Annex II

Marine Institute Bird Studies

River Shannon and Fergus Estuaries SPA: Appropriate Assessment of Aquaculture

May 2019

Notice

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Executive Summary

This report presents an Appropriate Assessment of aquaculture within the Shannon Estuary. There are a total of 60 aquaculture sites, covering a total area of 631 ha, included in this assessment. Five of the sites are located outside the River Shannon and River Fergus Estuaries Special Protection Area (SPA) in Carrigaholt and Rinnevella Bays. All the sites within the SPA are located in the lower part of the Shannon Estuary downstream of the Fergus Estuary. There are 52 sites (covering 200 ha) of intertidal oyster cultivation, three sites (97 ha) of bottom oyster cultivation, two sites (130 ha) of bouchet pole mussel cultivation, three sites (313 ha) of bottom mussel cultivation and two sites (29 ha) of mussel longline cultivation[1].

The report assesses the potential impact of the development of these aquaculture sites on the Special Conservation Interests (SCIs) of the River Shannon and River Fergus Estuaries SPA, and on the SCIs of other SPAs where these SCIs may have connectivity with the Shannon Estuary. The potential for cumulative impacts from development of these aquaculture sites in combination with other relevant activities and plans is also assessed. The in-combination activities and plans assessed include: three Fishery Orders, which permit additional aquaculture development in the River Shannon and River Fergus Estuaries SPA; the Strategic Integrated Framework Plan (SIFP) for the Shannon Estuary, which provides the framework for the development of various marine-related industries and activities in and around the River Shannon and River Fergus Estuaries SPA; and a range of water-based recreational and commercial activities.

The SCIs of the River Shannon and River Fergus Estuaries SPA covered by this assessment are: Whooper Swan, Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Pintail, Shoveler, Scaup, Cormorant, Golden Plover, Grey Plover, Lapwing, Ringed Plover, Curlew, Black-tailed Godwit, Bar-tailed Godwit, Knot, Dunlin, Greenshank, Redshank and Black-headed Gul. The SCIs of other SPAs covered by this assessment are: the Fulmar SCI of the Kerry Head SPA, the Kittiwake and Guillemot SCIs of the Loop Head SPA, and the Wigeon, Teal, Mallard, Shoveler and Black-tailed Godwit SCIs of the Ballyallia Lough SPA.

There is a high potential for development of intertidal aquaculture sites in the Ballylongford/Bunaclugga, Poulnasherry/Kilrush and Aughinish/Foynes areas to cause significant displacement impacts to Grey Plover and Bar-tailed Godwit, while significant displacement impacts to Light-bellied Brent Goose and Ringed Plover are also possible. There is potential for further significant cumulative impacts on some of these species from the development of the above sites in combination with oyster trestle cultivation in the Fishery Order that covers part of Poulnasherry Bay, and development of areas of opportunity identified in the SIFP for tidal energy in Tarbert Bay and for aquaculture in Clonderlaw Bay.

There are also a number of potential impacts that cannot be discounted at this stage due to lack of relevant information.

The possibility of significant disturbance impacts to high tide roosts used by Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Pintail, Shoveler, Golden Plover, Grey Plover, Lapwing, Ringed Plover, Curlew, Black-tailed Godwit, Bar-tailed Godwit, Knot and Dunlin from vessel activity associated with the development of sites in the Ballylongford/Bunaclugga and Aughinish/Foynes areas cannot be discounted due to a lack of information about the usage of high tide roost sites in these areas. The potential for cumulative impacts from this vessel activity in combination with other vessel activity in these areas also needs to be considered. Wigeon, Teal, Mallard, Shoveler and Black-tailed Godwit are also SCIs of the Ballyallia Lough SPA and there is potential interchange between these populations and the River Shannon and River Fergus Estuaries populations. Therefore, any significant impacts to these species in the River Shannon and River Fergus Estuaries could potentially also affect the conservation condition of these species in the Ballyallia Lough SPA.

The possibility of intertidal or subtidal aquaculture development affecting nocturnal roost sites used by Whooper Swan cannot be discounted as we have no information on the location of these roost sites.

The potential for intertidal oyster cultivation in Poulnasherry Bay to cause significant impacts to the availability of suitable foraging habitat for Scaup cannot be excluded due to lack of knowledge about the effects of oyster

[1] Note that some of the sites have multiple potential uses, so the summed total numbers and areas of the listed activities is greater than the total number and overall area of the aquaculture sites.

trestles on Scaup foraging behaviour. The potential for cumulative impacts from this activity in combination with oyster trestle cultivation in Fishery Order that covers part of Poulnasherry Bay and/or bottom oyster cultivation in the other Fishery Orders also needs to be considered.

The potential impact of intertidal aquaculture on Black-headed Gull cannot be assessed at this stage, due to lack of data on Black-headed Gull distribution within the River Shannon and River Fergus Estuaries SPA at the time of its likely peak usage of the area.

The potential cumulative impacts of disturbance from wildfowling activity in-combination with aquaculture activity in the River Shannon and River Fergus Estuaries SPA due to the lack of detailed information on the distribution and intensity of wildfowling activity within the SPA.

1. Introduction

1.1 Atkins (Ecology) was commissioned by the Marine Institute to provide ornithological services in relation to the appropriate assessment of aquaculture and shellfisheries on coastal Special Protection Areas (SPAs).

1.2 This report presents an Appropriate Assessment of aquaculture in the Shannon Estuary. The subject of the assessment are areas that have either already been licensed for aquaculture, or for which there are applications for such licenses; these are collectively referred to as aquaculture sites. The information on the licensing status of aquaculture sites used in this report was provided by the Department of Agriculture, Food and the Marine.

1.3 Most of the aquaculture sites are within the River Shannon and River Fergus Estuaries SPA. Five aquaculture sites in Carrigaholt and Rinnevella Bays, which are outside the River Shannon and River Fergus Estuaries SPA, are also included in this assessment. Therefore, the assessment covers all the aquaculture sites in the Shannon Estuary. The River Shannon and River Fergus Estuaries SPA is the primary focus of this assessment. In addition, following a screening exercise, Special Conservation Interests (SCIs) from three other SPAs are included in this assessment. These SPAs are: Ballyallia Lough SPA, Kerry Head SPA and Loop Head SPA. The SPAs covered by this assessment are shown in Figure 1.1.

1.4 This assessment is based on a desktop review of existing information. Where relevant, it identifies information gaps that may affect the reliability of the conclusions of this assessment.

1.5 The data analysis and report writing was done by Tom Gittings. Paul O'Donoghue assisted with project design, document preparation and undertook document review. Data entry was carried out by Owen Twomey.

1.6 This report relies heavily on the research carried out for a previous Marine Institute project: *The effects of intertidal oyster culture on the spatial distribution of waterbirds*. The results of this project have been published as technical report (Gittings and O'Donoghue, 2012) and a scientific paper (Gittings and O'Donoghue, 2016b). The report and paper, and additional unpublished data from this project, are referred to hereafter as the *trestle study*.

1.7 Scientific names and British Trust for Ornithology (BTO) species codes of bird species mentioned in the text are listed in Appendix A.

Structure of this report

1.8 The structure of the report is as follows: -

- Chapter 2 of the report describes the methodology used for the assessment.
- Chapter 3 of the report contains a preliminary screening assessment that reviews the Special Conservation Interests (SCIs) of the River Shannon and River Fergus Estuaries SPA, and the SCIs of other SPAs in the wider vicinity, and screens out SCIs that do not show any significant spatial overlap with the activities being assessed.
- Chapter 4 of the report describes the Conservation Objectives, and their attributes and targets, of the SCIs that were screened in for this assessment.

- Chapter 5 of the report contains a brief summary of waterbird habitats and distribution in the River Shannon and River Fergus Estuaries SPA, and of the status and distribution of the SCI species included in the assessment. This chapter only contains a very brief summary of distribution patterns; detailed analyses of distribution patterns of individual, species are carried out, as appropriate, in the impact assessment chapters later in the document.

- Chapter 6 provides a description of the current and proposed future extent of the aquaculture activities covered by this assessment and the nature of their operations.

- Chapter 7 assesses the likely impact of the intertidal aquaculture activities included in this assessment on the SCIs that were screened in for this assessment.

- Chapter 8 assesses the likely impact of the subtidal aquaculture activities included in this assessment on the SCIs that were screened in for this assessment.

- Chapter 9 contains an assessment of cumulative impacts.

- Chapter 10 concludes the report by assessing the impact of aquaculture activities in the Shannon Estuary, and any in-combination impacts (if relevant), on the conservation objectives of the SCIs included in this assessment.

Constraints to this assessment

1.9 This assessment is based on a desktop review of waterbird data and other relevant information combined with a limited number of site visits. The waterbird data available for the River Shannon and River Fergus Estuaries SPA is very limited, and there are also issues with the available intertidal mapping. Therefore, the conclusions derived from the analysis of this data are subject to very significant caveats, which are discussed in the relevant sections of this report.

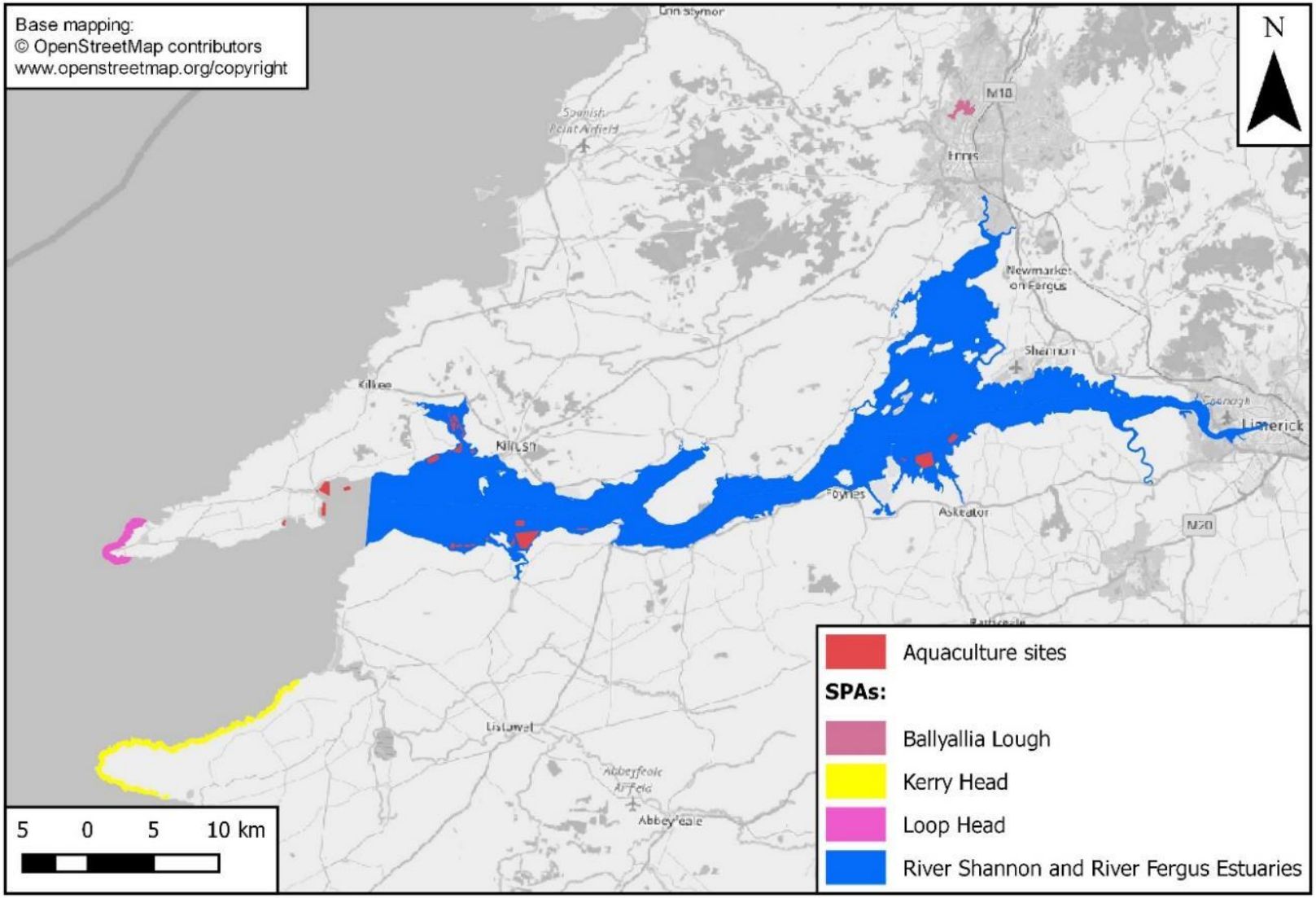

Figure 1.1 SPAs included in this assessment.

2. Methodology

General

2.1 This assessment is based on a desktop review of existing information about waterbird population trends and distribution in the River Shannon and River Fergus Estuaries SPA, supplemented by site visits to assess the habitat characteristics and tidal regimes in the areas around the aquaculture sites.

Data sources

2.2 The SPA boundaries are derived from NPWS shapefiles[2] (which were last updated on 09/11/2015).

2.3 The spatial extents of the aquaculture sites have been derived from shapefiles supplied by the Marine Institute (shapefile dated 14th September 2016).

2.4 Information on the development and current practices of aquaculture activities in the Shannon Estuary was obtained from the aquaculture profile document compiled by Bord Iascaigh Mhara (BIM) in May 2016, supplemented by additional information provided by BIM in response to specific queries, and information from the CLAMS report (CLAMS, 2002).

2.5 The bird data sources used for the assessment are as follows: -

- Bird usage counts carried out in 2000-2002 by NPWS.
- Irish Wetland Bird Survey (I-WeBS) counts, 1994/95-2012/13.
- NPWS Waterbird Survey Programme (WSP) 2010/11 counts.
- The descriptions of waterbird distribution within the River Shannon and River Fergus Estuaries SPA in the SPA Conservation Objectives Supporting Document (NPWS, 2012c), and other reviews of waterbird distribution and waterbird count coverage in the River Shannon and River Fergus Estuaries SPA (Natura, 2012; Lewis *et al*., 2016).
- Data collected during the 2011 trestle study (Gittings and O'Donoghue, 2012, 2016b), including unpublished data not presented in these publications.
- General observations made during site visits by TG in October and November 2010 (for the trestle study) and in February and March 2017.

2.6 Information on the distribution of biotopes in the River Shannon and River Fergus Estuaries SPA is taken from the surveys of intertidal, subtidal and reef habitats by AQUAFACT (2011a, b, c), and the map showing the distribution of benthic communities in NPWS (2012b).

2.7 Data on the timing and height of low tides were obtained from the United Kingdom Hydrographic Offices Admiralty EasyTide website (http://easytide.ukho.gov.uk/).

[2] http://www.npws.ie/maps-and-data/designated-site-data/download-boundary-data (accessed 19th January 2017).

Mapping

Intertidal habitat definitions and mapping

2.8 Ordnance Survey Ireland (OSI) mapping from the early 20th century forms the basis for the mapping of the mudflats and sandflats not covered by seawater at low tide (1140) Annex I habitat by NPWS (see 2012b). Subsequent changes in extent of this habitat will not be reflected in the OSI base mapping, nor in the subsequent NPWS mapping of intertidal habitat. Therefore, the NPWS mapping does not provide an accurate representation of the current distribution of intertidal habitat in the River Shannon and River Fergus Estuaries SPA.

2.9 An additional source of error in the NPWS mapping is that significant areas of *Spartina* beds are included in the area mapped as the *mudflats and sandflats not covered by seawater at low tide (1140)* Annex I habitat (per sobs), and the associated intertidal marine community types, in NPWS (2012b).

2.10 To have obtained accurate mapping of intertidal habitat for this assessment, it would have been necessary to carry out tideline mapping over tens of kilometres of intertidal habitat under a range of tidal conditions. This was beyond the scope of this assessment. Therefore, for the purposes of this assessment we have used the following procedure to draw up intertidal mapping for the entire River Shannon and River Fergus Estuaries SPA: -

- We used the mapping of the extent of intertidal mapping, which appears to be based on Admiralty mapping, and the division into shore types (sediment, mixed and rock) by AQUAFACT (2011a) as the basis for our mapping.
- This mapping defines all areas up to the 0m chart datum as intertidal habitat, which represents the area exposed on extreme spring low tides. The OSI mapping maps the intertidal habitat to the mean low tide (as recorded at the time of the surveys). Therefore, we used the tideline position from the OSI mapping to subdivide the AQUAFACT mapping into mean and spring low tide zones.
- For the aquaculture areas, we also reviewed the upper edge of the intertidal mapping and edited it to match the current shoreline as shown on recent aerial imagery, excluding areas of *Spartina* beds and miscellaneous other intrusions.
- For the GLIN AQUA, we also reviewed the shore type divisions mapped by AQUAFACT and edited it to match the habitat boundaries shown in recent aerial imagery.
- During out site visits, we made notes about any major discrepancies that we observed between the actual extent of intertidal habitat, and the areas mapped above. We used the observations to qualitatively modify assessments made from quantitative analysis of the above mapping.

2.11 The above procedure, provides a broad assessment of the likely distribution of open intertidal habitat in the River Shannon and River Fergus Estuaries SPA, with particular reference to the areas around the aquaculture sites.

2.12 Note that *Spartina* beds, and other saltmarsh habitats, are in the intertidal zone. However, this assessment focuses on open (unvegetated) intertidal habitats: i.e., intertidal habitats defined as littoral rock or littoral sediment habitats in Fossitt (2007). Therefore, in this report references to intertidal habitat refer to open (unvegetated) intertidal habitats.

Subtidal habitat definitions and mapping

2.13 We divided subtidal habitats into three categories to reflect waterbird usage of the habitat: shallow, moderately deep and deep. We defined shallow subtidal habitat as subtidal habitat less than 0.5m deep. This corresponds to the depth range used by most species of geese and dabbling ducks for foraging (Kirby *et al*., 2000; Cramp and Simmons, 2004). We defined moderately deep subtidal habitat as subtidal habitat less than 5m deep. This corresponds to the depth range used by various species of seaduck and grebes, including Scaup (Kirby *et al*., 2000; Cramp and Simmons, 2004). All subtidal habitat more than 5m deep was defined as deep subtidal habitat. Species associated with offshore and pelagic habitats, including Cormorant, can feed in this depth range.

2.14 We used the Admiralty Chart mapping to assess the distribution of these subtidal habitat categories within the River Shannon and River Fergus Estuaries SPA. We defined the shallow subtidal zone as the zone between the intertidal/subtidal boundary and the 0m contour on the Admiralty Chart, which represents the lowest astronomical tides, and we used -5m contour on the Admiralty Chart to define the boundary between the moderately deep and deep subtidal zones. In reality the spatial extent of the shallow subtidal zone will vary on each low tide, but the overall distribution of the zone between subsites is likely to remain similar. Varying amounts of the shallow subtidal zone will be exposed on spring low tides. Therefore, the shallow subtidal zone was also treated as being available to birds that feed in the intertidal zone on spring tides.

Aquaculture mapping

2.15 No detailed mapping of the existing extent of aquaculture activity (i.e., the areas of the aquaculture sites that are currently in use) in the River Shannon and River Fergus Estuaries SPA was available for this assessment.

2.16 A sketch map of the extent of trestles in the inner part of Poulnasherry Bay in 2000 was included in the NPWS bird usage data. We carried out some limited GPS mapping, supplemented by sketch mapping, of trestle blocks in the Poulnasherry Bay area, and in Ballylongford and Bunaclugga Bays in 2010, and made sketch mapping of the extent of trestle blocks in these areas on our site visits in 2017.

Site divisions

Waterbodies

2.17 The River Shannon and River Fergus Estuaries SPA is a very large site. The total area of the *mudflats and sandflats not covered by seawater at low tide (1140)* Annex I habitat mapped by NPWS in the SPA is over 8500 ha. This compares to areas ranging from around 5000 ha (Wexford Harbour and Slobs SPA) to 2300 ha (Lough Swilly) and 4300 ha (Castlemaine), in other coastal SPAs subject to similar assessments. The mapping of transitional and coastal waterbodies for the Water Framework Directive (WFD) divides the River Shannon and River Fergus Estuaries SPA into four main divisions, and all the aquaculture sites are in the Lower Shannon Estuary transitional waterbody, or the Mouth of the Shannon coastal waterbody. The total area of intertidal habitat within the Lower Shannon Estuary WFD site and the section of the Mouth of the Shannon coastal waterbody within the SPA is around 2500 ha, which is more comparable to the scale of the above previous assessments. Therefore, for analysing broad patterns of waterbird distribution, the River Shannon and River Fergus Estuaries SPA was divided into three waterbodies based on the WFD mapping: the Lower Shannon, the Upper Shannon and the Fergus Estuary (Figure 2.1). Furthermore, the assessment of potential displacement impacts consider the significance of the potential displacement in the context of the distribution of the species within the Lower Shannon waterbody, as well as in the context of the overall River Shannon and River Fergus Estuaries SPA.

Aquaculture sites

2.18 The aquaculture sites within the River Shannon and River Fergus Estuaries SPA can be divided into three distinct clusters: Poulnasherry Bay and surrounding area, Ballylongford and Bunaclugga Bays and the Aughinish area. Each of these clusters occurs in discrete areas of intertidal habitat separated from each other, and from other similar areas, by open water and/or long sections of shoreline with negligible amounts of intertidal habitat. For each of these clusters, the distribution of intertidal habitat, and the boundaries of waterbird count subsites have been used to define an *aquaculture area* (AQUA): the *Ballylongford/Bunaclugga AQUA*, the *Poulnasherry/Kilrush AQUA*, and the *Aughinish/Foynes AQUA*.

2.19 There are two additional outlying aquaculture sites within the River Shannon and River Fergus Estuaries SPA: one near Glin on the southern shore, and one near Killimer on the northern shore. The *Glin AQUA* has been defined using two waterbird count subsites around the site. The area around the Killimer site is referred to as the *Killimer AQUA*, but, as there is no discrete waterbird count data for this area, the extent of this AQUA has not been mapped.

2.20 The aquaculture sites outside the River Shannon and River Fergus Estuaries SPA that are included in this assessment are clustered in Carrigaholt Bay and the nearby Rinnevella Bay. These sites and the surrounding waters are collectively referred to as the *Carrigaholt AQUA*.

2.21 The above AQUAs form the main focus of detailed analysis of habitat and waterbird distribution patterns in this assessment. These AQUAs are shown in Figure 2.2.

2.22 Some of the discussions and analyses of waterbird distribution and impact assessments in the Poulnasherry/Kilrush AQUA make reference to Poulnasherry Bay. The area referred to as Poulnasherry Bay in this report is the estuarine bay that is enclosed by Cammoge Point, and is approximately defined by WSP subsite 0H519 and 520 (see Figure 7.2).

Waterbird count subsites

2.23 The River Shannon and River Fergus Estuaries SPA was divided into 66 subsites for the 2010/11 WSP survey. However, the analyses of waterbird distribution in this assessment focus on the subsites within the AQUAs (Table 2.1).

Table 2.1 - WSP subsites included in aquaculture areas (AQUAs).

AQUA	WSP subsites included
Ballylongford/Bunaclugga AQUA	0K507, 508 and 509
Poulnasherry/Kilrush AQUA	0H 507, 517, 518, 519 and 520
Glin AQUA	0I442 and443
Aughinish/Foynes AQUA	0I432, 436, 437, 438, 439, 449, 458 and 491

2.24 A large number of subsites have been used over the years for I-WeBS counts in the River Shannon and River Fergus Estuaries SPA. There have been different subsites used for aerial and ground-based surveys, and different subsites used between seasons for the same survey method. A detailed review of subsite coverage of the River Shannon and River Fergus Estuaries SPA has been carried out by Lewis *et al*. (2016). In this assessment, we only make limited use of I-WeBS data (for reasons discussed below) and we define the relevant I-WebS subsites as and when they are mentioned in the text.

Wintering waterbird datasets

I-WeBS

2.25 Waterbird populations and distribution in the River Shannon and River Fergus Estuaries SPA has been monitored as part of the Irish Wetland Bird Survey (I-WeBS) each winter since 1994/95.

2.26 The I-WeBS scheme aims to carry out monthly counts each winter between September and March in all sites that are important for non-breeding waterbird populations. However, this level of coverage is not always possible to achieve in a volunteer-based scheme, and the River Shannon and River Fergus Estuaries SPA is a particularly difficult site to cover due to its size and access issues in some of the major areas. Aerial surveys have been carried out most winters and these provide good coverage of certain species. However, many waterbird species are difficult to count accurately in aerial surveys. Also, the subsites used for the aerial surveys are generally very large, so they do not provide a high resolution of data on spatial distribution. Variable levels of counts have also been carried out from ground-based surveys.

2.27 I-WeBS data for the River Shannon and River Fergus Estuaries SPA is difficult to interpret due to variable coverage between winters, difference in the subsites used between winters, and issues with comparing aerial and ground-based survey data. Also, GIS mapping of the I-WeBS subsites was not available, although some of the subsites are shown in Lewis *et al*. (2016). Therefore, for this assessment we have only made limited use of the I-WeBS data.

Waterbird Survey Programme

2.28 Details of the Waterbird Survey Programme (WSP) methodology and results in the River Shannon and River Fergus Estuaries SPA are described in Cummins and Crowe (2011), NPWS (2012c) and Lewis and Tierney (2014).

Counts

2.29 Four low tide and one high tide counts were carried out. The counts were carried out by a coordinated team of eight professional counters. Each count was completed over two days (Cummins and Crowe, 2011). The low tide counts were carried out on 20-21st October 2010, 22nd and 24th November 2010, and 6th-7th January 2011 and 18th-19th February 2011. The high tide count was carried out on 26th-27th January 2011.

2.30 The WSP counted feeding and roosting birds separately. However, we have not analysed their distribution separately. In general, birds at low tide usually roost in the same area as they feed and often the roosting birds are mainly just roosting for short periods of time before resuming feeding. Therefore, the division between feeding and roosting may be a matter of chance depending upon the exact timing of the count.

Flock maps

2.31 As part of the WSP the approximate position of the main flocks encountered were mapped. These flock map data have been used to supplement the analyses of species distribution from the WSP counts. In particular, the flock map data is useful in indicating relationships between species distributions and broad topographical/habitat zones, such as biotopes, edges of tidal channels, upper shore areas, etc.

2.32 There are some limitations to the interpretation of flock map data because of the difficulties of accurately mapping positions of distant flocks from shoreline vantage points and also the different observers may have varied in the extent to which they mapped flocks.

High tide roost survey

2.33 As part of the WSP, a high tide roost survey was carried out on 24th and 25th February 2011. This survey counted each high tide roost and mapped its position.

Trestle study

2.34 Poulnasherry Bay was included in a study carried out of the relationship between oyster trestle cultivation and waterbird distribution (Gittings and O'Donoghue, 2012, 2016b). This work included an extensive study across six sites, and one of these sites was Poulnasherry Bay.

2.35 At Poulnasherry Bay, a study area was defined that included the main block of trestles then present (which was located along the lower intertidal to the south of Black Island), and five control areas comprising trestle-free intertidal habitat. The control areas were selected to represent similar intertidal habitat to those occupied by trestles. Because of the extensive area of algal cover in the upper part of the Poulnasherry Bay, and the intermingled presence of areas of mixed sediment shore habitat, there were only limited areas of suitable control habitat.

2.36 Four counts were carried out in January and February 2011. Each count was carried out on low tides of 0.5-0.7 m (Kilrush), during the period when the intertidal habitat within the study area was fully exposed. On each count the numbers of all waterbird species were counted in each sector and their location (within or outside trestle blocks), position (tideline or intertidal) and activity (feeding or roosting/other) were recorded. The position of the tideline was also mapped in each sector.

NPWS bird usage counts

2.37 NPWS carried out a series of 21 low tide waterbird counts of Poulnasherry Bay in March-April 2000, February-April 2001 and November 2001-April 2002. These counts covered the inner bay, approximately corresponding to the area covered by WSP subsite 0H 519.

2.38 On each count, the positions of all, or most, of the birds counted were mapped (see example of a count map in Figure 2.3). The count area was also divided into eleven sectors, although sector count data was not included for all the count dates in the material that we received.

Analyses of waterbird distribution

Quantitative analyses

2.39 The quantitative analyses of waterbird distribution in this assessment focus on distribution patterns of feeding, or potentially feeding birds, as the main potential impacts will be to the availability and/or quality of feeding habitat. However, we have included assessment of potential impacts on roosting birds, where relevant.

2.40 We compared the broad waterbird distribution patterns of waterbirds across the River Shannon and River Fergus Estuaries SPA by calculating the mean percentage of each WSP count (including the high tide count) that occurred in each of the waterbodies. This analysis was restricted to birds that were recorded in intertidal and subtidal habitat on the low tide counts, but included birds recorded

in supratidal and terrestrial habitat on the high tide count (as many of the birds that feed in intertidal habitat at low tide may roost in supratidal or terrestrial habitat at high tide).

2.41 To assess the occurrence of waterbird species in each of the AQUAs we calculated the mean percentages of the total SPA count, and of the total Lower Shannon count, that occurred in the AQUA on each WSP count (including the high tide count). Again, the analysis was restricted to birds that were recorded in intertidal and subtidal habitat on the low tide counts, but included birds recorded in supratidal and terrestrial habitat on the high tide count.

2.42 To assess the distribution of waterbird species within the AQUAs we calculated the mean count that occurred in each of the WSP subsites within the AQUA on each WSP low tide count. We used the mean subsite count rather than mean percentages of the total AQUA count because the overall numbers of many species were so low that mean percentages would be biased by the random effects of small count totals. These calculations were restricted to birds that were recorded in intertidal and subtidal habitat.

2.43 In Poulnasherry Bay, we made an additional analysis using the NPWS bird usage counts. This analysis compared the mean, and range of, total numbers recorded between the bird usage count dataset with the WSP dataset. To do this we restricted the analysis of the bird usage count dataset to counts from the same seasonal period as the WSP counts, so we only used the bird usage counts from February 2011 and November 2011-February 2012. We restricted the analysis of the WSP count dataset to birds recorded in intertidal and subtidal habitat in subsite 0H519.

2.44 In the analyses using percentage distributions, we excluded counts with very low overall totals from the analyses.

Flock mapping data

2.45 We used the WSP flock mapping data to supplement our analyses of waterbird distribution patterns. The flock mapping data can be useful in indicating relationships between species distributions and broad topographical/habitat zones, such as biotopes, edges of tidal channels, upper shore areas, etc. However, there are some limitations to the interpretation of flock map data because of the difficulties of accurately mapping positions of distant flocks from shoreline vantage points and also the different observers may have varied in the extent to which they mapped flocks. Therefore, in reviewing flock mapping data we compared it with the subsite counts and if there were significant discrepancies (e.g., lack of flocks mapped in the subsite that held the largest numbers), we interpreted the data with caution.

2.46 In Poulnasherry Bay we were also able to use the flock mapping data from the NPWS bird usage counts. To do this we mapped the centroid of each flock position mapped on each count. As these counts effectively mapped all of the birds counted, and given the number of counts and the nature of the area counted (which makes mapping of bird positions more reliable than in many of the other areas covered by the WSP), this flock mapping data is likely to provide a fairly reliable picture of low tide waterbird distribution within Poulnasherry Bay during the period covered by the counts.

Trestle study data

2.47 We used the site-specific data for Poulnasherry Bay from the trestle study to analyse patterns of association with oyster trestles. We tested the null hypothesis that bird distribution within our study area at Poulnasherry Bay was not affected by the presence of oyster trestles, so that the observed occurrence of birds within areas of oyster trestles was not significantly different from that predicted by the percentage of the available habitat occupied by the oyster trestles. We calculated the numbers that would be expected to occur within the oyster trestle blocks under the null hypothesis

and then used Jacobs' Index (D; Jacobs 1974) to quantify the degree of positive or negative association with trestle blocks. D can vary from -1 (indicating complete avoidance) to +1 (strong preference). Full details of these analyses are provided in Gittings and O'Donoghue (2016b).

Assessment methodology

Screening

2.48 The SCIs of the River Shannon and River Fergus Estuaries SPA, and other nearby SPAs, were reviewed and screened in for detailed assessment if: -

- The SCI was considered likely to have significant spatial overlap with the aquaculture activities in the Shannon Estuary, or the potential for such overlap could not be discounted; and
- The SCI was considered likely to be adversely impacted by the aquaculture activities, or the potential for adverse impacts could not be discounted.

2.49 For SCIs of other SPAs it is difficult to determine the likelihood of spatial overlap as there is generally little information about movements of wintering birds between sites, or about the foraging ranges from breeding colonies.

2.50 For waterbird SCIs of other SPAs designated for their wintering populations, we considered the general ecology of the species and, in particular, their known usage of non-tidal habitats[3] and/or the degree of site faithfulness.

2.51 For SCIs designated for their breeding populations, we used information from the literature to define typical foraging ranges for various species.

2.52 The main source for our information on foraging ranges was the BirdLife Seabird Foraging Database (Thaxter *et al.*, 2012). This provides a range of values for foraging ranges (the mean, the mean maximum and the maximum). The explanatory document for the BirdLife Seabird Foraging Database (Lascelles, 2008) says "*it may be useful to think of areas within the average foraging range as a core zone of activity being exploited by the majority of the birds the majority of the time, and those between the average and the maximum foraging range as a buffer zone, exploited by fewer birds for less of the time*" (although it also acknowledges that this is not always the case). Therefore, we have generally focused on the mean foraging range (rather than the mean maximum or maximum) to give an indication of the core foraging zones.

2.53 It should be noted that the above approach is analogous to the approach recommended by Scottish Natural Heritage for considering connectivity between SPAs and wind farm developments for the purposes of screening (Scottish Natural Heritage, 2013). The Scottish Natural Heritage guidance states that: -

> "*In most cases the core range should be used when determining whether there is connectivity between the proposal and the qualifying interests. Maximum ranges are also provided to indicate that birds will, at times, travel further. In exceptional cases distances up to the maximum foraging range may be considered; for example, whilst osprey core foraging range is 10 km an osprey foraging at a loch well beyond this distance from its SPA may still be connected if there is a lack of other closer foraging sites.*"

[3] Waterbird SCIs that make significant use of non-tidal habitats are more likely to move away from the SPA that they are a SCI of, and, therefore, may be more likely to have some interchange with the River Shannon and River Fergus Estuaries SPA.

2.54 We are not aware of any other explicit guidance relating to this issue. Therefore, we consider that our approach for screening the SCIs designated for their breeding populations is in accordance with recognised best practise for assessing potential connectivity between breeding bird populations and development proposals.

Identification of potential impacts

2.55 The potential impacts of the activities covered in this assessment were assessed under three broad categories: ecosystem effects, habitat impacts and disturbance impacts.

Ecosystem effects

2.56 Large-scale bivalve aquaculture could, theoretically, have impacts on ecosystem functioning and reduce the abundance of food resources for waterbird species. This could occur as a result of reduced recruitment (due to direct consumption of eggs and larvae by the cultured bivalves), and/or through indirect food web effects (e.g., consumption of organic matter by the cultured bivalves that would have otherwise been available to support other species). We describe these potential impacts as ecosystem effects as they are not spatially restricted to the areas in the vicinity of the aquaculture sites, but could affect the whole ecosystem.

2.57 Detailed consideration of ecosystem effects and / or ecosystem modelling in order to provide a robust assessment of potential impacts is beyond the scope of this assessment. However, the scale of the aquaculture activities covered by this assessment, relative to the overall size of the River Shannon and River Fergus Estuaries SPA ecosystem indicates that ecosystem effects from these activities are unlikely to be an issue at the SPA scale in the River Shannon and River Fergus Estuaries SPA. Therefore, we have not analysed potential ecosystem impacts in this assessment.

Habitat and disturbance impacts

2.58 Potential negative impacts to SCI species have been identified where the activity may cause negative impacts to prey resources and/or cause disturbance impacts, where there is evidence of a negative response to the activity by the species from previous work, and/or where a negative response is considered possible by analogy to activities that have similar types of impacts on habitat structure and/or by analogy to ecologically similar species.

2.59 For each of the aquaculture activities included in this assessment, we reviewed the scientific literature to assess the potential impact of the activity of intertidal and subtidal habitat structure and function and how this might affect the availability of food resources for the SCI species covered by this assessment.

2.60 For two of the aquaculture activities included in this assessment we were able to use the results of detailed research to directly assess the potential impacts on waterbirds: the trestle study (Gittings and O'Donoghue, 2012, 2016b) for the assessment of oyster trestle cultivation; and work by Roycroft *et al*. (2004, 2007) in Bantry Bay (the Bantry Bay study) for the assessment of suspended mussel cultivation. The trestle study was carried out during periods with typical levels of husbandry activity, and the Bantry Bay study was also carried out using operational farms where it can be assumed that typical levels of husbandry activity were taking place. Therefore, the effects of disturbance due to husbandry activity associated with these assessments are included in the categorisation of species responses by these studies.

2.61 The trestle study focused on species associated with the intertidal and/or shallow subtidal habitats and did not assess potential impacts to fish-eating species that may use the trestle areas at high tide, while detailed scientific information on the potential impacts to waterbirds of the other aquaculture activities included in this assessment (bottom mussel culture and bouchet mussel

culture) is not available. For these potential impacts/activities, we used the literature review of the potential impact on food resources, as well as information from studies of analogous types of physical impacts, to assess the potential impacts of habitat alteration, and we used information on the timing and frequency of husbandry activity, and the sensitivity of the species concerned, to assess the potential impact of disturbance.

2.62 We also assessed the potential impact of disturbance from travel to/from the aquaculture sites by reviewing the access routes in relation to potentially sensitive areas, and taking into account the timing and frequency of the usage of these routes.

Assessment of impact magnitude

Displacement impacts

2.63 Where potential impacts from an aquaculture activity on a SCI species have been identified, or cannot be ruled out, the spatial overlap between the distribution of the species and the spatial extent of the activity was assessed. This overlap is considered to represent the potential magnitude of the impact, as it represents the maximum potential displacement if the species has a negative response to aquaculture activity.

2.64 In previous assessments (e.g., Gittings and O'Donoghue, 2014) we have used detailed quantitative analyses to assess potential displacement impacts. However, in the present assessment we considered that the quality of the available data was not sufficient to support quantitative analysis. This was due to the poor quality of the marine community types mapping supplied by NPWS, the very limited amount of data on waterbird distribution within the River Shannon and River Fergus Estuaries SPA, and the limitations of the scope of the work for this assessment which precluded detailed site surveys. Therefore, for this assessment, we have qualitatively assessed the potential displacement impacts using the scale defined in Table 2.2.

2.65 We assessed potential displacement impacts separately in each AQUA.

Table 2.2 - Impact magnitude scale used to assess displacement impacts.

Magnitude level	Criteria
Negligible	Subsite(s) containing the aquaculture site(s) appears to hold very low numbers and/or appears to be irregularly used Subsite(s) containing the aquaculture site(s) appears to hold low or moderate number numbers, but habitat characteristics or other factors suggest that the birds do not make significant use of the sections of the subsite(s) around the aquaculture site(s)
Minor	Subsite(s) containing the aquaculture site(s) appears to hold low numbers Subsite(s) containing the aquaculture site appears to hold moderate number numbers, but habitat characteristics or other factors suggest that the birds show preferences for sections of the subsite(s) away from the aquaculture site(s)
Moderate	Subsite(s) containing the aquaculture site(s) appears to hold moderate numbers Subsite(s) containing the aquaculture site(s) appears to hold large numbers, but habitat characteristics or other factors suggest that the birds show preferences for sections of the subsite(s) away from the aquaculture site(s)
Substantial	Subsite(s) containing the aquaculture site(s) appears to hold moderate numbers, but habitat characteristics or other factors suggest that the birds are likely to be concentrated in sections of the subsite(s) around the aquaculture site(s) Subsite(s) containing the aquaculture site(s) appears to hold large numbers, and habitat characteristics or other factors suggest that the birds will make significant use of the aquaculture site(s)

Impacts on population trends

2.66 There has been aquaculture activity in the River Shannon and River Fergus Estuaries SPA since at least the 1970s (CLAMS, 2002). Therefore, in theory, analysis of the waterbird population trends in relation to the development of the aquaculture activity could reveal evidence about the nature of any impacts from aquaculture on the waterbird populations. However, the information on the timing of the development of aquaculture activity in the River Shannon and River Fergus Estuaries SPA is very limited, while the issues with I-WeBS coverage affect the reliability of the data on waterbird population trends in the River Shannon and River Fergus Estuaries SPA[4]. Therefore, we do not consider that it would be appropriate to attempt to assess the potential impact of past aquaculture development on waterbird population trends in the River Shannon and River Fergus Estuaries SPA.

Assessment of significance

2.67 The significance of any potential impacts identified has been assessed with reference to the attributes and targets specified by NPWS (2012b, 2016a, b and c). Potential negative impacts are either assessed as significant (if the assessment indicates that they will have a detectable effect on the attributes and targets) or not significant. The significance levels of potential positive impacts have not been assessed.

[4] For all species, except Whooper Swan and Wigeon, where population trends were assessed by NPWS (2012c), a moderate or high level of caution was assigned to the assessed trend, and site conservation condition was only categorised for Whooper Swan and Wigeon.

River Shannon and River Fergus Estuaries SPA wintering waterbird SCIs

Attribute 2 – Distribution

2.68 For these SCIs, we have focused on attribute 2 (distribution) of the conservation objectives.

2.69 Assessing significance with reference to attribute 2 is difficult because the level of decrease in the range, timing or intensity of use of areas that is considered significant has not been specified by NPWS. There are two obvious ways of specifying this threshold: (i) the value above which other studies have shown that habitat loss causes decreases in estuarine waterbird populations; and (ii) the value above which a decrease in the total River Shannon and River Fergus Estuaries population would be detectable against background levels of annual variation.

