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Marine Institute Bird Studies

Dungarvan Harbour SPA: Monitoring of waterbird distribution across the tidal cycle.

2018-2019

Lead Agency: Marine Institute

Authors: ATKINS:

Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
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An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

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Foras na Mara
Marine Institute

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Notice

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1. Introduction

Brief

1.1 Atkins (Ecology) was commissioned by the Marine Institute to carry out tidal cycle monitoring of waterbird numbers and distribution at Dungarvan Harbour, Co. Waterford.

1.2 The brief for this work was as follows: -

> *1. This programme will focus on systematic monitoring of bird distribution on Whitehouse Bank (Dungarvan Harbour), specifically in response to a management action to create a single 400m buffer zone among oyster trestle culture sites which was created as a consequence of mitigation recommendations following appropriate assessment of aquaculture in Dungarvan Harbour, Co. Waterford. The programme requires contractors to conduct a series of tidal cycle monitoring focusing specifically on Grey Plover and Dunlin use of the tidal break/corridor. Incidental use of the 'break/corridor' by other bird species should also be documented. The monitoring regime should target two monitoring days per month, during neap and spring low tide. Each monitoring event should cover the full duration of exposure of Whitehouse Bank.*
>
> *2. Monitoring to include the period September 2018 to March 2019, inclusive.*
>
> *3. Prepare a report identifying site-use by the aforementioned species providing a commentary on the effectiveness of the management measure specifically as it relates to species distribution at the site.*

1.3 Due to the seasonal and diurnal pattern of the tidal cycle, and weather constraints, there were limitations to the range of tidal variation that could be covered in this survey.

Context

1.4 This study builds on the monitoring work carried out as part of the oyster trestle study (Gittings and O'Donoghue, 2012) in 2011, the assessment, based on that work, carried out for the Dungarvan Harbour SPA Appropriate Assessment (Gittings and O'Donoghue, 2014) and subsequent monitoring of the distribution of selected waterbird species across the tidal cycle in the winters of 2014/15 (Gittings and O'Donoghue, 2015), 2016/17 (Gittings and O'Donoghue, 2018a) and 2017/18 (Gittings and O'Donoghue, 2018a).

1.5 The Appropriate Assessment found that intertidal oyster cultivation is potentially having significant negative displacement impacts on four of the Special Conservation Interests (SCIs) of the Dungarvan Harbour SPA: namely, Grey Plover (*Pluvialis squatarola*)[1], Knot (*Calidris canutus)*, Dunlin (*Calidris alpina*) and Bar-tailed Godwit (*Limosa lapponica*). These species are referred to, hereafter as the target species. In the case of Grey Plover, Knot and Dunlin, the main displacement impact appeared to be exclusion of most, or all, birds from Whitehouse Bank during the low tide period when the tideline is within the zone occupied by the oyster trestles; the evidence for this was the occurrence of large flocks of these species in the upper shore zone of Whitehouse Bank on the rising/falling tide, before/after the tideline reached the trestles. In the case of Bar-tailed Godwit, the density of birds on Whitehouse Bank is much lower than the density on the Ballyrandle Sandflats,

[1] Referred to by the common name Black-bellied Plover in North American literature.

despite the two areas being broadly similar intertidal biotopes (however, there is some evidence that there may be differences in food resources between the two areas).

1.6 The monitoring studies in 2014/15, 2016/17 and 2017/18 used tidal cycle counts to record the movement of the target species onto/off Whitehouse Bank on the ebb/flood tide and the distribution of the target species across Dungarvan Harbour at low tide. In the first season of monitoring work, we found evidence of a marked decrease in the utilisation of Whitehouse Bank by Grey Plover at low tide over recent winters and this may have been linked to changes in the configuration of the trestles that eliminated the trestle-free corridors that had been present on Whitehouse Bank. Arising from the results of this study, a reorganisation of aquaculture licences was carried out, as part of the process of approving licence renewals and new applications. This reorganisation was designed to create a trestle-free corridor (the *Bird Corridor*) approximately 400 m wide in a section of Whitehouse Bank where Grey Plover had been recorded at low tide in the 2011 trestle study.

1.7 The Bird Corridor was established in the summer of 2016, although the last trestles were not removed from it until October 2017. In addition to snapshot counts of the Bird Corridor during the low tide component of the tidal cycle counts, the Bird Corridor was continuously monitored throughout the low tide period on four days in March 2017 and 15 days between September 2017 and March 2018 to provide more detailed data on bird usage of the Bird Corridor, and disturbance impacts from husbandry activities. The occurrence of target species in the Bird Corridor was erratic. On some days, large flocks of one or more target species remained in the Bird Corridor throughout most of the low tide period. On other days, the target species only occurred for brief periods and/or only towards the end of the low tide period, while there were also days on which all the target species were largely absent from the Bird Corridor. There was some evidence that their occurrence in the Bird Corridor may be affected by disturbance from husbandry activity, although the evidence was inconclusive and the apparent relationship may have been an artefact.

1.8 Building on the results of the previous monitoring work, the 2018/19 monitoring included two components. The tidal cycle counts were continued to provide comparable data to previous winters, with a total of eight counts carried out. The Bird Corridor monitoring was continued with a total of 12 counts carried out.

1.9 As in previous winters, data was also collected on an additional four species: Light-bellied Brent Goose (*Branta bernicla hrota*), Ringed Plover (*Charadrius hiaticula*), Golden Plover (*Pluvialis apricaria*) and Sanderling (*Calidris alba*). These species are referred to as the additional monitored species. Light-bellied Brent Goose is a SCI of the Dungarvan Harbour SPA, and while it appears to have a neutral/positive association with oyster trestles at Dungarvan Harbour, it can show an apparent negative association with oyster trestles at other sites (Gittings and O'Donoghue, 2012). Golden Plover is a SCI of the Dungarvan Harbour SPA, and there is some indication of potential displacement impacts from oyster trestles on its population in Dungarvan Harbour. Ringed Plover and Sanderling are not SCIs of the Dungarvan Harbour SPA, but occur in numbers close to national importance levels, and are species that appear to show a strong negative response to oyster trestles. Data was collected on these two species to inform potential future requirements for Environmental Impact Assessment (EIA) of any new applications for intertidal oyster licensing in Dungarvan Harbour (as EIA requirements are not restricted to SCI species). In addition, this data can be used to inform future appropriate assessments of other coastal SPAs where these species are SCIs.

1.10 The data collected on the additional monitored species is included in Appendix A of this report, but is not analysed or discussed here.

Limitations

1.11 The decisions of waders to utilise areas for feeding, and the timings of movements between areas, will usually be based on the availability of suitable food resources and the density of potential competitors. Therefore, detailed information on benthic invertebrates would be required to fully analyse wader distribution patterns, and the potential displacement impacts of intertidal oyster cultivation, in Dungarvan Harbour.

1.12 The configuration of the oyster trestle blocks on Whitehouse Bank is subject to ongoing change. The accuracy of mapping available to the contract also impacts on the accuracy of the recording of the tideline position at low tide on Whitehouse Bank.

Personnel

1.13 The survey design, analysis and report writing was carried out by Tom Gittings. Paul O'Donoghue assisted with project design, document preparation and undertook document review. The fieldwork was carried out by Darío Fernández-Bellon, Tom Gittings, Lesley Lewis, John Meade and Pat Smiddy. Data entry was carried out by Siobhán Gallagher.

2. Methods

Study area and count sectors

2.1 Dungarvan Harbour was divided into three broad zones by Gittings and O'Donoghue (2014) for the purposes of broad-scale analyses of waterbird distribution: the Inner Harbour, the Outer Sandflats and the Outer Bay (Figure 2.1). The Outer Sandflats were also divided into two sub-zones: the Ballyrandle Sandflats and Whitehouse Bank. For the present monitoring work, the Inner Harbour zone was divided into two sub-zones: the Inner Harbour (main) and the Inner Harbour (upper). This division reflects the distribution patterns of the target species, which rarely occur in the Inner Harbour (upper).

2.2 The Bird Corridor is a 400 m wide corridor extending from the upper to the lower edges of the oyster trestle zone in the northern part of sector OY2 (Figure 2.2).

2.3 The study area for the tidal cycle counts was: Whitehouse Bank and the eastern section of the Inner Harbour (main) for the ebb and flood tide counts; and the Outer Sandflats and the Inner Harbour for the low tide counts. The Bird Corridor monitoring was carried out within Whitehouse Bank and covered the Bird Corridor, as well as sectors CS1 and CS2 on the ebb and flood tide. The Inner Harbour monitoring covered most of the Inner Harbour (main).

2.4 The count sectors used in this study are shown in Figure 2.1. In the Ballyrandle Sandflats and Whitehouse Bank, the counts used the sectors defined for the trestle study (Gittings and O'Donoghue, 2012). However, sector OY2 was subdivided between the Bird Corridor and the remaining area of the sector. In the Inner Harbour, the counts used the NPWS Waterbird Survey Programme subsites.

2.5 The oyster trestles occur within the lower part of Whitehouse Bank (sectors OY1-OY4; Figure 2.1). The most recent mapping available of the trestles across the whole of Whitehouse Bank is from the summer of 2014, which was provided by the Department of Agriculture, Fisheries and the Marine. However, the trestles in, and around, the Bird Corridor were mapped by GPS by Tom Gittings in October 2017.

Survey design

Tidal cycle counts

2.6 The survey included three components: -

- Ebb tide counts: a series of four counts at 30 minute intervals across the ebb tide period, focussing on Whitehouse Bank and the adjacent area of the Inner Harbour (main).
- Low tide count: a single low tide count covering the Inner Harbour, Ballyrandle Sandflats and Whitehouse Bank.
- Flood tide counts: a series of four counts at 30 minute intervals across the flood tide period, focussing on Whitehouse Bank and the adjacent area of the Inner Harbour (main).

2.7 On the ebb and flood tide counts, the objective was to achieve complete coverage of Whitehouse Bank. The counts of the adjacent area of the Inner Harbour (main) covered (approximately) the sections of 0M419 and 427 to the east of the main tidal channel. However, the objective of these

latter counts was to record positions that birds moving to/from Whitehouse Bank came from, or moved to, and the counts were not intended to provide accurate data on the bird numbers in the Inner Harbour (main).

2.8 The count periods are shown in Table 2.1. The ebb and flood tide counts covered the periods when the tideline was above the trestle zone but below the top of the beach. The low tide count covered the main period when the tideline was within, or below, the trestle zone. The 30 minute gaps between the end of the ebb counts and start of the low tide count, and between the end of the low tide count and the start of the flood tide counts, allowed time for the counters covering the Inner Harbour and Ballyrandle Sandflats to travel between these areas and Whitehouse Bank.

2.9 Note that the numbering of the ebb tide counts in this report follows that used for the 2016/17 and 2017/18 surveys (Gittings and O'Donoghue, 2018a, 2018b), which differs from that used for the 2014/15 survey (Gittings and O'Donoghue, 2015). The counts numbered EBB0-EBB3 in Gittings and O'Donoghue (2015) are now numbered EBB1-EBB4. The count numbered EBB4 in Gittings and O'Donoghue (2015) corresponds to the 30 minute interval between the count numbered EBB4 in this report and the start of the low tide period.

Table 2.1 - Count periods used for the tidal cycle counts.

Period	Count	Start time	Finish time
Ebb tide	EBB1	-04:00	-03:30
	EBB2	-03:30	-03:00
	EBB3	-03:00	-02:30
	EBB4	-02:30	-02:00
Low tide	LT	-01:30	+01:30
Flood tide	FLOOD1	+02:00	+02:30
	FLOOD2	+02:30	+03:00
	FLOOD3	+03:00	+03:30
	FLOOD4	+03:30	+04:00

All times are relative to low tide.

Bird corridor monitoring

2.10 The main objective of the Bird Corridor monitoring was to continuously monitor the Bird Corridor throughout its period of tidal exposure. In addition, monitoring of the adjacent areas of the upper shore was carried out on the ebb and flood tides to help understand movement patterns of birds onto/off the Bird Corridor.

2.11 Counts were generally carried out at 30 minute intervals from four hours before low tide to four hours after low tide (Table 2.2), although full sets of ebb and flood tide counts were not completed on all the dates (see footnotes to Table 2.2).

2.12 During the period when the Bird Corridor was exposed (usually EBB5-FLOOD0 counts), all waterbirds within the Bird Corridor were counted. The ebb and flood tide counts outside that period only covered the target species and the additional monitored species within sectors CS1 and CS2 (and OY1-OY3 for Light-bellied Brent Goose).

Table 2.2 - Count periods used for the Bird Corridor monitoring.

Period	Count	Start time	Finish time
Ebb tide	EBB1	-04:00	-03:30
	EBB2	-03:30	-03:00
	EBB3	-03:00	-02:30
	EBB4	-02:30	-02:00
	EBB5	-02:00	-01:30
Low tide	LT1	-01:30	-01:00
	LT2	-01:00	-00:30
	LT3	-00:30	00:00
	LT4	00:00	+00:30
	LT5	+00:30	+01:00
	LT6	+01:00	+01:30
Flood tide	FLOOD0	+01:30	+02:00
	FLOOD1	+02:00	+02:30
	FLOOD2	+02:30	+03:00
	FLOOD3	+03:00	+03:30
	FLOOD4	+03:30	+04:00

All times are relative to low tide.

Count dates and timings

2.13 The tidal cycle counts were carried out on eight dates between October 2018 and March 2019 (Table 2.3). The selection of count dates to allow full tidal cycle counts was constrained by the need to have a low tide in the middle of the day. In midwinter, with the short day length, this meant that there were only a few suitable dates each month. As the timing of the low tide is broadly linked to the spring-neap cycle, this further constrained the range of tidal conditions that could be sampled. The counts were carried out on days with low tides of 0.2-0.8 m (Table 2.3), representing spring-mean low tides (mean low water spring = 0.4 m; mean low tide = 0.75 m).

Table 2.3 - Count dates and timings for the tidal cycle counts.

Date	Low tide		Count timings		
	time	height	Ebb	LT	Flood
24/10/2018	12:16	0.6	08:15-10:15	10:45-13:41	14:15-16:15
10/11/2018	13:13	0.6	09:15-11:15	11:45-14:36	15:15-17:15
07/12/2018	11:42	0.6	07:45-09:45	09:54-13:05	13:45-15:45
08/01/2019	13:05	0.8	09:05-11:05	11:35-14:29	15:05-17:05
23/01/2019	13:27	0.3	09:25-11:25	11:55-15:15	15:25-17:25
07/02/2019	13:15	0.7	09:15-11:15	11:45-14:17	15:15-17:15
22/02/2019	13:53	0.2	09:50-11:50	12:20-15:20	15:50-17:50
07/03/2019	12:22	0.5	08:20-10:20	10:50-13:16	14:20-16:20

Low tide data source: Admiralty tidal predictions for Dungarvan (www.ukho.gov.uk/easytide).

2.14 The Bird Corridor monitoring counts were carried out on thirteen dates between September 2017 and March 2018 days with low tides of 0.3-1.0 m (Table 2.4). However, one of these counts was incomplete because it had to be abandoned due to heavy fog.

Table 2.4 - Count dates and timings for the Bird Corridor counts.

Date	Low tide		Count timings		
	time	height	Ebb	LT	Flood
11/09/2018	13:43	0.3	10:00-12:10	12:10-15:10	15:10-17:19
24/09/2018	12:16	0.6	08:00-10:30	10:30-13:30	13:30-16:00
28/09/2018	14:26	0.6	10:15-12:45	12:45-15:45	15:45-18:15
09/10/2018	12:41	0.2	08:55-11:10	11:10-14:10	14:10-16:10
23/10/2018	11:43	0.6	08:15-10:15	10:15-13:15	13:15-15:15
13/11/2018	15:05	1.0	11:15-13:35	13:35-16:35	16:35-16:35
24/11/2018	12:12	0.5	08:10-10:40	10:40-13:40	13:40-16:10
10/12/2018	13:25	0.8	09:35-11:55	11:55-14:55	14:55-15:55
07/01/2019	12:35	0.7	09:05-11:05	11:05-14:05	14:05-16:15
22/01/2019	12:40	0.3	08:55-11:10	11:10-14:10	14:10-16:25
06/02/2019	12:46	0.7	09:05-11:15	11:15-14:15	14:15-16:00
24/02/2019	15:22	0.4	12:00-13:50	13:50-14:05	no counts
06/03/2019	11:57	0.6	08:30-10:25	10:25-13:25	13:25-15:15

Low tide data source: Admiralty tidal predictions for Dungarvan (www.ukho.gov.uk/easytide).

Count abandoned during the LT period on 24/02/2019 due to heavy fog and LT2-FLOOD4 counts not carried out. EBB1 count not carried out on 23/10/2018. 07/01/2019, 24/02/2019 and 06/03/2019. FLOOD1-FLOOD4 counts not carried out on 13/11/2018. FLOOD3-4 counts not carried out on 10/12/2018. FLOOD4 count not carried out on 06/02/2019 and 06/03/2019.

Counter organisation

2.15 All the tidal cycle counts were carried out with three counters. The areas covered by each counter on each count are shown in Table 2.5. The coverage arrangements were modified slightly from those used in previous winters to allow the direction of the low tide coverage of Whitehouse Bank to be alternated between working from the north to the south and working from the south to north[2]. Therefore, the coverage arrangements alternated between the two coverage sequences shown in Table 2.5 (i.e., the first, third, fifth and seventh tidal cycle counts used coverage sequence 1, while the second, fourth, sixth and eight used coverage sequence 2).

2.16 All the Bird Corridor monitoring counts were carried out by a single counter (Pat Smiddy on 24th and 28th September and 24th November 2018; Tom Gittings on all the other dates).

Count methodology

2.17 The tidal cycle counts were mainly carried out from shoreline vantage points, apart from the low tide count on Whitehouse Bank. In the latter case, the trestle blocks obscured the detection of birds from shoreline vantage points. Instead, these counts were carried out by walking a transect roughly parallel to, and a few 100 m above, the tideline, and carefully scanning along each row of trestles. As most birds occur on, or close to, the tideline, and the birds are habituated to the presence of humans through husbandry activity, it was possible to carry out counts in this way without causing significant disturbance.

[2] Note this coverage arrangement was also used for the final three tidal cycle counts in 2017/18.

Table 2.5 – Coverage of the tidal cycle counts.

