EMFF Operational Programme 2014-2020

Marine Biodiversity Scheme

Marine Institute Bird Studies

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

2014-2015

Lead Agency: Marine Institute

Authors: ATKINS:

Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
Co-funded by the Irish Government and the European Union

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

EUROPEAN UNION
This measure is part-financed by the European Maritime and Fisheries Fund

Foras na Mara
Marine Institute

Operational Programme	European Maritime and Fisheries Fund (EMFF) Operational Programme 2014-2020
Priority	Union Priority 1 Sustainable Development of Fisheries Union Priority 6 Fostering the implementation of the Integrated Maritime Policy
Thematic Objective	TO 6 - Preserving and protecting the environment and promoting resource efficiency
Specific Objective	UP1 SO1 - Reduction of the impact of fisheries and aquaculture on the marine environment, including the avoidance and reduction, as far as possible, of unwanted catch. UP1 SO2 - Protection and restoration of aquatic biodiversity and ecosystems. UP6 SO1 - Development and implementation of the Integrated Maritime Policy
Measure	Marine Biodiversity Scheme
Project No.	MB/2019/08
EMFF Certifying Body	Finance Division, Department of Agriculture, Food and the Marine
Managing Authority	Marine Agencies & Programmes Division, Department of Agriculture, Food and Marine
Specified Public Beneficiary Body	Marine Institute
Grant Rate	100%
EU Co-Financing Rate	50%
Legal Basis	Article 29, 40 & 80 EMFF
Details	Report to the Marine Institute ATKINS.

This project or operation is part supported by the Irish government and the European Maritime & Fisheries Fund as part of the EMFF Operational Programme for 2014-2020

Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
Co-funded by the Irish Government and the European Union

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

EUROPEAN UNION
This measure is part-financed by the European Maritime and Fisheries Fund

Foras na Mara
Marine Institute

Marine Institute Bird Studies

Dungarvan Harbour SPA: Monitoring of waterbird distribution across the tidal cycle, 2014/15

June 2015

Notice

Document History

JOB NUMBER: 2927			DOCUMENT REF: 2927_Dg24_Dungarvan Monitoring_2014/15.docx			
1	Final Report	TG & POD	POD	POD	JN	23-6-2015
0	Draft for Comment	TG & POD	POD	POD	JN	22-6-2015
Revision	Purpose Description	Originated	Checked	Reviewed	Authorised	Date

Contents

Section Page

List of Tables

List of Figures

Appendices

List of Tables

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: -

> *"Conduct a series of tidal cycle monitoring of Grey Plover, Knot and Dunlin, Bar-tailed Godwit - by carrying out systematic monitoring of bird distribution within Whitehouse Bank, and bird movements onto/off Whitehouse Bank, across the tidal cycle. A suitable monitoring regime should target three monitoring days per month, during neap, mean and spring low tide. The monitoring period should cover the full duration of exposure of Whitehouse Bank."*

1.3 This brief was subsequently amended to cover two survey days per month. In addition, 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, and the assessment, based on that work, carried out for the Dungarvan Harbour SPA Appropriate Assessment (Gittings and O'Donoghue, 2014a). This 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*). 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, 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).

1.5 The primary objective of the monitoring was to collect detailed data on the distribution patterns, and movements, of these species (referred to as the target species) across the tidal cycle, in order to inform the assessment as to whether the apparent movement on to/off Whitehouse Bank was due to the presence of the trestles, or due to some other factor. In addition, the monitoring was also used to extend the analyses of low tide distribution patterns in relation to the presence of trestles for these species by covering the late autumn/early winter period, which was not represented in the dataset used by Gittings and O'Donoghue (2014a).

1.6 Data was also collected on an additional three species: Ringed Plover (*Charadrius hiaticula*), Golden Plover (*Pluvialis apricaria*) and Sanderling (*Calidris alba*). These species are referred to as the additional monitored species. 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

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

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.

Limitations

1.7 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.

1.8 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.

1.9 The timing of the commissioning of this study allowed little time for development and testing of the methodology. Therefore, there was some degree of trial and error in the first three counts carried out before the final methodology was settled upon.

Personnel

1.10 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 Tom Gittings, John Deasy, Lesley Lewis and Pat Smiddy. Data entry was carried out by John Deasy.

2. Methods

Study area and count sectors

2.1 Dungarvan Harbour was divided into three broad zones by Gittings and O'Donoghue (2014a) 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: 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 study area for the present monitoring work 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 (main) for the low tide counts.

2.3 The count sectors used in this study are shown in Figure 2.1. In Ballyrandle Sandflats and Whitehouse Bank, the counts used the sectors defined for the trestle study (Gittings and O'Donoghue, 2012). In the Inner Harbour, the counts used the NPWS BWS subsites. In addition a count sector was defined for Clonea Strand.

2.4 The oyster trestles occur within the lower part of Whitehouse Bank (Figure 2.1). Mapping of the oyster trestles from summer 2014 was provided by the Department of Agriculture, Fisheries and the Marine, although this mapping was not received until after we had completed the survey work. As the operators are continually adjusting the trestle positions, this mapping will not represent the configuration of the trestles during our study with complete accuracy. We consider that the mapping provides a reasonable representation of the broad configuration, but there were some noticeable differences. In particular, during our study there was more extensive coverage of trestles in the northern part of sector OY1 than is depicted in the mapping.

Survey design

2.5 The survey included three components: -

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

2.6 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).

2.7 On the first three counts, ebb/flood tide counts were carried out on Ballyrandle Sandflats. This was discontinued for the subsequent counts to allow better coverage of the Whitehouse Bank area.

2.8 On the first two counts, the low tide counts included in the Inner Harbour (upper) and Clonea Strand. Systematic coverage of these areas was discontinued for the subsequent counts to allow better coverage of the Inner Harbour (main). However, there was selective coverage of the Inner Harbour (upper) sub-zone on the last two counts when bird movements indicated the presence of some of the target species in this area.

2.9 The count periods are shown in Table 2.1. The counts were originally designed to cover the following periods: 03:30-02:00 hours before low tide (ebb tide counts); 01:30 before-01:30 after low tide (low tide count); and 02:00-03:30 hours after low tide (flood tide counts). This allowed for four ebb tide and four flood tide counts at 30 minute intervals: 03:30, 03:00, 02:30 and 02:00 hours before low tide (ebb tide counts) and 02:00, 02:30, 03:00 and 03:30 hours after low tide (flood tide counts). However, this design assumed instantaneous counts, while, depending upon the level of bird activity it could take 10-20 minutes to complete the count. This meant that there was an asymmetry in the design with the flood tide counts extending for a longer period after low tide than the ebb tide counts extended before low tide. Therefore, a fifth ebb tide count was introduced (Ebb0) for most of the later counts, so that the Ebb0-Ebb3 counts covered the same period as the Flood 1-Flood4 counts. A Flood0 count (which would be equivalent to the Ebb4 count) was not introduced for timing reasons (two of the counters had to travel back from Ballyrandle after completing the low tide count), and because the tideline would still be within the trestle zone during this period.

Table 2.1 - Count periods.

Period	Count	Start time	Finish time
Ebb tide	Ebb0	-04:00	-03:30
	Ebb1	-03:30	-03:00
	Ebb2	-03:00	-02:30
	Ebb3	-02:30	-02:00
	Ebb4	-02:00	-01:30
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.

Count dates and timings

2.10 Counts were carried out on eleven dates between October 2014 and February 2015. 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. Due to adverse weather conditions on the initially selected days, some counts were carried out on days when the timing of the low tide prevented completion of flood tide counts.

2.11 A total of seven complete tidal cycle counts were completed, as well as three counts with complete ebb tide and low tide coverage, and one count with only ebb tide coverage (Table 2.2). Most of the counts were carried out on days with low tides of 0.6-0.9 m (Table 2.3), which is around the mean low tide height (0.75 m). Three counts were carried out on days with low tides of 0.2-0.5 m (Table

2.3), which represent spring low tide conditions (mean low water spring = 0.4 m). No counts were carried out on days with low tides of 1.0-1.3 m, as these low tides occurred around dawn or dusk.

Table 2.2 - Count dates and coverage.

Date	Ebb count	LT count	Flood count	Notes
23/10/2014	√	√	√	
27/10/2014	√	√	√	
12/11/2014	√	√	x	Flood period extended past dusk
24/11/2014	√	√	√	
10/12/2014	√	√	x	Flood period extended past dusk
22/12/2014	√	√	√	
05/01/2015	√	x	x	Count abandoned due to poor weather
08/01/2015	√	√	x	Flood period extended past dusk
21/01/2015	√	√	√	
06/02/2015	√	√	√	
19/02/2015	√	√	v	

Table 2.3 - Count dates and timings.

Date	Low tide		Count timings		
	time	height	Ebb	LT	Flood
23/10/2014	12:06	0.6 m	08:30-10:30	10:30-13:30	13:30-15:30
27/10/2014	13:32	0.7 m	09:40-12:30	12:00-15:00	15:30-17:30
12/11/2014	15:09	0.9 m	11:40-13:40	13:40-16:40	
24/11/2014	12:38	0.6 m	09:00-10:30	11:00-14:00	14:30-16:30
10/12/2014	14:03	0.8 m	08:50-12:30	12:30-15:30	
22/12/2014	11:44	0.5 m	08:15-10:15	10:15-13:15	13:45-15:45
05/01/2015	11:58	0.6 m	08:30-10:30		
08/01/2015	13:38	0.7 m	09:40-12:10	12:10-15:10	
21/01/2015	12:17	0.3 m	08:15-10:45	10:45-13:45	14:15-16:15
06/02/2015	13:12	0.6 m	09:10-11:40	11:40-14:40	15:10-17:10
19/02/2015	12:01	0.2 m	08:00-10:30	10:30-13:30	14:00-16:00

Counter organisation

2.12 All counts were carried out with three counters. The first three counts involved some trial and error to establish the most efficient use of counters to cover the key areas. From the fourth count onwards, a standard procedure was followed. The areas covered by each counter on each count are shown in Table 2.4.

Table 2.4 – Coverage.

Count	Period	Counter	Coverage
23/10/2014	Ebb and flood tide	John Deasy	western side of Inner Harbour (main)
		Tom Gittings	Whitehouse Bank (CS2 and CS3) and eastern side of Inner Harbour (main)
		Pat Smiddy	Ballyrandle Sandflats
	Low tide	John Deasy	Inner Harbour (upper) and Clonea Strand
		Tom Gittings	Whitehouse Bank
		Pat Smiddy	Ballyrandle Sandflats and Inner Harbour (main)
27/10/2014	Ebb and flood tide	John Deasy	Whitehouse Bank (CS1 and CS2)
		Tom Gittings	Whitehouse Bank (CS2 and CS3) and eastern side of Inner Harbour (main)
		Pat Smiddy	Ballyrandle Sandflats
	Low tide	John Deasy	Inner Harbour (upper) and Clonea Strand
		Tom Gittings	Whitehouse Bank
		Pat Smiddy	Ballyrandle Sandflats and Inner Harbour (main)
12/11/2014	Ebb and flood tide	John Deasy	Whitehouse Bank (CS1 and CS2) and eastern side of Inner Harbour (main)
		Tom Gittings	Whitehouse Bank (CS2 and CS3) and eastern side of Inner Harbour (main)
		Lesley Lewis	Ballyrandle Sandflats
	Low tide	John Deasy	Inner Harbour (main)
		Tom Gittings	Whitehouse Bank
		Lesley Lewis	Ballyrandle Sandflats and Inner Harbour (main)
24/11/2014-19/02/2015	Ebb and flood tide	John Deasy	Whitehouse Bank (CS1)
		Tom Gittings	Whitehouse Bank (CS3) and eastern side of Inner Harbour (main)
		Lesley Lewis/ Pat Smiddy	Whitehouse Bank (CS2) and eastern side of Inner Harbour (main)
	Low tide	John Deasy	Ballyrandle Sandflats and Inner Harbour (main)
		Tom Gittings	Whitehouse Bank
		Lesley Lewis/ Pat Smiddy	Ballyrandle Sandflats and Inner Harbour (main)

Count methodology

2.13 The 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.

2.14 On each count, all the target species, and additional monitored species, present were counted. Birds were counted separately in each count sector. Counters also recorded the behaviour of the birds (feeding, or roosting/other), whether birds were 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.

2.15 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 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).

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

2.17 Detailed recording instructions were provided to the counters (see Appendix B), and the count data was recorded on standard recording forms and maps.

Data processing

2.18 All count data was entered into Excel spreadsheets and tideline positions were digitised in ArcMap 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.

2.19 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 analysis

2.20 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.

2.21 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 Dunlin and Bar-tailed Godwit, as the other monitored species never occurred within the trestle blocks.

2.22 These analyses were based on the methodology used in the trestle study (Gittings and O'Donoghue, 2012). However, as noted the configuration of trestles is subject to change and had in fact changes since the site was previously mapped; as a consequence use of available mapping to calculate the areas of intertidal habitat occupied by trestles may have been misleading and was therefore avoided. In the Outer Sandflats zone, both Dunlin and Bar-tailed Godwit mainly occurred on, or close to the tideline: on three of the six counts with significant numbers of Dunlin present 86-100% occurred on the tideline, while on the other three counts, the main flocks occurred in the intertidal zone just above the tideline; and on eight of the ten counts, 95-100% of the Bar-tailed Godwits were on the tideline, while on the other two counts large Bar-tailed Godwit flocks occurred in the intertidal zone just above 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

2.23 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 not used by Dunlin and 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.

2.24 The tideline lengths within the relevant areas on Whitehouse Bank were calculated from the tidelines mapped during the low tide counts. 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.

2.25 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, 2014). 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.

2.26 We then compared the observed number with the expected number. We used scattergraphs to assess the relationship between observed and expected numbers.

2.27 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: -

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

2.28 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.

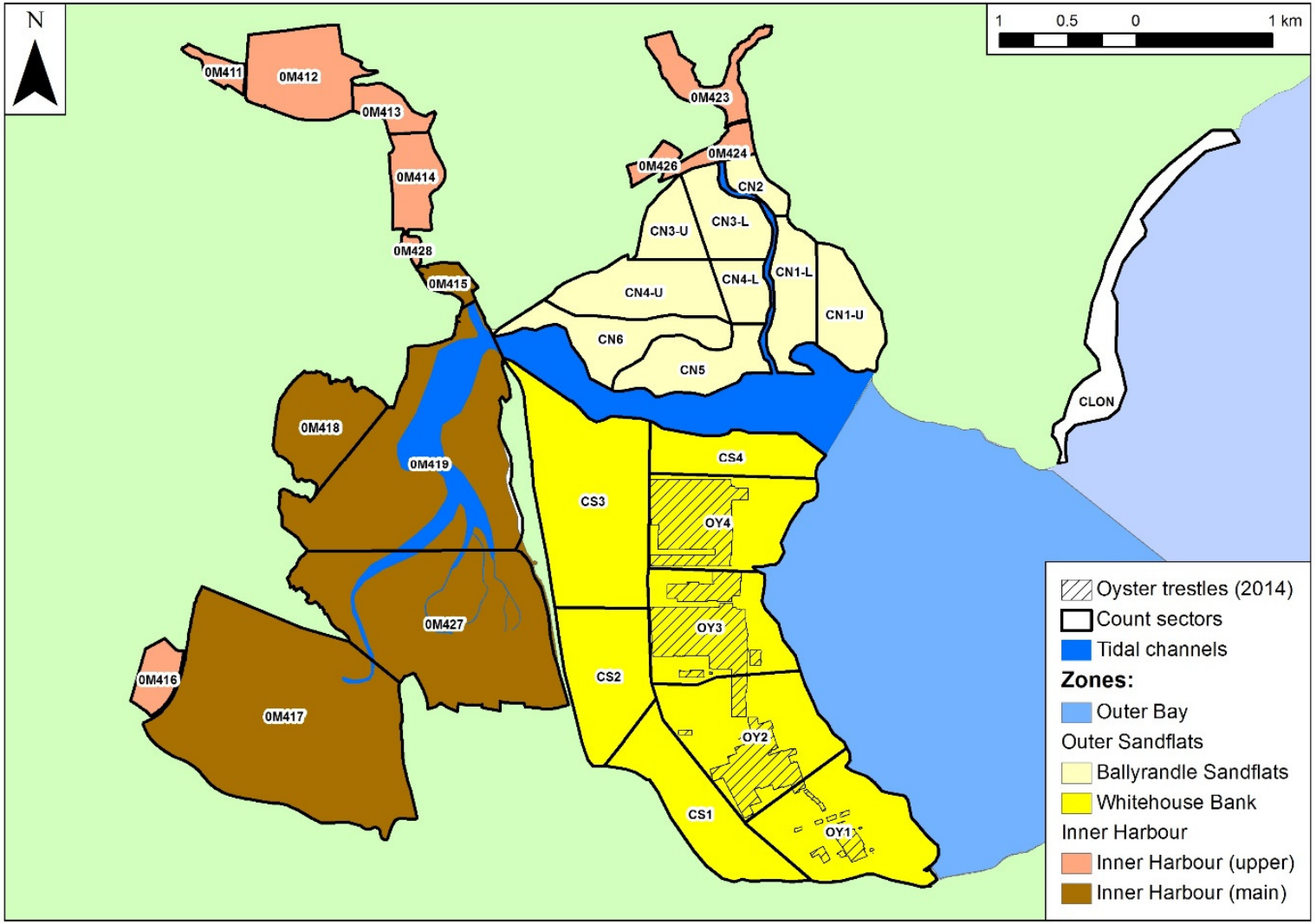


Figure 2.1 - Zones and count sectors.

3. Results

Tidal exposure

Whitehouse Bank

3.1 The tidal exposure period on Whitehouse Bank spans an eight hour period around low tide: at the start of the Ebb0 count (four hours before low tide) and the end of the Flood4 count (four hours after low tide), all of the sandflats on Whitehouse Bank were covered, apart from very small patches adjacent to the car park at the southern end of the Cunnigar.

3.2 The tidelines during the ebb/flood tide periods on all the count days (except 23/10/2014) are shown in Figure 3.1-Figure 3.5.

3.3 On the ebb tide, the tideline generally reached the trestle zone during the Ebb3 period (2.5-2 hours before low tide), although on the two days with tides approaching neap conditions (0.8-0.9 m low tides) the tideline was only just beginning to enter the trestle zone during the Ebb4 period (2-1.5 hours before low tide). On the two days with very low spring tides, the tideline was just beginning to enter the trestle zone during the Ebb2 period (3-2.5 hours before low tide).

3.4 On the flood tide, the tideline reached the area above the trestle zone during the Flood1 period (2-2.5 hours after low tide).

3.5 The tideline alignments at low tide are shown in Figure 3.8. On low tides of 0.6 m or less, the tideline falls below the trestles over much of the length of Whitehouse Bank. These tides accounted for 39% of the low tides during the October 2014-February 2015 period (Table 3.1). On the extreme spring low tides covered in our counts (0.2-0.3 m tides), the tideline was below the trestles in sector OY2 for a period of around two hours centred on low tide.

3.6 It should be noted that the tidelines shown in Figure 3.8 represent the tideline alignment at full low tide. However, the low tide counts of sectors OY1-OY4 took around two hours to complete. As the tideline is moving throughout the low tide period, the tideline position in each sector when it was counted did not necessarily correspond to the position shown in Figure 3.8. In particular, due to the sequence that was used for the counts, the tidelines in sectors OY3 and OY4 were largely within the trestle blocks, even on days when the tideline would fall below the trestle blocks at full low tide.

Table 3.1 - Frequency distribution of low tide heights, October 2014-February 2015.

Tide height (m)	Cumulative frequency
0.1	2%
0.2	5%
0.3	9%
0.4	15%
0.5	22%
0.6	39%
0.7	51%
0.8	63%
0.9	75%
1.0	85%
1.1	93%
1.2	100%

Source: calculated from EasyTide data for Dungarvan Harbour (www.ukho.gov.uk/Easytide).

Inner Harbour

3.7 The section of the Inner Harbour on the western side of the Cunnigar (i.e., subsites 0M419 and 427) has a slightly shorter tidal exposure period, compared to Whitehouse Bank. However, due to the different nature of the habitat (mudflats with tidal channels, rather than gradually shelving sandbanks), the intertidal habitat becomes much more rapidly exposed once the tideline does start to retreat. On the Ebb0 and Flood4 period, this section is generally fully flooded, apart from a very narrow strip of mud (< 50 m wide) along the western side of the Cunnigar in subsite 0M427. This shoreline strip widens in the Ebb1 count to a few 100 m wide. In the Ebb2 period the mudflats in the central part of this area rapidly become exposed and by the Ebb3 period the mudflats are almost fully exposed.

Ballyrandle Sandflats

3.8 At Ballyrandle Sandflats, there was little exposure of intertidal habitat up to the Ebb2 period, with the tideline then advancing rapidly during the Ebb3 and Ebb4 periods (Figure 3.6). However, the intertidal habitat on the east side of the tidal channel was still largely flooded at the end of the Ebb4 period. On a tide approaching neap conditions on 12/11/2014, there was also relatively limited exposure of the outer intertidal habitat on the western side of the tidal channel by the end of the Ebb4 period (Figure 3.7). On the flood tide, the intertidal habitat was almost fully covered by the Flood3 period on 27/10/2014, but there were still substantial area of intertidal habitat exposed at this stage on a slightly lower tide on 23/10/2014 (Figure 3.6).