2.70 There have been some studies that have used individual-based models (IBMs; see Stillman and Goss-Custard, 2010) to model the effect of projected intertidal habitat loss on estuarine waterbird populations. West *et al*. (2007) modelled the effect of percentage of feeding habitat of average quality that could be lost before survivorship was affected. The threshold for the most sensitive species (Black-tailed Godwit) was 40%. Durell *et al*. (2005) found that loss of 20% of mudflat area had significant effects on Oystercatcher and Dunlin mortality and body condition, but did not affect Curlew. Stillman *et al*. (2005) found that, at mean rates of prey density recorded in the study, loss of up to 50% of the total estuary area had no influence on survival rates of any species apart from Curlew. However, under a worst-case scenario (the minimum of the 99% confidence interval of prey density), habitat loss of 2-8% of the total estuary area reduced survival rates of Grey Plover, Black-tailed Godwit, Bar-tailed Godwit, Redshank and Curlew, but not of Oystercatcher, Ringed Plover, Dunlin and Knot. Therefore, the available literature indicates that generally quite high amounts of habitat loss are required to have significant impacts on estuarine waterbird populations, and that very low levels of displacement are unlikely to cause significant impacts. However, it would be difficult to specify a threshold value from the literature as these are likely to be site specific.

2.71 If a given level of displacement is assumed to cause the same level of population decrease (i.e., all the displaced birds die or leave the site), then displacement will have a negative impact on the conservation condition of the species. However, background levels of annual variation in recorded waterbird numbers are generally high, due to both annual variation in absolute population size and the inherent error rate in counting waterbirds in a large and complex site. Therefore, low levels of population decrease will not be detectable (even with a much higher monitoring intensity than is currently carried out). For example, a 1% decrease in the baseline population of Turnstone would be a decrease of two birds. The minimum error level in large-scale waterbird monitoring is considered to be around 5% (Hale, 1974; Prater, 1979; Rappoldt, 1985). Therefore, any population decrease of less than 5% is unlikely to be detectable, so 5% can be taken to be the threshold value below which displacement effects are not considered to be significant. This is a conservative threshold, as error levels combined with natural variation are likely to, in many cases; prevent detectability of higher levels of change. This threshold is also likely to be very conservative in relation to levels that would cause reduced survivorship (see above).

2.72 In this assessment, we have not calculated quantitative displacement levels (for the reasons discussed above; see paragraph 2.64). Instead we have taken a substantial displacement impact in one AQUA, or a combination of moderate displacement impacts across more than one AQUA, as being equivalent to exceeding the threshold of a 5% displacement level.

Attribute 1 - Population trends

2.73 Impacts on this attribute are only likely to occur if there are high levels of displacement impacts. However, there is a high level of uncertainty about the magnitude of the displacement impacts that

are likely to occur. Therefore, we do not consider that it would be appropriate to attempt to assess the impact on this attribute given the current level of available data.

River Shannon and River Fergus Estuaries SPA breeding Cormorant SCI

2.74 We used the relevant attributes and targets to qualitatively assess the significance of potential impacts to the breeding Cormorant SCI of the River Shannon and River Fergus Estuaries SPA.

Ballyallia Lough SPA SCIs

2.75 NPWS have only published generic conservation objectives for this SPAs. However, as the SCIs screened in from this SPA are wintering waterbird populations, we have assumed that the same attributes and targets apply as for the River Shannon and River Fergus Estuaries SPA wintering waterbird SCIs.

Kerry Head and Loop Head SPA SCIs

2.76 Three SCIs were screened in from these SPAs: the Fulmar breeding population in the Kerry Head SPA and the Kittiwake and Guillemot breeding population in the Loop Head SPA.

2.77 NPWS have only published generic conservation objectives for these SPAs. However, for the Fulmar, purposes of our assessment, we have assumed that the attributes and targets specified for the Kittiwake and Guillemot breeding populations in the Saltee Islands SPA (NPWS, 2011a) also apply to these SCIs.

2.78 We used these attributes and targets to qualitatively assess the significance of potential impacts to these three SCIs.

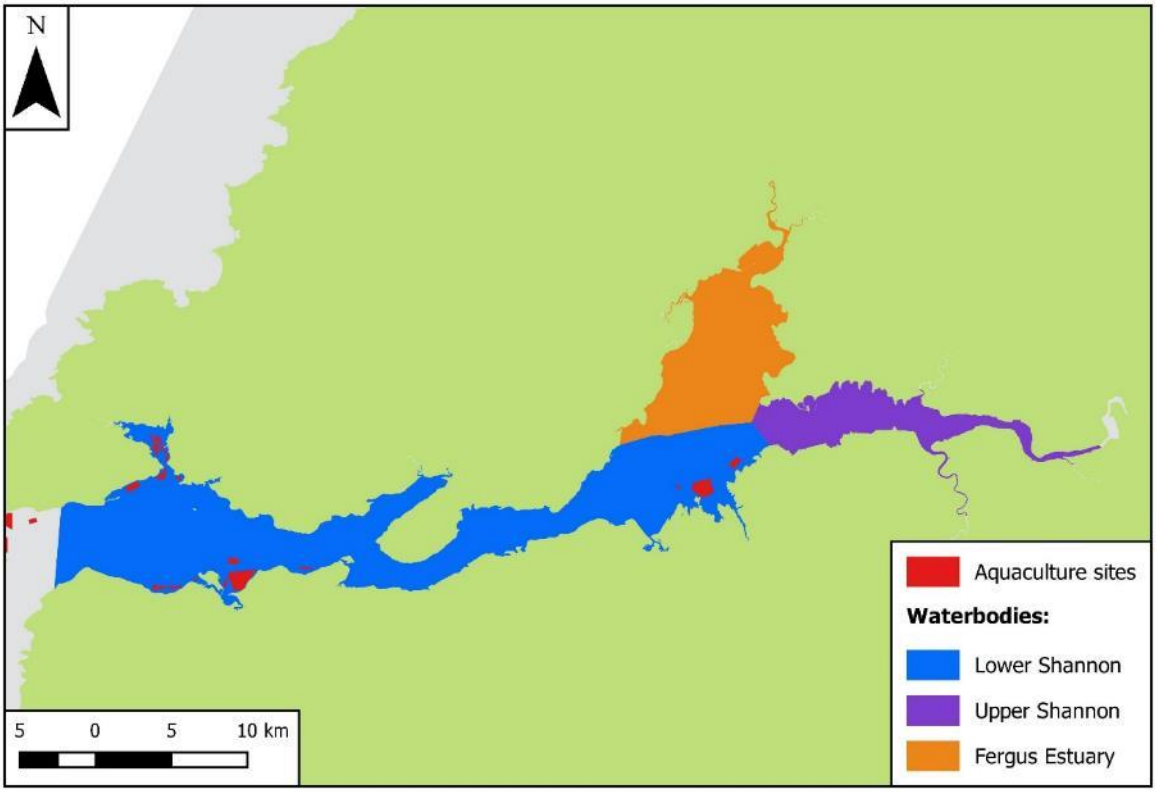

Figure 2.1 Waterbodies used for broad divisions of the River Shannon and River Fergus Estuaries SPA.

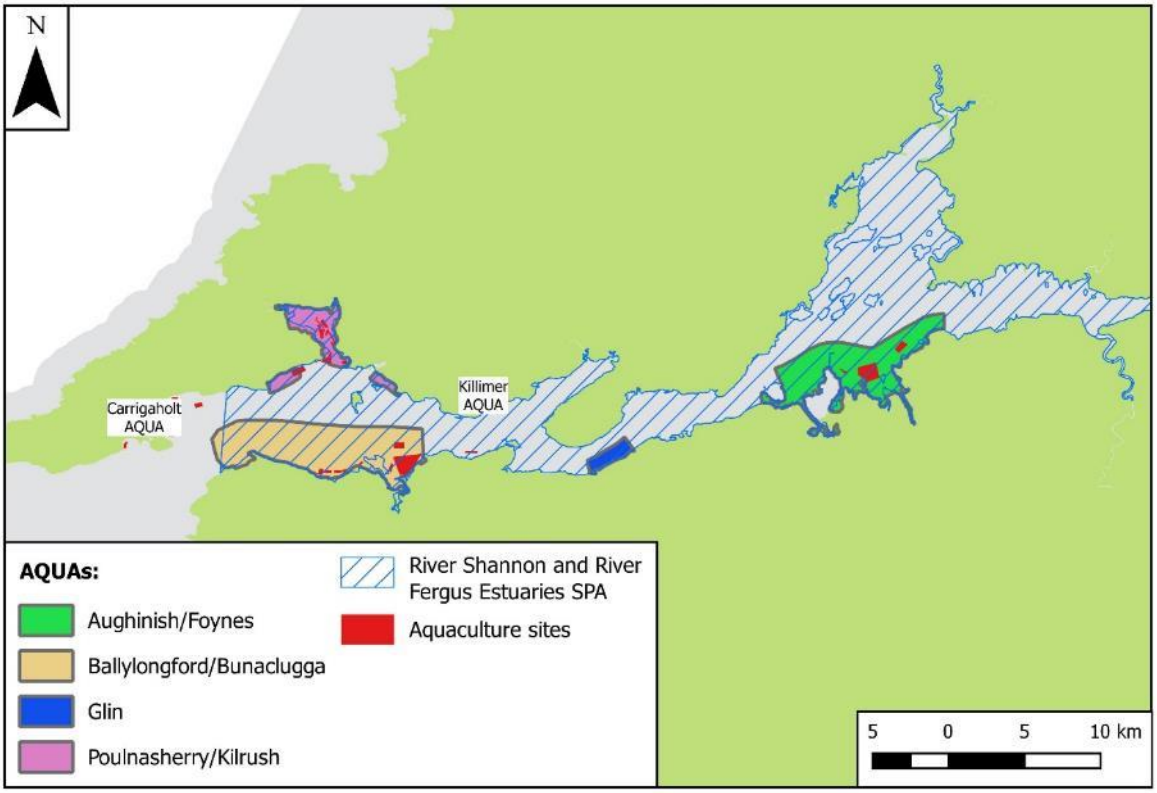

Figure 2.2 Aquaculture Areas (AQUAs) used for detailed assessments.

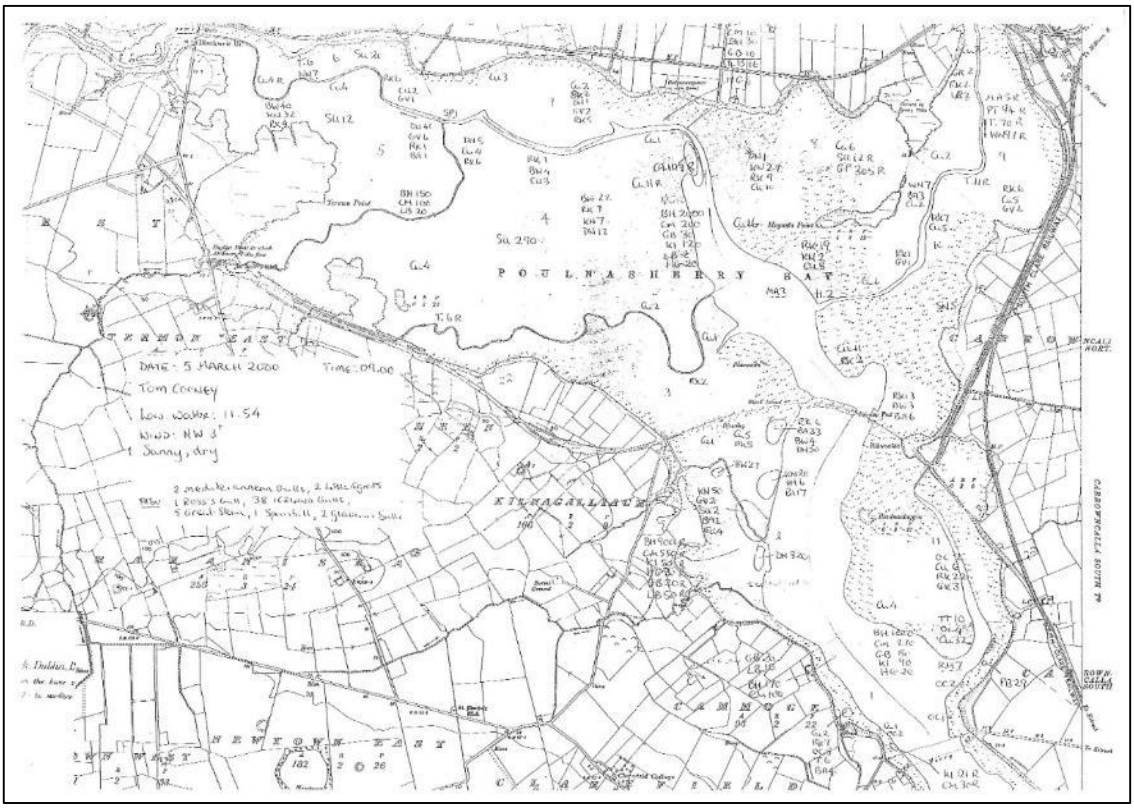

Figure 2.3 Example of a count map from the NPWS bird usage counts.

3. Screening

Introduction

3.1 In addition to the River Shannon and Fergus Estuaries SPA, there are five other SPAs within 15 km of the aquaculture sites in the Shannon Estuary: the Illaunonearaun SPA, the Kerry Head SPA, the Loop Head SPA, the Mid-Clare Coast SPA, and the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (Figure 3.1). There is also potential connectivity with the Ballyallia Lough SPA (Figure 3.1).

River Shannon and Fergus Estuaries SPA

Waterbird SCIs

3.2 All of the SCI species (Whooper Swan, Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Pintail, Shoveler, Scaup, Cormorant, Golden Plover, Grey Plover, Lapwing, Ringed Plover, Curlew, Black-tailed Godwit, Bar-tailed Godwit, Knot, Dunlin, Greenshank, Redshank and Black-headed Gull) make significant use of subtidal and/or intertidal habitat in the River Shannon and Fergus Estuaries. The aquaculture activities covered in this assessment will affect 631 ha of intertidal and subtidal habitat and have the potential to cause significant changes to habitat structure and/or food availability. Therefore, the activities being assessed could potentially have significant impacts on SCIs that use subtidal and/or intertidal habitat.

Wetlands and waterbirds

3.3 The Conservation Objectives define the favourable conservation condition of the wetlands and waterbird SCI in the River Shannon and Fergus Estuaries SPA purely in terms of habitat area.

3.4 None of the activities being assessed will cause any change in the permanent area occupied by wetland habitat. Therefore, the activities being assessed are not likely to have any significant impact on this SCI and it has been screened out from any further assessment.

Illaunonearaun SPA

3.5 The only SCI of the Illaunonearaun SPA (site code 004114) is Barnacle Goose. This species has not been recorded in any of the available waterbird counts for the River Shannon and Fergus Estuaries. Therefore, the Illaunonearaun SPA can be screened out from further assessment.

Kerry Head SPA

3.6 The SCIs of the Kerry Head SPA (site code 004189) are Fulmar and Chough.

3.7 Fulmar has a mean foraging range of 47.5 km, which would bring the aquaculture sites in the outer part of the Shannon Estuary into the potential range of birds from the Kerry Head colony. Therefore, the Fulmar SCI of the Kerry Head SPA has been screened in for further assessment.

3.8 Chough does not make significant use of intertidal or subtidal habitat. Therefore, this SCI can be screened out from further assessment.

Loop Head SPA

3.9 The SCIs of the Loop Head SPA (site code 004119) are Kittiwake and Guillemot. Kittiwake has a mean foraging range of 24.8 km, and Guillemot has a mean foraging range of 37.8 km. Therefore, the aquaculture sites in the outer part of the Shannon Estuary are within the potential range of birds from the Loop Head colony and these SCIs have been screened in for further assessment.

Mid-Clare Coast SPA

3.10 The Mid-Clare Coast SPA (site code 004182) is 7km from the nearest aquaculture sites in the Shannon Estuary. However, this SPA is on the northern side of the Loop Head peninsula, and the distance for a bird travelling around the coast is around 40km.

3.11 The SCIs of the Mid-Clare Coast SPA are Barnacle Goose, Cormorant, Ringed Plover, Turnstone, Sanderling, Dunlin and Purple Sandpiper.

3.12 Barnacle Goose can be screened out from further assessment as it does not occur in the River Shannon and Fergus Estuaries (see above).

3.13 Ringed Plover, Turnstone, Sanderling, Dunlin and Purple Sandpiper are all species that are classified as having high site fidelity (NPWS, 2014). Therefore, given the distance of the Mid-Clare Coast SPA from the River Shannon and Fergus Estuaries, and the fact that all these species are unlikely to make inland movements, these SCIs can all be screened out from further assessment.

3.14 Cormorant is listed as a SCI of the Mid-Clare Coast SPA for its breeding population. The Cormorant breeding colony in the Mid-Clare Coast SPA occurs on Mattle Island. This is around 14.5km from the aquaculture sites in Poulnasherry Bay, which are the nearest aquaculture sites in the Shannon Estuary, and around 45km for a bird travelling around the coast from the aquaculture sites in Carrigaholt Bay, which are the nearest aquaculture sites in the Shannon Estuary for a bird travelling around the coast. The mean foraging range of Cormorant from breeding colonies is 8.5km, and the mean maximum is 25km. Cormorant do regularly travel overland. However, even for birds travelling overland the aquaculture sites in the Shannon Estuary are outside the likely core foraging range for birds from the Mattle Island breeding colony. Therefore, this SCI has been screened out from further assessment.

Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA

3.15 The Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (site code 004161) is 3km from the nearest aquaculture sites in the Shannon Estuary. The only SCI of this SPA is its breeding population of Hen Harrier. This species does not make significant use of intertidal or subtidal habitat. Therefore, this SCI can be screened out from further assessment.

Ballyallia Lough SPA

3.16 Ballyallia Lough SPA (site code 004041) is 24 km from the nearest aquaculture sites in the Shannon Estuary. However it is in the catchment of the River Fergus and is only 6 km from the upper edge of the River Shannon and River Fergus Estuaries SPA. Therefore, there is significant potential for waterbird movements between Ballyallia Lough and the River Shannon and River Fergus Estuaries SPA.

3.17 The SCIs of the Ballyallia Lough SPA are Wigeon, Gadwall, Teal, Mallard, Shoveler, Coot and Black-tailed Godwit. Black-tailed Godwit has high site fidelity (NPWS, 2012c), but given the nature of the species wintering behaviour in Ireland, and the proximity of Ballyallia Lough to the Fergus Estuary, movements between Ballyallia Lough and the Fergus Estuary are likely to occur. Therefore, this SCI has been screened in for further assessment. The other species all have moderate, weak or unknown site fidelity (NPWS, 2011b, 2012c). Gadwall rarely occur in the Shannon and Fergus Estuaries (only eleven records across all I-WeBS counts), while Coot generally do not use intertidal or subtidal habitat. Therefore, these species have been screened out from further assessment. Wigeon, Teal, Mallard and Shoveler regularly occur in the Shannon and Fergus Estuaries and these SCIs have been screened in for further assessment.

3.18 Note that Wigeon, Teal, Shoveler and Black-tailed Godwit are all also SCIs of the River Shannon and River Fergus Estuaries SPA.

Other SPAs

3.19 Other SPAs in the wider vicinity of the Shannon Estuary were also reviewed during this screening exercise. No potential for significant connectivity between SCIs of these SPAs and the aquaculture activities in the Shannon Estuary was identified due to the distance of these SPAs from the aquaculture sites, the presence of physical barriers to movement (e.g. the configuration of the coastline) and/or the ecology of the species concerned.

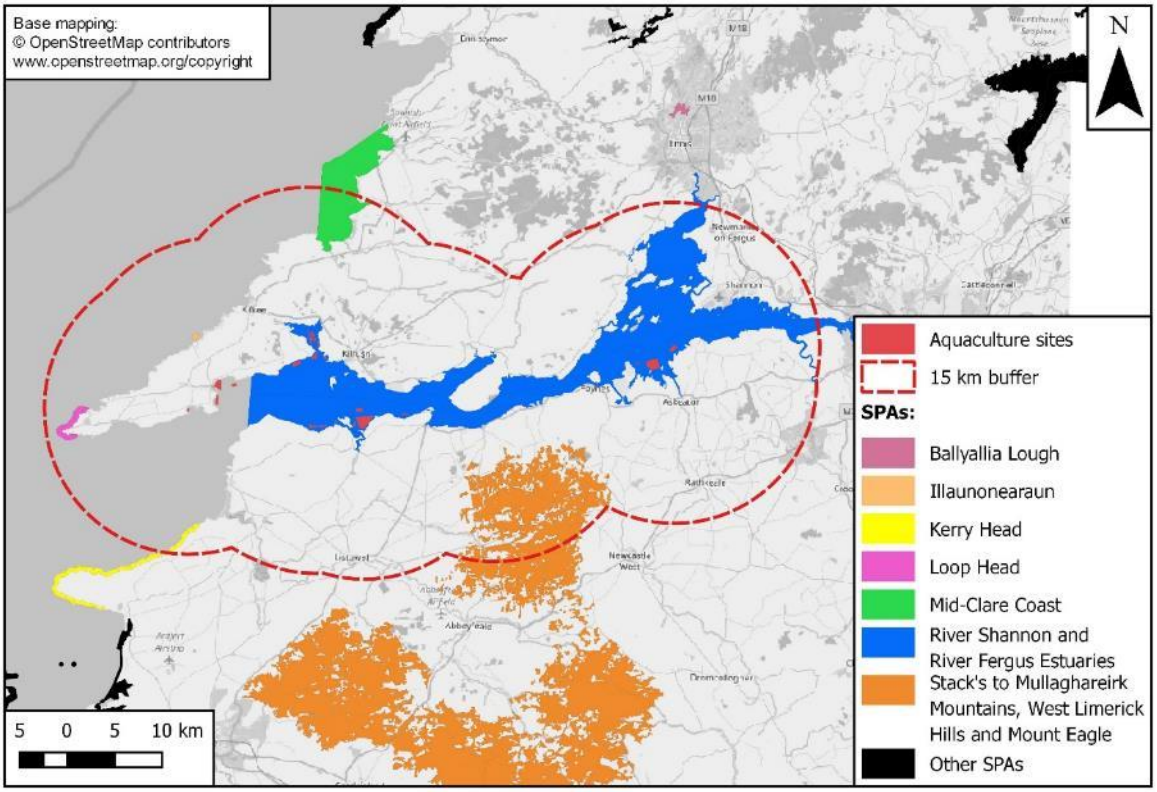

Figure 3.1 SPAs in the wider vicinity of the Shannon Estuary.

4. Conservation objectives

River Shannon and Fergus Estuaries SPA

SCIs listed for their wintering populations

4.1 The conservation objectives for the wintering populations of Whooper Swan, Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Pintail, Shoveler, Scaup, Cormorant, Cormorant, Golden Plover, Grey Plover, Lapwing, Ringed Plover, Curlew, Black-tailed Godwit, Bar-tailed Godwit, Knot, Dunlin, Greenshank, Redshank and Black-headed Gull in the River Shannon and Fergus Estuaries SPA are to maintain their favourable conservation condition (NPWS, 2012b).

4.2 The favourable conservation conditions of these SCIs in the River Shannon and Fergus Estuaries SPA are defined by various attributes and targets, which are shown in Table 4.1.

Table 4.1 - Attributes and targets for the conservation objectives for the wintering populations of Whooper Swan, Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Pintail, Shoveler, Scaup, Cormorant, Cormorant, Golden Plover, Grey Plover, Lapwing, Ringed Plover, Curlew, Black-tailed Godwit, Bar-tailed Godwit, Knot, Dunlin, Greenshank, Redshank and Black-headed Gull in the River Shannon and Fergus Estuaries SPA.

Attribute	Measure	Target	Notes
1 Population trend	Percentage change	Long term population trend stable or increasing	Waterbird population trends are presented in part four of the Conservation Objectives Supporting Document
2 Distribution	Range, timing and intensity of use of areas	There should be no significant decrease in the range, timing and intensity of use of areas used by the … [SCI species] other than that occurring from natural patterns of variation	As determined by regular low tide and other waterbird surveys. Waterbird distribution from the 2010/11 waterbird survey programme is discussed in part five of the conservation objectives supporting document

Source: NPWS (2012b).

Attributes are not numbered in NPWS (2012b), but are numbered here for convenience.

SCI listed for its breeding population

4.3 The conservation objective for the breeding population of Cormorant in the River Shannon and Fergus Estuaries SPA is to maintain its favourable conservation condition (NPWS, 2012b). The favourable conservation condition of this population is defined by the following attributes: breeding population abundance, productivity rate, distribution of breeding colonies, availability of prey biomass, barriers to connectivity, and disturbance at the breeding site.

Kerry Head SPA

4.4 The conservation objective for the breeding population of Fulmar in the Kerry Head SPA is to maintain or restore its favourable conservation condition (NPWS, 2016b). Site-specific conservation objectives have not been published for this SPA.

Loop Head SPA

4.5 The conservation objective for the breeding populations of Kittiwake and Guillemot in the Loop Head SPA is to maintain or restore its favourable conservation condition (NPWS, 2016c). Site-specific conservation objectives have not been published for this SPA.

Ballyallia Lough SPA

4.6 The conservation objective for the populations of Wigeon, Teal, Mallard, Shoveler and Black-tailed Godwit in the Ballyallia Lough SPA are to maintain or restore their favourable conservation condition (NPWS, 2016a). Site-specific conservation objectives have not been published for this SPA.

5. Status and habitats and distribution of the SCI species

Status of the SCI species

River Shannon and Fergus Estuaries

5.1 The population trends and site conservation conditions assessed by NPWS (2012c) for the wintering waterbird SCIs of the River Shannon and River Fergus Estuaries SPA are shown in Table 7.5. Most species for which the trends have been assessed appear to show large declines over the period covered by the assessment (1994/95 to 2008/09). However, high, or moderate, levels of caution apply to these population trends. Site conservation condition categories have only been assigned for two species: Whooper Swan, which is assessed as being in favourable condition, and Wigeon, which is assessed as being in highly unfavourable condition.

Table 5.1 - Population trends and site conservation conditions for the wintering waterbird SCIs of the River Shannon and River Fergus Estuaries SPA.

Species	Population trend	Level of caution applied	Site conservation condition
Whooper Swan	Increase	Low	Favourable
Light-bellied Brent Goose	Decline >50%	Moderate	Undetermined
Shelduck	Decline >50%	Moderate	Undetermined
Wigeon	Decline >50%	Low	Highly unfavourable
Teal	Decline >50%	Moderate	Undetermined
Pintail	-		Undetermined
Shoveler	-		Undetermined
Cormorant	Decline 1.0 – 24.9%	Moderate	Undetermined
Golden Plover	Decline >50%	Moderate	Undetermined
Grey Plover	Decline >50%	Moderate	Undetermined
Lapwing	Decline >50%	Moderate	Undetermined
Ringed Plover	Decline >50%	High	Undetermined
Curlew	Decline >50%	Moderate	Undetermined
Black-tailed Godwit	Decline >50%	High	Undetermined
Bar-tailed Godwit	-		Undetermined
Knot	Decline >50%	Moderate	Undetermined
Dunlin	Decline >50%	High	Undetermined
Greenshank	Decline -25.0% to -49.9%	High	Undetermined
Redshank	Decline >50%	Moderate	Undetermined
Black-headed Gull	Decline -25.0% to -49.9%	Moderate	Undetermined

Source: Table 4.2 in NPWS (2012c).

5.2 The Cormorant breeding population of the River Shannon and River Fergus Estuaries SPA was estimated as 93 occupied nests in 2010 (NPWS, unpublished data). There is no information available on the population trends of this population of the River Shannon and River Fergus Estuaries SPA, and its conservation condition has not been assessed by NPWS.

Other SPAs

5.3 The conservation conditions of the SCIs screened in from other SPAs for this assessment have not been assessed by NPWS.

Waterbird habitats and distribution in the River Shannon and Fergus Estuaries

Waterbird habitats

Intertidal habitats

5.4 A total of around 8,500 ha of intertidal littoral sediment and rock habitat was mapped by NPWS in their marine community types mapping of the River Shannon and River Fergus Estuaries SPA (NPWS, 2012b). Potential sources of error associated within this mapping are discussed in paragraphs 2.8-2.9. Most of the intertidal habitat occurs in the Fergus Estuary and in the upper section of the Shannon Estuary. Downstream of Foynes Island, there is generally only a narrow intertidal zone, with more extensive areas of intertidal habitat being restricted to a few bays and inlets such as Clonderlaw Bay and Poulnasherry Bay on the northern shore and Tarbert Bay and Ballylongford Bay on the southern shore (Figure 5.1).

5.5 The intertidal littoral sediment and rock habitat was classified by NPWS (2012b) into three marine community types: the *fucoid-dominated intertidal reef community complex*, the *intertidal sand to mixed sediment with polychaetes, molluscs and crustaceans community complex* and then *intertidal sand with Scolelepis squamata and Pontocrates spp. community.*

5.6 The *intertidal sand to mixed sediment with polychaetes, molluscs and crustaceans community complex* includes most of the intertidal littoral sediment habitat within the River Shannon and River Fergus Estuaries SPA and covers a wide range of variation in sediment types from soft muddy sediments in the upper parts of the SPA and in the estuaries and bays in the lower parts of the SPA, to firm sandflat type habitat along the exposed shorelines in the lower parts of the SPA, and also includes areas of mixed sediment habitat with gravel and cobbles mixed in muddy and/or sandy sediments.

5.7 The *intertidal sand with Scolelepis squamata and Pontocrates spp. community* only occurs in the outer part of the River Shannon and River Fergus Estuaries SPA along the southern shoreline to the west of Carrig Island. This appears to represent areas with shores of loose, dry sand and the mapped area corresponds to the area mapped as *beach* on the OS Discovery mapping.

5.8 The *fucoid-dominated intertidal reef community complex* appears to represent a range of littoral rock habitats. It occurs extensively along the shoreline of the lower parts of the River Shannon and River Fergus Estuaries SPA, both in narrow bands along steeply shelving sections of shoreline, where it is the only mapped intertidal habitat, and around the upper edges of more extensive intertidal areas in bays and inlets.

5.9 *Zostera noltii* was recorded in Poulnasherry Bay by Falvey *et al*. (1997). However, no *Zostera* beds have been identified in the NPWS marine community types classification of the River Shannon and River Fergus Estuaries SPA. We understand that the site is to be resurveyed by the EPA in 2018.

5.10 More detailed analysis of the intertidal habitats in the AQUAs is included in Chapter 7.

Subtidal habitats

5.11 The majority of subtidal habitat within the River Shannon and River Fergus Estuaries SPA is deep subtidal habitat, with depths ranging from around 5-40 m below chart datum. Moderately deep subtidal habitat (0-5 m below chart datum) only occurs in narrow bands around 50-200 m wide along most of the shoreline of the Lower Shannon waterbody, but with more extensive areas in the Aughinish/Foynes area, Clonderlaw Bay, Poulnasherry Bay and Ballylongford Bay. The distribution of shallow subtidal habitat (areas of water depth less than 0.5 m deep at low tide) reflects the distribution of intertidal habitat.

Habitat use

5.12 The majority of the waterbird species considered in this assessment are typically associated with intertidal habitat and in the WSP low tide counts, most species were mainly recorded in intertidal habitat (Table 5.2). The exceptions were Whooper Swan and Shoveler. The Whooper Swan wintering population in the Shannon Estuary area mainly forage on agricultural fields outside the River Shannon and River Fergus Estuaries SPA boundary (NPWS, 2012c). Therefore, their recorded distribution during the WSP counts was not an accurate reflection of the overall distribution of the habitats used by this population. Shoveler were mainly recorded in the Shannon Airport lagoon, and at Mangan's Lough on Aughinish Island, although a flock of 37 was recorded from intertidal habitat in Poulnasherry Bay during the high tide count.

5.13 The other species that typically feed in fields (Golden Plover, Lapwing, Black-tailed Godwit, Curlew and Black-headed Gull) were rarely, or never, recorded in the terrestrial zone during the WSP counts. However, again, this presumably reflects the survey methodology and does not necessarily indicate an absence of field feeding behaviour by these species.

5.14 The high percentage of Cormorant in the intertidal zone might seem surprising, as this species normally feeds in subtidal habitat. However, all the birds recorded feeding were in subtidal habitat. The high percentage in the intertidal zone reflects the habit of this species in forming daytime roosts in the intertidal zone.

Table 5.2 - Habitat use in the 2010/11 WSP low tide counts.

Species	Mean percentage of total count in habitat zones:			
	Intertidal	Subtidal	Supratidal	Terrestrial
Whooper Swan	31%	12%	0%	57%
Light-bellied Brent Goose	70%	0%	0%	30%
Shelduck	95%	5%	0%	0%
Wigeon	65%	20%	1%	14%
Teal	78%	10%	1%	11%
Mallard	53%	32%	1%	14%
Pintail	91%	4%	2%	4%
Shoveler	4%	4%	0%	92%
Scaup	0%	100%	0%	0%
Cormorant	64%	18%	14%	4%
Golden Plover	97%	0%	0%	3%
Grey Plover	99%	0%	0%	1%
Lapwing	94%	0%	0%	5%
Ringed Plover	97%	3%	0%	0%
Curlew	94%	2%	1%	3%

Species	Mean percentage of total count in habitat zones:			
	Intertidal	Subtidal	Supratidal	Terrestrial
Black-tailed Godwit	96%	1%	0%	4%
Bar-tailed Godwit	100%	0%	0%	0%
Knot	100%	0%	0%	0%
Dunlin	98%	1%	0%	1%
Greenshank	86%	9%	0%	4%
Redshank	99%	0%	0%	1%
Black-headed Gull	74%	22%	0%	4%

Data source: 2010/11 Waterbird Survey Programme as undertaken by the National Parks & Wildlife Service.
Sample sizes: n = 4 for all species, except Whooper Swan and Scaup (n = 1) and Light-bellied Brent Goose (n =2).

Distribution

5.15 The broad patterns of distribution of waterbird species during the WSP low tide counts is summarised in Table 5.3. This indicates that some species are more or less uniformly distributed across the site (e.g., Dunlin, Curlew and Redshank), while others are concentrated in particular waterbodies: e.g., Light-bellied Brent Goose, Cormorant, Ringed Plover, Grey Plover, Curlew and Greenshank in the Lower Shannon; and Golden Plover, Black-tailed Godwit, Knot and Dunlin in the Upper Shannon and Fergus Estuaries).

5.16 The occurrence of the waterbird species in the aquaculture areas during the WSP low tide counts is summarised in Table 5.4 and discussed in more detail in the relevant sections of Chapters 7 and 8.

5.17 The Cormorant breeding colony in the River Shannon and River Fergus Estuaries SPA occurs at Bunlicky Lake in the Upper Shannon. Based on typical Cormorant foraging ranges from breeding colonies the potential foraging range from this colony is likely to be mainly within the Upper Shannon and Fergus Estuary waterbodies (Figure 5.2).

Table 5.3 - Mean percentage distribution of waterbird species between the three waterbodies defined for the River Shannon and River Fergus Estuaries SPA, during the 2010/11 WSP low tide counts.

Species	Lower Shannon	Upper Shannon	Fergus Estuary
Whooper Swan	92%	0%	8%
Light-bellied Brent Goose	100%	0%	0%
Shelduck	56%	33%	11%
Wigeon	47%	15%	38%
Teal	61%	18%	22%
Mallard	57%	11%	32%
Pintail	100%	0%	0%
Shoveler	72%	0%	28%
Scaup	100%	0%	0%
Cormorant	61%	6%	33%
Golden Plover	24%	35%	42%
Grey Plover	61%	29%	9%
Lapwing	37%	9%	54%
Ringed Plover	99%	0%	1%
Curlew	72%	13%	15%
Black-tailed Godwit	25%	40%	35%
Bar-tailed Godwit	60%	38%	3%
Knot	20%	62%	17%
Dunlin	20%	46%	34%
Greenshank	78%	13%	9%
Redshank	49%	28%	24%
Black-headed Gull	36%	13%	51%

Data source: 2010/11 Waterbird Survey Programme as undertaken by the National Parks & Wildlife Service.

Sample sizes: n = 5 for all species, except: Whooper Swan, Shoveler and Scaup (n = 1); Light-bellied Brent Goose (n= 2); and Pintail and Golden Plover (n = 4).

Table 5.4 - Mean percentage occurrence of waterbird species in the AQUAs, during the 2010/11 WSP low tide counts.

Species	Ballylongford /Bunaclugga	Poulnasherry/ Kilrush	Glin	Aughinish/ Foynes	Other
Whooper Swan	0%	54%	25%	0%	21%
Light-bellied Brent Goose	54%	45%	0%	0%	0%
Shelduck	2%	25%	0%	9%	64%
Wigeon	19%	3%	1%	9%	67%
Teal	4%	23%	1%	12%	60%
Mallard	8%	13%	1%	18%	61%
Pintail	1%	99%	0%	0%	0%
Shoveler	0%	54%	0%	18%	28%
Scaup	0%	10%	0%	0%	90%
Cormorant	6%	2%	0%	5%	86%
Golden Plover	12%	0%	1%	2%	85%
Grey Plover	16%	16%	0%	23%	46%
Lapwing	9%	2%	1%	16%	72%
Ringed Plover	55%	5%	10%	2%	28%
Curlew	12%	7%	2%	15%	64%
Black-tailed Godwit	1%	0%	0%	24%	75%
Bar-tailed Godwit	11%	3%	0%	13%	73%
Knot	1%	2%	0%	3%	94%
Dunlin	4%	1%	0%	3%	91%
Greenshank	14%	7%	5%	21%	53%
Redshank	5%	4%	1%	13%	77%
Black-headed Gull	9%	1%	1%	10%	78%

Data source: 2010/11 Waterbird Survey Programme as undertaken by the National Parks & Wildlife Service.

Sample sizes: n = 5 for all species, except: Whooper Swan, Shoveler and Scaup (n = 1); Light-bellied Brent Goose (n= 2); and Pintail and Golden Plover (n = 4).

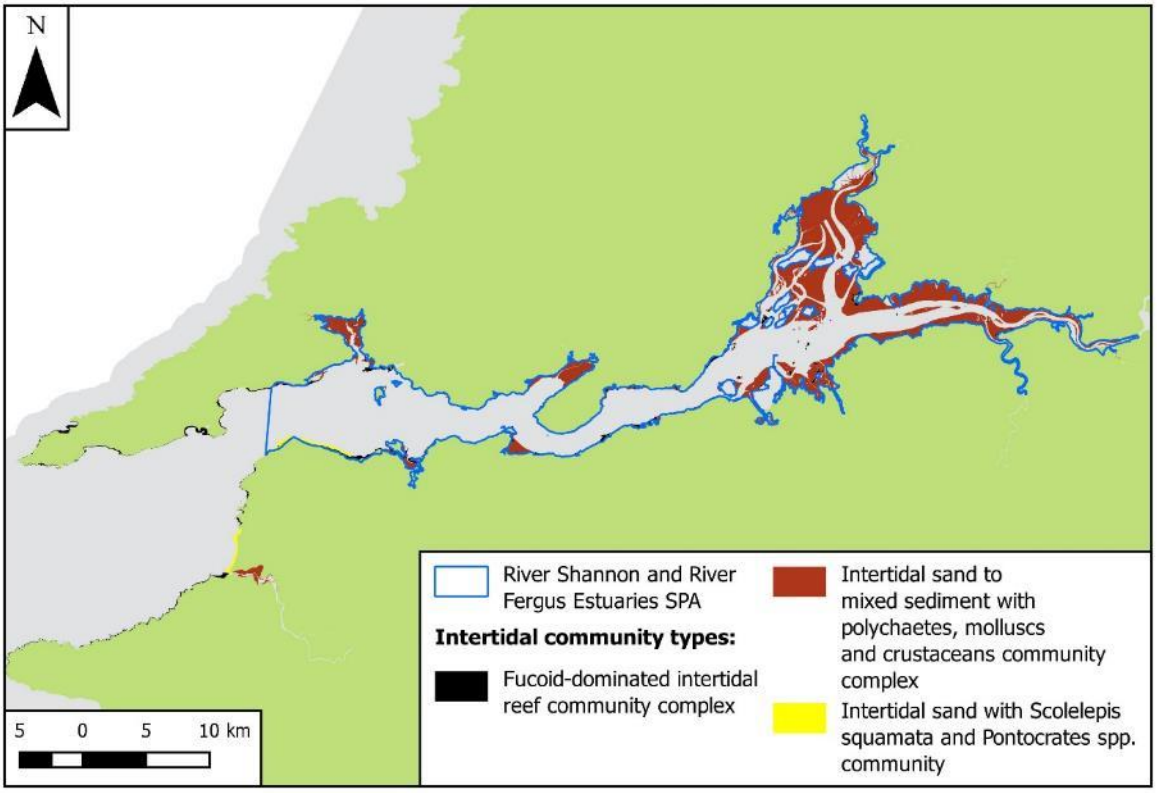

Figure 5.1 Distribution of intertidal community types mapped by NPWS in the River Shannon and River Fergus Estuaries SPA.