Period	Counter	Coverage sequence 1	Coverage sequence 2
Ebb tide	Lesley Lewis	Whitehouse Bank (CS1)	Whitehouse Bank (CS2) and eastern side of Inner Harbour (main)
	Tom Gittings	Whitehouse Bank (CS3) and eastern side of Inner Harbour (main)	Whitehouse Bank (CS1)
	Pat Smiddy	Whitehouse Bank (CS2) and eastern side of Inner Harbour (main)	Whitehouse Bank (CS3) and eastern side of Inner Harbour (main)
Low tide	Lesley Lewis	Ballyrandle Sandflats and sectors 0M423-424 in Inner Harbour (upper)	
	Tom Gittings	Whitehouse Bank (north to south)	Whitehouse Bank (south to north)
	Pat Smiddy	Inner Harbour (main) and sectors 0M412-414 in Inner Harbour (upper)	
Flood tide	Lesley Lewis	Whitehouse Bank (CS2) and eastern side of Inner Harbour (main)	Whitehouse Bank (CS1)
	Tom Gittings	Whitehouse Bank (CS1)	Whitehouse Bank (CS3) and eastern side of Inner Harbour (main)
	Pat Smiddy	Whitehouse Bank (CS3) and eastern side of Inner Harbour (main)	Whitehouse Bank (CS2) and eastern side of Inner Harbour (main)

John Meade counted the sections normally covered by Lesley Lewis on 10/11/2018. Darío Fernández-Bellon counted the sections normally covered by Lesley Lewis on 23/01/2019.

2.18 The Bird Corridor counts were mainly carried out from shoreline vantage points. The counts of the Bird Corridor during its period of exposure (EBB5-FLOOD0 counts) were carried out from the Whitehouse Bank car park (Figure 2.2), which provides a view line approximately down the middle of the Bird Corridor. On the EBB1-EBB4 and FLOOD1-FLOOD4 counts, the counts were carried out from the shoreline to the east of the car park at a position that provided views of the upper shore on both sides of the Bird Corridor (Figure 2.2).

2.19 On each tidal cycle count, all the target species, and additional monitored species, present were counted. Birds were counted separately in each count sector and in the two sub-divisions of sector OY2. In addition, on the low tide count, all waterbird species in sectors OY1 and OY2 (including the Bird Corridor) were counted.

2.20 During the Bird Corridor monitoring counts, all waterbird species in the Bird Corridor were counted on counts when the Bird Corridor was exposed (usually the EBB5-FLOOD0 counts). The counts took place at the start of each count period and normally took 5-10 minutes to complete. For the remainder of each count period, the Bird Corridor was monitored and any arrivals or departures of the target and additional monitored species (excluding Light-bellied Brent Goose) were recorded. The EBB1-EBB4 and FLOOD1-FLOOD4 counts covered the target and additional monitored species within sectors CS1 and CS2 (and OY1-OY3 for Light-bellied Brent Goose). Some of the counts for CS2 were of low accuracy due to the distances involved.

2.21 During the tidal cycle and Bird Corridor monitoring counts, counters also recorded the behaviour of the birds (feeding or roosting/other), whether birds were in subtidal habitat, on the tideline, or in intertidal habitat away from the tideline, and whether birds were within, or outside, trestle blocks. The counters also mapped the main flock locations during each count, and recorded details of any observations of bird movements between sectors.

2.22 The counters mapped the tideline positions during each ebb/flood tide count, and (on Whitehouse Bank) during the low tide counts. On the ebb/flood tide counts the red buoys on Whitehouse Bank were used to guide the mapping of the tideline positions. On the low tide tidal cycle counts, the percentage of the tideline within the trestle blocks in each count sector was estimated (by recording the distances of trestle blocks and/or trestle-free areas along the transect route).

2.23 On each count day, the number of tractors in each count sector on Whitehouse Bank was counted at 30 minute intervals centred on low tide throughout their period of occurrence. The tractors were classified as working (parked or active within the trestles), travelling (moving between trestle blocks), arriving (arriving on the beach), or leaving (leaving the beach). During the Bird Corridor monitoring counts, the tractor counts only covered part of sector OY2 and did not cover sector OY1, due to the position of the vantage point used during the low tide period. Also, during these counts, the number of tractors within 250 m of either side of the Bird Corridor was also counted. These latter counts did not include tractors that had been parked within these zones but had no associated husbandry activity.

2.24 The counters also recorded the nature and location of any other human activity within the intertidal zone, and recorded the weather conditions during the counts.

2.25 Detailed recording instructions were provided to the counters and the count data was recorded on standard recording forms and maps.

Data processing

2.26 All count data was entered into Excel spreadsheets and the Whitehouse Bank low tide tideline positions were digitised in QuantumGIS shapefiles. In line with internal quality assurance, we double-checked the spreadsheet and shapefile data against the original count forms to pick up any errors in data entry.

2.27 The notes on bird movements, and the timings of counts, were reviewed to identify potential double-counts. Where double-counts were identified, these were excluded from calculations of count totals.

Data analyses

Distribution of birds at low tide in relation to the presence of oyster trestles

2.28 The distribution of birds at low tide in relation to the presence of oyster trestles was analysed by comparing the observed numbers within oyster trestle blocks with the numbers that would be predicted if the birds were distributed evenly throughout suitable habitat, and were not affected by the presence of oyster trestles. These analyses were restricted to Bar-tailed Godwit, as Dunlin distribution patterns in 2018/19 violated the assumptions required for this analysis, and Grey Plover and Knot never occurred within the trestle blocks during the tidal cycle counts.

2.29 These analyses were based on the methodology used in the trestle study (Gittings and O'Donoghue, 2012). However, because up to date mapping of the trestle configuration on Whitehouse Bank was not available, the methodology was modified to use data on the proportion of tideline within oyster trestles only. In the Outer Sandflats zone, Bar-tailed Godwit mainly occurred on, or close to the tideline: on the six tidal cycle counts, 92-100% (mean 98%) of the Bar-tailed Godwits were on the tideline. Therefore, we considered that the tideline length provided a reasonable representation of the availability of suitable habitat, and calculated the expected number of birds in areas of oyster trestles using the following formula:

Expected number = total number * proportion of tideline within oyster trestles

2.30 We only included counts with totals of ten or more birds in these analyses. We carried out two analyses: one using all the relevant sectors within the Outer Sandflats zone (all sectors analysis) and the other using only the relevant sectors on Whitehouse Bank (close sectors analysis). The relevant sectors were CN1-CN5 in Ballyrandle Sandflats, and OY1-OY4 on Whitehouse Bank. CN6 in Ballyrandle Sandflats was excluded as this sector is largely occupied by mixed sediment habitat

(and was not included in the trestle study). CS1-CS4 on Whitehouse Bank were excluded because these sectors are usually not used by Bar-tailed Godwit at low tide: CS1-CS3 are upper shore areas which are largely empty of birds at low tide, while CS4 is an area of sandflat adjacent to the main tidal channel which is little used by waterbirds.

2.31 The tideline lengths within, and outside, the trestle blocks in the relevant areas on Whitehouse Bank were calculated from the tidelines mapped during the low tide counts and the estimated proportions of the tidelines that were within the trestle blocks. In calculations of tideline length we also excluded the narrow sandbanks that are exposed below the main tideline in sector OY1: these sandbanks have steeply shelving shorelines, and, therefore, do not provide much tideline habitat.

2.32 The tideline lengths within the relevant areas on Ballyrandle Sandflats were derived from the mapping of tidelines carried out for the AA report (see Appendix D in Gittings and O'Donoghue, 2014a). This mapping provides tideline alignments and lengths for representative low tides from extreme neap to spring tide conditions. For each count day, we selected the tideline length for the appropriate tidal condition.

2.33 We then compared the observed number with the expected number. We used scatter graphs to assess the relationship between observed and expected numbers.

2.34 We also used an adapted version of Jacobs Index (Jacobs, 1974) to compare the predicted and observed occurrence of birds within trestle blocks on each count. The index is defined as:

$$D = r - p / (r + p - 2rp)$$

2.35 D can vary from -1 (indicating complete avoidance) to +1 (strong preference). We defined r as the proportion of the total count recorded within the trestle blocks and p as the predicted number within the trestle blocks divided by the total count. We calculated index values for each count with predicted numbers of ten or more. To examine the overall pattern of association we calculated the mean index value across all counts (with expected numbers < 10) in each dataset (all sectors and close controls in the extensive study and the intensive study). We examined the correlations between index values and total numbers in case the pattern of association was affected by the numbers present.

Other analyses

2.36 The patterns of husbandry activity on Whitehouse Bank were assessed by calculating tractor minutes, where each tractor on each tractor count represent 15 tractor minutes (tractors arriving or leaving), or 30 tractor minutes (tractors travelling or working)

2.37 The patterns of bird numbers on Whitehouse Bank, and bird movements onto/off Whitehouse Bank, during the ebb and flood tide periods was compared to the movement of the tideline on Whitehouse Bank, and in the adjacent section of the Inner Harbour, to identify whether birds occurrence on Whitehouse Bank was related to either the tideline reaching the trestle zone, or the exposure of intertidal habitat in the Inner Harbour.

2.38 To quantify the overall usage of the Bird Corridor by the target species, we calculated the total bird-minutes per day for each species in the Bird Corridor as the product of the number of birds present and the duration for which they remained in the Bird Corridor. For Grey Plover and Dunlin which mainly occur in the Inner Harbour at low tide, and for which the extent of suitable low tide habitat in the Inner Harbour is more or less constant across the low tide period, we compared the usage of the Bird Corridor with the estimated usage of the Inner Harbour. The latter was calculated by first estimating the total Dungarvan Harbour population present on each Bird Corridor monitoring day via interpolation from the tidal count data. We then multiplied this figure by the mean percentage of

the low tide count that occurred in the Inner Harbour (from Table 3.7) to obtain the estimated number of birds occurring in the Inner Harbour. Finally we multiplied the latter figure by 240 to represent the duration of exposure of the Bird Corridor. We did not carry out similar analyses for Bar-tailed Godwit and Knot. Bar-tailed Godwit mainly occurs in Ballyrandle Sandflats at low tide and it is more difficult to quantify the area of suitable habitat here as it constantly changes over the low tide period with the movement of the tideline. Knot has a variable distribution pattern at low tide.

2.39 The usage of the Bird Corridor relative to the usage of the Inner Harbour by Grey Plover and Dunlin was compared with the extent of suitable habitat in the two areas. The exposure of intertidal habitat in the Bird Corridor varies continuously across the low tide period. The maximum area exposed at low tide as mapped during the Bird Corridor monitoring varies from around 25-35 ha. Therefore the mean area exposed across the low tide period was taken to be 15 ha. The area of suitable low tide habitat in the Inner Harbour was estimated from flock mapping of Grey Plover and Dunlin during the low tide counts. As extent of intertidal habitat exposed does not change significantly over the low tide period in the Inner Harbour, no adjustments needed to be made for exposure period.

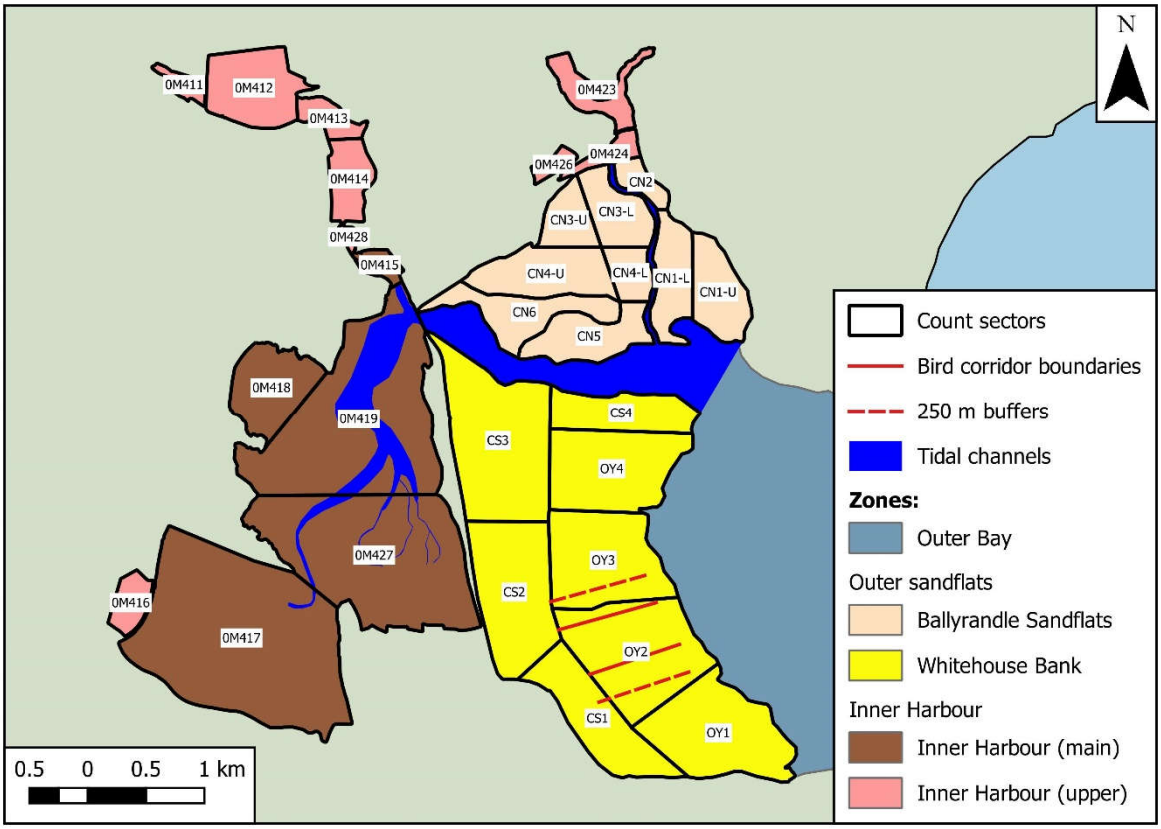


Figure 2.1 – Zones and count sectors.

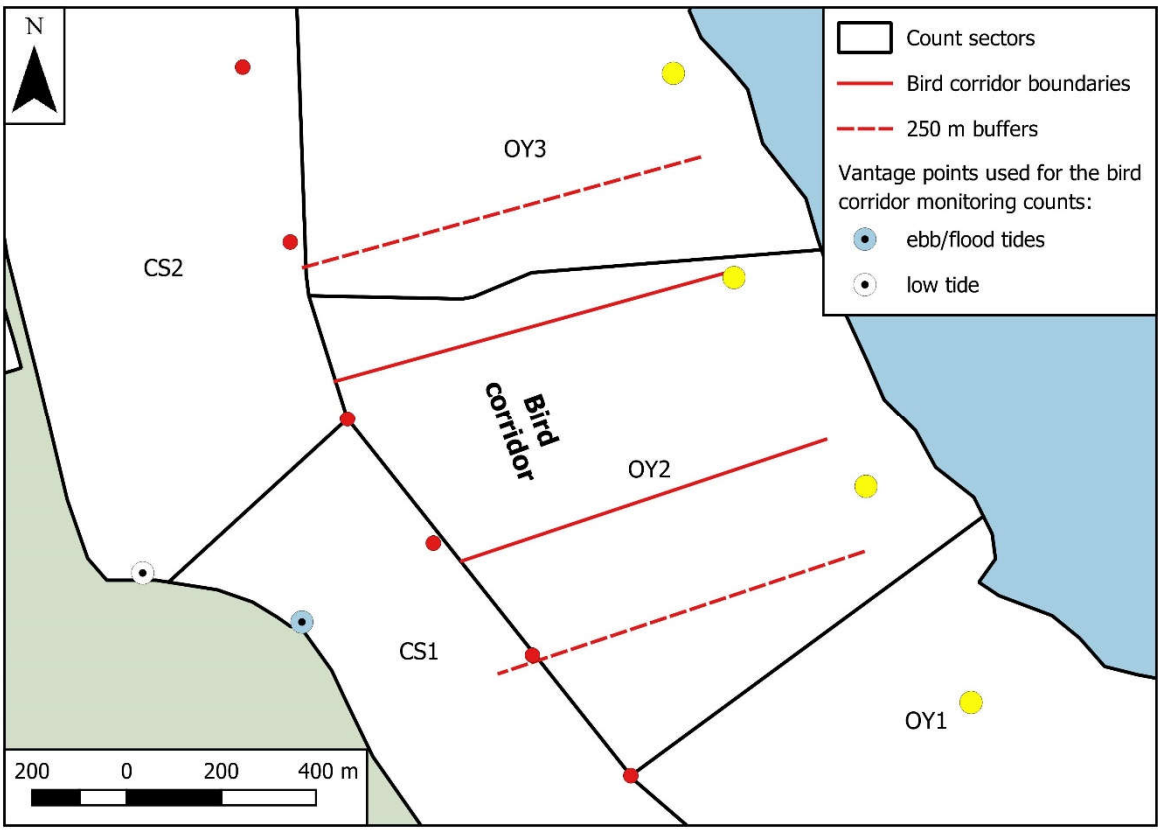


Figure 2.2 – Bird corridor.

3. Results: Tidal cycle counts

Introduction

3.1 This chapter presents the results of the 2018/19 tidal cycle counts for the target species, excluding the data on their occurrence in the Bird Corridor which is included in Chapter 4. Where relevant, comparisons are made with similar data from previous winters.

3.2 The results of the tidal cycle counts for the additional monitored species are included in Appendix A.

Oyster cultivation activity

3.3 The most recent trestle mapping available from DAFM is from the summer of 2014. However, Google aerial imagery from June 2018 provides more up to date mapping of the trestle configuration on Whitehouse Bank (Figure 3.1-Figure 3.4) and we consider this imagery to provide a good representation of the trestle configuration during the winter of 2018/19.

