lough (02903). The population as a whole over the lough has remained stable in the short-, medium- and long-terms, although Inner Larne Lough (02902) shows a moderate increase in the short-term and Outer Larne Lough (02903) shows a moderate decrease over the same time period, suggesting a redistribution of Mallard within the lough during this period. Overall, there is little to suggest that the Larne Lough population is behaving any differently to the population in Northern Ireland as a whole.

4.1.9. Pintail (*Anas acuta*)

There were insufficient Pintail recorded at high-tide in Larne Lough to generate trends at the sector- or site-level.

4.1.10. Pochard (*Aythya ferina*)

There were insufficient Pochard recorded at high-tide in Larne Lough to generate trends at the sector- or site-level.

4.1.11. Eider (*Somateria mollissima*)

The Eider population has increased in Northern Ireland since 2004/05 with some fluctuations. Larne Lough contains less than 5% of the Northern Irish population with the greatest proportion of birds found in Outer Larne Lough (02903). The trend for Larne Lough (02401) as a whole show a moderate increase in the medium- and long-terms and a stable trend in the short-term. There were insufficient data to derive trends for Inner Larne Lough (02902), but Outer Larne Lough (02903) showed a significant increase in the long-term and a moderate increase in the medium- and short-terms, suggesting that numbers are broadly following the Northern Irish trend.

4.1.12. Red-breasted Merganser (*Mergus serrator*)

Red-breasted Merganser declined in Northern Ireland since 2007/08 but appeared to stabilise in more recent years. Larne Lough is an important site for these birds, accounting for over 30% of their regional population during the study period. The stability in numbers of Red-breasted Merganser in Larne Lough across all time periods against the backdrop of regional-level declines has resulted in the site becoming more important for the species in Northern Ireland. Inner Larne Lough (02902) underwent moderate declines in the long- and medium-terms, but has been stable in the short-term. The majority of birds were recorded in Outer Lough Larne (02903) where a moderate increase in the medium-term is sandwiched between two periods of stability in the long- and short-terms. An increase in the proportion of the lough's Red-breasted Merganser found in Outer Larne Lough compared to Inner Larne Lough may suggest some redistribution of the species within the lough, indicative of local pressures in some areas.

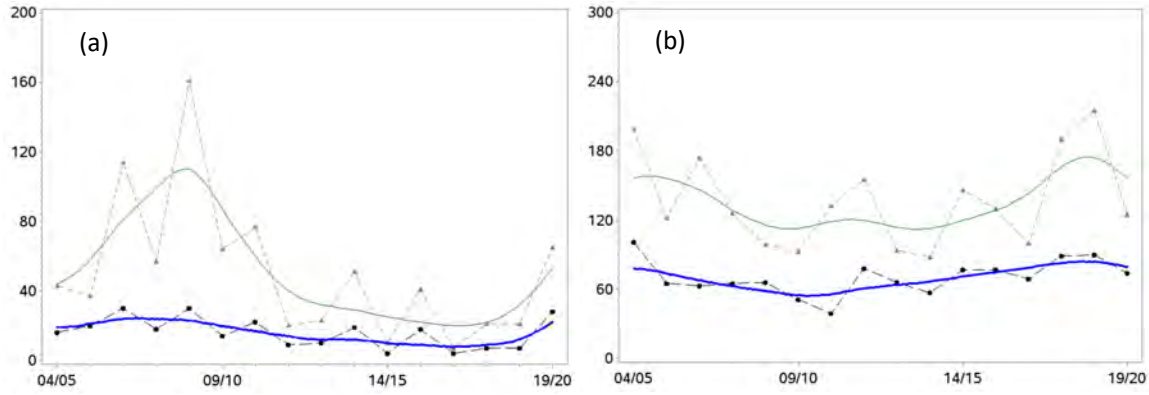


Figure 4.1.12(a) The trend in the number of Red-breasted Merganser on Inner Larne Lough (02902). (b) The trend in the number of Red-breasted Merganser on Outer Larne Lough (02903). The upper (green) trend line is fitted through the winter peak counts whilst the lower (blue) line is fitted through the winter mean counts.

4.1.13. Goldeneye (*Bucephala clangula*)

Goldeneye underwent a very steep decline in Northern Ireland since 2004/05. Although the numbers in Larne Lough population also declined, these have been less severe, resulting in a very small increase in the overall importance of the lough in the Northern Irish context (to approximately 5% by 2019/20). The long- and medium-term trends for Goldeneye on Larne Lough showed a moderate decline, stabilising in the short-term. This mirrors Outer Larne Lough (02903) where the majority of records were made; no trends could be assessed for Inner Larne Lough (02902) due to a lack of data. The less severe decline in Larne Lough, and in particular Outer Larne Lough, and the slight increase in importance of this population to Northern Ireland suggest that conditions here are relatively favourable, but the population is still likely being affected from other non-site related factors.

4.1.14. Great Crested Grebe (*Podiceps cristatus*)

The Northern Irish population of Great Crested Grebe declined steeply between 2006/07 to 2014/15 and underwent a slight recovery up to 19/20. The population at Larne Lough showed a moderate decline in the long- and medium-terms but was stable in the short-term. Although a small population, it has fared better than the wider Northern Irish population, suggesting that conditions remain good for Great Crested Grebe at this site. Larne Lough has a modest proportion of the regional population (<10%) but this rose slightly in 2019/20. Most of the records are from Outer Larne Lough (02903) (c. 40) with fewer than 10 in Inner Larne Lough (02902); the lack of records in Inner Larne Lough (02902) resulted in an inability to produce a trend for this section. There was a slight decrease in the proportion of the site total found in Inner Larne Lough from 2010/11 onwards suggesting some redistribution of the species within the lough, potentially indicative of local pressures in some areas.

4.1.15. Cormorant (*Phalacrocorax carbo*)

Cormorant declined across Northern Ireland between 2004/05 to 2013/14 after which they largely stabilised or increased slightly. Larne Lough has less than 10% of the Northern Irish population with just over 40 -50 birds regularly counted, mostly in Outer Larne Lough (02903). The population has remained stable across the lough although no trends could be derived for Inner Larne Lough (02902) where numbers were low.

4.1.16. Oystercatcher (*Haematopus ostralegus*)

Oystercatcher declined steadily in Northern Ireland since at least 2004/05, and less that 10% of the Northern Irish population was found in Larne Lough. The lough experienced a moderate decline in the long-term but has remained stable since, showing a similar trend to that of the regional population. This suggests that declines within the lough are not due to site-specific conditions. Most of the population on Larne Lough are found on Outer Larne Lough (02903) (c.>70%) which has undergone a moderate decline in the long- and short-terms, in contrast to the smaller population in Inner Larne Lough (02902) which showed a significant increase in the short-term, potentially indicative of changing local conditions within the lough.

4.1.17. Ringed Plover (*Charadrius hiaticula*)

There were insufficient Ringed Plover recorded at high-tide in Larne Lough to generate trends at the sector- or site-level.

