Galway Harbour Company

Galway Harbour Extension

APPENDICES TO NATURA IMPACT STATEMENT

ADDENDUM / ERRATA

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Appendices to Natura Impact Statement

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Appendix No. 2.1 – Lough Atalia and Renmore Lagoon Habitats

[From Chapter 7 of the EIS – Pages 7-11 to 7-37]

2.1 LOUGH ATALIA AND RENMORE LOUGH HABITATS

Lough Atalia and Renmore Lough lie in the inner part of Galway Bay and are defined as "lagoons" within the EU Habitats Directive. Lagoons are listed as priority habitats in this Directive. As these water bodies lie close to the site of a proposed extension of Galway Harbour, an assessment of the possible impact of the proposed development on the ecology of both water bodies was undertaken.

A review of existing salinity data and information collected as part of this study showed that recorded salinities ranged from 0.4 to 29.4 psu (practical salinity unit). The calculated full range of salinities is from zero to 30.0 psu. Initial results from a broad scale 2 dimensional hydrodynamic model indicated that salinities might decrease and for this reason, a fine scale 3 dimensional modelling study was carried out (See Chapter 8 of the EIS).

This report describes the conservation status, morphology, bathymetry, current speeds and directions, salinity and biology of Lough Atalia and Renmore Lough. The species recorded in each water body are listed and are then discussed individually in terms of their salinity tolerances. The discussion at the end of the report comments on the likely effect the predicted temporal decreases in salinity may have on the conservation status of the water bodies.

2.1.1 Conservation Status

Both water bodies lie within Galway Bay candidate Special Area of Conservation (cSAC) and Lough Atalia only lies within the Galway Bay Special Protection Area (SPA) (see Figure 2.1.2). However, habitat quality in both is poor and in a review of Irish lagoons, Oliver (2007) states that "Lough Atalia is an "estuarine" lagoon and most of the bed of the lagoon appears to be bare, soft mud. It is also highly polluted, so that even on hard surfaces very few algal plants were found. Based on aquatic vegetation, the site is regarded as of no conservation value as a coastal lagoon." Oliver (*loc. cit.)* did not survey Renmore Lough.

The conservation objectives for Galway Bay cSAC and SPA were recently published by National Parks and Wildlife and the section on lagoons in the cSAC is presented in the following Table 2.1.1.

Conservation Objectives for Lagoons in Galway Bay cSAC		
Annex I Habitat	**Coastal lagoons* [1150]**	**Assessment of Impact**
Measure : Hectares	**Attribute:** Habitat Area **Target**: Permanent habitat increasing or stable. Area stable, subject to slight natural variation. Favourable reference area 76.7ha. Notes. Areas calculated from spatial data derived from Oliver (2007). Site codes IL037, IL038, IL039, IL046, IL047, IL048, IL049, IL050, IL051, and IL052. N.B. There may be more, as yet unmapped, lagoons within this cSAC.	No change to habitat area
Measure : Occurrence	**Attribute:** Habitat distribution **Target:** No decline, subject to natural processes. Notes. Site codes IL037, IL038, IL039, IL046, IL047, IL048, IL049, IL050, IL051, and IL052 in Oliver (2007). N.B. There may be more, as yet unmapped, lagoons within this SAC.	No change to habitat distribution.
Measure : Practical salinity unit (psu)	**Attribute**: Salinity regime **Target:** Median annual salinity and temporal variation within natural ranges maintained. Notes. The lagoons in the site vary from oligohaline to euhaline. Lough Atalia and Renmore Lough are poikilohaline systems (see Table 6.5 for definitions).	Fluctuations on the existing variability possible though deemed not to have any impact on the functioning of the ecosystem.
Measure: Water depth	**Attribute:** Hydrological regime **Target:** Current annual water level fluctuations and minima maintained within natural ranges. Note. Most of the lagoons listed for the site are considered to be shallow; however, Aughinish and Lough Atalia do have deeper (at least 3m) parts.	Water levels will be maintained and will not be altered by the development.

Table 2.1.1 - Conservation Objectives for lagoons in Galway bay cSAC

Conservation Objectives for Lagoons in Galway Bay cSAC		
Annex I Habitat	**Coastal lagoons* [1150]**	**Assessment of Impact**
Measure: Barrier	**Attribute:** Barrier **Target:** Permeability of barrier maintained. Appropriate hydrological connections between lagoons and sea, including where necessary, appropriate management. Notes. The lagoons within this site exhibit a variety of barrier types including cobble/shingle, karst and artificial embankment/causeway. Several are recorded as having sluices.	There will be no impact on the barrier/sill.
Measure: Chlorophyll a	**Attribute**: Water Quality (Chlorophyll a) **Target:** Annual median chlorophyll a reduced within natural ranges and less than 5μg/l. Note. Target based on Roden and Oliver (2010).	There will be no impact on chlorophyll a.
Measure: Phosphorous	**Attribute:** Water Quality (MRP: Molybdate reducing Phosphorous) Target: Annual median MRP reduced within natural ranges 0.1mg/l. Note. Target based on Roden and Oliver (2010).	The development will not alter MRP levels.
Measure: Nitrogen	**Attribute:** Water Quality (DIN; dissolved inorganic Nitrogen) **Target:** Annual median DIN a reduced within natural ranges and less than 0.15mg/l. Note. Target based on Roden and Oliver (2010).	The development will not alter DIN level.