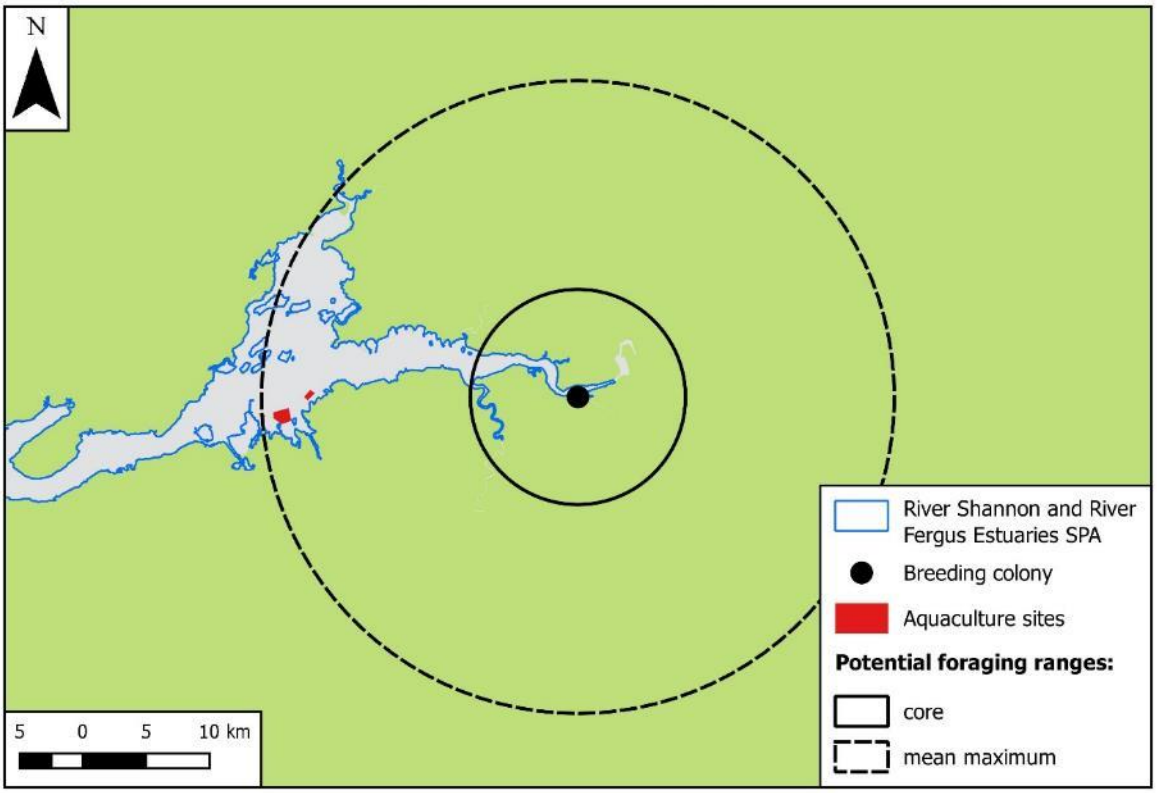

Figure 5.2 Location of the Cormorant breeding colony and potential foraging ranges from this colony.

6. Aquaculture activities within the Shannon Estuary

Scope of activity

6.1 Within the Shannon Estuary, there are a total of 60 aquaculture sites, covering a total area of 631 ha. These include seven renewal sites with a total area of 112 ha, and 53 application sites with a total area of 520 ha. The distribution of these aquaculture sites is shown in Figure 6.1 and summarised in Table 6.1. Five of the sites are located outside the River Shannon and River Fergus Estuaries SPA in Carrigaholt and Rinnevella Bays. All the sites within the SPA are located in the Lower Shannon waterbody.

Table 6.1 - Distribution of aquaculture sites.

AQUA	Number of sites	Area (ha)
Carrigaholt	5	107
Ballylongford/Bunaclugga	9	229
Poulnasherry/Kilrush	41	133
Glin	1	0.7
Killimer	1	0.7
Aughinish/Foynes	3	162

6.2 Most of the sites are predominantly located within the intertidal zone (Figure 6.2).

6.3 There are eight cultivation types that are currently being used, or that are being proposed, in the aquaculture sites: bottom, bouchet and longline cultivation of mussels; bottom, longline and trestle cultivation of oysters; trestle cultivation of scallops; and longline cultivation of seaweed (Table 2.1). The distribution of the main species/cultivation types is shown in Figure 6.3. More detailed maps of the distribution of the aquaculture sites within the Ballylongford/Bunaclugga, Poulnasherry/Kilrush, GLIN and Aughinish/Foynes AQUAs are included in Chapter 7.

Table 6.2 - Species and cultivation methods.

Species	Culture method	Number of sites	Area (ha)
Mussels	subtidal (bottom)	4	312
Mussels	intertidal (bouchet)	2	129
Mussels	subtidal (longlines)	2	29
Oysters	subtidal (bottom)	3	97
Oysters	intertidal (trestles)	52	199
Scallops	intertidal (trestles)	1	8
Seaweed	subtidal (longlines)	2	29

Note that some sites are being/will be used for more than one species/cultivation type, so the total numbers and areas of sites will not be the same as in Table 6.1.

6.4 In addition to the aquaculture sites, there are three areas within the Shannon Estuary covered by Fishery Orders (Figure 6.4). These areas are not the subject of the present assessment, but are included within the in-combination assessment (Chapter 9).

History of activity

6.5 The CLAMS report (CLAMS, 2002) provides some information on the development of aquaculture activity in the Shannon Estuary. Oyster trestle cultivation began in Poulnasherry Bay in the 1970s. Bottom oyster farming trials began in Carrigaholt Bay in 1999-2000. Bottom mussel farming trials began in 1996.

6.6 Aquaculture production data for the Shannon Estuary is summarised in Table 6.3. Note that a strong “health warning” applies to this data. In the Carrigaholt and Ballylongford/Bunaclugga AQUAs, there appear to have been declines in production levels in recent years, and, on our site visits, we noted a reduction in the extent of active trestles in Ballylongford/Bunaclugga between 2010 and 2017. In the Poulnasherry/Kilrush AQUA, production levels appear to have remained fairly constant over most of the period, but with an apparent increase in production levels in 2013-2015. However, trestle mapping indicates that there had been a substantial increase in the area of trestles by 2010 (Figure 6.5). In the Aughinish/Foynes AQUA, the production data indicates very little activity occurring before 2008.

Table 6.3 - Aquaculture production data (tonnes) for the Shannon Estuary.

Year	Carrigaholt	Ballylongford/ Bunaclugga	Poulnasherry/ Kilrush	Aughinish/Foynes	Total
2000	40	51	110	2	202
2001	40	45	111	0	196
2002	40	43	119	2	204
2003	80	18	131	2	231
2004	0	11	79	2	91
2005	0	12	107	1	119
2006	60	24	138	0	222
2007	0	9	163	0	172
2008	0	1	89	35	125
2009	20	26	147	0	193
2010	50	9	113	30	202
2011	10	5	109	6	130
2012	10	14	120	30	174
2013	10	4	214	18	246
2014	0	0	189	18	207
2015	0	0	231	15	246

Data supplied by BIM.

Intertidal oyster cultivation

6.7 Intertidal oyster cultivation is the most widespread aquaculture activity within the Shannon Estuary (Table 6.4).

Table 6.4 - Intertidal oyster cultivation sites within the Shannon Estuary.

AQUA	Parameter	Renewal sites	Application sites
Carrigaholt	Number of sites	2	3
	Area (ha)	11	13.5
Ballylongford/Bunaclugga	Number of sites	3	3
	Area (ha)	23	26
Poulnasherry/Kilrush	Number of sites	32	9
	Area (ha)	61	110
Glin	Number of sites	0	1
	Area (ha)	0	1
Kill	Number of sites	0	1
	Area (ha)	0	1
Aughinish/Foynes	Number of sites	1	0
	Area (ha)	6	0

6.8 All the existing and proposed intertidal oyster cultivation sites involve suspended oyster cultivation using the bag and trestle method. Four sites in Ballylongford/Bunaclugga plan to use oyster longlines as well, while some of the sites in Poulnasherry/Kilrush are planning to also use hanging baskets. Suspended oyster cultivation using the bag and trestle method also takes place within Fishery Order T08/080FO, with about 25% of the area currently in use.

6.9 The oyster longlines method involves placing a line approximately 120 m long made from steel rope on the intertidal. The rope will be kept upright with two strainer posts at each end, with upright posts in between along the line. Approximately four or five baskets (0.6 m x 9m dimensions) will be placed between each stay/upright with the baskets hanging around 0.5 m above the substrate. This cultivation method can be used both for seed and for ongrowing.

6.10 The hanging baskets method involves attaching plastic baskets to the trestles using clips to allow the baskets to pivot from the trestles thereby letting the tide turn the oysters. This allows the oysters to open and feed when the tide is in as they are in the water. When the tide goes out, the oysters are exposed to the air which helps to harden the shell. Tidal movement will allow the oysters to move freely in the baskets allowing better shape and meat content.

6.11 The bag and trestle method and the hanging baskets method are essentially the same in terms of their potential impacts on waterbirds. Therefore, in this assessment, the two methods are collectively referred to as *oyster trestle cultivation*.

Bottom oyster cultivation

6.12 There are three sites (two renewals and one application) for bottom oyster cultivation in Carrigaholt Bay. All of these sites are subtidal sites and are outside the River Shannon and River Fergus Estuaries SPA. These sites cover a total area of 97 ha, of which 82 ha are in the renewal sites. These sites are/will be used for ongrowing of oysters from the trestle sites in Carrigaholt Bay. No further details about the cultivation of oysters on these sites are available.

6.13 Oyster bottom culture also takes place in Fishery Order T08/004A, in which around 34 ha is used to finish oysters from the trestle site in the Aughinish/Foynes AQUA (T07/007). No further details about the cultivation of oysters in this Fishery Order area are available.

Bouchet pole mussel cultivation

6.14 There are two sites that are planned to be used for bouchet pole mussel cultivation in the Aughinish/Foynes AQUA. The total area covered by these site is 130 ha. However, these sites have multiple uses planned, so not all of this area will be used for bouchet pole cultivation.

6.15 Bouchet pole mussel cultivation involves attaching ropes of mussels to tall wooden poles placed in the intertidal zone. The poles will be spread in blocks of two rows, with the poles spaced 1 m apart in each row, and with a spacing of 10 m between each pair of rows. This equates to a density of 2,000 poles/ha. In year 1 it is envisaged to pilot the method using 1 ha.

6.16 In year one after the initial deployment of the poles the site will be tended to once every 4-6 weeks. Thinning will happen once during the growth cycle and this will last maybe 1-2 weeks

6.17 Harvesting from poles will be at half-tide. The boat will come alongside the poles and the mussels will be scraped off the poles

Bottom mussel cultivation

6.18 There are four sites (two applications and two renewal) for bottom mussel cultivation in Ballylongford/Bunaclugga and Aughinish/Foynes. Two of the sites are subtidal sites and one is an intertidal site. These sites cover a total area of 313 ha, of which 21 ha are in the renewal site.

Table 6.5 - Bottom mussel cultivation sites.

LOCATION	Values	Renewal	Application
Ballylongford/Bunaclugga	Number of sites	1	0
	Area (ha)	151	0
Aughinish/Foynes	Number of sites	1	2
	Area (ha)	6	156

6.19 The site in the Ballylongford/Bunaclugga AQUA (T06/233) has not been extensively utilised over the years but there are plans to further utilise the site in coming years. The site is used for on growing of mussels using seed sourced from the east coast. The seed will be relaid during the seed season (August-September) by pumping it, mixed with seawater, from the hold of the boat onto the site. Relaying will take place during a few weeks each year, depending on seed availability. Normally this will be during September on two tides per month. The vessels are fitted with a pumping system. This pattern of relaying is achieved by the vessels moving across the site during pumping in an effort to achieve an even distribution of mussel on the site in order to maximise survival and growth. Mussels are harvested during October-December in the second winter following planting. The dredge uses 2-4 single dredges while harvesting. The type of dredges used are 2 m mussel dredges with a flat bar that is designed to skim the surface of the substrate and separate mussel seed from the underlying sediment of the substrate and remove the mussel seed. Harvesting will take place on approximately 1-2 days/week between November and January.

6.20 The two sites in the Aughinish/Foynes AQUA (T07/12 and T07/14) will be used for relaying mussel seed sourced from one of the mussel longline sites in the Ballylongford/Bunaclugga AQUA (site T06/394), or from another approved site. The seed will be relaid in August-September. On each site, relaying will take place on 5-10 days per year. At site T07/12, which is predominantly in the intertidal zone, the relaying of the seed will take approximately 1-2 hours during the high tide period. At site T07/14, the relaying of the seed can take place at any stage of the tide as this site is subtidal and, therefore, there is always 2-3 m of water on the site. The mussels will be harvested in during October-December in the second winter following planting. At site T07/12, harvesting will take place

at high tide over a maximum period of four hours on approximately two days per week. At site T07/14, harvesting can take place at any stage of the tide as the site is sub-tidal, but a similar level, and duration, of harvesting activity is anticipated.

Mussel longline cultivation

6.21 There are two application sites for subtidal mussel cultivation using mussel longlines in the Ballylongford/Bunaclugga AQUA. These sites cover a total area of 29 ha. These sites will be used as collector sites for mussel seed which will then be used for bouchet mussel production and bottom mussel production in the Aughinish/Foynes AQUA.

6.22 These sites will be accessed once a week, to check lines on an ongoing basis. Harvesting will take place over a 2-3 week period during August and September.

Other species

6.23 It is planned to also produce seaweed on the two mussel longline sites in the Ballylongford/Bunaclugga AQUA (T06/394A and T06/394B). The seaweed will be seeded onto the lines using ropes produced from the Tralee Bay Oyster Hatchery. The seaweed to be cultured will be seaweed indigenous to the area such as Red Seaweeds (*Palmarias*) and Brown Seaweeds (*Laminarias*). No non-native seaweeds will be grown.

6.24 Scallops are/will be grown in hanging baskets on the oyster trestles in site T08/055 in the Carrigaholt AQUA.

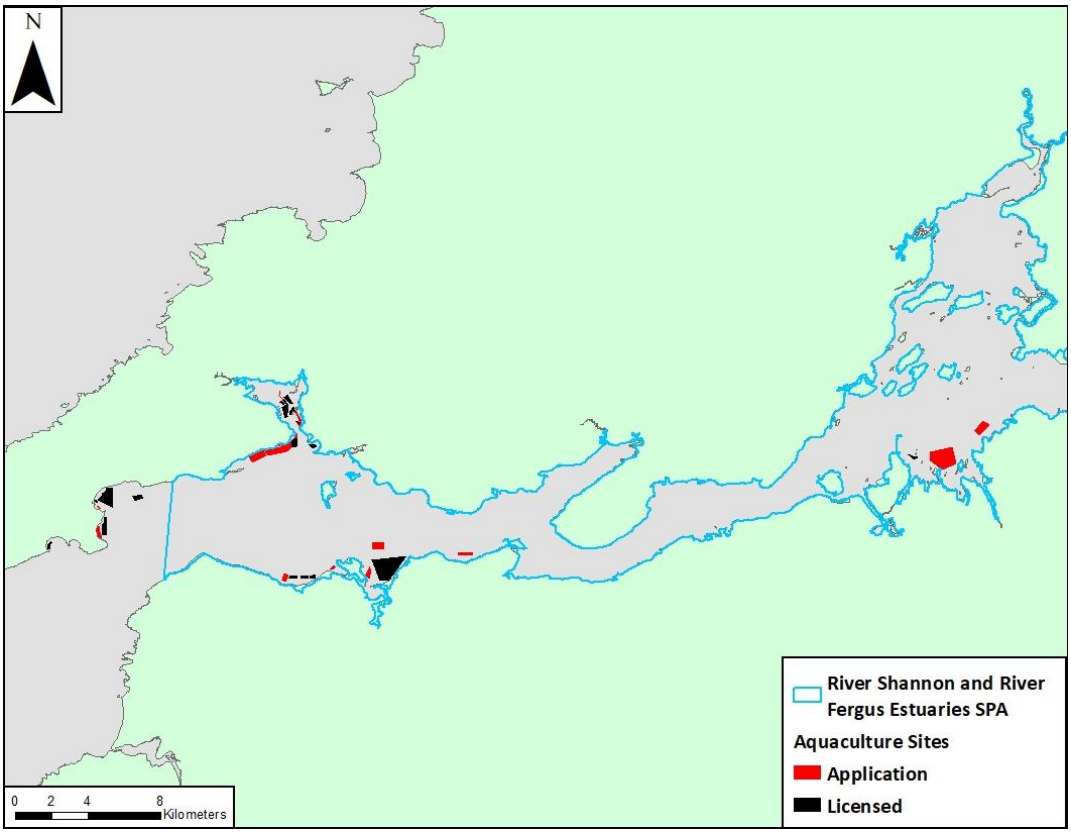

Figure 6.1 Aquaculture sites classified by site status.

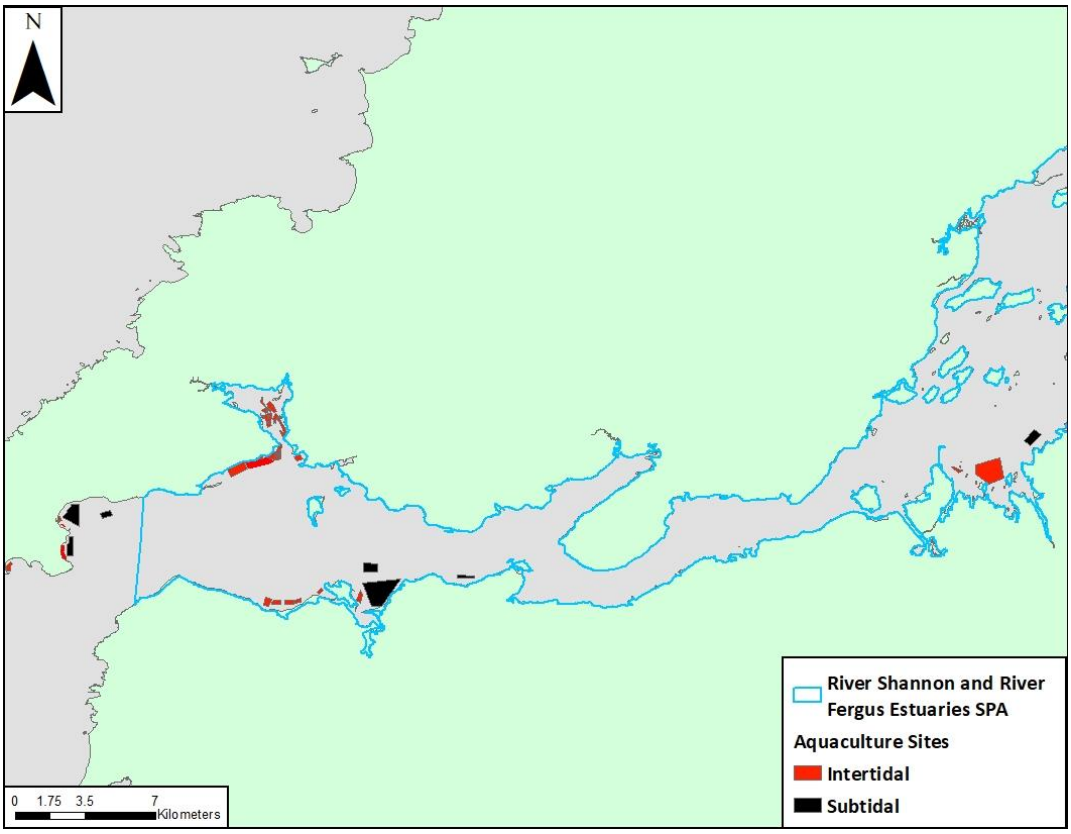

Figure 6.2 Aquaculture sites classified by predominant tidal zone.

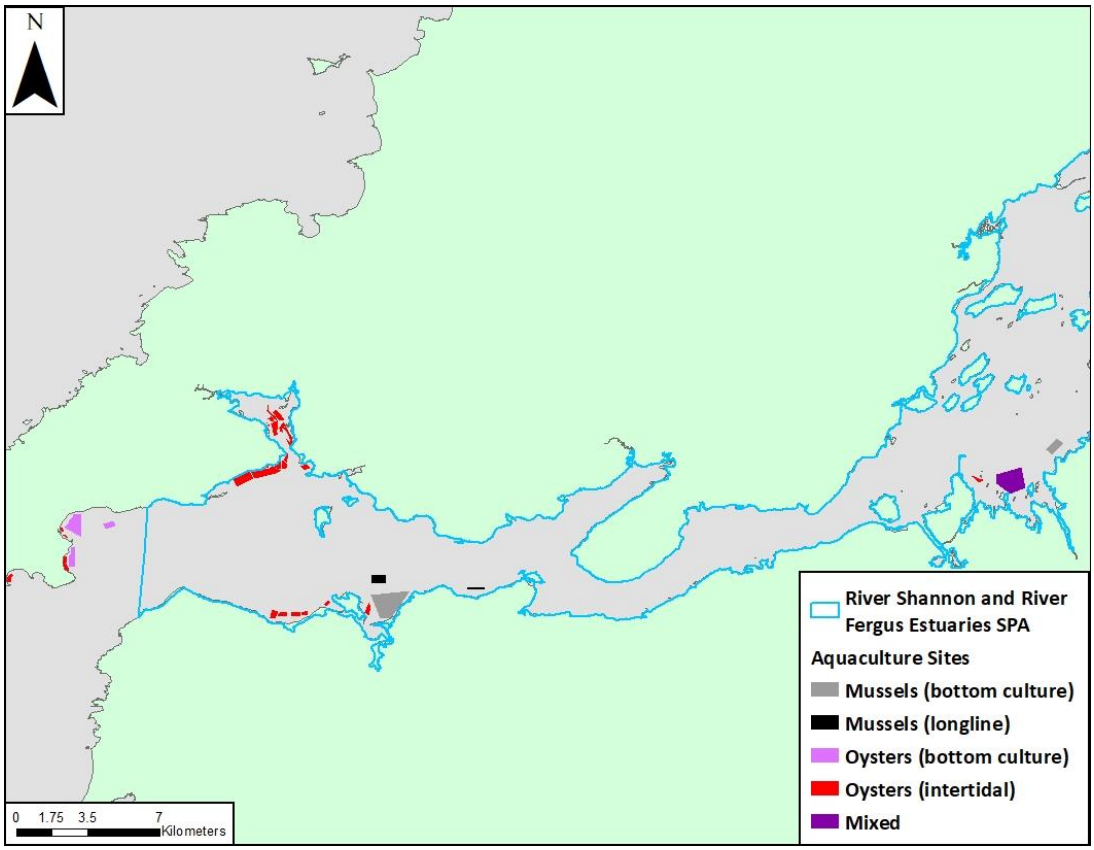

Figure 6.3 Aquaculture sites classified by predominant species and cultivation method.

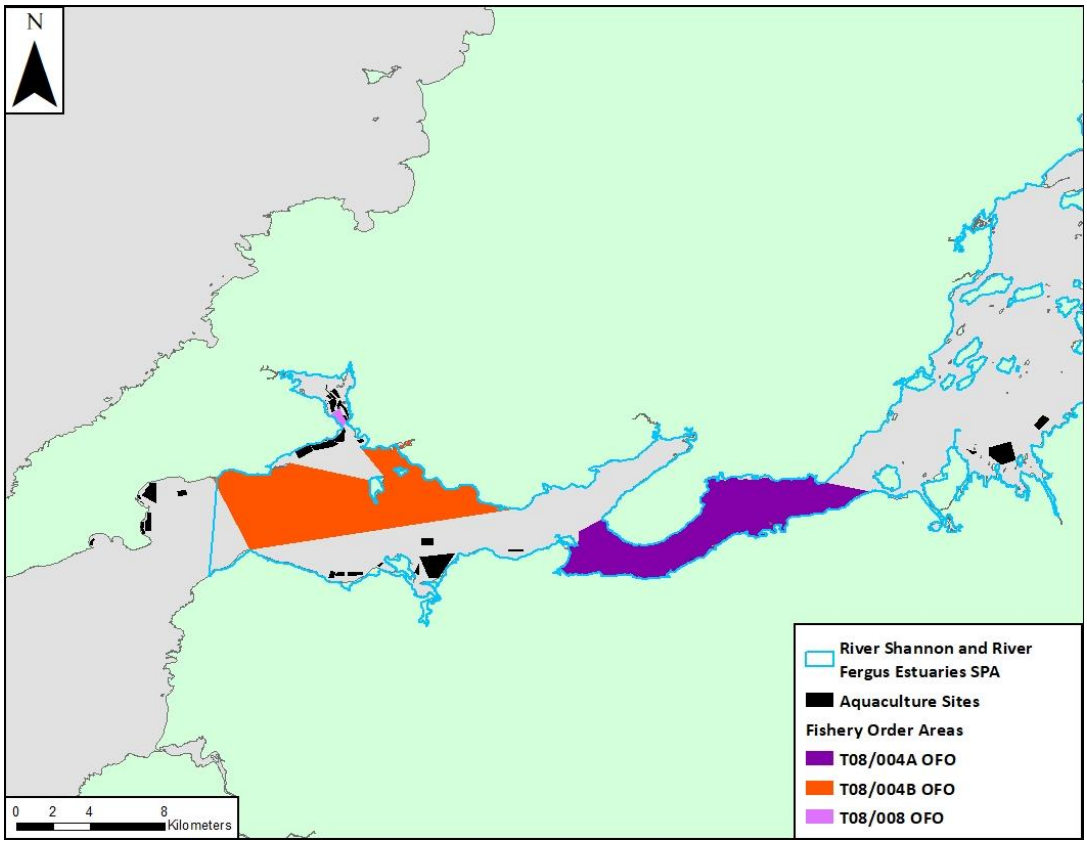

Figure 6.4 Fishery Order areas within the Shannon Estuary.

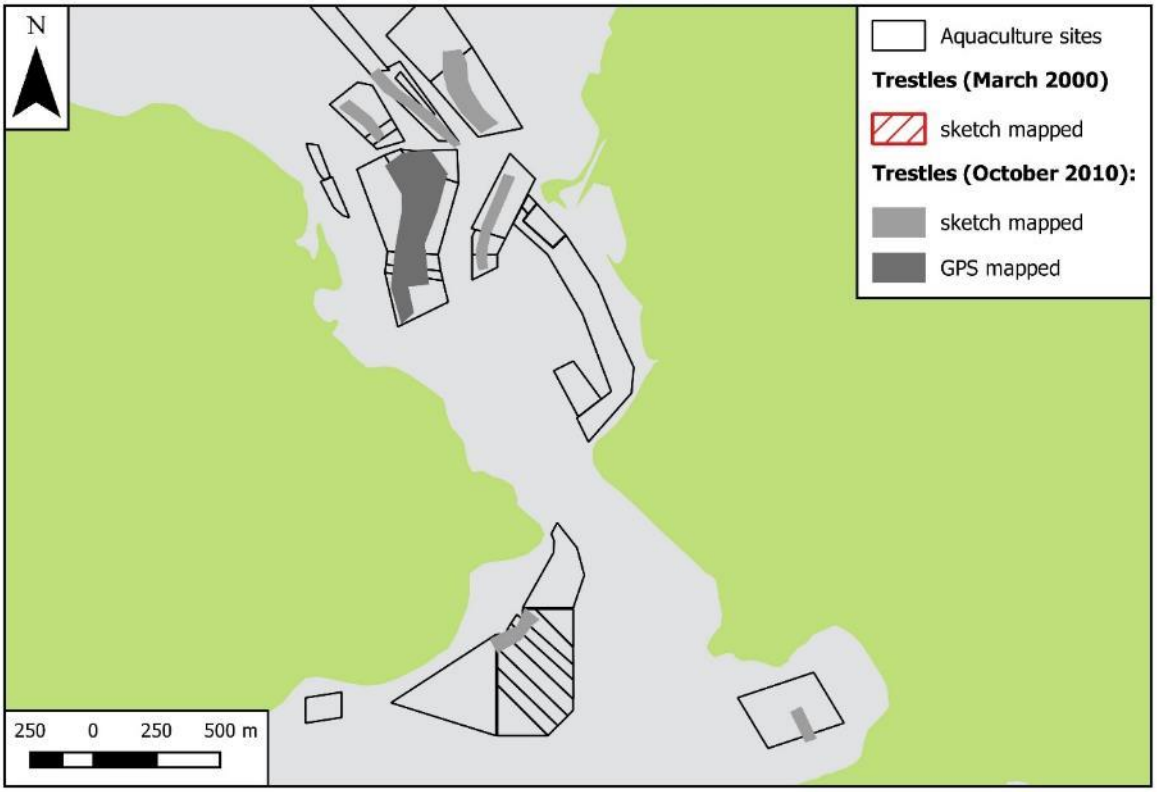

Figure 6.5 Oyster trestles in Poulnasherry Bay.

7. Assessment of impacts to birds using intertidal habitats

Introduction

7.1 This chapter assesses the potential impacts of aquaculture activity on SCIs using intertidal and shallow subtidal habitats. The following SCIs are assessed in this chapter: Whooper Swan, Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Mallard, Golden Plover, Grey Plover, Lapwing, Ringed Plover, Curlew, Black-tailed Godwit, Bar-tailed Godwit, Knot, Dunlin, Greenshank, Redshank, and Black-headed Gull. The impacts of aquaculture activity on Whooper Swan, Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Mallard and Black-headed Gull when they are using moderately deep, or deep subtidal habitats are assessed in Chapter 8.

7.2 The impacts of intertidal aquaculture activity on SCIs that may potentially use the affected habitat at high tide (Scaup, Cormorant, Fulmar, Kittiwake and Guillemot) are assessed in Chapter 8, as at this time the habitat becomes moderately deep subtidal habitat.

7.3 The assessment in this chapter is structured by the AQUAs, as it makes most sense to consider the potential impacts from all the aquaculture sites together within each AQUA. However, we have assessed the potential impact on Whooper Swan, and potential disturbance impacts to the intertidal zone from subtidal aquaculture activity, across all AQUAs combined, due to the general nature of these assessments.

Potential impacts

Oyster trestle cultivation

Habitat structure

7.4 Oyster trestle cultivation causes a significant alteration to the three-dimensional structure of the intertidal habitat (which includes the airspace occupied by birds feeding on the habitat) through the placement of physical structures (oyster trestles) on the intertidal habitat. This alteration may alter the suitability of the habitat for waterbirds by interfering with sightlines and/or creating barriers to movement. Based on the characteristics of species showing positive/neutral or negative responses to trestles, we have hypothesised that trestles may interfere with flocking behaviour causing species that typically occur in large, tightly packed flocks to avoid the trestles. Trestles could also interfere with the visibility of potential predators causing increased vigilance and reduced foraging time (Gittings and O'Donoghue, 2012, 2016b).

Food resources (benthic fauna)

7.5 Oyster trestle cultivation may cause impacts to benthic invertebrates and this could potentially affect food resources for waterbird species.

7.6 In a review of the literature, Dumbauld *et al*. (2009) found variation in the effects of intertidal oyster cultivation on the benthic fauna. In studies in England, France and New Zealand, intertidal oyster cultivation caused increased biodeposition, lower sediment redox potential and reduced diversity and abundance of the benthic fauna. However in studies in Ireland and Canada, few changes in the benthic fauna were reported, due to high currents preventing accumulation of biodeposits.

7.7 The Irish study referred to above was carried out at Dungarvan Harbour (De Grave *et al*., 1998). This study compared an oyster trestle block (in the north-eastern section of the main block of trestles) with a control site approximately 300 m away, with both areas being at the mean tide level. Within the trestle block areas underneath trestles and areas in access lanes were compared. The study found no evidence of elevated levels of organic matter or high densities of organic enrichment indicator species within the trestle blocks. There were minor differences in the benthic community between the control area and the areas sampled under the trestles (higher densities of *Nephtys hombergii*, *Bathyporeia guiiliamsoniana*, *Gammarus crinicomis*, *Microprotopus maculatus* and *Tellina tenuis* including increased abundance of *Capiteila capitata* in the latter area), but these were considered to be probably due to increased predation by epifaunal decapods and fishes. There appeared to be stronger changes in the benthic community in the access lanes with increased densities of three polychaete species (*Scolopos armiger*, *Eteone longa* and *Sigalion mathildae*) and higher overall diversity, and these changes were considered to be due to the compaction of the habitat by vehicular traffic.

7.8 In more recent work commissioned by the Marine Institute, Forde *et al*. (2015) looked at benthic invertebrates along access tracks, under trestles and in close controls at a four sites along the west and south coasts of Ireland. There was a strong site effect from the study in that significant differences were observed using a variety of invertebrate response (dependent) variables among the sites. Access routes were considered more disturbed than trestle and control locations; most likely due to the influence of compaction from regular vehicle movements. Abundance (among other variables) was significantly higher in control and trestle samples when compared with those derived from access routes. No noticeable difference between control and trestle samples was detected. This research indicates that oyster trestle cultivation in typical Irish sites is unlikely to have had major impacts on food resources for waterbirds that feed on benthic fauna.

7.9 The potential impacts of oyster trestle cultivation on food resources for fish eating waterbirds are reviewed in Chapter 8.

Disturbance

7.10 Oyster trestle cultivation requires intensive husbandry activity and this may cause impacts to waterbirds using intertidal and/or shallow subtidal habitats through disturbance. Disturbance will not affect high tide roosts, or waterbirds that mainly, or only, use trestle areas when they are covered at high tide (such as Cormorant and Scaup), because no husbandry activity takes place during the high tide period.

7.11 There is a very extensive literature on the impact of disturbance from human activity on waterbirds. However, the trestle study (Gittings and O'Donoghue, 2012, 2016b) examined the combined potential effects of habitat alteration and disturbance from husbandry activity. The sites included in the study included some with very high levels of husbandry activity. Therefore, it is not necessary to consider the disturbance component of the potential impacts separately for the species covered by the trestle study.

Waterbird responses

7.12 The results of the trestle study (Gittings and O'Donoghue, 2012, 2016b) allowed us to categorise the nature of the association between oyster trestles and bird distribution patterns for many of the species included in this assessment. The overall response of the waterbird species to oyster trestles is summarised in Table 7.1, along with evidence about their response to oyster trestles at Poulnasherry Bay (where available). The latter is presented in the form of Jacobs Index (D) values, which represent the degree of positive or negative association with oyster trestles: D can vary from -1 (indicating complete avoidance) to +1 (strong preference).

7.13 Ringed Plover, Grey Plover and Knot appear to be completely excluded from areas occupied by oyster trestles. This was first demonstrated in the data from the trestle study and has been further supported by subsequent monitoring work at Donegal Bay (O'Donoghue and Trewby, 2016) and Dungarvan Harbour (Gittings and O'Donoghue, 2015). These species did not occur in sufficient numbers in the trestle study counts to calculate D index values for Poulnasherry Bay.

7.14 Dunlin and Bar-tailed Godwit both showed strong avoidance of oyster trestles in the data from the trestle study and this avoidance was further supported by subsequent monitoring work at Dungarvan Harbour (Gittings and O'Donoghue, 2015 and unpublished data). The D index value from Poulnasherry Bay for Dunlin conforms to this pattern.

7.15 Light-bellied Brent Goose showed a variable response pattern in the trestle study with neutral/positive patterns of association at some sites, and negative patterns at other sites. These species did not occur in sufficient numbers in the trestle study counts to calculate D index values for Poulnasherry Bay. This species often feeds on the algae that attaches to the trestle bags and at some sites large numbers can be present on the trestles on the ebb/flood tides to exploit this food source. Wigeon also can feeds on the attached algae, and was similarly classified as having a variable response.

7.16 Curlew and Black-headed Gull showed a variable response pattern in the trestle study with neutral/positive patterns of association at some sites, and negative patterns at other sites[5]. The D index values from Poulnasherry Bay indicate a neutral association for Curlew and a negative association for Black-headed Gull. However, these should be interpreted with caution given that these are based on the data from only four counts.

7.17 In the trestle study report, Redshank was classified as having an overall neutral/positive pattern of association with oyster trestles. The D index value from Poulnasherry Bay conforms to this pattern.

Table 7.1 - Summary of patterns of association with oyster trestles.

Species	Overall response	Jacobs index (D) values for Poulnasherry Bay
Light-bellied Brent Goose	Variable	-
Wigeon	(Variable)	-
Mallard	(Negative)	
Ringed Plover	Negative	-
Grey Plover	Negative	-
Knot	Negative	-
Dunlin	Negative	-0.45
Black-tailed Godwit	(Negative)	-
Bar-tailed Godwit	Negative	-
Curlew	Variable	0.07
Redshank	Neutral/Positive	0.73
Black-headed Gull	Variable	-0.45

Overall response is as classified by Gittings and O'Donoghue (2016). Responses in parentheses indicate that the evidence base supporting the response categorisation is limited.

7.18 The other species included in this assessment are: Shelduck, Teal, Pintail, Shoveler, Golden Plover, Lapwing, Black-tailed Godwit and Greenshank. These species were not recorded in

[5] Note that Curlew was classified as having a neutral/positive pattern of association in Gittings and O'Donoghue (2012), but based on further analysis of the dataset re-classified the as variable in Gittings and O'Donoghue (2016b).

sufficient numbers in the trestle study to carry out formal analyses of their association with trestles across sites. This reflects that fact that these species tend to occur on muddier sediments, unlike the sandier sediments typically used for intertidal oyster cultivation. However, for Shelduck, Lapwing, Black-tailed Godwit and Greenshank, the trestle study found some weak evidence of negative (Shelduck, Lapwing and Black-tailed Godwit), or positive (Greenshank) association with trestles, from ordination analyses and/or qualitative assessment of count data (Gittings and O'Donoghue, 2012). For Golden Plover, we have some evidence of a negative association with trestles from other work (Gittings and O'Donoghue, 2015 and unpublished data).

7.19 Shelduck are large ducks that stand over 0.5 m tall. Therefore, trestles may impede their movements while foraging as, unlike smaller waders, they will not be able to freely move under the trestles.

7.20 Golden Plover and Lapwing mainly use intertidal areas for roosting. Golden Plover typically roost in large expanses of open mudflat or sandflat, while Lapwing use more varied substrates for roosting, including mixed sediments and rocky shores. It is very unlikely that Golden Plover would roost within trestle blocks but one could imagine that Lapwing might roost on trestles. Monitoring work at Dungarvan Harbour has provided some evidence that roosting Golden Plover flocks avoid trestles (Gittings and O'Donoghue, 2015 and unpublished data).

7.21 Black-tailed Godwit is behaviourally and ecologically similar to Bar-tailed Godwit, as indicated by the fact that small numbers of Bar-tailed Godwits often associate with Black-tailed Godwits in Cork Harbour. Therefore, it seems likely that Black-tailed Godwit will show a similarly strong negative response to trestles, as shown by Bar-tailed Godwit.

7.22 We have no evidence about the nature of the response of Teal, Mallard, Pintail and Shoveler to trestles. For these species, we have made a precautionary classification of a negative response.

Oyster longline cultivation

7.23 Oyster longline cultivation may have similar interactions with benthic invertebrates, as discussed above for oyster trestle cultivation.

7.24 The potential impacts of intertidal longline oyster culture was studied by Connolly and Colwell (2005) at Humboldt Bay, California. The longline oyster culture at their study site involved lines of oysters suspended from plastic pipes inserted vertically into the substrate. The lines were usually spaced into rows 70 cm wide, and the photograph in Figure 2 of Connolly and Colwell (2005) indicates that the height of the lines above the substrate was similar to this width. At three sites, every fifth row was 1.5 m wide, and at all sites there were regular 2 m wide aisles perpendicular to the rows. They used five study sites, with a longline plot paired with a control plot that was similar in area, shape, substrate, micro-channelization and elevation.

7.25 They compared waterbird abundances on longline and control plots separately for each study site. In 32 of the 68 pairwise comparisons, there were significant differences between longline and control plots, with higher numbers in the longline plots in 25 of these comparisons. Species that were more abundant in longline plots (number of sites in parentheses) were: Peeps (2), Dowitcher (1), Whimbrel (4), Willet (4) and Black Turnstone (2). Species that were more abundant in control plots (number of sites in parentheses) were: Great Blue Heron (1) and Grey Plover[6] (2). Species with mixed responses were: Dunlin (more abundant on longline plots in 1 site, more abundant on control plots in 2 sites), Marbled Godwit (3, 1) and Long-billed Curlew (1, 1). Species diversity was

[6] Referred to as Black-bellied Plover in Connolly and Colwell (2005).

greater on longline plots compared to control plots. In 15 of 60 comparisons, bird use of wide areas exceeded availability, with the strongest preference for wide rows being among the larger species.

Bottom mussel cultivation

7.26 The potential impacts of bottom mussel cultivation on habitat structure and benthic fauna are reviewed in Chapter 8.

7.27 In the intertidal zone, bottom mussel cultivation may also have potential impacts on waterbirds by altering the physical structure of the habitat. If an area of open intertidal sediment habitat is changed by mussel relaying to a mussel bed, with accumulation of mussels over a period of years, birds associated with open intertidal sediment habitat may be displaced. This impact could result from birds being deterred from using the habitat due to reduced sightlines, which may interfere with visibility of predators and/or flocking behaviour (notably in the case of smaller species). However, any such impacts may be difficult to distinguish from impacts due to changes in prey resources.

7.28 Work carried out at Castlemaine Harbour indicates that, of the species assessed in this chapter, Curlew, Redshank and Greenshank are likely to have a neutral or positive response to intertidal mussel cover (Gittings and O'Donoghue, 2011a and unpublished data). In addition, Knot feed on mussel beds and are, therefore, also likely to have a neutral or positive response. Therefore, these species can be screened out from further assessment relating to bottom mussel cultivation. Similarly, Caldow *et al*. (2003) also found neutral or positive responses from Curlew, Redshank and Black-headed Gull following mussel relay in intertidal habitats, although there was some indication of decreases in Redshank in the areas with the highest densities of mussels.