4.1.18. Golden Plover (*Pluvialis apricaria*)

There were insufficient Golden Plover recorded at high-tide in Larne Lough to generate trends at the sector- or site-level.

4.1.19. Grey Plover (*Pluvialis squatarola*)

There were insufficient Grey Plover recorded at high-tide in Larne Lough to generate trends at the sector- or site-level.

4.1.20. Lapwing (*Vanellus vanellus*)

The regional population of Lapwing is in long-term decline, and there were steep declines in the long- and medium-terms and a moderate decline in the short-term in Larne Lough. The lough consistently held less than 5% of the Northern Irish population during the study period, suggesting that site-level declines were not due to local pressures. Lapwing are distributed nearly equally between Outer Larne Lough (02903) and Inner Larne Lough (02902), and while both sectors declined steeply over the medium- and long-terms, Outer Larne Lough remained stable in the short-term.

4.1.21. Dunlin (*Calidris alpina*)

Dunlin in Northern Ireland underwent a decline in numbers until 2010/11 when they began to stabilise. At Larne Lough this decline was very pronounced with a population >200 falling to about 20 by 2019/20, with less than 5% of the Northern Irish population recorded here during the majority of the study period. Significant declines in the long- and medium-terms at Larne Lough as a whole was also seen in the subsite Inner Larne Lough (02902). There were insufficient data to derive a trend for Outer Larne Lough (02903).

4.1.22. Sanderling (*Calidris alba*)

There were insufficient Sanderling recorded at high-tide in Larne Lough to generate trends at the sector- or site-level.

4.1.23. Knot (*Calidris canutus*)

There were insufficient Knot recorded at high-tide in Larne Lough to generate trends at the sector- or site-level.

4.1.24. Black-tailed Godwit (*Limosa limosa*)

There were insufficient Black-tailed Godwit recorded at high-tide in Larne Lough to generate trends at the sector- or site-level.

4.1.25. Bar-tailed Godwit (*Limosa lapponica*)

There were insufficient Bar-tailed Godwit recorded at high-tide in Larne Lough to generate trends at the sector- or site-level.

4.1.26. Turnstone (*Arenaria interpres*)

Turnstone have been in decline in Northern Ireland, although total numbers increased slightly in 2019/20. Small numbers occurred in Larne Lough, and remained stable in the long- and short-terms but underwent a moderate decline in the medium-term. Turnstones were largely absent from Inner Larne Lough (02902), and therefore the trend for the site echoes that of the Outer Larne Lough (02903) sector, which contained the majority of Turnstone during the study period. Conditions in Outer Larne Lough therefore may be more favourable to Turnstone than those seen at elsewhere in Northern Ireland, as the declines were less severe than that of Northern Ireland as a whole, although overall numbers were low in the lough.

4.1.27. Curlew (*Numenius arquata*)

Across the full study period, Northern Irish Curlew populations experienced a steady decline. Less than 10% of the Northern Irish population was found in Larne Lough, and these remained stable in the long-, medium- and short-terms, following the regional trend. Trends in Outer Larne Lough (02903) showed moderate declines in the long- and short-terms, dropping from about 120 birds in 2004/05 to about 80 in 2019/20. Inner Larne Lough (02902) had roughly double that population, with about 160 in 2019/20. There was no strong difference in the importance of either sector in relation to the other across the study period, suggesting that conditions in these sectors have remained largely consistent for Curlew.

4.1.28. Redshank (*Tringa tetanus*)

Redshank underwent a period of decline in Northern Ireland, although the trend increased slightly since 2017/18. The population in Larne Lough represented less than 10% of the regional population, and remained stable in the short-, medium- and long-terms. The picture between the two sectors in Larne Lough was slightly more complicated however. The population in Inner Larne Lough (02902) underwent a significant decline in the long-term and a moderate decline in the medium- and short-terms. This was in contrast to a moderate increase in the medium- and short-terms in Outer Larne Lough (02903). During the short-term Outer Larne Lough also became the more important site hosting up to 80% of the birds on the lough. The reason for this change isn't clear but may represent a change in the availability of resources between the sectors or the impacts of some external factors such as disturbance.

4.2. Species Trends – Killough Harbour (01403) Core Counts (high tide): 2000/2001 to 2015/2016

4.2.1. Mute Swan (*Cygnus olor*)

There were insufficient Mute Swan recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.2. Whooper Swan (*Cygnus cygnus*)

There were insufficient Whooper Swan recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.3. Light-bellied Brent Goose (*Branta bernicla hrota*)

There were insufficient Light-bellied Brent Geese recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.4. Greylag Goose (*Anser anser*)

There were insufficient Greylag Geese recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.5. Shelduck (*Tadorna tadorna*)

There were insufficient Shelduck recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.6. Wigeon (*Anas penelope*)

Northern Ireland's Wigeon population underwent a steep decline between 2003/04 and 2012/13, but then increased up to 2015/16. Killough Harbour only holds a small proportion of the Northern Irish population, but numbers here increased by at least 100% over the long-, medium- and short-terms. This has resulted in the population going from nearly zero in 2000/01 to approximately 70 birds in 2015/16. Although the numbers are small, this contrasts with the declines seen at the regional scale and might indicate improving conditions for Wigeon in Killough Harbour.

4.2.7. Teal (*Anas crecca)*

The regional trend for Teal has remained relatively stable between 2000/01 and 2015/16. Although representing less than 5% of the national population, the Killough Harbour population has increased significantly (by at least 100%) in the medium- and short-terms, from low single figures in 2005/06 to about 70 birds in 2015/16. Similar to Wigeon this may indicate improving conditions at Killough Harbour in more recent years.

4.2.8. Mallard (*Anas platyrhynchos*)

There were insufficient Mallard recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.9. Pintail (*Anas acuta*)

There were insufficient Pintail recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.10. Pochard (*Aythya ferina*)

There were insufficient Pochard recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.11. Red-breasted Merganser (*Mergus serrator*)

There were insufficient Red-breasted Merganser recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.12. Goldeneye (*Bucephala clangula*)

There were insufficient Goldeneye recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.13. Great-crested Grebe (*Podiceps cristatus*)

There were insufficient Great-crested Grebe recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.14. Cormorant (*Phalacrocorax carbo*)

There were insufficient Cormorant recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.15. Oystercatcher (*Haematopus ostralegus*)

Oystercatchers underwent a moderate decline in Northern Ireland between 2000/01 and 2015/16, but numbers remained stable at Killough Harbour throughout the long-, medium- and short-terms. Although Killough Harbour has a very small proportion of the national Oystercatcher population it is doing better here than in other parts of Northern Ireland.