Table 2.1.1 contd/. - Conservation Objectives for lagoons in Galway bay cSAC

Conservation Objectives for Lagoons in Galway Bay cSAC		
Annex I Habitat	**Coastal lagoons* [1150]**	**Assessment of Impact**
Measure: Macrophytic growth	**Attribute:** Depth of Macrophyte Colonisation **Target:** Increase colonization to maximum depth. Note. Macrophyte colonisation at least 2m depth.	Development will not alter macrophyte communities
Measure: Floral diversity	**Attribute:** Typical Plant Species **Target:** Maintain number and extent of listed lagoonal specialists, subject to natural variation. Note. Species listed in Oliver (2007).	The development will not alter floral lagoonal specialists.
Measure: Faunal diversity	**Attribute**: Typical Animal Invertebrate Species **Target:** Maintain listed lagoon specialists, subject to natural variation. Note. Species listed in Oliver (2007).	The development will not alter faunal lagoonal specialists.
Measure: Negative indicator species	**Attribute:** Negative Indicator Species **Target:** Negative indicator species absent or under control. Note. Low salinity, shallow water and elevated nutrient levels increase the threat of accelerated encroachment by reed beds.	The development will not alter negative indicator species.

Table 2.1.1 contd/:. Conservation Objectives for lagoons in Galway Bay cSAC.

Turbidity is not listed in the conservation objectives as an attribute. However, sediments suspended during the dredging operations have the potential to enter the lagoon on flooding tides. As a result of the oceanographic conditions within the lagoon, this sediment will not be remobilised and will be retained within it. The result could be the loss of water depth (*ca* 10mm) in the northeastern section of the lagoon. This will be mitigated by permitting dredging only under ebbing tides.

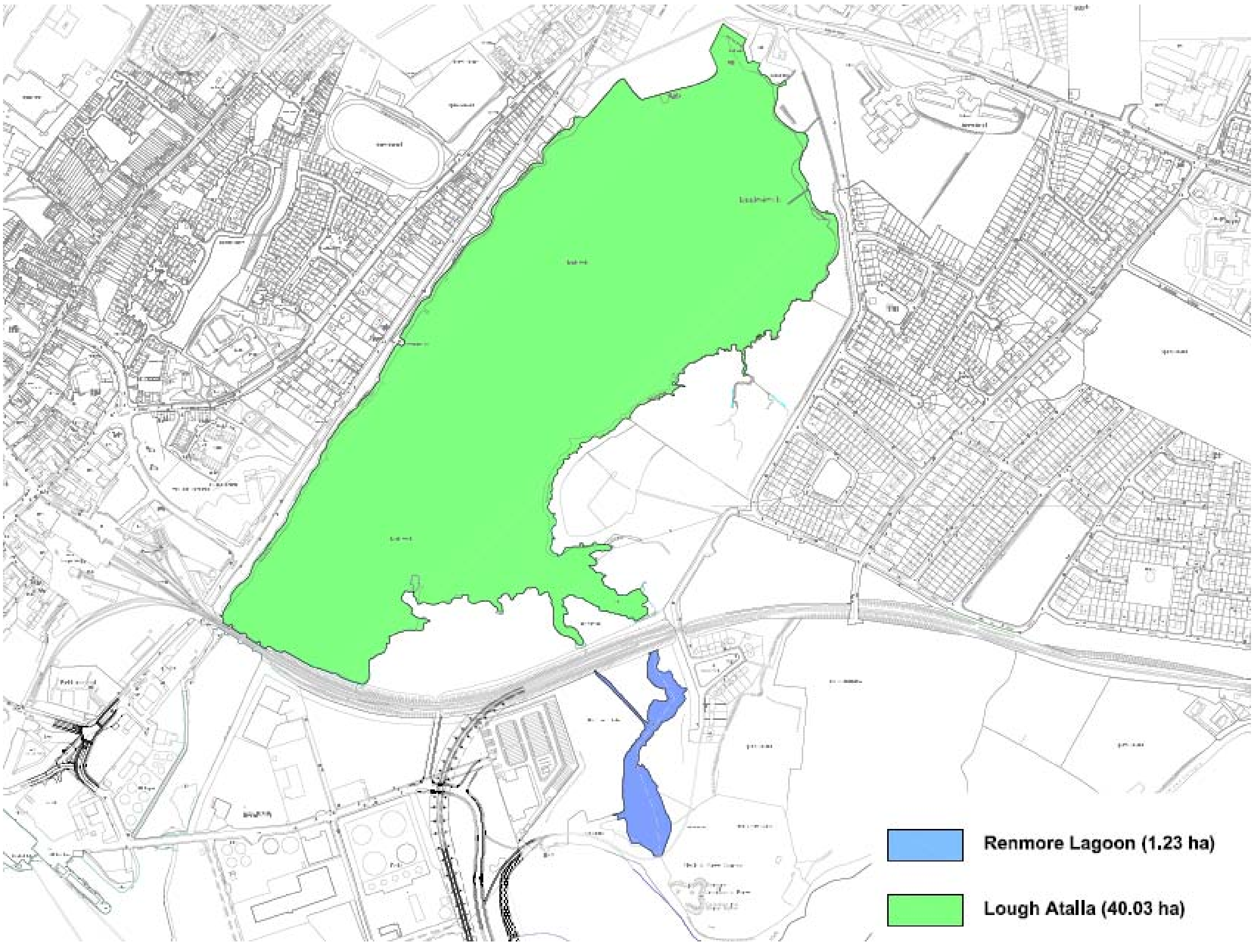


Figure 2.1.1 – Map showing Coastal Lagoons [Priority Habitats]