Waterbird numbers

3.9 The total numbers recorded across the ebb, low tide and flood tide periods on each count day are shown in Table 3.2 and Table 3.3. 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.

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	23/10/2014	68	0	59
	27/10/2014	73	0	37
	12/11/2014	34	15	no count
	24/11/2014	86	56	97
	10/12/2014	204	110	no count
	22/12/2014	120	111	156
	05/01/2015	189	no count	no count
	08/01/2015	179	197	no count
	21/01/2015	127	103	142
	06/02/2015	161	122	96
	19/02/2015	174	132	180
Knot	23/10/2014	48	1	5
	27/10/2014	258	42	3
	12/11/2014	267	371	no count
	24/11/2014	83	418	99
	10/12/2014	427	380	no count
	22/12/2014	6	329	262
	05/01/2015	76	no count	no count
	08/01/2015	293	447	no count
	21/01/2015	32	474	334
	06/02/2015	608	181	323
	19/02/2015	335	720	345
Dunlin	23/10/2014	313	175	340
	27/10/2014	289	1	204
	12/11/2014	955	606	no count
	24/11/2014	262	468	570
	10/12/2014	1570	1752	no count
	22/12/2014	1279	1504	1554
	05/01/2015	1611	no count	no count
	08/01/2015	2207	1237	no count
	21/01/2015	2318	2283	1783
	06/02/2015	2399	1490	1451
	19/02/2015	1657	1419	1581

Species	Date	Maximum count		
		Ebb	LT	Flood
Bar-tailed Godwit	23/10/2014	642	455	402
	27/10/2014	312	356	272
	12/11/2014	328	524	no count
	24/11/2014	130	687	313
	10/12/2014	1027	886	no count
	22/12/2014	265	867	481
	05/01/2015	280	no count	no count
	08/01/2015	1229	652	no count
	21/01/2015	130	591	618
	06/02/2015	364	583	198
	19/02/2015	303	988	324

Data are the maxima across four or five 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 - 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
Golden Plover	23/10/2014	1650	0	0
	27/10/2014	1000	1	0
	12/11/2014	3610	0	no count
	24/11/2014	0	3200	0
	10/12/2014	0	2500	no count
	22/12/2014	0	2100	0
	05/01/2015	2	no count	no count
	08/01/2015	0	3500	no count
	21/01/2015	0	102	0
	06/02/2015	1500	1000	0
	19/02/2015	0	3000	0
Ringed Plover	23/10/2014	1	0	107
	27/10/2014	202	2	97
	12/11/2014	187	175	no count
	24/11/2014	38	0	30
	10/12/2014	20	0	no count
	22/12/2014	35	114	63
	05/01/2015	59	no count	no count
	08/01/2015	65	71	no count
	21/01/2015	55	45	72
	06/02/2015	76	57	59
	19/02/2015	31	34	139

Species	Date	Maximum count		
		Ebb	LT	Flood
Sanderling	23/10/2014	61	0	59
	27/10/2014	65	0	1
	12/11/2014	68	83	no count
	24/11/2014	58	45	53
	10/12/2014	53	72	no count
	22/12/2014	0	0	42
	05/01/2015	73	no count	no count
	08/01/2015	0	43	no count
	21/01/2015	9	63	93
	06/02/2015	44	83	76
	19/02/2015	0	0	0

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

Tidal cycle counts

3.10 The counts of the target species across the tidal cycle on Whitehouse Bank are shown in Table 3.4. On the ebb tide, Grey Plover, Knot and Dunlin mainly occurred on the Ebb0 and Ebb1 counts. Some Grey Plover remained on the Ebb2 count, but significant numbers only stayed until the Ebb3 period on two of the eleven counts. Knot rarely remained on Whitehouse Bank after the Ebb1 period. Dunlin occurred in large numbers on the Ebb0 and Ebb1 period (1000-2000 birds), with most birds leaving before the Ebb2 period. Bar-tailed Godwit also tended to occur in larger numbers during the Ebb0 and Ebb1 periods, but the pattern was less marked and significant numbers remained on Whitehouse Bank throughout the ebb tide period and into the low tide period on several dates. The occurrence of all the target species on Whitehouse Bank during the flood tide period was more erratic, but significant numbers could be present early in the flood tide period.

3.11 The counts of the additional monitored species across the tidal cycle on Whitehouse Bank are shown in Table 3.5. Large flocks of Golden Plover were recorded during the early ebb tide period on the first three counts. Ringed Plover and Sanderling were erratic in their occurrence on Whitehouse Bank, but, when they did occur, they typically were present throughout the ebb and/or flood tide periods, and were often also present at low tide.

3.12 On the ebb tide counts, the Grey Plover and Knot flocks on Whitehouse Bank often mainly consisted of roosting birds (Table 3.6). Apart from the Ebb0 period, the Dunlin and Bar-tailed Godwit flocks on Whitehouse Bank mainly consisted of feeding birds (Table 3.6). Golden Plover and Ringed Plover flocks on Whitehouse Bank mainly consisted of roosting birds, while Sanderling flocks mainly consisted of feeding birds (Table 3.7).

Table 3.4 - Counts of the target species across the tidal cycle on Whitehouse Bank.

Species	Date	Ebb tide					Low tide	Flood tide			
		0	1	2	3	4		1	2	3	4
Grey Plover	23/10/2014		65	1	0	0	0	0	0	0	0
	27/10/2014		60	44	0	0	0	3	0	0	2
	12/11/2014		32	1	0	0	0				
	24/11/2014		82	1	1	0	0		3	1	3
	10/12/2014	204	167	1	3	0	0				
	22/12/2014		119	48	0	0	1	1	2	90	108
	05/01/2015		142	105	59	26					
	08/01/2015	113	118	0	0	0	0				
	21/01/2015	66	62	18	0	0	0	20	10	80	1
	06/02/2015	121	6	3	0	1	0	0	0	0	0
	19/02/2015	174	123	56	23	5		53	11	10	84
Knot	23/10/2014		0	0	0	0	1	0	0	0	0
	27/10/2014		0	0	0	0	0	0	0	0	0
	12/11/2014		164	0	0	0	0				
	24/11/2014		83	13	1	0	1	0	0	0	1
	10/12/2014	427	295	0	0	0	0				
	22/12/2014		0	0	0	0	0	0	0	54	17
	05/01/2015		0	3	0	0					
	08/01/2015	221	235	0	0	0	0				
	21/01/2015	0	0	0	0	0	0	211	65	100	70
	06/02/2015	608	0	0	0	0	1	0	0	0	1
	19/02/2015	335	234	145	4	0	220	0	0	2	31
Dunlin	23/10/2014		7	0	0	0	61	0	0	4	0
	27/10/2014		0	0	0	0	1	0	0	4	0
	12/11/2014		26	20	23	2	15				
	24/11/2014		76	1	2	2	19	0	0	0	0
	10/12/2014	1570	1018	15	14	0	8				
	22/12/2014		982	203	14	10	41	4	54	157	173
	05/01/2015		1311	37	15	1					
	08/01/2015	2090	2207	0	0	2	6				
	21/01/2015	1092	598	75	0	0	0	1050	83	147	113
	06/02/2015	1639	6	0	0	0	0	0	0	1	0
	19/02/2015	1459	406	0	0	0	0	0	0	2	20

Species	Date	Ebb tide					Low tide	Flood tide			
		0	1	2	3	4		1	2	3	4
Bar-tailed Godwit	23/10/2014		1	2	0	0	22	8	2	2	16
	27/10/2014		260	132	87	11	41	76	176	131	152
	12/11/2014		150	19	9	7	34				
	24/11/2014		130	115	38	17	55	2	32	231	303
	10/12/2014	1027	624	68	49	79	64				
	22/12/2014		136	216	147	168	70	60	112	302	216
	05/01/2015		87	78	32	26					
	08/01/2015	1202	472	13	8	11	322				
	21/01/2015	64	44	28	31	3	68	550	160	328	448
	06/02/2015	270	118	70	41	11	243	10	63	82	142
	19/02/2015	171	272	48	75	159	806	143	149	172	126

Ebb tide counts were carried out from around four hours before low tide (Ebb0 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 (Ebb0 count) to four hours after low tide (Ebb4 count). Grey cells indicate no counts were carried out.

Table 3.5 - Counts of the additional monitored species across the tidal cycle on Whitehouse Bank.

Species	Date	Ebb tide					Low tide	Flood tide			
		0	1	2	3	4		1	2	3	4
Golden Plover	23/10/2014		0	1240	0	0	0	0	0	0	0
	27/10/2014		1000	0	0	0	1	0	0	0	0
	12/11/2014		3000	3610	0	2	0				
	24/11/2014		0	0	0	0	0	0	0	0	0
	10/12/2014	0	0	0	0	0	0				
	22/12/2014		0	0	0	0	0	0	0	0	0
	05/01/2015		0	2	0	0					
	08/01/2015	0	0	0	0	0	0				
	21/01/2015	0	0	0	0	0	0	0	0	0	0
	06/02/2015	0	0	0	0	0	0	0	0	0	0
	19/02/2015	0	0	0	0	0	0	0	0	0	0
Ringed Plover	23/10/2014		1	0	0	0	0	0	61	107	105
	27/10/2014		100	122	4	0	2	16	66	97	0
	12/11/2014		37	157	123	171	175				
	24/11/2014		3	0	3	0	0	0	0	0	0
	10/12/2014	0	17	19	0	0	0				
	22/12/2014		6	7	32	35	35	52	57	50	26
	05/01/2015		0	23	0	0					
	08/01/2015	58	56	1	1	65	66				
	21/01/2015	17	35	9	2	0	0	0	0	67	71
	06/02/2015	0	0	1	0	0	0	0	12	0	0
	19/02/2015	0	6	13	15	16	0	40	41	110	60
Sanderling	23/10/2014		58	0	0	0	0	0	0	1	0
	27/10/2014		50	65	62	0	0	0	1	1	0
	12/11/2014		0	34	32	4	7				
	24/11/2014		53	48	52	58	45	0	7	53	48
	10/12/2014	26	52	4	31	44	51				
	22/12/2014		0	0	0	0	0	42	42	42	42
	05/01/2015		0	68	73	71					
	08/01/2015	0	0	0	0	0	0				
	21/01/2015	0	0	9	0	0	12	30	15	93	59
	06/02/2015	0	16	35	44	44	28	2	66	62	76
	19/02/2015	0	0	0	0	0	0	0	0	0	0

See notes to Table 3.11.

Table 3.6 - Percentages of feeding birds of the target species across the tidal cycle on Whitehouse Bank.

Species	Date	Ebb tide					Low tide	Flood tide			
		0	1	2	3	4		1	2	3	4
Grey Plover	23/10/2014		5%								
	27/10/2014		0%	32%							
	12/11/2014		47%								
	24/11/2014		59%								
	10/12/2014	0%	4%								
	22/12/2014		62%	0%						100%	41%
	05/01/2015		0%	0%	5%	35%					
	08/01/2015	0%	0%								
	21/01/2015	97%	100%	100%				100%	100%	54%	
	06/02/2015	27%									
	19/02/2015	10%	50%	57%	87%			21%	100%	100%	0%
Knot	23/10/2014										
	27/10/2014										
	12/11/2014		100%								
	24/11/2014		96%	100%							
	10/12/2014	0%	42%								
	22/12/2014									100%	100%
	05/01/2015										
	08/01/2015	0%	0%								
	21/01/2015							100%	100%	100%	100%
	06/02/2015	51%									
	19/02/2015	100%	100%	41%			9%				100%
Dunlin	23/10/2014						80%				
	27/10/2014										
	12/11/2014		100%	20%	96%		60%				
	24/11/2014		100%				58%				
	10/12/2014	0%	81%	67%	100%						
	22/12/2014		95%	67%	93%	70%	95%		96%	98%	99%
	05/01/2015		73%	51%	67%						
	08/01/2015	1%	5%								
	21/01/2015	99%	87%	97%				100%	100%	88%	93%
	06/02/2015	22%									
	19/02/2015	57%	48%								0%

Species	Date	Ebb tide					Low tide	Flood tide			
		0	1	2	3	4		1	2	3	4
Bar-tailed Godwit	23/10/2014						95%				50%
	27/10/2014	64%	98%	87%	99%	100%	93%	100%	98%	98%	1%
	12/11/2014		97%	100%			100%				
	24/11/2014		93%	99%	82%	100%	98%		94%	99%	91%
	10/12/2014	1%	48%	100%	6%	75%	77%				
	22/12/2014		73%	83%	89%	100%	97%	95%	100%	99%	96%
	05/01/2015		100%	87%	100%	100%					
	08/01/2015	5%	17%	100%		100%	91%				
	21/01/2015	100%	100%	100%	68%		96%	96%	97%	94%	66%
	06/02/2015	98%	72%	100%	100%	100%	80%	100%	51%	71%	100%
	19/02/2015	70%	43%	63%	33%	92%	92%	100%	98%	99%	80%

Percentages are only included for counts where > 9 birds were recorded. Grey cells indicate no counts were carried out. See notes to Table 3.11 for details of count timings.

Table 3.7 - Percentages of feeding birds of the additional monitored species across the tidal cycle on Whitehouse Bank.

Species	Date	Ebb tide					Low tide	Flood tide			
		0	1	2	3	4		1	2	3	4
Golden Plover	23/10/2014			19%							
	27/10/2014		0%								
	12/11/2014		0%	0%							
Ringed Plover	23/10/2014								0%	2%	100%
	27/10/2014		50%	64%				63%	12%	3%	
	12/11/2014		0%	20%	40%	25%	97%				
	10/12/2014		100%	11%							
	22/12/2014				22%	37%	43%	17%	9%	36%	0%
	05/01/2015			100%							
	08/01/2015	9%	25%			0%	0%				
	21/01/2015	100%	14%							0%	0%
	06/02/2015								0%		
	19/02/2015			0%	0%	0%		48%	0%	0%	0%
Sanderling	23/10/2014		0%								
	27/10/2014		100%	65%	77%						
	12/11/2014			100%	88%						
	24/11/2014		100%	98%	100%	98%	100%			100%	100%
	10/12/2014	0%	100%		100%	100%	100%				
	22/12/2014							100%	100%	100%	100%
	05/01/2015			100%	100%	90%					
	08/01/2015										
	21/01/2015						100%	100%	100%	100%	100%
	06/02/2015		100%	97%	100%	100%	100%		100%	100%	100%

See notes to Table 3.6.

Tidal cycle movements

3.13 Direct observations of movements of the target species onto/off Whitehouse Bank during the ebb and flood tide are shown in Appendix C. Most Grey Plover, Knot and Dunlin movements were between Whitehouse Bank and the Inner Harbour, while Bar-tailed Godwits on Whitehouse Bank moved to/from both the Inner Harbour and Ballyrandle. During the ebb tide most movements occurred early (in periods Ebb0 and Ebb1) and involved birds moving off Whitehouse Bank. Fewer movements were recorded during the flood tide, reflecting the lower numbers/frequency of occurrence of the target species on Whitehouse Bank during the flood tide. The patterns of movements were also more complex.

3.14 The timing of the movements of birds off Whitehouse Bank during the ebb tide period was identified from the tidal cycle counts (see Table 3.4 and Table 3.5). For the target species, most movements off Whitehouse Bank occurred during the Ebb0 and Ebb1 periods (Table 3.8). This compares to the tideline reaching the trestle zone during the Ebb3 period, and the exposure of significant areas of intertidal habitat in the Inner Harbour in the Ebb2 period. The pattern of movements of the additional monitored species was less clear (Table 3.9). On the three days when significant numbers of Golden Plovers occurred, the movements took place in the Ebb1 and Ebb2 periods. Ringed Plover and Sanderling often showed complex movement patterns (with birds moving on to Whitehouse Bank at later stages in the ebb tide period), and/or with high numbers remaining present into the low tide period.

3.15 We made few observations of movements of the target species onto/off Whitehouse Bank during the low tide counts. However, the few direct observations of movements, combined with some observations of birds appearing after the area had been counted, indicated that Knot, Dunlin and Bar-tailed Godwit can move into sector OY2, from outside Whitehouse Bank, during the low tide period (Table 3.10). These included two observations of flocks apparently flying into OY2, but not settling, because the tideline was within (19/02/2015), or just above (10/12/2014) the trestles.

3.16 It is difficult to identify clear patterns in the timing of the movements of birds onto Whitehouse Bank during the flood tide period. This probably reflects two opposing factors: (1) on some counts large flocks of the target species moved onto Whitehouse Bank during the low tide period (see paragraph 3.15), with birds subsequently departing during the early part of the flood tide period; and (2), towards the end of the flood tide period (usually smaller) numbers of birds may move onto Whitehouse Bank to roost when the Inner Harbour becomes fully flooded.

Table 3.8 - Ebb tide periods when the main movements of the target species off Whitehouse Bank occurred.

Species	Period	Number of counts
Grey Plover	Ebb0	4
	Ebb1	1
	Ebb1-3	1
	Ebb2	1
	Ebb2-4	1
Knot	Ebb0	1
	Ebb1	5
Dunlin	Ebb0-1	2
	Ebb1-2	4
	Ebb2	1
Bar-tailed Godwit	Ebb0-1	2
	Ebb1	3
	Ebb1-2	1
	Ebb1-3	1
	High numbers remained into low tide period	1

The period when the main movement occurred was assigned as the last period with high numbers present on Whitehouse Bank: i.e., on 23/10/2014 65 Grey Plover were present on the Ebb1 count and 1 was present on the Ebb2 count, so the movement occurred in the Ebb1 period (as the counts take place at the start of the period). For Dunlin and Bar-tailed Godwit, only days with counts of > 100 are included.

Table 3.9 - Ebb tide periods when the main movements of the additional monitored species off Whitehouse Bank occurred.

Species	Period	Number of counts
Golden Plover	Ebb1	1
	Ebb2	2
Ringed Plover	Ebb1	2
	Ebb2	2
	variable movements	3
	high numbers remained into low tide period	2
Sanderling	Ebb3	2
	high numbers remained into low tide period	4

See notes to Table 3.9.

Table 3.10 - Observations indicating movement of the target species onto/off Whitehouse Bank during the low tide period.

Date	Time	Species	Count	Observations
10/12/2014	-00:38 to -00:23	Knot	c. 100	flew south along tideline past OY4, then returned flying north 15 minutes later
		Bar-tailed Godwit	c. 200	
08/01/2015	+00:02	Bar-tailed Godwit	c. 200	flew in from north (presumably from Ballyrandle Sandflats) and landed on tideline behind trestles in OY2
	+01:40	Grey Plover	22	on tideline in OY2 (tideline above trestles); presumably arrived during the low tide period
		Knot	c. 100	
		Dunlin	c. 1200	
		Bar-tailed Godwit	c. 500	
21/01/2015	+01:17	Bar-tailed Godwit	c. 200	on tideline in OY2 (after completion of low tide count in OY2); presumed to have arrived during the one hour period after low tide
	+02:00	Knot	211	in OY2 during Flood1 count, likely to have arrived towards the end of the low tide period
	+02:00	Dunlin	1050	
06/02/2015	+01:06	Dunlin	500+	large flock on tideline behind trestles (after completion of low tide count in OY2); 135 BA previously counted in OY2
		Bar-tailed Godwit	500+	
19/02/2015	-01:04	Knot	c. 200	flew south along tideline past OY4, presumably from Ballyrandle Sandflats to OY2; 571 BA and 220 KN subsequently counted in OY2
		Bar-tailed Godwit	c. 100	
	+02:02	Dunlin	c. 300	flew to tideline in OY2 (tideline within trestles), circled around for a while, then flew back to Inner Harbour

Low tide distribution

Distribution across Dungarvan Harbour

3.17 During the low tide counts, all the target species usually occurred in low numbers on Whitehouse Bank (Table 3.11). Grey Plover and Knot occurred very rarely on Whitehouse Bank. However, a flock of 220 Knot were recorded on Whitehouse Bank on one count, and other observations indicate that Knot may occur on Whitehouse Bank at low tide more regularly than is indicated by the results of the low tide counts (see paragraph 3.15). Grey Plover usually mainly occurred in the Inner Harbour, apart from one count when the main flock occurred at Ballyrandle. Knot and Dunlin also generally occurred in larger numbers in the Inner Harbour, although large numbers occurred at Ballyrandle on several counts. Bar-tailed Godwits usually mainly occurred at Ballyrandle, but large flocks occurred on Whitehouse Bank on three counts.

3.18 At low tide, Golden Plover occurred almost exclusively in the Inner Harbour, Ringed Plover occurred either in the Inner Harbour or on Whitehouse Bank, while Sanderling occurred either at Ballyrandle or on Whitehouse Bank (Table 3.12).