4.2.16. Ringed Plover (*Charadrius hiaticula*)

There were insufficient Ringed Plover recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.17. Golden Plover (*Pluvialis apricaria*)

The Northern Irish population of wintering Golden Plover suffered a steep decline between 2005/06 and 2010/11. Similarly, the population of Killough Harbour underwent declines of at least 50% across all time periods, although this decline didn't begin until 2009/10 resulting in Killough Harbour holding just under 10% of the Northern Irish population in 2008/09. The population had effectively abandoned the site by 2015/16.

4.2.18. Grey Plover (*Pluvialis squatarola*)

There were insufficient Grey Plover recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.19. Lapwing (*Vanellus vanellus*)

In contrast to the regional level, numbers of Lapwing at Killough Harbour bucked the trend somewhat, increasing significantly (by at least 100%) in the short-, medium- and long-terms, in contrast with a significant decline over the same time periods in Northern Ireland. This resulted in the proportion of the Killough Harbour population rising to about 5% of the Northern Irish population with numbers just over 100 in 2015/16. Although the year-on-year numbers are quite variable it indicates that conditions at Killough Harbour may now be more favourable than other areas in Northern Ireland.

4.2.20. Dunlin (*Calidris alpina*)

Dunlin in Northern Ireland underwent a decline between 2003/04 and 2010/11 but have seen a very slight increase since. In Killough Harbour, the long-term trend showed a moderate decline, but this was stable during the medium- and short-terms. Killough Harbour had a small (<5%) proportion of the regional population and its annual fluctuations were broadly in line with the Northern Irish trend.

4.2.21. Knot (*Calidris cauntus*)

There were insufficient Knot recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.22. Black-tailed Godwit (*Limosa limosa*)

There were insufficient Black-tailed Godwit recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.23. Bar-tailed Godwit (*Limosa lapponica*)

There were insufficient Bar-tailed Godwit recorded at high-tide in Killough Harbour to generate trends at the site-level.

4.2.24. Turnstone (*Arenaria interpres*)

Turnstones declined across Northern Ireland but showed increases of at least 100% over the long- and medium-terms at Killough Harbour. This led to an increase of the importance of this site at a regional-level to around 5%. The population was quite small, with an annual average of less than 80 birds. The rising population, stabilising in the short-term, suggests local conditions were at least reasonable for these birds.

4.2.25. Curlew (*Numenius arquata*)

The winter population of Curlew in Northern Ireland declined steadily between 2000/01 and 2015/16. In contrast, the population in Killough Harbour increased by at least 100% across all time

periods. The population of about 70-80 birds in the latter years rose sharply in 2010/11 suggesting better conditions at this site than at many others in Northern Ireland, however it still held less than 5% of the regional population.

4.2.26. Redshank (*Tringa tetanus*)

Redshank declined across Northern Ireland between 2000/01 and 2015/16, while in contrast at Killough Harbour it increased significantly (by at least 100%) in the long- and medium-terms, and moderately (33% to 100%) in the short-term, numbers reaching about 150 on site. The increase is particularly noticeable from 2009/10 onwards suggesting Killough Harbour was more favourable than many other places in Northern Ireland from this time.

4.3. Species trends – Dundrum Inner Bay Core Counts (high tide): 2001/2002 to 2016/2017

4.3.1. Mute Swan (*Cygnus olor*)

The regional trend for Mute Swan stabilised from 2009/10, but in Dundrum Inner Bay there were declines of at least 50% across all time periods. Within the site, only South Inner Bay (01433) had enough records to assess a trend, and this mimicked the declining site-level trend. The numbers at this site are now very low and this may suggest that the difference between the regional and local scale was largely down to small numbers rather than necessarily any site-specific issues. However, the average count in 2002/03 was nearly 30 birds so it is apparent the site can certainly hold more than have been present in recent years.

4.3.2. Whooper Swan (*Cygnus cygnus*)

There were insufficient Whooper Swan recorded at high-tide in Dundrum Inner Bay to generate trends at the site- or sector-level.

4.3.3. Light-bellied Brent Goose (*Branta bernicla hrota*)

The regional population of Light-bellied Brent Goose in Northern Ireland increased for a period between 2005/06 and 2010/11 but then stabilised. This increase was also observed in Dundrum Inner Bay with an increase from about 100 birds in 2001/02 to 800 birds in 2011/12, after which the population stabilised. At a sector level this equates to a significant decline of at least 50% in Green Island (01431) and Ardilea and Blackstaff (01432) in the short-term. Throughout this period the largest concentration of Light-bellied Brent Goose occurred at South Inner Bay (01433). However, the population is distributed throughout the Bay and Channel (01435) is the only Dundrum Inner Bay subsite where there was insufficient data to create trends.

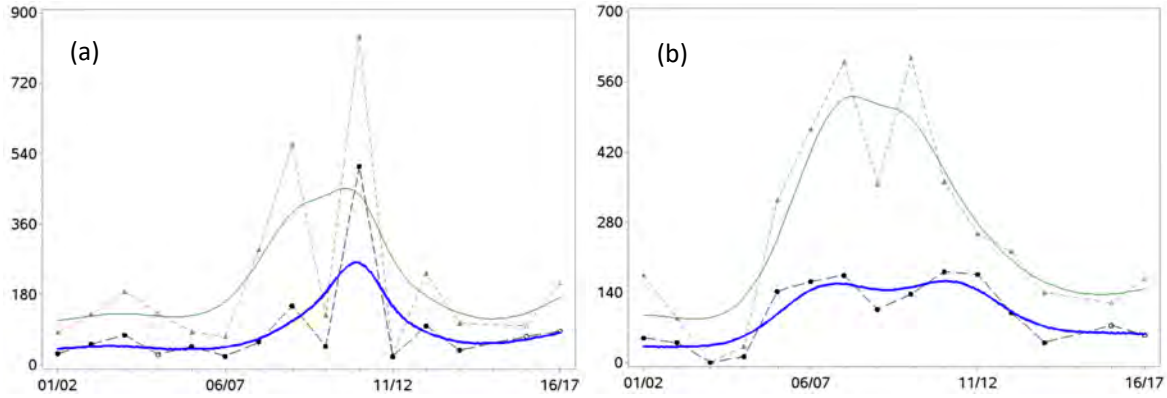


Figure 4.3.3 (a) The trend in the number of Light-bellied Brent Goose on Green Island (01431), Dundrum Bay Inner. (b) The trend in the number of Light-bellied Brent Goose on Ardilea and Blackstaff (01432), Dundrum Bay Inner. The upper (green) trend line is fitted through the winter peak counts whilst the lower (blue) line is fitted through the winter mean counts.

4.3.4. Greylag Goose (*Anser anser*)

There were insufficient Greylag Geese recorded at high-tide in Dundrum Inner Bay to generate trends at the site- or sector-level.