Figure 2.1.2 - Lough Atalia and Renmore Lough within the cSAC and SPA

2.1.2 Description of Lough Atalia and Renmore Lough.

Lough Atalia and its small off-shoot, Renmore Lough comprises an area of ca 40 ha of Inner Galway Bay (see Figure 2.1.3). Given the presence of at least 3 lagoonal specialists in the Lough Atalia/Renmore Lough water body, the wide variability in salinities and the fact that it only partially empties, this habitat falls within the definition of a lagoon. Lagoons are listed in Annex I of the Habitats Directive as a priority habitat, ‘Coastal Lagoons’ (Natura 2000 Code 1150).

Figure 2.1.3 - Lough Atalia and Renmore Lough

Lough Atalia has a narrow channel to the south-west connecting it with Inner Galway Bay (see Figure 2.1.3). There is a shallow sill at the entrance to the lough (see Figure 2.1.6) which restricts full tidal flow into it. This corresponds to the characterisation by Healy (2003) of lagoons being at least partially separated from, while still having exchange of water, with the sea. The presence of the sill in Lough Atalia leads to an asymmetrical tide of ca nine hours ebb and three hours flood. The sill also acts to retain water at low tide with approximately 80% of the lough remaining inundated at low tide (Oliver, 2007). Such asymmetrical tides are typical of water bodies with significant sills and other examples in Co. Galway are Curanroo, Lough Rusheen, several other Lough Atalias in Connemara and Salt Lake, Clifden. Some systems *e.g.* Inverbeg and Loch Aneera, both in Kilkieran Bay, only receive salt water on equinoctial Spring tides. This denser water sinks underneath the lighter freshwater and lies on the lake bed where it becomes anoxic. However, due to the significant flows into and out of Lough Atalia, anoxia in the water column does not occur. The intertidal, muddy area in the northern part of Lough Atalia is relatively small in comparison to the large area of water retained.

The connection channel (Figure 2.1.3) has undergone a number of changes in the last *ca* 150 years. It was partially narrowed as part of the construction of the railway line into Galway City in the 1860s by the building of an abutment on the eastern side and two piers to support the rail bridge. Further alterations occurred in the 1960s and 90s when the sides of the channel (between the railway bridge and a newly constructed road bridge to the south allowing access to the Galway Enterprise Park and southwards) were straightened. Other changes include the construction of storm water overflows at the northern and eastern end of the lough. There is a freshwater well on the western side of the lagoon called St. Augustine’s Well.

Renmore Lough (Figure 2.1.3) is connected to the south-east of Lough Atalia via a cut channel under the railway. It was historically connected to Lough Atalia by a natural channel but this was closed up when the railway line was built and a small channel was opened ca 100m to the west of the original access point and this goes under the railway line to join the main body of Lough Atalia (Figure 2.1.3). The water level in Renmore Lough is ca 1 m higher than the top of the culvert under the railway line (marked on Figure 2.1.3 as “Present Connection”). This indicates that sea water rarely accesses Renmore Lough from Lough Atalia.

2.1.3 Bathymetry

A bathymetric survey of Lough Atalia was carried out using a Precision SonarMite Echo Sounder in conjunction with a Trimble® GeoXT™ to record depths within Lough Atalia. Depths are mostly shallow (less that 1 m) but there is a deeper area towards the south-western section of the mouth with depths of up to ca 4m and which can reach >5.5m at high water (see Figure 2.1.4). This figure also shows a blow up of the access channel into Lough Atalia from the open sea. Its narrow width, shallow depths and sill (coloured in gold) all restrict ingress of water into Lough Atalia and give rise to the asymmetrical tides noted above.

Depths of Renmore Lough, taken at a neap low water 14/03/2012 ranged between 0.15-0.85 and for this reason, a vessel-based bathymetric survey was not possible.