7.29 Species mainly associated with open intertidal habitats might be expected to be negatively affected by the development of intertidal mussel beds. However, work carried out by Waser *et al*. (2016) in the Dutch Wadden Sea found that most waterbird species showed positive associations with bivalve beds compared with open intertidal habitats; this may in part be associated with the greater habitat heterogeneity of bivalve beds. The species showing positive associations included Greenshank and Redshank (preference factors of 13.3-15.2), Golden Plover, Curlew and Knot (preference factors of 5.8-8.9) and Shelduck, Mallard, Pintail, Grey Plover, Bar-tailed Godwit, Dunlin and Black-headed Gull (preference factors of 1.2-4.9). Only three species showed negative associations (Ringed Plover, Sanderling and Great Black-backed Gull), with a preference factor of 0.2 for Ringed Plover indicating a significant decrease in abundance on bivalve beds.

Bouchet pole mussel cultivation

7.30 There is no detailed information available about the potential impacts of bouchet pole mussel cultivation on waterbirds, or on the habitats and food resources used by waterbirds. However, it has been noted that in bouchet pole farms in Brittany "*there are usually very few waterfowl and waders feeding*" in bouchet pole farms in Brittany, although they "*can attract large numbers of gulls*" (Guillaume Gélinaud, Bretagne Vivante-SEPNB, Réserve Naturelle des Marais de Séné, pers. comm.).

7.31 In terms of the physical structures used, bouchet pole cultivation appears to be somewhat analogous to the intertidal longline oyster culture studied by Connolly and Colwell (2005). The results of their study are summarised above.

Other potential disturbance impacts

7.32 There is potential for boat access to/from aquaculture sites, and/or husbandry activity in moderately deep, or deep, subtidal habitat to cause disturbance impacts to waterbirds roosting in intertidal and shoreline habitats at high tide and/or waterbirds using intertidal and shallow subtidal habitat at low

tide and/or on ebb/flood tides. A summary of the likely timing of boat access to the various relevant sites is provided in Chapter 8.

Preliminary screening

Aquaculture sites

7.33 The intertidal aquaculture sites in the Carrigaholt AQUA are outside the SPA. There is very limited intertidal habitat in the Carrigaholt AQUA and the area is around 8 km from the nearest area of intertidal habitat (Poulnasherry Bay), so significant utilisation of this area by the SCI populations covered by this section of the assessment is unlikely to occur. Furthermore, these sites are outside the SPA so, by definition, impacts to these sites will not affect attribute 2 of the conservation objectives for the SCI species.

7.34 There is no waterbird count data available for the Killimer AQUA. However, the only aquaculture site in this AQUA is a very small site (0.7 ha), located in narrow mixed sediment/rocky shore intertidal zone, and is not close to any significant areas of intertidal habitat. Therefore, the site does not provide a significant habitat resource for waterbirds using intertidal habitat.

7.35 For the above reasons, it can be concluded that the intertidal aquaculture sites in the Carrigaholt and Killimer AQUAs will not cause significant impacts to any of the SCI species assessed in this chapter (Whooper Swan, Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Mallard, Golden Plover, Grey Plover, Lapwing, Ringed Plover, Curlew, Black-tailed Godwit, Bar-tailed Godwit, Knot, Dunlin, Greenshank, Redshank, and Black-headed Gull).

Species

7.36 Two of the SCI species assessed in this chapter (Greenshank and Redshank) have neutral/positive associations with oyster trestle cultivation (Gittings and O'Donoghue, 2012, 2016) and are likely also to have neutral/positive associations with bottom mussel cultivation (see paragraphs 7.28-7.29). There is no specific information available on the nature of their association with oyster longline cultivation or bouchet pole mussel cultivation. However, as these activities are less physically intrusive than oyster trestle cultivation and, in the case of bouchet pole mussel cultivation, will have lower potential disturbance impacts, it is reasonable to conclude that these species will also have neutral/positive associations with these activities. Therefore, these species have been screened out from further assessment in this chapter.

Assessments

Ballylongford/Bunaclugga AQUA

Habitats

7.37 The distribution of intertidal habitat in the Ballylongford/Bunaclugga AQUA is shown in Figure 7.1. The eastern section in subsite 0K509 has the estuary of Ballylongford Creek, which has extensive beds of *Spartina*. The shoreline to the east of this estuary has only a narrow shingle shore. In subsites 0K507 and 508, the intertidal habitat is mainly open sandflat, but with mixed sediment/rocky shoreline habitat in the eastern part of 0K508. The NPWS marine community types map classifies the littoral sediment habitat in subsite 0K509 as the *intertidal sand to mixed sediment with polychaetes, molluscs and crustaceans community complex*, and the littoral sediment habitat in subsites 0K507 and 508 as the *intertidal sand with Scolelepis squamata and Pontocrates spp. community*. The latter corresponds to dry, sand shore type substrate. In the eastern part of 0K508,

littoral sediment habitat occurs below the mixed sediment/rocky shoreline habitat, but is not mapped by NPWS. This littoral sediment habitat is a firm sandflat-type substrate but muddier than the sand shore habitat, and may also continue to the west in the spring low tide zone below the sand shore habitat.

Waterbirds

7.38 The occurrence and distribution of waterbirds in the Ballylongford area during the WSP counts is shown in Table 7.2. This area is particularly important for Light-bellied Brent Goose and Ringed Plover, and also holds significant numbers of a number of other species. Shelduck, Wigeon, Teal, Golden Plover, Lapwing and Dunlin all appear to be concentrated in subsite 0K509, where they were presumably associated with the muddier estuarine habitat in Ballylongford Creek.

Table 7.2 - Occurrence and distribution of waterbirds in intertidal habitats in the Ballylongford/Bunaclugga AQUA during the WSP low tide counts.

Species	Mean % of		Mean count			Non-zero counts
	SPA	LS zone	0K507	0K508	0K509	
Light-bellied Brent Goose	49%	49%	37	7	7	4
Shelduck	2%	4%	0	0	12	1
Wigeon	14%	25%	0	87	95	4
Teal	3%	4%	0	3	67	4
Mallard	6%	10%	1	3	25	4
Golden Plover	12%	37%	33	0	226	4
Grey Plover	5%	9%	1	1	4	4
Lapwing	7%	19%	59	2	237	4
Ringed Plover	39%	40%	6	35	15	4
Curlew	8%	11%	22	70	47	4
Black-tailed Godwit	0%	9%	0	10	2	2
Bar-tailed Godwit	10%	14%	11	11	5	4
Knot	1%	5%	1	1	3	2
Dunlin	4%	26%	1	51	397	4
Black-headed Gull	9%	24%	68	77	80	4

This table shows: (1) the mean of each low tide count in the intertidal and subtidal zones across all the subsites in the Ballylongford/Bunaclugga AQUA as percentages of the total count across the whole SPA, and across the Lower Shannon zone, respectively; and (2) the mean low tide count in each of the Ballylongford/Bunaclugga AQUA subsites.

7.39 The WSP flock maps from the low tide counts show that the mapped flock positions were concentrated in the south-western section of 0K507, the eastern section of 0K508 and the inner parts of 0K509 (Appendix B). These maps indicate an avoidance by most waterbirds of the dry sand shore habitat in the northern part of 0K507 and the western part of 0K508, as might be expected from the nature of the habitat.

Aquaculture

7.40 There are seven aquaculture sites that include intertidal habitat in the Ballylongford/Bunaclugga AQUA. Six of these are oyster trestle cultivation sites, and one is a bottom mussel culture site. The five oyster trestle cultivation sites to the west of Carrig Island may also be used for oyster longline cultivation. However, for the purposes of this assessment, we have assumed that the entire area of each of these sites will be used for oyster trestle cultivation, as this is likely to have more negative impacts on waterbirds.

7.41 One of the oyster trestle cultivation sites is located on the eastern side of Carrig Island in subsite 0K509. The other five sites are located along a 3 km stretch of shoreline to the west of Carrig Island, with one of these being in subsite 0K509 and the other four in subsite 0K508. All the sites are low down on the shore and are mainly within, or below, the spring low tide zone as defined for this assessment. Only the westernmost of the sites includes a significant area within the mean low tide zone. However, based on our observations during site visits, the mapping used to define the exposure of intertidal habitat in this area significantly underestimates the exposure of intertidal habitat to the west of Carrig Island: for example on 9th February 2009 on a 0.4 m low tide (Tarbert), site T06/370, which appears to be below the spring low tide zone according to the mapping, was almost fully exposed by about one hour before low tide.

7.42 Because the oyster trestle cultivation sites are mainly below the mean low tide zone, most of the area occupied by the sites are classified as subtidal community types by NPWS. The site to the east of Carrig Island (T06/331A) includes a mixed sediment shingle ridge with muddy sand occupying the adjoining intertidal. The sites to west of Carrig Island are generally occupied by a firmer, more sandy, substrate, although the upper edges of sites T06/347A, T06/347B and T06/347C extend into mixed sediment habitat. The westernmost site (T06/386A) overlaps the area mapped as the *intertidal sand with Scolelepis squamata and Pontocrates spp. community* type by NPWS, which, from our observations, appears to correspond to much drier sand shore habitat.

7.43 The bottom mussel culture site (T06/233) occupies a large area of subtidal habitat on the eastern side of Carrig Island. This site just about extends into the intertidal zone along the south-eastern side of Ballylongford Bay. However, this is a steeply shelving shingle shoreline and, unlike the areas to the west of Carrig Island, there does not appear to be any significant exposure of additional intertidal habitat below the mapped extent. Therefore, given the nature of the proposed activity, we have assumed that the overlap with the intertidal zone is a mapping artefact and there will not be any aquaculture activity within the intertidal zone in this site.

Impact assessment

7.44 The assessment of potential impacts in this area is complicated by the fact that part of the area occupied by the aquaculture sites are below the mapped extent of intertidal habitat. Therefore, simple quantification of the area of intertidal habitat affected, based on the mapped extent of intertidal habitat, will underestimate the actual impact. As we do not know the true distribution of intertidal habitat in this area, it is not possible to quantify the actual impact in terms of the percentage of the available habitat that will be affected under various tidal conditions. However, based on both the mapping data, and our own observations, it does appear that most of the intertidal habitat affected will only be exposed on spring low tides. Therefore, oyster trestle cultivation in this area only has the potential to cause measurable displacement impacts on less than half the low tides.

7.45 The intertidal habitat to the west of Carrig Island can be divided into two distinct zones: a muddy sand zone with mixed sediment/rocky substrate along the upper shore extending from Carrig Island to around site T06/386A and a dry sand zone extending west from this point. The flock mapping data indicates that most of the waterbird records from subsite 0K508 were concentrated into eastern section of the subsite, indicating that they were associated with the muddy sand zone. The aquaculture sites occupy approximately 50-60% of the shoreline length in the muddy sand zone. Therefore, on spring low tides there is potential for high levels of displacement of species associated with intertidal sediment from this subsite. However, Ringed Plover, the species for which the Ballylongford/Bunaclugga AQUA is most important for, is more likely to use the full extent of intertidal habitat in this subsite, as it is often associated with dry sand shore habitat (there were only two flock map records of this species in this subsite).

7.46 To the east of Carrig Island, the oyster trestle cultivation site occupies around 35% of the intertidal habitat in the outer part of the Ballylongford Creek estuary. On spring low tides, a lot of the waterbirds in Ballylongford Creek are likely to move out to this area, although some will probably remain in the upper part of the creek as waterbirds in estuarine habitats are less constrained by the tideline than in open sandflat habitat.

7.47 The magnitude of the potential displacement impact for each SCI species is categorised in Table 7.3.

7.48 Ringed Plover appears to be completely excluded from oyster trestles. The Ballylongford / Bunaclugga area appears to hold a relatively high proportion of the total SPA Ringed Plover population so the potential displacement impact to this species could be significant. However, the birds may be widely spread across the full extent of intertidal habitat within this area, in which case the potential displacement impact will be of lower magnitude. Therefore, the potential impact is assessed as moderate.

7.49 Light-bellied Brent Goose shows a variable pattern of association with oyster trestles. However, the available count data indicates that the species may be associated with the western part of the AQUA area away from any of the aquaculture sites. Therefore, the potential impact magnitude has been assessed as minor-moderate with low confidence about any impact occurring.

7.50 Black-headed Gull also shows a variable pattern of association with oyster trestles. However, in southern Ireland peak usage of intertidal habitat by Black-headed Gull appears to occur in late summer/autumn (outside the period covered by the WSP count data. Therefore, the potential displacement impact to this species cannot be assessed with any degree of confidence due to lack of appropriate data.

7.51 Impacts to the other species have been assessed as negligible where the species are likely to be predominantly concentrated in Ballylongford Creek, and otherwise as minor-moderate (depending on the relative numbers of the species).

Table 7.3 - Assessment of potential displacement impact from intertidal aquaculture in the Ballylongford/Bunaclugga AQUA.

Species	Likelihood of negative impact	Assessment of impact magnitude	
		SPA	LS zone
Light-bellied Brent Goose	1	minor-moderate	minor-moderate
Shelduck	2	negligible	negligible
Wigeon	1	moderate	moderate
Teal	2	negligible	negligible
Mallard	2	negligible	negligible
Golden Plover	2	negligible	negligible
Grey Plover	3	minor	minor
Lapwing	2	negligible	negligible
Ringed Plover	3	moderate	moderate
Curlew	1	minor	minor
Black-tailed Godwit	2	negligible	minor
Bar-tailed Godwit	3	moderate	moderate
Knot	3	negligible	negligible
Dunlin	3	negligible	minor

Species	Likelihood of negative impact	Assessment of impact magnitude	
		SPA	LS zone
Black-headed Gull	1	not assessed	not assessed

Likelihood of a negative impact: 1 = species shows a variable response to oyster trestles, so a neutral or positive impact may occur; 2 = species considered to show a negative response to oyster trestles but evidence for this is weak; 3 = strong evidence that species shows a negative response to oyster trestles.

Impact magnitude levels are defined in Table 2.2. The confidence level for all impact magnitude assessments is low.

Poulnasherry/Kilrush AQUA

Habitats

7.52 The distribution of intertidal habitat in the Poulnasherry/Kilrush AQUA is shown in Figure 7.2. There are extensive areas of soft sediment intertidal habitat within the estuary, although there is extensive algal cover on the upper areas of mudflat. Outside the bay, most of the soft sediment intertidal habitat is only exposed at low tide.

7.53 All the soft sediment intertidal habitat in the Poulnasherry/Kilrush AQUA is classified as the *intertidal sand to mixed sediment with polychaetes, molluscs and crustaceans community complex* by NPWS. However, there are clear visual differences between the intertidal habitat within Poulnasherry Bay and the intertidal habitat in the outer parts of the Poulnasherry/Kilrush AQUA. The former is soft intertidal mudflat/muddy sand, while the latter comprises much firmer sandflat type substrate. There are also extensive areas of intertidal habitat within Poulnasherry Bay that are covered by algal growth. This is a feature that was recorded in a survey in 1996 (Falvey *et al*., 1997), which recorded up to 80% cover of filamentous green algae on the upper 300 m of the intertidal, and which we noted this on site visits in both 2010 and 2017. The algal cover persists through the winter, as there was still extensive algal growth in March 2017.

7.54 Mixed sediment shore habitat occurs extensively around the shoreline of Poulnasherry Bay, as well as around small islands in the middle of Poulnasherry Bay and its distribution pattern is more complex than mapped. There are also extensive areas of this mixed sediment/rocky shore habitat in the outer sections of the Poulnasherry/Kilrush AQUA to the east, but only a narrow strip of shingle shoreline to the west. Large beds of *Spartina* occur around the upper/inner sections of Poulnasherry Bay.

Waterbirds

7.55 The distribution of waterbirds in the WSP counts is shown in Table 7.4. The Poulnasherry/Kilrush AQUA held the entire SPA population of Pintail during these counts, and was also important for Shelduck, Teal and Grey Plover.

Table 7.4 - Occurrence and distribution of waterbirds in intertidal habitats in the Poulnasherry/Kilrush AQUA during the WSP low tide counts.

Species	Mean % of		Mean count					Non-zero counts
			Poulnasherry Bay		outer sections			
	SPA	LS zone	0H519	0H520	0H507	0H517	0H518	
Whooper Swan	25%	30%	4	0	0	0	0	2
Light-bellied Brent Goose	30%	30%	8	6	0	0	0	3
Shelduck	25%	41%	115	0	0	0	0	4
Wigeon	3%	5%	40	0	0	4	0	4

Species	Mean % of		Mean count					Non-zero counts
			Poulnasherry Bay		outer sections			
	SPA	LS zone	0H519	0H520	0H507	0H517	0H518	
Teal	21%	36%	402	0	0	94	0	4
Mallard	11%	19%	56	0	0	1	0	4
Pintail	99%	99%	47	0	0	0	0	3
Grey Plover	16%	29%	24	0	0	0	0	4
Lapwing	2%	5%	46	0	0	12	6	2
Ringed Plover	5%	5%	7	0	0	5	0	1
Curlew	7%	10%	124	1	0	7	21	4
Black-tailed Godwit	0%	1%	5	0	0	0	0	2
Bar-tailed Godwit	3%	6%	0	10	0	0	0	4
Knot	2%	12%	11	0	0	0	0	2
Dunlin	1%	8%	230	0	0	2	3	4
Black-headed Gull	1%	4%	29	0	3	1	0	4

This table shows: (1) the mean of each low tide count in the intertidal and subtidal zones across all the subsites in the Poulnasherry/Kilrush AQUA as percentages of the total count across the whole SPA, and across the Lower Shannon zone, respectively; and (2) the mean low tide count in each of the Poulnasherry/Kilrush AQUA subsites.

7.56 A series of low tide waterbird counts was also carried out in Poulnasherry Bay the winters of 1999/00-2001/02. The species numbers recorded in these counts are compared with the numbers recorded in the WSP counts in Table 7.5. The comparisons have to be interpreted with caution, due to the low number of WSP counts. Nevertheless, most species appear to have declined in numbers in Poulnasherry Bay, which is in accordance with the overall population trends reported for the SPA by NPWS (2012c).

Table 7.5 - Comparison of waterbird counts from Poulnasherry Bay.

Species	2000/01-2001/02		2010/11		SPA trend
	mean	range	mean	range	
Whooper Swan	0	-	4	0-13	Increase
Light-bellied Brent Goose	77	7-170	8	0-18	Decline 3
Shelduck	139	22-212	115	25-196	Decline 3
Wigeon	258	9-579	40	2-61	Decline 3
Teal	217	83-503	402	301-510	Decline 3
Mallard	18	0-39	56	23-98	-
Pintail	43	2-91	47	0-94	-
Shoveler	1	0-5	1	0-4	-
Golden Plover	585	0-1560	2	0-7	Decline 3
Grey Plover	53	20-114	24	15-37	Decline 3
Lapwing	526	0-1848	46	0-155	Decline 3
Ringed Plover	23	8-61	7	0-28	Decline 3
Curlew	305	0-702	124	0-205	Decline 3
Black-tailed Godwit	2	0-22	5	0-10	Decline 3
Bar-tailed Godwit	47	0-70	0	-	-
Knot	229	18-499	11	0-33	Decline 3

Species	2000/01-2001/02		2010/11		SPA trend
	mean	range	mean	range	
Dunlin	1397	322-2320	230	100-457	Decline 3
Black-headed Gull	36	0-135	29	19-41	Decline 2

This table compares the count data from the months of November-February in the 2000/01-2001/02 low tide count dataset (n = 10), with the low tide count data from subsite 0H519 in the 2010/11 dataset (n= 4).

SPA trends from NPWS (2012c): Decline 2 = 25-50% decline; Decline 3 = > 50% decline. Note, moderate, or high, levels of caution apply to these trends.

7.57 The 1999/00-2001/02 counts included mapping of the approximate positions of most of the birds counted (see example in Figure 2.3). This mapping is summarised in Appendix C.

7.58 Shelduck, Wigeon, Teal, Pintail, Golden Plover and Lapwing all showed associations with the upper sections of the estuary and/or with shoreline areas in the lower sections. This distribution pattern was noted for Shelduck, Wigeon and Teal, on our site visit in March 2017, with the Shelduck distribution appearing to be concentrated in the areas of heavy algal growth (no Pintail, Golden Plover or Lapwing were present).

7.59 Most of the other species were fairly widely distributed through the available habitat in the NPWS bird usage counts, but with Grey Plover, Ringed Plover, Bar-tailed Godwit, Knot and Dunlin all appearing to avoid the mixed sediment shoreline areas. For these species, there is some indication in these distribution patterns of an association with the more central areas of the estuary, which may reflect association with the tideline/lower intertidal. However, there is evidence from a number of studies that algal cover can modify wader distribution and/or feeding behaviour (Cabral *et al*., 1999; Lewis and Kelly, 2001; Lopes *et al*., 2006; Lewis *et al*., 2014; Green *et al*., 2015). Although the evidence is mixed (Múrias *et al*., 1996), and we not know the extent of algal growth in the early 2000s, it is possible that the above distribution patterns may be influenced by this factor.

Aquaculture

7.60 All the aquaculture sites in the Poulnasherry/Kilrush AQUA are oyster trestle cultivation sites.

7.61 There are 28 sites in the inner part of Poulnasherry Bay, which are mainly distributed along the central tidal channel in the middle of the bay. Parts of some of these sites extend below the mapped intertidal zone, but, based on our observations, all of these sites are likely to be more or less fully exposed on spring low tides.

7.62 A further 13 sites occur in the outer sections of the Poulnasherry/Kilrush AQUA, with the majority of the area occupied by these sites being in the spring low tide zone (as mapped).

Displacement

7.63 The aquaculture sites in the outer part of the Poulnasherry/Kilrush AQUA occur in subsites that appear to hold very low numbers of waterbirds and are mainly only exposed on spring low tides. Therefore, any displacement impacts from these sites are likely to be very minor.

7.64 The aquaculture sites in Poulnasherry Bay overlap areas that are used by relatively large numbers of waterbirds. For the purposes of this assessment we have assumed that all of the areas occupied by these sites are exposed on spring low tides so that the total area of intertidal habitat exposed within this subsite on spring low tides is the mapped extent plus the extra area of the aquaculture sites. Therefore, based on the mapped extent of intertidal habitat, and the above assumption, the sites will occupy around 12% of the intertidal habitat at mean low tide, and around 18% at spring low tide. If the area of intertidal habitat occupied by heavy algal growth is excluded then the

aquaculture sites occupy around 16% of the intertidal habitat at mean low tide, and around 24% at spring low tide.

7.65 Shelduck, Wigeon, Teal, Mallard, Pintail, Golden Plover and Lapwing mainly occur in the upper sections of the estuary and/or in shoreline areas in the lower sections, away from the aquaculture sites. Therefore, development of the aquaculture sites is unlikely to cause measurable displacement impacts to these species and the potential impact is assessed as negligible.

7.66 Grey Plover appears to be completely excluded from oyster trestles. Poulnasherry Bay appears to hold a relatively high proportion of the total River Shannon and River Fergus Estuaries SPA Grey Plover population so the potential displacement impact to this species may be significant. As Grey Plover is a visual feeder it may avoid areas of heavy algal growth (Cabral *et al*., 1999; Green *et al*., 2015) increasing the potential displacement impact. Therefore, the potential impact is assessed as substantial.

7.67 Ringed Plover, Bar-tailed Godwit, Knot and Dunlin also show strong patterns of negative association with oyster trestles, and these species may show an association with the middle/lower part of the bay where the aquaculture sites are concentrated. Poulnasherry Bay does not appear to hold significant proportions of the SPA populations of these species (although the bird usage counts indicate that this area may have been more important for Dunlin in the early 2000s). Therefore, the potential displacement impact is likely to be minor at the SPA scale but moderate at the Lower Shannon (LS) scale

7.68 Black-tailed Godwit also probably shows strong patterns of negative association with oyster trestles. However, it does not appear to occur regularly, and/or in significant number in Poulnasherry Bay. Therefore, the potential displacement impact is likely to be negligible at both the SPA scale and the Lower Shannon scale.

7.69 Light-bellied Brent Goose shows a variable pattern of association with oyster trestles. At Poulnasherry Bay it was not observed feeding on trestles during the trestle study counts, but the overall numbers observed during those counts were very low (mean count of 3 birds). Small numbers were observed feeding on trestles on our site visit in March 2017. The Poulnasherry/Kilrush AQUA appears to be relatively important for the SPA population. However, the birds are likely to use the mixed sediment shore habitat both in Poulnasherry Bay and in the outer sections of the Poulnasherry/Kilrush AQUA, and may also feed on the algal covered mudflats in Poulnasherry Bay. Therefore, even if it is potentially negatively affected by oyster trestle cultivation in the Poulnasherry/Kilrush AQUA, it is less sensitive to the potential impacts than the wader species discussed above. Therefore, the potential impact magnitude has been assessed as moderate negative with low confidence about any negative impact actually occurring.

7.70 Curlew also shows a variable pattern of association with oyster trestles. In the trestle study, there was a neutral pattern of association between Curlew and trestles at Poulnasherry Bay. However, as this is only based on four counts, some caution needs to be applied. The distribution pattern of this species in Poulnasherry/Kilrush also indicates that it is less sensitive to potential displacement impacts. The potential impact magnitude has been assessed as moderate negative with low confidence about any negative impact actually occurring.

7.71 The numbers of Black-headed Gull recorded at Poulnasherry/Kilrush during both the WSP counts were very low, and similar numbers were also recorded during the 2000/01 and 2001/02 bird usage counts. However, very high numbers of Black-headed Gull were recorded in the bird usage counts in March 2001. As discussed above, the potential displacement impact to Black-headed Gull cannot be assessed with any degree of confidence due to lack of appropriate data due to the likely seasonal timing of its peak period of usage of intertidal habitat. However, it should be noted that in

the trestle study, there was a negative pattern of association between Black-headed Gull and trestles at POU; although as this is only based on four counts, some caution needs to be applied.

Table 7.6 - Assessment of potential displacement impact from intertidal aquaculture in the Poulnasherry/Kilrush AQUA.

Species	Likelihood of negative impact	Assessment of impact magnitude	
		SPA	LS zone
Light-bellied Brent Goose	1	moderate	moderate
Shelduck	2	negligible	negligible
Wigeon	1	negligible	negligible
Teal	2	negligible	negligible
Mallard	2	negligible	negligible
Pintail	2	negligible	negligible
Grey Plover	3	substantial	substantial
Lapwing	2	negligible	negligible
Ringed Plover	3	minor	minor
Curlew	1	moderate	moderate
Black-tailed Godwit	2	negligible	negligible
Bar-tailed Godwit	3	minor	moderate
Knot	3	minor	moderate
Dunlin	3	minor	moderate
Black-headed Gull	1	not assessed	not assessed

Likelihood of a negative impact: 1 = species shows a variable response to oyster trestles, so a neutral or positive impact may occur; 2 = species considered to show a negative response to oyster trestles but evidence for this is weak; 3 = strong evidence that species shows a negative response to oyster trestles.

Impact magnitude levels are defined in Table 2.2. The confidence level for all impact magnitude assessments is low.

Glin AQUA

Habitats

7.72 The distribution of intertidal habitat in the Glin AQUA is shown in Figure 7.3. This area has a narrow intertidal zone, which mainly consists of mixed sediment/rocky shore habitat (mapped by NPWS as the *fucoid-dominated intertidal reef community complex*). Some intertidal sediment occurs, mainly in the eastern section, although this is not recognised in the NPWS mapping. The Admiralty Chart indicates that there is a steeply shelving shoreline below the intertidal zone and there does not appear to be an extensive area of lower intertidal exposed on spring low tides.

Waterbirds

7.73 The distribution of waterbirds in the WSP counts is shown in Table 7.2. As these are relatively small subsites, the overall numbers recorded for most species were low. However, the area did hold a high percentage of the SPA Ringed Plover population. The mapped flock positions Ringed Plover in these subsites were all in, or on the edge of, areas of intertidal sediment (Figure 7.3).

Table 7.7 - Occurrence and distribution of waterbirds in intertidal habitats in the Glin AQUA during the WSP low tide counts.

Species	Mean % of		Mean count		Non-zero counts
	SPA	LS zone	0I442	0I443	
Whooper Swan	12%	14%	0	1	1
Wigeon	1%	2%	6	10	4
Teal	0%	1%	5	4	4
Mallard	1%	1%	2	1	3
Golden Plover	1%	6%	0	78	2
Grey Plover	0%	0%	0	0	0
Lapwing	1%	1%	0	27	2
Ringed Plover	10%	10%	6	6	4
Curlew	1%	2%	3	25	4
Dunlin	0%	2%	10	30	4
Black-headed Gull	1%	3%	26	8	4

This table shows: (1) the mean of each low tide count in the intertidal and subtidal zones across all the subsites in the Glin AQUA as percentages of the total count across the whole SPA, and across the Lower Shannon zone, respectively; and (2) the mean low tide count in each of the Glin AQUA subsites.

Aquaculture

7.74 The single aquaculture site in the Glin AQUA (T07/13A) is an oyster trestle cultivation site, with an area of 0.72 ha. This site occupies a narrow section of shoreline in the western section of subsite 0I443. Around half of the site is on rocky shore habitat in the mean low tide zone and half is on intertidal sediment habitat in the spring low tide zone.

Impact assessment

7.75 Ringed Plover is a species that is probably completely excluded from areas occupied by oyster trestles. However, the oyster trestle cultivation site in the Glin AQUA is only likely to cause displacement of Ringed Plover on spring low tides as the habitat occupied by the site in the mean low tide zone is rocky shore. The total area of intertidal sediment habitat exposed on spring low tides is around 27 ha and the site will occupy around 1% of this area in a peripheral zone of the habitat. Unlike many other waders, Ringed Plover do not appear to be strongly associated with tideline areas, even in open sandflat habitats. Therefore, the overall displacement impact of development of site T07/13A on Ringed Plover is likely to be negligible.

7.76 All the other waterbird species appear to occur in very low numbers in this area. Therefore, any displacement impacts from development of site T07/13A on these species are likely to be negligible.

Aughinish/Foynes AQUA

Habitats

7.77 The distribution of intertidal habitat in the Aughinish/Foynes AQUA is shown in Figure 7.4. This area has a complex configuration of intertidal habitat. There are extensive areas of intertidal habitat in the open bays between Foynes Island and Aughinish, and between Aughinish and Beagh Castle, as well as upper intertidal habitat along the Robertstown River, Poulaweela Creek and the River Deel. There is a complex mixture of intertidal sediment and mixed sediment/rocky shore habitat, and the mapped extent of these habitat types is a simplification of the true distribution patterns. Significant areas mapped by NPWS as *1140 tidal mudlfats and sandflats* are occupied by *Spartina*

beds and have been excluded from the mapped extent of intertidal habitat used for this assessment. Over most of this area, the mapped extent of the additional intertidal area exposed on spring low tides is quite small, but there is a large area of this zone mapped in area to the east of Aughinish Island. All the soft sediment intertidal habitat in this area is classified as the *intertidal sand to mixed sediment with polychaetes, molluscs and crustaceans community complex* by NPWS.

Waterbirds

7.78 The distribution of waterbirds in the WSP counts is shown in Table 7.2. The Aughinish/Foynes AQUA appears to hold significant components of the SPA populations of a number of waterbird species. In the outer section, the bay to the east of Aughinish Island (subsites 0I437 and 491) appear to hold the main concentrations of waterbirds, while significant numbers of some species occur along Robertstown River and Poulaweela Creek (subsites 0I439 and 436).

7.79 The concentrations of waterbirds indicated by the flock mapping data from the WSP counts does not correspond to the distribution patterns indicated by the count data. There are very few flocks mapped in subsite 0I491, or in the outer parts of 0I437, despite the relatively large numbers of most species that occurred in these subsites, while the distribution between subsites of mapped flocks of several species does not correspond to the relative numbers that occurred in the subsites. This may reflect difficulties in coverage of these areas and could possibly indicate that the outer parts of these subsites were poorly covered.

Table 7.8 - Occurrence and distribution of waterbirds in intertidal habitats in the Aughinish/Foynes AQUA during the WSP low tide counts.

Species	Mean % of		Mean count								Non-zero counts
			outer subsites					inner subsites			
	SPA	LS zone	0I440	0I438	0I437	0I491	0I432	0I439	0I436	0I458	
Shelduck	7%	14%	2	9	11	3	1	4	0	2	4
Wigeon	7%	13%	0	0	27	51	0	4	16	0	4
Teal	10%	15%	11	0	56	50	3	21	79	17	4
Mallard	14%	23%	0	5	23	14	2	5	14	1	4
Golden Plover	2%	6%	0	0	0	42	0	71	0	0	3
Grey Plover	19%	35%	0	0	26	0	1	0	0	3	4
Lapwing	10%	25%	1	0	12	134	7	109	63	0	4
Ringed Plover	2%	2%	0	2	0	0	0	0	0	0	1
Curlew	11%	15%	4	25	22	26	15	35	30	6	4
Black-tailed Godwit	16%	82%	1	2	135	5	14	15	104	1	4
Bar-tailed Godwit	13%	16%	3	1	25	0	0	4	0	0	3
Knot	3%	15%	0	1	0	0	6	0	0	10	4
Dunlin	2%	12%	0	85	83	40	6	2	0	0	4
Black-headed Gull	8%	25%	47	99	40	10	10	71	20	0	4

This table shows: (1) the mean of each low tide count in the intertidal and subtidal zones across all the subsites in the Aughinish/Foynes AQUA as percentages of the total count across the whole SPA, and across the Lower Shannon zone, respectively; and (2) the mean low tide count in each of the Aughinish/Foynes AQUA subsites.

Aquaculture

7.80 There are two aquaculture sites in the Aughinish/Foynes AQUA that occupy intertidal habitat: sites T07/007 and T07/012A.

7.81 Site T07/007 covers an area of 5.6 ha of intertidal habitat within the mean low tide zone on a sandbank off the eastern side of the Aughinish Island. This area was mapped as mixed rock/sediment habitat by Aquafact (2011a). However, aerial imagery indicates that over 80% of the site is soft sediment. This site will be used for oyster trestle cultivation and bouchet pole mussel cultivation.

7.82 Site T07/012A covers an area of 124 ha of mainly intertidal soft sediment habitat in the middle of the bay to the east of Aughinish Island. Over half of the intertidal habitat in this site is within the spring low tide zone. The site also includes small areas of tidal channel habitat that are likely to be permanently flooded. This site will be used for bouchet pole and bottom mussel cultivation. While no details have been provided, it seems reasonable to assume that the bouchet pole cultivation will take place in the higher elevation sections of the site.

Impact assessment

7.83 The assessment of potential impacts from development of sites T07/007 and T07/012A is complicated by lack of information about: the distribution of waterbirds within the large, and heterogeneous subsites that contain the sites; the impacts of bouchet mussel and bottom mussel cultivation on intertidal waterbirds; and the planned division of the activities within the sites. Therefore, a very low degree of confidence applies to all the following assessments given these constraints.

7.84 The two sites together occupy 45 ha of intertidal habitat within the mapped mean low tide zone and further 63 ha of intertidal habitat within the mapped spring low tide zone. This amounts to around 8%, and 17%, respectively of the total mapped extent of intertidal habitat exposed at mean and spring, low tides in subsites 0I437 and 491.

7.85 Of the species that occur in relatively high number in the Aughinish/Foynes AQUA, Grey Plover is probably the most sensitive to potential displacement impacts from the development of sites T07/007 and T07/012A. This species is likely to utilise the type of open intertidal habitat occupied by the aquaculture sites and two of the three mapped flock positions from the WSP counts were adjacent to site T07/007. This species was also shown to be potentially displaced by intertidal longline oyster cultivation, which can be viewed as somewhat analogous to bouchet pole mussel cultivation (see paragraph 7.31). Therefore, the potential displacement impact to this species has been assessed as being substantial at both the SPA and Lower Shannon scales.

7.86 Bar-tailed Godwit is also likely to utilise the outer intertidal habitats occupied by the aquaculture sites, although it may be less sensitive to displacement impacts than Grey Plover (it is not completely excluded from areas occupied by oyster trestles). Therefore, the potential displacement impact to this species has been assessed as being substantial at both the SPA and Lower Shannon scales.

7.87 Black-tailed Godwit also appears to occur in relatively high numbers in the Aughinish/Foynes AQUA, particularly in the Lower Shannon context. However, this species is more likely to be associated with muddier sediments in the inner parts of subsites 0I437 and 491, than with the outer areas occupied by sites T07/007 and T07/012A. Therefore, potential displacement impact to this species has been assessed as being minor at the SPA level, but still being substantial at the Lower Shannon scale due to the relative numbers that occur within this area.

7.88 Knot and Dunlin may also make significant use of the outer intertidal areas occupied by the aquaculture sites, although they appear to be less concentrated in these areas than Grey Plover and Bar-tailed Godwit. The numbers of these species that appear to occur in the Aughinish/Foynes AQUA are very low in the SPA context, but more significant in the Lower Shannon context. Therefore, the potential displacement impacts to these species have been assessed as being negligible at the SPA scale, but moderate at the Lower Shannon scale.

7.89 As discussed above, the potential displacement impact to Black-headed Gull cannot be assessed with any degree of confidence due to lack of appropriate data due to the likely seasonal timing of its peak period of usage of intertidal habitat.

7.90 The other SCI waterbird species that occur in the Aughinish/Foynes AQUA are likely to be mainly associated with the upper/inner intertidal areas (Shelduck, Wigeon, Teal, Mallard, Golden Plover and Lapwing), or widely distributed throughout the area without particular concentrations in the outer intertidal area (Curlew). Therefore, the potential impacts to these species have been assessed as being negligible at the SPA scale and negligible-minor at the Lower Shannon scale, depending upon the relative numbers that occur in this AQUA and the likely degree of concentration in the upper/inner intertidal areas.

Table 7.9 - Assessment of potential displacement impact from intertidal aquaculture in the Aughinish/Foynes AQUA.

Species	Likelihood of negative impact	Assessment of impact magnitude	
		SPA	LS zone
Shelduck	2	negligible	minor
Wigeon	1	negligible	minor
Teal	2	negligible	minor
Mallard	2	minor	moderate
Golden Plover	2	negligible	negligible
Grey Plover	3	substantial	substantial
Lapwing	2	negligible	minor
Ringed Plover	3	negligible	negligible
Curlew	1	negligible	minor
Black-tailed Godwit	2	minor	substantial
Bar-tailed Godwit	3	substantial	substantial
Knot	3	negligible	moderate
Dunlin	3	negligible	moderate
Black-headed Gull	1	not assessed	not assessed

Likelihood of a negative impact: 1 = species shows a variable response to oyster trestles, so a neutral or positive impact may occur; 2 = species considered to show a negative response to oyster trestles but evidence for this is weak; 3 = strong evidence that species shows a negative response to oyster trestles.

Impact magnitude levels are defined in Table 2.2. The confidence level for all impact magnitude assessments is low.

Whooper Swan

7.91 The Whooper Swan wintering population in the Shannon Estuary area mainly forage on agricultural fields outside the River Shannon and River Fergus Estuaries SPA boundary (NPWS, 2012c). However, they have been recorded on tidal habitats within the River Shannon and River Fergus Estuaries SPA during both WSP and I-WeBS counts. In general, Whooper Swan are likely to mainly used tidal habitats as roosting sites, either as disturbance refuges during the day, or as nocturnal roost sites (Gittings and O'Donoghue, 2013, 2016b). In the WSP counts, two of the five records from tidal habitats involved feeding birds. However, all the records on the WSP counts involved

small numbers of birds (1-13 birds) and it is likely that significant numbers of Whooper Swan only use tidal habitats within the River Shannon and River Fergus Estuaries SPA for roosting.

7.92 During the WSP counts, there were two records of Whooper Swan from subsite 0H519, which covers the outer part of Poulnasherry Bay. The records of birds on two of the four low tide counts in Poulnasherry Bay might be interpreted as indicating regular usage of this area. However, during the NPWS bird usage counts, Whooper Swan was only recorded on one out of the 21 counts (547 birds in the south-eastern part of the inner bay on 21st March 2001). During I-WeBS counts, Whooper Swan have only been recorded from Poulnasherry Bay on three counts across the entire period for which data is available, all of which were in the same winter (3-5 birds between 18th October and 31st December 1998). There are also a further three I-WeBS records from the eastern side of the Poulnasherry/Kilrush AQUA, away from any of the aquaculture sites[7]. Therefore, the frequency of records from this area during the WSP counts appears to be misleading, and Whooper Swan does not appear to regularly make use of tidal habitats in Poulnasherry Bay.

7.93 Whooper Swan have also been recorded from the Ballylongford/Bunaclugga, GLIN and Aughinish/Foynes AQUAS, but again the frequency of records is very low: three records from I-WeBS counts in the Ballylongford/Bunaclugga AQUA (2-8 birds); one record from the WSP counts in the GLIN AQUA, and three records from I-WeBS counts in the Aughinish/Foynes AQUA (7-22 birds)[7].

7.94 Overall, therefore, the available data indicates that Whooper Swan does not make regular daytime use of tidal habitats in any of the AQUA areas. However, we do not have any information on the location of the nocturnal roost sites used by Whooper Swan in the Shannon Estuary area.

7.95 The response of Whooper Swan to intertidal aquaculture activity is not known. However, it seems reasonable to assume that Whooper Swan would be deterred from using areas occupied by significant physical structures (such as oyster trestles and bouchet poles), while husbandry activity would be likely to cause disturbance impacts. However, as Whooper Swan do not appear to make significant daytime use of any of the AQUA areas, any such impacts are not likely to significantly affect the daytime habitat use by the SHSAP Whooper Swan population.