4.3.5. Shelduck (*Tadorna tadorna*)

Following a period of decline from 2005/06, the population of Shelduck in Northern Ireland showed an increasing trend between 2014/15 and 2016/17. The population in Dundrum Inner Bay however declined steeply (by over 100%) across all time periods, with only a small population of about 10 birds in the latter years. Shelduck had a small proportion (<5%) of their Northern Irish population in Dundrum Inner Bay, but the declines in the short-term contrasted with the increases at the regional level, and may suggest that there are some local factors at play. Due to insufficient records at other sectors, trends could only be derived for Ardilea and Blackstaff (01432) and South Inner Bay (01433), both of which follow the same trends as the site as a whole, showing significant declines throughout the time period.

4.3.6. Wigeon (*Anas penelope*)

The population of Wigeon in Northern Ireland declined significantly between 2001/02 and 2011/12, but then increased up to 2016/17. In contrast the population in Dundrum Bay Inner remained stable during this time. The Dundrum Inner Bay population peaked above the 10% threshold for regional importance in 2012/13 but remained slightly under that threshold during most of the time period. This increase in importance coincided with the beginning of a recovery in the Northern Irish population which suggests conditions remained more favourable in Dundrum Inner Bay than in other parts of the country. Trends are only available for Ardilea and Blackstaff (01432), which saw moderate declines in the long- and medium-term but a stable trend in the short-term, and South Inner Bay (01433) which remained stable throughout the period (Figure 4.3.6a). South Inner Bay (01433) is the more important of these two sites od (Figure 4.3.6b), regularly having an average count of over 100 birds, whereas Ardilea and Blackstaff (01432) regularly fall below this number.

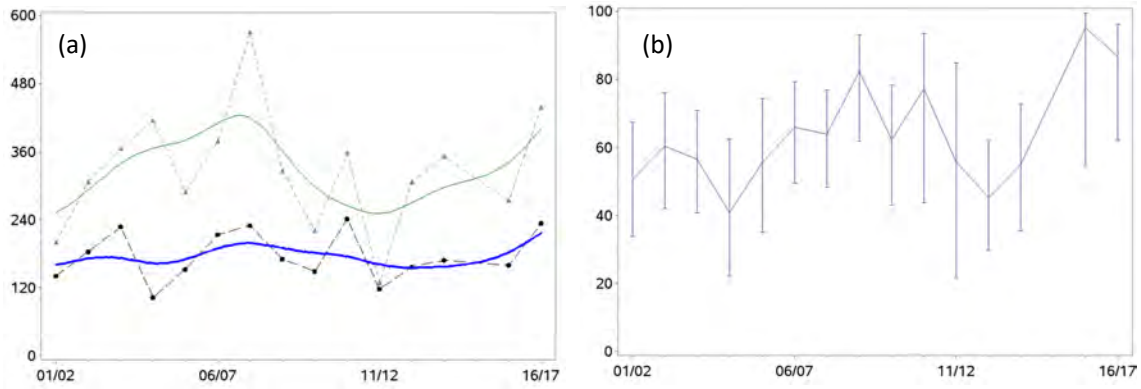


Figure 4.3.6 (a) The trend in the number of Wigeon on South Inner Bay (01433). The upper (green) trend line is fitted through the winter peak counts whilst the lower (blue) line is fitted through the winter mean counts. (b) The percent proportion of Wigeon in Dundrum Inner Bay that have been recorded South Inner Bay (01433) between the winters of 2001/02 and 2016/17.

4.3.7. Teal (*Anas crecca*)

The population of Teal in Northern Ireland underwent a slight increase overall between 2001/02 and 2016/17. It was only possible to develop a trend for Dundrum Inner Bay as a whole due to the small numbers of birds recorded at the sectors within the site. The site-level trend shows a long-term increase of over 100% but was stable in the medium- and short-terms, following the Northern Irish trend.

4.3.8. Mallard (*Anas platyrhynchos*)

Mallard declined in Northern Ireland between 2001/02 and 2016/17. In contrast, the Dundrum Inner Bay population showed a moderate increase in the long-term and a stable-trend in the medium- and short-terms. Dundrum Inner Bay contained only a small proportion (<5%) of the Northern Irish population of Mallard. Trends for Ardilea and Blackstaff (01432) showed increases of over 100% over the long- and short-terms, and a stable trend in the medium-term, while South Inner Bay (01433) showed a stable trend in the long-term but a moderate decline (25% to 50%) in the medium- and short-terms. Inner South Bay (01433) generally held more birds, but Ardilea and Blackstaff (01432) was occasionally the more important sector, suggesting movements across the site. The difference in trends between the Northern Ireland and Dundrum Inner Bay may suggest that locally conditions were more favourable than elsewhere, but care should be taken in interpreting any differences as the numbers involved were modest.

4.3.9. Pintail (*Anas acuta*)

There were insufficient Pintail recorded at high-tide in Dundrum Inner Bay to generate trends at the site- or sector-level.

4.3.10. Pochard (*Aythya ferina*)

There were insufficient Pintail recorded at high-tide in Dundrum Inner Bay to generate trends at the site- or sector-level.

4.3.11. Red-breasted Merganser (*Mergus serrator*)

There were insufficient Pochard recorded at high-tide in Dundrum Inner Bay to generate trends at the site- or sector-level.

4.3.12. Goldeneye (*Bucephala clangula*)

There were insufficient Goldeneye recorded at high-tide in Dundrum Inner Bay to generate trends at the site- or sector-level.

4.3.13. Great-crested Grebe (*Podiceps cristatus*)

There were insufficient Great-crested Grebe recorded at high-tide in Dundrum Inner Bay to generate trends at the site- or sector-level.

4.3.14. Cormorant (*Phalacrocorax carbo*)

The Northern Irish population of Cormorant declined between 2005/06 and 2012/13, showing some signs of stabilisation or recovery between 2013/14 and 2016/17. The population in Dundrum Inner Bay has undergone a moderate decline (25% to 50%) in the long- and short-terms. The site population made up less than 5% of the Northern Irish population. While small numbers of Cormorant were recorded across all sectors, Channel (01435) was the most important sector. Trends here followed the site trend.

4.3.15. Oystercatcher (*Haematopus ostralegus*)

At the Northern Irish level, the Oystercatcher declined between 2001/02 and 2016/17. Within Dundrum Bay Inner the population remained largely stable apart from a moderate (25% to 50%) short-term decline. The site has held more than 10% of Northern Ireland's Oystercatchers in certain years highlighting the importance of this site for these birds. Channel (01435) was the most important sector, regularly hosting over 50% of the Oystercatchers on the site, and at times over 90% (Figure 4.3.15b). This sector stayed relatively stable in the long-term (Figure 4.2.15a) with a moderate increase (33% to 100%) in the medium-term. The second most important sector was Green Island (01431) which showed a moderate increase in the medium-term and significant increase (of over 100%) in the long- and short-terms. Other sectors were less important for Oystercatchers, but Ardilea and Blackstaff (01432) saw significant increases for all time periods, South Inner Bay (01433) underwent significant declines (over 50%) in the long- and medium-terms and a moderate decline in the short-term, and Harbour (01434) underwent a significant increase in the medium-term followed by a significant decrease in the short-term due to a single high count in 2010/11. Although the presence of differing sector-level trends suggest some variability in local conditions may have influenced Oystercatcher distribution in Dundrum Inner Bay over time, the overall site trend is not too dissimilar from the Northern Irish trend.