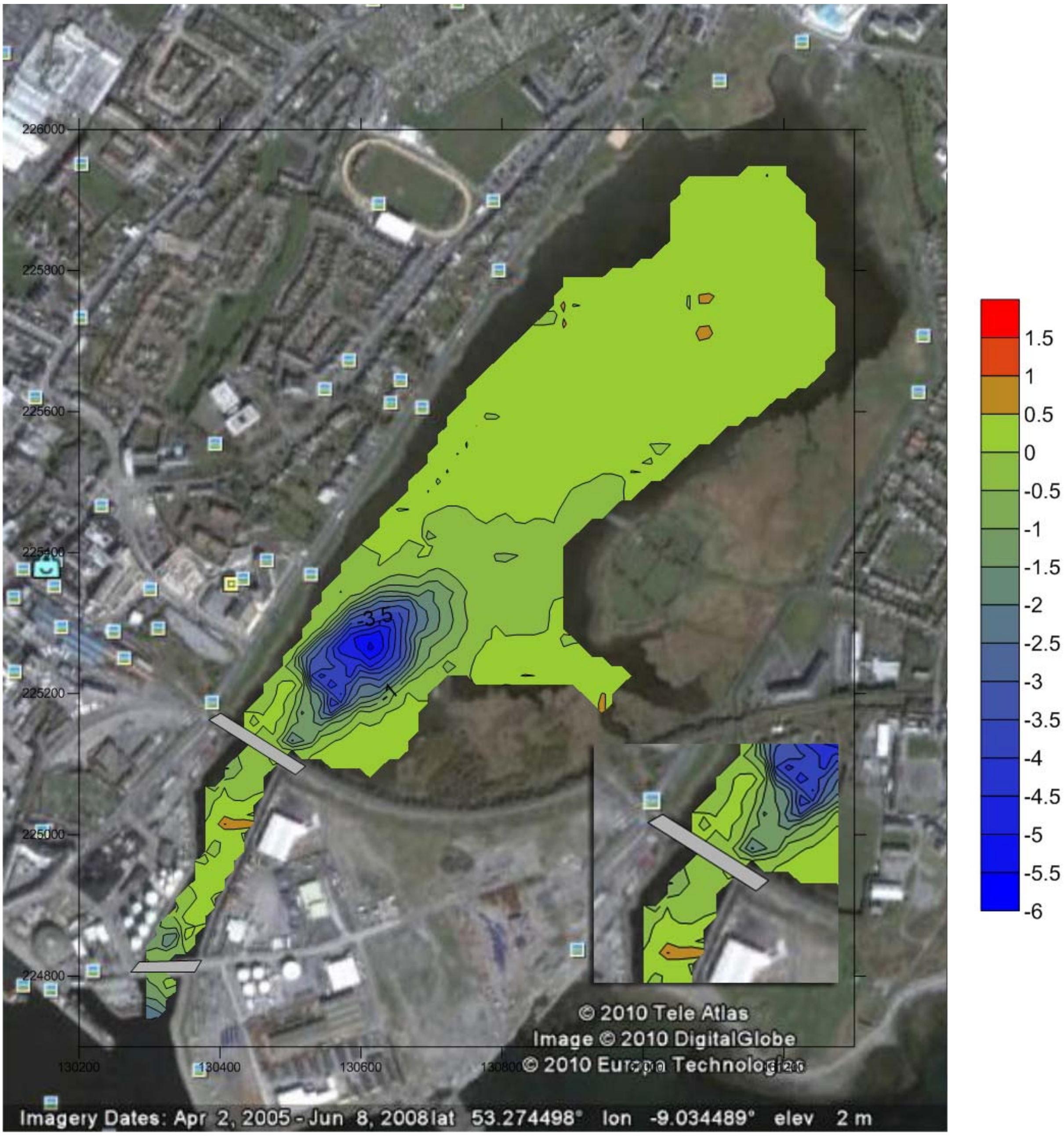


Figure 2.1.4- Bathymetry of Lough Atalia.

2.1.4 Current speeds and directions

Current flow at the mouth of Lough Atalia was measured by deploying a continuous recording current meter between 8 January and 1 February 2013 and for a second period between 11 March and 25 March 2013 (see Figure 2.1.8 for location and Appendix 7.2 [Vol. 2C Appendices to EIS] for graphical representation of data).

There is greater water flow near the south-western mouth of the lough compared to its north-eastern head. The increased velocity of water at the mouth is caused by water movement over the sill and these forces are less in waters towards the north-eastern end. Hydrodynamic model output shows Lough Atalia to have greater and more variable velocities during spring tides. Velocities around the mouth vary from 0.15 - 3m/s with lower velocities in the rest of the lough often at the minimum of 0m/s but sometimes rising to 0.05m/s in the centre. Weak water currents compared to those of estuaries are a characteristic of lagoons (Healy, 2003). The water velocity patterns result in the sediment at the mouth comprising gravel, compared to the soft muds found towards the north-eastern end.

Directions of flow are northeast on a rising tide and southwest on a falling tide.

Run off and seepage from land flows into Renmore Lough in accordance with levels of rain fall. Because Renmore Lough is perched (+1m above mean high water neap), water flows out of it into Lough Atalia for a much longer period than water flows into it (see Figure 2.1.6 for cross sections from the sea into Lough Atalia and from Lough Atalia into Renmore Lough). It is only under highest astronomical Spring tides that sea water can access Renmore Lough.