3.19 The low tide distribution patterns recorded in this study showed some differences from those recorded in previous low tide counts of Dungarvan Harbour (Table 3.13 and Table 3.14). The almost complete absence of Grey Plover at low tide from Whitehouse Bank contrasted to the patterns recorded in 2009/10 and 2011, when significant numbers of Grey Plover regularly occurred on Whitehouse Bank at low tide, and were largely absent from Ballyrandle Sandflats. The other striking difference was the much larger numbers of Bar-tailed Godwits recorded on Whitehouse Bank in this study (and in the trestle study), compared to the BWS counts. This latter difference may reflect the

difficulty of counting birds that occur within, or below, the trestle blocks from the shoreline vantage points that were used for the BWS counts.

Table 3.11 - Distribution of the target species at low tide.

Species	Date	Inner Harbour		Outer Sandflats	
		upper	main	Ballyrandle	Whitehouse
Grey Plover	23/10/2014	0	0	0	0
	27/10/2014	0	0	0	0
	12/11/2014		15	0	0
	24/11/2014		56	0	0
	10/12/2014		108	2	0
	22/12/2014		73	37	1
	08/01/2015		3	194	0
	21/01/2015		81	22	0
	06/02/2015	0	80	42	0
	19/02/2015	0	111	21	0
Knot	23/10/2014	0	0	0	1
	27/10/2014	0	0	42	0
	12/11/2014		45	326	0
	24/11/2014		6	411	1
	10/12/2014		339	41	0
	22/12/2014		303	26	0
	08/01/2015		393	54	0
	21/01/2015		212	262	0
	06/02/2015	180	0	0	1
	19/02/2015	165	335	0	220
Dunlin	23/10/2014	114	0	0	61
	27/10/2014	0	0	0	1
	12/11/2014		591	0	15
	24/11/2014		422	27	19
	10/12/2014		1678	66	8
	22/12/2014		1213	250	41
	08/01/2015		862	369	6
	21/01/2015		1563	720	0
	06/02/2015	0	1200	290	0
	19/02/2015	0	1419	0	0
Bar-tailed Godwit	23/10/2014	0	0	433	22
	27/10/2014	0	0	315	41
	12/11/2014		0	490	34
	24/11/2014		1	631	55
	10/12/2014		289	533	64
	22/12/2014		51	743	70
	08/01/2015		2	328	322
	21/01/2015		84	438	68
	06/02/2015	0	0	340	243
	19/02/2015	0	173	9	806

Grey cells indicate no counts were carried out.

Table 3.12 - Distribution of the additional monitored species at low tide.

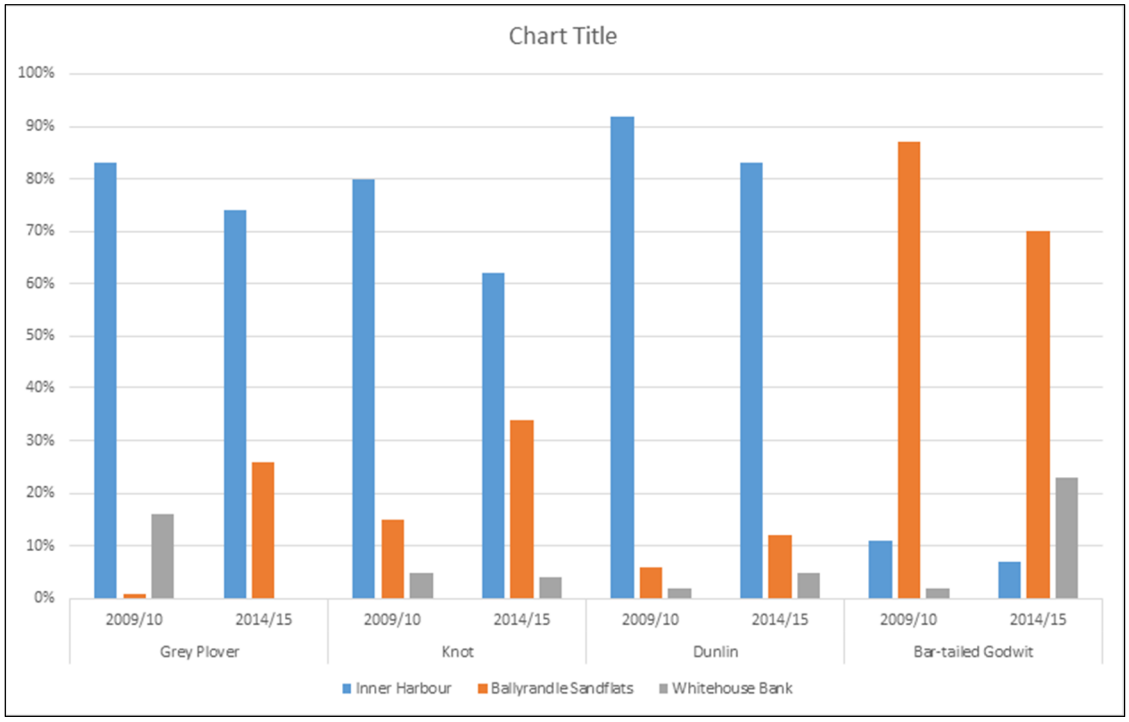
Species	Date	Inner Harbour		Outer Sandflats	
		Upper	Main	Ballyrandle	Whitehouse
Golden Plover	23/10/2014	0	0	0	0
	27/10/2014	0	0	0	1
	12/11/2014		0	0	0
	24/11/2014		3200	0	0
	10/12/2014		2500	0	0
	22/12/2014		2100	0	0
	08/01/2015		3500	0	0
	21/01/2015		102	0	0
	06/02/2015	1000	0	0	0
	19/02/2015	3000	0	0	0
Ringed Plover	23/10/2014	0	0	0	0
	27/10/2014	0	0	0	2
	12/11/2014		0	0	175
	24/11/2014		0	0	0
	10/12/2014		0	0	0
	22/12/2014		79	0	35
	08/01/2015		5	0	66
	21/01/2015		45	0	0
	06/02/2015	0	57	0	0
	19/02/2015	0	34	0	0
Sanderling	23/10/2014	0	0	0	0
	27/10/2014	0	0	0	0
	12/11/2014		0	76	7
	24/11/2014		0	0	45
	10/12/2014		0	21	51
	22/12/2014		0	0	0
	08/01/2015		0	43	0
	21/01/2015		0	51	12
	06/02/2015	0	0	55	28
	19/02/2015	0	0	0	0

Grey cells indicate no counts were carried out.

Table 3.13 - Mean percentage occurrence of the target species in the main zones of Dungarvan Harbour in 2009/10 and 2014/15.

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
Knot	2009/10	80%	15%	5%	4
	2014/15	62%	34%	4%	8
Dunlin	2009/10	92%	6%	2%	4
	2014/15	83%	12%	5%	9
Bar-tailed Godwit	2009/10	11%	87%	2%	4
	2014/15	7%	70%	23%	10

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

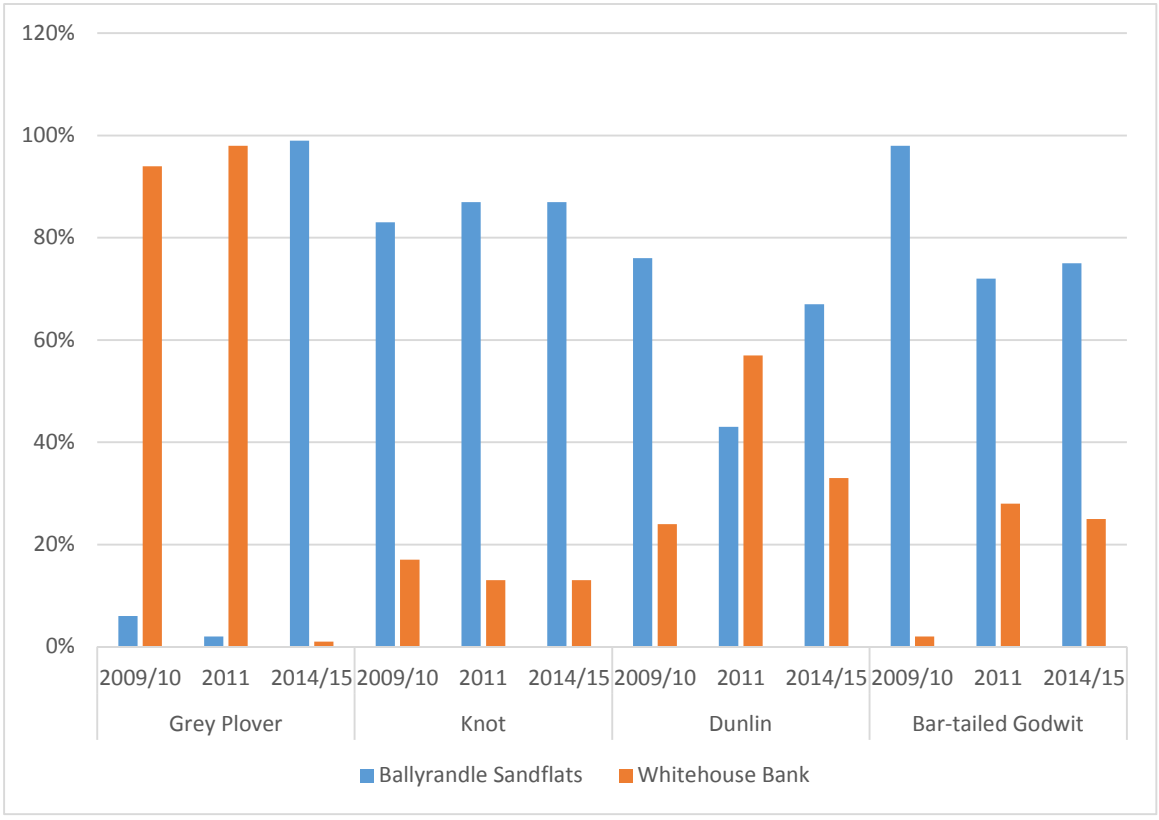


Text Figure 3.1 – Histogram presentation of data from Table 3.13.

Table 3.14 - Mean percentage occurrence of the target species in the subdivisions of the Outer 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
Knot	2009/10	83%	17%	3
	2011	87%	13%	3
	2014/15	87%	13%	8
Dunlin	2009/10	76%	24%	4
	2011	43%	57%	4
	2014/15	67%	33%	8
Bar-tailed Godwit	2009/10	98%	2%	4
	2011	72%	28%	5
	2014/15	75%	25%	10

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



Text Figure 3.2 – Histogram presentation of data from Table 3.14.

Distribution within Whitehouse Bank

3.20 Only two of the target species regularly occurred on Whitehouse Bank at low tide. Dunlin occurred in small numbers, either on the upper sandflats (sectors CS2 and CS3) or within the oyster trestle blocks (sectors OY2 and OY4), with the percentage occurrence within trestle blocks reflecting this variable distribution pattern (Table 3.15). Bar-tailed Godwit occurred almost exclusively on the lower sandflats, with the largest numbers usually in sectors OY2 and OY3. On the three days when large numbers were present at low tide, the main flock occurred along the tideline in the northern part of sector OY2 (and extending into the adjacent area of sector OY3). Their percentage occurrence within the trestle blocks (Table 3.15) varied from 13-63% (mean 33%), with higher percentage occurrences within the trestle blocks generally occurring when lower total numbers were present (mean of five lowest counts = 44%; mean of five highest counts = 23%).

3.21 Two of the additional monitored species occurred on Whitehouse Bank at low tide: Ringed Plover and Sanderling. Both these species occurred exclusively on the upper sandflats, mainly in sector CS3. Neither species was ever recorded within the oyster trestle blocks.

Table 3.15 - 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	
Dunlin	23/10/2014	61	0	100%
	27/10/2014	1	0	
	12/11/2014	0	15	0%
	24/11/2014	17	2	89%
	10/12/2014	2	6	
	22/12/2014	0	41	0%
	08/01/2015	4	2	
Bar-tailed Godwit	23/10/2014	10	12	45%
	27/10/2014	19	22	46%
	12/11/2014	9	25	26%
	24/11/2014	21	34	38%
	10/12/2014	40	24	63%
	22/12/2014	27	43	39%
	08/01/2015	28	294	9%
	21/01/2015	12	56	18%
	06/02/2015	89	154	37%
	19/02/2015	101	705	13%

Percentages are only included where the total count was > 9.

Bar-tailed Godwit distribution on Ballyrandle Sandflats

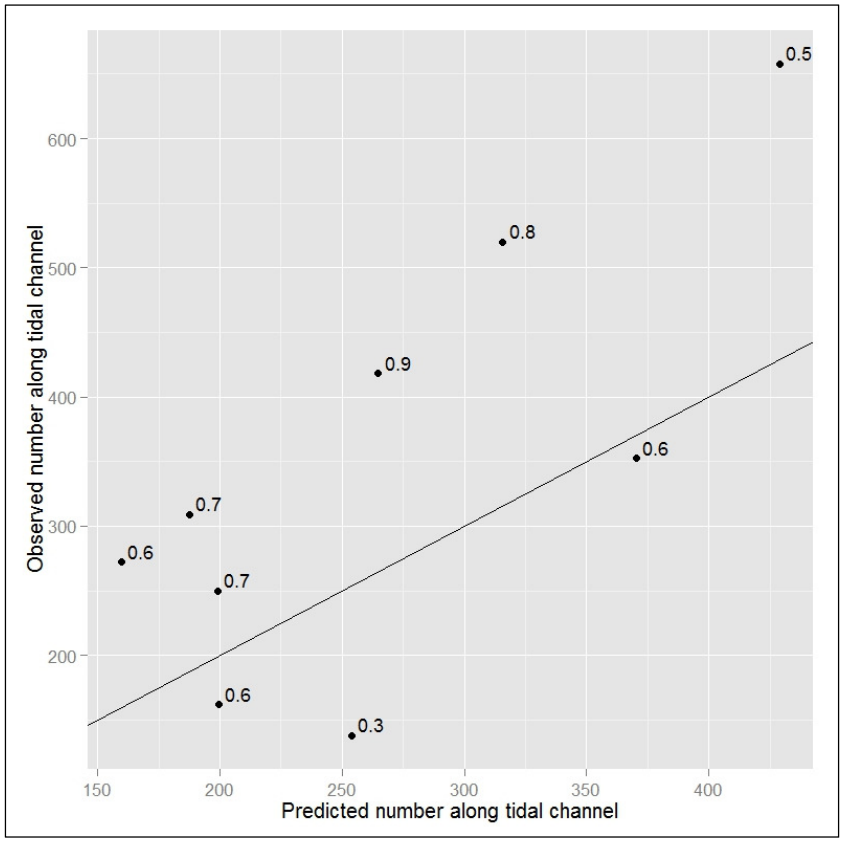
3.22 The distribution of Bar-tailed Godwit flocks at low tide on Ballyrandle Sandflats is shown in Figure 3.10 to Figure 3.12. The flocks occurred along both the tidal channel and along the outer tideline. On most counts the majority of birds occurred along the tidal channel (Table 3.16). This reflects the fact that the majority of tideline habitat occurred along the tidal channel, as the tidal channel provides a double tideline. However, the number of Bar-tailed Godwit on the tideline were usually greater than that predicted by assuming that the birds were distributed in proportion to the available habitat (Text Figure 3.1). In fact the preference for tidal channel habitat is probably stronger than indicated

by Text Figure 3.1 because a variable length of the upper tidal channel would largely dry out at low tide, making it unsuitable habitat.

Table 3.16 - Distribution of Bar-tailed Godwits on Ballyrandle Sandflats at low tide.

Date	Tide	Number of Bar-tailed Godwits			Percentage on tidal channel
		tidal channel	outer tideline	junction	
23/10/2014	0.6 m	272	0	0	100%
27/10/2014	0.7 m	309	0	0	100%
12/11/2014	0.9 m	418	100	0	81%
27/10/2014	0.6 m	289	215	127	55%
10/12/2014	0.8 m	520	0	0	100%
22/12/2014	0.5 m	650	65	16	90%
08/01/2015	0.7 m	250	78	0	76%
21/01/2015	0.3 m	69	215	138	33%
06/02/2015	0.6 m	0	16	324	48%
19/02/2015	0.2 m	0	7	2	-

Flocks on the intertidal were assigned to closest location. Junction refers to the junction between the tideline and the tidal channel. 50% of the numbers in the junction were assigned to the tidal channel for the purposes of calculating the percentage on the tideline.



Text Figure 3.1 - Relationship between the number of Bar-tailed Godwits at Ballyrandle Sandflats that were observed along the tidal channel, and the number predicted if their distribution was not influenced by the presence of the tidal channel (low tide heights in parentheses).

Distribution patterns in relation to the presence of oyster trestles

3.23 Of the target species, Grey Plover and Knot were never recorded within the trestle blocks. Both species rarely occurred on Whitehouse Bank during the low tide counts, but did occur regularly on Ballyrandle Sandflats.

3.24 Dunlin and Bar-tailed Godwit did occur within the trestle blocks. For both species, in the all sectors analyses, the observed numbers within the trestles were generally lower than the predicted numbers, with a higher deviation from the predicted numbers increasing when the predicted numbers were higher (Text Figure 3.2). In the close sectors analyses, Bar-tailed Godwit showed a similar pattern (Text Figure 3.2). However, for Dunlin in 2014/15, observed numbers within the trestles were generally similar to predicted numbers in the close sectors analyses (Text Figure 3.2).

3.25 The Jacob's Index values for both species, in both analyses, were negative, indicating avoidance of the oyster trestles (Table 3.17). However, the 95% confidence intervals for the Dunlin indices included zero (apart from the all sectors 2011 and 2014/15 analysis). The index values did not show any obvious relationship to the total numbers present (Text Figure 3.3). However, the index values did show a generally negative relationship with the predicted numbers (Text Figure 3.4), and this relationship was almost significant for the Bar-tailed Godwit all sectors analysis (Spearman's $r = -0.360$, $p = 0.071$, $n = 15$).

3.26 The mean densities outside the trestle blocks were 5-8 times (Dunlin), or 5 times (Bar-tailed Godwit) higher than the densities within the trestle blocks (Table 3.18).

Table 3.17 - Mean Jacob's index (D) values (± 95% C.I.).

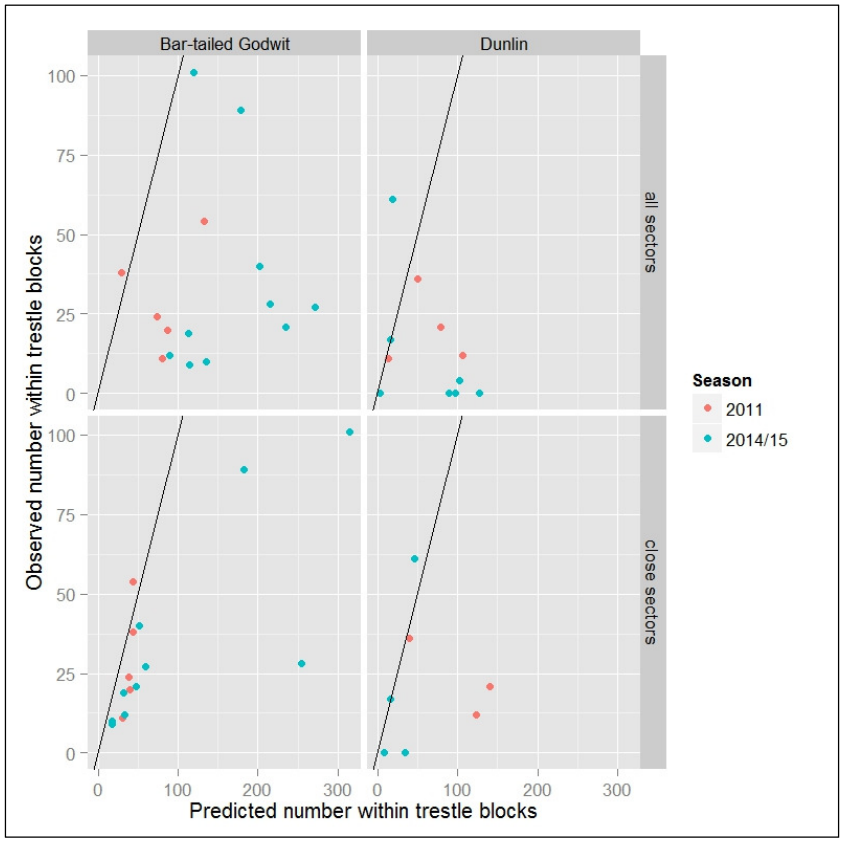
Species	Seasons	All sectors			Close sectors		
		Mean D	D > 0	n	Mean D	D > 0	n
Dunlin	2014/15	-0.56 (± 0.73)	2	7	-0.21 (± 1.55)	2	4
	2011 and 2014/15	-0.51 (± 0.43)	2	11	-0.37 (± 0.71)	2	7
Bar-tailed Godwit	2014/15	-0.72 (± 0.19)	0	10	-0.65 (± 0.11)	0	10
	2011 and 2014/15	-0.64 (± 0.18)	1	15	-0.51 (± 0.18)	1	15

Table 3.18 - Mean densities (birds/km tideline length) within and outside trestle blocks.