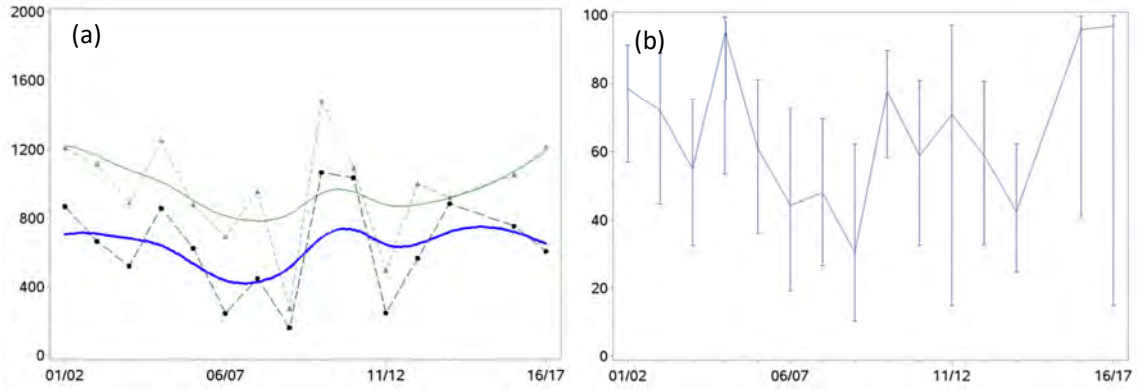


Figure 4.3.15 (a) The trend in the number of Oystercatcher on Channel (01435). The upper (green) trend line is fitted through the winter peak counts whilst the lower (blue) line is fitted through the winter mean counts. (b) The percent proportion of Oystercatcher in Dundrum Inner Bay that have been recorded Channel (01435) between the winters of 2001/02 and 2016/17.

4.3.16. Ringed Plover (*Charadrius hiaticula*)

The small Ringed Plover population in Northern Ireland underwent a decline between 2005/06 and 2010/11 but showed signs of stabilising and maybe even increasing by 2016/17. There was a general increase in Dundrum Inner Bay between 2004/05 and 2009/10. This led to an increase in the importance of the site in the Northern Irish context, however numbers quickly declined, and very few were recorded in 2016/17. While Green Island (01431), South Inner Bay (01433) and Harbour (01434) were the most important sectors for Ringed Plover during the study period, numbers were too low to generate trends.

4.3.17. Golden Plover (*Pluvialis apricaria*)

There was a moderate increase then a very steep decline in the number of Golden Plover in Northern Ireland between 2001/02 and 2009/10 with some stabilisation of numbers between 2010/11 and 2016/17, albeit at half the population compared to a high in 2005/06. Dundrum Inner Bay underwent a similar trend with an increase in 2003/04 to 2004/05 followed by a rapid decline, this is shown in the trends as a significant steep decline of over 50% across all time periods. The only sector-level trend that could be generated was for the medium-term in Farm (01436), where site- and regional-level steep declines were echoed. Between 2002/03 and 207/08 this sector annual averages were between 60 to 400 birds, but these had disappeared in the sector by 2009/10.

4.3.18. Grey Plover (*Pluvialis squatarola*)

The small regional population of Grey Plover declined steeply between 2001/02 and 2016/17. The Dundrum Inner Bay population regularly exceeded 10% of the Northern Irish population between 2001/02 and 2016/17 but the population underwent a similar trend with significant declines in the long-, medium- and short-terms.

4.3.19. Lapwing (*Vanellus vanellus*)

The population of Lapwing in Northern Ireland declined between 2001/02 and 2016/17. Site-level trends in Dundrum Inner Bay, which held less than 10% of Northern Ireland's Lapwing during the study period, were similar to the regional-level, showing significant declines of over 50% the long-

and medium-terms and a stable trend in the short-term. The sectors with the highest five-year mean peak and mean winter peak of Lapwing were Farm (01436) and Ardilea and Blackstaff (01431). Of the four sectors for which trends could be calculated, declines were prevalent across the medium- and long-terms, although a significant increase in the short term at Farm made it the most important sub-site in 2016/17. However, sector-level declines are likely largely driven by factors external to the site, since the overall site-level importance in a Northern Irish context did not change across the study period.

4.3.20. Dunlin (*Calidris alpina*)

The Northern Irish population of Dunlin declined sharply between 2002/03 and 2010/11 with a subsequent levelling off. In Dundrum Inner Bay the trend has remained stable across all time periods. However, a small increase in numbers in 2012/13 corresponded to an increased importance of the sites Dunlin population in Northern Ireland when it reached about 18% of the regional population. By 2016/17 it was just under 10%, due to a decline in later years. While there appeared to have been favourable conditions in Dundrum Inner Bay in the early 2010's when the regional population was stabilising following a significant decline, the population has since followed the regional trend more closely. At the sector level there were steep declines (of over 50%) throughout the study period at South Inner Bay (01433, Figure 4.3.20 (a)) and moderate declines (25% to 50%) in the medium- and short-terms at Ardilea and Blackstaff (01432) and a moderate short-term decline at Green Island (01431). These declines were offset at the site level by significant increases at Harbour (01434) and Channel (01435, Figure 4.3.20 (b)), suggesting that there may be potential within-site changes affecting the distribution of Dunlin in Inner Dundrum Bay. Many sectors had notable peaks in the short-term, but all sites seemed to dip again by 2016/17. The most important sectors in terms of their five-year mean peaks for Dunlin within the site were Green Island, Ardilea and Blackstaff and Channel.

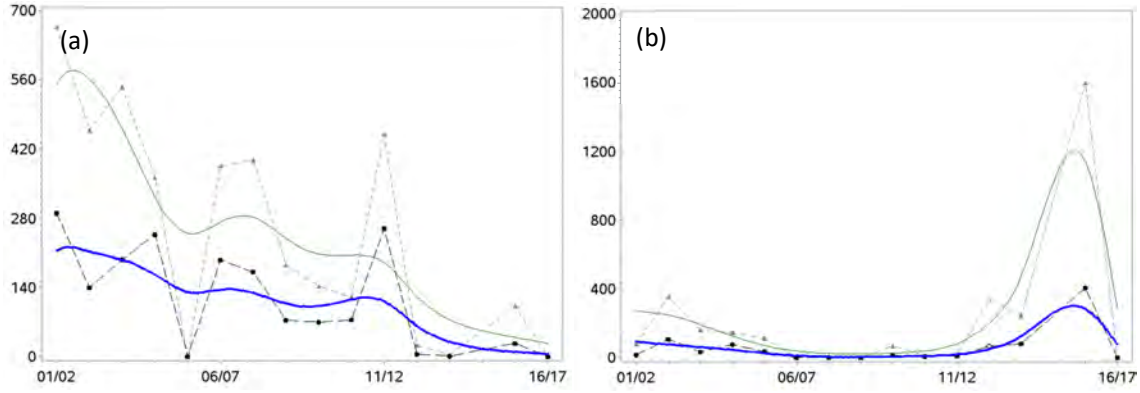


Figure 4.3.20 (a) The trend in the number of Dunlin on South Inner Bay (01433), Dundrum Bay Inner. (b) The trend in the number of Dunlin in Channel (01435), Dundrum Bay Inner. The upper (green) trend line is fitted through the winter peak counts whilst the lower (blue) line is fitted through the winter mean counts.