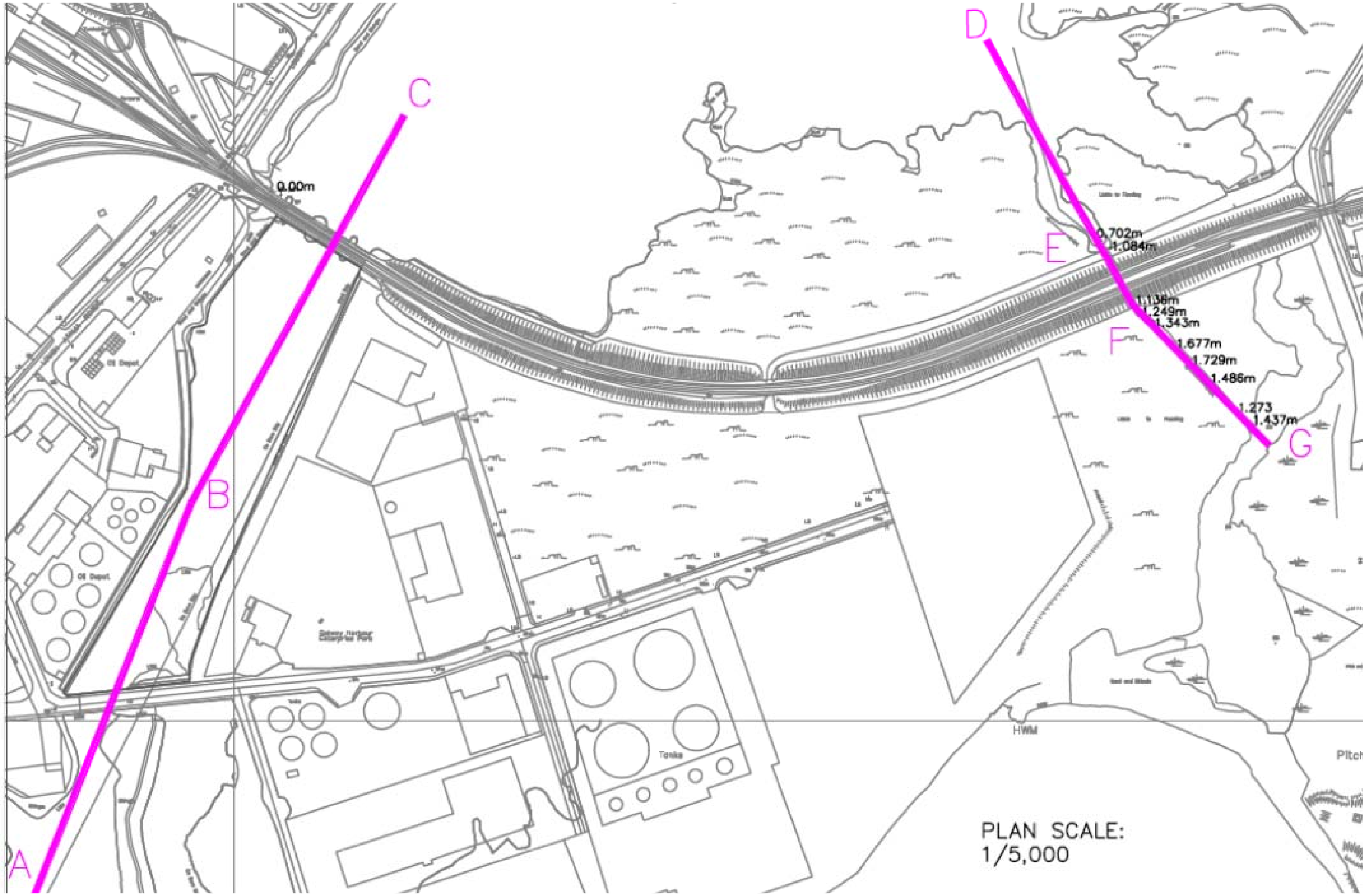


Figure 2.1.5 - Plan of Channels:

Plan of Channels:
Open Sea to Lough Atalia A-B-C
Lough Atalia to Renmore Lough D-E-F-G