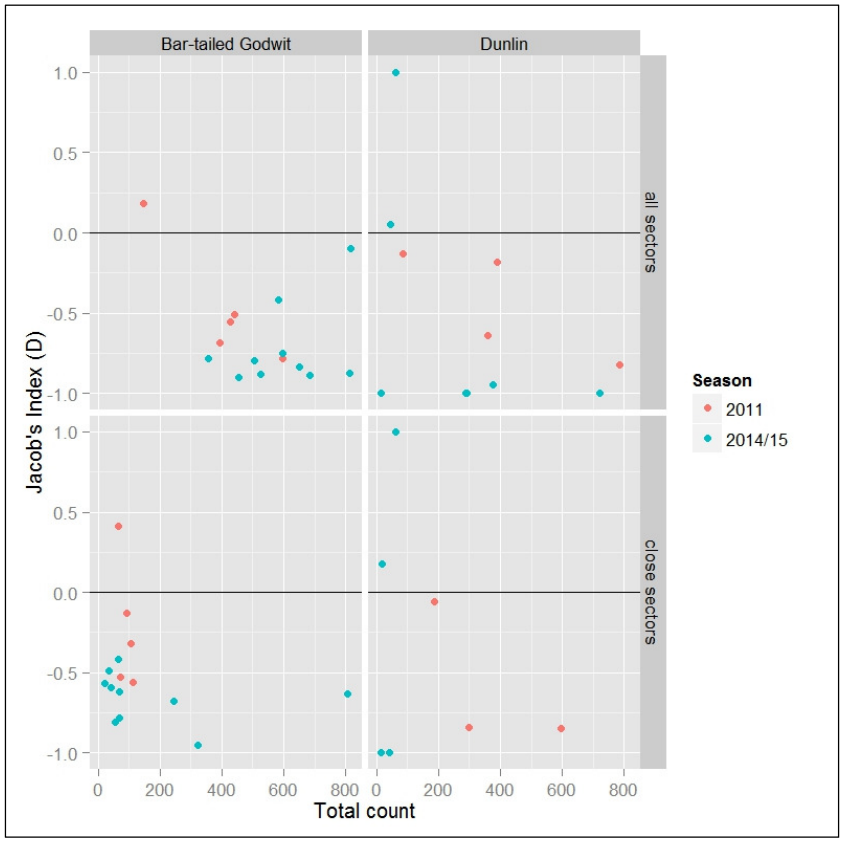
Species	Analysis	Outside		Within	
		Mean	CI	Mean	CI
Dunlin	all sectors	43.3	29.8	5.9	4.6
	close sectors	23.3	19.1	5.9	4.6
Bar-tailed Godwit	all sectors	84.8	16.9	18.0	10.5
	close sectors	98.6	74.2	18.0	10.5

Analyses use the combined 2011 and 2014/15 datasets.

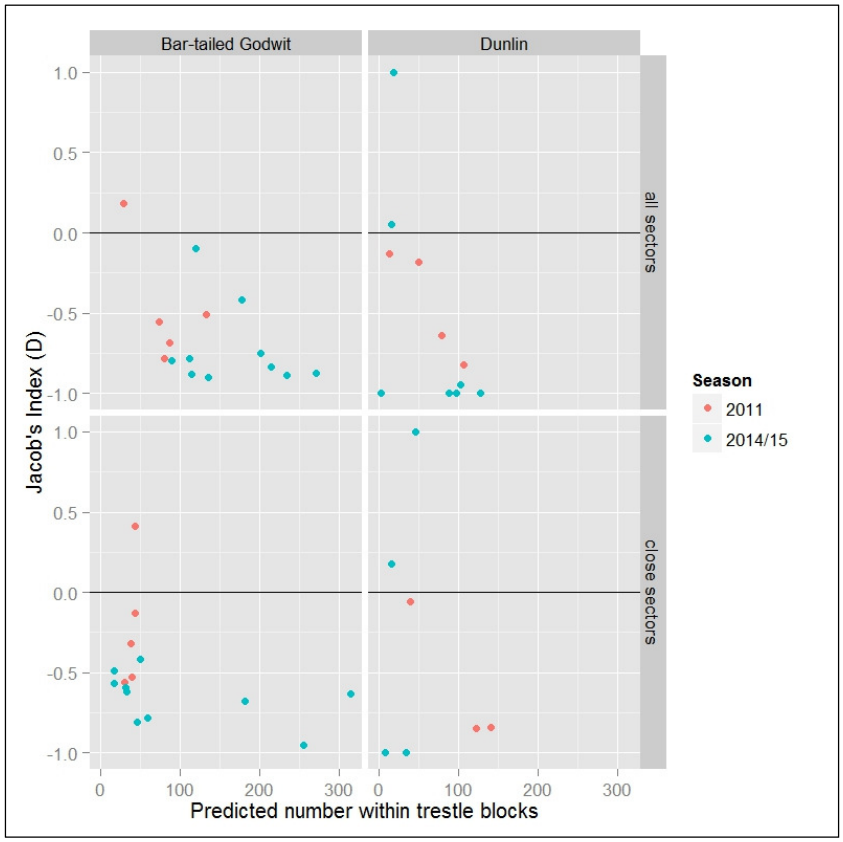
3.27 None of the additional monitored species were recorded within the trestle blocks. Golden Plover did not occur on Ballyrandle Sandflats or Whitehouse Bank at low tide (apart from a single bird on one count). Ringed Plover and Sanderling occurred in significant numbers on Whitehouse Bank on some low tides. The distribution of the flock locations recorded for these two species across all counts (Figure 3.9) shows that they occurred widely across the upper sandflats in sectors CS2 and (especially) CS3 down to the boundary with the trestle zone. The absence of records from within the trestle zone does, therefore, indicate avoidance of oyster trestles.



Text Figure 3.2 - Observed compared to predicted occurrence of Dunlin and Bar-tailed Godwit within oyster trestle blocks at Dungarvan Harbour.



Text Figure 3.3 - Relationship between the Jacob's Index values and the total count for Dunlin and Bar-tailed Godwit at Dungarvan Harbour.



Text Figure 3.4 - Relationship between the Jacob's Index values and the predicted occurrence of within oyster trestle blocks for Dunlin and Bar-tailed Godwit at Dungarvan Harbour.

Disturbance

3.28 Detailed results of the disturbance recording are not presented here. However, the following are some of the key observations: -

- In contrast to the 2011 study, horse riding occurred less frequently on Whitehouse Bank and was not observed to cause significant disturbance impacts.
- Husbandry activity on Whitehouse Bank was not observed to cause significant disturbance impacts. On several occasions, large flocks of birds (including Bar-tailed Godwits) were observed feeding within 50-100 m of husbandry activity and/or tractors accessing the oyster trestles without any obvious disturbance response. When birds were flushed they rarely moved long distances, but usually resettled in, or close to, the same area. The main exception was Light-bellied Brent Goose, which would often move out of the count sector when flushed.
- Pedestrian activity along Whitehouse Bank may cause significant disturbance to birds at, or close to, high tide. This may explain the usually lower numbers recorded on the Flood3 and Flood4 counts, compared to the Ebb0 and Ebb1 counts: there were generally higher levels of pedestrian activity on the Flood counts (which took place in the late afternoon), compared to the Ebb counts (which usually took place in the early morning).

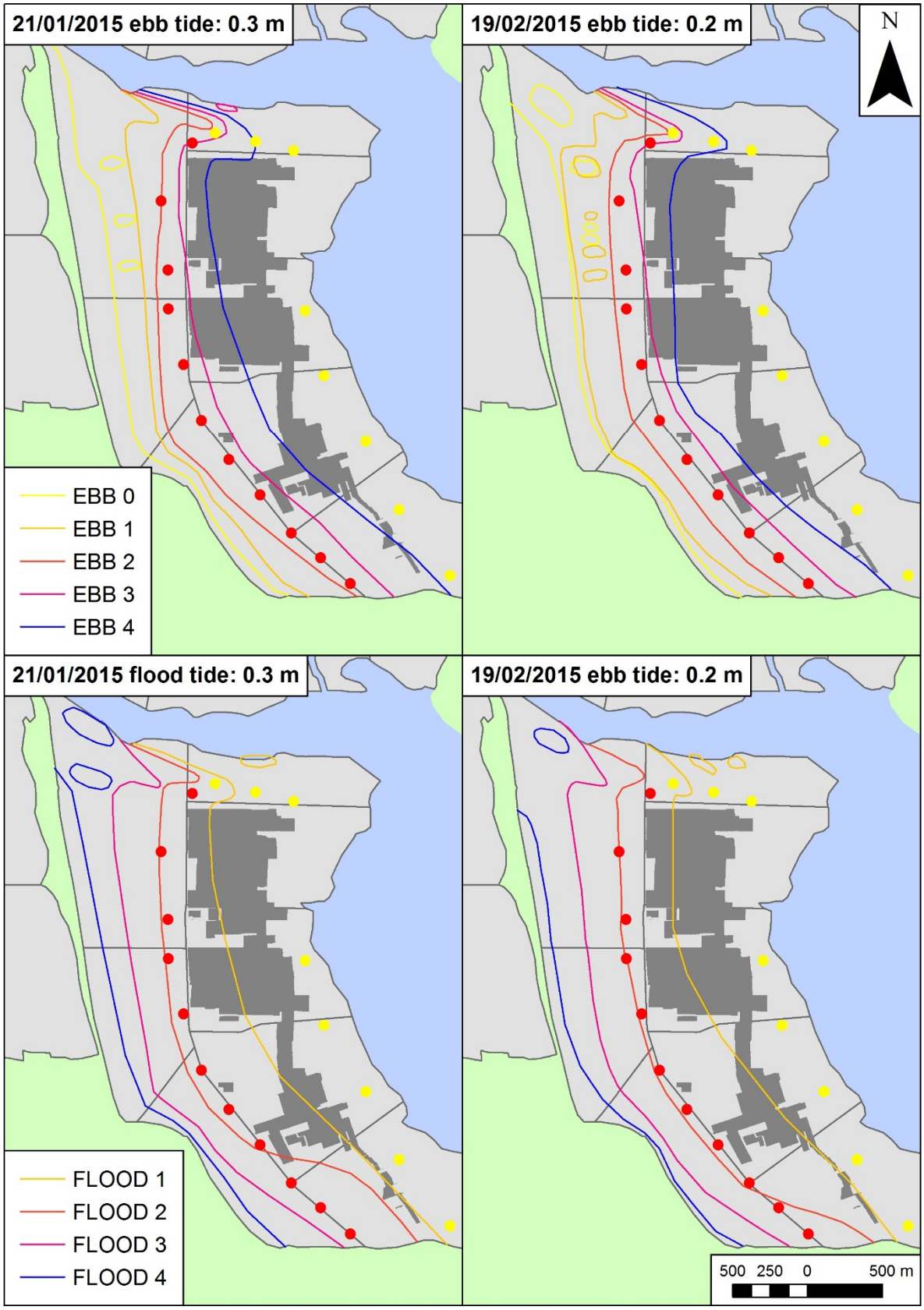


Figure 3.1 - Tidelines on Whitehouse Bank on days with low tides of 0.2-0.3 m.

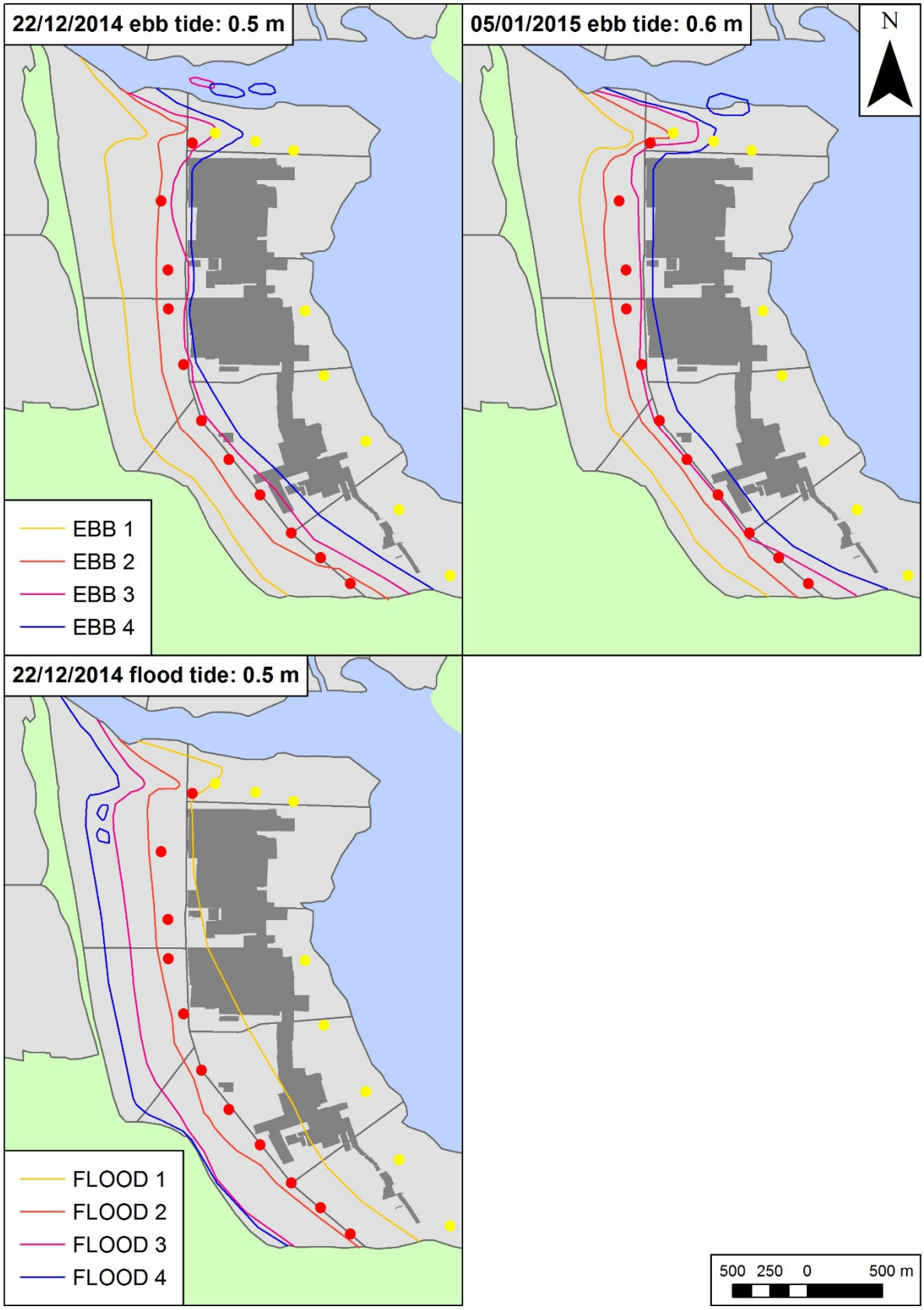


Figure 3.2 - Tidelines on Whitehouse Bank on days with low tides of 0.5-0.6 m.

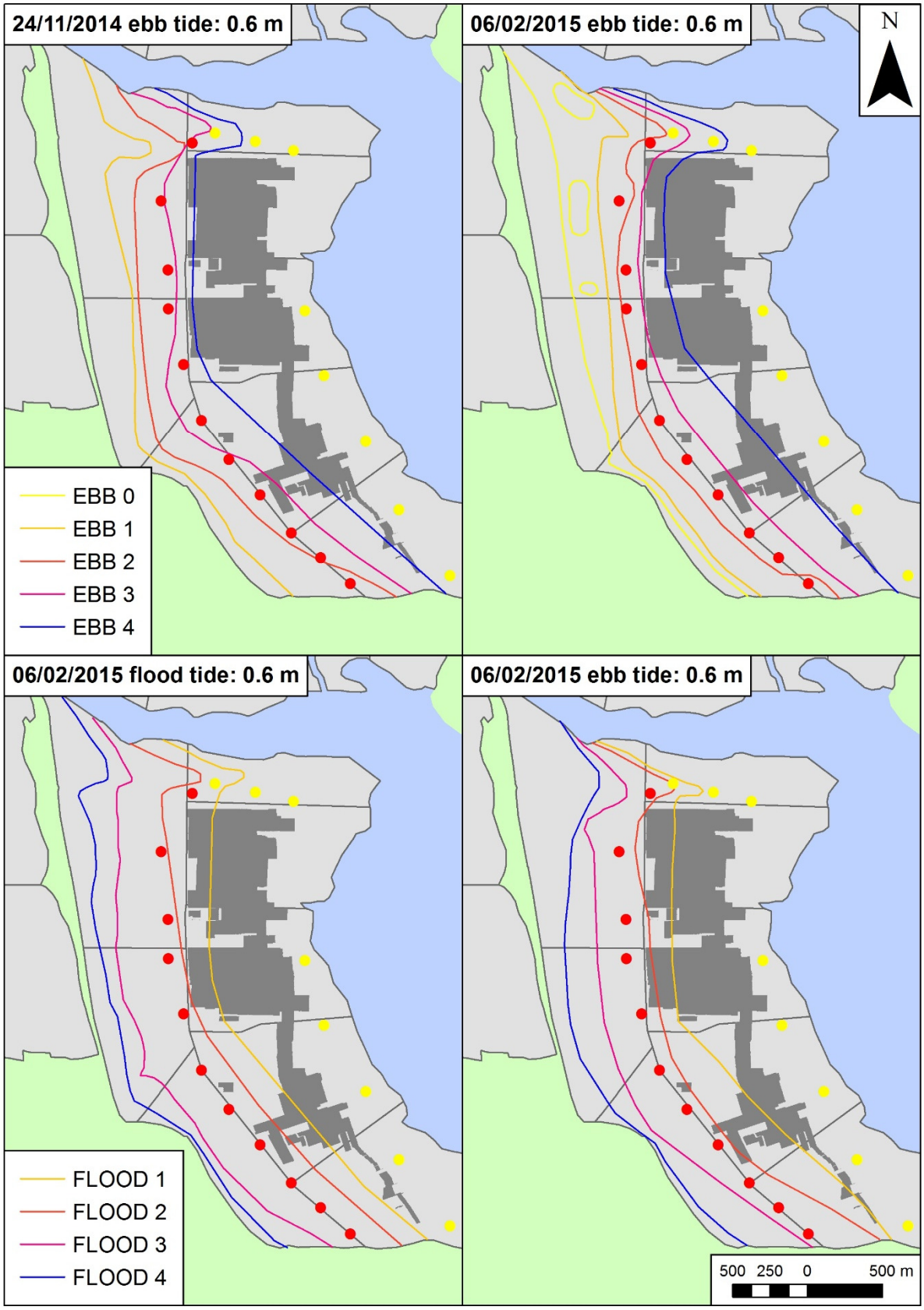


Figure 3.3 - Tidelines on Whitehouse Bank on days with low tides of 0.6 m.

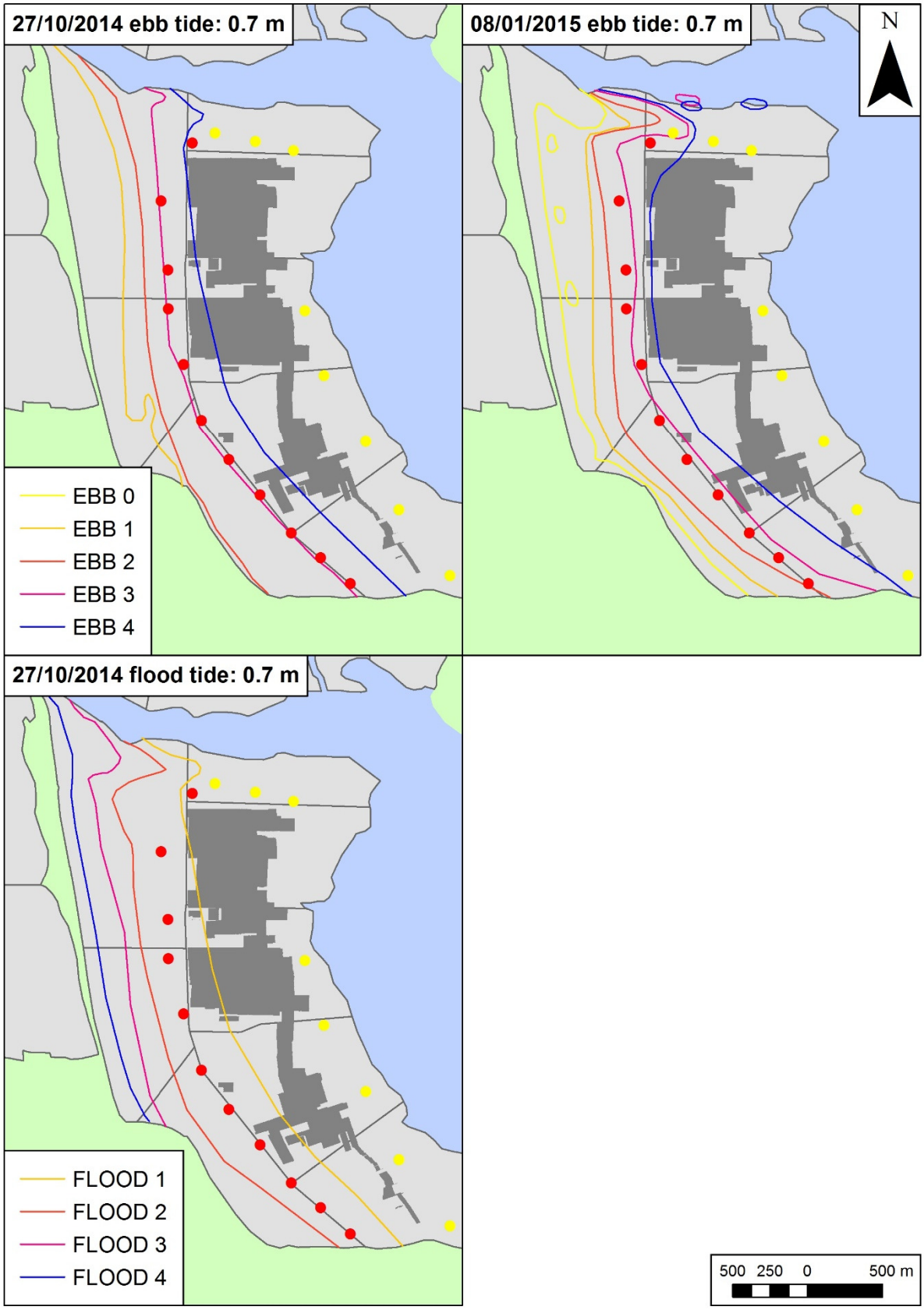


Figure 3.4 - Tidelines on Whitehouse Bank on days with low tides of 0.7 m.