4.3.21. Sanderling (*Calidris alba*)

There were insufficient Sanderling recorded at high-tide in Dundrum Inner Bay to generate trends at the site- or sector-level.

4.3.22. Knot (*Calidris canutus*)

The Northern Irish population of Knot fluctuated significantly between 2001/02 and 2016/17, but from the smoothed trend line it can be seen that there was an overall slight to moderate decline over the period. Dundrum Inner Bay was an important area for Knot in Northern Ireland holding up to 40% of the population, although this significantly fluctuated year on year and fell to below 5% in 2016/17. Trends for Knot declined by over 50% across all time periods in Dundrum Inner Bay. This is mirrored in the two sectors with enough records to draw trends; Green Island (01431) and Channel (01435).

4.3.23. Black-tailed Godwit (*Limosa limosa*)

The Northern Ireland trend for Black-tailed Godwit increased between 2001/02. Although Dundrum Inner Bay only contained a small proportion of that population (approximately 5%) it followed a similar trajectory with a significant increase in numbers of at least 100% across all time periods. There were insufficient data to assess trends at a sector-level.

4.3.24. Bar-tailed Godwit (*Limosa lapponica*)

There were insufficient Bar-tailed Godwit recorded at high-tide in Dundrum Inner Bay to generate trends at the site- or sector-level.

4.3.25. Turnstone (*Arenaria interpres*)

An increase in the Northern Irish population between 2001/02 and 2006/07 was followed by a decline from 2012/13. Dundrum Inner Bay only has a small proportion of this population (<5%) but it has undergone declines of over 50% across all time periods. This is also seen in the only sector where it was possible to derive trends, South Inner Bay (01433).

4.3.26. Curlew (*Numenius arquata*)

There was a steady decline in the Northern Irish wintering Curlew population over the study period. The Dundrum Inner Bay population contributed <5% to the regional population. Although there was an increase in Curlew in Dundrum Inner Bay between 2004/05 and 2011/12, declines up to 2016/17 resulted in steep declines across all time periods, which appeared to be a little more pronounced for the site than for Northern Ireland as a whole. This is largely observed at all four sectors where sufficient data existed, including declines of at least 50% across all time periods at Green Island (01431) and over the short-term at Ardilea and Blackstaff (01432), the two most important sectors by five-year-mean peak.

4.3.27. Redshank (*Tringa tetanus*)

There was a large decline in wintering Redshank in Northern Ireland between 2001/02 and 2016/17. Dundrum Inner Bay (01404) held just under 10% of the regional population although this also declined over the study period, showing a steep decline in the long-term and a moderate decline in the medium- and short-terms. However, the declines at Dundrum Inner Bay appeared to be a little less severe than the region as a whole and may suggest that conditions here are more favourable than some other sites. Across five of the six sectors for which analysis was possible, decline was the predominant trend direction. South Inner Bay (01433) was the most important sector in terms of five-year-mean peak, and its trends mirrored those of the site overall. Green Island (01431) and Ardilea and Blackstaff (01432) were also important sectors, holding over 20% of the five-year-mean

peak counts, both periods of decline and stability across the varying time periods. Only two of the five sectors for which trends could be analysed showed any increase in Redshank; Harbour (01434) over the long-term, and Farm (01436) over the short-term.

4.4. Broad Patterns

4.4.1. Larne Lough

Shelduck and waders

As in Austin et al. (2008) and Ross-Smith et al. (2013), Shelduck and waders are discussed together because all these species feed on mudflat invertebrates, and are therefore likely to respond in similar ways to changes in the environment. Of the seven species considered, five declined over at least one time period in Larne Lough in the 15 winters covered by this report. Nearly all wader species on Larne Lough underwent a decline, with only Curlew and Redshank remaining stable throughout the entire reporting period, although trends varied between the two sectors. Shelduck also underwent a decline in the long term. With the exception of the small numbers of Turnstone in Larne Lough which declined at a slower rate that the regional trend, the species in this group appeared to follow the regional trend. Therefore, while there may not be specific local pressures influencing populations, Larne Lough is not immune to or buffering against regional drivers of decline.

Dabbling ducks

The three species of dabbling ducks for which there was sufficient data to derive trends show a mixed picture. Teal increased whilst Wigeon and Mallard remained mostly stable with a moderate decline in the medium-term for the smaller population of Wigeon. These results are similar to the regional trends for these species so trends for dabbling ducks in Larne Lough may be more explainable at the regional-level than by site-level drivers.

Seaducks, diving ducks and grebes

Both Goldeneye and Great-crested Grebe showed moderate declines during the long-and medium-terms but stabilised in the short-term. Red-breasted Merganser remained stable throughout, while Eider have shown moderate increases in the long- and medium-term stabilising in the short-term. The populations of these species are small in Larne Lough so annual fluctuations in numbers can have big impacts on trends. All species appear to have done better in Larne Lough during this period than in the rest of Northern Ireland, suggesting that local conditions may be more favourable in Larne Lough for this group compared with other sites at the regional-level. However, the exception to this was Eider, which followed the regional trend quite closely.

Swans, geese and other wildfowl

A moderate decline in the medium-term shown by Mute Swan and Light-bellied Brent Goose is the only similarity in their trends. Light-bellied Brent Goose was mostly stable, faring better than the declining Mute Swan, while Greylag Goose saw significant increases in the long- and medium-terms in Inner Larne Lough (014902). There was little to link the trends of these three species, which appeared to largely follow the regional trend, suggesting that local drivers do not have a strong impact on these populations in Larne Lough.

4.4.2. Killough Harbour

Waders

Generally speaking, wader populations appeared to perform better in Killough Harbour than at the regional-level. Four species had substantial increases between 2009/10 and 2011/12 (Curlew,

Lapwing, Redshank and Turnstone) after which they either further increased (Lapwing) or stabilised (Curlew, Redshank and Turnstone). Oystercatchers, while stable in Killough, appeared to be maintaining their population against regional-level losses. These gains and stability in the wader populations of Killough may reflect relatively favourable conditions at this site compared to conditions more broadly in Northern Ireland. However, the loss of Golden Plover at the site and the long-term decline in Dunlin followed Northern Irish trends.