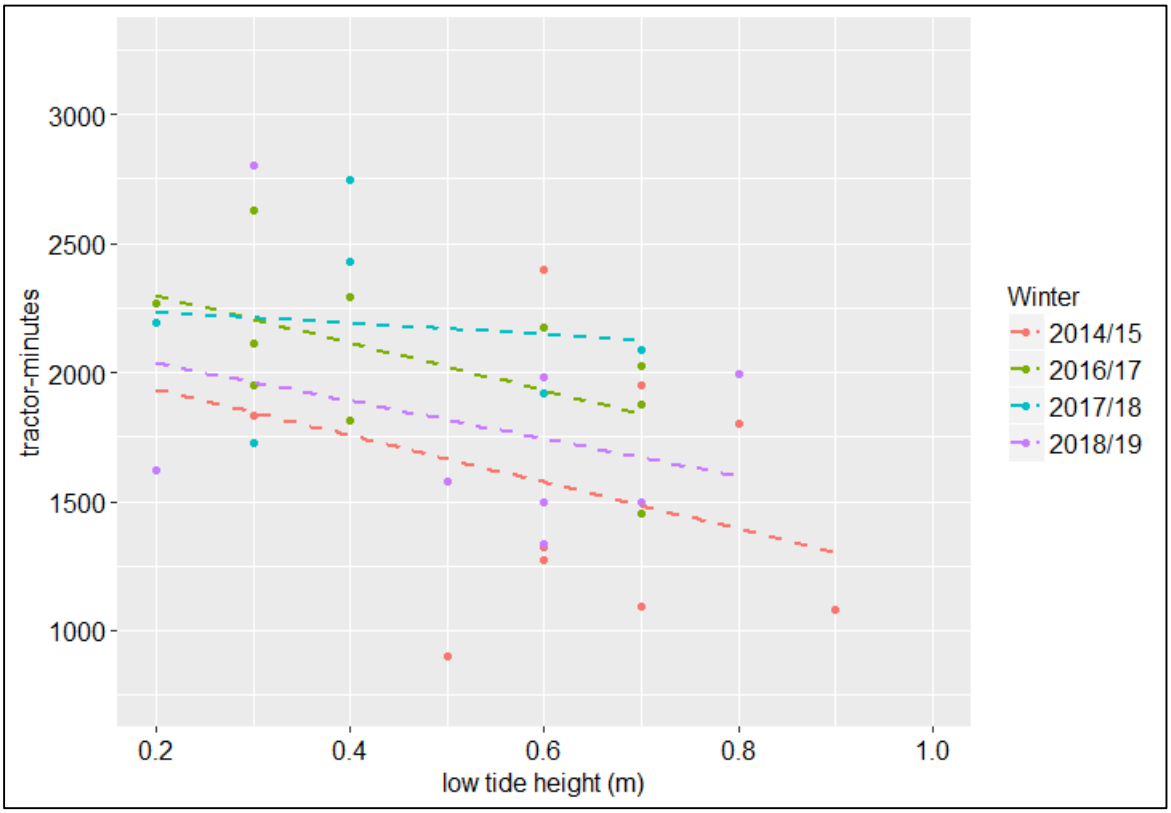
3.4 Comparison of the June 2018 aerial imagery with the trestle mapping from 2014, shows a significant expansion of trestle occupancy along the lower shore in sector OY1 (Figure 3.1), the clearance of trestles from the Bird Corridor in sector OY2 (Figure 3.2), substantial expansion of trestle occupancy in the mid and upper shore in sector OY3 (Figure 3.3), and expansion of trestles into the newly licensed sites at the northern end of sector OY4 (Figure 3.4).

3.5 There was a mean of 1,789 (range 1,335-2,805) tractor minutes per count day in the winter of 2018/19, compared to 2,182 (range 1,920-2,745) in the winter of 2017/18, 2,060 (range 1,455-2,625) in the winter of 2016/17 and 1,584 (range 900-2,400) in the winter of 2014/15. Across all these winters, tractor minutes per count day were negatively correlated with the low tide height (Spearman's $r = -0.426$, one-sided $p = 0.006$, $n = 34$). Therefore, as the mean low tide height per count day was lower in 2017/18 and 2016/17 compared to 2014/15 and 2018/19 (0.43 m in 2017/18 and 0.46 m in 2016/17, compared to 0.54 in 2018/19 and 0.59 in 2014/15), a higher mean level of tractor activity would have been expected in 2017/18 and 2016/17, compared to 2018/19 and 2014/15.

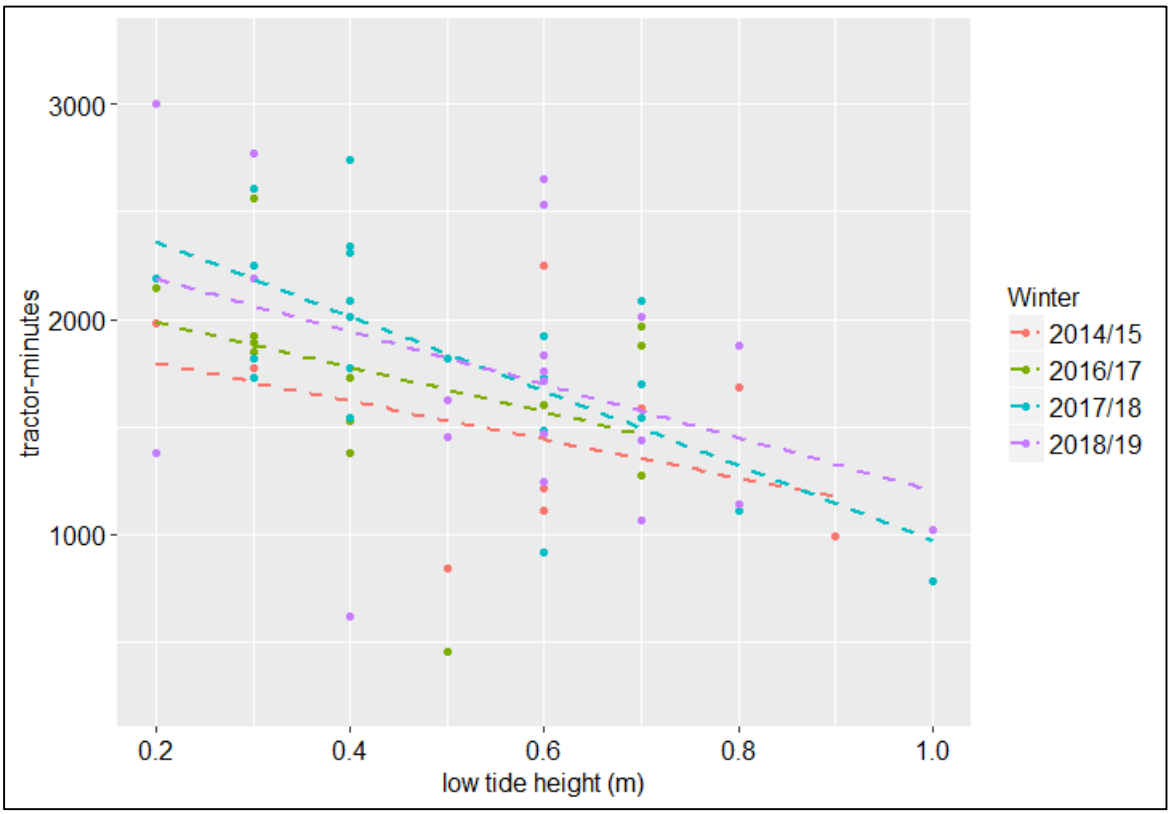
3.6 Text Figure 3.1 shows the relationship between tide height and tractor minutes in each of the four winters. The trend lines fitted to the 2014/15, 2016/17 and 2018/19 datasets had similar slopes but the *y* intercept was higher in 2016/17 compared to 2014/15 and 2018/19 (Text Figure 3.1). The 2017/18 dataset shows a different relationship between tide height and tractor minutes, but both the 2017/18 and 2018/19 datasets are smaller than 2014/15 and 2016/17 due to the lower number of tidal cycle counts in those winters.

3.7 Inclusion of data from the Bird Corridor monitoring counts increases the sample sizes of the 2017/18 and 2018/19 datasets. These counts did not cover sector OY1. However, in the tidal cycle counts, the tractor minutes in OY2, OY3 and OY4 were strongly correlated with the total tractor minutes Spearman's $r = 0.946$, one-sided $p < 0.001$, $n = 34$). Text Figure 3.1 shows the relationship between tide height and tractor minutes including data from the Bird Corridor monitoring counts and excluding the data from sector OY1. In this analysis, the trend lines for the 2014/15, 2016/17 and 2018/19 are all very similar, with increasing y intercepts across the three winters. The trend line for the 2017/18 winter is also negative, with the highest y intercept, but has a steeper slope.

3.8 Overall, these analyses indicate an increasing level of tractor activity at Dungarvan Harbour.



Text Figure 3.1 – Relationship between tractor activity in all sectors and low tide height using data from the tidal cycle counts.



Text Figure 3.1 – Relationship between tractor activity in sectors OY2-OY4 and low tide height, using data from the tidal cycle and Bird Corridor monitoring counts.

3.9 Tractor activity usually occurred from 150-120 minutes before low tide to 90-120 minutes after low tide, with the highest levels of activity between around 75 minutes before low tide and 45 minutes after low tide, and with similar activity patterns across all four winters included in the dataset (Table 3.1). Overall, across the four winters, there was more tractor activity before low tide (mean percentage of total activity = 52%, range = 37-73%) compared to after low tide (mean percentage of total activity = 31%, range = 4-46%), and there were only four count days on which more tractor activity occurred after low tide.

Table 3.1 – Distribution of tractor activity across the tidal cycle, shown as the mean percentage of tractor minutes per count day at 30 minute intervals.

Winter	Minutes before/after low tide								
	≤ -120	-90	-60	-30	0	+30	+60	+90	≥ +120
2014/15	6%	10%	17%	19%	19%	14%	9%	5%	1%
2016/17	6%	11%	16%	17%	16%	14%	11%	6%	4%
2017/18	11%	11%	15%	15%	14%	14%	10%	6%	4%
2018/19	8%	15%	16%	19%	18%	10%	8%	4%	3%
Overall	8%	12%	16%	17%	16%	13%	10%	5%	3%

Each data column in this table, apart from the end columns, represent a 30 minute period centred on the time given; e.g., -90 minutes before low tide represents the period from -115 to -75 minutes before low tide.

Waterbird numbers

3.10 The total numbers of the target species recorded across the ebb, low tide and flood tide periods on each count day are shown in Table 3.2. The low tide counts covered a larger area than the ebb and flood tide counts and would, therefore, be expected to record the highest numbers. However, this was not always the case.

Tidal cycle distribution

3.11 The counts of the target species across the tidal cycle on Whitehouse Bank are shown in Table 3.3.

3.12 On the ebb tide counts, the Grey Plover flocks mainly contained roosting flocks, but on the flood tide counts they mainly contained feeding birds (Table 3.4). On both the ebb and flood tide counts, the Knot, Bar-tailed Godwit and Dunlin flocks on Whitehouse Bank mainly consisted of feeding birds (Table 3.4).

3.13 The movement patterns of Grey Plover and Bar-tailed Godwit onto/off Whitehouse Bank during the ebb tide period were similar in 2018/19, compared to previous winters (Table 3.5 and Text Figure 3.2). Grey Plover numbers generally remained high across the EBB1 and EBB2 count periods, decreasing in the EBB3 count period and with most birds gone by the EBB4 count period (Text Figure 3.2). The apparent differences in mean percentages between the winters in Table 3.5 are due to the means from the small 2017/18 dataset not reflecting the general patterns in Text Figure 3.2. Bar-tailed Godwit numbers showed a general pattern of decrease (Table 3.5), but with a lot of variability, across the ebb tide period (Text Figure 3.2). Dunlin showed an intermediate pattern between the rapid movement off Whitehouse Bank in 2014/15, and the generally prolonged stays across the ebb tide period in 2016/17 and 2017/18 (Text Figure 3.2).

3.14 As in previous winters, most observations of Grey Plover, Knot and Dunlin movements were of birds moving between Whitehouse Bank and the Inner Harbour, while Bar-tailed Godwits on Whitehouse Bank moved to/from both the Inner Harbour and the Ballyrandle Sandflats.

Table 3.2 - Maximum counts of the four target species recorded during ebb, low and flood tide periods on each count day.

Species	Date	Maximum count		
		Ebb	LT	Flood
Grey Plover	24/10/2018	30	11	0
	10/11/2018	42	7	31
	07/12/2018	100	8	63
	08/01/2019	104	148	39
	23/01/2019	49	188	59
	07/02/2019	173	146	129
	22/02/2019	43	105	166
	07/03/2019	61	25	4
Bar-tailed Godwit	24/10/2018	10	274	6
	10/11/2018	151	190	38
	07/12/2018	361	520	58
	08/01/2019	166	510	186
	23/01/2019	110	364	385
	07/02/2019	214	398	120
	22/02/2019	345	519	450
	07/03/2019	36	136	29
Knot	24/10/2018	0	25	0
	10/11/2018	28	0	0
	07/12/2018	1	114	116
	08/01/2019	170	33	43
	23/01/2019	38	278	139
	07/02/2019	21	175	50
	22/02/2019	365	430	268
	07/03/2019	0	0	0
Dunlin	24/10/2018	522	498	169
	10/11/2018	1049	641	119
	07/12/2018	1015	2769	1544
	08/01/2019	1417	1483	2522
	23/01/2019	480	2831	2144
	07/02/2019	2138	2647	969
	22/02/2019	1296	2684	2665
	07/03/2019	165	126	45

Data are the maxima across four ebb tide counts, one low tide count, and four flood tide counts. The areas covered varied between counts (see text for details).

Table 3.3 - Counts of the target species across the tidal cycle on Whitehouse Bank.

Species	Date	Ebb tide				Low tide	Flood tide			
		1	2	3	4		1	2	3	4
Grey Plover	24/10/2018	0	30	0	0	0	0	0	0	0
	10/11/2018	38	18	0	0	0	0	0	14	31
	07/12/2018	50	82	92	0	0	0	0	0	63
	08/01/2019	70	94	0	0	0	0	0	12	0
	23/01/2019	19	49	11	11	0	0	0	1	3
	07/02/2019	122	138	131	0	0	62	60	8	5
	22/02/2019	33	24	22	0	89	87	105	77	0
	07/03/2019	51	49	52	0	0	0	0	0	0
Bar-tailed Godwit	24/10/2018	2	10	7	2	13	4	6	0	2
	10/11/2018	151	104	0	46	23	9	13	38	0
	07/12/2018	0	5	0	361	54	46	8	56	58
	08/01/2019	10	106	93	29	91	44	181	186	2
	23/01/2019	110	81	51	22	253	84	67	61	13
	07/02/2019	101	214	65	60	34	44	84	54	120
	22/02/2019	341	344	325	276	152	269	406	240	315
	07/03/2019	6	12	10	34	20	8	22	22	4
Knot	24/10/2018	0	0	0	0	0	0	0	0	0
	10/11/2018	18	18	0	0	0	0	0	0	0
	07/12/2018	0	0	0	0	0	0	0	0	66
	08/01/2019	170	36	0	0	1	0	18	43	0
	23/01/2019	0	38	0	0	0	0	0	14	0
	07/02/2019	7	21	0	0	0	0	0	0	14
	22/02/2019	60	135	307	0	196	2	226	249	0
	07/03/2019	0	0	0	0	0	0	0	0	0
Dunlin	24/10/2018	56	274	89	522	378	129	169	75	109
	10/11/2018	404	272	6	13	26	0	24	0	12
	07/12/2018	200	233	220	195	77	0	44	156	229
	08/01/2019	905	335	97	0	28	0	0	22	0
	23/01/2019	147	280	27	12	63	34	81	78	0
	07/02/2019	242	132	0	0	0	138	119	28	54
	22/02/2019	342	222	554	36	234	0	21	42	20
	07/03/2019	11	2	0	0	1	0	1	1	0

Ebb tide counts were carried out from around four hours before low tide (EBB1 count) to two hours before low tide (EBB4 count), low tide counts were carried out over a three hour period centred around low tide, and flood tide counts were carried out from around two hours after low tide (FLOOD1 count) to four hours after low tide (FLOOD4 count).

Table 3.4 - Percentages of feeding birds of the target species across the tidal cycle on Whitehouse Bank.

Species	Date	Ebb tide				Low tide	Flood tide			
		1	2	3	4		1	2	3	4
Grey Plover	24/10/2018		53%							
	10/11/2018	24%	100%						0%	100%
	07/12/2018		0%	0%						0%
	08/01/2019	0%	100%						100%	
	23/01/2019	16%	0%	0%	0%					
	07/02/2019	0%	4%	0%			100%	100%		
	22/02/2019	0%	0%	0%		11%	100%	93%	100%	
	07/03/2019	10%	24%	13%						
Bar-tailed Godwit	24/10/2018		100%			83%				
	10/11/2018	30%	100%		96%	90%		100%	95%	
	07/12/2018				0%	96%	67%		0%	0%
	08/01/2019	100%	100%	100%	83%	69%	86%	99%	100%	
	23/01/2019	90%	94%	100%	100%	80%	3%	93%	89%	0%
	07/02/2019	52%	40%	100%	98%	91%	100%	96%	100%	99%
	22/02/2019	56%	67%	100%	100%	68%	13%	100%	100%	0%
	07/03/2019		100%	100%	100%	95%		45%	86%	
Knot	24/10/2018									
	10/11/2018	100%	100%							
	07/12/2018									82%
	08/01/2019	0%	100%					100%	100%	
	23/01/2019		0%						43%	
	07/02/2019		100%							100%
	22/02/2019	0%	59%	87%		12%		100%	100%	
	07/03/2019									
Dunlin	24/10/2018	0%	99%	100%	100%	79%	100%	88%	48%	24%
	10/11/2018	36%	69%		100%	100%		100%		0%
	07/12/2018		100%	100%	100%	98%		100%	36%	75%
	08/01/2019	100%	100%	100%		96%			100%	
	23/01/2019	100%	48%	100%	100%	98%	91%	75%	38%	
	07/02/2019	0%	44%				100%	100%	100%	100%
	22/02/2019	100%	82%	100%	100%	78%		100%	100%	0%
	07/03/2019	100%								

Percentages are only included for counts where > 9 birds were recorded. See notes to Table 3.6 for details of count timings.

Table 3.5 – Mean percentage of the maximum ebb tide count recorded in each count period across the ebb and low tides on Whitehouse Bank.