.

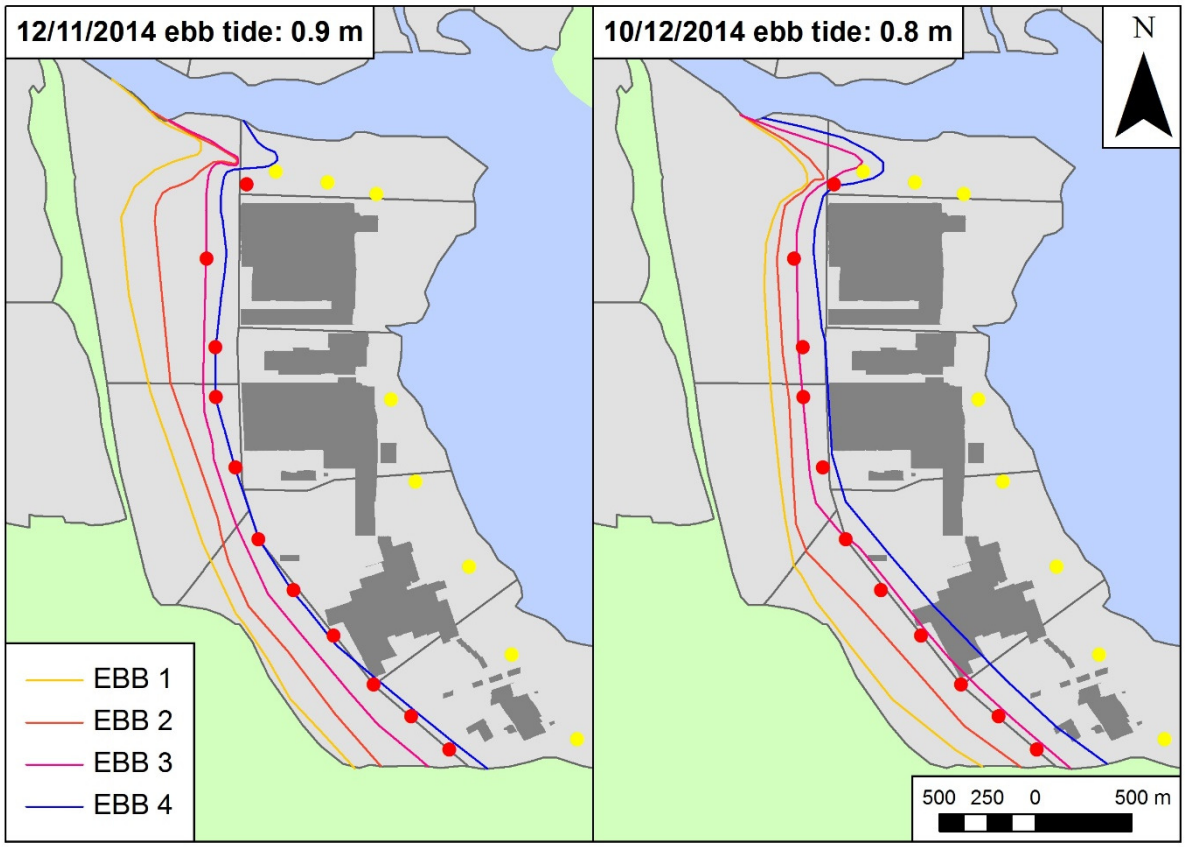


Figure 3.5 - Tidelines on Whitehouse Bank on days with tides of 0.8-0.9 m.

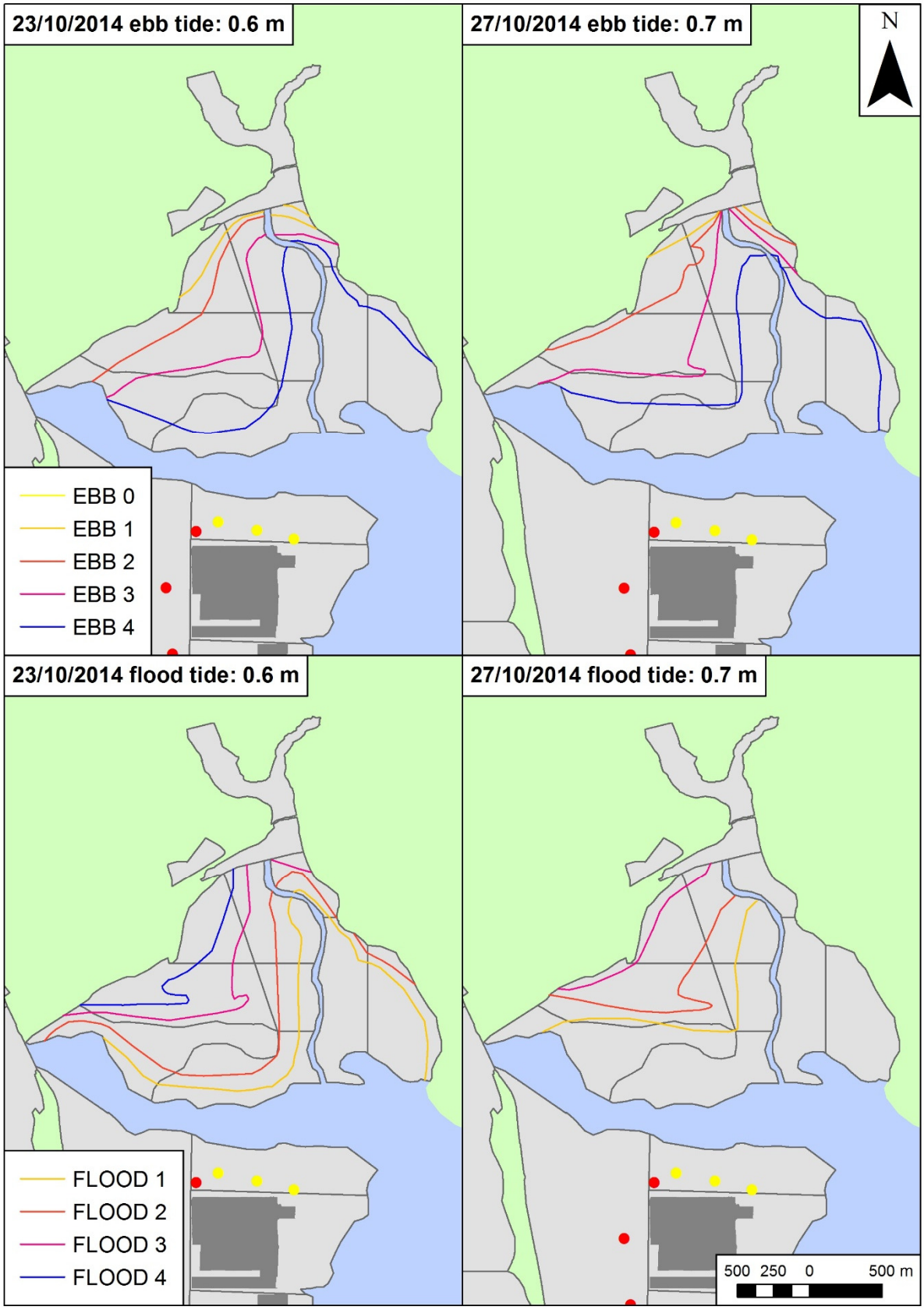


Figure 3.6 - Tidelines during the ebb and flood tide periods on Ballyrandle Sandflats on 23 and 27/10/2014.

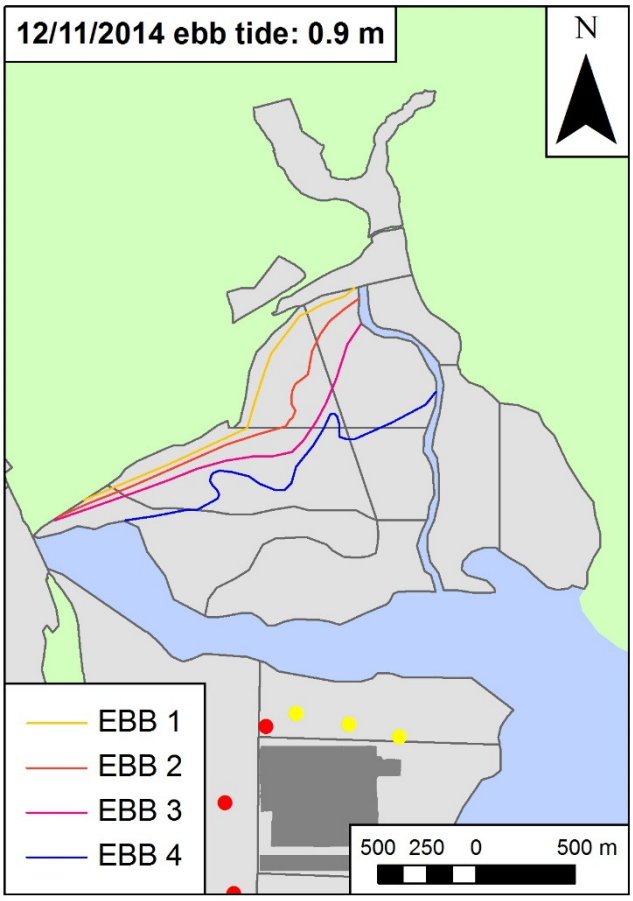


Figure 3.7 - Tidelines during the ebb tide period on Ballyrandle Sandflats on 12/11/2014.

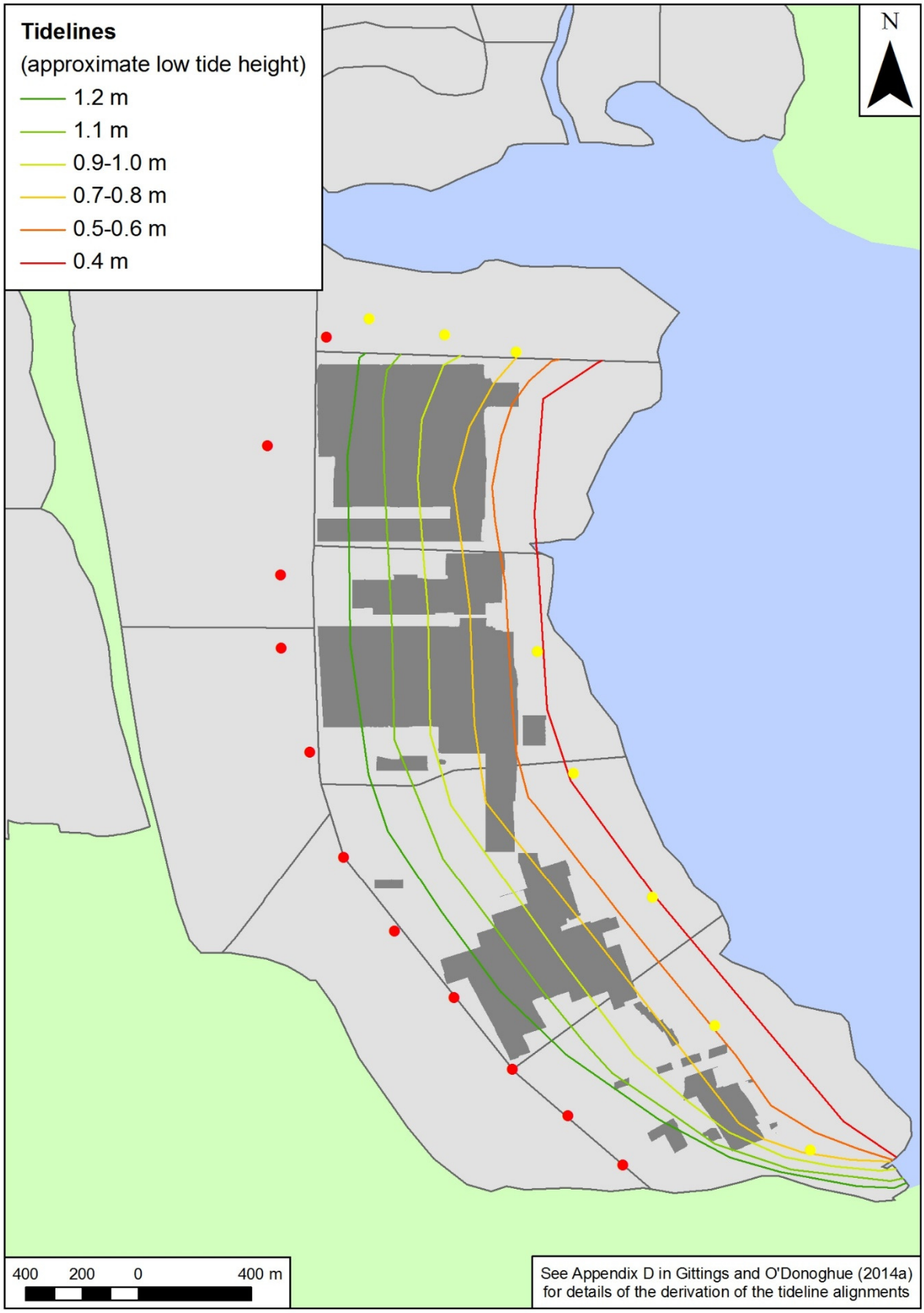


Figure 3.8 - Low tide tidelines on Whitehouse Bank.

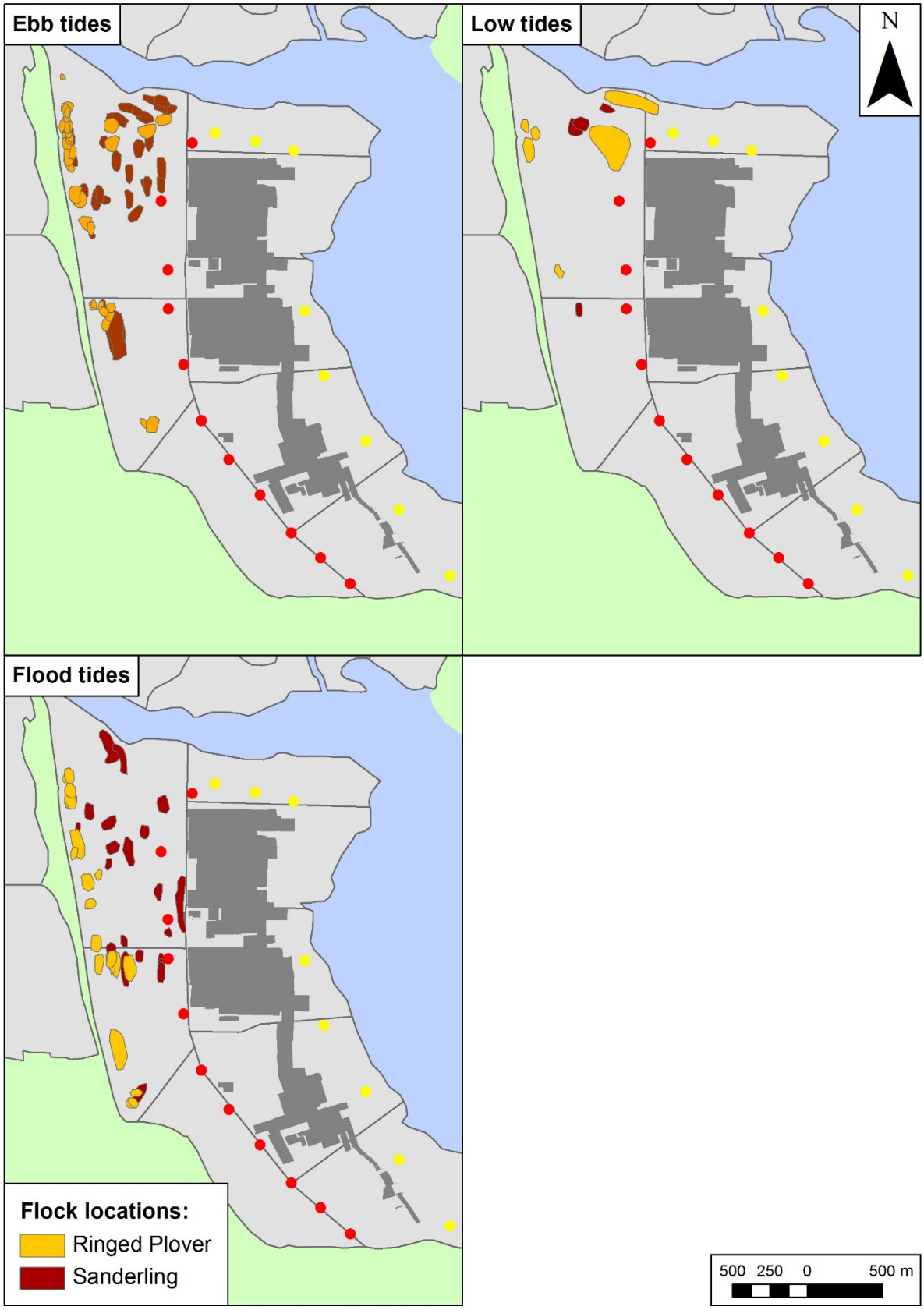


Figure 3.9 - Distribution of Ringed Plover and Sanderling flocks recorded on Whitehouse Bank.

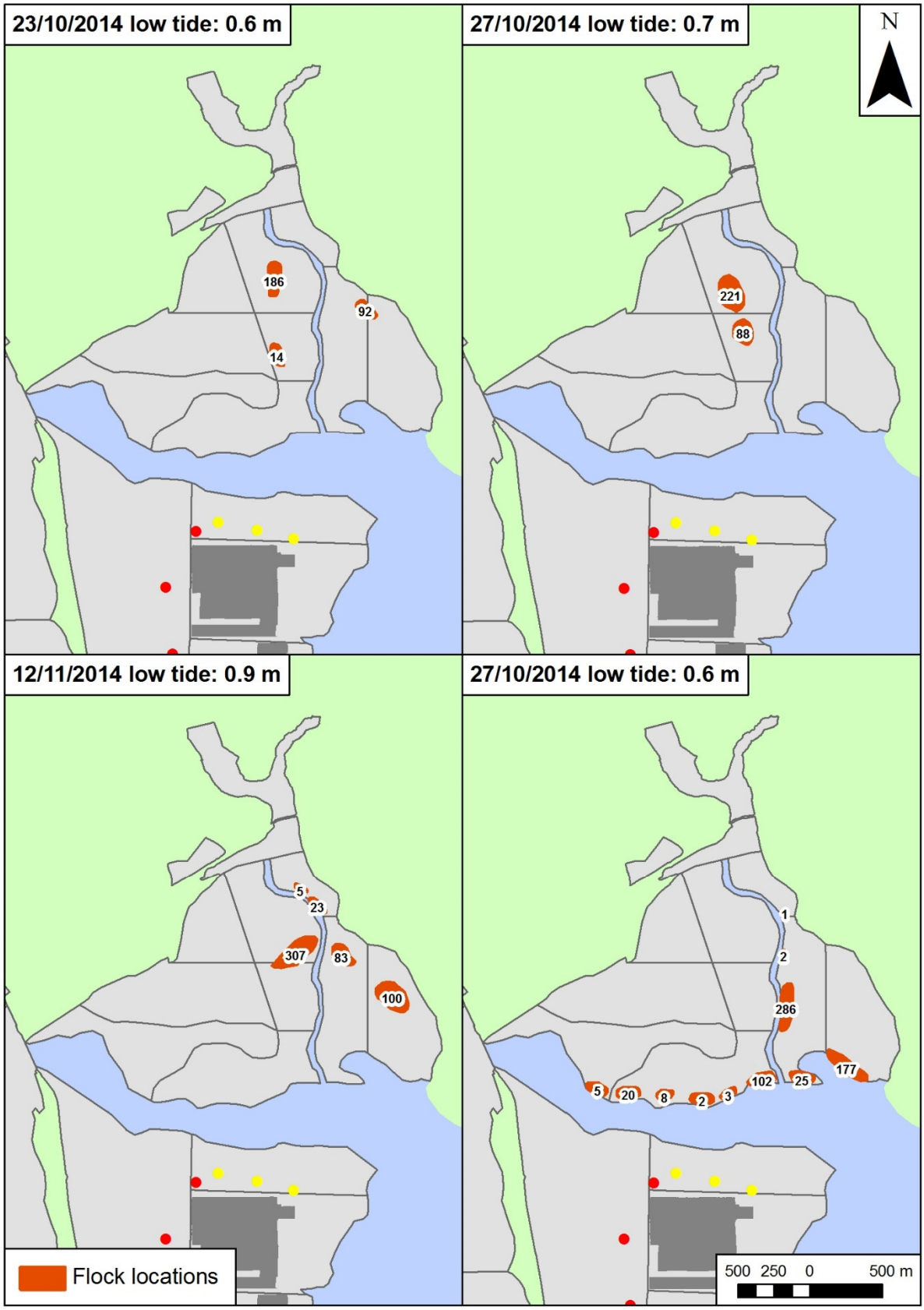


Figure 3.10 - Distribution of Bar-tailed Godwit flocks at low tide on Ballyrandle Sandflats in October and November 2014.