Dabbling ducks

Both Teal and Wigeon increased on Killough Harbour from populations at or near zero in 2000/01. The increase was relatively constant for Wigeon but was particularly pronounced for Teal between 2008/09 and 2011/12 after which is seems to have stabilised until 2015/16, the end of the reporting period. These trends were more positive than the regional-level trend, which suggests that conditions have become favourable in Killough Harbour and remained so over this period for these two species of dabbling ducks.

4.4.3. Dundrum Inner Bay

Shelduck and waders

Many of the species in this group underwent significant declines in all or at least two time periods (long, medium and short), these were Shelduck, Ringed Plover, Golden Plover, Grey Plover, Lapwing, Knot, Turnstone and Curlew. Redshank underwent significant and moderate declines. Oystercatcher and Dunlin remained relatively stable and only Black-tailed Godwit increased. There is variation in how the trends of these species for Dundrum Inner Bay relate to their regional trends. However, most followed similar trajectory i.e. declining: Golden Plover, Grey Plover, Lapwing, Knot, Curlew, Redshank; increasing: Black-tailed Godwit, suggesting that site-level conditions do not have a strong impact relative to regional trends for these species. In contrast, both Knot and Curlew appeared to decline at a greater rate in Dundrum Inner Bay than regionally, whilst the site trends for Oystercatcher and Dunlin were slightly more positive, suggesting that site-level conditions here may play a role in population trends for these species locally.

Dabbling ducks

Wigeon, Mallard and a small population of Teal all followed similar trajectories in Dundrum Inner Bay, with some increases in the long-term but were more generally stable over the reporting period. Wigeon and Mallard fared better on this site than regionally so it may suggest that conditions remain favourable here.

Swans, geese and other wildfowl

The only species with sufficient records to include in this section were Mute Swan and Light-bellied Brent Goose. Very few Mute Swans were recorded in Dundrum Inner Bay and they underwent significant declines against a regional-level stabilisation, whilst the Light-bellied Brent Goose underwent significant increases, increasing in the proportion of the regional total held in the site.

4.5 Broad Patterns in Relation to Aquaculture in Sectors

While there have been a number of studies that showed a negative association between mussel and cockle fisheries on shorebirds (e.g. Atkinson *et al*. 2003; Goss-Custard *et al*. 2004; Smit *et al*. 1998) (although for positive associations, see Caldow *et al.* 2003) there has been little research to date on the impacts of intertidal oyster cultivation on wintering waterbirds, and much of it suffers from limited spatial and temporal scope. It is hypothesised that intertidal oyster cultivation may reduce waterbird (particularly shorebird) abundance by interfering with access to foraging habitat and from disturbance caused by aquaculture husbandry (Ahmed and Solomon 2016). Anthropogenic

disturbances may cause birds to fly away to alternate areas (Goss-Custard et al., 2006; Gittings and O'Donoghue, 2016; Jarrett et al., 2018, 2020) although this may not be the case in all situations (Gill et al., 2001; Collop et al., 2016; Maslo et al., 2020).

Kelly *et al*. (1996) found that the abundance of shorebirds was reduced in areas of intertidal oyster trestles, and likewise Hilgerloh *et al.* (2001) found that while the presence of intertidal oyster trestles did not impact the behaviour of six waterbird species, some species occurred at lower numbers within the trestle area. Wigeon and Brent Geese were also observed feeding on the algae attached to the trestles, but the effect of this was not tested (Hilgerloh *et al.* 2001). However, in both Kelly *et al.* (1996) and Hilgerloh *et al.* (2001), differences in bird abundance may have been the result of habitat differences between the trestle and non-trestle areas. In agreement with these studies, Maslo et al (2020) found waders in Delaware Bay did not avoid oyster trestle areas unless they were being tended, when there was a slight reduction in wader presence, and they did not detect an impact of tended or un-tended oyster trestles on foraging rates. However, closer to home a comprehensive study of intertidal oyster cultivation in the Republic of Ireland, Gittings and O'Donoghue (2012) found that assemblages of birds were different within and outside of trestle areas. In addition it was found that the flocking tendencies of species influenced their aversion to trestle areas; species that feed in small or widely dispersed flocks (e.g. Curlew, Oystercatcher, Redshank, and Turnstone) had a neutral or positive response to trestles, whereas species that forage in large, dense flocks (e.g. Knot, Sanderling, Dunlin, Black-tailed Godwit, Bar-tailed Godwit and Ringed Plover) had an aversion to the trestle areas (Gittings and O'Donoghue 2012). This negative association was thought to be due to the trestle areas interfering with the flocking of these species. Interestingly, the researchers frequently observed Oystercatchers, Dunlin, Bar-tailed Godwit and Redshank feeding within 50-100m of husbandry activity, without appearing to be disturbed.

In the sites covered by this report, only three intertidal oyster farms were recorded as active in the latest available data (2018/19). Because Killough Harbour did not have sector divisions in which to compare trends between sectors with and without active aquaculture, and both sector divisions in Larne Lough were spanned by the same active aquaculture area, sub-site level patterns in trends could not be related to the presence of aquaculture for these sites. Therefore, this section will focus on Inner Dundrum Bay, where one licenced oyster trestle area was active in 2018/19, overlapping two sectors: Green Island (01431) and Harbour (01434) (Figure 2.2.iii).

4.5.1. Dundrum Inner Bay

Short-term trends (2011/12 - 2016/17) in the high tide sectors Green Island (01431) and Harbour (01434) were compared with the short-term trends across the site as a whole (Table 10). While shellfish have been cultivated in Dundrum Inner Bay since the 1980s (Ferreira *et al.,* 2021), due to a lack of information about the length of activity of the licenced area in question, only the short-term trend was considered, as the last known activity of this site was in 2018/19 (data from NIEA). It is assumed that oyster aquaculture occurred throughout the 2011/12 – 2016/17 period. Likewise, no year-to-year tonnage information was available.

Of the species that Murlough ASSI (which includes Dundrum Inner Bay) is important for in an all-Ireland context, there were no short-term trend estimates for Green Island (01431) and Harbour (01434) for: Mute Swan, Shelduck, Red-Breasted Merganser, and Great Crested Grebe (Table 10). In addition, Lapwing, Knot and Curlew did not have a short-term trend for Harbour (01434), having not been recorded enough in this sector to produce trends.

Light-bellied Brent Goose, Oystercatcher, Dunlin and Redshank all had trends that contrasted between the Green Island (01431) and Harbour (01434) sectors, and that also differed from the

overall site trend (Table 10). However, there was no pattern between one sector having a more positive or negative trend than the other across the different species for which this could be compared. We might expect that, if oyster trestles were influencing wintering waterbird abundance at high tide, because the licenced area covered more of Green Island (01431) than Harbour (01434), then we might expect an effect in the same direction, but stronger in Green Island than Harbour. However, as was explored above, we would not necessarily expect consistent impacts between species. Some species have been shown to use oyster trestles as foraging habitat, for example Brent Geese (Hilgerloh et al. 2001), whereas Dunlin may avoid the trestles, which interfere with flocking behaviour (Gittings and O'Donoghue 2012). It also must be noted that recent WeBS low tide data are not available in Dundrum Inner Bay, when the trestles are exposed for 2.5 to 3.5 hr per day (Ferreira *et al.,* 2021). This is when interactions between waterbirds, the trestle area and people accessing the trestles for maintenance and harvesting is more likely to occur.