Species	Season	EBB1	EBB2	EBB3	EBB4	LT	n
Grey Plover	2014/15	99%	84%	23%	5%	0%	11
	2016/17	80%	73%	31%	8%	2%	10
	2017/18	80%	38%	20%	17%	13%	6
	2018/19	69%	88%	48%	3%	34%	8
Bar-tailed Godwit	2014/15	93%	78%	42%	26%	72%	10
	2016/17	73%	64%	53%	60%	24%	7
	2017/18	100%	52%	17%	8%	29%	4
	2018/19	53%	68%	41%	55%	66%	7
Knot	2014/15	99%	73%	10%	0%	11%	6
	2016/17	60%	95%	84%	32%	0%	4
	2017/18	61%	95%	65%	92%	18%	2
	2018/19	40%	55%	33%	0%	21%	3
Dunlin	2014/15	99%	59%	4%	0%	1%	7
	2016/17	99%	65%	47%	28%	33%	9
	2017/18	73%	54%	29%	23%	25%	4
	2018/19	73%	64%	33%	28%	26%	7

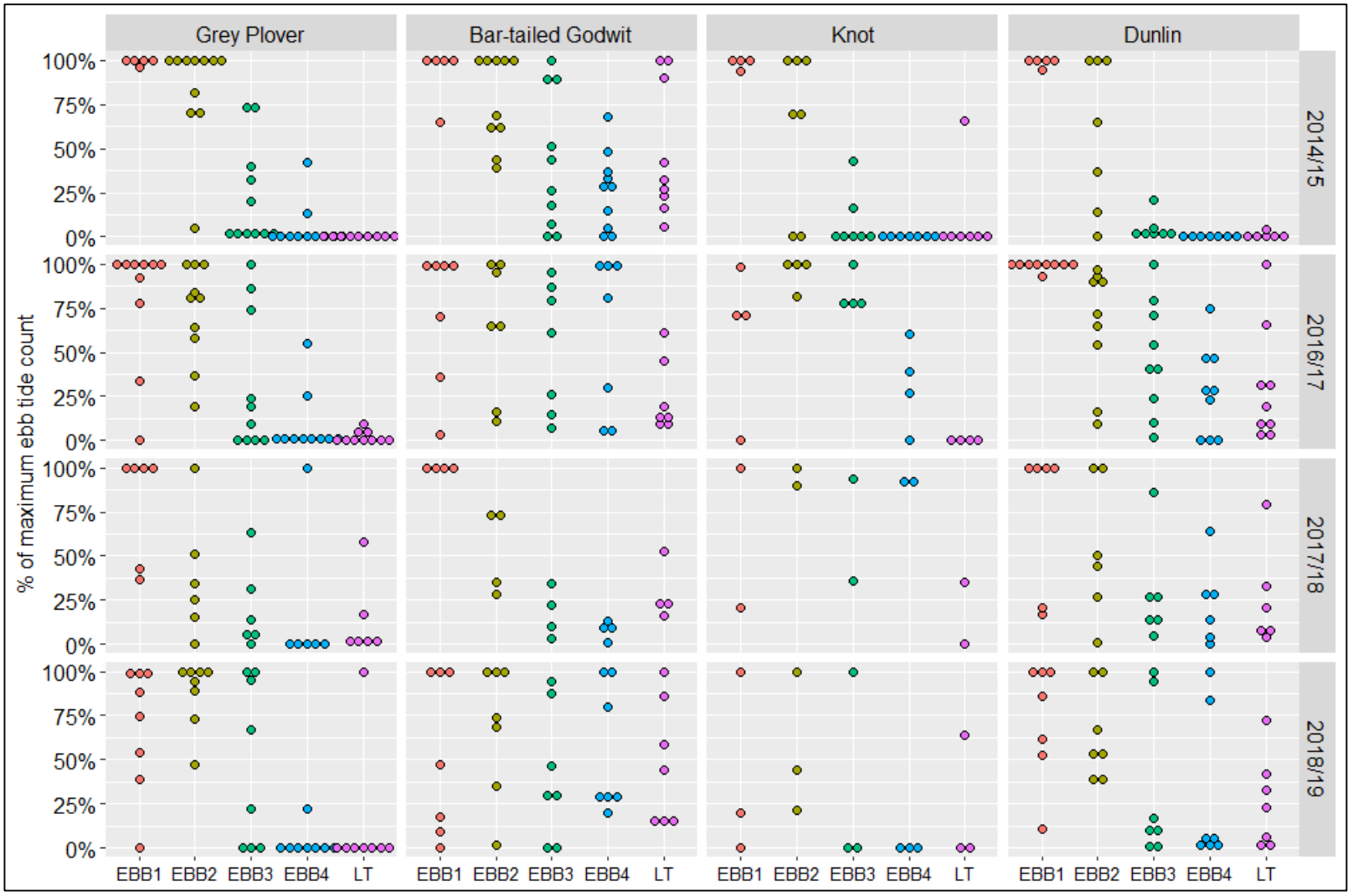
Data is only included for count days where the maximum Whitehouse Bank ebb tide count was > 25 (Grey Plover), > 50 (Bar-tailed Godwit and Knot) or > 100 (Dunlin). Note that EBB1 counts were only carried out on five of the eleven count days in 2014/15 and no low tide count was carried out on one of the count days in 2014/15.

Low tide distribution

Distribution across Dungarvan Harbour

3.15 During the low tide counts, Grey Plover occurred erratically, Knot occurred very rarely, and Bar-tailed Godwit and Dunlin occurred in relatively low numbers, on Whitehouse Bank (Table 3.6). Grey Plover mainly occurred in the Inner Harbour. However on six of the eight counts the total numbers recorded at low tide were lower than the maximum ebb/flood tide count indicating that not all the Grey Plover were located at low tide. Dunlin also mainly occurred in the Inner Harbour. Knot and Bar-tailed Godwits usually mainly occurred on the Ballyrandle Sandflats.

3.16 The overall low tide distribution patterns across Dungarvan Harbour in 2018/19 were broadly similar to those recorded in previous winters (Table 3.7). Within the Outer Sandflats zone, similar overall numbers of Grey Plover occurred on the Ballyrandle Sandflats and Whitehouse Bank, while Bar-tailed Godwit and Knot mainly occurred on the Ballyrandle Sandflats and Dunlin mainly occurred on Whitehouse Bank (Table 3.8).



Text Figure 3.2 – Occurrence pattern of the target species on Whitehouse Bank across the ebb and low tide periods. The dot plots show the percentages of the maximum ebb tide count recorded on each ebb tide count and on the low tide count on each count day. The following low tide counts that were > 100% of the maximum ebb tide count are shown as 100% in these dot plots: 1 no. count of Grey Plover in 2018/19 (270%); 2 no. counts of Bar-tailed Godwit in 2014/15 (106% and 304%) and 1 no. count in 2018/19 (228%); and 1 no. count of Dunlin in 2016/17 (120%).

Table 3.6 - Distribution of the target species at low tide.

Species	Date	Inner Harbour		Outer Sandflats	
		upper	main	Ballyrandle	Whitehouse
Grey Plover	24/10/2018	0	11	0	0
	10/11/2018	0	7	0	0
	07/12/2018	0	8	0	0
	08/01/2019	0	119	29	0
	23/01/2019	0	181	7	0
	07/02/2019	0	141	5	0
	22/02/2019	0	16	0	89
	07/03/2019	0	25	0	0
Bar-tailed Godwit	24/10/2018	0	6	255	13
	10/11/2018	0	7	160	23
	07/12/2018	0	0	466	54
	08/01/2019	0	0	419	91
	23/01/2019	0	1	110	253
	07/02/2019	0	95	269	34
	22/02/2019	0	164	203	152
	07/03/2019	0	6	110	20
Knot	24/10/2018	0	25	0	0
	10/11/2018	0	0	0	0
	07/12/2018	0	55	59	0
	08/01/2019	0	4	28	1
	23/01/2019	0	278	0	0
	07/02/2019	0	146	29	0
	22/02/2019	0	204	30	196
	07/03/2019	0	0	0	0
Dunlin	24/10/2018	0	120	0	378
	10/11/2018	0	565	50	26
	07/12/2018	7	2685	0	77
	08/01/2019	0	1455	0	28
	23/01/2019	0	2768	0	63
	07/02/2019	0	2630	17	0
	22/02/2019	0	2450	0	234
	07/03/2019	0	125	0	1

Table 3.7 - Mean percentage occurrence of the target species in the main zones of Dungarvan Harbour in 2009/10, 2014/15 and 2016/17-2018/19.

Species	Season	Mean percentage of total count			n
		Inner Harbour	Ballyrandle Sandflats	Whitehouse Bank	
Grey Plover	2009/10	83%	1%	16%	4
	2014/15	74%	26%	0%	8
	2016/17	79%	21%	0%	4
	2017/18	60%	15%	25%	5
	2018/19	72%	7%	21%	4
Bar-tailed Godwit	2009/10	11%	87%	2%	4
	2014/15	7%	70%	23%	10
	2016/17	11%	74%	15%	10
	2017/18	1%	82%	18%	5
	2018/19	8%	71%	21%	8
Knot	2009/10	80%	15%	5%	4
	2014/15	62%	34%	4%	8
	2016/17	89%	10%	0%	8
	2017/18	15%	71%	14%	4
	2018/19	70%	19%	11%	4
Dunlin	2009/10	92%	6%	2%	4
	2014/15	83%	12%	5%	9
	2016/17	92%	0%	7%	10
	2017/18	92%	2%	6%	4
	2018/19	97%	0%	3%	5

Counts with low total numbers present are excluded from the analyses.

Table 3.8 - Mean percentage occurrence of the target species in the subdivisions of the Outer Sandflats zone of Dungarvan Harbour in 2009/10, 2011 and 2014/15.

Species	Season	Mean percentage of Outer Sandflats count		n
		Ballyrandle Sandflats	Whitehouse Bank	
Grey Plover	2009/10	6%	94%	2
	2011	2%	98%	5
	2014/15	99%	1%	5
	2016/17	100%	0%	2
	2017/18	53%	47%	3
	2018/19	50%	50%	2
Bar-tailed Godwit	2009/10	98%	2%	4
	2011	72%	28%	5
	2014/15	75%	25%	10
	2016/17	84%	16%	10
	2017/18	82%	18%	5
	2018/19	77%	23%	8
Knot	2009/10	83%	17%	3
	2011	87%	13%	3
	2014/15	87%	13%	8
	2016/17	95%	5%	7
	2017/18	86%	14%	4
	2018/19	77%	23%	4
Dunlin	2009/10	76%	24%	4
	2011	43%	57%	4
	2014/15	67%	33%	8
	2016/17	1%	99%	6
	2017/18	24%	76%	4
	2018/19	13%	87%	6

Counts with low total numbers present in the Outer Sandflats zone are excluded from the analyses.

Distribution within Whitehouse Bank

3.17 Only two of the target species (Bar-tailed Godwit and Dunlin) regularly occurred on Whitehouse Bank in significant numbers at low tide.

3.18 Bar-tailed Godwit occurred almost exclusively along the tideline on the lower sandflats in sectors OY2-OY4. Their percentage occurrence within the trestle blocks (Table 3.9) varied from 11-100% (mean 67%), compared to 8-76% (mean 29%) in 2017/18, 0-90% (mean 38%) in 2016/17 and 9-63% (mean 33%) in 2014/15. The relatively high percentage occurrence in this winter reflected the high tideline percentage within the trestles across the counts (Table 3.10). Across the five winters of monitoring waterbird distribution on Whitehouse Bank, Bar-tailed Godwit have shown a northward shift in distribution (Table 3.11).

3.19 Dunlin occurred in small numbers, either on the upper sandflats (usually in sector CS3) or within the oyster trestle blocks (mainly sectors OY3 and OY4) (Table 3.12). Therefore, the Dunlin distribution appears to have been concentrated in the northern section of Whitehouse Bank. This distribution pattern was similar to 2016/17 and 2017/18, but differs from the more erratic distribution patterns recorded in previous winters, which did not show a clear pattern of concentration in one section of Whitehouse Bank (Table 3.12). Their percentage occurrence within the trestle blocks in

2018/19 (Table 3.9) reflected their relative distribution between sectors CS3 and OY3-OY4, and varied from 1-99% (mean 51%) compared to 8-100% (mean 38%) in 2017/18, 3-100% (mean 57%) in 2016/17 and 0-100% (mean 47%) in 2014/15.

Table 3.9 - Distribution of Dunlin and Bar-tailed Godwit on Whitehouse Bank at low tide in relation to the presence of oyster trestles.

Species	Date	Count		% within trestle blocks
		Within trestle blocks	Outside trestle blocks	
Bar-tailed Godwit	24/10/2018	11	2	85%
	10/11/2018	18	5	78%
	07/12/2018	39	15	72%
	08/01/2019	57	34	63%
	23/01/2019	27	226	11%
	07/02/2019	33	1	97%
	22/02/2019	44	108	29%
	07/03/2019	20	0	100%
Dunlin	24/10/2018	157	221	42%
	10/11/2018	23	3	88%
	07/12/2018	76	1	99%
	08/01/2019	12	16	43%
	23/01/2019	21	42	33%
	07/02/2019	0	0	-
	22/02/2019	3	231	1%
	07/03/2019	1	0	-

Table 3.10 – Percentages of the tideline within trestle blocks during waterbird counts of Whitehouse Bank, 2011/12-2018/19.

Season	% of tideline within trestle blocks			n
	mean	range	% of days < 60%	
2011/12	48%	26-71%	80%	5
2014/15	69%	39-86%	30%	10
2016/17	72%	33-88%	30%	10
2017/18	58%	29-84%	67%	6
2018/19	76%	58-88%	13%	8

Table 3.11 – Distribution of Bar-tailed Godwit between count sectors during low tide counts of Whitehouse Bank

Season	Date	OY1	OY2	OY3	OY4
2010/11	06/01/2011	1	52	17	21
	22/01/2011	16	47	31	11
	03/02/2011	8	13	33	11
	21/02/2011	27	42	22	22
	03/03/2011	18	23	20	10
2014/15	23/10/2014	5	6	9	2
	27/10/2014	6	10	15	9
	10/11/2014	2	23	1	8
	24/11/2014	1	35	15	4
	10/12/2014	3	24	21	15
	22/12/2014	0	13	47	10
	08/01/2015	0	244	64	14
	21/01/2015	0	26	14	28
	06/02/2015	0	135	65	43
	19/02/2015	0	571	232	3
2016/17	04/10/2016	3	5	11	2
	18/10/2016	1	11	3	0
	02/11/2016	2	9	2	4
	16/11/2016	2	40	49	14
	30/11/2016	1	10	12	14
	15/12/2016	0	23	42	18
	13/01/2017	0	0	15	29
	31/01/2017	0	0	18	31
	13/02/2017	0	0	23	47
	28/02/2017	0	0	10	20
2017/18	06/10/2017	11	1	2	0
	07/11/2017	3	11	1	0
	05/12/2017	0	14	92	32
	19/01/2018	0	1	43	15
	02/02/2018	0	2	35	14
	19/02/2018	0	5	40	37
2018/19	24/10/2018	2	2	5	4
	10/11/2018	2	0	7	12
	07/12/2018	0	1	23	29
	08/01/2019	0	33	28	30
	23/01/2019	0	14	172	52
	07/02/2019	0	5	20	9
	22/02/2019	0	14	99	20
	07/03/2019	0	3	17	0

Data for sectors CS1-CS4 not shown: across all winters there were only 12 records of1-15 birds in these sectors, apart from one record of 212 birds in sector CS3 on 30/11/2016.

Table 3.12 – Distribution of Dunlin between count sectors during low tide counts of Whitehouse Bank

Season	Date	Count sector						
		CS1	CS2	CS3	OY1	OY2	OY3	OY4
2018/19	24/10/2018	0	0	120	0	3	217	38
	10/11/2018	0	0	0	0	0	14	12
	07/12/2018	0	0	0	0	1	1	75
	08/01/2019	0	0	16	0	0	3	9
	23/01/2019	0	0	42	0	0	11	10
	22/02/2019	0	0	230	0	0	0	4
	07/03/2019	0	0	0	0	1	0	0
2017/18	06/10/2017	0	0	250	10	28	46	0
	07/11/2017	0	0	0	0	3	16	0
	05/12/2017	0	26	122	0	9	40	26
	19/01/2018	0	0	36	0	3	31	0
	02/02/2018	0	0	135	28	9	40	0
	19/02/2018	0	0	99	0	6	3	0
2016/17	04/10/2016	0	31	318	6	1	10	23
	18/10/2016	0	0	0	0	0	81	111
	02/11/2016	0	0	7	0	0	78	101
	16/11/2016	0	0	260	0	35	52	134
	30/11/2016	0	0	4	0	6	21	15
	15/12/2016	0	1	0	0	3	1	99
	13/01/2017	0	0	0	0	1	1	23
	31/01/2017	0	0	32	0	0	3	4
	13/02/2017	0	0	71	0	2	11	1
	28/02/2017	0	0	260	0	0	2	7
2014/15	23/10/2014	0	0	0	0	0	1	60
	27/10/2014	0	0	0	1	0	0	0
	10/11/2014	0	0	14	0	0	0	0
	12/11/2014	0	0	1	0	0	0	0
	24/11/2014	0	0	2	0	0	0	17
	10/12/2014	0	0	0	0	6	0	2
	22/12/2014	0	31	10	0	0	0	0
	08/01/2015	0	0	2	0	0	0	4
2010/11	06/01/2011	48	32	142	0	65	23	37
	22/01/2011	0	1	0	0	9	6	1
	03/02/2011	0	0	0	12	1	2	0
	21/02/2011	0	135	443	0	7	9	3
	03/03/2011	0	0	7	0	282	7	2

Distribution patterns in relation to the presence of oyster trestles

3.20 Of the target species, Grey Plover and Knot were never recorded within the trestle blocks during the tidal cycle low tide counts. Bar-tailed Godwit and Dunlin did occur within the trestle blocks.

3.21 For Bar-tailed Godwit, as in previous winters, the Jacob's Index values were negative, and the confidence intervals did not include zero, for the all sectors analysis, indicating avoidance of the oyster trestles (Table 3.13). The Jacob's Index values for the close sectors analysis in 2018/19 was zero indicating neutral association with the oyster trestles (Table 3.13). However, the overall Jacob's Index values for the close sectors analysis across all winters remains significantly negative (Table 3.13).

3.22 Using the combined dataset across all seasons, the mean Bar-tailed Godwit densities outside the trestle blocks were five times higher than the densities within the trestle blocks (Table 3.14).