7.96 The possibility of aquaculture development affecting nocturnal roost sites used by Whooper Swan cannot be discounted as we have no information on the location of these roost sites.

Disturbance impacts to the intertidal zone from subtidal aquaculture activity

Waterbird species roosting in intertidal and shallow subtidal habitat

7.97 Boat access to/from aquaculture sites, and/or husbandry activity in moderately deep, or deep subtidal habitat could potentially cause disturbance impacts to waterbirds roosting in intertidal and shoreline habitats at high tide. Waterbirds using these types of roosts are typically more sensitive to disturbance than waterbirds roosting in subtidal habitat because the availability of suitable habitat in each roost site is usually tightly constrained. This means that if the birds are disturbed they will often flush and abandon the roost site completely, while birds roosting in subtidal habitat can usually move short distances to a safe distance away from the disturbance source.

7.98 The WSP high tide roost survey identified a number of small roost sites (each holding 1-50 birds) in the outer part of Ballylongford Creek and along the south-eastern shoreline of Ballylongford Bay (Figure 8.1). These sites could potentially be affected by disturbance from boat activity associated

[7] Note that records from I-WeBS counts may include birds on non-tidal habitat.

with travel to/from sites T06/233, T06/394A and T06/394B, and/or husbandry activity in site T06/233.

7.99 The survey also identified a number of mainly small roost sites (each holding 1-50 birds), and one larger roost site (holding 50-99 birds) along the lower part of the River Deel tidal channel and in the outer part of subsite 0I437. These roosts could potentially be affected by disturbance from boat activity associated with travel to/from sites T07/007, T07/012A and T07/014A, and/or husbandry activity in site T07/012A (Figure 8.2).

7.100 The small numbers of birds using these roost sites and the proximity of alternative roost sites that displaced birds could potentially move to, suggest that any such disturbance impacts would not be significant. However, the mapping of high tide roost sites is based on a survey carried out on a single day. Waterbird usage of high tide roost sites can be very variable. There can be significant seasonal variation in roost site usage, while other factors such as the spring-neap cycle and water conditions can affect high roost distribution. Therefore, without more detailed information on usage of high tide roost sites in these areas it is not possible to exclude the possibility that development of sites T06/233, T06/394A, T06/394B, T07/007, T07/012A and T07/014A may cause significant disturbance impacts to important high tide roost sites for the SCI species covered by this assessment.

Waterbirds feeding in intertidal and shallow subtidal habitat

7.101 Boat access to/from aquaculture sites, and/or husbandry activity in moderately deep, or deep subtidal habitat could potentially cause disturbance impacts to waterbirds using intertidal and shallow subtidal habitat at low tide and/or on ebb/flood tides.

7.102 The potential disturbance impacts of boats travelling to/from aquaculture sites are likely to be very minor, as there are only likely to be two movements (at most) per tidal cycle and birds on adjacent intertidal and shallow subtidal habitat can move a short distance away if disturbed and then return when the boat has passed.

7.103 The only sites where husbandry activity could have the potential to cause disturbance to birds using intertidal and shallow subtidal habitat are site T06/233 in the Ballylongford/Bunaclugga AQUA and site T07/014A in the Aughinish/Foynes AQUA.

7.104 Site T06/233 includes intertidal habitat along the south-eastern shoreline of Ballylongford Bay. However, this intertidal habitat is a steeply shelving shingle shore that is likely to only be used by very low numbers of a few species such as Curlew. Therefore, any disturbance impacts to birds using this shoreline would not affect significant numbers of birds.

7.105 Site T06/233 also extends to within around 70-150 m of the mapped extent of intertidal habitat exposed on spring low tides on the western side of Ballylongford Bay. However, it is likely that husbandry activity will not take place on spring low tides as the much of the site would probably not be accessible by boat.

7.106 Site T07/014A extends to within around 10-15 m of the mapped extent of intertidal habitat exposed on spring low tides, and to within around 100 m of the mapped extent of intertidal habitat exposed on mean low tides. However, it is likely that husbandry activity will not take place on spring low tides as the upper parts of the site will probably not be accessible by boat. The intertidal habitat adjacent to this site is within subsite 0I432, and this subsite appears to support relatively low numbers of birds (see Table 7.8).

7.107 Waterbirds using intertidal and shallow subtidal habitat at low tide do not appear to be very sensitive to disturbance from boat activity in adjacent subtidal habitat. For example, in two winters of low tide

surveys in the mussel beds in Castlemaine Harbour, we did not observe any incidences of disturbance to waterbirds in intertidal and shallow subtidal zones from regular mussel dredging activity within a few 100 m of the tideline.

7.108 Therefore, given the nature and distribution the associated boat activity, the nature of the bird utilisation of the areas potentially affected by disturbance and the low sensitivity of waterbirds to disturbance impacts from this type of activity, it can be concluded the development of aquaculture sites in moderately deep and deep subtidal habitat will not cause significant disturbance impacts to waterbirds using intertidal and shallow subtidal habitat at low tide and/or on ebb/flood tides.

Conclusions

7.109 The assessments of potential impacts of intertidal aquaculture in each individual AQUA are summarised in Table 7.10 (SPA scale) and Table 7.11 (Lower Shannon scale). At the SPA scale significant overall impacts are considered likely for Grey Plover and Bar-tailed Godwit, and possible for Light-bellied Brent Goose and Ringed Plover. At the Lower Shannon scale significant overall impacts are considered likely for Grey Plover and Bar-tailed Godwit, and possible for Light-bellied Brent Goose, Ringed Plover, Black-tailed Godwit, Knot and Dunlin. However, it should be noted that for Light-bellied Brent Goose the likelihood of any negative impact occurring is uncertain.

7.110 The potential impact of intertidal aquaculture on Black-headed Gull cannot be assessed at this stage, due to lack of data on Black-headed Gull distribution within the River Shannon and River Fergus Estuaries SPA at the time of its likely peak usage of the area. However, it should be noted that for Black-headed Gull the likelihood of any negative impact occurring is uncertain.

7.111 Intertidal aquaculture is unlikely to significantly affect the daytime habitat use by the River Shannon and River Fergus Estuaries SPA Whooper Swan population, but possible impacts on nocturnal roost sites used by Whooper Swan cannot be discounted due to lack of information.

7.112 The possibility that vessel activity associated with the development of sites T06/233, T06/394A, T06/394B, T07/007, T07/012A and T07/014A may cause significant disturbance impacts to important high tide roost sites for the SCI species covered by this assessment cannot be excluded due to lack of information about the usage of high tide roost sites in these areas.

Table 7.10 - Summary of potential impact magnitudes assessed for each AQUA, and the probability of a significant overall impact, at the SPA scale.

Species	Likelihood of negative impact	AQUA				Probability of significant overall impact
		Ballylongford/ Bunaclugga	Poulnasherry/ Kilrush	Glin	Aughinish/ Foynes	
Light-bellied Brent Goose	1	minor-moderate	moderate	-	-	possible
Shelduck	2	negligible	negligible	-	negligible	unlikely
Wigeon	1	moderate	negligible	negligible	negligible	unlikely
Teal	2	negligible	negligible	negligible	negligible	unlikely
Mallard	2	negligible	negligible	negligible	minor	unlikely
Pintail	2		negligible			unlikely
Golden Plover	2	negligible	-	negligible	negligible	unlikely
Grey Plover	3	minor	substantial	negligible	substantial	likely
Lapwing	2	negligible	negligible	negligible	negligible	unlikely
Ringed Plover	3	moderate-substantial	minor	negligible	negligible	possible
Curlew	1	minor	moderate	negligible	negligible	unlikely
Black-tailed Godwit	2	negligible	negligible	-	minor	unlikely
Bar-tailed Godwit	3	moderate	minor		substantial	likely
Knot	3	negligible	minor		negligible	unlikely
Dunlin	3	negligible	minor	negligible	negligible	unlikely
Black-headed Gull	1	not assessed	not assessed	not assessed	not assessed	not assessed

Likelihood of a negative impact: 1 = species shows a variable response to oyster trestles, so a neutral or positive impact may occur; 2 = species considered to show a negative response to oyster trestles but evidence for this is weak; 3 = strong evidence that species shows a negative response to oyster trestles.

Impact magnitude levels are defined in Table 2.2. The confidence level for all impact magnitude assessments is low.

Table 7.11 - Summary of potential impact magnitudes assessed for each AQUA, and the probability of a significant overall impact, at the LS scale.

Species	Likelihood of negative impact	AQUA				Probability of significant overall impact
		Ballylongford/ Bunaclugga	Poulnasherry/ Kilrush	Glin	Aughinish/ Foynes	
Light-bellied Brent Goose	1	minor-moderate	moderate	-	-	possible
Shelduck	2	negligible	negligible		minor	unlikely
Wigeon	1	moderate	negligible	negligible	minor	unlikely
Teal	2	negligible	negligible	negligible	minor	unlikely
Mallard	2	negligible	negligible	negligible	moderate	unlikely
Pintail	2	-	negligible	-	-	unlikely
Golden Plover	2	negligible	-	negligible	negligible	unlikely
Grey Plover	3	minor	substantial	negligible	substantial	likely
Lapwing	2	negligible	negligible	negligible	minor	unlikely
Ringed Plover	3	moderate-substantial	minor	negligible	negligible	possible
Curlew	1	minor	moderate	negligible	minor	unlikely
Black-tailed Godwit	2	minor	negligible	-	substantial	possible
Bar-tailed Godwit	3	moderate	moderate	-	substantial	likely
Knot	3	negligible	moderate	-	moderate	possible
Dunlin	3	minor	moderate	negligible	moderate	possible
Black-headed Gull	1	not assessed	not assessed	not assessed	not assessed	not assessed

Likelihood of a negative impact: 1 = species shows a variable response to oyster trestles, so a neutral or positive impact may occur; 2 = species considered to show a negative response to oyster trestles but evidence for this is weak; 3 = strong evidence that species shows a negative response to oyster trestles.

Impact magnitude levels are defined in Table 2.2. The confidence level for all impact magnitude assessments is low.

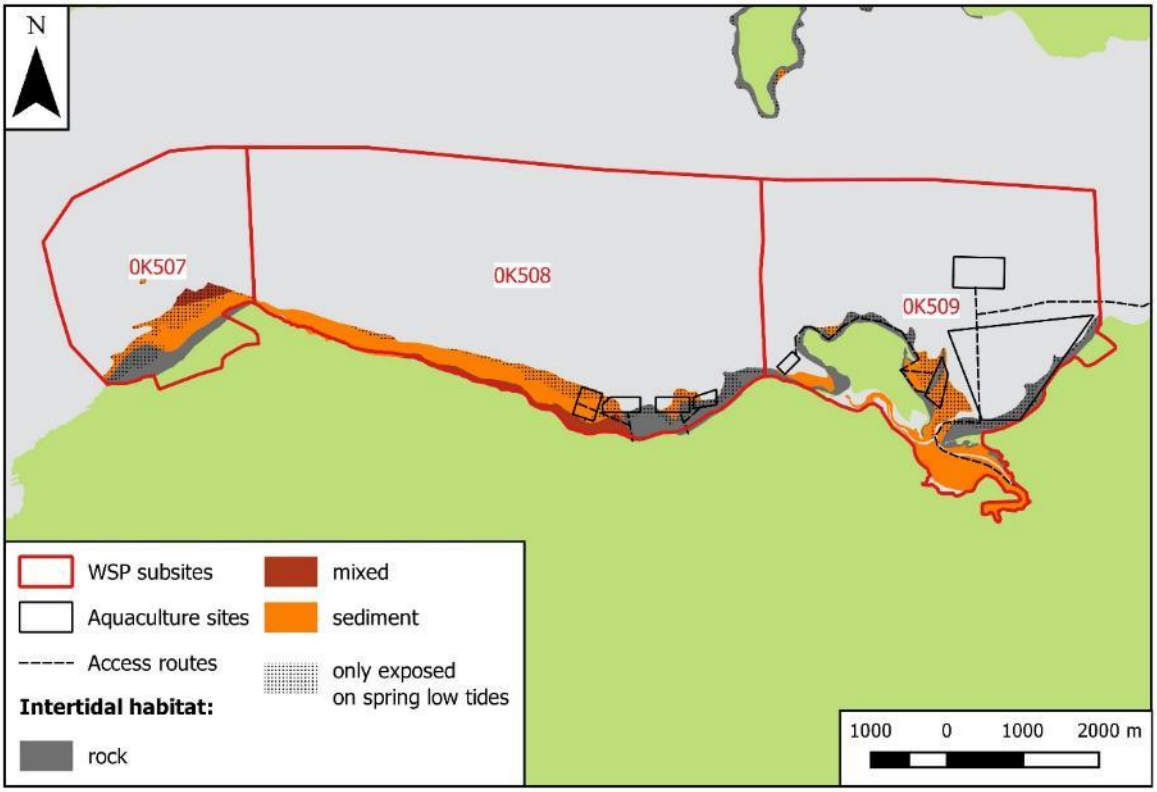

Figure 7.1 Distribution of intertidal habitat in the Ballylongford/Bunaclugga AQUA.

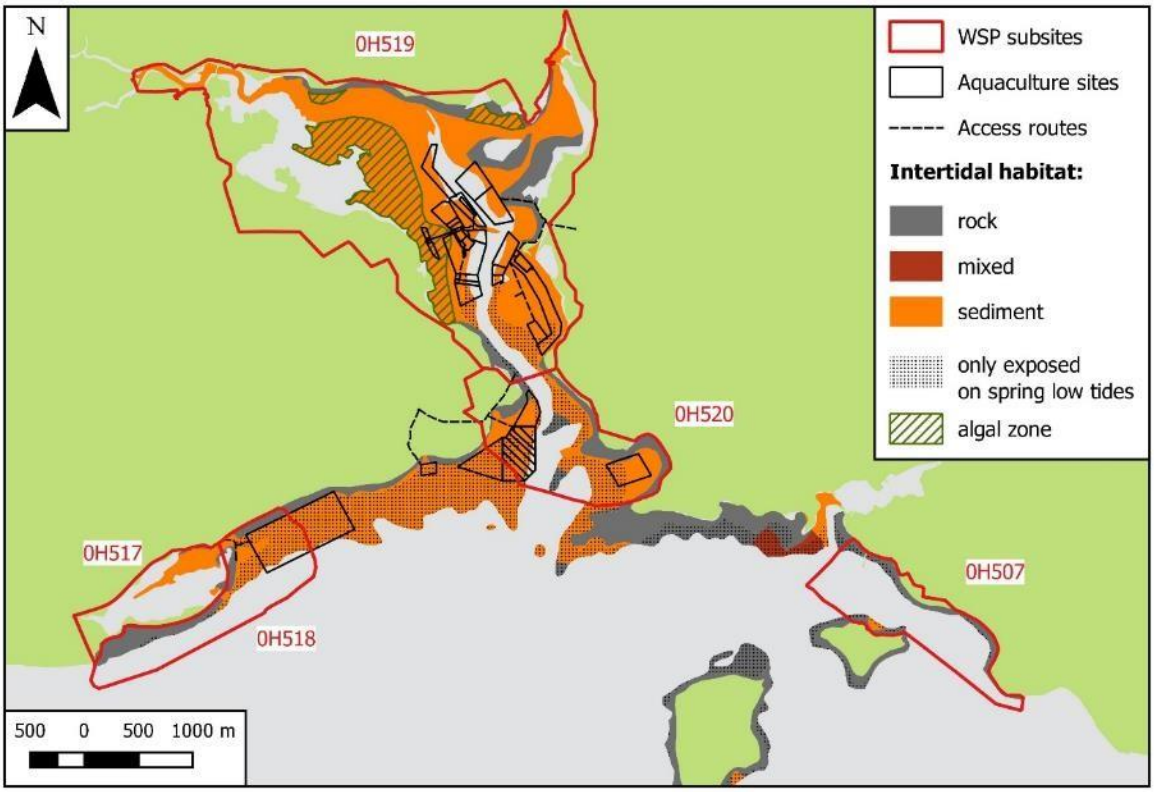

Figure 7.2 Distribution of intertidal habitat in the Poulnasherry/Kilrush AQUA.

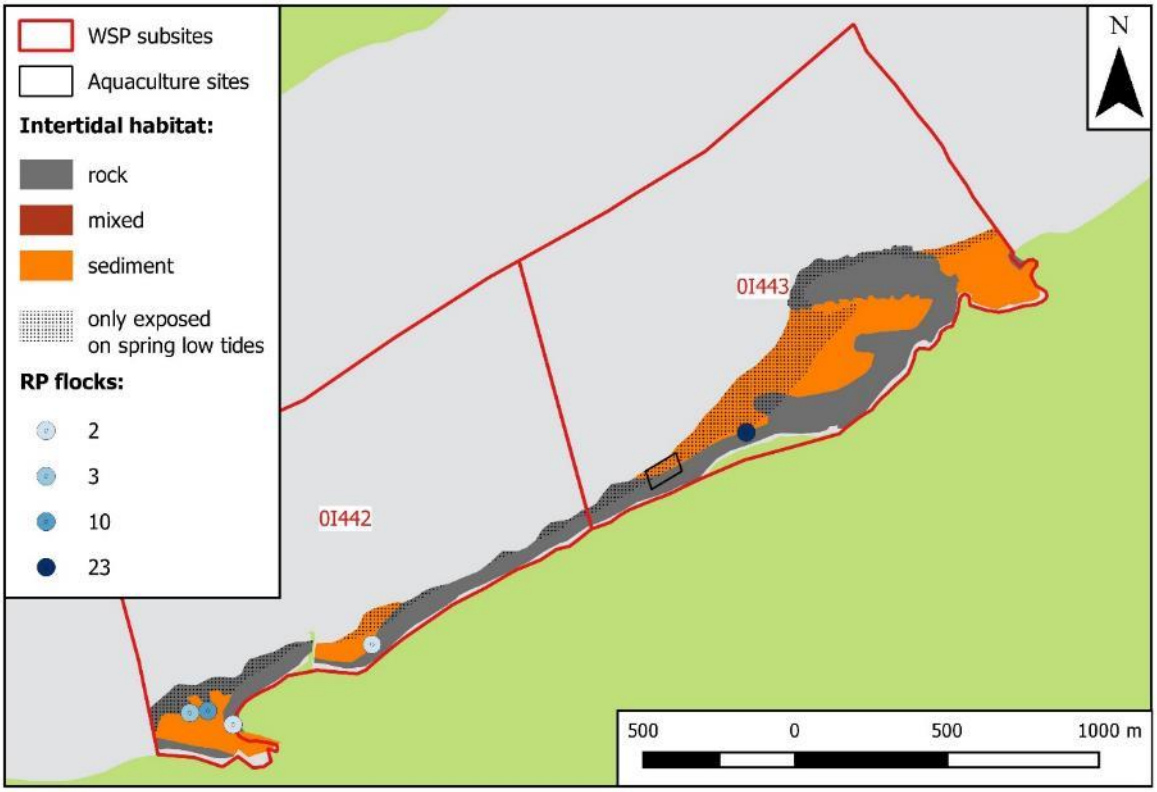

Figure 7.3 Distribution of intertidal habitat in the Glin AQUA.

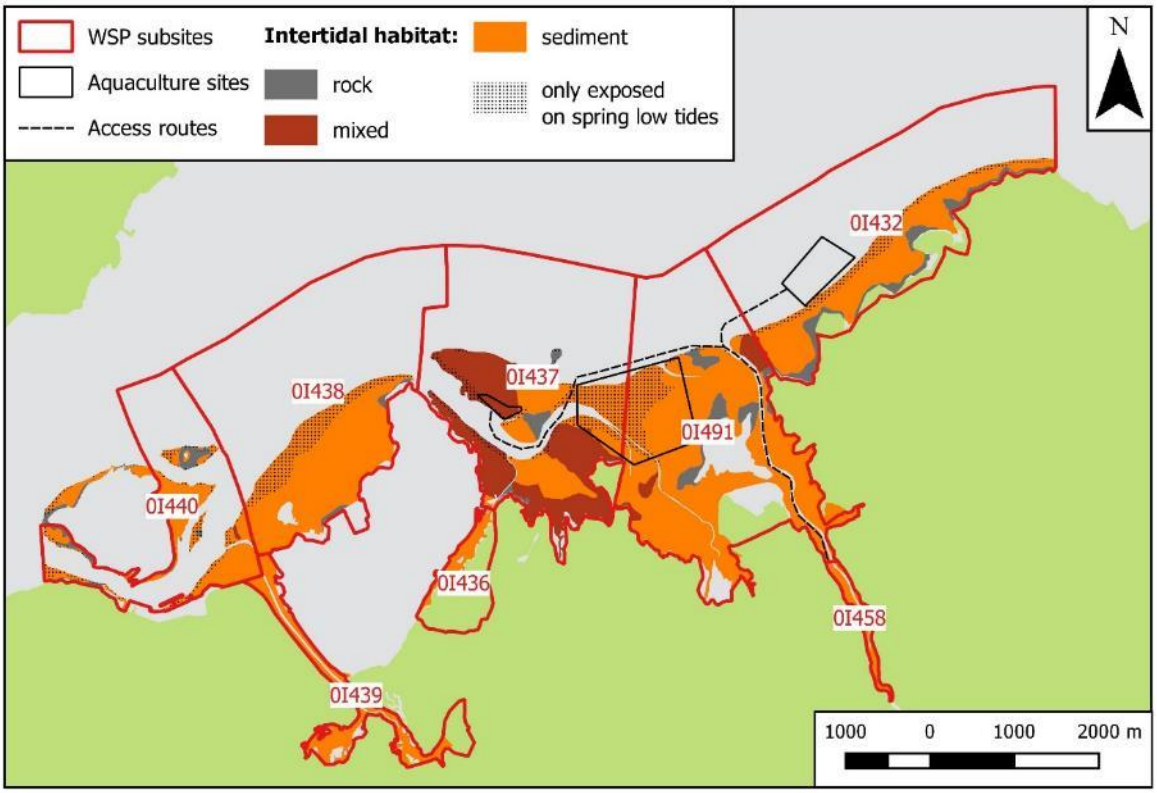

Figure 7.4 Distribution of intertidal habitat in the Aughinish/Foynes AQUA.

8. Assessment of impacts on birds using subtidal habitats

Introduction

8.1 This chapter assesses the potential impacts of aquaculture activity on SCIs using moderately deep, and deep, subtidal habitat. The following SCIs are assessed in this chapter: Whooper Swan, Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Mallard, Pintail, Scaup, Fulmar, Cormorant, Kittiwake, Black-headed Gull and Guillemot.

8.2 This chapter includes assessment of the impacts of intertidal aquaculture activity on SCIs that may potentially use the affected habitat at high tide, as at this time the habitat becomes moderately deep subtidal habitat.

Sites

8.3 There are four aquaculture sites that occupy predominantly, or only, subtidal habitat within the River Shannon and River Fergus Estuaries SPA (Table 4.1). In addition, there are other aquaculture sites that are predominantly within the intertidal zone, but which appear to extend into permanent subtidal habitat, while intertidal aquaculture could potentially also affect birds using subtidal habitat during the high tide period when the sites are flooded.

Table 8.1 - Subtidal aquaculture sites within the River Shannon and River Fergus Estuaries SPA.

AQUA	Site	Type	Area (ha)
Ballylongford/ Bunaclugga	T06/233	Bottom mussels	151
	T06/394A	Mussel longlines and seaweed	18
	T06/394B	Mussel longlines and seaweed	11
Aughinish/ Foynes	T07/014A	Bottom mussels	32

Species

8.4 There are five screened-in SCI species (Scaup, Fulmar, Cormorant, Kittiwake and Guillemot) that are predominantly associated with subtidal habitat. Another two species (Whooper Swan and Black-headed Gull) may make significant use of subtidal habitat for foraging and/or roosting. Other species (Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Mallard and Pintail) utilise shallow subtidal habitat (generally less than 0.5 m deep) as foraging habitat and may also use deeper subtidal habitat for roosting.

Potential impacts

8.5 The potential impacts of the development of aquaculture sites in the intertidal zone on species using shallow subtidal habitat are dealt with in Chapter 7. Therefore, this chapter is mainly concerned with potential impacts on species using moderately deep (0.5-5 m) or deep (> 5 m) subtidal habitat. These impacts may arise either from development of sites in the permanent subtidal zone, or from the impact of intertidal sites when they are flooded at high tide.

Habitat alteration impacts

Bottom mussel culture

8.6 Bottom culture of mussels can be disturbing to certain subtidal biotopes, due to extirpation of the characteristic infaunal species from the area covered by mussels, and, in some cases, the sensitivity of characteristic species to organic enrichment, smothering and/or physical disturbance from dredging (Marine Institute, 2013).

8.7 From a review of the literature (Appendix D), the following general patterns can be identified. Mussel culture beds can increase the diversity and abundance of epibenthic fauna by providing an additional food resource for species that predate on the mussels themselves or other species that may be attracted to the mussel bed to predate on the species that are attracted to the mussel beds for refuge. This change in epibenthic fauna contrasts with a reduction in diversity of infaunal species as increased organic rich sediments deposited by the mussels changes the characteristics of the sediments beneath the culture plot (assuming that deposition rates are high; Francis O'Beirn, Marine Institute, pers. comm.). There is disagreement as to the nature of the effect of mussel beds on the abundance of other filter feeding benthic species: a positive effect, by providing an additional habitat for larvae to establish; or a negative effect, by consuming the larvae of other species that may otherwise occupy the area. In general, it appears the effects of bottom mussel culture have been found to be localised in extent but may persist in time depending in the biotic and abiotic processes operating in the area.

8.8 Increasing the density of mussels has been demonstrated to cause reduced abundance and diversity of invertebrates. This is due to complete dominance of mussels in terms of space and quite likely filtration (competitive exclusion). There is very little reference to fishes in mussel literature and speculation might lead us to assume that tightly packed mussels will result in homogeneous habitat and little provision of refugia for fishes. This scenario would be more likely to refer to natural seed beds found intertidally which would not have been subject to any erosion or stratification due to aging of the mussels in the beds and which would be uniform in terms of age and size. However, if an area comprises patches of mussels (of varying densities) among sandy/muddy habitat then this could provide sufficient complexity of habitat to support a diverse fish assemblage. This scenario is more likely to apply to cultivated mussel beds (Francis O'Beirn, Marine Institute, pers. comm.).

8.9 In Wexford Harbour, which has the most intensive development of this activity in Ireland, analysis of aerial imagery indicates that the second scenario applies to the cultivated mussel beds (Gittings and O'Donoghue, 2016c). Furthermore, the draft SAC assessment for Wexford Harbour (Marine Institute, 2016) states that: "*in Wexford Harbour, mussel culture practices result in a mottled distribution of mussels on the seabed forming in a heterogeneous habitat structure" and that "such a structural arrangement is likely to benefit overall system diversity*" in line with the conclusions of other studies "*that mussel reef systems (on sedimentary habitats), as found in Wexford, enhance habitat heterogeneity and species diversity at the ecosystem level*".

8.10 If the patterns of bottom mussel cultivation in Wexford Harbour are typical of the likely development of this activity in the Shannon, it can be concluded that bottom culture of mussels is unlikely to reduce food resources for benthic invertebrate eating, and/or fish-eating, species.

Bottom oyster culture

8.11 Bottom culture of oysters can be disturbing to intertidal and subtidal biotopes when some of the characteristic species are sensitive to organic enrichment, smothering and/or physical disturbance from dredging (Marine Institute, 2013).

8.12 It is considered unlikely that increases in oyster density (even to 10's per m^2) would impact negatively on fishes. In fact, it is possible that fish production/abundance would increase. The oysters, along with shell '*hash*', provides a low relief habitat that will increase general heterogeneity in overall structure and which has been shown to increase diversity and abundance of fish species. However, it should be noted that these conclusions relate to work conducted on a different oyster species, *Crassostrea virginica* in the US (Francis O'Beirn, Marine Institute, pers. comm.; Lenhert and Allen, 2002; Scyphers, *et. al.*, 2011; Tolley and Volety, 2005).

Suspended mussel culture

8.13 Subtidal mussel culture using longlines or rafts causes a physical alteration to the structure of the subtidal habitat through the placement of physical structures (anchors, longlines and rafts) in the subtidal habitat. It may also cause impacts to benthic invertebrates through sedimentation and eutrophication, and this could potentially affect food resources for waterbird species. However, it is likely to increase the abundance of fish, due to the structures attracting fish, and/or the prey resources provided by the epifauna associated with the structures (McKindsey *et al*., 2011).

Intertidal oyster cultivation

8.14 Dumbauld *et al*. (2009) reviewed studies of the effects of bivalve shellfish aquaculture on nekton (fish and mobile invertebrates such as crabs). There was only one study that specifically examined intertidal oyster cultivation using bags and trestles (Laffargue *et al*., 2006). This study found that, in an experimental pond mesocosm, sole used the oyster trestles as resting areas during the day, moving out into the open areas (which simulated tidal flats) to forage at night and the authors considered that the "*oyster trestles offered cover, camouflage, and safety and were therefore attractive to sole (as artificial reef-structuring effects)*". Similarly, De Grave *et al*., (1998) noted that the trestles in their Dungarvan Harbour study site acted as refuges for scavenging crabs and shrimps. There were also a number of studies reviewed by Dumbauld *et al*. (2009) of related types of oyster cultivation (included suspended culture in subtidal waters, rack and bag systems, longlines and oyster grow-out cages). These all involve placing physical structures in the intertidal or subtidal waters and the potential impacts from organic enrichment and benthic community changes associated with oyster cultivation, so provide some degree of analogous situations to intertidal oyster cultivation using bags and trestles. These have generally found either little differences between oyster cultivation areas and nearby uncultivated habitats, or higher densities of nekton in the oyster cultivation areas.

Disturbance

8.15 Subtidal bottom mussel cultivation, mussel longline cultivation and some of the intertidal cultivation could cause impacts to waterbirds using moderately deep, or deep, subtidal habitat through disturbance associated with husbandry activities and/or travel to/from the sites.

8.16 Both bottom mussel cultivation sites in the Aughinish/Foynes AQUA will be accessed by boat from the River Deel. Relaying at these sites will take place in August-September, while harvesting will take place in October-December on approximately two days per week. On site T07/12, husbandry activities will take place over the high tide period, while at site T07/14, husbandry activities can take place at any stage of the tide. The intertidal oyster cultivation/bouchet mussel cultivation site in the Aughinish/Foynes area will also be accessed by boat from the River Deel. As husbandry activity in this site will presumably take place at low tide, the boat access will presumably be on the ebb and flood tides.

8.17 The mussel cultivation sites in the Ballylongford/Bunaclugga AQUA will be accessed by boat from Ballylongford Creek. The timing of the husbandry activity in the bottom mussel site (site T06/233) will be the same as that for the sites in the Aughinish area. The mussel longline sites will be

accessed once a week to check lines, with harvesting taking place over a 2-3 week period during August and September. All the husbandry activity in the Ballylongford/Bunaclugga AQUA sites can presumably take place at any stage of the tide.

8.18 All the other aquaculture sites are predominantly intertidal sites (with some extending partly into the shallow subtidal zone). These sites will be accessed on foot/by tractor from the shoreline and husbandry activity will take place at low tide. Therefore, no potential impacts to species utilising moderately deep, or deep, subtidal habitat will arise from these sites.

Species responses

8.19 Roycroft *et al*. (2004; 2007) studied the interactions of waterbirds and seabirds (mainly divers, cormorants, gulls and auks) with suspended mussel culture using longlines in deep subtidal habitat in Bantry Bay. This study found no evidence of adverse impacts from suspended mussel culture on waterbirds and seabirds. The mussel sites in Roycroft *et al*.'s study varied in size from 7-43 ha, compared to 11-18 ha in the River Shannon and River Fergus Estuaries SPA sites. While no detail is provided of the level of husbandry activity in the mussel sites in Roycroft *et al*.'s study, it is reasonable to assume, from the size of the sites, that it would be of similar, or greater intensity, compared to the husbandry activity that will take place in the River Shannon and River Fergus Estuaries SPA sites. Roycroft *et al*.'s study included one of the SCI species that feed in subtidal habitat the River Shannon and River Fergus Estuaries SPA (Cormorant), as well as grouped data for gulls (including Black-headed Gull and Kittiwake) and auks (including Guillemot), and provides strong evidence that suspended mussel culture using longlines does not affect Cormorant, Black-headed Gull, Kittiwake or Guillemot. Moreover, the range of species covered by their study provides evidence that fish-eating species in general are not affected by suspended mussel culture, and suspended mussel culture may actually increase prey resources for these species (see above).

8.20 No information is available on the responses of species associated with subtidal habitat to habitat alteration caused by bottom mussel culture, bottom oyster culture or intertidal oyster cultivation. However, there is some evidence that mussel dredging activity associated with bottom mussel culture in Wexford Harbour may cause significant disturbance impacts to Red-breasted Merganser (Gittings and O'Donoghue, 2016a), and possibly some other species (Gittings and O'Donoghue, 2016c).

Assessments

Whooper Swan

8.21 Whooper Swan may use subtidal habitat within the River Shannon and River Fergus Estuaries SPA as disturbance refuges during the day and/or as nocturnal roost sites. The occurrence of Whooper Swan in tidal habitats within the River Shannon and River Fergus Estuaries SPA is reviewed in Chapter 7. Overall, the available data indicates that Whooper Swan does not make regular daytime use of tidal habitats in any of the AQUA areas. Therefore, the development of the subtidal aquaculture sites is not likely to significantly affect the daytime habitat use by the River Shannon and River Fergus Estuaries SPA Whooper Swan population.

8.22 Apart from known roost sites, such as Shannon Lagoon and Ballyalia Lake, there is no information is available on the location of nocturnal roost sites used by the River Shannon and River Fergus Estuaries SPA Whooper Swan population. However, any such roost sites in subtidal habitat are likely to be located in sheltered waters. Therefore, the mussel longline sites (T06/394A and T06/394B) in the Ballylongford/Bunaclugga AQUA, and the bottom mussel site in the Aughinish/Foynes AQUA (T07/014A) are unlikely to provide suitable roost sites. However, the bottom mussel site in the Ballylongford/Bunaclugga AQUA (T06/233) could potentially provide

suitable roosting habitat. In Wexford Harbour, some mussel dredging takes place at night (Gittings and O'Donoghue, 2016c), and the tidally constrained nature of site T06/233 suggests that nocturnal activity may also be required at this site. Whooper Swan are probably more sensitive to disturbance than the other waterbird species considered in this assessment, and birds roosting at night are also more likely to be sensitive to disturbance. Therefore, if Whooper Swan use site T06/233 as a nocturnal roost, night dredging activity in this site could cause significant disturbance impacts.

Scaup

8.23 During the WSP counts, very few Scaup were recorded. They were recorded on all four low tide counts in WSP subsite 0H519, which covers the outer part of Poulnasherry Bay (2-8 birds), and on two counts at Clonderalaw Bay (9-26 birds), which lies on the northern shore of the estuary opposite Tarbert.

8.24 During I-WeBS counts, the areas that produced most records of concentrations of Scaup (defined as counts of ten or more birds) were Clonderalaw Bay (I-WeBS subsite 0H496; 7 records with a mean flock size of 32); Poulnasherry Bay (I-WeBS subsite 0H498; 6 records with a mean flock size of 24); Tarbert-Aughinish (I-WeBS subsite 0I466; 6 records with a mean flock size of 64); and Tarbert Bay (I-WeBS subsite 0I492; 4 records with a mean flock size of 40). In the most recent five winter, most records of Scaup from I-WeBS counts have been from Coonagh Ponds (I-WeBS subsite 0I013; 10 records of 1-3 birds), and there have been single records of single birds from Limerick City (I-WeBS subsite 0I477) and Tarbert Bay (I-WeBS subsite 0I492).

8.25 Overall the available data on Scaup distribution indicate that the most favourable habitat for this species occurs in the outer part of the River Shannon and River Fergus Estuaries SPA. This pattern might appear to be contradicted by the distribution patterns from the most recent I-WeBS counts, but the latter probably just reflect the ease of seeing the species in relatively small, easily viewable, subsites.

8.26 The number of subsite counts of ten or more birds dropped from a mean of 5.0 per winter in 1994/95-1998/99 to 1.2 per winter in 2002/03-2006/07, and there have been no such records since 2006/07. Therefore, the low numbers recorded in the WSP counts appear to reflect a genuine decline in this species in the SPA.

Habitat impacts

8.27 Bottom culture of mussels is likely to cause reduced abundances of other bivalves within the relaid areas, but may cause increased abundances of various crustaceans. In marine habitats Scaup appear to feed predominantly on molluscs (Cramp and Simmons, 2004). However, based on typical sizes of relaid mussel and growth patterns in the bottom mussel culture sites in Wexford Harbour (Gittings and O'Donoghue, 2016c), the relaid mussels are likely to quickly grow above the typical size range consumed by Scaup. Therefore, for the period of time after the relaid mussels have grown out of the size range consumed by Scaup, there is likely to be a reduction in available food resources for Scaup within the relaid mussel beds. This time period will be all, or part, of the first winter following relay and the entire second winter following relay (because even after harvesting it will take a period of time for recovery to occur). Therefore, if the bottom mussel cultivation sites occupy particularly favourable habitat for Scaup, development of the sites could potentially cause some reduction in food resources for Scaup during some of growth cycle of the mussels. However, this could be offset by increased food resources during the early phases of the growth cycle (if the sites do not currently contain natural mussel beds providing similar resources).

8.28 The bottom mussel sites do not occur in any of the areas identified above as being particularly favourable for Scaup, although the limitations of the data have to be acknowledged. However, if suitable Scaup habitat is widely distributed throughout the lower sections of the SPA, then the area

occupied by the bottom mussel sites will be a very small proportion of the overall extent of the habitat.

8.29 The suspended mussel sites occur in water depths of greater than 5 m, so these sites are unlikely to provide suitable foraging habitat for Scaup.

8.30 The potential impact of intertidal oyster culture on benthic prey resources for Scaup at high tide is not known. The research discussed above (see paragraphs 8.6-8.10) suggests that intertidal oyster culture in Ireland generally does not cause large changes to benthic communities and should not, therefore, have significant effects on the availability of food resources for Scaup. However, it is possible that the trestles may impede access to the benthic habitat for diving birds. This could potentially have a significant impact on Scaup, which mainly feeds in the benthic zone. There are a number of intertidal oyster cultivation sites in Poulnasherry Bay. This area appears to be particularly favourable habitat for Scaup. The sites probably occupy around 15-30% of the total area of suitable habitat at high tide in Poulnasherry Bay. Therefore, if oyster trestles impede access to benthic habitat, the development of these sites could cause a significant reduction in the availability of suitable foraging habitat for Scaup in one of the main sites for the species in the SPA.

Disturbance impacts

8.31 Scaup numbers in Ireland generally peak in late winter (January-March), with very few occurring in the autumn (September-October) (Crowe, 2005). Therefore, the potential period of occurrence for Scaup in the SPA is unlikely to significantly overlap the seed relaying period, or the mussel longline harvesting period. There will be some overlap with the bottom mussel harvesting period. Also, weekly boat access to/from the mussel longline sites and regular access to/from intertidal oyster cultivation/bouchet mussel cultivation sites in the Aughinish/Foynes AQUA will take place throughout the winter. There will be no potentially disturbing to Scaup husbandry activity in the Poulnasherry/Kilrush AQUA. Overall, the scale, timing and distribution of husbandry activity associated with the aquaculture activity in the SPA is not likely to cause significant disturbance impacts to Scaup.

Conclusion

8.32 The potential for intertidal oyster cultivation to cause significant impacts to the availability of suitable foraging habitat for Scaup in the Poulnasherry/Kilrush AQUA cannot be excluded due to lack of knowledge about the effects of oyster trestles on Scaup foraging behaviour.

8.33 None of the other aquaculture activities covered by this assessment are likely to cause significant impacts to availability of suitable foraging habitat for Scaup, or to cause significant disturbance impacts to Scaup.

Cormorant

Distribution patterns

8.34 Cormorant is listed as a SCI of the River Shannon and River Fergus Estuaries SPA for both its breeding and wintering populations. The breeding colony is located at the eastern end of the SPA. The likely core foraging range of birds from this colony does not include any of the aquaculture sites, although some of the sites in the Aughinish/Foynes AQUA may be within the outer part of the foraging range (Figure 5.2).

8.35 Wintering birds are widely distributed throughout the SPA, although the WSP show concentrations of birds in certain areas, reflecting the presence of daytime roosting aggregations (see below).

Habitat impacts

8.36 Cormorant are fish-eating birds. In general bottom mussel, suspended mussel and intertidal oyster cultivation is likely to either have no effect on, or increase local abundances of fish (see paragraphs 8.6-8.14). Therefore, development of the aquaculture sites are not likely to have negative effects on the availability of food resources for Cormorant within the River Shannon and River Fergus Estuaries SPA.

Disturbance

8.37 Cormorant foraging in subtidal habitat tend to be widely dispersed, although occasional aggregations of feeding birds may occur. The boat activity associated with the development of the aquaculture sites in the River Shannon and River Fergus Estuaries SPA will only cause limited potential disturbance of small areas at any one time (e.g., a radius of 100-200 m around the boat). The Bantry Bay study (Roycroft *et al*., 2004, 2007; see paragraph 8.19) shows that the typical levels of husbandry activity associated with suspended mussel cultivation sites of similar size to those proposed for the River Shannon and River Fergus Estuaries SPA does not cause significant disturbance impacts to Cormorant using subtidal habitat. In Wexford Harbour, foraging Cormorant do not appear to show strong disturbance responses to vessel activity associated with bottom mussel culture (Gittings and O'Donoghue, 2016c). A similar, or lesser, level of activity as in the Bantry Bay study, and a lesser level of activity compared to Wexford Harbour, will be involved in the development of the bottom mussel cultivation sites, and access to the intertidal oyster cultivation/bouchet pole sites in the Aughinish/Foynes AQUA. Therefore, a similar lack of disturbance impacts can be predicted.