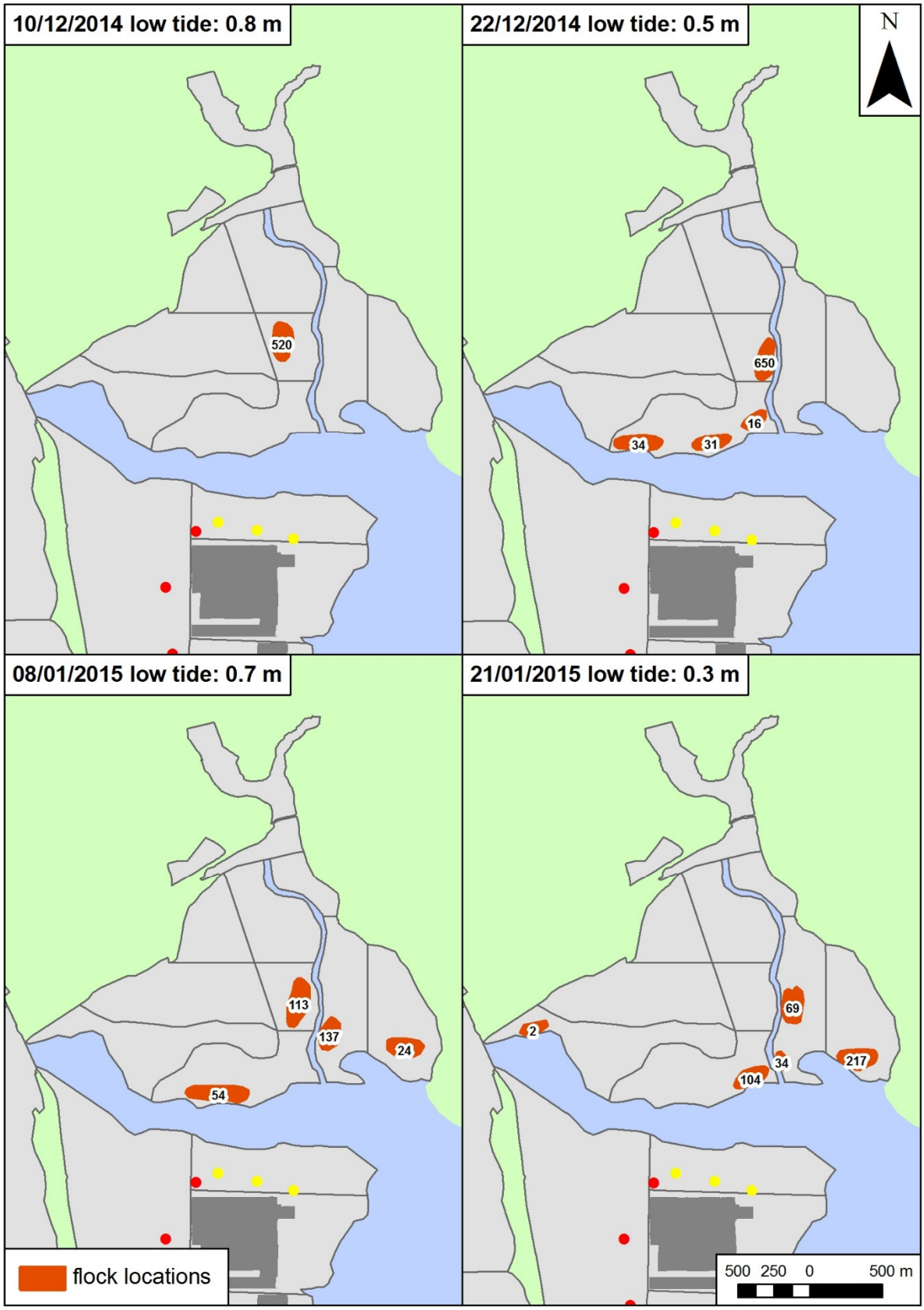


Figure 3.11 - Distribution of Bar-tailed Godwit flocks at low tide on Ballyrandle Sandflats in December 2014 and January 2015.

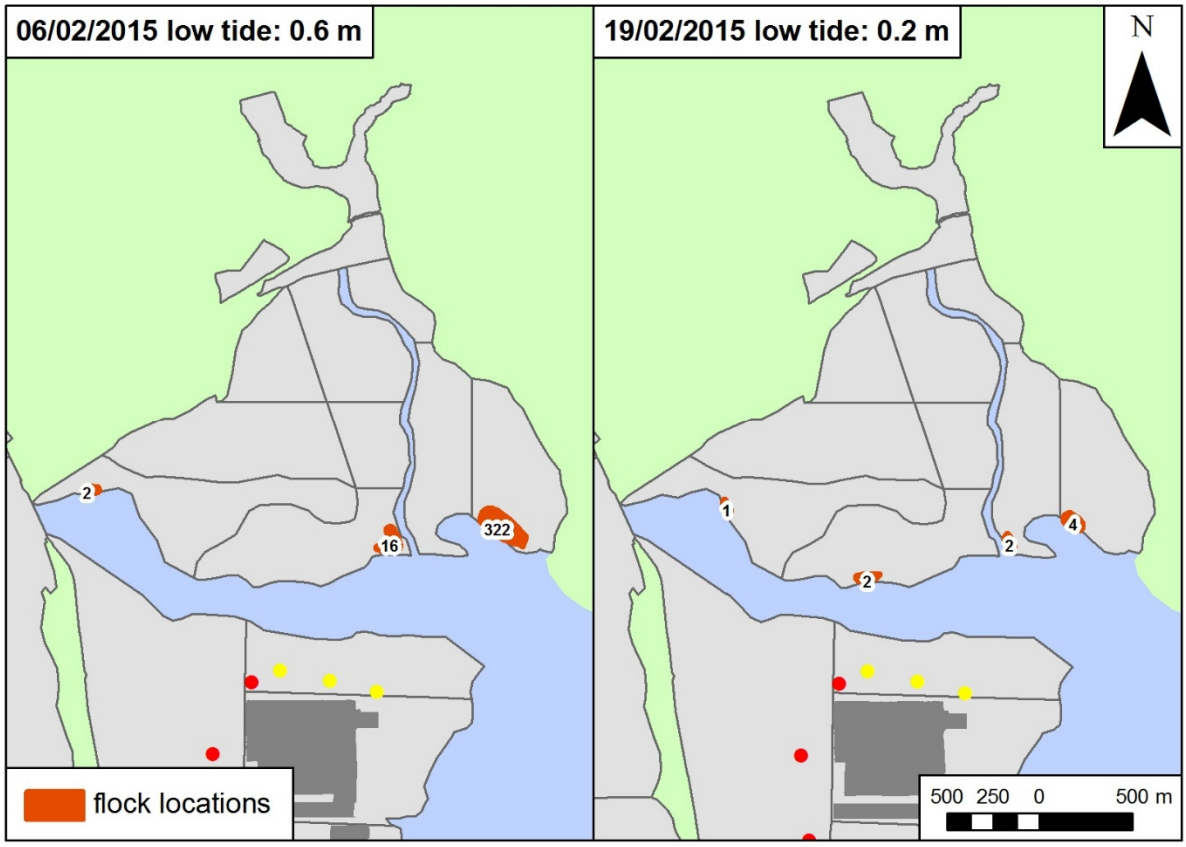


Figure 3.12 - Distribution of Bar-tailed Godwit flocks at low tide on Ballyrandle Sandflats in February 2015.

4. Discussion

Count accuracy

Ebb and flood tide counts

4.1 The coverage of Whitehouse Bank on the ebb and flood tide counts was improved over the first four counts. On the first count, a single observer covered the area and sector CS1 was not covered. On the second and third counts, two observers covered the area, while from the fourth count onwards, three observers covered the area. Therefore, the ebb and flood tide numbers from the first three counts (particularly the first count) may be under-estimates of the numbers occurring on Whitehouse Bank. But it should be noted that Bar-tailed Godwit is the only species to regularly occur in significant numbers in sector CS1, and sector CS1 is more or less fully flooded during the Ebb0-1 and Flood3-4 periods, when the peak numbers on Whitehouse Bank were usually recorded.

4.2 Once the final methodology had been established, from the fourth count onwards, we consider that the ebb and flood tide counts on Whitehouse Bank were very accurate. This is reflected in the count data for target species in the ebb tide period that generally shows 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 (see paragraph 3.16).

Low tide counts

4.3 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. There were a number of factors that probably affected the accuracy of the low tide counts.

4.4 The organisation of the counters was improved, by trial and error, over the first three counts, and the generally better recording of species on the subsequent low tide counts probably represents the improved organisation of the latter counts.

4.5 However, after the first two counts the Inner Harbour (upper) sub-zone was not systematically covered on the low tide counts. The first two low tide counts, and the results of the 2009/10 BWS low tide counts, indicate that none of the target species, or additional monitored species, regularly occur in significant numbers in these areas. However, selective coverage of sections of the Inner Harbour (upper) sub-zone during the last two low tide counts, as a result of observations of bird movements, did record significant numbers of Golden Plover and Knot in these areas. Therefore, it is possible that some of the discrepancies between the ebb/flood tide maximum counts, and the low tide counts are due to birds moving to the Inner Harbour (upper) sub-zone.

4.6 The Inner Harbour (main) sub-zone is a challenging area to cover at low tide. The area has to be covered from a number of different vantage points and there are a lack of clear divisions, which can be used to differentiate coverage between vantage points. Bird movements, while counters are moving between vantage points, could cause under-counting, or double-counting, although the use of two counters for the majority of the low tide counts addressed this problem to some extent. Also, birds can be hidden along the deep creeks within the mudflats.

4.7 The pattern of Knot, Dunlin and Bar-tailed Godwit moving to Whitehouse Bank from Ballyrandle Sandflats during the low tide period (see below) could also cause double-counting (if the birds had already been counted on Ballyrandle Sandflats and moved before the count in OY2 had been carried out), or under-counting (if the birds moved before they were counted on Ballyrandle

Sandflats, but after the count in OY2 had been completed). This may have explained the discrepancies in the Dunlin count on 08/01/2015 and 06/02/2015, and in the Bar-tailed Godwit count on 08/01/2015.

4.8 The above 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: one to cover the Inner Harbour (upper), two to cover the Inner Harbour (main), one to cover Ballyrandle Sandflats and two to cover Whitehouse Bank. This would allow completion of co-ordinated low tide counts within a short period of time, and simultaneous observation of all the areas where concentrations of the target species are likely to occur.

Tidal cycle movements

4.9 This study has confirmed the preliminary observations from the trestle study that large number of Grey Plover, Knot and Dunlin regularly occur on Whitehouse Bank on the ebb and (to a lesser extent) flood tides.

4.10 This study has also found that large numbers of Bar-tailed Godwit regularly occur on Whitehouse Bank on the ebb and flood tides. This was not reported by the trestle study. However, in that study, the ebb/flood tide data comes from casual observations that were outside the main focus of the study. Because higher numbers of Bar-tailed Godwit occur on Whitehouse Bank at low tide, compared to the other three target species, the increased numbers on the ebb and flood tides are less obvious and may have been overlooked in the trestle study.

4.11 The direct observations of movements indicate that Grey Plover, Knot and Dunlin mainly move to/from the Inner Harbour, while Bar-tailed Godwit move to/from both the Inner Harbour and Ballyrandle.

4.12 The pattern of the tidal cycle counts indicate that the proximal cause of bird movements off Whitehouse Bank is the exposure of mudflats in the Inner Harbour, rather than the tideline reaching the trestle zone: the movements mainly occurred in the Ebb0 and Ebb1 periods, reflecting the beginning of the exposure of mudflat in the Inner Harbour in the Ebb1 and Ebb2 periods, while the tideline did not reach the trestle zone until the Ebb3 period.

4.13 However, the fact that the proximal cause of bird movements off Whitehouse Bank appears to be the exposure of mudflats in the Inner Harbour does not necessarily mean that that presence of oyster trestles does not influence these movements.

Responses to intertidal oyster cultivation

Overall responses

4.14 This study has confirmed the patterns of response to oyster trestles identified by the trestle study (Gittings and O'Donoghue, 2012a): -

- Grey Plover and Knot do not occur in areas occupied by oyster trestles. Therefore, the presence of oyster trestles appears to cause complete exclusion of these species from the affected habitat.

- Dunlin and Bar-tailed Godwit occur in lower numbers in areas occupied by oyster trestles, compared to similar habitat that is not occupied by oyster trestles. Therefore, the presence of oyster trestles appears to cause reduced densities of these species in the affected habitat.

4.15 The trestle study did not have sufficient data to allow firm categorisation of the responses to oyster trestles of Golden Plover, Ringed Plover and Sanderling, but the responses were provisionally categorised as negative. The results of the present study, combined (in the case of Sanderling) with the results of monitoring work at Donegal Bay, indicate that Ringed Plover and Sanderling do not occur in areas occupied by oyster trestles. Therefore, the presence of oyster trestles appears to cause complete exclusion of these species from the affected habitat.

Additional observations

Grey Plover

4.16 There has been a marked decrease in the utilisation of Whitehouse Bank by Grey Plover at low tide over recent winters. In 2009/10 and 2011, the mean percentage occurrence of Grey Plover on Whitehouse Bank was 16% of the total Dungarvan Harbour count (2009/10) and 94-98% of the Outer Sandflats count. This compares to 0% of the total Dungarvan Harbour count and 1% of the Outer Sandflats count in the present study.

4.17 If Grey Plover numbers were lower in 2014/15, the absence of birds from Whitehouse Bank could simply be due to the numbers in the preferred Inner Harbour (main) sub-zone not reaching the level where the habitat is saturated. Grey Plover numbers in 2009/10 may have been higher: a total of 410 was recorded on the high tide count in January 2010. In 2010/11, the peak IWeBS counts was 243, indicating similar numbers to 2014/15 (although there were only two counts from 2010/11). However, the fact that Grey Plover occurred in significant numbers on Ballyrandle Sandflats in 2014/15, in contrast to their distribution patterns in 2009/10 and 2010/11, indicates that Inner Harbour (main) sub-zone habitat did reach saturation, and, instead of moving to Whitehouse Bank, the overspill moved to Ballyrandle Sandflats.

4.18 We consider that the reason for the disappearance of Grey Plover at low tide from Whitehouse Bank is likely to be the change in configuration of the trestle blocks on Whitehouse Bank. In 2011, Grey Plover occurred mainly in sectors OY1 and OY2. The configuration of trestle blocks in these sectors included strips perpendicular to the tideline that were clear of trestles throughout the tidal cycle. In 2014/15, the changes to the configuration of the trestles meant that there that were no such areas clear of trestles throughout the tidal cycle.

4.19 Grey Plover is a visual feeder which typically occurs at low densities. Each individual bird requires open areas to detect prey at the surface over a wide area, and to allow it to make sudden runs to capture the prey (see Pienkowski, 1981). Oyster trestles are likely to interfere with this behaviour. As prey activity it likely to be affected by the drying of the sediments over the low tide period, Grey Plover presumably require access to suitable areas close to the tideline throughout the low tide period. Therefore, even a relatively narrow band of trestles may be enough to affect the suitability of the habitat for Grey Plover if it means that there will be period when the entire tideline will be within/close to trestles.

Bar-tailed Godwit distribution on Ballyrandle Sandflats

4.20 Bar-tailed Godwits generally occur in much higher numbers on Ballyrandle Sandflats, compared to Whitehouse Bank. As the biotope type in the two areas is similar, this difference may indicate displacement of birds due to the presence of oyster trestles on Whitehouse Bank. However, the presence of a tidal channel running through Ballyrandle Sandflats is a habitat difference between the two areas. Analysis of benthic invertebrate data from the two areas in Gittings and O'Donoghue (2014a) provided some indications that there may be better food resources for this species on Ballyrandle Sandflats, although the evidence was not conclusive.

4.21 The flock distributions recorded in the present study shows that Bar-tailed Godwits on Ballyrandle Sandflats tend to occur along the tidal channel. The analyses of the benthic invertebrate data in Gittings and O'Donoghue (2014a) indicate that relatively high densities of large polychaetes (which are the favoured prey item of Bar-tailed Godwits; Duijns *et. al.*, 2013) occur along this tidal channel (although the data is limited). Therefore, the present study provides some further evidence that at least part of the reason for the higher numbers of Bar-tailed Godwits on Ballyrandle Sandflats compared to Whitehouse Bank is due to underlying habitat differences between the two areas, rather than the presence of oyster trestles on Whitehouse Bank. However, this is not conclusive, and even if this is the case, it is likely that the trestles are still having a displacement effect (see below).

Low tide movement on to Whitehouse Bank

4.22 Our observations indicate a pattern of Knot, Dunlin and Bar-tailed Godwits moving into sector OY2 on Whitehouse Bank from Ballyrandle Sandflats (and possibly also the Inner Harbour) just before full low tide (after the tideline has fallen below the trestles), or after full low tide (after the tideline has risen above the trestles again), with such movements being observed, or suspected to have occurred on four of the low tide counts, and a failed movement attempt on a further day (Table 3.10). The successful movements occurred on all the low tide counts in January and February 2015, while no successful movements were recorded in the October-December counts, possibly indicating a seasonal pattern to this behaviour.

4.23 We observed two incidences when flocks apparently moved to Whitehouse Bank but failed to settle because the tideline was within, or just above, the trestles (Table 3.10). While the birds seem deterred from settling before the tideline falls below the trestles, they appear to be able to maintain their presence as the tideline returns through the trestle zone at the start of the flood tide. Therefore, these movement patterns may be linked to broader patterns of habitat utilisation within Dungarvan Harbour. In particular, there may be an asymmetry in the suitability of habitat within the Inner Harbour: the mudflats will presumably dry out over a period of time after they become fully exposed, but will only rewet over a shorter period of time on the flood tide when the creeks fill up.

5. Conclusions

Tidal cycle monitoring

5.1 A key consideration to be assessed as part of the 2014/15 monitoring programme was whether the differences between ebb/flood tide and low tide counts on Whitehouse Bank could allow one to quantify the potential displacement impact of intertidal oyster cultivation in Dungarvan Harbour and use this as a monitoring tool moving forward.

5.2 The pattern of the tidal cycle counts, however, indicate that the proximal cause of bird movements off Whitehouse Bank is the exposure of mudflats in the Inner Harbour, rather than the tideline reaching the trestle zone. That said, the fact that the proximal cause of bird movements off Whitehouse Bank appears to be the exposure of mudflats in the Inner Harbour does not necessarily mean that that presence of oyster trestles does not influence these movements.

5.3 The tidal cycle monitoring had the potential to provide confirmatory evidence that significant displacement impacts are occurring (if the movements had been clearly linked to the tideline reaching the trestle-zone). However, because historical displacement impacts cannot be detected by post-impact monitoring, the absence of this confirmatory evidence does not mean that significant displacement impacts have not occurred.

Golden Plover

5.4 With respect to Golden Plover the Appropriate Assessment stated: -

> *"Most of the potential future expansion of intertidal oyster cultivation will not affect areas that appear to be favoured by Golden Plover. There is one application plot (T04/041) at the northern end of the area currently occupied by oyster trestles, which extends to within 100 m of one of the Golden Plover flock locations recorded in 2009/10. It is possible that development of this plot might reduce the utilisation of the adjacent area by Golden Plover. However, given the current patterns of occurrence of Golden Plover flocks, it seems unlikely that this would affect the overall occurrence of Golden Plover within the northern part of Whitehouse Bank".*

5.5 NPWS expressed a concern (DAHG to DAFM; 15th May 2014) that "*the zone of suitable roosting area for Golden Plover within the Whitehouse Bank is currently constrained by both recreational activities and intertidal oyster. It is conceivable that a further constriction of this zone (either by increasing the trestle footprint at the northern end of the Whitehouse Bank or through an increase in recreation-related disturbance or a combination of the two pressures) may result in these large flocks ceasing to use Whitehouse Bank…*".