3.23 The assumptions required for calculating expected values were clearly violated for Dunlin in 2018/19, as their distribution patterns indicated that some other factor, apart from the presence of oyster trestles, was influencing their distribution pattern within the Outer Sandflats zone (see paragraph 3.19). Furthermore, as they mainly occurred on the intertidal away from the tideline, tideline length did not provide a reasonable representation of the availability of suitable habitat. Therefore, we have not calculated expected numbers of Dunlin, or D index values for Dunlin. However, based on their percentage occurrence within trestle blocks, Dunlin distribution within the Outer Sandflats zone did not have an obvious negative association with oyster trestles in 2018/19.

Table 3.13 - Mean Jacob's index (D) values (± 95% C.I.).

Species	Seasons	All sectors			Close sectors		
		Mean D	D > 0	n	Mean D	D > 0	n
Bar-tailed Godwit	2018/19	-0.62 (± 0.08)	0	8	+0.03 (± 0.56)	5	8
	2017/18	-0.59 (± 0.48)	1	6	-0.57 (± 0.33)	0	6
	2016/17	-0.73 (± 0.13)	0	10	-0.51 (± 0.34)	1	10
	2014/15	-0.72 (± 0.19)	0	10	-0.65 (± 0.11)	0	10
	2011	-0.47 (± 0.47)	1	5	-0.25 (± 0.72)	1	4
	all	-0.65 (± 0.09)	2	39	-0.42 (± 0.14)	2	30

Table 3.14 - Mean densities (birds/km tideline length) within and outside trestle blocks.

Species	Analysis	Outside		Within	
		Mean	CI	Mean	CI
Bar-tailed Godwit	all sectors	60.0	10.0	12.7	4.3
	close sectors	60.2	30.0	12.7	4.3

Analyses use the combined 2011, 2014/15, 2016/17, 2017/18 and 2018/19 datasets.

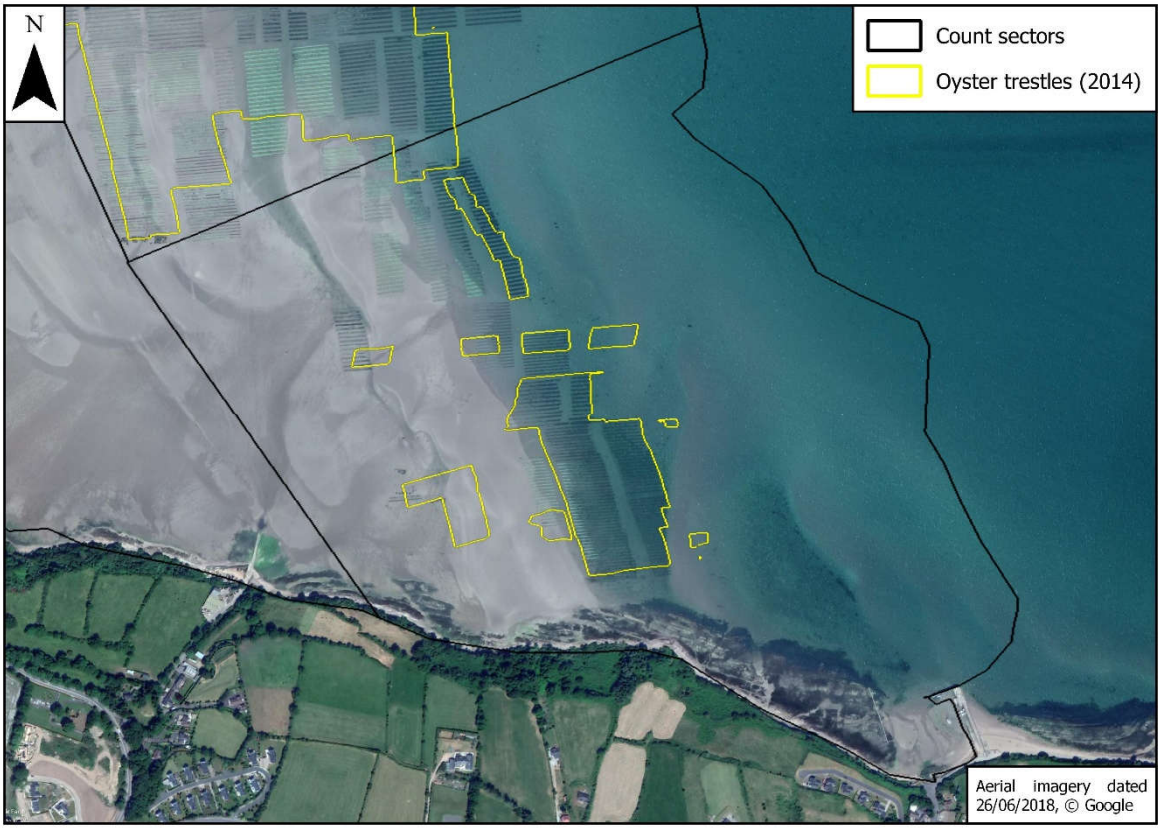


Figure 3.1 – Configuration of oyster trestles in count sector OY1 in June 2018.

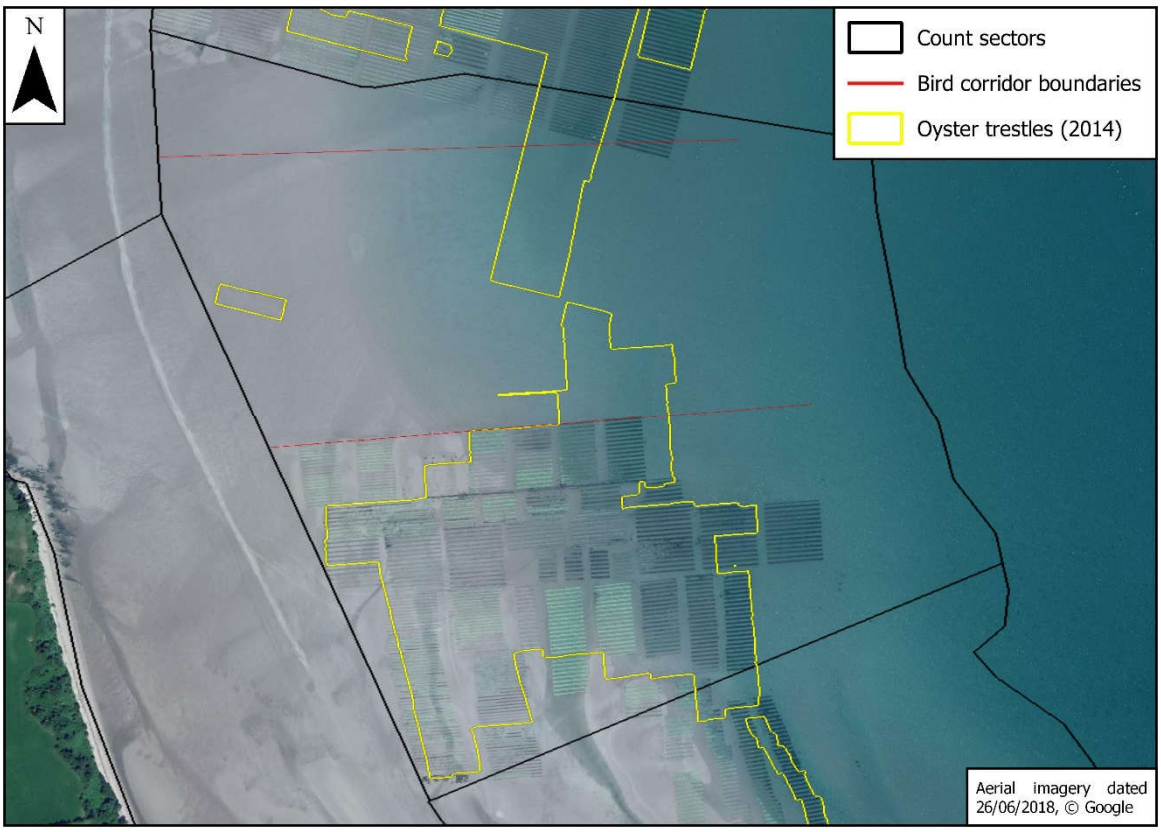


Figure 3.2 - Configuration of oyster trestles in count sector OY2 in June 2018.

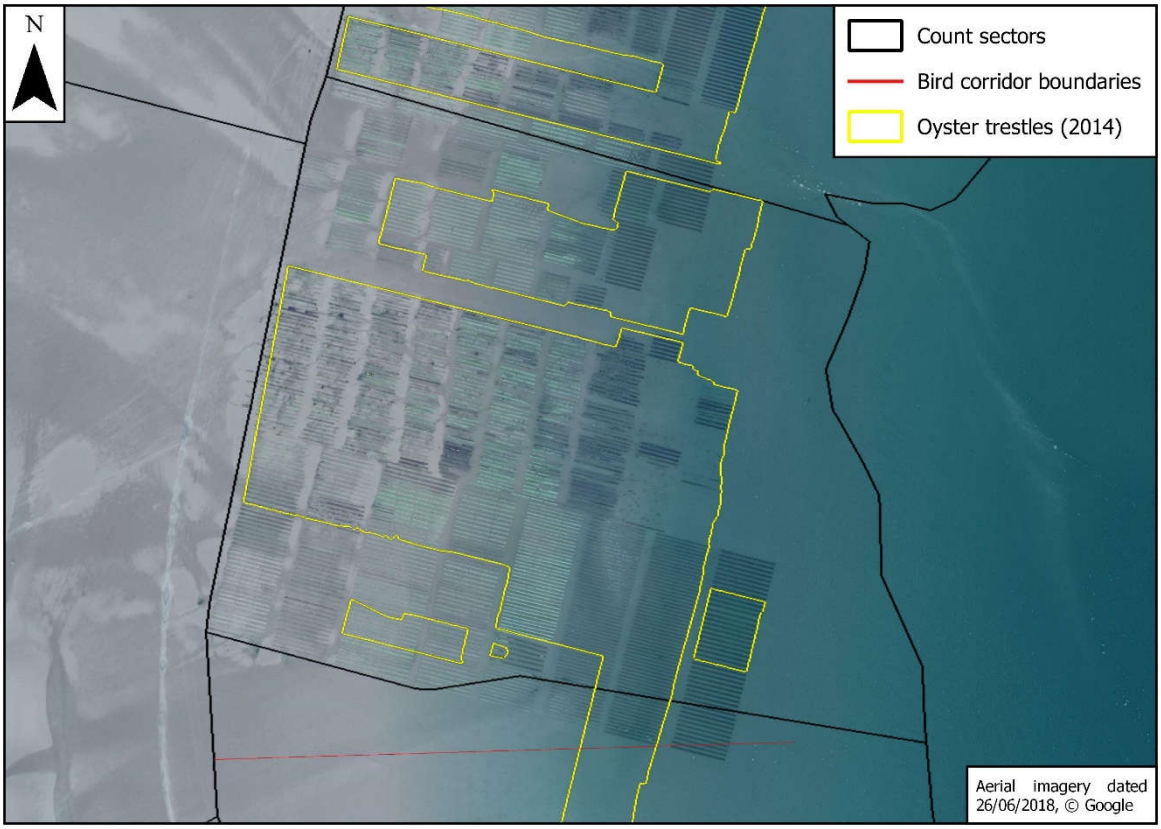


Figure 3.3 - Configuration of oyster trestles in count sector OY3 in June 2018.

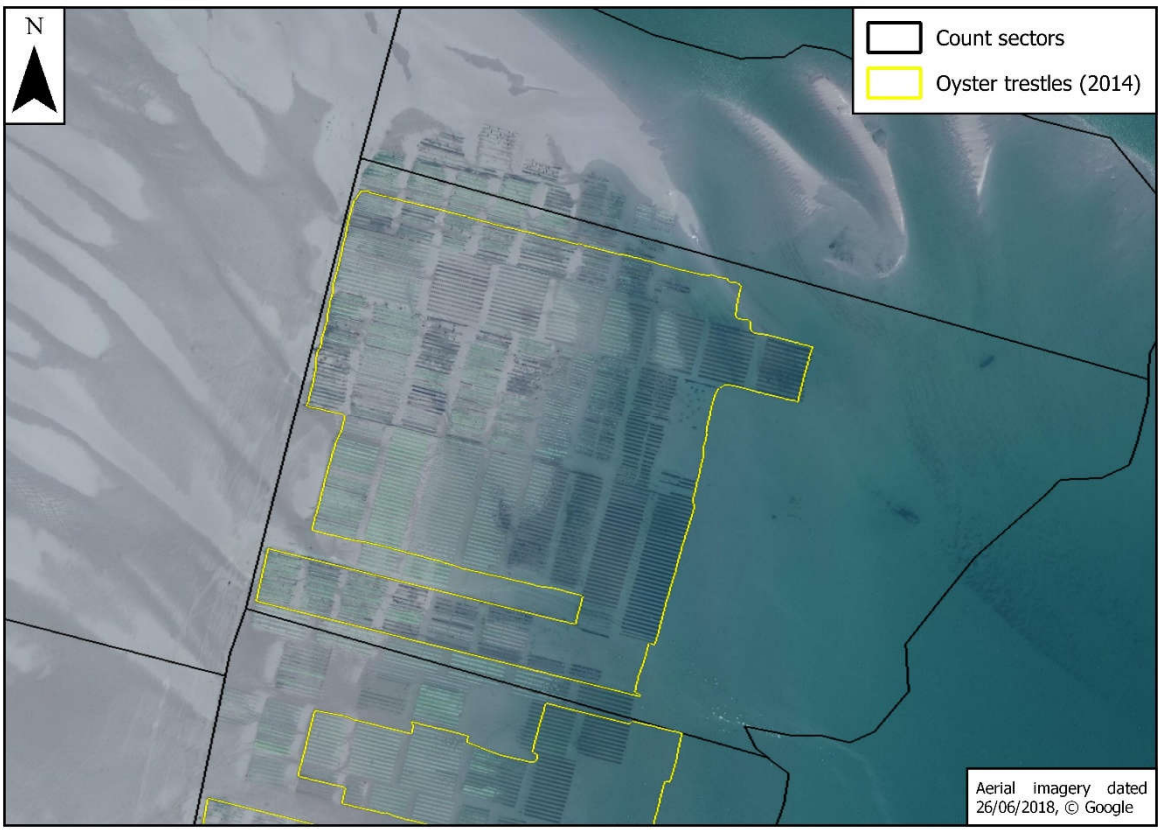


Figure 3.4 - Configuration of oyster trestles in count sector OY4 in June 2018.

4. Results: Bird corridor monitoring

Introduction

4.1 This chapter presents the results from the Bird Corridor monitoring counts on occurrence of the target species within the Bird Corridor, as well as summary data on the occurrence of other waterbird species within the Bird Corridor, and data from the tidal cycle counts on the occurrence of the target species within the Bird Corridor. The results of the Bird Corridor monitoring counts for the additional monitored species are included in Appendix A, additional count data is included for the target species in Appendix B, and the full count data for other waterbird species within the Bird Corridor are included in Appendix C.

Oyster cultivation activity

4.2 The last trestles were removed from the Bird Corridor in October 2017 (Gittings and O'Donoghue, 2018b) and the Bird Corridor remained clear of trestles throughout the 2018/19 monitoring period. The trestles extended up to the southern edge of the Bird Corridor along most of the length of the Bird Corridor, apart from the lowermost section that was exposed on spring low tides. At the northern end of the Bird Corridor, trestles extended up to the Bird Corridor boundary in the lower shore but there was a 150-200 m gap between the Bird Corridor boundary and the nearest trestles in the upper section. The configuration of trestles adjacent to the northern and southern edges of the Bird Corridor as represented in aerial imagery from June 2018 is shown in Figure 4.1.

4.3 During the tidal cycle counts, there were 1-6 tractors working within 250 m of the Bird Corridor at the time the Bird Corridor was counted (Table 4.1). No tractor movements through the Bird Corridor were recorded during the tidal cycle counts in 2018/19.

Table 4.1 – Husbandry activity around the Bird Corridor recorded during the tidal cycle counts.

Date	Tractors within 250 m
19/10/2018	1
10/11/2018	3
07/12/2018	6
08/01/2019	1
23/01/2019	6
07/02/2019	1
22/02/2019	4
07/03/2019	6

4.4 On the Bird Corridor monitoring count days, there were usually several tractors working within 250 m of the Bird Corridor for most of the period of tidal exposure of the Bird Corridor (Table 4.2). There was also a general pattern of higher levels of tractor numbers during the first half of the low tide period, compared to the second half (Table 4.2). There were 8-28 tractor movements within, and adjacent to, the Bird Corridor on the Bird Corridor monitoring count days and, again, there was a general pattern of higher levels of tractor movement during the first half of the low tide period, compared to the second half (Table 4.3). Most of the tractor movements were above the Bird Corridor, with some movements through the upper section, and along the edges, of the Bird Corridor, but very few movements through the middle section of the Bird Corridor and no movements along the tideline through the Bird Corridor (Table 4.4).

Table 4.2 – Tractor numbers within 250 m of the Bird Corridor.

Date	EB4	EB5	LT1	LT2	LT3	LT4	LT5	LT6	FL0	FL1	Totals per day
09/09/2018	5	3	7	6	6	6	5	9	9	3	59
24/09/2018	0	0	4	2	0	0	1	0	0	0	7
28/09/2018	0	4	4	3	4	2	1	1	1	0	20
09/10/2018	3	6	5	5	5	5	5	5	2	1	42
23/10/2018	0	2	6	4	5	3	2	1	1	0	24
13/11/2018	0	2	6	0	0	0	0	0	0	0	8
24/11/2018	0	0	0	0	1	2	0	0	0	0	3
10/12/2018	0	2	7	6	6	1	1	1	0	0	24
07/01/2019	0	3	3	1	1	0	0	0	0	0	8
22/01/2019	0	5	3	4	5	4	3	0	0	0	24
06/02/2019	0	0	0	2	2	0	1	0	0	0	5
24/02/2019	5	4	4	0	0	0	0	0	0	0	13
06/03/2019	0	0	0	4	4	4	6	0	0	0	18
Totals per count period	13	31	49	37	39	27	25	17	13	4	255

Table 4.3 – Tractor movements within, and adjacent to, the Bird Corridor during the Bird Corridor monitoring counts.