8.38 Cormorant daytime roosts in intertidal habitat, or night-time roosts in shoreline habitats, would be more sensitive to potential disturbance impacts. The distribution of these roost sites in the River Shannon and River Fergus Estuaries SPA is not known (apart from roosts mapped in the high tide roost survey, which will only represent a sample of the range of roost sites used). Small daytime roosts of 5-20 Cormorant are likely to be widely distributed but disturbance to such roost sites would not be significant as the birds could easily move to a nearby alternative roost site. However, there may be a small number of larger daytime roost sites, which may function, in part, as pre-roost gatherings for the night time roosts, and disturbance to such roost sites might be more significant.

8.39 During the WSP counts, significant numbers of roosting birds were not recorded in any of the subsites containing aquaculture sites, or containing boat access routes to aquaculture sites, indicating that important daytime roosts do not occur in the vicinity of these sites.

8.40 Cormorant night roosts generally occur along tree-lined shores, or secure areas of cliffs/rocky shores where the birds will be secure from disturbance and will not have to move in response to the tide during the night. While the distribution of Cormorant night roosts in the SPA is not known, none of the aquaculture sites occur in close proximity to shoreline areas that would be potentially suitable as night roost sites.

Conclusion

8.41 None of the aquaculture activities covered by this assessment are likely to cause significant impacts to availability of suitable foraging habitat for Cormorant, or to cause significant disturbance impacts to Cormorant.

Black-headed Gull

Distribution patterns

8.42 Black-headed Gull is widely distributed within the SPA.

Habitat impacts

8.43 Black-headed Gull have a wide and variable diet, but birds foraging in moderately deep and deep subtidal habitat within the River Shannon and River Fergus Estuaries SPA are likely to be predominantly feeding on fish. In general, bottom mussel, suspended mussel and intertidal oyster cultivation is likely to either have no effect on, or increase local abundances of fish (see paragraphs 8.6-8.14). Therefore, development of the aquaculture sites are not likely to have negative effects on the availability of subtidal food resources for Black-headed Gull within the SPA.

8.44 The potential impact of development of the aquaculture sites on intertidal food resources for Black-headed Gull within the River Shannon and River Fergus Estuaries SPA is assessed in Chapter 7.

Disturbance

8.45 Black-headed Gull foraging in subtidal habitat tend to be very tolerant of human activity, often following boats and aggregating around fishing discards, etc. In Wexford Harbour, we have observed Black-headed Gull following mussel dredgers while they were dredging for mussels (Gittings and O'Donoghue, 2016c). The Bantry Bay study (Roycroft *et al*., 2004, 2007; see paragraph 8.19) shows that the typical levels of husbandry activity associated with suspended mussel cultivation sites of similar size to those proposed for the SPA does not cause significant disturbance impacts to Black-headed Gull using subtidal habitat. As a similar, or lesser, level of activity will be involved in the development of the bottom mussel cultivation sites, and access to the intertidal oyster cultivation/bouchet pole sites in the Aughinish/Foynes AQUA, a similar lack of disturbance impacts can be predicted.

8.46 Flocks of roosting gulls can be flushed by human activity, but the birds will generally resettle nearby (unless there is a high level of very intense activity). In Cork Harbour, the main gull roost (which can hold in excess of 20,000 Black-headed Gulls) occurs in Lough Mahon, extending from the lower part of the River Lee channel, adjacent to Tivoli Docks, across Lough Mahon to the outer part of the Douglas Estuary and the Little Island and Rochestown shores. This roost occurs around the shipping channel into Tivoli Docks. Passage of large ships through the roost causes some localised movements of birds, but does not cause any major spatial displacement of birds and does not cause significant disturbance effects to the roost (Tom Gittings, personal observations). Therefore, development of the aquaculture sites is not likely to cause significant disturbance impacts to Black-headed Gull roosts within the River Shannon and River Fergus Estuaries SPA.

Conclusion

8.47 None of the aquaculture activities covered by this assessment are likely to cause significant impacts to availability of suitable subtidal foraging habitat for Black-headed Gull, or to cause significant disturbance impacts to Black-headed Gull roosting in subtidal habitat.

Other species

Roosting wildfowl in moderately deep, or deep, subtidal habitat

8.48 Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Mallard and Pintail may use moderately deep, or deep subtidal habitat, as roosting sites, particularly where such habitat can provide secure

disturbance refuges close to important foraging areas. Therefore, such usage is most likely to occur in areas of sheltered waters that lie offshore from areas of intertidal and shallow subtidal habitat that hold significant concentrations of these species.

8.49 Site T06/233 in the Ballylongford/Bunaclugga AQUA provides potentially suitable conditions for this type of usage. The other sites in moderately deep, or deep subtidal habitat are too exposed and/or too distant from important intertidal and shallow subtidal habitat to be likely to be used in this way to any significant extent. However, even if site T06/233 is used in this way, the scale and level of husbandry activity within this site, relative to the size of the site, mean that any disturbance impacts are unlikely to be significant.

Seabirds

8.50 Three seabird species, which are SCIs of SPAs outside the Shannon Estuary, have been screened in for this assessment, because the aquaculture sites in the Shannon Estuary are within their potential foraging ranges. These are Fulmar, which is a SCI of the Kerry Head SPA, and Kittiwake and Guillemot, which are SCIs of the Loop Head SPA.

8.51 These seabird species all feed in subtidal habitat and generally do not come into tidal inlets, enclosed bays, etc. Therefore, the only aquaculture sites that could potentially overlap habitat regularly used by these species within the River Shannon and River Fergus Estuaries SPA are the mussel longline sites in the Ballylongford/Bunaclugga AQUA (sites T06/394A and T06/394B) and the subtidal bottom mussel cultivation site in the Aughinish/Foynes AQUA (site T07/014A). In addition, the oyster bottom cultivation sites in the Carrigaholt AQUA (sites T08/076A, T08/076B and T08/092A) could potentially overlap habitat regularly used by these species.

8.52 Fulmar, Kittiwake and Guillemot are all fish-easting species. In general, bottom mussel, bottom oyster and suspended mussel cultivation is likely to either have no effect on, or increase local abundances of fish (paragraphs 8.6-8.14). Therefore, development of these aquaculture sites are not likely to have negative effects on the availability of subtidal food resources for these species within the Shannon Estuary.

8.53 The Bantry Bay study (Roycroft *et al*., 2004, 2007; see paragraph 8.19) shows that the typical levels of husbandry activity associated with suspended mussel cultivation sites of similar size to those proposed for the SPA does not cause significant disturbance impacts to Kittiwake and Guillemot using subtidal habitat. As a similar, or lesser, level of activity will be involved in the development of the bottom mussel and oyster cultivation sites, a similar lack of disturbance impacts can be predicted.

8.54 Fulmar was not covered by the Bantry Bay study. However, as Fulmar is considered to have a lower sensitivity to disturbance than Kittiwake or Guillemot (Furness *et al*., 2013), a similar lack of disturbance impacts can also be predicted for this species.

Conclusions

8.55 Any night time activity occurs in site T06/233 could reduce the potential suitability of this site as a Whooper Swan nocturnal roost site.

8.56 The potential for intertidal oyster cultivation in the Poulnasherry/Kilrush AQUA to cause significant impacts to the availability of suitable foraging habitat for Scaup cannot be excluded due to lack of knowledge about the effects of oyster trestles on Scaup foraging behaviour (noting that trestles extend in subtidal waters).

8.57 No other potentially significant impacts were identified from the activities assessed in this chapter.

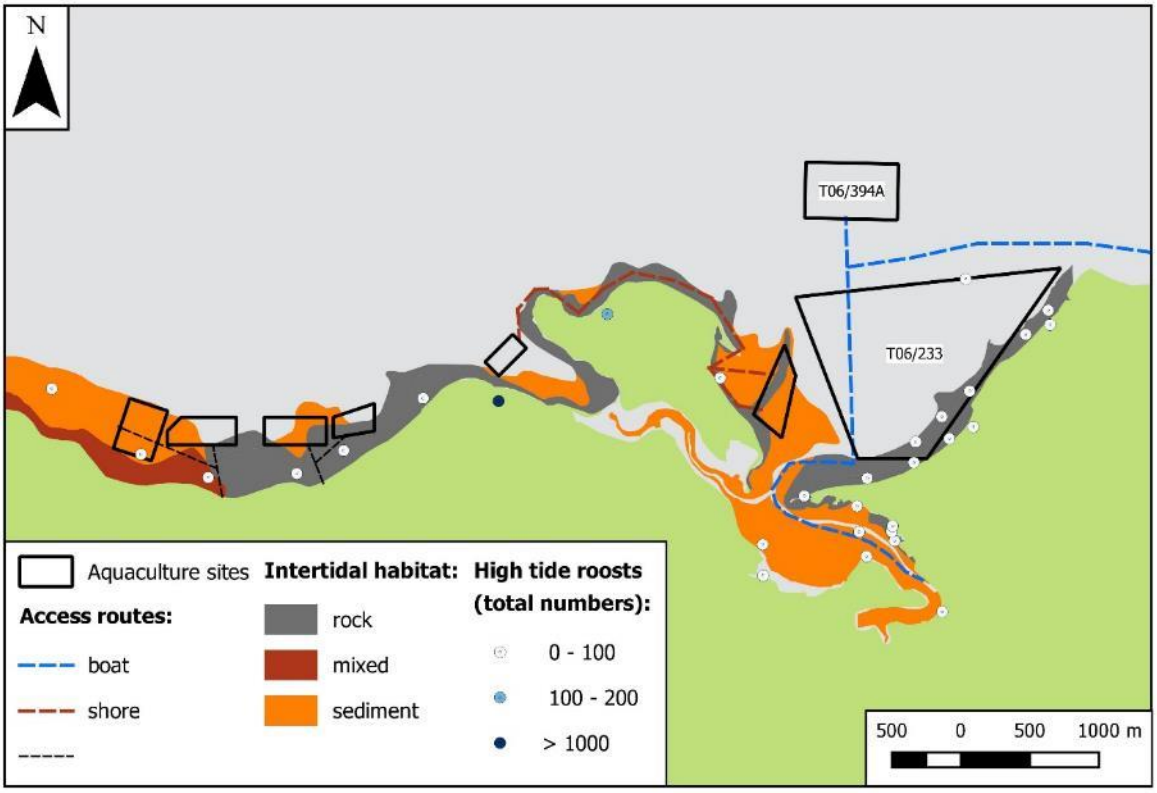

Figure 8.1 High tide roosts recorded in the Ballylongford/Bunaclugga AQUA by the WSP roost survey.

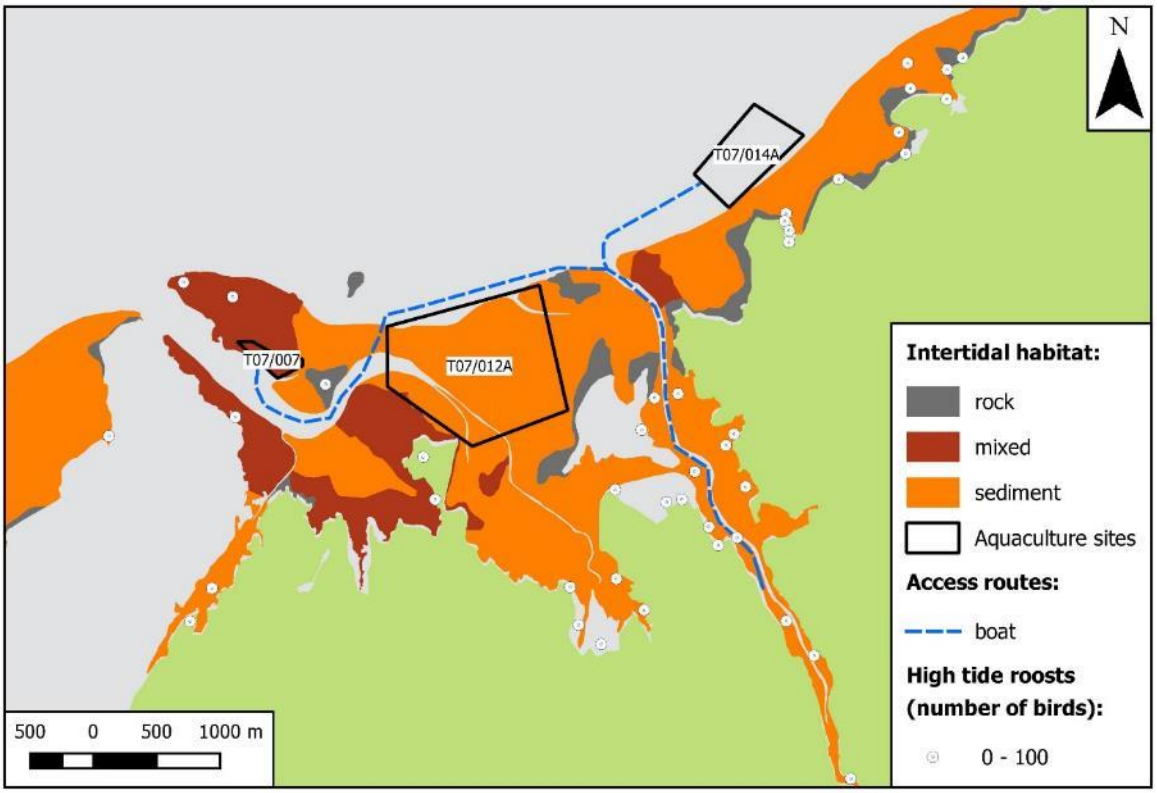

Figure 8.2 High tide roosts recorded in the eastern part of the Aughinish/Foynes AQUA by the WSP roost survey.

9. Assessment of cumulative impacts

Introduction

9.1 This chapter examines the potential for cumulative impacts from the aquaculture activities covered by this assessment in combination with other relevant activities. The chapter first considers two specific issues with particular relevance to this assessment: Fishery Orders, which permit additional aquaculture development in the River Shannon and River Fergus Estuaries SPA; and the Strategic Integrated Framework Plan for the Shannon Estuary, which provides the framework for the development of various marine-related industries and activities in and around the River Shannon and River Fergus Estuaries SPA. The chapter then reviews a wide range of other activities that occur in the Shannon Estuary and which have potential for impacts on waterbird populations.

Fishery Orders

Habitats and aquaculture activities

9.2 There are three areas within the River Shannon and River Fergus Estuaries SPA covered by Fishery Orders (Figure 9.1). The following is a description of the habitats and aquaculture activities in these areas. The description of the aquaculture activities is based on information supplied by BIM.

9.3 Fishery Order T8/004A is located in the middle section of the Lower Shannon waterbody and occupies a total area of 3,515 ha (Figure 9.2). Most of the area covered by this order comprises subtidal habitat with generally narrow hard substrate intertidal zones along both shores with a few small bays containing areas of soft sediment intertidal habitat. A more extensive intertidal area, with soft sediment habitat, occurs in Tarbert Bay. Currently one producer is working this Fishery Order. Around 34 ha are being utilised for the relaying of seed and half grown oysters, which are then harvested once they reach commercial size. No information is available on the location that is currently being used. However, from the description of the activity provided, we have assumed that the current activity takes place in the subtidal zone. As no information has been provided on plans to expand activities in this Fishery Order we have assumed that no such expansion will occur.

9.4 Fishery Order T8/004B is located in the outer section of the Lower Shannon waterbody and occupies a total area of 4,548 ha (Figure 9.3). Most of the area covered by this order comprises subtidal habitat with only very narrow mainly hard substrate intertidal zones along the northern shoreline and around Scattery and Inishbig Islands. This Fishery Order does not include any intertidal habitat along the southern shoreline. One producer has leased the entire area and plans to use different methods of oyster cultivation in various places depending on the suitability of the areas for the cultivation methods. These methods may include: rafts, longlines, floating flupsys[8], bottom culture, trestles, and tidal and sub-tidal frames. Based on the information provided, we have assumed that there is no current activity within this Fishery Order.

9.5 Fishery Order T8/008 is located in the lower section of the inner part of Poulnasherry Bay and occupies a total area of 40 ha (Figure 9.4). The area covered by this Fishery Order is mainly occupied by soft sediment intertidal habitat, with a permanent tidal channel running through the middle of the area. Around 25% of the order area is currently being used for oyster trestle cultivation. Potentially, in the future all the order area may be utilised, apart from, presumably, the tidal channel.

[8] floating upweller system.

Potential in-combination effects

9.6 Fishery Order T8/008 is located within Poulnasherry Bay and includes around 28 ha of intertidal habitat. The assessment of oyster trestle cultivation in the aquaculture sites in Poulnasherry Bay concluded that the potential displacement impacts could be substantial to Grey Plover, moderate to Light-bellied Brent Goose (but with a low likelihood), minor-moderate for Bar-tailed Godwit, Knot and Dunlin, and minor for Ringed Plover (see Chapter 7; Table 7.6). Full utilisation of the Fishery Order, combined with full development of the aquaculture sites, would substantially increase the percentage occupancy of intertidal habitat by oyster trestle cultivation in Poulnasherry Bay (Table 9.1). Therefore, the potential cumulative effects of oyster trestle cultivation in Fishery Order T8/008 in combination with oyster trestle cultivation in the aquaculture sites in Poulnasherry Bay is likely to increase the already potentially substantial impacts to Grey Plover, and could potentially cause significant impacts to other species.

Table 9.1 - Comparison of the percentage occupancy of intertidal habitat in Poulnasherry Bay by full development of the aquaculture sites only and full development of the aquaculture sites and the Fishery Order area.

Scenario	Tidal zone	% occupancy of intertidal habitat by:	
		aquaculture sites only	aquaculture sites and fishery order area
including algal zone	mean low tide	12%	16%
	spring low tide	18%	26%
excluding algal zone	mean low tide	16%	22%
	spring low tide	24%	35%

9.7 Oyster trestle cultivation in Poulnasherry Bay may also cause a reduction in the availability of foraging habitat for Scaup (see Chapter 8). The recorded distribution of Scaup in the WSP counts was in the outer part of the bay (subsite 0H520), outside the area occupied by Fishery Order T8/008. However, from general knowledge of Scaup habitat usage and distribution patterns, it seems likely that they would, at times, come into the lower part of the inner bay. Therefore, there is potential for the cumulative effects of oyster trestle cultivation in Fishery Order T8/008 in combination with oyster trestle cultivation in the aquaculture sites in Poulnasherry Bay to cause increased impacts to Scaup.

9.8 Fishery Order T8/004A only includes one significant area of intertidal habitat (Tarbert Bay), but the current activities within this Fishery Order area do not affect intertidal habitat. Fishery Order T8/004B does not include any significant areas of intertidal habitat. Therefore, the current and planned activities for Fishery Orders T8/004A and T8/004B in combination with development of the aquaculture sites covered by this assessment are not likely to cause significant cumulative impacts to waterbirds using intertidal habitat.

9.9 Fishery Orders T8/004A and T8/004B include large areas of subtidal habitat. Bottom culture of oysters occurs in T8/004A and is planned for T8/004B. There does not appear to be any information available about the suitability of oysters as a food resource for Scaup, but the name Scaup derives from its habit of feeding on beds of oyster and mussel shells, which were called *scawp* (Yarrell, 1845). Therefore, oyster beds may provide suitable foraging habitat for Scaup, but, if this is the case, the ducks will presumably only be able to feed on small oysters or other associated mollusc species. This means that bottom culture of oysters could potentially have complex effects on habitat quality for Scaup in a similar way to that discussed for bottom culture of mussels (see Chapter 8), with the balance between potential positive and negative effects depending on the timing of the growth of the relaid mussels in relation to the size classes that can be consumed by Scaup. Tarbert Bay in Fishery Order T8/004A is one of the areas that has held concentrations of Scaup in the past

(see Chapter 8). Therefore, depending upon the locations used and the net balance between potential positive and negative effects, there is potential for the cumulative effects of bottom culture of oysters in Fishery Orders T8/004A and T8/004B in combination with oyster trestle cultivation in the aquaculture sites in Poulnasherry Bay to cause increased impacts to Scaup.

9.10 Vessel activity associated with subtidal aquaculture activity in Fishery Orders T8/004A and T8/004B could cause disturbance to various waterbird species (see Chapter 8). However, without details of the likely extent and intensity of such activity it is not possible to assess these potential impacts.

Strategic Integrated Framework Plan for the Shannon Estuary

9.11 The Strategic Integrated Framework Plan for the Shannon Estuary *"is an inter-jurisdictional land and marine based framework plan to guide the future development and management of the Shannon Estuary*" (SIFP, 2013). The plan was developed by Clare County Council, Kerry County Council, Limerick City and County Councils, Shannon Development and the Shannon Foynes Port Company.

9.12 The plan includes general strategic policies as well as identification of specific land/marine areas for potential development of marine-related industry, tidal energy and aquaculture.

9.13 A number of the general policies within the plan have potential for impacts on waterbird SCIs of the River Shannon and River Fergus Estuaries SPA. These include policies supporting the growth of shipping movements (SPN 1.1), promoting the development of marina facilities (MTL 1.6), encouraging the expansion of marine based recreational activities (MTL 1.7), encouraging the development of sustainable commercial fishing and aquaculture activities (CPA 1.2), and supporting the provision of appropriate infrastructure for fishing and aquaculture activities (CPA 1.4).

9.14 The plan includes the identification of nine strategic development locations for marine-related industry, four areas of opportunity for tidal energy development and eight areas of opportunity for aquaculture (Figure 9.5). The strategic development locations are all land-based sites adjacent to the Shannon Estuary. The areas of opportunity for tidal energy development largely occur in subtidal habitat in the outer part of the estuary. However, the Tarbert Bay area of opportunity includes most of the intertidal habitat within the bay. The areas of opportunity for aquaculture largely reflect the distribution of the aquaculture sites assessed in the present report, so the potential impacts of the development of these sites have already been assessed. However, the area of opportunity at Clonderlaw Bay would represent an additional area of aquaculture development and could potentially affect a large area of intertidal habitat.

9.15 The plan also includes specific policies to ensure compliance with the Habitats Directive and other environmental legislation, and a Habitats Directive Assessment and a Strategic Environmental Assessment (RPS Group, 2013a, b) of the plan have been carried out. Because of the strategic nature of the plan, many of the potential impacts will need to be assessed by project-specific assessments. Therefore, there is limited scope to assess the potential cumulative impacts of the plan in-combination with the development of the aquaculture sites assessed in the present report.

9.16 The promotion of commercial shipping and growth in marine-related recreational activity, the development of the strategic locations for marine-related industry and the development of the areas of opportunity for tidal energy will mainly affect either offshore subtidal areas or adjacent terrestrial habitat. Therefore, they all generally have limited potential for impact on waterbird SCIs of the SPA as most of the waterbird SCIs are associated with intertidal and shallow subtidal habitat. However, there will be potential for disturbance impacts depending upon the specific details of the activities or developments. More specifically, there is also potential for impact on habitats used by field-feeding waterbirds from the development of the strategic locations for marine-related industry, while development of the Tarbert Bay area of opportunity for tidal energy could affect a significant area

of intertidal habitat. While aquaculture development in most of the areas of opportunity has already been assessed in the present report, the area of opportunity at Clonderlaw Bay would represent a significant expansion of aquaculture activity with the potential for significant impacts on waterbird SCIs of the River Shannon and River Fergus Estuaries SPA.

9.17 Based on the above, the main potential actions in the Strategic Integrated Framework Plan for the Shannon Estuary where there is potential for cumulative impacts in-combination with the development of the aquaculture sites assessed in the present report are the development of Tarbert Bay area of opportunity for tidal energy and the expansion of aquaculture activity into Clonderlaw Bay. While the development of the strategic locations for marine-related industry could have impacts on habitats used by field-feeding waterbirds, the potential for cumulative impacts is limited because the species most likely to be affected were generally assessed as having negligible risks of impact from development of the aquaculture sites.

Other activities

Disturbance generating activities

Types and distribution of activities

9.18 An indicative map of the general distribution of activities likely to cause disturbance to waterbirds across the River Shannon and River Fergus Estuaries SPA is shown in Figure 9.6.

9.19 Beach recreation areas occur in the outer part of the River Shannon and River Fergus Estuaries SPA. Beale Strand is an extensive sandy beach along the southern shore from Beal Point to Bunaclugga Bay. This beach is listed on the Discover Ireland and Wild Atlantic Way websites, but there is minimal development of tourism infrastructure indicating a relatively low degree of usage. Cappa Beach is a small rocky beach adjacent to Kilrush. This beach is a Blue Flag beach and has a lifeguard during the bathing season. There is also a small sandy beach at Doonaha on the northern shore west of Poulnasherry Bay. Elsewhere in the River Shannon and River Fergus Estuaries SPA, there is generally rather limited public access to the shoreline and the nature of the sediments do not provide attractive conditions for beach recreation. However, there is likely to be some degree of local, small-scale, recreational activity where public roads provide access to sections of shoreline with suitable conditions for walking. During the WSP counts, 28 instances of recreational activity (walking along the shoreline and/or dogs) were recorded. These were widely scattered throughout the River Shannon and River Fergus Estuaries SPA. Curiously, the subsite with the most frequent level of this activity recorded was 0H535 which is located on the northern shore at Mountshannon West, between Labasheeda Bay and Clonderlaw Bay, and which does not appear to have any particular features likely to attract recreational activity. However, the analysis by NPWS (2012c) indicated that subsite 0I428, in the Upper Shannon waterbody, had the highest potential disturbance impact from this activity due to the “frequency of occurrence and the regular presence of loose dogs in this subsite”.

9.20 No bait digging or hand collection of shellfish activity (such as winkle picking) was recorded during the WSP counts. However, winkle picking was recorded in Poulnasherry Bay on all four of the trestle study counts in January and February 2011, and on site visits in October 2010 and March 2017, and in Bunaclugga Bay on site visits in September 2010 and February 2017. Seven bait point locations are mapped in the outer part of the River Shannon and River Fergus Estuaries SPA by IFI (undated). Both these activities are likely to be widespread in suitable areas throughout the River Shannon and River Fergus Estuaries SPA but the lack of records from the WSP counts indicate that they do not occur at high intensity. Shore fishing is probably also widespread throughout most

of the River Shannon and River Fergus Estuaries SPA and 22 shore fishing locations are mapped by IFI (undated)[9].

9.21 Shooting (presumably wildfowling) was recorded relatively frequently during the WSP counts with a total of 20 instances recorded. However, these were concentrated in four subsites: three in the Fergus Estuary and one in the Upper Shannon.

9.22 Water-based recreational activities within the SFPA appear to be of relatively limited extent. There are marinas at Kilrush and Limerick City and yacht clubs at Foynes and Kilrush. Most boat angling takes place in the outer part of the SPA, west of Tarbert (IFI, undated). Inshore activities such as kayaking and windsurfing presumably occur but there is no information on the distribution of these activities, or their intensity.

9.23 There are some fishery activities towards the mouth of the River Shannon. These activities comprise shrimp potting (south shore of river near Ballylongford) and tangle net (crayfish), trammel net (baitfish), creel (lobster and crab) all at the mouth of the estuary (Marine Institute, 2015). All wild fisheries are confined to static gear and present no risk to habitat features.

9.24 Commercial ports are located at Foynes and Limerick Docks, with private port terminals at Aughinish, Moneypoint, Shannon Airport and Tarbet. The navigation channel runs the length of the Upper and Lower Shannon sections of the SPA. A car ferry runs between Tarbert and Killimer.

Potential impacts

9.25 There is an extensive and complex literature on the impacts of disturbance from human activities on waterbirds in intertidal and shallow subtidal habitats. It is difficult to use this literature to make specific predictions about the nature and extent of potential disturbance impacts as the effects of disturbance vary between species and, within species, vary between sites and within sites. However, in general, with beach walks and/or when access is mainly along the shoreline (i.e. with little activity in the intertidal or shallow subtidal zone), disturbance impacts, while causing local (a few hundred metres) displacement of birds, does not appear to affect the large-scale distribution of birds across sites (e.g., Colwell and Sundeen, 2000; Lafferty, 2001; Gill *et al*., 2001a & b; Neuman *et al*., 2008; Trulio and Sokale, 2008; Yasué, 2006; but see Burton *et al*., 2002b) or survivorship (Durell *et al*., 2007; but see Stillman *et al*., 2012). Disturbance in the intertidal zone will generally have greater impacts (Stillman *et al*., 2012) and, where disturbance rates are high and/or concentrated areas of species food resources are affected, may cause significant impacts to large-scale distribution (Mathers *et al*., 2000) and/or survivorship (Durell *et al*., 2008; Goss-Custard *et al*., 2006; Stillman *et al*., 2012; West *et al*., 2008). However, some studies of shellfish gathering in the intertidal zone have concluded that it does not affect waterbird populations (Dias *et al*., 2008; Navedo and Masero (2007).

9.26 The main concentration of activity in the intertidal is likely to be in the beach recreation areas at Beale Strand and Cappa Beach. While this will presumably mainly occur during summer, it may overlap with build-up of significant numbers of some of the SCI species in late summer/early autumn. The sandy areas likely to be favoured for recreational activities at Beale Strand appear to hold relatively few waterbirds (see Chapter 7). Cappa Beach only contains a small area of rocky intertidal habitat. Shellfish gathering and bait digging will also involve activity in the intertidal zone. However, the levels of these activities appear to be low and they are unlikely to cause significant disturbance impacts.

[9] The WSP disturbance recording methodology did not include a specific category for shore angling, so any instances of such activity that did occur on the counts would have been recorded under the *other* category. It is not possible to assess the frequency with which this activity occurred on the WSP counts from the available information.

9.27 Wildfowling causes direct mortality of quarry species, as well as wider disturbance impacts. The quarry species include Wigeon, Teal, Mallard, Pintail, Shoveler, Scaup and Golden Plover. Any shooting of Pintail, Shoveler and Scaup may have significant impacts on their River Shannon and River Fergus Estuaries SPA populations, due to the small sizes of these populations, while quarry species may be particularly sensitive to disturbance impacts (Laursen *et al*., 2005). These species mainly occur in the Lower Shannon away from the wildfowling areas in the Fergus Estuary and the Upper Shannon (assuming that the WSP data provides an accurate representation of the distribution of wildfowling in the River Shannon and River Fergus Estuaries SPA), although it is possible that the wildfowling is modifying their distribution patterns. Non-quarry species may also be affected by disturbance impacts. However, it is not possible to assess the potential cumulative impacts of wildfowling in-combination with aquaculture activity in the River Shannon and River Fergus Estuaries SPA due to the lack of detailed information on the distribution and intensity of wildfowling activity within the SPA.

9.28 Boat activity will generally not affect waterbirds in intertidal and shallow subtidal habitat. However, some types of recreational watersports activities can occur in very shallow waters and have been observed to cause disturbance to waterbirds. For example, we have observed jet skiers in Ballycotton Bay travelling up tidal channels and across shallowly flooded areas causing disturbance to important feeding and roosting areas. In Cork Harbour, kayakers and windsurfers in the Aghada area can come close into the shoreline causing disturbance to high tide roosts. These activities will mainly take place around the high tide period and may cause disturbance to feeding waterbirds in intertidal and shallow subtidal habitat on ebb/flood tides. However, given the nature and distribution of the main intertidal areas within the River Shannon and River Fergus Estuaries SPA it seems unlikely that such activities would overlap with significant numbers of waterbirds.

9.29 Boat traffic to/from quays and marinas may also cause disturbance to waterbirds roosting in shoreline areas or islands at high tide. The locations of the marinas and yacht clubs at Foynes, Kilrush and Limerick City indicate that boat traffic to/from these facilities is unlikely to pass close to sensitive roost sites. However, we have already identified the potential for disturbance to roost sites from vessel traffic associated with aquaculture activity from quays in Ballylongford Creek and the River Deel. Any additional boat traffic to from these locations, such as small fishing boats, could have significant cumulative impacts on high tide roosts in-combination with the vessel traffic generated by aquaculture activity.

Activities affecting waterbird food resources

Bait digging and shellfish collecting

9.30 Bait digging and shellfish collecting will remove food resources that would otherwise be available for consumption by waterbirds and may also cause mortality to non-target species (Masero *et al*., 2006). Therefore, if these activities are extensive and/or affect concentrated food resources they could affect waterbird distribution (by causing displacement from depleted areas) and/or survivorship (by reducing the overall carrying capacity of the system). However, the Masero *et al*. (2006) study involved an area with a high intensity of bait-digging activity with bait digger numbers of 46-544 throughout the year. In the River Shannon and River Fergus Estuaries SPA, bait digging and shellfish gathering appear to be low intensity activities. Therefore, it seems unlikely that bait digging or winkle picking is having measurable impacts in terms of resource depletion or physical habitat disturbance in River Shannon and River Fergus Estuaries SPA, and it is not necessary to consider potential in-combination effects with aquaculture activities.

Effluent discharge

9.31 Organic and nutrient inputs to estuaries increase productivity and may increase food resources for waterbirds. Therefore, adverse impacts to waterbirds might be expected to be caused by declines in organic and nutrient inputs associated with improvements in wastewater treatment. There are a

number of studies that document the effects of organic and nutrient loading from effluent discharges on the benthic fauna and typically the zones affected by individual discharges are restricted to within a few hundred metres of the outfall (Burton *et al*., 2002a). The available evidence on the effects of nutrient reductions on estuarine waterbird populations is limited but, to date, no significant impacts have been reported (Burton *et al*., 2002a, 2003). One study (Alves *et al*., 2012) has reported localised (within 100 m) association between wastewater inputs and bird distribution; in this study the outfalls discharged in the intertidal zone and streams of sewage ran across the intertidal habitat. Therefore, given the size of the River Shannon and River Fergus Estuaries SPA, and the fact that any impacts to waterbird populations from upgrades in wastewater treatment are likely to be localised to the immediate vicinity of the existing outfall locations, it is unlikely that such upgrades would have measurable impacts to populations at the SPA scale. Therefore, it is not necessary to consider potential in-combination effects of such upgrades with the aquaculture activities covered in this assessment.

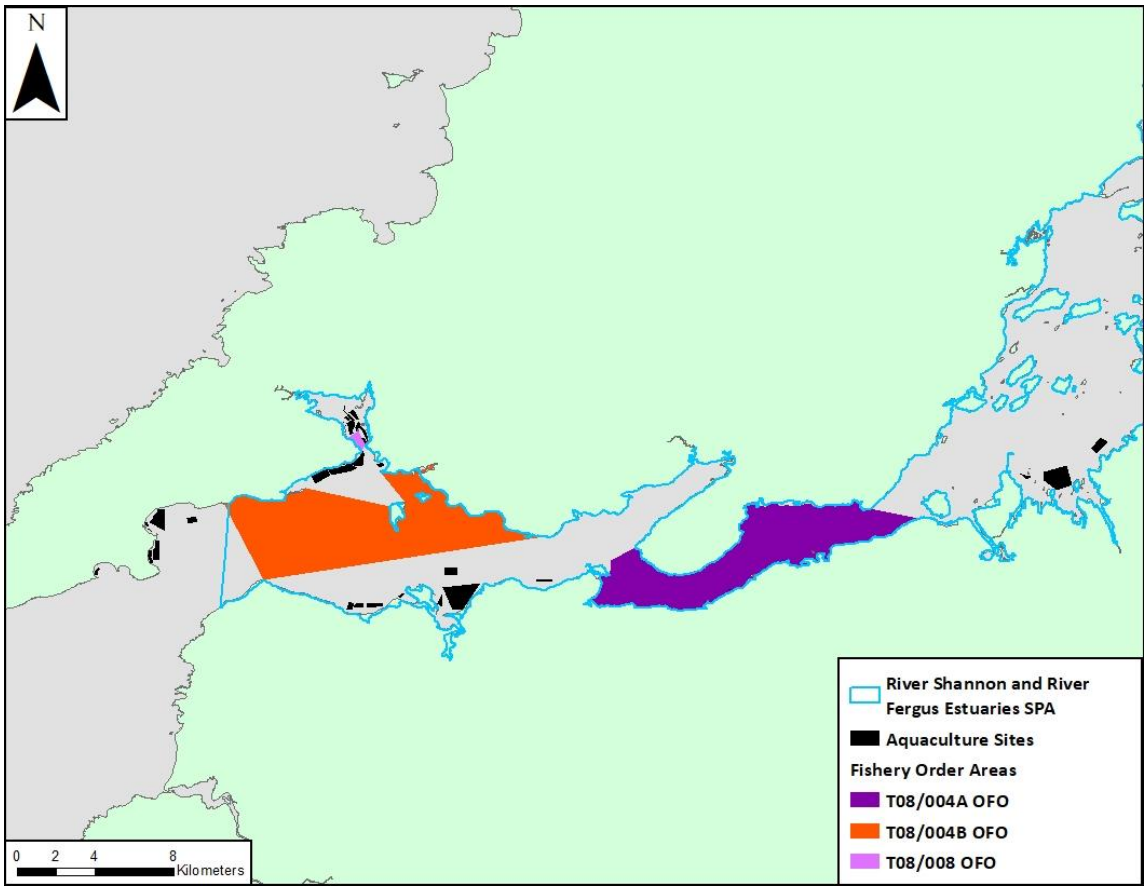

Figure 9.1 Fishery Order areas within the Shannon Estuary.

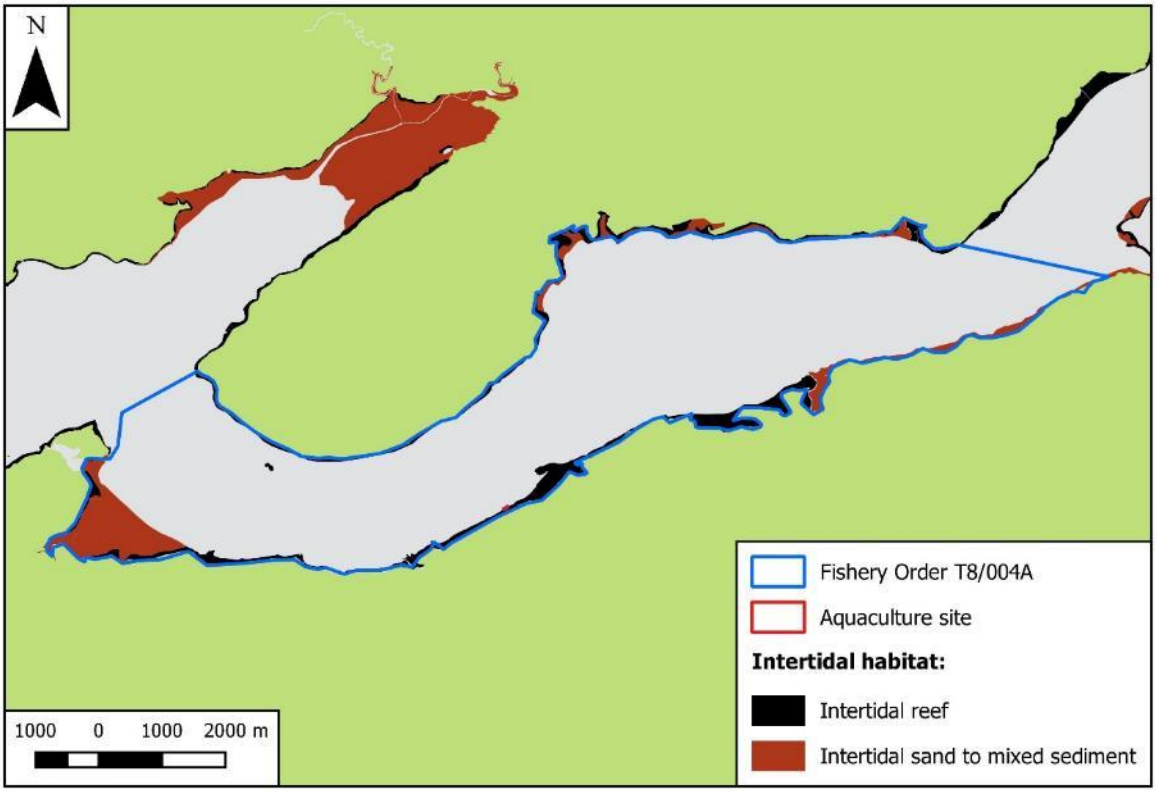

Figure 9.2 Fishery Order T08/004A.