5.6 The 2014/15 field surveys, however, did not find evidence of consistent use of this area by Golden Plover, with large flocks recorded on only three occasions. Furthermore, with respect to recreational pressure, as noted in pg. 3.32; in contrast to the 2011 study, while riding along the tide line was observed, in general horse riding occurred less frequently on Whitehouse Bank and was not observed to cause significant disturbance impacts. While pedestrian activity along Whitehouse Bank was highlighted as potentially being a significant disturbance to birds at, or close to, high tide; Golden Plover which use the sandflats as a low tide roost are less likely to be affected (unless dogs are on the shore).

Grey Plover, Knot, Dunlin and Bar-tailed Godwit

5.7 As noted above the target species considered in this report are Grey Plover, Knot, Dunlin and Bar-tailed Godwit. This is further to observations on the draft Appropriate Assessment received from DAHG (dated 15th May 2014 & 26th August 2014[2]) which raised concerns regarding the displacement of these species within the bay[3]. Specifically, the letter of 15th May 2014 states that with respect to Grey Plover, Knot and Dunlin "*the proposed extent of intertidal oyster cultivation at Dungarvan Harbour SPA would not seem consistent with the conservation objectives for these species*" and sought further clarification on how the proposed aquaculture operations were considered unlikely to have a significant effect on their conservation objectives. With respect to Bar-tailed Godwit, DAHG questions whether, notwithstanding that "*the Ballyrandle sandflats may have invertebrate communities that support greater numbers of foraging Bar-tailed Godwits or for a greater proportion of time, this might not reduce the importance of Whitehouse Bank that might be particularly important at certain stages of the tide …or at certain times of the year*".

5.8 Thus, as noted above we conducted tidal cycle monitoring of Grey Plover, Knot, Dunlin and Bar-tailed Godwit in order to address these concerns; and in particular to further explore Attribute No. 2 of the conservation objectives; namely that "*there should be no significant decrease in the numbers or range of areas used by these waterbird species, other than that occurring from natural patterns of variation*".

5.9 Analysis of the flock distribution patterns of **Bar-tailed Godwits** on Ballyrandle Sandflats (from the 2014/15 monitoring study) supports the previous assessment that part of the reason for the higher numbers of Bar-tailed Godwits on Ballyrandle Sandflats compared to Whitehouse Bank is due to underlying habitat differences between the two areas, rather than the presence of oyster trestles on Whitehouse Bank (including also the greater length of tideline along both sides of the creek at Ballyrandle). Therefore, analyses of bird distribution across the Outer Sandflats Zone are likely to overestimate the potential displacement impact of intertidal oyster cultivation in Dungarvan Harbour. The current conservation status of Bar-tailed Godwit on site is *Favourable* (see also Table 5.1 of the Appropriate Assessment; NPWS, 2012). In the context of current pressures, it would therefore appear that the Bar-tailed Godwit population at Dungarvan has adequate habitat available within Ballyrandle, and to a lesser degree within those areas of Whitehouse Bank which continue to be used, to maintain a favourable conservation status within the SPA. Of the remaining species the conservation status of Knot on site is also *Favourable* (see also Table 5.1 of the Appropriate Assessment; NPWS, 2012) and the same argument currently applies.

5.10 In contrast the conservation status of Grey Plover is *Intermediate (unfavourable)* defined as a population decline in the range 1.0 – 24.9% (NPWS, 2012). As noted in the Appropriate Assessment, the observed decline in Grey Plover at Dungarvan (i.e. -11.2 over 12 years / -2.8 over 5 years[4]) is substantially less than that observed nationally (-33.1[5]). Grey Plover in Dungarvan is therefore categorised by NPWS (2012) in the category - "*there is a potential for factors at a larger spatial scale to be influencing the observed trend at site level*". However, there are some indications that more recent data may indicate a stronger decline at Dungarvan Harbour, compared to the national trend.

5.11 The conservation status of Dunlin at Dungarvan is *Unfavourable* defined as a population decline in the range 25.0 – 49.0% (NPWS, 2012). As noted in the Appropriate Assessment, the observed

[2] Following a request for further clarification (17th July 2014) DAHG expanded upon how Attribute No. 2 should be interpreted in correspondence dated 26th August 2014.
[3] Note that comments from DAHG (15th May 2014) regarding Oystercatcher, Curlew, Redshank, Turnstone & Light-bellied Brent geese were addressed in May 2014.
[4] Site population trend analysis: 12 yr = 1995/96 – 2007/08; 5 yr = 2002/03 – 2007/08.
[5] All-Ireland trend calculated for period 1994/95 to 2008/09.

decline in Dunlin at Dungarvan (i.e. -38.4 over 12 years / -16.6 over 5 years) is less than that observed nationally (-46.5). As for Grey Plover, Dunlin is therefore categorised by NPWS (2012) in the category - "*there is a potential for factors at a larger spatial scale to be influencing the observed trend at site level*".

5.12 The change in low tide distribution of **Grey Plover** (which appears to be linked to changes in the configuration of the trestles), and the pattern of movement of Knot, Dunlin and Bar-tailed Godwit onto trestle-free areas in Whitehouse Bank during the low tide period, indicate that ecologically significant larger numbers of these species would occur on Whitehouse Bank at low tide if there were no trestles present. Furthermore, analyses restricted to bird distribution within Whitehouse Bank are likely to underestimate the potential displacement impact of intertidal oyster cultivation in Dungarvan Harbour due to built-in historical patterns of displacement.

5.13 The difficulty in reaching clear conclusions about the displacement impact of intertidal oyster cultivation in Dungarvan Harbour, reflects the difficulty in assessing an impact after it has occurred without having any pre-impact data. For example, if we did not have data from previous seasons we would not have been able to detect the change in Grey Plover distribution patterns that has occurred. Therefore, it is highly likely that other significant changes in distribution patterns have occurred during the development and expansion of intertidal oyster cultivation on Whitehouse Bank, but, because we do not have low tide data prior to 2009/10, we cannot detect these changes.

5.14 We are therefore somewhat restricted to looking at Attribute 1 – "*that the population trend is stable and increasing*" and commenting on Attribute 2 (i.e. on number and range of areas used) in so far as is practical in the absence of historical data; noting that intertidal oyster cultivation commenced on Whitehouse Bank as early as 1985, with licences first granted in 1993. Thus as concluded in the Appropriate Assessment "*The long-term population trends of all four of these species at Dungarvan Harbour are similar to, or more positive than, the national trends. Therefore, there is no evidence that the development of intertidal oyster cultivation at Dungarvan Harbour has affected the long-term population trends of these species at Dungarvan Harbour*".

5.15 Where a species is declining both nationally and at a site level (Grey Plover and Dunlin), it is not correct to interpret the site level decline as an indicator of negative impacts at the site level. However, this does not mean that we can rule out negative impacts at the site level as we do not know what would have happened if the population was stable or increasing at the national level. In the context of the conservation objectives, an important consideration is whether the site impacts would prevent recovery of the site population in the event that the national population recovered.

5.16 However, as noted the 2014/2015 study does suggest that alteration to trestle configuration has negatively impacted on Grey Plover; by closing previously open areas of tideline; this would suggest, however, that alteration to the configuration of trestles may equally reverse this trend and reinforces the need for ongoing monitoring and adaptive management of the site.

A.1.1 As noted (pg. 4.22-4.23) –our observations indicate a pattern of Knot, Dunlin and Bar-tailed Godwits moving into Whitehouse Bank from Ballyrandle Sandflats (and possibly also the Inner Harbour) which may be linked to broader patterns of habitat utilisation within Dungarvan Harbour and not just the presence of trestles. However, the pattern of large flocks of Knot, Dunlin and Bar-tailed Godwit moving onto Whitehouse Bank during the latter part of the low tide period in the January and February counts does provide some support to NPWS' concerns that Whitehouse Bank "*might be particularly important at certain stages of the tide …or at certain times of the year*".

Recommendations

5.17 While a detailed re-visiting of the Appropriate Assessment is outside the scope of this monitoring report, some key points did emerge: -

- The differences between ebb/flood tide and low tide counts on Whitehouse Bank does not allow one to quantify the potential displacement impact of intertidal oyster cultivation in Dungarvan Harbour (and to use this as a monitoring tool) as the proximal cause of bird movements off Whitehouse Bank appears to be the exposure of mudflats in the Inner Harbour, rather than the tideline reaching the trestle zone.

- There is no evidence that the count sector CS4 to the north of the existing trestle block (Figure 2.2. of the Appropriate Assessment) is used to any significant extent. Extension and / or relocation of trestles into this area is therefore an option. The available evidence does not indicate that roosting Golden Plover would be negatively impacted by such a move.

- As noted the observed reconfiguration of trestles appears to have resulted in a displacement of Grey Plover from Whitehouse Bank - as evidenced by 2014/2015 monitoring data. Consideration should be given to re-opening of tidal breaks through appropriate reconfiguration of trestles in order to reverse this impact.

- IWeBS count data for 2014/2015 were not compiled at the time of writing and therefore were not available for review. Given the observed impacts on Grey Plover; and as a full low-tide count of all of Dungarvan Harbour was not part of the 2014/15 monitoring brief, we would recommend that IWeBS count data for 2014/2015 be sourced from BirdWatch Ireland in order to update population trends for Grey Plover (but also for Knot, Dunlin and Bar-tailed Godwit).

- We would also recommend that data for Grey Plover be requested from BirdWatch Ireland from other key Grey Plover sites in order to determine up to date trends for Grey Plover at key sites in Ireland and relate this to observed changes in Dungarvan.

- As noted both Bar-tailed Godwit and Knot demonstrate *Favourable* conservation status on site; birds displaced from Whitehouse Bank therefore currently appear to be accommodated elsewhere within the SPA. The European Commission guidance document on the links between the Water Framework Directive and Habitats and Birds Directives states that: - "*Under the HD [Habitats Directive] the aim is to protect the presence of the protected species and the habitats occurring in the Natura 2000 site. Favourable conservation status is clearly linked to the species "maintaining itself on a long-term basis as a viable component of its natural habitats". This means measures under BHD [Birds and Habitats Directives] should aim at the protection of sustainable populations of those species but should not be interpreted as meaning "as many birds as possible*". Thus while displacement of birds from Whitehouse Bank has / and is clearly occurring (i.e. contrary to Attribute 2); based on current pressures the populations of Bar-tailed Godwit and Knot appear to be maintaining a favourable conservation status (i.e. in line with Attribute 1). That said ongoing monitoring is required to continue to monitor population trends in the context of current levels of site activity. It is critical, however, that a mechanism is found to report on such monitoring in a timely fashion and intervene as appropriate should negative population trends (influenced at the site level) be detected.

- In contrast, both Grey Plover and Dunlin are in Intermediate (unfavourable) and Unfavourable conservation status in Dungarvan, respectively. Furthermore, as noted above recent changes in trestle configuration appear to have resulted in further displacement of Grey Plover from Whitehouse Bank. NPWS (2012), however, indicates that in both cases that these are species whose populations are declining at both site level and all-Ireland level; therefore there is a

potential for factors at a larger spatial scale to be influencing the observed trend at site level (refer to recommendations above). For both these species ongoing monitoring, reporting and adaptive management is clearly required; it is critical, however, that a clear mechanism for delivery and reporting on this process is implemented.

- As noted, the proximal cause of bird movements off Whitehouse Bank appears to be the exposure of mudflats in the Inner Harbour, rather than the tideline reaching the trestle zone. Thus, to fully explore the impacts of population changes and or levels of on-site activity, rather than ongoing annual monitoring, the most time / cost effective approach would be an Individual-based model (IBM) as we have previously recommended (Gittings and O'Donoghue, 2014b). An IBM would allow the actual displacement impacts to be quantified, and would also allow assessment of whether the displacement impacts are likely to have population-level consequences (such as reduced survivorship, or increased emigration). Further information about IBMs, and preliminary recommendations for the development of an IBM in Dungarvan Harbour, are provided in in Appendix D.

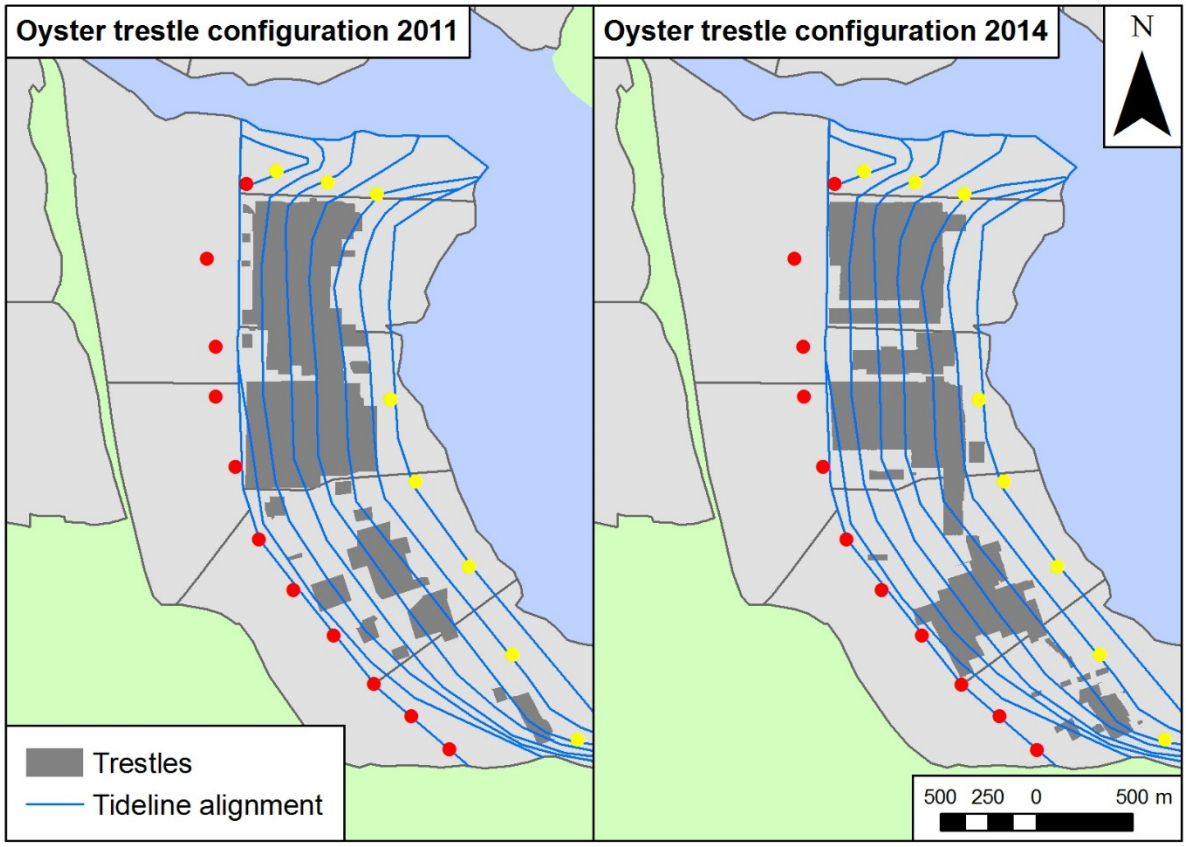


Figure 5.1 - Comparison of the configuration of oyster trestles in 2011 (at the time of the trestle study) and in 2014.

6. References

Duijns, S., Hidayati, N. & Piersma, T. (2013). Bar-tailed Godwits *Limosa l. lapponica* eat polychaete worms wherever they winter in Europe. *Bird Study*, 1–9.

Gittings, T. & O'Donoghue, P.D. (2012. *The Effects of Intertidal Oyster Culture on the Spatial Distribution of Waterbirds*. Report prepared for the Marine Institute, Atkins, Cork.

Gittings, T. & O'Donoghue, P.D. (2014a). *Dungarvan Harbour SPA Appropriate Assessment*. Report prepared for the Marine Institute, Atkins, Cork.

Gittings, T. & O'Donoghue, P.D. (2014b*). Dungarvan Harbour SPA Article 6 Assessment: Comments on the Interpretation of Potential Displacement Impacts and Recommendations for Further Work.* Report prepared for the Marine Institute, Atkins, Cork.

Pienkowski, M.W. (1980). *Aspects of the Ecology and Behaviour of Ringed and Grey Plovers* Charadrius hiaticula *and* Pluvialis squatarola. PhD thesis, Durham University.

NPWS (2012). *Conservation Objectives: Dungarvan Harbour SPA 004032. Version 1.0*. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht.

Appendix B
Recording Instructions

B.1 Detailed Recording instructions

Waterbird counts

B.1.1 Waterbird count data should be recorded using the supplied count forms (included at the end of this report). There are different count forms for the sectors containing oyster trestles, sectors with subdivisions, and the other sectors.

B.1.2 Complete a separate count form for each count.

B.1.3 Data from multiple sectors during a single count can be entered on the same count form.

Counter: enter counter name in this space.

Date: enter the date in the format dd/mm/yy.

Count type: enter ebb tide, low tide, or flood tide as appropriate.

Count number: for ebb tide and flood tide counts enter the sequential count number.

Count affected by disturbance: enter yes if birds in the sector were affected by a disturbance event during the count, or if a disturbance event prior to the count is considered to have affected the number of birds recorded. Enter details of the disturbance event and its effects on birds in the Notes section of the form. If a potentially disturbing activity occurred but is not considered to have affected the birds in the sector, enter no in this space.

Weather: weather conditions should be recorded using the same methodology and criteria as used for the Baseline Waterbird Surveys within Irish Coastal Special Protection Areas 2009/10 Waterbird Count Form, with the exception of wind. Wind speed and direction should be recorded using a compass direction and the Beaufort scale (e.g., NW5).

Bird counts: enter the number of each species recorded in the appropriate columns with regards to their sector, location and their behaviour (feeding or roosting/other), and enter the start and finish time of the count in the format hh:mm. The location and behaviour should be recorded as follows:

- For counts in sectors DUNG-OY1, DUNG-OY2, DUNG-OY3 and DUNG-OY4, birds should be counted separately in the oyster trestle areas and the clear areas.
- For counts in sectors DUNG-OY1, DUNG-OY2, DUNG-OY3 and DUNG-OY4, birds perched on top of oyster trestles should be recorded in the On trestles columns.
- Birds on the ground away from the tideline should be recorded in the Intertidal columns. For counts in sectors DUNG-CN1, DUNG-CN3 and DUNG-CN4 birds on the intertidal should be counted separately in the lower and upper shore zones of the sectors (where the lower shore is the zone closer to the tideline) and recorded in the appropriate columns (Intertidal (L) and Intertidal (U)).
- Birds on the ground along the tideline, or along the main tidal channels, or in the water within 10 m of the edge of the tideline/tidal channel, should be recorded in the Tidal channel/tideline columns.

- Birds should be assigned to behaviour categories (feeding and roosting/other) following the same guidelines and criteria as used for the Baseline Waterbird Surveys within Irish Coastal Special Protection Areas 2009/10.

Notes: use this section to enter details of any disturbance events that affected the count, details of any other factors that affected the data recording, and any other miscellaneous observations of interest. Observations about the behaviour of birds in the trestle area would be particularly useful.

Waterbird flock mapping

B.1.4 On each count, all significant flocks of the target species should be mapped using the supplied disturbance maps.

Disturbance recording

General

B.1.5 Disturbance recording should take place throughout the count period, including any gaps between counts, and should not be limited to events that take place during individual counts. However, **the waterbird counts should be prioritised if a conflict arises, due to limited time, between completing the required counts and recording disturbance activities.**

B.1.6 Counters should record all human activity in the intertidal zone within the sectors that they are counting.

B.1.7 Any other factors (birds of prey, or human activity outside the intertidal zone) that cause disturbance to the birds in the sectors being counted should be recorded.

B.1.8 Counters should record disturbance activities and impacts directly onto the supplied disturbance maps and forms in the field. Single disturbance maps and forms can be used for each count day, unless additional maps and forms are required because of the number of disturbance activities.

B.1.9 The spatial extent of each disturbance event should be recorded on the disturbance map and assigned a unique event reference. Details of the timing, nature and impacts (if any) of the event should be recorded on the disturbance activity form and cross-referenced to the disturbance map by the event reference.

B.1.10 Some activities may not cause any disturbance impacts. It is important that details of such activities are still recorded on the disturbance map and form.

B.1.11 Recording of disturbance activities and impacts may be a complex process, and the study methodology may not have anticipated all possible eventualities. Therefore, counters should be prepared to use their own judgement where circumstances arise that are not covered by the above methodology.

B.1.12 In the main block of trestles (DUNG-OY3 and DUNG-OY4) there may be high levels of activity and detailed recording of these activities may not be feasible. Instead the aim should be to summarise the main patterns of activities.

Instructions for completing the disturbance maps

B.1.13 Use a single disturbance map for each count day, unless additional maps are required because of the number of disturbance events.

B.1.14 Record the spatial extent of the disturbance event by either:

- an arrowed line to indicate the path of a human, vehicle or animal moving through the area; or
- a dashed line to indicate the area within which dispersed activity occurs, such as a group of people working on oyster trestles.