Date	EB4	EB5	LT1	LT2	LT3	LT4	LT5	LT6	FL0	FL1	Totals per day
09/09/2018	4	2	1	1	1	1	2	0	3	4	19
24/09/2018	0	2	3	0	1	0	0	0	0	0	6
28/09/2018	0	2	2	3	2	0	0	1	0	0	10
09/10/2018	0	0	3	1	0	0	1	5	7	0	17
23/10/2018	0	0	10	1	1	2	0	0	0	0	14
13/11/2018	0	4	0	5	3	2	0	0	0	0	14
24/11/2018	0	0	0	0	0	0	0	1	0	0	1
10/12/2018	0	0	3	1	3	0	4	0	0	0	11
07/01/2019	0	0	0	1	2	0	1	1	0	0	5
22/01/2019	0	5	0	3	0	1	0	0	0	0	9
06/02/2019	4	0	3	4	1	0	0	0	1	4	17
24/02/2019	2	0	0	0	0	0	0	0	0	0	2
06/03/2019	0	0	3	0	0	4	1	0	0	0	8
Totals per count period	10	15	28	20	14	10	9	8	11	8	133

Table 4.4 – Positions of the tractor movements recorded within, and adjacent to, the Bird Corridor during the Bird Corridor monitoring counts.

Date	above	edge	upper	middle	lower	Totals per day
11/09/2018	8	8	3	0	0	19
24/09/2018	6	0	0	0	0	6
28/09/2018	10	0	0	0	0	10
09/10/2018	8	4	1	4	0	17
23/10/2018	9	4	1	0	0	14
13/11/2018	8	6	0	0	0	14
24/11/2018	1	0	0	0	0	1
10/12/2018	11	0	0	0	0	11
07/01/2019	5	0	0	0	0	5
22/01/2019	8	0	1	0	0	9
06/02/2019	15	2	0	0	0	17
24/02/2019	2	0	0	0	0	2
06/03/2019	2	6	0	0	0	8
Totals per position	93	30	6	4	0	133

Positions: above = movements along the line of buoys that demarcate the upper edge of the oyster trestle zone; edge = movements along, or just inside, the northern and southern edge of the Bird Corridor; upper = movements through the upper third of the Bird Corridor; middle = movements through the middle third of the Bird Corridor; lower = movements through the lower third of the Bird Corridor (usually along the tideline).

4.5 Compared to 2017/18, the overall level of tractor activity recorded around the Bird Corridor was slightly lower (Table 4.5). There was a more marked reduction in tractor activity within the Bird Corridor (Table 4.5).

Table 4.5 – Comparison of daily totals of tractor activity within and around the Bird Corridor recorded in 2017/18 and 2018/19.

Count type	Activity	Parameter	2017/18	2018/19
Tidal cycle counts	Tractor numbers	mean	5	3.5
		range	2-8	1-6
	Tractor movements	mean	0.3	0
Bird corridor monitoring	Tractor numbers	mean	23	20
		range	1-45	3-59
	Tractor movements	mean	13	10
		range	7-21	1-19
	Tractor movements within bird corridor	mean	1.9	0.8
		range	0-8	0-5
		% of days recorded	60%	33%

Tidal cycle counts

4.6 During the tidal cycle counts, the target species were only recorded infrequently and/or in low numbers in the Bird Corridor at low tide (Table 4.6). There were also occasional records, including a few larger counts, during the FLOOD1 and FLOOD2 counts (Table 4.6). Another nine waterbird species were also recorded within the Bird Corridor at low tide, with Light-bellied Brent Goose,

Redshank, Black-headed Gull and Common Gull being the most abundant of these species (Table 4.7).

4.7 The mean tideline lengths during the tidal cycle counts were 423 m in the Bird Corridor, 425 m in sector OY2 outside the Bird Corridor and 863 m in sector OY3. Therefore, if waterbirds were uniformly distributed along the tideline through sectors OY2 and OY3, similar numbers should occur within and outside the Bird Corridor in sector OY2 and the numbers in the Bird Corridor should be around half of those in sector OY2. However, most waterbird species occurred in higher numbers relative to the tideline length in sector OY3 compared to the Bird Corridor and, to a lesser extent, compared to sector OY2 outside the Bird Corridor (Table 4.8).

4.8 Waterbird numbers in sectors OY2 and OY3 in 2010/11 and 2018/19 are compared in Table 4.9. As the Bird Corridor occupies around half of sector OY2, any changes in distribution patterns due to its establishment should be reflected in changes in the relative numbers occurring in sectors OY2 and OY3. For most species, the distribution patterns are broadly similar between the two winters. However, Light-bellied Brent Goose, Bar-tailed Godwit and Dunlin, and possibly also Curlew, all show apparent shifts in distribution from OY2 to OY3. In the case of Light-bellied Brent Goose, this might reflect the removal of trestles from the Bird Corridor as the geese feed on the trestles. The shift in distribution of Bar-tailed Godwit and Dunlin is in the opposite direction to the expectation of the effect of establishing the Bird Corridor but reflects a larger-scale shift in distribution that has occurred towards the northern part of Whitehouse Bank since 2010/11 (see Table 3.11 and Table 3.12).

Table 4.6 – Observations of target species in the Bird Corridor during the tidal cycle counts.

Species	Date	LT	Flood 1	Flood 2
Bar-tailed Godwit	24/10/2018	0	0	2
	08/01/2019	29	0	0
	23/01/2019	3	14	16
	22/02/2019	0	148	136
Knot	08/01/2019	1	0	0
	22/02/2019	0	2	2
Dunlin	24/10/2018	1	0	0
	07/12/2018	1	0	0

Data only shown for days on which the species was recorded in the Bird Corridor on at least one count.

Table 4.7 – Summary of counts of other waterbird species in the Bird Corridor during the tidal cycle counts.

Species	Mean	Range	Non-zero counts
Light-bellied Brent Goose	15	0-47	7
Grey Heron	0	0-2	2
Oystercatcher	2	0-6	3
Curlew	1	0-5	4
Redshank	5	0-30	5
Black-headed Gull	23	0-77	6
Common Gull	17	1-73	8
Herring Gull	2	0-8	5
Great Black-backed Gull	2	0-9	3

See Appendix A and Appendix C for the full count data.

Table 4.8 – Comparison of waterbird counts in the Bird Corridor and adjacent sectors during the tidal cycle counts.

Species	Parameter	OY2	BC	OY3
Light-bellied Brent Goose	mean	15	15	40
	range	0-47	0-47	0-194
	non-zero	7	7	7
Grey Heron	mean	1	0	2
	range	0-3	0-2	0-5
	non-zero	7	2	6
Oystercatcher	mean	23	2	52
	range	17-30	0-6	30-65
	non-zero	8	3	8
Curlew	mean	4	1	17
	range	1-8	0-5	2-33
	non-zero	8	4	8
Bar-tailed Godwit	mean	5	4	46
	range	0-14	0-29	5-172
	non-zero	7	2	8
Turnstone	mean	1	0	6
	range	0-4	0-0	0-16
	non-zero	3	0	7
Dunlin	mean	0	0	31
	range	0-2	0-1	0-217
	non-zero	2	2	5
Greenshank	mean	1	0	0
	range	0-2	0-0	0-1
	non-zero	5	0	2
Redshank	mean	28	5	72
	range	17-50	0-30	17-139
	non-zero	8	5	8
Black-headed Gull	mean	43	23	88
	range	2-118	0-77	0-259
	non-zero	8	6	7
Common Gull	mean	2	17	17
	range	0-6	1-73	0-94
	non-zero	5	8	5
Herring Gull	mean	14	2	30
	range	3-41	0-8	3-60
	non-zero	8	5	8
Great Black-backed Gull	mean	1	2	1
	range	0-6	0-9	0-1
	non-zero	3	3	4

Table 4.9 – Comparison of waterbird counts in sectors OY2 and OY3 in 2010/11 and 2018/19.

Species	Parameter	2010/11		2018/19	
		OY2	OY3	OY2	OY3
Light-bellied Brent Goose	mean	54	13	30	40
	range	6-192	0-48	3-74	0-194
	non-zero	100%	85%	100%	88%
Grey Heron	mean	1	1	2	2
	range	0-5	0-3	0-3	0-5
	non-zero	38%	46%	88%	75%
Oystercatcher	mean	37	60	24	52
	range	26-60	19-114	17-32	30-65
	non-zero	100%	100%	100%	100%
Curlew	mean	9	10	6	17
	range	0-27	0-31	1-13	2-33
	non-zero	85%	85%	100%	100%
Bar-tailed Godwit	mean	49	38	9	46
	range	13-89	17-85	9-33	5-172
	non-zero	100%	100%	88%	100%
Turnstone	mean	2	10	1	6
	range	0-10	1-30	0-4	0-16
	non-zero	92%	100%	38%	88%
Dunlin	mean	73	18	1	31
	range	0-336	0-59	0-3	0-217
	non-zero	92%	92%	38%	63%
Greenshank	mean	1	1	1	0
	range	0-3	0-3	0-2	0-1
	non-zero	62%	62%	63%	25%
Redshank	mean	38	67	33	72
	range	8-87	16-119	17-80	17-139
	non-zero	100%	100%	100%	100%
Black-headed Gull	mean	72	84	66	88
	range	0-191	0-277	2-145	0-259
	non-zero	92%	92%	100%	88%
Common Gull	mean	46	26	18	17
	range	1-262	1-140	2-79	0-94
	non-zero	100%	100%	100%	63%
Herring Gull	mean	12	11	16	30
	range	0-32	0-31	3-49	3-60
	non-zero	85%	92%	100%	100%
Great Black-backed Gull	mean	1	0	3	1
	range	0-13	0-1	0-15	0-1
	non-zero	23%	15%	50%	50%

Bird corridor monitoring

4.9 Grey Plover were recorded in the Bird Corridor on five of the twelve Bird Corridor monitoring days (Table 4.7). Apart from a single bird on an ebb tide count, they only occurred in the second half of the low tide period and/or at the start of the flood tide period. The mean peak count on the days that they occurred was 14 (range 1-34).

4.10 Bar-tailed Godwit were recorded in the Bird Corridor on ten of the twelve Bird Corridor monitoring days (Table 4.7). Flocks of over 100 were recorded on two dates, but, otherwise, numbers were generally very low. The mean peak count on the days that they occurred was 33 (range 2-135).

4.11 Knot were recorded in the Bird Corridor on two of the twelve Bird Corridor monitoring days with peak counts of 11-19 birds (Table 4.7).

4.12 Dunlin were recorded in the Bird Corridor on five of the twelve Bird Corridor monitoring days (Table 4.7). Their occurrence pattern did not show an obvious tidal pattern. The mean peak count on the days that they occurred was 125 (range 3-380).

4.13 Compared to 2017/18, Grey Plover, Knot and Dunlin all occurred less frequently in the Bird Corridor, and in lower numbers for shorter durations on the days on which they occurred (Table 4.11). Bar-tailed Godwit occurred with similar frequency and with similar numbers but longer durations on the days on which they occurred (Table 4.11).

4.14 The low tide distribution of Grey Plover and Dunlin is largely confined to the Inner Harbour and the total area of intertidal habitat used by these species in the Inner Harbour is around 350 ha. The average area of the Bird Corridor exposed across the low tide period is around 15 ha. Therefore, if the Bird Corridor was used at a similar intensity to the Inner Harbour by Grey Plover and Dunlin the total bird-hours of these species across the low tide period within the Bird Corridor should be around 4% of the total bird-hours of these species across the low tide period within the Inner Harbour. In 2017/18, the usage of the Bird Corridor by Grey Plover was around 7% of the total estimated Inner Harbour bird-hours, but for Grey Plover in 2018/19 and Dunlin in both seasons, the usage was 1% or less of the total estimated Inner Harbour bird-hours (Table 4.12).

4.15 Another 13 waterbird species were recorded in the Bird Corridor with Oystercatcher, Redshank, Black-headed Gull, Common Gull and Herring Gull being the most regularly occurring species (Table 4.13). Light-bellied Brent Goose occurred much less frequently and in lower numbers in 2018/19 compared to 2017/18, reflecting the lower total numbers recorded on Whitehouse Bank in 2018/19 (mean peak count of 287 in 2018/19, compared to 861 in 2017/18; November-February data only). However, the overall occurrence patterns of the other regularly occurring species were broadly similar between the two winters (Table 4.13).

Table 4.10 - Counts of target species in the Bird Corridor during the Bird Corridor monitoring counts.

Species	Date	EB4	EB5	LT1	LT2	LT3	LT4	LT5	LT6	FL0	FL1
Grey Plover	23/10/2018	1	0	0	0	0	0	0	0	0	0
	13/11/2018	0	0	0	0	0	34	17	8	0	0
	10/12/2018	0	0	0	0	0	0	0	0	29	28
	06/02/2019	0	0	0	0	0	0	5	5	0	0
	06/03/2019	0	0	0	0	0	0	0	3	0	0
Bar-tailed Godwit	11/09/2018	0	0	3	19	0	1	0	0	134	134
	09/10/2018	0	0	0	0	7	7	3	2	0	0
	23/10/2018	2	0	1	2	0	0	2	1	0	2
	13/11/2018	0	7	3	3	2	0	0	0	0	0
	24/11/2018	0	16	17	11	2	3	2	4	5	0
	10/12/2018	2	0	0	0	0	0	0	0	0	0
	07/01/2019	126	135	123	124	6	0	0	0	0	0
	22/01/2019	4	0	0	0	0	0	0	0	0	0
	06/02/2019	0	15	0	0	0	0	0	0	0	0
	06/03/2019	0	0	0	11	2	3	0	1	0	0
Knot	07/01/2019	10	11	11	11	0	0	0	0	0	0
	06/03/2019	0	0	0	0	0	0	0	19	0	0
Dunlin	11/09/2018	0	0	0	0	0	0	0	0	0	3
	09/10/2018	0	6	0	0	0	9	0	0	0	0
	23/10/2018	0	100	130	0	0	0	0	0	0	0
	13/11/2018	0	0	0	16	0	380	360	0	0	0
	10/12/2018	0	0	0	0	0	0	0	0	92	87

Table 4.11 – Comparison of the occurrence of the target species in the BC in 2017/18 and 2018/19.

Species	Parameter	2017/18	2018/19
Grey Plover	daily frequency	67%	33%
	non-zero counts	48%	22%
	mean peak count	27	14
	range	2-59	1-34
	bird-mins/day	1124	175
Bar-tailed Godwit	daily frequency	80%	83%
	non-zero counts	34%	41%
	mean peak count	35	33
	range	1-302	2-135
	bird-mins/day	912	1657
Knot	daily frequency	47%	17%
	non-zero counts	21%	25%
	mean peak count	17	15
	range	2-50	11-19
	bird-mins/day	5661	758
Dunlin	daily frequency	60%	42%
	non-zero counts	39%	25%
	mean peak count	289	123
	range	1-1306	3-380
	bird-mins/day	4340	1286

The non-zero counts shows the mean percentage of count periods (between the EBB5 and FLOOD0 counts) per day on which the species was recorded, excluding days when the species was not recorded. The mean peak count and range are for the days on which the species occurred. See text for the explanation of the bird/mins per day parameter.

Table 4.12 – Comparison of estimated bird-hours per day of Grey Plover and Dunlin in the Inner Harbour recorded with bird-hours per day in the Bird Corridor, 2017/18 and 2018/19.

Species	2017/18		2018/19	
	Inner Harbour	Bird Corridor	Inner Harbour	Bird Corridor
Grey Plover	258	19	258	3
Dunlin	5,937	72	5,398	21

Table 4.13 – Summary of counts of counts of other waterbird species in the Bird Corridor during the Bird Corridor monitoring counts.

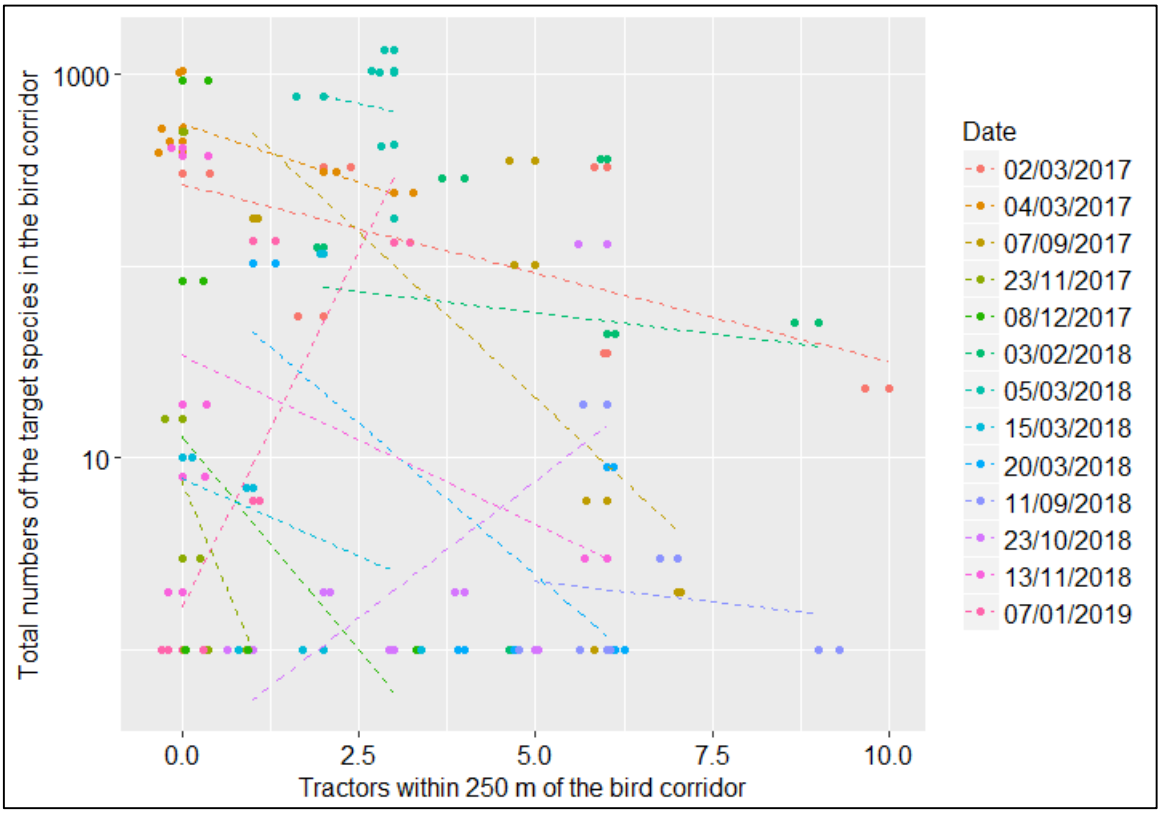
Species	Season	Daily frequency	Mean daily max	Maximum count	Non-zero counts
Light-bellied Brent Goose	2017/18	87%	42	167	69%
	2018/19	42%	17	43	68%
Little Egret	2017/18	13%	3	3	25%
	2018/19	25%	2	4	38%
Grey Heron	2017/18	40%	2	3	29%
	2018/19	42%	1	2	23%
Oystercatcher	2017/18	100%	14	57	80%
	2018/19	100%	12	26	74%
Curlew	2017/18	80%	5	13	63%
	2018/19	75%	9	24	75%
Greenshank	2017/18	7%	1	1	13%
	2018/19	8%	1	1	13%
Redshank	2017/18	80%	11	50	42%
	2018/19	75%	15	52	49%
Black-headed Gull	2017/18	100%	86	250	80%
	2018/19	100%	39	105	84%
Common Gull	2017/18	100%	42	263	83%
	2018/19	100%	25	175	59%
Lesser Black-backed Gull	2017/18	53%	2	5	25%
	2018/19	50%	3	9	29%
Herring Gull	2017/18	93%	7	36	68%
	2018/19	100%	2	6	40%
Great Black-backed Gull	2017/18	73%	3	11	28%
	2018/19	75%	1	2	24%
Sandwich Tern	2017/18	13%	1	1	13%
	2018/19	17%	4	5	19%

Additional species recorded in 2017/18, but not in 2018/19 were Teal, Shoveler, Golden Plover and Sanderling. The non-zero counts shows the mean percentage of count periods (between the EBB5 and FLOOD0 counts) per day on which the species was recorded, excluding days when the species was not recorded. See Appendix A and Appendix C for the full count data.