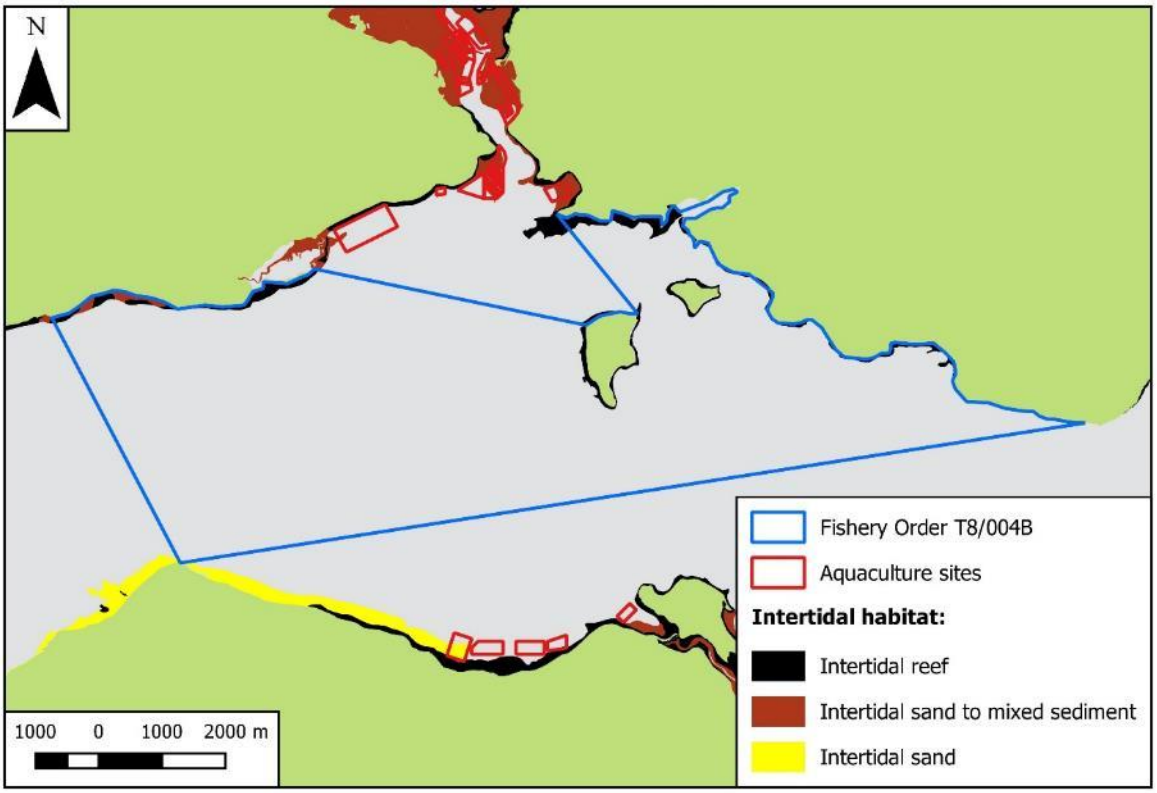

Figure 9.3 Fishery Order T08/004B.

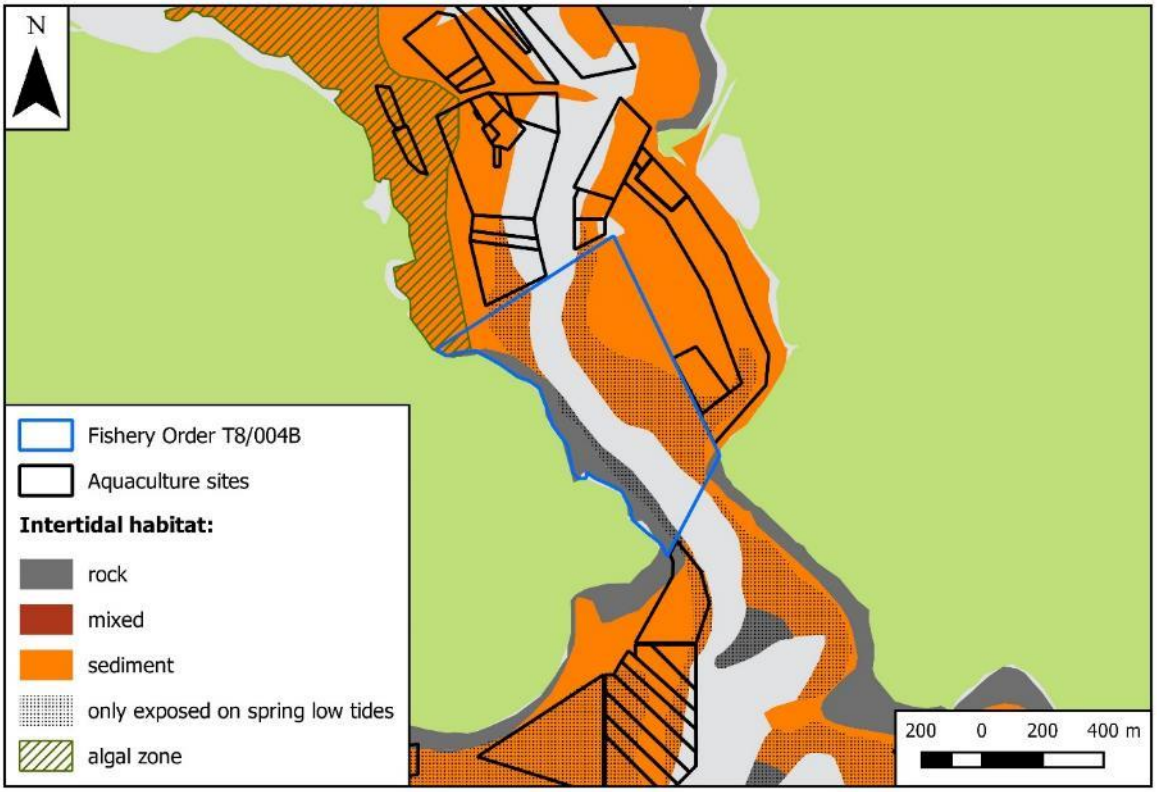

Figure 9.4 Fishery Order T08/008.

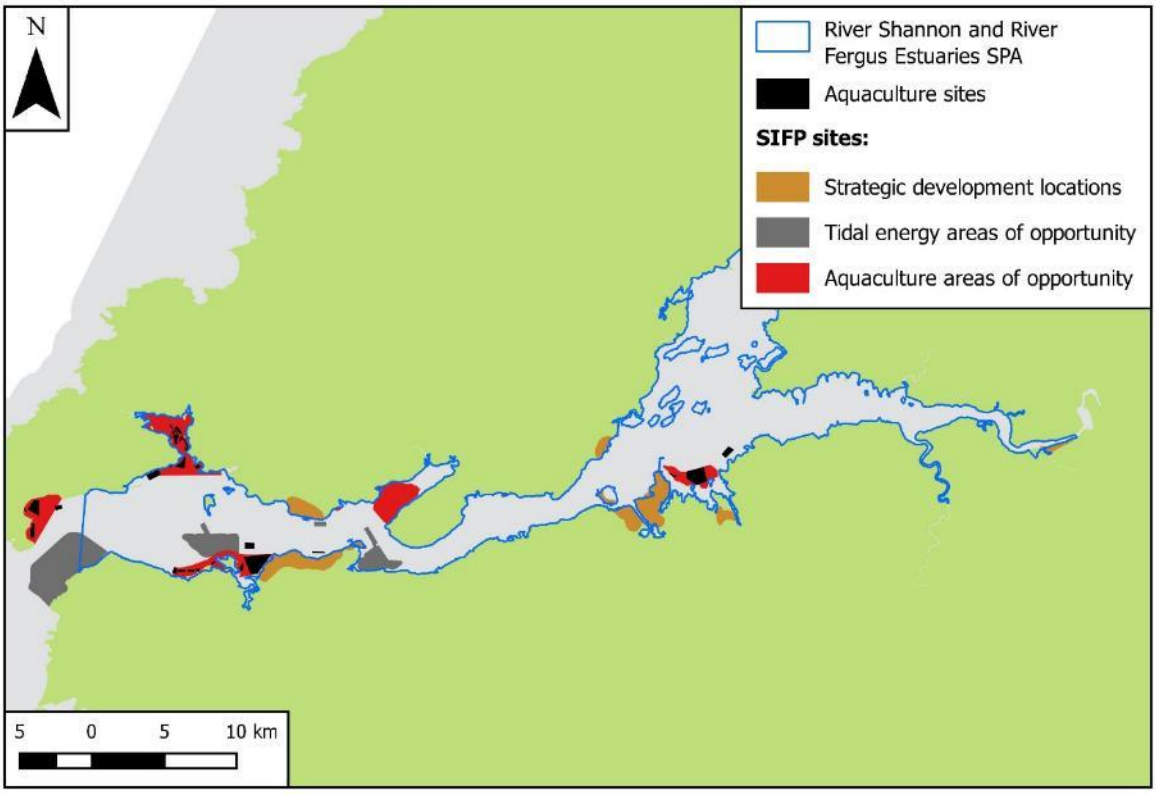

Figure 9.5 Strategic development locations and areas of opportunity identified in the Strategic Integrated Framework Plan for the Shannon Estuary.

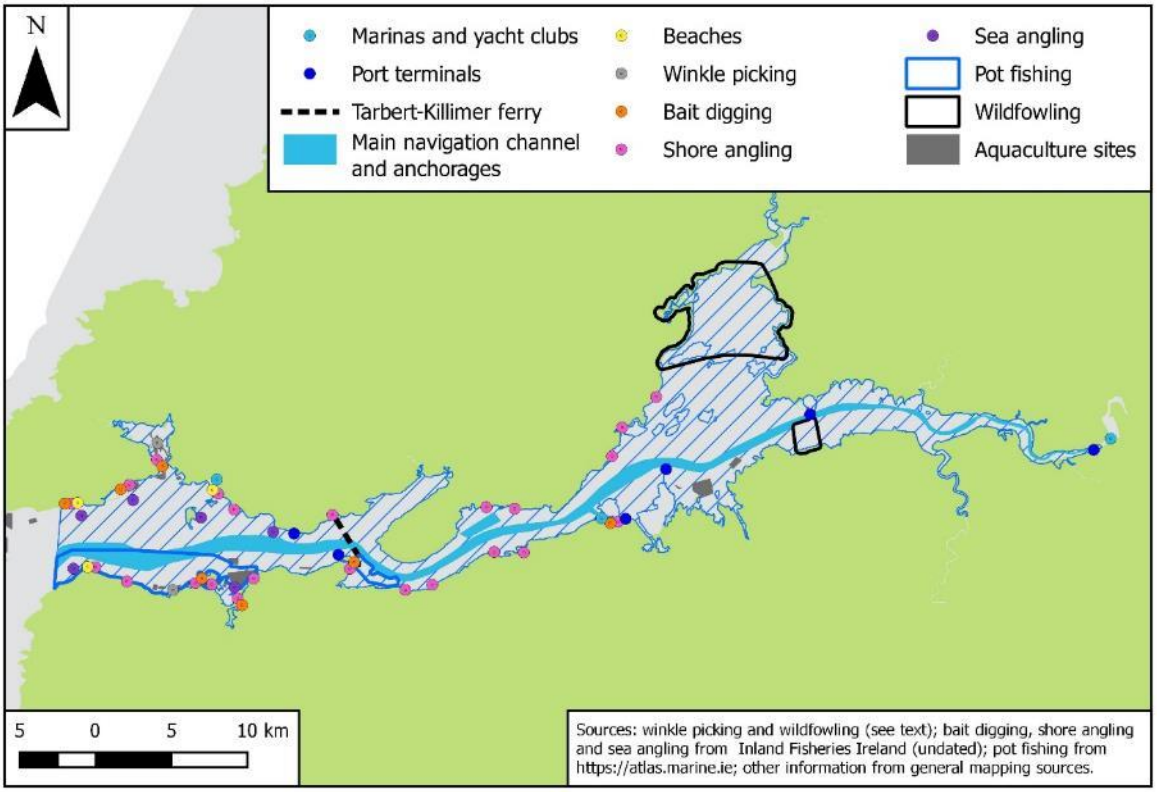

Figure 9.6 Disturbance pressures.

10. Assessment of impacts on conservation objectives

Introduction

10.1 Potential impacts on the screened-in SCIs are summarised below.

River Shannon and River Fergus Estuaries SPA

Whooper Swan

10.2 The possibility of intertidal or subtidal aquaculture development affecting nocturnal roost sites used by Whooper Swan cannot be discounted as we have no information on the location of these roost sites.

Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Pintail, Shoveler, Golden Plover, Grey Plover, Lapwing, Ringed Plover, Curlew, Black-tailed Godwit, Bar-tailed Godwit, Knot and Dunlin

10.3 There is a high potential for significant displacement impacts to Grey Plover and Bar-tailed Godwit, while significant displacement impacts to Light-bellied Brent Goose and Ringed Plover are also possible. These potential impacts would arise from intertidal aquaculture sites in the Ballylongford/Bunaclugga, Poulnasherry/Kilrush and Aughinish/Foynes AQUAs. There is potential for further significant cumulative impacts on some of these species from the development of the above sites in combination with oyster trestle cultivation in Fishery Order T08/008, development of the area of opportunity for tidal energy in Tarbert Bay, and/or development of the area of opportunity for aquaculture in Clonderlaw Bay.

10.4 Significant displacement impacts to Shelduck, Wigeon, Teal, Pintail, Shoveler, Golden Plover, Lapwing, Curlew, Black-tailed Godwit, Knot and Dunlin are considered to be unlikely.

10.5 The possibility of significant disturbance impacts to high tide roosts used by these species from vessel activity associated with the development of sites T06/233, T06/394A, T06/394B, T07/007, T07/012A and T07/014A cannot be discounted due to a lack of information about the usage of high tide roost sites in these areas. The potential for cumulative impacts from this vessel activity in combination with other vessel activity in these areas also needs to be considered.

10.6 It is not possible to assess the potential cumulative impacts of disturbance from wildfowling activity on these species in-combination with aquaculture activity in the River Shannon and River Fergus Estuaries SPA due to the lack of detailed information on the distribution and intensity of wildfowling activity within the SPA.

Scaup

10.7 The potential for intertidal oyster cultivation in the aquaculture sites in the Poulnasherry/Kilrush AQUA to cause significant impacts to the availability of suitable foraging habitat for Scaup cannot be excluded due to lack of knowledge about the effects of oyster trestles on Scaup foraging behaviour. The potential for cumulative impacts from the development of the above sites in combination with oyster trestle cultivation in Fishery Order T08/008 and/or bottom oyster cultivation in Fishery Orders T08/004A and T08/004B also needs to be considered.

Cormorant

10.8 None of the aquaculture activities covered by this assessment are likely to cause significant impacts to availability of suitable foraging habitat for Cormorant, or to cause significant disturbance impacts to Cormorant.

Black-headed Gull

10.9 The potential impact of intertidal aquaculture on Black-headed Gull cannot be assessed at this stage, due to lack of data on Black-headed Gull distribution within the River Shannon and River Fergus Estuaries SPA at the time of its likely peak usage of the area. However, it should be noted that for Black-headed Gull the likelihood of any negative impact occurring is uncertain.

10.10 None of the aquaculture activities covered by this assessment are likely to cause significant impacts to availability of suitable subtidal foraging habitat for Black-headed Gull, or to cause significant disturbance impacts to Black-headed Gull roosting in subtidal habitat.

Other SPAs

Fulmar SCI of the Kerry Head SPA

10.11 None of the aquaculture activities covered by this assessment are likely to cause significant impacts to the breeding Fulmar population of the Kerry Head SPA.

Kittiwake and Guillemot SCIs of the Loop Head SPA

10.12 None of the aquaculture activities covered by this assessment are likely to cause significant impacts to the breeding Kittiwake and Guillemot populations of the Loop Head SPA.

Wigeon, Teal, Mallard, Shoveler and Black-tailed Godwit SCIs of the Ballyallia Lough SPA

10.13 This assessment for the River Shannon and River Fergus Estuaries SPA concluded that the possibility of significant disturbance impacts to high tide roosts of these species within the River Shannon and River Fergus Estuaries SPA could not be discounted. If such impacts do occur, the effects of any such impacts on the conservation objectives for the Ballyallia Lough SPA would depend upon the connectivity between the two sites. If there connectivity is high, the two sites would effectively support a single population and it is possible that major displacement impacts within the River Shannon and River Fergus Estuaries SPA would affect attribute 1 (population trend) of the conservation objectives for the Ballyallia Lough SPA.

10.14 Any such impacts would not affect attribute 2 (distribution) of the conservation objectives for the Ballyallia Lough SPA as this attribute refers to distribution within Ballyallia Lough.

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Appendix A

Scientific names

Common name	Scientific names	BTO code
Barnacle Goose	*Branta leucopsis*	BY
Bar-tailed Godwit	*Limosa lapponica*	BA
Black Turnstone	*Arenaria melanocephala*	n.a.
Black-headed Gull	*Chroicocephalus ridibundus*	BH
Black-tailed Godwit	*Limosa limosa*	BW
Chough	*Pyrrhocorax pyrrhocorax*	CF
Coot	*Fulica atra*	CO
Cormorant	*Phalacrocorax carbo*	CA
Curlew	*Numenius arquata*	CU
Dunlin	*Calidris alpina*	DN
Gadwall	*Anas strepera*	GA
Golden Plover	*Pluvialis apricaria*	GP
Great Black-backed Gull	*Larus marinus*	GB
Great Blue Heron	*Ardea herodias*	n.a.
Great Egret	*Ardea alba*	HW
Greenshank	*Tringa nebularia*	GK
Grey Plover	*Pluvialis squatarola*	GV
Hen Harrier	*Circus cyaneus*	HH
Knot	*Calidris canutus*	KN
Light-bellied Brent Goose	*Branta bernicla hrota*	PB
Long-billed Curlew	*Numenius americanus*	n.a.
Mallard	*Anas platyrhynchos*	MA
Marbled Godwit	*Limosa fedoa*	n.a.
Night Heron	*Nycticorax nycticorax*	n.a.
Oystercatcher	*Haematopus ostralegus*	OC
Pintail	*Anas acuta*	PT
Purple Sandpiper	*Calidris maritima*	PS
Red-breasted Merganser	*Mergus serrator*	RM
Redshank	*Tringa totanus*	RK
Ringed Plover	*Charadrius hiaticula*	RP
Sanderling	*Calidris alba*	SS
Scaup	*Aythya marila*	SP
Shelduck	*Tadorna tadorna*	SU
Shoveler	*Anas clypeata*	SV
Snowy Egret	*Egretta thula*	n.a.
Teal	*Anas crecca*	T.
Turnstone	*Arenaria interpres*	TT
Whooper Swan	*Cygnus cygnus*	WS
Wigeon	*Anas penelope*	WN
Willet	*Catoptrophorus semipalmatus*	n.a.

Appendix B

Ballylongford/Bunaclugga AQUA flock maps

B.1 Introduction

B.1.1 This appendix shows maps of the distribution in the Ballylongford/Bunaclugga AQUA of the SCI species covered in this assessment, as recorded in the WSP flock maps.

B.2 Figures

B.2.1 Figure B.1 shows the total numbers of SCI dabbling duck and geese species (Light-bellied Brent Goose, Shelduck, Wigeon, Teal and Shoveler) in each mapped flock across all the low tide counts.

B.2.2 Figure B.2 shows the total numbers of SCI wader species (Golden Plover, Lapwing, Ringed Plover, Curlew, Black-tailed Godwit, Bar-tailed Godwit, Dunlin, and Redshank) in each mapped flock across all the low tide counts.

B.3 Interpretation of the figures

B.3.1 The positions mapped in the figures are the centroids of the positions shown on the count maps.

B.3.2 The figures were prepared in QuantumGIS 2.18.3 and use the point displacement function to handle overlapping points. This uses concentric rings to displace overlapping points. These rings are shown on the figures and indicate the degree of displacement applied.

B.3.3 The caveats discussed in Chapter 2 about the interpretation of the WSP flock map data need to be taken into account in interpreting these maps. It is because of these caveats that we have presented maps showing species groups, rather than maps for individual species.

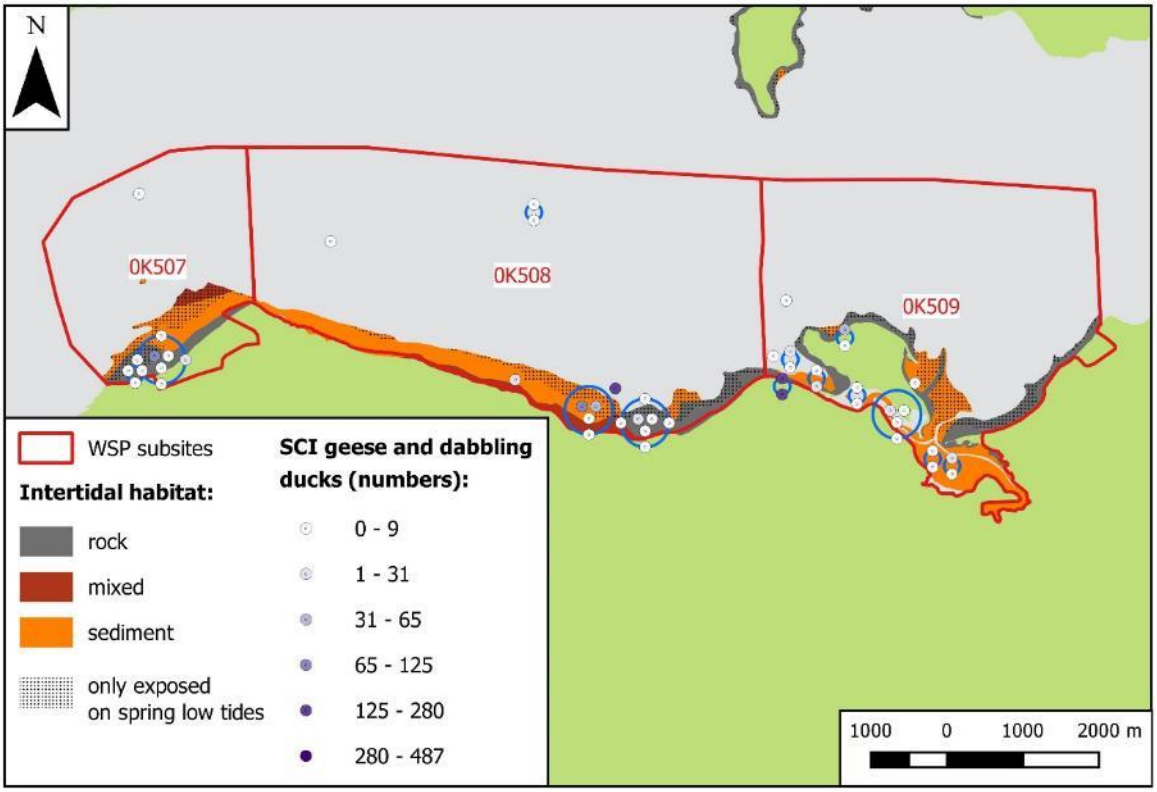

Figure B.1 SCI dabbling duck and geese species.

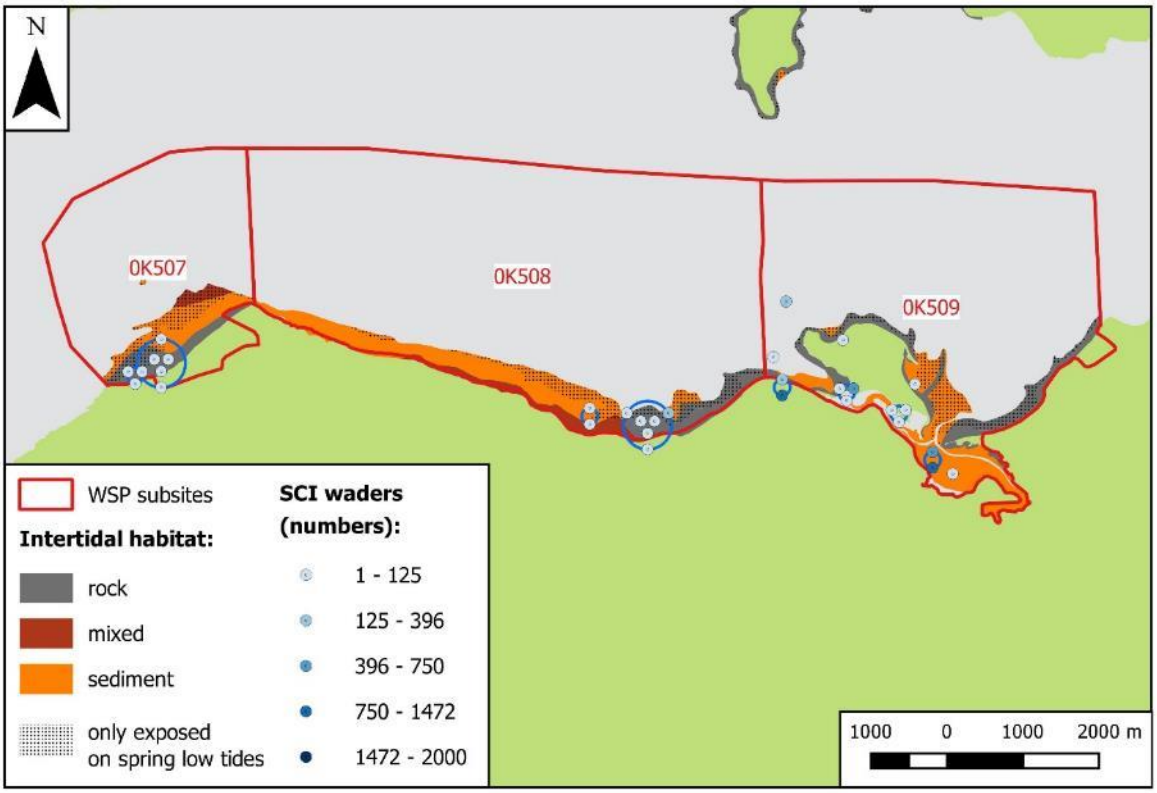

Figure B.2 SCI wader species.

Appendix C

Poulnasherry Bay flock maps

C.1 Introduction

C.1.1 This appendix shows maps of the distribution in Poulnasherry Bay in 2000-2002 of the SCI species covered in this assessment, as recorded in the NPWS bird usage counts.

C.2 Figures

C.2.1 Figure C.1-Figure C.1 show the distribution of Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Pintail, Cormorant, Golden Plover, Grey Plover, Lapwing, Ringed Plover, Curlew, Bar-tailed Godwit, Knot, Dunlin, Redshank and Black-headed Gull in Poulnasherry Bay during the NPWS bird usage counts.

C.3 Interpretation of the figures

C.3.1 For each bird usage count, maps were drawn up showing the positions of the birds recorded (see example in Figure 2.3). Comparison of the totals on the maps with the count totals indicate that most, or all, of the birds counted were mapped. For each species shown in Figure C.1-Figure C.1, the relevant figure shows all mapped positions recorded on these maps across all the counts.

C.3.2 The positions mapped in the figures are the centroids of the positions shown on the count maps. The exact positions mapped should be interpreted with caution, as birds will have been dispersed to varying degrees (depending upon the species and their behaviour on the day) around the mapped position, and there was also likely to be a degree of mapping error.

C.3.3 The figures were prepared in QuantumGIS 2.18.3 and use the point displacement function to handle overlapping points. This uses concentric rings to displace overlapping points. These rings are shown on the figures and indicate the degree of displacement applied.

C.3.4 The figures also the mapped position of trestles in March 2000, and the intertidal mapping used in this assessment.

C.3.5 The mapped position of trestles is taken from the count sector map supplied by NPWS with the bird usage count data. We do not have details of how the trestles were mapped, but presume that the mapping was done by eye (sketch mapping), so a degree of caution is required in the interpretation of the exact position of the trestles.

C.3.6 The details of the methods used for the intertidal mapping are given in Chapter 2. It should be noted that the mapping is based on recent aerial imagery, supplemented by observations from our site visits in 2010 and 2017. Therefore, the position of flocks in relation to this mapping should be interpreted with caution as there may have been changes in the distribution of the habitats, particularly in the extent of the algal zone.

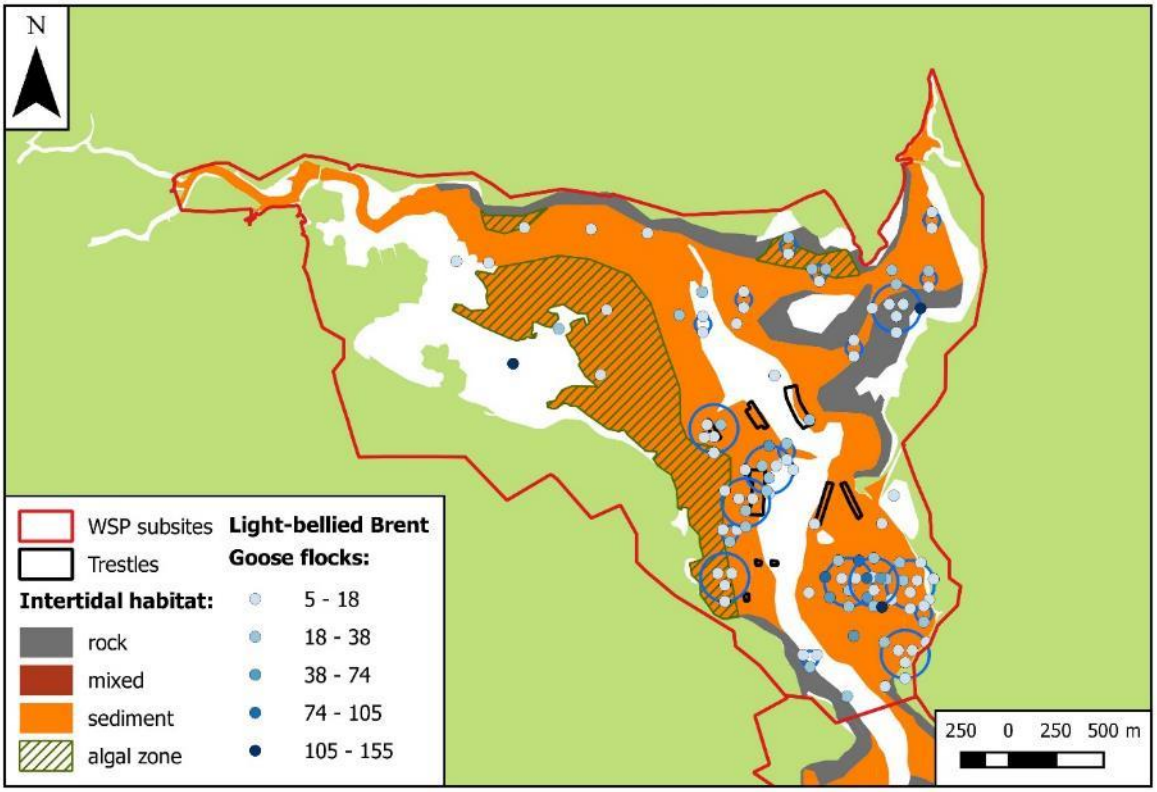

Figure C.1.1 Light-bellied Brent Goose.

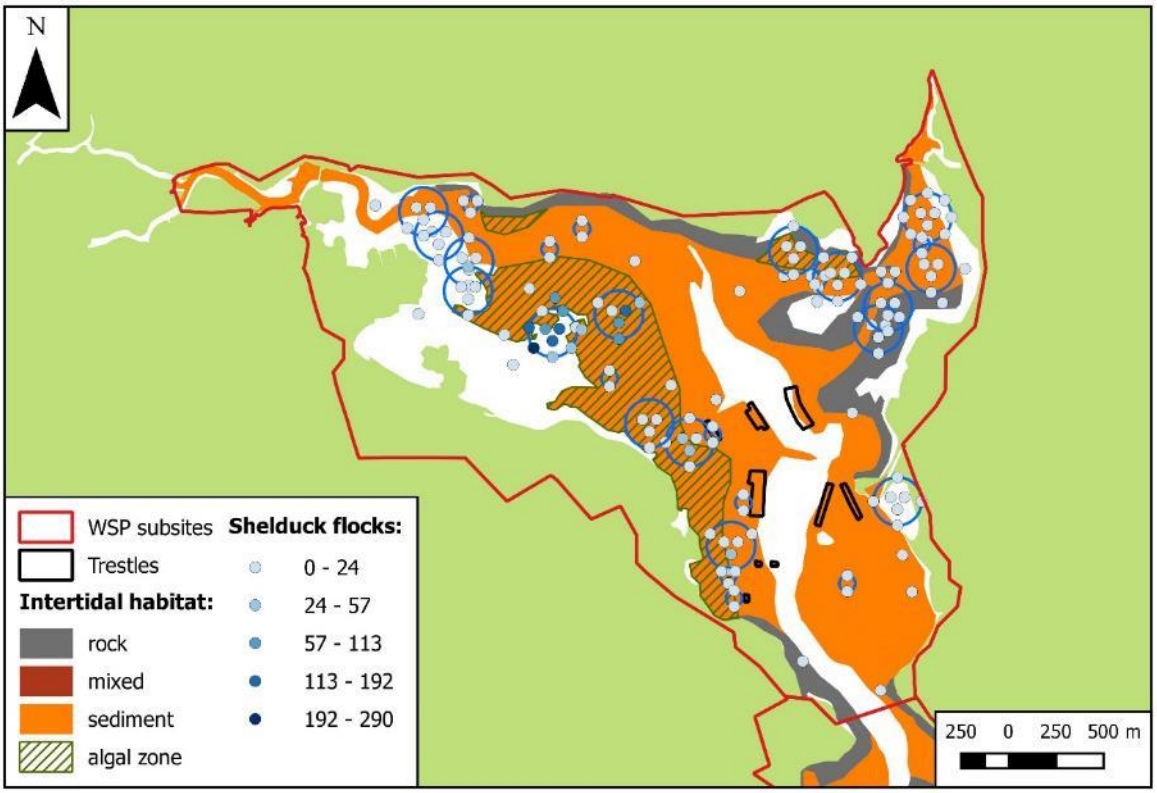

Figure C.1.2 Shelduck.

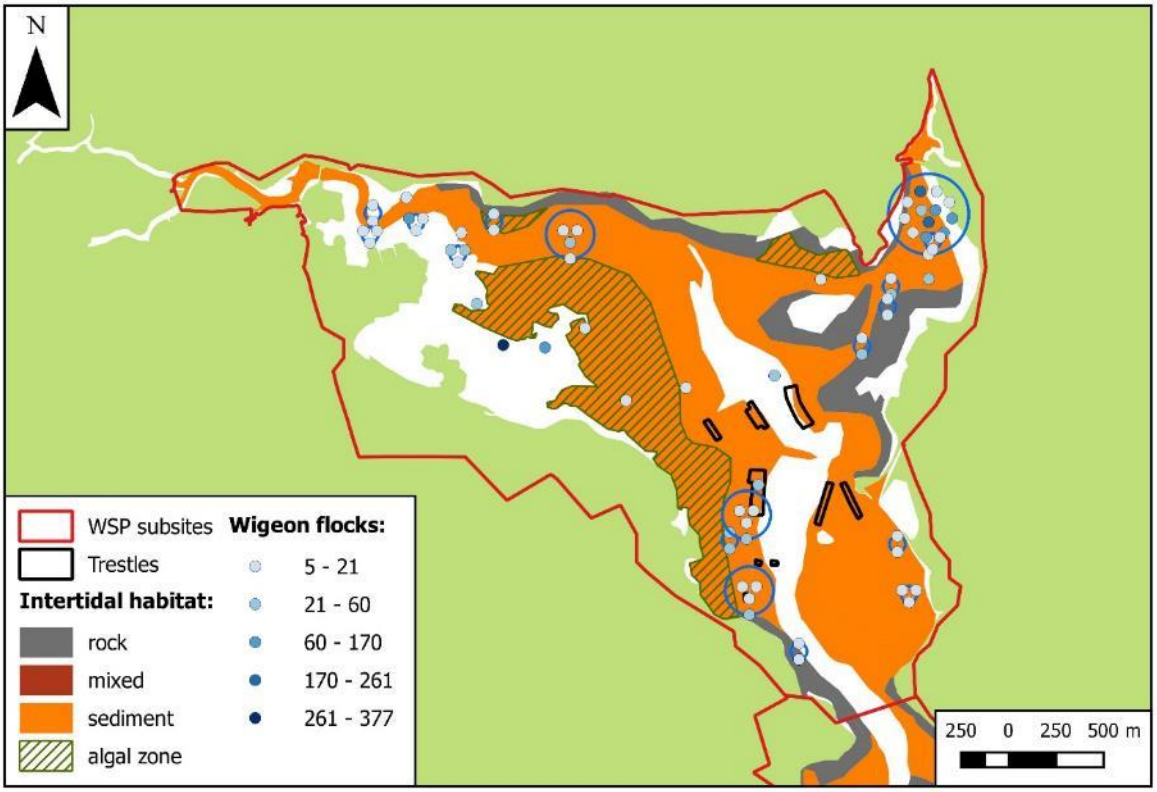

Figure C.1.3 Wigeon.

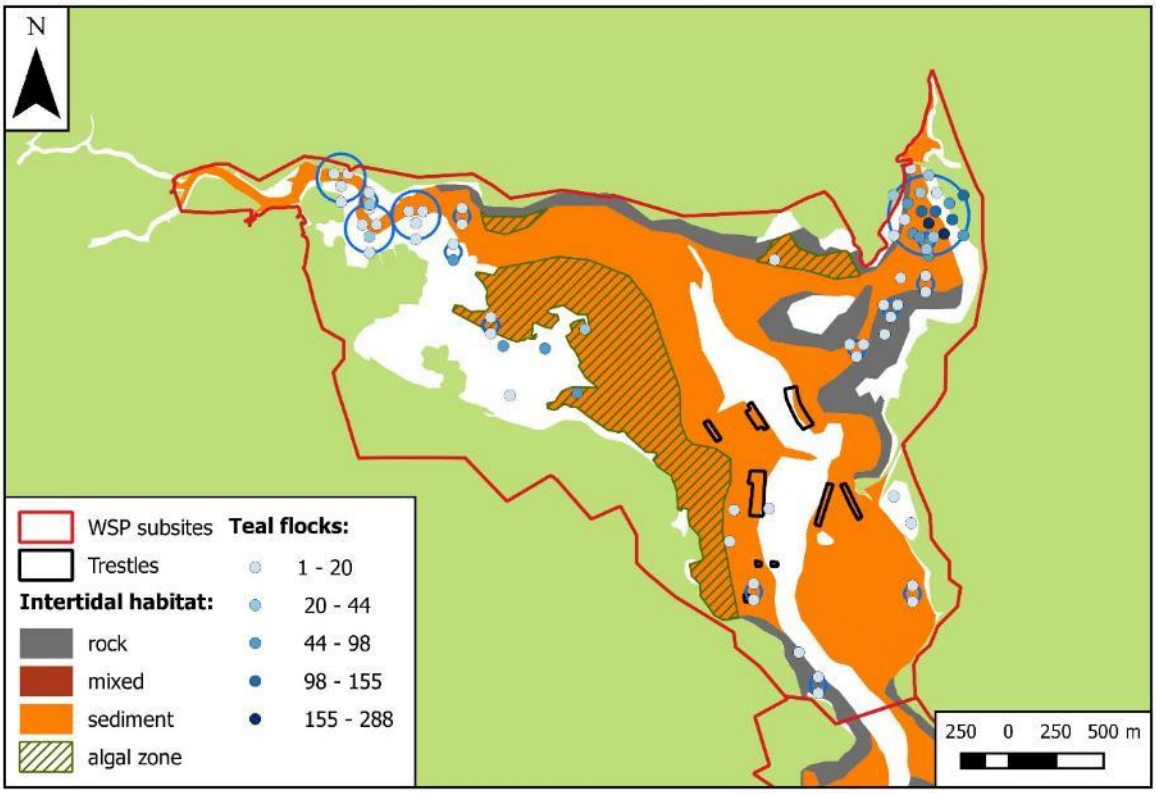

Figure C.1.4 Teal.

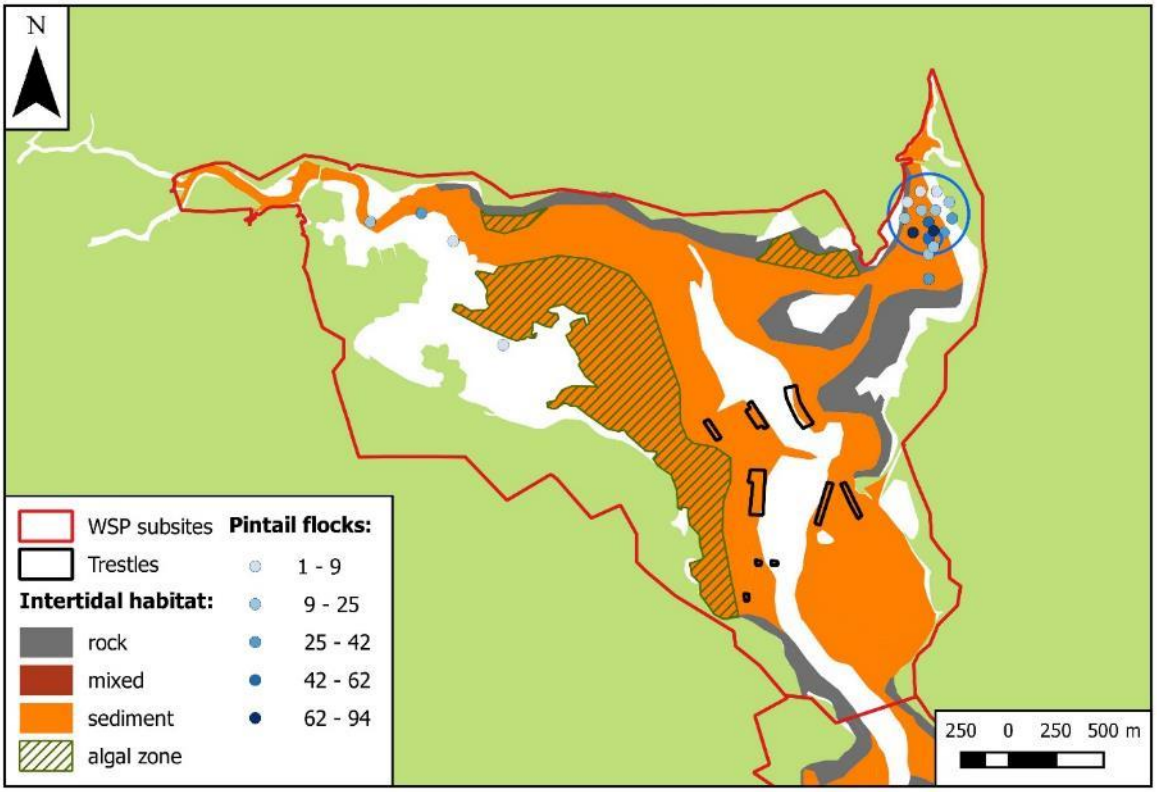

Figure C.1.5 Pintail.