B.1.15 In general, the arrowed line should be used for short duration events, such as a human walking through a count sector. More complex patterns of activity should be recorded using the dashed line.

B.1.16 Assign a unique event reference (A, B, C, etc.) to each disturbance event recorded on the map.

Instructions for completing the disturbance forms

B.1.17 Use a single disturbance form for each count day, unless additional forms are required because of the number of disturbance events.

- **Counter:** enter counter name in this space.
- **Date:** enter the date in the format dd/mm/yy.
- **Time:** enter the start and finish time of the entire observation period (i.e., from the first count to the last count) in the format hh:mm-hh:mm.
- **Disturbance events:** record details of all disturbance events marked on the disturbance map.
- **Event reference:** enter the unique sequential event reference that corresponds to the recording of the event on the disturbance map.
- **Start time and End time:** record the times in the format hh:mm.
- **Number of vehicles:** record the number of vehicles involved in the activity
- **Number of people/animals:** record the number of people/animals involved in the activity.
- **Impact:** record whether the activity had any impact on birds (yes/no).
- **Description of activity and impacts (if any):** describe the nature of the activity and its pattern. Also describe any observed impacts on birds. Note if birds are displaced and fly into another count sector and whether they stay there or fly back out into the areas from which they've been disturbed.

Tideline recording

B.1.18 During the counts, the position of the tideline in each sector **at the time when the sector is being counted** should be recorded by sketching it on the disturbance map. However, during the low tide counts in the Inner Harbour zone most of the mudflat will be fully exposed, so the tideline will only need to be mapped in 0M419.

B.1.19 Coloured pens/pencils can be used to avoid confusion between lines drawn for different counts.

Dungarvan Harbour waterbird monitoring 2014/15

Count form for non-oyster trestle sectors

Counter	
Date	
Count type	
Count number	
Count affected by disturbance?	

Weather (circle as appropriate)			
Cloud cover	1 0-33%	2 33-66%	3 66-100%
Rain	1 none	2 showers	3 drizzle
Wind speed (Beaufort scale) and direction			
Visibility	1 good	2 moderate	3 poor

Species	Sector	Time		Tidal channel/tideline		Intertidal		Intertidal (L)		Intertidal (U)	
		Start	Finish	F	R	F	R	F	R	F	R

Notes:

Dungarvan Harbour waterbird monitoring 2014/15

Count form for oyster trestle sectors

Sector:	
Counter:	
Date:	
Time:	
Count affected by disturbance?	

Weather (circle as appropriate)			
Cloud cover	1: 0-33%	2: 33-66%	3: 66-100%
Rain	1 none	2 showers	3 drizzle
Wind speed (Beaufort scale) and direction			
Visibility	1 good	2 moderate	3 poor

	Within oyster trestle areas								Outside oyster trestle areas			
	On trestles				Not on trestles				Tideline		Intertidal	
	Tideline		Intertidal		Tideline		Intertidal					
Species	F	R	F	R	F	R	F	R	F	R	F	R
Notes:												

Dungarvan Harbour waterbird monitoring 2014/15

Counter:	
Date:	

Event	Time	Number of vehicles	Number of people	Number of animals	Impact	During count?	Description of activity and impacts (if any)

Appendix C

Observations of bird movements onto/off Whitehouse Bank

Table C.1 - Ebb tide movements of target species

Species	Date	Period	Time	Number	Moved from	Moved to	Notes
Grey Plover	23/10/2014	EBB2/3	02:46-02:26	61	Whitehouse Bank	Inner Harbour	roosting flock in CS3 moved to 0M427 and started to feed
	27/10/2014	EBB0	03:47	35	Inner Harbour	Whitehouse Bank	Flock began roosting when they arrived
	12/11/2014	EBB1	03:21	6	Whitehouse Bank	Inner Harbour	
	24/11/2014	EBB4	01:44	2	Whitehouse Bank	Inner Harbour	flew across Cunnigar into middle of 0M419/427
	10/12/2014	EBB1	03:31	c. 50	Whitehouse Bank	Inner Harbour	
	08/01/2015	EBB1	03:28	67	Whitehouse Bank	Inner Harbour	most of the flock flew in to 0M427, although some seemed to fly towards 0M417 and others towards 0M418 or 0M419
	08/01/2015	EBB1	03:18	100	Whitehouse Bank	Inner Harbour	
	21/01/2015	EBB0	04:04	c. 10	Whitehouse Bank	Ballyrandle	
	21/01/2015	EBB1	03:24	34	Whitehouse Bank	Inner Harbour	
	19/02/2015	EBB1	03:21	42	Whitehouse Bank	Inner Harbour	moved in a single flock
Knot	08/01/2015	EBB1	03:18	130	Whitehouse Bank	Inner Harbour	
	06/02/2015	EBB0	03:35	100	Whitehouse Bank	Inner Harbour	
	06/02/2015	EBB1	03:32	100	Whitehouse Bank	Inner Harbour	
	19/02/2015	EBB1	03:31	230	Whitehouse Bank	Inner Harbour	moving in small groups
	19/02/2015	EBB1	03:17	c. 250	Whitehouse Bank	Inner Harbour	observed flying across the Cunnigar, probably having come from CS3, and appearing to head for 0M418 or 0M419
Dunlin	12/11/2014	EBB0	03:37	5	Whitehouse Bank	Inner Harbour	
	24/11/2014	EBB0	03:43		Whitehouse Bank	Inner Harbour	moving in small flocks
	10/12/2014	EBB1	03:31	c. 50	Whitehouse Bank	Inner Harbour	
	10/12/2014	EBB2	03:02	8	Whitehouse Bank	Inner Harbour	
	22/12/2014	EBB1	03:01	45	Whitehouse Bank	Inner Harbour	
	22/12/2014	EBB2	02:54	c. 100	Whitehouse Bank	Inner Harbour	flushed from roost on upper shore, flew to lower sandflats and briefly started feeding, then most birds flew to Inner Harbour
	22/12/2014	EBB3	02:15	c. 20	Whitehouse Bank	Inner Harbour	
	05/01/2015	EBB1	03:28	1200	Whitehouse Bank	Inner Harbour	flew into 0M427
	05/01/2015	EBB1	03:08	100	Whitehouse Bank	Inner Harbour	flushed from roost, most birds flew to Inner Harbour, a few settled on lower sandflats
	08/01/2015	EBB1	03:28	885	Whitehouse Bank	Inner Harbour	most of the flock flew in to 0M427, although some seemed to fly towards 0M417 and others towards 0M418 or 0M419
	08/01/2015	EBB1	03:18	1300	Whitehouse Bank	Inner Harbour	
	21/01/2015	EBB0	04:04	< 50	Whitehouse Bank	Ballyrandle	

Species	Date	Period	Time	Number	Moved from	Moved to	Notes
Dunlin	21/01/2015	EBB0	04:02		Whitehouse Bank	Inner Harbour	some flying into 0M427 from CS2
	21/01/2015	EBB1	03:32	50	Whitehouse Bank	Inner Harbour	flew from south end of CS3
	21/01/2015	EBB1	03:32		Whitehouse Bank	Inner Harbour	flew in to 0M427 from CS2
	21/01/2015	EBB2	02:54	2	Whitehouse Bank	Inner Harbour	
	06/02/2015	EBB0	04:02		Whitehouse Bank	Inner Harbour	flew in small flocks to various locations inn 0M427
	19/02/2015	EBB0	03:41	800	Whitehouse Bank	Inner Harbour	about 80% of the flock in CS2 flew to feed in 0M427 just west of the Cunnigar
	19/02/2015	EBB1	03:31	390	Whitehouse Bank	Inner Harbour	moving in small groups
Bar-tailed Godwit	24/11/2014	EBB3	02:05	5	Whitehouse Bank	Ballyrandle	
	22/12/2014	EBB3	01:59	2	Whitehouse Bank	Inner Harbour	
	08/01/2015	EBB0	03:48	50	Whitehouse Bank	Ballyrandle	moving in small groups
	08/01/2015	EBB1	03:28	285	Whitehouse Bank	Ballyrandle	birds in CS2 seemed to go to the north, probably to Ballyrandle
	08/01/2015	EBB1	03:18	175	Whitehouse Bank	Inner Harbour	mainly moved to Inner Harbour, a few moved to Ballyrandle
	21/01/2015	EBB0	04:04	< 25	Whitehouse Bank	Ballyrandle	
	21/01/2015	EBB3	02:17	10	Whitehouse Bank	Ballyrandle	
	19/02/2015	EBB1	03:19	300	Inner Harbour	Whitehouse Bank	flew over Cunnigar from Inner Harbour and far out to sea, circled around for a while and eventually moved towards CS1
	19/02/2015	EBB1	03:15	150	Whitehouse Bank	Ballyrandle	presumably part of the above flock; flew in from south, briefly landed in CS3 then flew off to Ballyrandle
	19/02/2015	EBB1	03:15	50	Whitehouse Bank	Inner Harbour	most of the birds in CS2 flew across Cunnigar, and appeared to head for 0M418
	19/02/2015	EBB1	03:15	150	Whitehouse Bank	Ballyrandle	briefly landed on tideline, then flew to Ballyrandle

Time refers to the time before low tide.

Table C.1 - Flood tide movements of target species

Species	Date	Period	Time	Number	Moved from	Moved to	Notes
Grey Plover	21/01/2015	FLOOD1	02:27	c. 20	Whitehouse Bank	Inner Harbour	very flighty mixed flock in OY2 and eventually a large portion moved to the Inner Harbour
Knot	21/01/2015	FLOOD1	02:27	c. 200	Whitehouse Bank	Inner Harbour	very flighty mixed flock in OY2 and eventually a large portion moved to the Inner Harbour
Dunlin	22/12/2014	FLOOD4	03:41	c. 500	Inner Harbour	Whitehouse Bank	flew out from 0M427 to join birds already in CS2
DN	21/01/2015	FLOOD1	02:27	c. 1000	Whitehouse Bank	Inner Harbour	very flighty and eventually a large portion flew in over the Cunnigar
DN	21/01/2015	FLOOD2	02:28		Whitehouse Bank	Inner Harbour	some birds flew into 0M427 from CS1
DN	21/01/2015	FLOOD2	02:57	51	Whitehouse Bank	Inner Harbour	flew to 0M427 from CS2
Bar-tailed Godwit	27/10/2014	FLOOD3	03:13	40	Inner Harbour	Whitehouse Bank	flocks of 10 and 30 flew across the middle of the Cunnigar, and up to the northern end of CS3 where they joined the main flock
BA	24/11/2014	FLOOD3	02:54	120	Ballyrandle	Whitehouse Bank	increase in numbers probably due to arrival of birds from Ballyrandle
BA	24/11/2014	FLOOD3	02:57	20	Ballyrandle	Whitehouse Bank	
BA	24/11/2014	FLOOD3	03:15	158	Ballyrandle	Whitehouse Bank	mostly probably arrived from Ballyrandle
BA	21/01/2015	FLOOD1	02:27	c. 500	Whitehouse Bank	Inner Harbour	very flighty mixed flock in OY2 and eventually a large portion moved to the Inner Harbour
BA	21/01/2015	FLOOD2	02:28		Whitehouse Bank	Ballyrandle	flew north from CS1 to either CS3 or Ballyrandle
BA	19/02/2015	FLOOD4	03:32	83	Whitehouse Bank	Ballyrandle	

Time refers to the time before low tide.

Table C.1 - Ebb and flood tide movements of the additional monitored species

Species	Date	Period	Time	Number	Moved from	Moved to	Notes
Ebb tide							
Ringed Plover	27/10/2014	EBB2	02:58	40	Whitehouse Bank	Inner Harbour	roosting flock in CS3 moving to 0M427, flying across the Cunnigar in small groups
		EBB3/4	02:32	4	Whitehouse Bank	Inner Harbour	
	12/11/2014	EBB2	02:54	c. 100	Inner Harbour	Whitehouse Bank	moving across Cunnigar in small groups to join flock of 37 already present in CS3
	21/01/2015	EBB2	02:54	5	Whitehouse Bank	Inner Harbour	
	19/02/2015	EBB4	01:48	12	Whitehouse Bank	Inner Harbour	
Golden Plover	12/11/2014	EBB2	02:49	c. 3600	Whitehouse Bank	Inner Harbour	
Sanderling	23/10/2014	EBB2	03:06	58	Whitehouse Bank	Inner Harbour	
Flood tide							
Ringed Plover	23/10/2014	FLOOD3	02:57	61	Inner Harbour	Whitehouse Bank	moving across the Cunnigar in small groups to CS3; nearly all birds went to roost immediately after they arrived
		FLOOD3	03:08	44	Inner Harbour	Whitehouse Bank	
Sanderling	24/11/2014	FLOOD1	01:57	c. 50	Whitehouse Bank	Ballyrandle	flew NW across CS3, probably to Ballyrandle

Time refers to the time before low tide.

Appendix D
Individual-based models

D.1 Rationale

D.1.1 In simple terms, the ecological consequences of displacement on species populations will depend upon whether mortality rates are density-dependent, or likely to become density-dependent when the overall density increases as a result of the displacement impact. As mortality rates for non-breeding waterbirds are generally related to food resources, the issue is to what extent will the displaced birds be able to find alternative food resources that will allow them to survive in good condition? In simplistic terms, this will depend upon the availability of "spare" food resources: i.e., food resources that birds can access without having to compete for the resources with other birds.

D.1.2 The most appropriate method of assessing whether displacement impacts are likely to have population-level consequences (such as reduced survivorship, or increased emigration) would be to develop an individual-based model.

D.1.3 IBMs are models that follow each individual of a population across the course of a specified time period (usually the non-breeding season for waterbird IBMs) and use fitness-maximising rules to model the behaviour of each individual (e.g., where and how long it feeds, how it responds to disturbance, etc.) on a daily basis (Stillman and Goss-Custard, 2010). Population-level parameters, such as survival rates, can be predicted from the fate of all the modelled individuals. The basic site-specific parameters required to specify the model are the distribution and abundance of birds and prey resources at the beginning of the modelled period, while other parameters relating to bird energetics and foraging efficiency can usually be derived from literature sources. The model can be validated by comparing predictions with observations (e.g., bird distribution across the site, or bird diet, and how these change across the duration or the model). Once a basic model has been developed, the effects of specified scenarios of environmental impact can be examined. For example, for models examining disturbance impacts, the effects of varying the intensity and pattern of activity can be compared with baseline no disturbance scenarios. Usually any decrease in survival rates is taken as being a significant impact, as even small decreases in survival rates can have large cumulative impacts if continued over a period of years.

D.1.4 IBMs have been developed for a number of estuarine sites in Britain and Europe, and the results of most of these have been published in peer-reviewed scientific journals. The IBMs have generally been judged to be successful, as measured by the validation of the model outputs, while, in some cases at least, sensitivity analyses have shown that the models are robust to variations in the assumptions that need to be made. Recently, however, an IBM developed for to investigate the impact of recreational pressure on various wader species in the Solent (Chichester Harbour and Southampton Water) (Stillman *et al.*, 2012) has received some criticism (ABP Marine Environmental Research Ltd., 2012). This was a particularly challenging IBM to develop, due both to the complexity of the site, which caused difficulties in accounting for bird movements within the site, and the nature of the impacts being investigated, which are difficult to accurately characterise and parameterise.

D.2 Data requirements for an IBM

D.2.1 In an IBM, the site is divided into a number of patches that represent discrete areas with different prey availability. The IBM uses optimal foraging theory to model the distribution of each individual bird through each low tide period across the duration of the winter. Birds emigrate or die when the model predicts that they are unable to find enough food to meet their energy requirements.

Parameterising the model

D.2.2 The minimum data requirements for an IBM are:

- Duration of the tidal exposure period for each patch.
- The distribution and density of prey species by size classes between patches at the start of the winter.
- The distribution of birds between the patches at the start of the winter.

D.2.3 Prey depletion during the winter can be modelled by the IBM using the consumption of prey by birds predicted by the model, mortality from external sources (such as shellfisheries) and overwinter background mortality rates from the literature. However, data on the distribution and density of prey species by size classes at the end of the winter will improve the model by allowing site-specific natural mortality rates to be calculated.

Validating the model

D.2.4 Data also needs to be collected to validate the model. This can include:

- The distribution of bird species between patches.
- The amount of time spent feeding.
- The composition of the diet in terms of prey species and/or size classes.
- Mortality rates.

D.3 Developing an IBM at Dungarvan Harbour

D.3.1 An IBM for Grey Plover, Knot, Dunlin and Bar-tailed Godwit at Dungarvan Harbour would probably have to include all of the Inner Harbour and the Outer Sandflats zones. It might be possible to exclude the uppermost sections of the Inner Harbour along the Colligan and Brickey, as these areas do not support significant numbers of the species concerned, but exclusion of these areas would not significantly reduce the sampling effort required.

D.3.2 The main requirement for an IBM is detailed data on the distribution and density of prey species by size classes at the start of the winter. Durell *et al*. (2005) used a 250 x 250 m grid sampling approach, with a single core sample collected at each sampling point, to collect baseline data on wader food resources in the Exe Estuary, and to derive habitat patches for the development of an IBM. The total area of intertidal habitat in Dungarvan Harbour is around 1400 ha, which would require 224 samples at this sampling intensity. However, it may be possible to review existing benthic invertebrate data for Dungarvan Harbour and reduce the sampling intensity required by identifying areas of homogeneous invertebrate communities.

D.3.3 It would be necessary to divide Dungarvan Harbour into a number of patches for the model. The natural divisions of Dungarvan Harbour (the tidal channels and the Cunnigar) would probably provide suitable divisions, while analysis of the invertebrate sampling data could also inform the identification of the patches.

D.3.4 The tidal exposure of the patches can be estimated from general knowledge of the site, and the tideline mapping carried out for the trestle study and for the present study, as published IBMs tend not to be very precise in measuring this parameter. However, the use of the UISCE MarGIS model to inform the parameterisation of this variable could also be explored.

D.3.5 The most practical way of validating the model would be to collect data on bird distribution between patches and the amount of time spent feeding.

D.4 References

ABP Marine Environmental Research Ltd. (2012). *Scientific Peer Review of Outputs of the Solent Disturbance and Mitigation Project*.

Durell, S.E.A. le V. dit, McGrorty, S., West, A.D., Clarke, R.T., Goss-Custard, J.D. & Stillman, R.A. (2005). A strategy for baseline monitoring of estuary Special Protection Areas. *Biological Conservation*, 121, 289–301.

Stillman, R.A. & Goss-Custard, J.D. (2010). Individual-based ecology of coastal birds. *Biological Reviews*, 85, 413–434.

Stillman, R.A., West, A.D., Clarke, R.T., Liley, D. & Barrow, F. (2012). *Solent Disturbance and Mitigation Project Phase II: Predicting the Impact of Human Disturbance on Overwintering Birds in the Solent*. Report to the Solent Forum.

Atkins is one of the world's leading providers of professional, technology based consultancy services. With over 18,000 staff worldwide, Atkins has expanded in recent years from its historical base in traditional engineering into related technological consultancy services. In Ireland, Atkins can deliver the full range of services to clients in both the public and private sector.

Our clients are varied and include governments, local and regional authorities, funding agencies and commercial and industrial enterprises. We help our clients to realise their objectives by developing and delivering practical solutions, adding value to their businesses through the application of our experience, innovative thinking and state-of-the-art technology. Atkins in Ireland is an integral part of WS Atkins plc and has offices in Dublin, Cork and Galway. In addition, it is able to draw on the expertise of other Atkins divisions in the UK to provide appropriate staff on a project by project basis.

Atkins in Ireland provides a wide range of engineering, architectural, technical support and management services in the following key areas:-

- Architecture & Design
- Engineering
- Roads (Highways & Bridges)
- Environment & Landscape
- Transportation & Planning Services
- Rail
- Water
- Cost Management and Quantity Surveying

Atkins
Unit 2B
2200 Cork Airport Business Park
Cork
Telephone +353 21 4290300
Fax +353 21 4290360

Atkins House
150 Airside Business Park
Swords
Co Dublin
Tel: +353 1 810 8000
Fax: +353 1 810 8001

2nd Floor
Technology House
Parkmore Technology Park
Galway
Telephone +353 91 786050
Fax +353 91 779830

www.atkinsireland.ie
email: info.ie@atkinsglobal.com

Further details available on www.emff.marine.ie

Managing Authority EMFF 2014-2020	Specified Public Beneficiary Body
Department of Agriculture Food & the Marine Clogheen, Clonakilty, Co. Cork. P85 TX47 Tel: (+)353 (0)23 885 9500 www.agriculture.gov.ie/emff	Marine Institute Rinville, Oranmore, Co. Galway, H91 R673 Phone: (+)353 (0)91 38 7200 www.marine.ie

This project or operation is part supported by the Irish government and the European Maritime & Fisheries Fund
as part of the EMFF Operational Programme for 2014-2020

Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
Co-funded by the Irish Government and the European Union

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

EUROPEAN UNION
This measure is part-financed by the European Maritime and Fisheries Fund

Foras na Mara
Marine Institute