Disturbance

4.16 Across all the Bird Corridor monitoring days (2016/17-2018/19), the overall occurrence of target species in the Bird Corridor was not correlated with the numbers of tractors working within 250 m of the Bird Corridor (Spearman's r = 0.064, 1-sided p = 0.631, n = 30), or with the number of tractor movements within and adjacent to the Bird Corridor (Spearman's r = -0.177, 1-sided p = 0.174, n = 30).

4.17 The relationship between the total numbers of target species in the Bird Corridor on each 30 minute count during the low tide period and the numbers of tractors working within 250 m of the Bird Corridor is shown in Text Figure 4.2. This shows that, while there is a lot of variability in the data, there was a negative trend on 11 of the 13 count days included in the analysis. However, the overall relationship across all the count days is not significant (Spearman's r = -0.126, 1-sided p = 0.136, n = 78)



Text Figure 4.1 - Relationship between tractor activity and numbers of target species in the Bird Corridor during the Bird Corridor monitoring low tide counts. Only days with peak counts of ≥ 50 birds are included. The data from the EBB and FLOOD counts is excluded because the Bird Corridor has limited or no exposure during these periods.

4.18 In 2018/19, one instance of target species within the Bird Corridor apparently being flushed by tractor movements was observed during the Bird Corridor monitoring counts (Table 4.14). There were 15 instances where tractor movements or husbandry activity were observed to not have any detectable disturbance impact on birds within the Bird Corridor (Table 4.14). These included one instance at a distance of 100-200 m, and two instances at distances of 200-300 m.

Table 4.14 - Disturbance responses of the target species within the Bird Corridor to tractor movement and husbandry activity within and around the Bird Corridor (2018/19 data).

Species	Response	Number of observations at distances of:					
		0-100 m	100-200 m	200-300 m	300-400 m	400-500 m	> 500 m
Bar-tailed Godwit	none	0	1	2	1	0	10
	flush	0	0	1	0	0	0
Dunlin	none	0	0	0	0	0	1
	flush	0	0	0	0	0	0

There were no observations of interactions between tractor movement and Grey Plover or Knot.

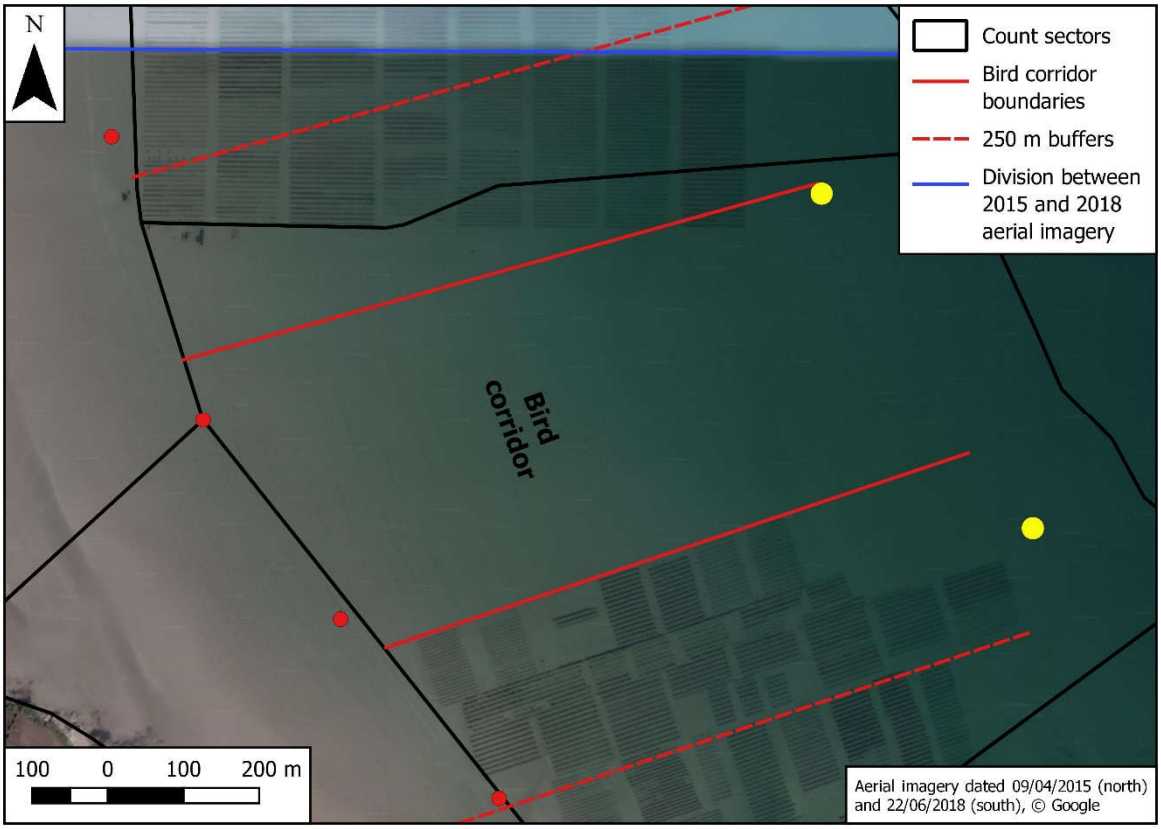


Figure 4.1 – Configuration of oyster trestles around the Bird Corridor in June 2018.

5. Discussion

Count accuracy

5.1 The ebb and flood tide counts followed the methodology established in 2014/15 (Gittings and O'Donoghue, 2015) and we consider that the ebb and flood tide counts on Whitehouse Bank were generally very accurate. This is reflected in the count data for target species in the ebb tide period that generally showed a consistent pattern of decrease across the ebb tide period, reflecting the movement of birds off Whitehouse Bank during this period. The count data in the flood tide period showed a less consistent pattern, but this appears to have reflected more complex movement patterns.

5.2 As in previous winters, the fact that the maximum count on the ebb or flood tide counts often exceeded the low tide count shows that there were some issues with count accuracy during the low tide counts. Grey Plover was particularly affected by these issues, with lower numbers at low tide, compared to the maximum count ebb/flood tide count, on all of the tidal cycle count dates. There were a number of factors that probably affected the accuracy of the low tide counts (Gittings and O'Donoghue, 2015). These issues illustrate the challenges in carrying out accurate low tide counts of highly mobile species in complex intertidal sites. At Dungarvan Harbour, fully accurate low tide counts for the target species would probably require a team of at least six observers (Gittings and O'Donoghue, 2015).

Distribution patterns

5.3 Overall, the comparison of the low tide distribution patterns between the five winters for which we have data shows that, while the broad distribution patterns remain fairly constant (i.e., the concentration of Grey Plover, Knot, apart from 2017/18, and Dunlin in the Inner Harbour and Bar-tailed Godwit on the Ballyrandle Sandflats), the finer scale patterns can be quite variable (e.g., the relative distribution of Grey Plover and Dunlin between the Ballyrandle Sandflats and Whitehouse Bank, and the distribution of Dunlin within Whitehouse Bank). Also, both Bar-tailed Godwit and Dunlin appear to have shown a northward shift in their low tide distribution in Whitehouse Bank across the five winters monitored. Similarly, the broad pattern of large numbers of the target species occurring on Whitehouse Bank at the start of the ebb tide and returning on the flood tide is repeated each winter, but the finer scale timings of the movements onto/off Whitehouse Bank can vary between winters. Without data on the availability of food resources, it is not possible to interpret the significance of these finer scale patterns.

Responses to intertidal oyster cultivation

5.4 The distribution patterns of the target species in relation to oyster trestles were similar to those of the past two winters (Dunlin) or all the winters (Grey Plover, Bar-tailed Godwit and Knot).

5.5 As in previous winters, Grey Plover and Knot were more or less completely absent from the areas occupied by oyster trestles. Across the four winters that we have monitored waterbird distribution on Whitehouse Bank, there have only been two records of a total of five birds of Grey Plover within trestle blocks during low tide counts, as well as occasional records of Grey Plover and Knot roosting on trestle blocks at the start of the flood tide period. While it could be argued that the apparent avoidance of the oyster trestles is an artefact of the low numbers/absence of these species from Whitehouse Bank at low tide, the occurrence of large numbers of these species in the Bird Corridor on some of the Bird Corridor monitoring days indicates that it is the presence of oyster trestles on

Whitehouse Bank that is, at least in part, causing the low numbers/absence of these species from Whitehouse Bank.

5.6 The large-scale (all sectors analysis) distribution patterns of Bar-tailed Godwit showed a negative association with oyster trestles, although at the smaller-scale (close sectors analysis) Bar-tailed Godwit showed a neutral association with oyster trestles. The latter may have been due to the high tideline percentage within the trestles across the counts, which, apart from the Bird Corridor, left little tideline outside the trestles on most counts. The lack of detailed data on benthic fauna means we still do not know whether the large scale distribution pattern is due to avoidance of the trestles, or whether differences in prey resources between Ballyrandle Sandflats and Whitehouse Bank are an important factor. However, it is interesting to note that Hutchinson (1979) stated that "*the sand beach east of the Cunnigar provides cockles and lugworms respectively for the largest flocks of Oystercatchers and Bar-tailed Godwit in the county [Waterford]*". This indicates that much higher numbers of Bar-tailed Godwit occurred on Whitehouse Bank prior to the development of oyster trestles in the 1980s-1990s.

5.7 As in 2016/17 and 2017/18, Dunlin distribution in the Outer Sandflats zone was concentrated in the northern part of Whitehouse Bank and did not have an obviously negative association with oyster trestles, in contrast to the patterns shown in 2010/11 and 2014/15. It seems likely that in the last three winters, food resources, rather than the presence of oyster trestles, was the main factor determining Dunlin distribution patterns at low tide in the Outer Sandflats zone. However, the much larger Dunlin flocks recorded at low tide in the Bird Corridor on some of the Bird Corridor monitoring days suggests that the presence of trestles on Whitehouse Bank may have limited the overall numbers in the Outer Sandflats zone.

Utilisation of the Bird Corridor

5.8 We have now completed three winters of waterbird monitoring following establishment of the Bird Corridor. In the first winter (2016/17), the trestles had not been completely removed from the Bird Corridor and there was also significant additional tractor activity within the Bird Corridor (Gittings and O'Donoghue, 2018a). In addition, the Bird Corridor monitoring was only carried out at the end of the winter, following the realisation that the tidal cycle counts were not an effective method of monitoring bird activity within the Bird Corridor (Gittings and O'Donoghue, 2018a). In the second winter (2017/18), the last trestles were removed from the Bird Corridor in October and there was little tractor activity in the Bird Corridor (Gittings and O'Donoghue, 2018b). In the third winter (2018/19), the Bird Corridor remained clear of trestles and there was virtually no tractor activity within the Bird Corridor (this report). In 2017/18 and 2018/19, 15 and 12 days of Bird Corridor monitoring were completed, respectively, spread throughout each winter. Therefore, we now have a good picture of waterbird utilisation of the Bird Corridor in the absence of oyster trestles and tractor activity within the Bird Corridor.

5.9 In all three winters, all four target species were recorded within the Bird Corridor. Significant numbers of each species were recorded on some dates in each winter, although their overall occurrence patterns were erratic. Grey Plover and Knot are completely excluded by the presence of oyster trestles, while large flocks of Bar-tailed Godwit and Dunlin do not occur within trestle blocks. Therefore, the occurrence of Grey Plover and Knot, and of large flocks of Bar-tailed Godwit and Dunlin, in the Bird Corridor at low tide indicates that the presence of oyster trestles is limiting their utilisation of intertidal habitat on Whitehouse Bank.

5.10 It is more difficult to assess the extent to which the removal of trestles from the Bird Corridor has increased its utilisation by these species as the tidal cycle counts (which are the only pre-removal) data are not an effective way of monitoring the occurrence of these species in the Bird Corridor. Clearly, the removal of the trestles will have increased the area of habitat. Furthermore, as most of

the trestles occurred at around the same position relative to the tideline, and as these species usually occur on, or close to, the tideline, when they occur within the Bird Corridor, the removal of the trestles will have increased the duration over which these species can stay in the Bird Corridor.

5.11 In 2017/18, Grey Plover appeared to use the Bird Corridor with similar, or greater intensity, as their usage of their favoured low tide habitats in the Inner Harbour. However, Grey Plover in 2018/19, and Dunlin in both winters, appeared to use the Bird Corridor with much lower intensity as their usage of their favoured low tide habitats in the Inner Harbour. The latter results are not surprising, as the small size of the Bird Corridor is likely to limit its usage by both these species, as indicated by the Inner Harbour monitoring results in 2017/18 (Gittings and O'Donoghue, 2018b).

5.12 It might be expected that the target species would have occurred more frequently within the Bird Corridor in 2018/19, compared to 2017/18, as birds would have become habituated to its presence and the absence of aquaculture activity within it. However, Grey Plover, Knot and Dunlin were all recorded less frequently, while the occurrence patterns of Bar-tailed Godwit were similar across the two winters. The temporally aggregated occurrence patterns of these species means that there is probably a large degree of random sampling error in the Bird Corridor monitoring data. It is notable that apart from Light-bellied Brent Goose, the occurrence patterns of the other regularly occurring waterbird species was similar in the two winters.

5.13 A complicating factor in the interpretation of the usage patterns of the Bird Corridor is that there appears to have been a northward shift in the low tide distribution of Bar-tailed Godwit and Dunlin on Whitehouse Bank that predates the establishment of the Bird Corridor. The low tide distribution patterns of most other regularly occurring waterbird species on Whitehouse Bank does not appear to show a similar northward shift (although the dataset for the other species is limited to a comparison across sectors OY2 and OY3 between the winters of 2010/11 and 2018/19 only).

5.14 As in 2017/18, very little tractor activity was recorded within the Bird Corridor so little additional data on the disturbance responses of the target species to tractor activity was collected. The overall Bird Corridor monitoring dataset across all three winters still shows some indications of a negative relationship between tractor numbers adjacent to the Bird Corridor and target species numbers within the Bird Corridor. However, as previously discussed (Gittings and O'Donoghue, 2018b), this apparent relationship could be an artefact of the relationship of both tractor numbers and target species movement patterns with the low tide cycle.

Conclusions

5.15 The broad patterns of tidal cycle movements, low tide distribution and association with oyster trestles recorded in the 2017/18 waterbird monitoring of the target species at Dungarvan Harbour are largely similar to those recorded in previous winters. However, as in 2016/17 and 2017/18, Dunlin distribution in the Outer Sandflats zone did not show an obvious negative association with oyster trestles, although the trestles may still be causing displacement at a larger scale. There appears to have been a northward shift in both Bar-tailed Godwit and Dunlin low tide distribution on Whitehouse Bank since 2010/11 and this complicates interpretation of usage patterns of the Bird Corridor relative to adjacent count sectors.

5.16 Large numbers of all four of the target species were recorded in the Bird Corridor at low tide on some counts, but their occurrence was erratic. Grey Plover, Knot and Dunlin occurred less frequently and in lower numbers in the Bird Corridor in 2018/19 compared to 2017/18.

5.17 In 2017/18, Grey Plover appeared to use the Bird Corridor with similar, or greater intensity, as their usage of their favoured low tide habitats in the Inner Harbour. However, Grey Plover in 2018/19,

and Dunlin in both winters, appeared to use the Bird Corridor with much lower intensity as their usage of their favoured low tide habitats in the Inner Harbour.

5.18 There is some evidence that tractor movements and husbandry activities may be limiting the usage of the Bird Corridor, and may also be having larger-scale effects on waterbird utilisation of Whitehouse Bank at low tide. However, it is also possible that the apparent relationships with tractor activity are artefacts of a relationship between waterbird numbers and low tide stage.

Recommendations for further work

5.19 Gittings and O'Donoghue (2018b) recommended updating the population trend analyses for the target species, carrying out benthic surveys to quantify the distribution and biomass of the prey resources used by the target species, and developing an individual-based model to assess the population-level consequences of the displacement impacts on the target species. These recommendations still apply.

6. References

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Gittings, T. & O'Donoghue, P.D. (2018a). *Dungarvan Harbour SPA: Monitoring of waterbird distribution across the tidal cycle, 2016/17*. Report prepared for the Marine Institute, Atkins, Cork.