Therefore, while there did not appear to be a signal in the high tide WeBS trends of the influence of oyster aquaculture on wintering waterbird abundance in Dundrum Inner Bay, this would be better assessed using low tide data, and a more bespoke study of abundance throughout the tidal cycle, focused on the active area itself.

Table 10 High tide short-term trends (taken from Table 7) of wintering waterbirds for Green Island and Harbour sectors overlapping licenced intertidal oyster cultivation in Dundrum Inner Bay, and the site level trend. Red – a decline in numbers of at least 50%; orange – a decline in numbers of at least 25% but less than 50%; white – 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%; grey – insufficient data.

	Green Island (01431)	Harbour (01434)	Dundrum Inner Bay
Mute Swan			
Whooper Swan			
Bewick's Swan			
Light-bellied Brent Goose			
Greylag Goose			
Shelduck			
Wigeon			
Teal			
Mallard			
Pintail			
Pochard			
Red-breasted Merganser			
Goldeneye			
Great Crested Grebe			
Slavonian Grebe			
Cormorant			
Oystercatcher			
Ringed Plover			
Golden Plover			
Grey Plover			
Lapwing			
Dunlin			
Sanderling			
Knot			
Black-tailed Godwit			
Bar-tailed Godwit			
Turnstone			
Curlew			
Redshank			

5. CONCLUSIONS AND RECOMMENDATIONS

Site- and sector-level analysis of WeBS data from Larne Lough, Killough Harbour and Dundrum Inner Bay highlighted areas and species in the loughs with declining trends. Because these sites are important both nationally and internationally for waterbirds (Table 1), it is recommended that further research is conducted into the causes of these declines. Unlike Parts 1 and 2 of this report series, the sites within this report were limited in the number of sector-level trends that could be assessed, with only seven sub-divisions of Dundrum Inner Bay, two in Larne Lough and no sub-divisions in Killough Harbour. For this reason, much of the interpretation had to be focused on site-level trends compared to the regional-level.

Due to the length of time each site had been surveyed for, analyses for each site covered slightly different time periods, which complicates comparison. However, for the 15 species for which sector-level trends in Dundrum Inner Bay (2001/02 – 2016/17) were generated, these appeared to be more commonly in decline than trends for Larne Lough (2004/05 - 2019/20) or Killough Harbour (2000/01 - 2015/16). While Killough Harbour consisted of a single sector, the nine species for which trends could be created were largely increasing or stable, with only Golden Plover in steep decline. Overall, it appeared that conditions in Killough Harbour were favourable relative to other sites, with trends generally more positive than the regional trend during this time period. Larne Lough in contrast was more mixed, with some species groups declining (diving ducks and grebes, waders) and some increasing or remaining largely stable (geese, seaducks, dabbling ducks). However, with the exception of diving ducks and grebes which appeared to be buffered slightly from regional declines, trends across groups tended to follow the regional trend.

The relative importance of different sectors in the sites was not relevant for Killough Harbour or Larne Lough, with only a single and two sectors respectively. However, for Dundrum Inner Bay, areas in the north and south arms of the lagoon, including Green Island, Ardilea and Blackstaff and South Inner Bay, which are characterised by sand and mud flats covered only at high tide, were generally the most important sectors of the site. Given that the count data analysed here are recorded at high tide, these sectors are likely important to birds for roosting between low tides.

To better understand the trends and distribution of foraging waterbirds birds in Larne Lough, Killough Harbour, and Dundrum Inner Bay, counts of WeBS LowTide Count sectors should be prioritised. The objective of the LowTide Count scheme is to quantify the within-site distribution of species over the low tide period as so identify important habitat for feeding waterbirds. Like the Core Counts, this is a volunteer-led scheme. With the support of NIEA, the BTO has made strong headway in bringing more people into biodiversity monitoring and expanding core monitoring schemes in Northern Ireland, and will build on this success over the next five years. Due to their critical importance for wintering waterbirds in Northern Ireland, the sites featured in this report series without current LowTide coverage (Part 1 – Carlingford; Part 2 – Lough Foyle, Part 3 – Larne Lough, Killough Harbour and Dundrum Inner Bay) will be prioritised. In addition to volunteer-led surveys, specific data collection describing how the numbers and behaviour (e.g. feeding, diving, resting) of waterbirds vary through the tidal cycle would be of particular importance, as the tide has a strong influence on both the behaviour of waterbirds in estuaries, and also influences the husbandry activity in intertidal oyster trestle areas.

During the winter of 2021/22, a BTO field study that aimed to quantify disturbance from aquaculture and other sources in Strangford Lough, Carlingford Lough, Larne Lough, Killough Harbour and Dundrum Inner Bay was conducted. The results of this study are in preparation (Haddad et al, *in prep*). However, similarly to this study, inference on the impacts of aquaculture were limited by a lack of detailed information on the activities associated with inter-tidal aquaculture in Northern

Ireland, particularly: hours of activity per tide/day/week/month, number of people and vehicles involved in activities, area of active aquaculture, tonnage, access routes to trestles, and human behaviour in trestle areas. Better information on these factors might be gained in the future through building working relationships and engagement with collaborate with all stakeholders non-government and government to understand more about the specifics of inter-tidal aquaculture, and with on-the-ground staff, for example through events and workshops, which may also provide an opportunity for aquaculture businesses to understand and value the important wintering waterbird species in their farms.

It is important to ensure that the biodiversity of Northern Ireland's sea-loughs is protected while their sustainable use is promoted. Therefore, to build on the findings of this report we recommend continuing to develop more targeted field-based studies to assess the potential impact of disturbance associated with aquaculture activity on waterbirds, including data on specific bird behaviours, building working relationships with aquaculture businesses in areas of ornithological importance to better understand husbandry activity and promote environmental awareness, and to continue to upskill and grow the volunteer surveyor base in Northern Ireland to ensure long-term, high quality low tide data collection at sites of national and international significance to wintering waterbirds.

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Analysis of waterbird population trends for Northern Ireland's sea loughs: assessing the potential impacts of aquaculture and disturbance.

Part 3 – Larne Lough, Killough Harbour and Dundrum Inner Bay

This study reports on the sector-level analysis of Wetland Bird Survey (WeBS) data in Northern Ireland on three of its sea-loughs. This will improve understanding of the fluctuations in numbers of waterbirds within the sites and inform the consenting of operations and assessment of development plans.

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