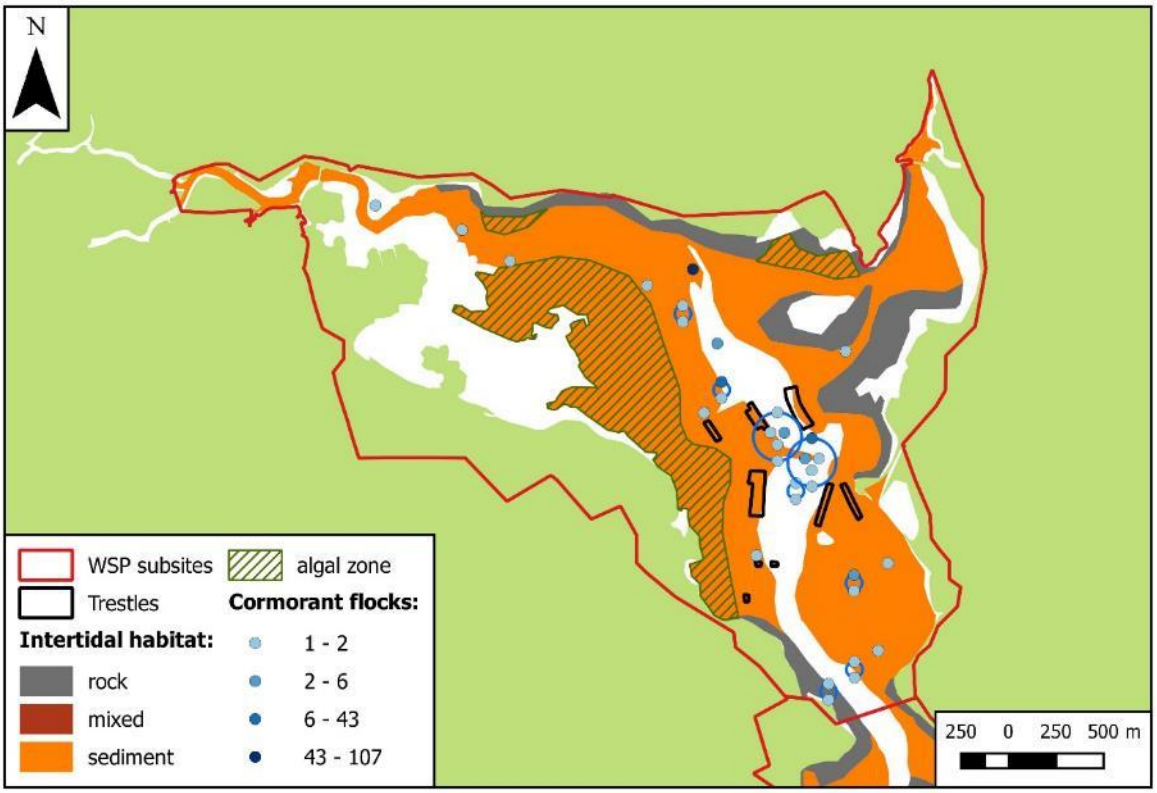

Figure C.1.6 Cormorant.

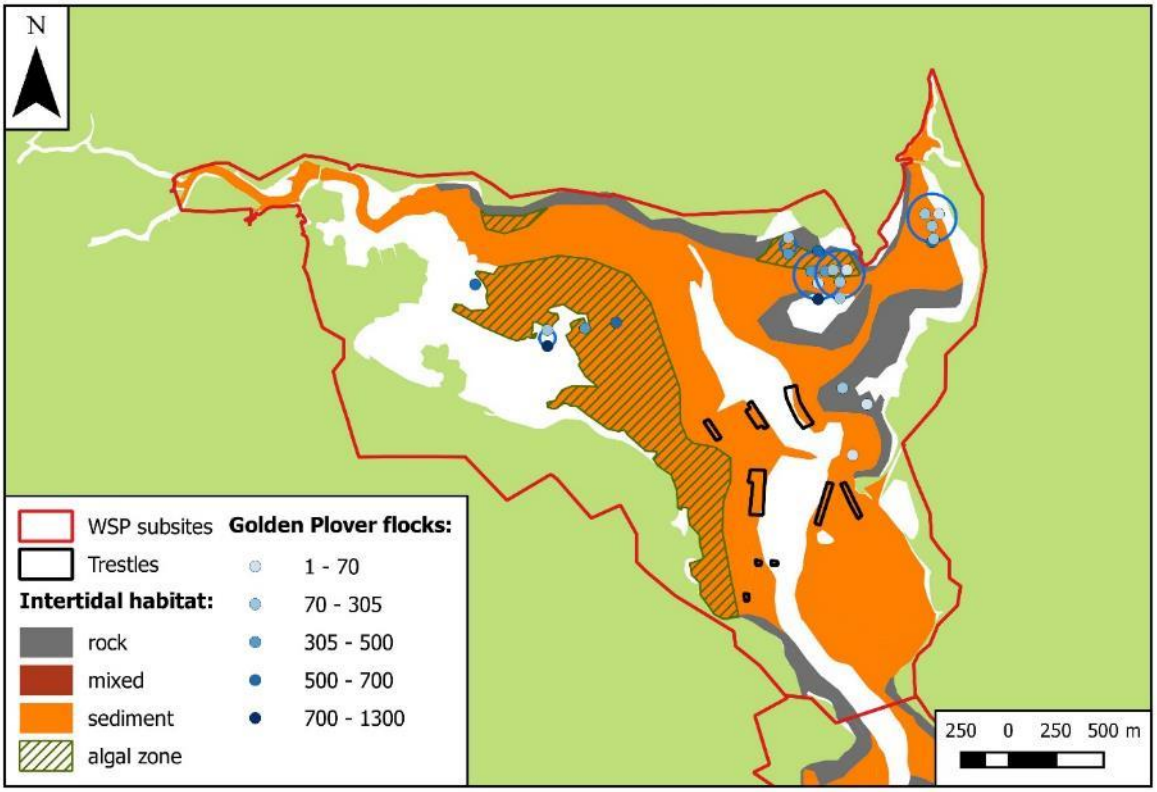

Figure C.1.7 Golden Plover.

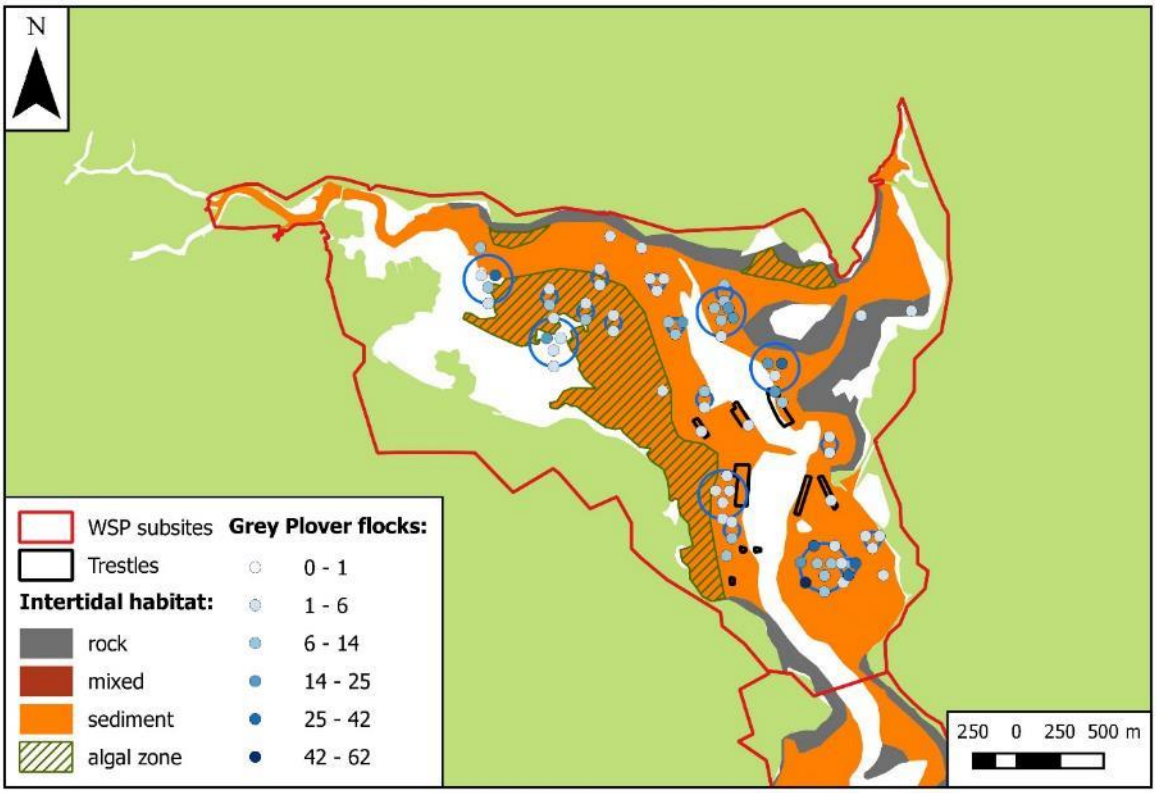

Figure C.1.8 Grey Plover.

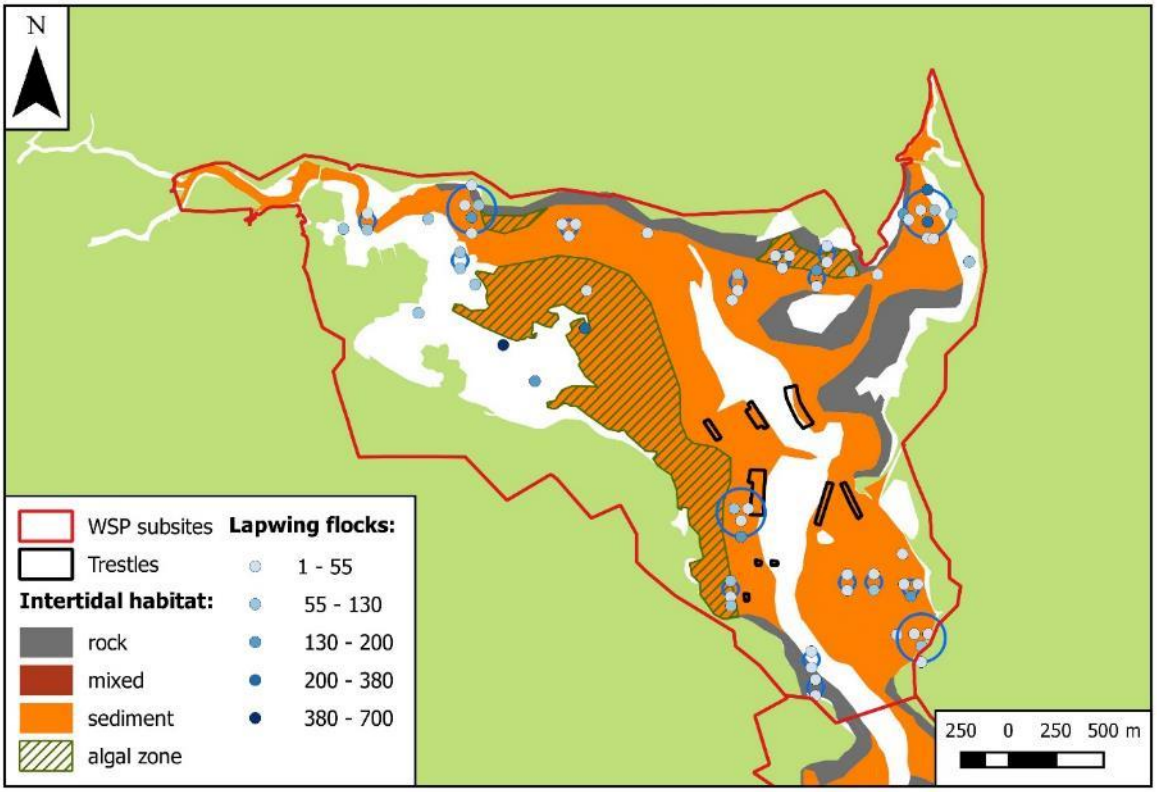

Figure C.1.9 Lapwing.

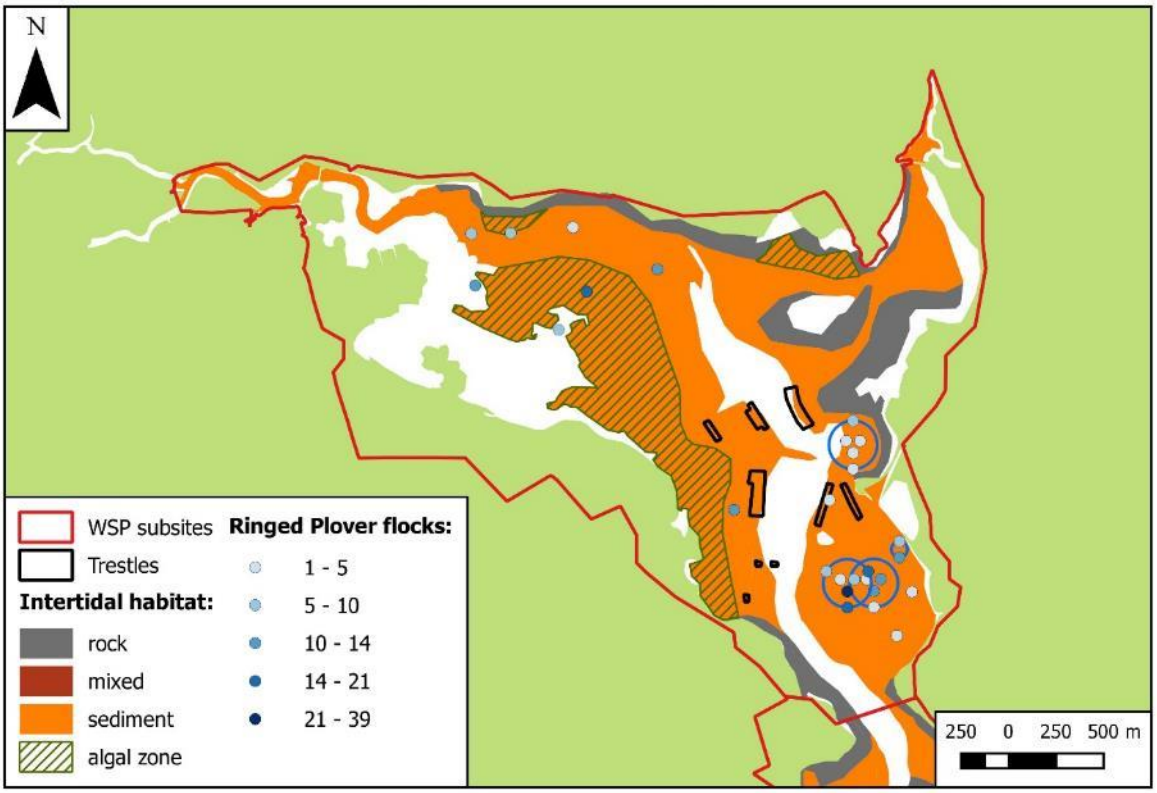

Figure C.1.10 Ringed Plover.

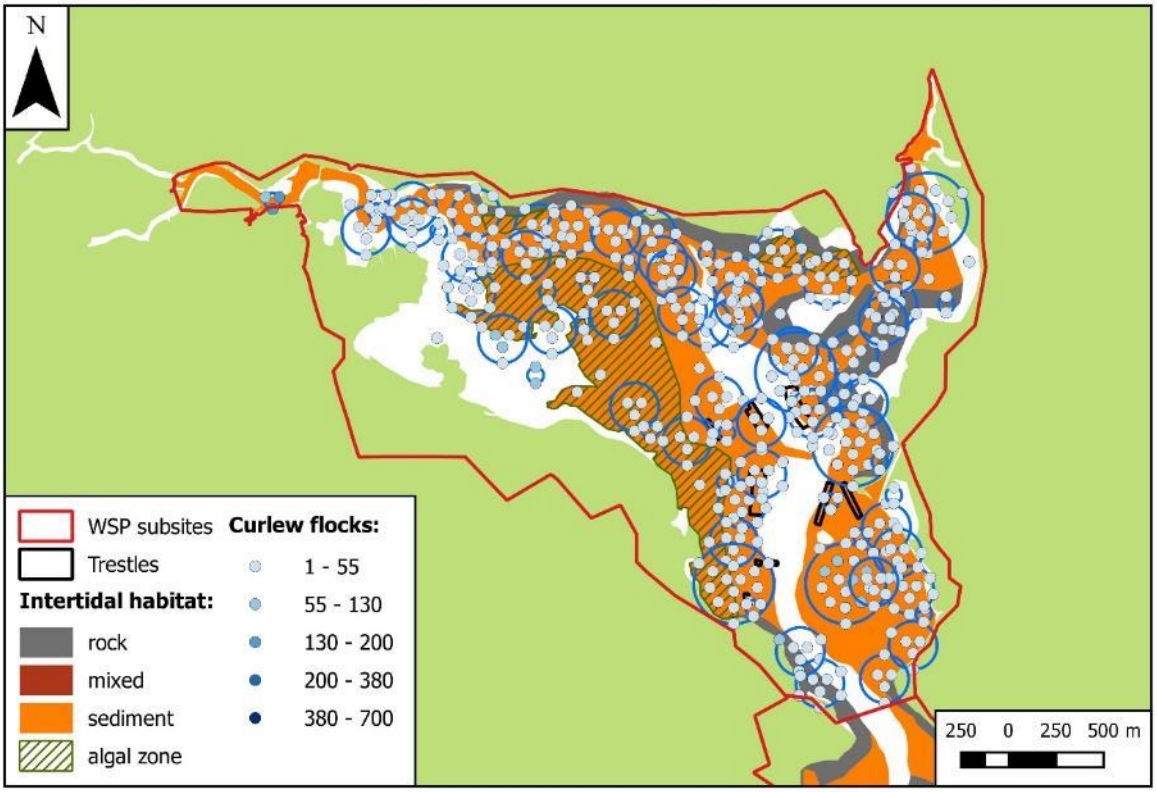

Figure C.1.11 Curlew.

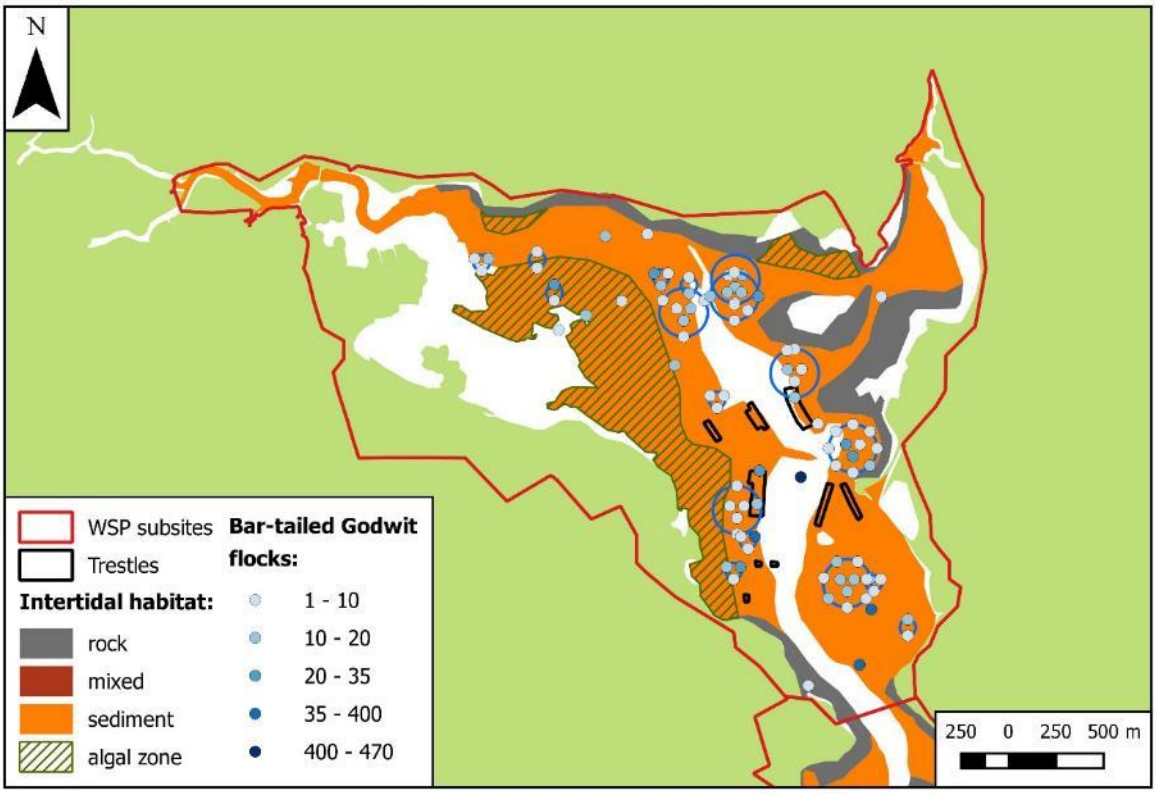

Figure C.1.12 Bar-tailed Godwit.

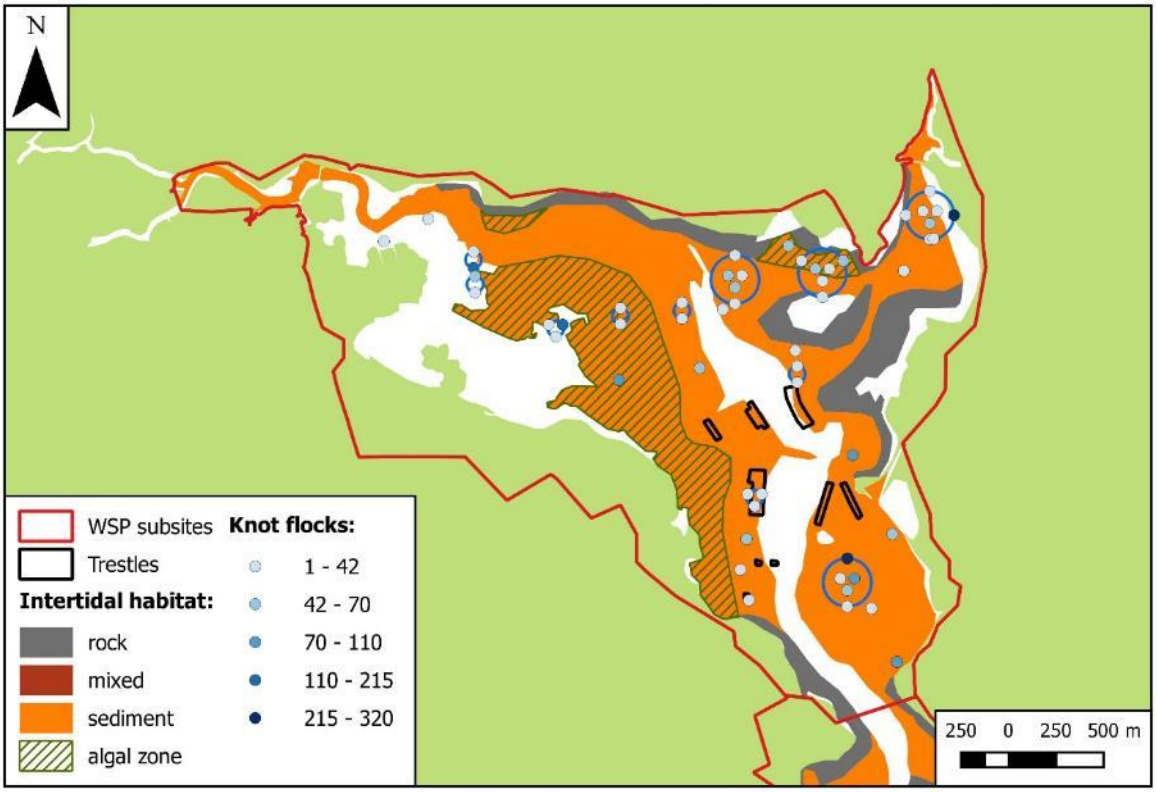

Figure C.1.13 Knot.

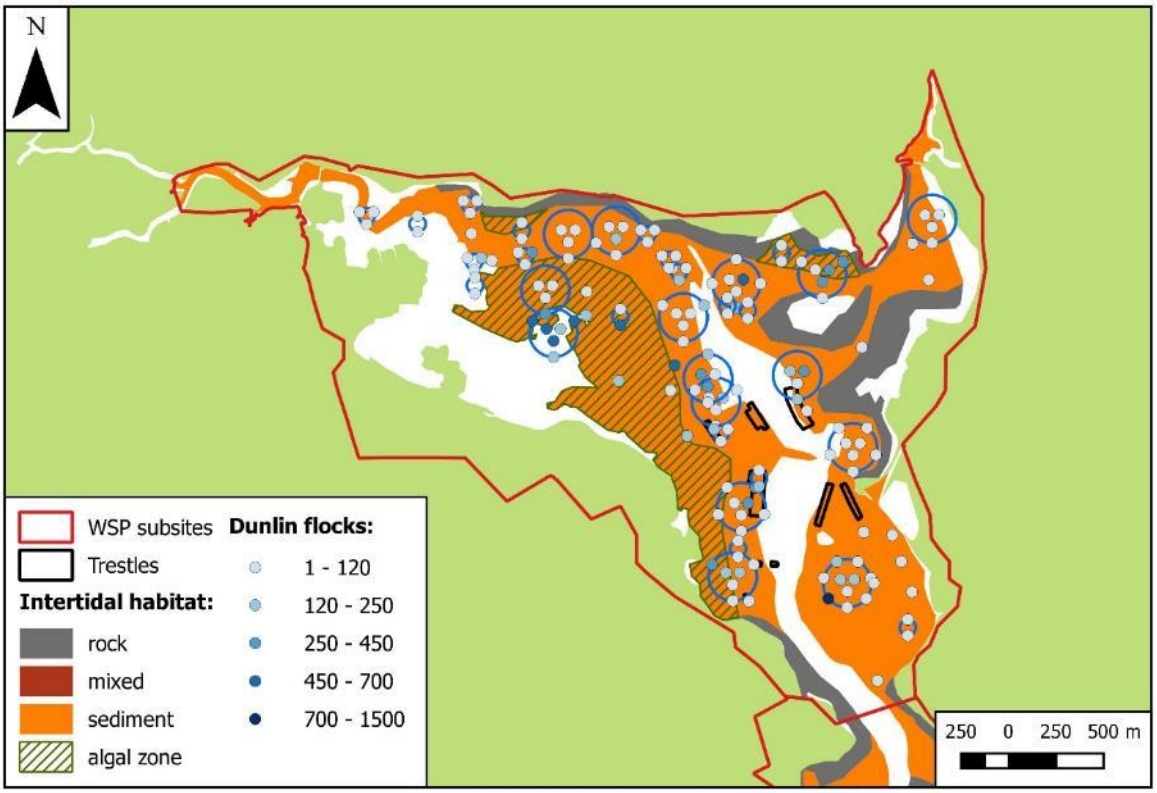

Figure C.1.14 Dunlin.

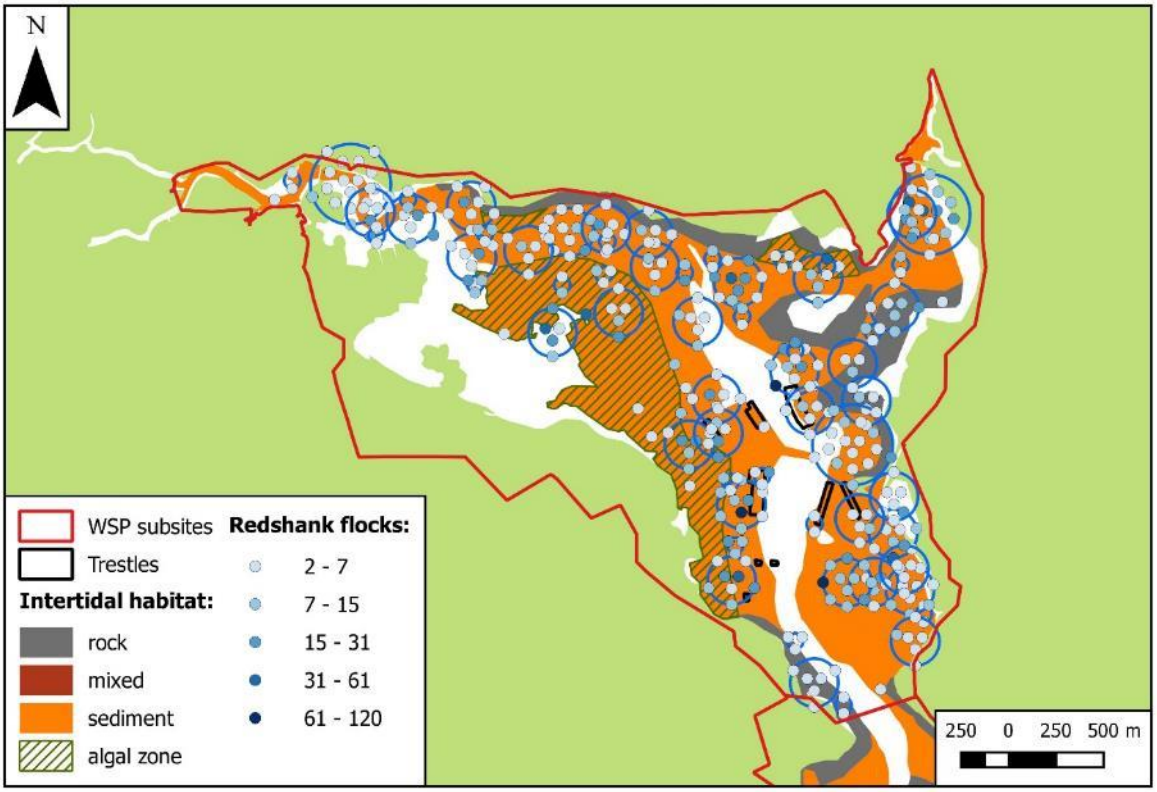

Figure C.1.14 Redshank.

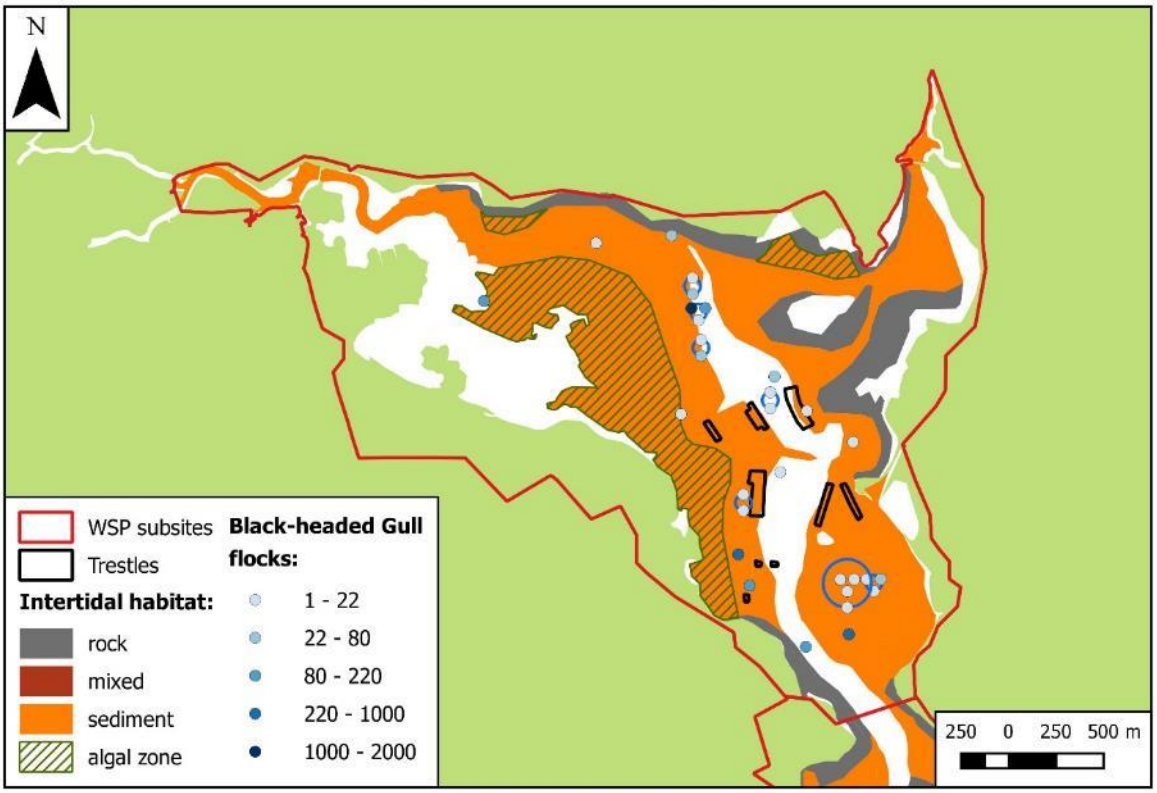

Figure C.1.15 Black-headed Gull.

Appendix D

Literature review - Impacts of bottom mussel culture on benthic fauna

D.1 Review

D.1.1 Bottom culture accounts for about half of all mussels produced in Ireland (Heffernan, 1999). In 1995, 5,570 tonnes were produced. Bottom cultivation involves the location, collection and transplantation of wild mussel spat into richer, shallower waters using a dredger. Successful on-growing of re-laid spat requires sandy shallow beds. When the mussels reach commercial size (9-18 months later), they are harvested by dredger (Joyce, 1992 cited in Heffernan, 1999). This method is practised successfully on a large scale in Wexford Harbour and also in Carlingford Lough (Heffernan, 1999).

D.1.2 Heffernan (1999) could not find any literature on the impact of bottom culture on benthic fauna and it was presumed that the culture beds were analogous to natural mussel beds. In the intervening years, a number of studies have been undertaken to assess the impacts of bottom mussel culture on benthic fauna.

D.1.3 Smith and Shackley (2004) investigated the development of bottom mussel culture in inner Swansea Bay, Wales. The area was a shallow, sublittoral and high tidal energy environment. The results of this study found that the establishment of bottom mussel culture led to a reduction in the number and abundance of species due to habitat change and regular harvesting. There was an increase in abundance in carnivorous and deposit feeding species. In addition, the study found that the mussels reduced the chance of other filter feeding benthic species from becoming established by filtering their larvae or by physically smothering them. Smith and Shackley (2004) predicted that the establishment of bottom mussel culture at the Swansea site would lead to a change in benthic fauna and as a result, potentially impact the availability of prey species of juvenile flatfish that use the area as a nursery. Furthermore, an increased number of mussels in the area may reduce the potential food source of other filter feeding species in the area.

D.1.4 These finding are in contrast to those of Dolmer (2002) who reported that there is a positive relationship between mussel abundance and the number of associated species due to the increased complexity of the substratum in mussel beds compared to the surrounding sediments. In effect, the mussels become ‘ecosystem engineers’ (Jones *et al*. 1994; 1997). The presence of mussel beds can control the benthic environment directly by providing habitat and indirectly by enhancing larval settlement (Dolmer, 2002), providing shelter from predation, trapping sediment and altering water flow (Gutiérrez *et al*. 2003).

D.1.5 At study sites in western Sweden, Norling *et al*. (2015) examined the effects of blue mussel plots, one containing live mussels and the other with post mortem shells, on the epifaunal and infaunal assemblages. Notably, this study included the effect on fish species which were not considered in some of the other studies. This study supported previous studies which found that the ecosystem engineering effects of plots containing live mussels and dead shells both had an increase in epibenthic species richness, total abundance and biomass compared to the control plot which consisted of bare sand. Notably, small crustaceans were positively affected by the presence of blue mussel plots whereas fish species were positively affected by the presence of oyster plots which were also studied.

D.1.6 Ysebaert *et al*. (2009), made a comparison study between bottom mussel culture at sites in Denmark (a shallow, wind dominated, mixed water environment with microtidal range and low current conditions) and the Netherlands (a deeper, marine dominated environment with greater tidal range and currents). They reported the change in the habitat due the presence of bottom culture

mussels had a positive effect on the benthic community, especially in the Netherlands site where an increase in the number of epibenthic species was seen.

D.1.7 However, it is important to consider the impact of biodeposition on the benthic fauna, in particular the infaunal assemblages. The presence of bottom culture mussel beds means the habitat is dominated by single species on the seabed. This may lead to the transformation of an infaunal dominated community to an epifaunal dominated community and also cause alteration of sediment type and chemistry due to the production of mussel mud (Marine Institute, 2013). Relaid mussels lead to the development of mussel mud (a mix of dead shells, silt and faeces/pseudofaeces) beneath the mussel beds as the filtration and feeding activities of the mussels increase the sedimentation rate (Kaiser *et al*., 1998). The effects of this were observed by Beadman *et al*. (2004) who noted that an increase in the abundance of mussels resulted in a decrease of both infaunal diversity and abundance through provision of a complex habitat, input of organically rich material and larval removal through filter feeding at a study site in Bangor Pier, north Wales. However, these impacts were local in nature (0 to 10 m) and were not detectable at greater distances.

D.1.8 Ysebaert *et al*. (2009) also found that the influence of bottom cultures on the sedimentary environment and on the macrobenthic community was found to be very local. Kaiser *et al*. (1998) argue that although local in extent, these changes may persist in time following the removal of mussel beds as although the fine sediments are reworked, the remaining shell material effectively creates a new benthic habitat that may have more long term effects on the composition of benthic fauna in the area.

D.1.9 In contrast, Van der Zee *et al*. (2012) reported that mixed blue mussel and oyster beds can have large scale effects (>100 m) as the beds have effects on consumer-resource interactions far beyond their own physical spatial boundaries in intertidal soft-sediment systems. This is a result of increasing organic matter in the sediment, increasing the silt fraction in the sediment and decreasing the redox potential all of which can influence the distribution of benthic species (Norling *et al*., 2015).

D.1.10 In relation to the effects on surrounding sediment, Norling *et al*. (2015) again reported that the presence of live blue mussels on the seabed significantly increased the organic content in the surrounding sediment by both excreting organic-rich particles and also by trapping passing organic rich particles due to the heterogeneous structure of the mussel bed compared to the surround sandy seabed. However, no significant effects on infaunal species richness or abundance were found during this study though there was a trend towards reduced infaunal abundance in both oyster and blue mussel plots (both alive and dead). Dittmann (1990) reported that blue mussel beds reduce macroinfauna abundances compared to the surrounding sandflats with a change in the composition of the assemblages from Polychaeta in the sandflats to Oligochaeta in the mussel beds. Kochmann *et al*. (2008) report that the presence of mussel beds on the seabed results in a change in the species composition but not in richness. Species which are more tolerant to the changing organic content in the sediment move into the mussel beds whereas less tolerant species remain in the bare sand. The abundances of infaunal species increased under the mussel beds, possibly due to the cover provided by the mussels from predators.

D.1.11 With respect to fish species, Norling *et al*. (2015) found that live blue mussel beds had a positive effect on the fish assemblages with an increase in species richness, abundance and total biomass particularly for oyster beds but also to a lesser degree for live blue mussel beds. Similar positive relationships between blue mussel beds and fish in the Baltic Sea (Jansson *et al*., 1985). However, the other studies cited in Norling *et al*. (2015) of observations of an increases in fish diversity and abundance over bivalve beds made by Norling *et al*. (2015) were all based on oyster beds (Breitburg, 1999; Posey *et al*., 1999; Trolley and Volety, 2005) and in the United States by Peterson *et al*., (2003). In particular the differences in physical structure of oyster beds compared to blue mussel beds to attract different suites of species, the ability of oyster beds to form reefs and so persist for much longer and the lack of information relating to use of fish on dead blue mussel beds are all factors that need to be considered when evaluating the impact of bivalve plots on benthic fauna.

D.1.12 The use of dredges to harvest the mussel beds had an impact on the non-target infaunal benthic fauna at a site in Denmark with polychaetes associated with mussel beds having a reduced density after dredging. In addition, gastropods and bivalves were also reduced in number after dredging. These impacts are reported to be short term in nature (Dolmer *et al*. 2002). The invasion of scavenging brown shrimps into the dredged area accelerates the transport of energy to higher trophic levels, and thereby changes the trophic structure of the ecosystem. (Dolmer *et al*. 2002).

D.1.13 Hoffmann and Dolmer (2000) found that the use of dredges had no long-term effects on the epifauna composition, however further studies suggest that taxa such as sponges, echinoderms, anthozoans, molluscs, crustaceans and ascideans occurred at reduced density or were not observed at all 4 months after an area had been fished, indicating that the fishery has a short-term effect on the epifauna (P. Dolmer, unpublished results). In contrast, harvesting, as well as habitat change, was proposed as an explanation for a decrease in the number of species and in the total number of individuals in their study site (Smith and Shakley, 2004).

D.1.14 In summary, it appears that mussel culture beds can increase the diversity and abundance of epibenthic fauna by providing an additional food resource for species that predate on the mussels themselves or other species that may be attracted to the mussel bed to predate on the species that are attracted to the mussel beds for refuge. This change in epibenthic fauna is contrasted with a change of infaunal species as increased organic rich sediments deposited by the mussels changes the characteristics of the sediments beneath the culture plot. There is disagreement as to the effectiveness of mussel beds to increase or decrease the abundance of other filter feeding benthic species positively by providing an additional habitat for larvae to establish or negatively by consuming the larvae of other species that may otherwise occupy the area. Local site specific factors may play an important role in determining the impact of bottom mussel plots on benthic fauna.

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