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Appendix A

Count data for the additional monitored species

Table A.1 - Maximum counts of the additional monitored species recorded during ebb, low and flood tide periods on each count day.

Species	Date	Maximum count		
		Ebb	LT	Flood
Light-bellied Brent Goose	24/10/2018	112	77	115
	10/11/2018	229	240	171
	07/12/2018	396	802	245
	08/01/2019	283	792	350
	23/01/2019	126	736	656
	07/02/2019	209	464	159
	22/02/2019	336	902	244
	07/03/2019	227	690	255
Golden Plover	24/10/2018	1600	3019	3050
	10/11/2018	3000	47	4350
	07/12/2018	0	5150	0
	08/01/2019	0	5500	4500
	23/01/2019	0	10	0
	07/02/2019	4000	4000	0
	22/02/2019	3000	3650	5570
	07/03/2019	1030	1000	2850
Ringed Plover	24/10/2018	121	128	48
	10/11/2018	101	90	90
	07/12/2018	100	58	151
	08/01/2019	93	54	150
	23/01/2019	101	52	70
	07/02/2019	60	43	89
	22/02/2019	43	42	42
	07/03/2019	18	22	30
Sanderling	24/10/2018	68	134	83
	10/11/2018	84	0	112
	07/12/2018	125	150	8
	08/01/2019	114	34	62
	23/01/2019	137	22	72
	07/02/2019	35	24	33
	22/02/2019	113	72	90
	07/03/2019	0	2	17

Data are the maxima across four ebb tide counts, one low tide count, and four flood tide counts. The areas covered varied between counts (see text for details).

Table A.1 - Counts of the additional monitored species across the tidal cycle on Whitehouse Bank.

Species	Date	Ebb tide				Low tide	Flood tide			
		1	2	3	4		1	2	3	4
Light-bellied Brent Goose	24/10/2018	69	71	64	106	57	52	64	3	39
	10/11/2018	2	34	47	42	98	61	47	80	18
	07/12/2018	314	374	302	176	49	43	12	8	6
	08/01/2019	255	267	217	160	208	63	84	79	27
	23/01/2019	8	20	68	41	76	12	88	38	590
	07/02/2019	159	93	121	107	112	155	137	53	38
	22/02/2019	80	80	91	206	236	42	38	19	110
	07/03/2019	114	128	151	148	298	125	119	121	60
Golden Plover	24/10/2018	0	0	1600	1600	3011	3028	3014	3006	3050
	10/11/2018	0	3000	3000	3000	17	4350	0	0	0
	07/12/2018	0	0	0	0	0	0	0	0	0
	08/01/2019	0	0	0	0	0	0	0	0	0
	23/01/2019	0	0	0	0	0	0	0	0	0
	07/02/2019	0	0	0	0	0	0	0	0	0
	22/02/2019	0	1000	0	0	0	5570	2080	0	0
	07/03/2019	0	790	790	1030	1000	36	2850	2850	2850
Ringed Plover	24/10/2018	0	0	106	121	128	48	44	40	20
	10/11/2018	101	76	35	21	0	90	43	41	0
	07/12/2018	0	0	0	21	0	0	61	151	143
	08/01/2019	82	82	93	33	54	0	0	0	0
	23/01/2019	57	69	78	58	52	48	58	70	0
	07/02/2019	28	30	9	10	7	42	44	44	41
	22/02/2019	39	43	33	37	42	19	19	5	42
	07/03/2019	4	15	10	18	22	28	29	30	24
Sanderling	24/10/2018	0	0	68	8	134	72	71	83	72
	10/11/2018	76	84	64	73	0	112	92	58	68
	07/12/2018	100	115	125	34	76	0	8	4	0
	08/01/2019	67	114	113	59	34	0	0	62	0
	23/01/2019	82	37	7	0	22	63	48	72	0
	07/02/2019	0	20	32	35	24	0	0	33	28
	22/02/2019	113	107	77	73	72	82	90	70	65
	07/03/2019	0	0	0	0	2	17	16	14	0

See notes to Table 3.3.

Table A.1 - Percentages of feeding birds of the additional monitored species across the tidal cycle on Whitehouse Bank.

Species	Date	Ebb tide				Low tide	Flood tide			
		1	2	3	4		1	2	3	4
Light-bellied Brent Goose	24/10/2018	17%	42%	41%	37%	72%	2%	67%		0%
	10/11/2018		59%	26%	64%	62%	87%	100%	63%	0%
	07/12/2018	0%	24%	84%	61%	80%	100%	17%		
	08/01/2019	35%	9%	91%	91%	69%	62%	98%	9%	41%
	23/01/2019		20%	84%	90%	86%	100%	64%	53%	0%
	07/02/2019	60%	38%	100%	95%	82%	100%	100%	100%	100%
	22/02/2019	100%	100%	75%	79%	49%	81%	92%	100%	0%
	07/03/2019	89%	92%	50%	84%	48%	90%	47%	6%	57%
Golden Plover	24/10/2018			0%	0%	0%	0%	0%	0%	2%
	10/11/2018		0%	0%	0%	0%	0%			
	07/12/2018									
	08/01/2019									
	23/01/2019									
	07/02/2019									
	22/02/2019						3%	4%		
	07/03/2019		0%	4%	6%	0%	0%	0%	0%	0%
Ringed Plover	24/10/2018			100%	100%	118%	100%	82%	38%	0%
	10/11/2018	71%	83%	71%	10%		62%	100%	32%	
	07/12/2018				100%			33%	72%	100%
	08/01/2019	100%	100%	100%	100%	100%				
	23/01/2019	0%	100%	100%	100%	100%	17%	3%	0%	
	07/02/2019	4%	40%		40%		100%	100%	100%	100%
	22/02/2019	100%	100%	100%	100%	100%	100%	37%		88%
	07/03/2019		33%	100%	100%	100%	100%	97%	0%	0%
Sanderling	24/10/2018			100%		143%	100%	73%	99%	100%
	10/11/2018	100%	100%	98%	97%		100%	100%	100%	100%
	07/12/2018		100%	100%	100%	100%				
	08/01/2019	100%	100%	100%	100%	100%			100%	
	23/01/2019	100%	73%			100%	95%	17%	1%	
	07/02/2019		100%	100%	100%	100%			100%	100%
	22/02/2019	100%	100%	100%	100%	100%	100%	100%	100%	65%
	07/03/2019						100%	100%	0%	

See notes to Table 3.4.

Table A.1 - Distribution of the additional monitored species at low tide.

Species	Date	Inner Harbour		Outer Sandflats	
		upper	main	Ballyrandle	Whitehouse
Light-bellied Brent Goose	24/10/2018	0	16	4	57
	10/11/2018	0	122	20	98
	07/12/2018	12	411	330	49
	08/01/2019	0	236	348	208
	23/01/2019	0	308	352	76
	07/02/2019	10	217	125	112
	22/02/2019	54	329	283	236
	07/03/2019	63	192	137	298
Golden Plover	24/10/2018	0	8	0	3011
	10/11/2018	30	0	0	17
	07/12/2018	0	5150	0	0
	08/01/2019	0	5500	0	0
	23/01/2019	0	0	10	0
	07/02/2019	0	4000	0	0
	22/02/2019	0	3650	0	0
	07/03/2019	0	0	0	1000
Ringed Plover	24/10/2018	0	0	0	128
	10/11/2018	0	90	0	0
	07/12/2018	0	58	0	0
	08/01/2019	0	0	0	54
	23/01/2019	0	0	0	52
	07/02/2019	0	36	0	7
	22/02/2019	0	0	0	42
	07/03/2019	0	0	0	22
Sanderling	24/10/2018	0	0	0	134
	10/11/2018	0	0	0	0
	07/12/2018	0	74	0	76
	08/01/2019	0	0	0	34
	23/01/2019	0	0	0	22
	07/02/2019	0	0	0	24
	22/02/2019	0	0	0	72
	07/03/2019	0	0	0	2

Table A.1 - Observations of additional monitored species in the Bird Corridor during the tidal cycle counts.

Species	Date	EBB4	LT	Flood 1
Light-bellied Brent Goose	24/10/2018	19	47	7
	10/11/2018	0	27	0
	07/12/2018	0	8	0
	08/01/2019	0	12	0
	23/01/2019	0	1	0
	07/02/2019	0	19	0
	07/03/2019	0	2	0

Data only shown for days on which the species was recorded in the Bird Corridor on at least one count. Sanderling, Golden Plover and Ringed Plover were not recorded in the Bird Corridor on any of the tidal cycle counts.

Table A.1 - Observations of the additional monitored species in the Bird Corridor during the Bird Corridor monitoring counts.

Species	Date	EBB5	LT1	LT2	LT3	LT4	LT5	LT6	Flood 0
Light-bellied Brent Goose	23/10/2018	38	39	37	43	17	15	27	6
	13/11/2018	2	2	0	0	3	0	0	0
	24/11/2018	7	3	2	16	17	22	24	10
	07/01/2019	0	2	10	7	6	6	0	0
	06/02/2019	0	3	0	0	2	2	0	0

Golden Plover, Ringed Plover and Sanderling not recorded in the Bird Corridor on any of the Bird Corridor monitoring counts. EBB3 counts: 5 Light-bellied Brent Goose on 23/10/2018. EBB4 counts: 13 Light-bellied Brent Goose on 23/10/2018. FLOOD1 counts: 21 Light-bellied Brent Goose on 23/10/2018.

Appendix B

Additional Bird Corridor count data for the target species

Table B.1 - Maximum counts of target species on Whitehouse Bank during the ebb and flood tide periods on the Bird Corridor monitoring days.

Species	Date	Maximum counts:	
		ebb tide	flood tide
Grey Plover	11/09/2018	22	0
	24/09/2018	33	0
	28/09/2018	32	0
	09/10/2018	30	23
	23/10/2018	35	0
	13/11/2018	40	0
	24/11/2018	0	18
	10/12/2018	0	72
	07/01/2019	0	0
	22/01/2019	0	30
	06/02/2019	50	0
	06/03/2019	53	0
Bar-tailed Godwit	11/09/2018	52	150
	24/09/2018	7	6
	28/09/2018	13	15
	09/10/2018	6	6
	23/10/2018	9	14
	13/11/2018	26	0
	24/11/2018	16	27
	10/12/2018	46	31
	07/01/2019	135	13
	22/01/2019	76	26
	06/02/2019	239	101
	06/03/2019	243	6
Knot	11/09/2018	0	0
	24/09/2018	0	0
	28/09/2018	0	0
	09/10/2018	0	0
	23/10/2018	0	0
	13/11/2018	14	0
	24/11/2018	0	20
	10/12/2018	11	0
	07/01/2019	0	0
	22/01/2019	10	0
	06/02/2019	0	0
	06/03/2019	2	0
Dunlin	11/09/2018	30	3
	24/09/2018	0	0
	28/09/2018	32	45
	09/10/2018	480	160
	23/10/2018	450	0
	13/11/2018	45	0

Species	Date	Maximum counts:	
		ebb tide	flood tide
Dunlin	24/11/2018	0	85
	10/12/2018	0	960
	07/01/2019	0	0
	22/01/2019	210	0
	06/02/2019	500	0
	06/03/2019	110	0

Note: the ebb and flood tide counts only covered sectors CS1 and CS2, and counts of birds in the northern section of CS2 were of low quality (see text).

Appendix C

Bird corridor count data for other waterbird species

Table C.1 - Counts of other waterbird species in the Bird Corridor during the Bird Corridor monitoring watches.

Species	Date	EB4	EB5	LT1	LT2	LT3	LT4	LT5	LT6	FL0	FL1
Little Egret	11/09/2018	0	0	0	0	0	0	0	0	1	2
	24/09/2018	0	0	0	0	0	2	2	2	2	0
	28/09/2018	0	0	0	1	0	1	0	2	4	0
Grey Heron	11/09/2018	0	0	0	0	0	0	1	2	1	1
	24/09/2018	0	0	0	0	0	0	0	1	0	0
	28/09/2018	0	0	0	0	0	1	0	0	0	0
	09/10/2018	0	0	0	0	1	1	0	0	2	0
	10/12/2018	0	0	0	0	0	0	0	0	0	1
	07/01/2019	0	0	0	0	0	0	0	0	1	0
Oyster-catcher	11/09/2018	8	6	8	14	16	20	21	20	16	12
	24/09/2018	0	9	10	13	11	13	12	10	10	0
	28/09/2018	0	6	13	6	6	6	12	14	10	0
	09/10/2018	1	3	1	1	13	19	19	10	7	1
	23/10/2018	10	7	1	7	7	9	8	5	6	2
	13/11/2018	0	1	0	0	1	3	0	0	0	0
	24/11/2018	0	15	14	16	20	26	25	23	15	0
	10/12/2018	2	11	7	0	0	3	0	1	4	4
	07/01/2019	11	9	3	0	2	1	2	0	0	2
	22/01/2019	10	6	0	0	1	7	2	2	1	0
	06/02/2019	1	1	2	0	0	0	0	0	0	5
	06/03/2019	0	0	0	0	8	0	0	0	1	0
Curlew	11/09/2018	2	12	8	7	9	11	13	10	6	11
	24/09/2018	0	5	12	10	13	4	5	4	4	0
	28/09/2018	0	6	7	2	2	8	11	8	8	0
	09/10/2018	0	0	1	3	9	4	9	4	4	2
	23/10/2018	3	1	5	5	6	10	7	5	4	6
	13/11/2018	0	0	0	0	1	0	0	2	1	0
	24/11/2018	0	24	18	15	20	23	19	18	10	0
	07/01/2019	1	0	1	0	0	0	1	0	0	0
	22/01/2019	0	0	0	0	0	1	1	0	0	1
Green-shank	09/10/2018	0	0	1	0	0	0	0	0	0	0
Red-shank	24/09/2018	0	0	5	0	0	0	0	0	0	0
	09/10/2018	0	28	20	17	0	1	0	0	0	0
	23/10/2018	0	10	52	2	10	2	0	0	0	0
	13/11/2018	0	10	26	23	18	14	18	11	12	0
	24/11/2018	0	6	7	3	2	5	4	7	9	0
	10/12/2018	3	8	1	6	2	0	0	4	2	0
	07/01/2019	0	0	4	0	0	0	0	0	0	0
	22/01/2019	0	0	0	6	0	0	0	0	0	0
	06/02/2019	0	0	0	1	0	0	0	0	0	0

Species	Date	EB4	EB5	LT1	LT2	LT3	LT4	LT5	LT6	FL0	FL1
Black-headed Gull	11/09/2018	14	24	46	10	23	23	23	17	13	8
	24/09/2018	0	20	42	38	67	62	45	15	13	0
	28/09/2018	0	72	105	23	69	39	31	21	11	0
	09/10/2018	137	64	42	40	19	14	2	7	5	2
	23/10/2018	24	43	25	15	23	15	2	0	0	0
	13/11/2018	0	12	11	0	1	0	22	6	0	0
	24/11/2018	0	27	24	27	18	12	7	12	13	0
	10/12/2018	2	5	22	14	3	11	4	9	5	3
	07/01/2019	0	4	16	5	22	22	3	4	5	2
	22/01/2019	1	3	3	5	3	3	5	1	1	0
	06/02/2019	0	0	17	5	0	2	1	0	0	0
	06/03/2019	0	0	0	0	4	0	0	32	0	0
Common Gull	11/09/2018	0	0	0	1	0	2	4	4	0	0
	24/09/2018	0	7	17	15	20	27	28	15	0	0
	28/09/2018	0	0	3	8	23	31	16	15	2	0
	09/10/2018	0	0	0	1	1	1	5	0	0	0
	23/10/2018	0	0	0	0	1	0	0	0	0	7
	13/11/2018	0	0	2	0	6	3	19	11	4	0
	24/11/2018	0	175	126	121	72	70	47	40	17	0
	10/12/2018	9	0	1	3	0	7	7	8	4	9
	07/01/2019	0	1	0	1	8	12	1	0	0	0
	22/01/2019	0	1	0	7	2	10	2	0	0	0
	06/02/2019	0	0	0	0	1	0	0	0	0	0
	06/03/2019	0	1	1	0	0	0	1	0	0	0
Lesser Black-backed Gull	24/09/2018	0	0	0	0	0	0	0	2	0	0
	23/10/2018	1	0	0	0	0	0	0	1	0	0
	13/11/2018	0	0	0	0	0	0	0	9	0	0
	24/11/2018	0	3	0	0	0	0	2	3	0	0
	10/12/2018	0	0	0	0	0	0	0	0	0	1
	07/01/2019	0	0	0	1	1	1	0	0	0	0
	22/01/2019	0	0	0	2	2	3	4	0	2	0
Herring Gull	11/09/2018	1	1	0	0	2	2	3	2	1	1
	24/09/2018	0	0	0	1	0	1	0	0	1	0
	28/09/2018	0	1	1	1	0	0	0	0	0	0
	09/10/2018	0	0	0	0	0	0	2	1	0	0
	23/10/2018	0	0	1	0	0	0	2	1	0	0
	13/11/2018	0	0	0	0	2	0	0	1	0	0
	24/11/2018	0	4	3	1	0	0	0	3	2	0
	10/12/2018	0	0	0	0	0	0	1	0	0	0
	07/01/2019	0	0	1	0	0	1	0	1	0	0
	22/01/2019	0	2	0	1	2	0	0	1	1	0
	06/02/2019	2	0	1	1	0	0	0	0	0	0
	06/03/2019	0	0	1	0	6	5	0	0	0	0

Species	Date	EB4	EB5	LT1	LT2	LT3	LT4	LT5	LT6	FL0	FL1
Great Black-backed Gull	11/09/2018	0	0	0	0	2	0	1	1	0	0
	24/09/2018	0	0	0	0	1	0	0	0	0	0
	09/10/2018	0	2	0	0	0	0	1	0	0	0
	23/10/2018	0	0	0	0	1	1	1	0	0	0
	13/11/2018	0	0	0	0	2	0	0	0	0	0
	10/12/2018	0	0	0	0	0	0	0	0	1	0
	22/01/2019	0	0	0	0	0	0	0	1	0	0
	06/02/2019	0	1	0	0	0	2	0	0	0	0
	06/03/2019	0	1	1	0	0	1	0	0	0	0
Sandwich Tern	11/09/2018	0	0	0	0	3	0	0	0	0	0
	28/09/2018	0	5	4	0	0	0	0	0	0	0

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