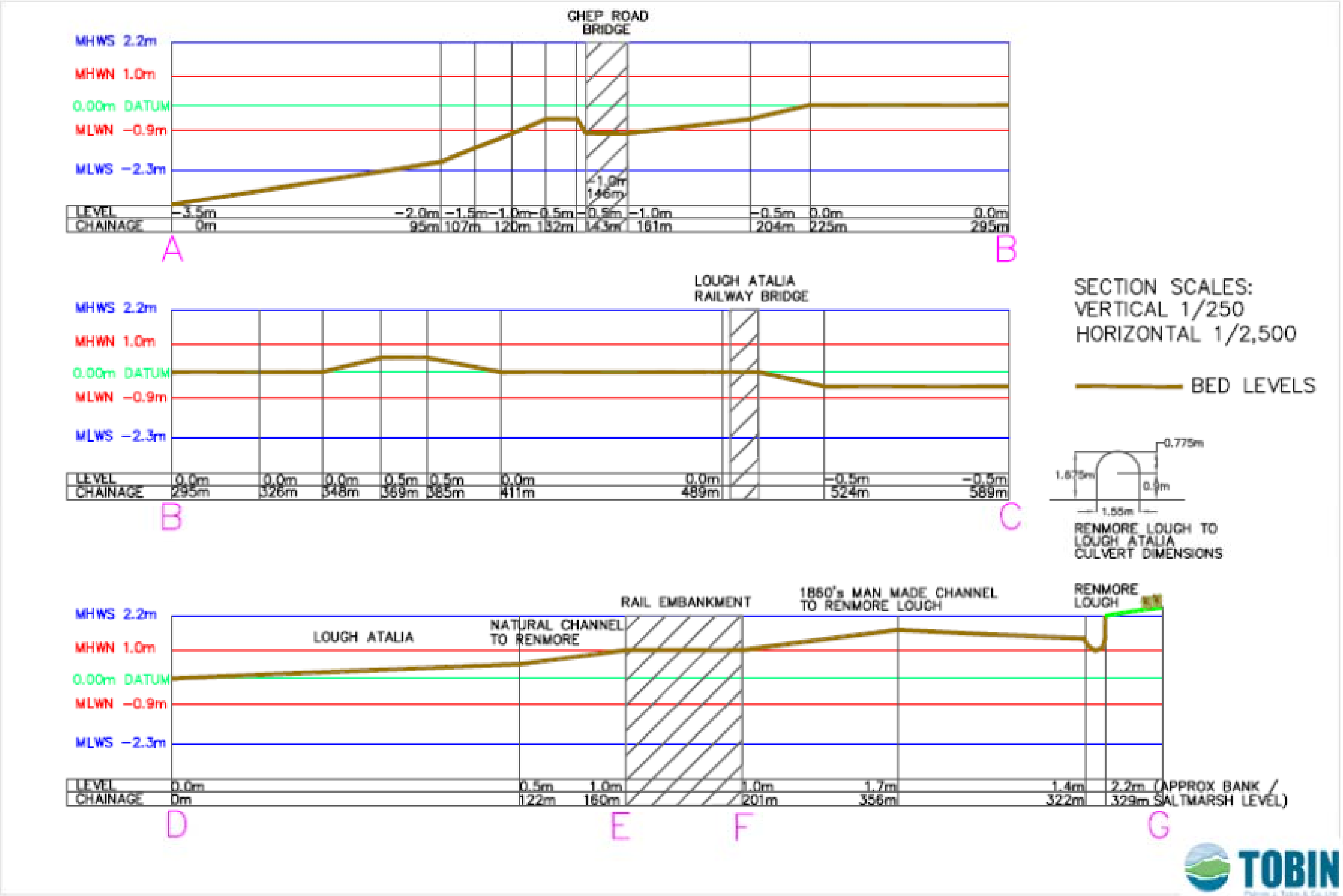


Figure 2.1.6 - Long section of channel from the open sea to Lough Atalia and from Lough Atalia to Renmore Lough

2.1.5 Salinity

Existing data reported by Sotillo *et al.* (2011) and data collected by AQUAFACT were used to describe the salinity conditions in both Lough Atalia and Renmore Lough. Sotillo *et al.* (2011) used a field probe to record values at different depths and locations while the AQUAFACT surveys included both a field probe deployed along the shoreline (surface readings only) and from a boat (at 50 cms depth intervals) and *in situ* continuous recording salinity meters. The different survey types and durations are listed below. Figure 2.1.7 shows the initial location of 21 profile stations used to describe salinity in profile while Figure 2.1.8 shows the locations of the reduced 10 profiling stations.

Shore Surveys

In August 2011, salinity measurements were taken at 4 stations on the western shore of Lough Atalia.

Between 12 September 2011 and 29 November 2011, salinity measurements were recorded at Renmore Lough, on 5 separate occasions. Further salinity measurements were recorded at Renmore Lough between 5th March 2012 and 2nd May 2012 on 14 separate occasions. A salinity measurement was also taken at a site located on the NE shore of Lough Atalia, as part of the 2012 surveys.

Between 14th January 2013 and 24th January 2013, salinity measurements were recorded at the south and north ends of Renmore Lough.

On 6th March 2013, salinity measurements were taken at the bridge over the mouth of Lough Atalia, between 9am and 5pm, at 15 minute intervals, with readings recorded at surface, 0.5m, 1m, 1.5m, and 2m depth.

Boat Surveys

In August 2011, 7 vertical salinity profiles were taken along a transect from south to north Lough Atalia.

In March 2012, depth measurements were taken in Renmore Lough along a transect from north to south.

At 21 stations located in Lough Atalia, salinity measurements were taken by boat on 5 separate occasions, between 4th April 2012 and 4th May 2012.

At 10 stations in Lough Atalia, salinity was measured by boat on 8 separate occasions, between 4th December 2012 and 24th January 2013. Fauna and sediment samples for particle size analysis and organic carbon were taken at these 10 stations on 4th December 2012.

Continuous current and salinity recordings

Current metering using a bottom mounted, upward looking Acoustic Doppler Current Profiler, (ADCP) and salinity readings were recorded between 8 January 2013 and 1 February 2013, and between 11 March 2013 and 25 March 2013. Figure 2.1.9 shows how these meters were deployed. Readings were recorded every 30 minutes.

Figure 2.1.7 - Figure showing the 21 stations where salinity profiles were recorded with a probe

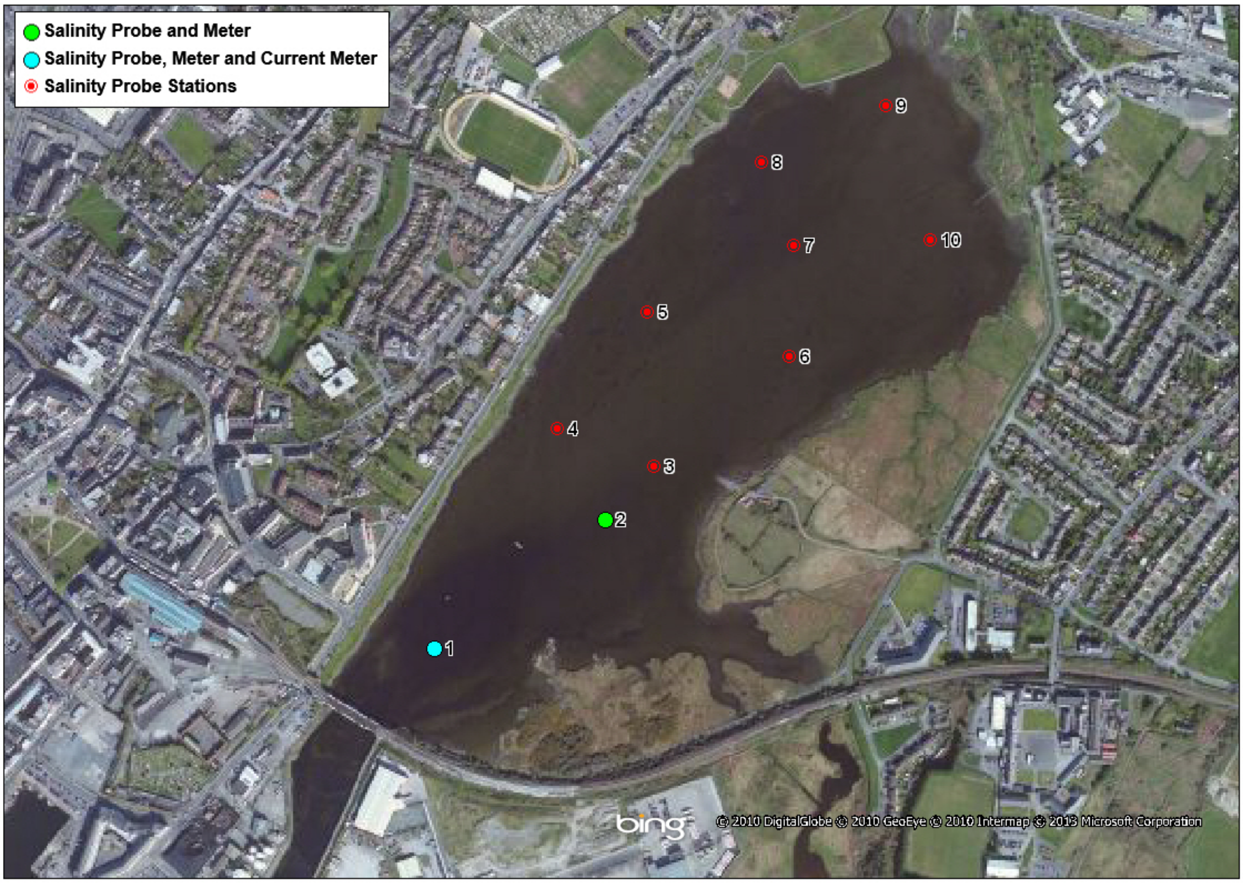


Figure 2.1.8 - Figure showing the 10 stations where salinity profiles using a probe were collected, the two sites where continuous recording meters for both salinity and the single site where the continuous recording current meter was deployed

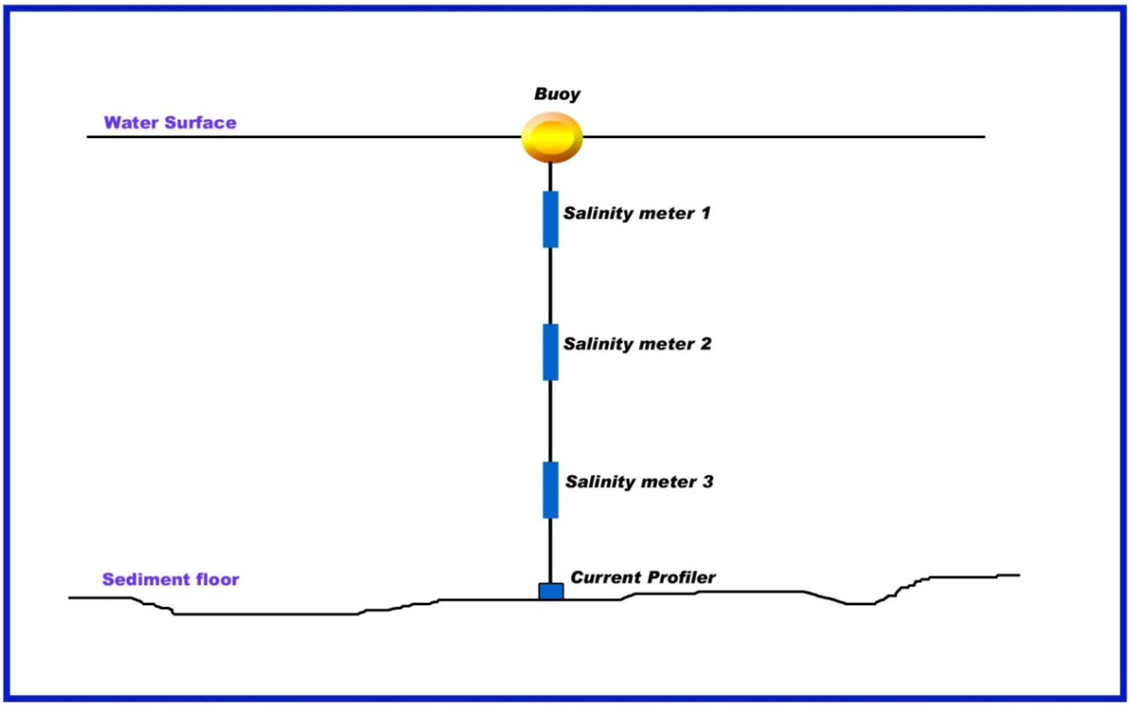


Figure 2.1.9 - Diagram showing layout of current and salinity meter strings [Vol. 2C – Appendices to EIS]

Results of some of the data collected using the probe are presented in Appendix 7.2 along with data and graphs collected by the continuous recording meters over the period March 11th – 25th, 2013.

During the study period, salinities within Lough Atalia ranged from 0.4 to 29.4 psu (practical salinity unit). Over the course of Spring-Neap tidal cycles, surface salinities range from 0.4 to 28.8 psu and bottom salinities range from 10 to 29.4 psu. Surface salinities are generally lower near the southern end of the lough where the mouth is located. However, low surface salinities were also recorded towards the northern end of the lough. Salinities increase with depth, leading to the highest salinities being recorded at the deepest areas of the lough. The low values at the northern end reflect the effects of surface run off. Low surface salinities recorded at the mouth are due to Corrib River water being brought in to the lough by flooding tides. There is some evidence to suggest the formation of a temporary halocline (halocline = a strong discontinuity in salinity with depth) in Lough Atalia under conditions of low mixing which disappears in high mixing conditions such as during a flooding tide.

Salinity in Renmore Lough ranged from 2.2 to 23.9 psu and extreme values were recorded at its northern end. As noted above in the section on bathymetry and shown in Figure 2.1.4, it is only under highest astronomical tides that water can access Renmore Lough from Lough Atalia and it is the salinity characteristics of this inflowing water that regulates salinity within the Lough. If the River Corrib is in spate at the time of these high tides, salinities will be lowered (as in the recording of 2.2 psu above) whereas if River Corrib flow is low, the salinity of inflowing water from Lough Atalia into Renmore Lough will be high (23.9 psu recorded above).The salinities within Renmore Lough remain more or less constant between the southerly end and the northerly end (averaging 10.3-10.4 psu), which is further from the sea, suggesting that there are no pathways directly between the sea and Renmore Lough through the narrow land bank.

The extensive range of salinities recorded both in Lough Atalia and Renmore Lough classifies them as poikilohaline systems (poikilohaline = high variability in salinities). Millar *et al*. (1990) note that mean salinity values range from 0 – 35 psu and comment that lagoonal species are usually quite tolerant of a wide salinity range.

<u>Salinity Units ppt and psu</u>

It should be noted that the salinity measurement data referred to in this report are in the units of psu, whereas the hydrodynamic salinity model TELEMAC-3D refers to salinities in grams of salt per kilogram of solution (g/l or parts per thousand (ppt)). The modern oceanographic definition of salinity is the Practical Salinity Scale of 1978 (PSS-78). The numeric unit from PSS-78 is psu (practical salinity unit) and is distinct from the previous physical quantity ppt (kg salt per kg water in parts per thousand). Salinity values in ppt and psu are nearly equivalent by design, and for the purposes of this assessment can be treated as equivalent.

2.1.6 Turbidity

Turbidity measurements returned a value of 0 NTU (Nephelometric Turbidity Units).This value of 0 NTU was also measured in Galway Bay and on Wolfe Tone Bridge at the mouth of the River Corrib. Secchi disc measurements taken in Lough Atalia resulted in a visible reading off bottom for most stations due to the shallow depths. At the deeper stations, Secchi values of 2.5 to 2.75m were recorded. As Renmore Lough is less than 1 m depth and the sea bed could be seen on each site visit, Secchi disc measurements were not made.

2.1.7 Flora and fauna

49 taxa of flora and fauna recorded in Lough Atalia and Renmore Lough is shown in Table 2.1.2. Taxa only recorded within Renmore Lough are coded with R.L. (= Renmore Lough). This table was compiled from surveys by Oliver (2007), Sotillo *et al.*, (2011) and AQUAFACT (2010 - 2013). *Chaetomorpha linum, Jaera nordmanni* and *Palaemonetes varians* are considered to be lagoonal specialist species (Healy, 2003; Oliver, 2007). The numeral in the column on the extreme right is given to direct the reader to the species' salinity tolerance given in Section 2.1.8 below.

Flora and fauna recorded in Lough Atalia and Renmore Lough (based on Oliver, 2007; Sotillo *et al.*, 2011 and AQUAFACT surveys)			
Phylum	**Division/Class**	**Species**	
Plantae	Chlorophycota	*Chaetomorpha linum*	1
		Enteromorpha sp.	2
		Ulva lactuca	3
	Phaeophycota	*Fucus serratus*	4
		Fucus spiralis	5
		Fucus vesiculosus	6
		Pelvetia canaliculata	7
	Rhodophycota	*Ceramium sp.*	8
		Chondrus crispus	9
	Xanthophyceae	*Vaucheria* sp.	10
	Angiosperm	*Ruppia* sp.	11
Cnidaria	Hydrozoa	*Cordylophora caspia*	12
Nematoda		Indet.	13

Table 2.1.2 - Flora and fauna recorded in Lough Atalia and Renmore Lough (based on Oliver, 2007; Sotillo et al., 2011 and AQUAFACT surveys)

Flora and fauna recorded in Lough Atalia and Renmore Lough (based on Oliver, 2007; Sotillo *et al.*, 2011 and AQUAFACT surveys)			
Phylum	**Division/Class**	**Species**	
Annelida	Polychaeta	*Hediste* (*Nereis*) *diversicolor*	14
		Polydora ciliata	15
		Pygospio elegans	16
	Oligochaeta	*Nais sp.*	17
		Heterochaeta costata (R.L.)	18
Crustacea	Cirripedia	*Elminius modestus*	19
	Copepoda	*Nitokra spinipes* (R.L.)	20
		Cyclopoida	21
	Mysidacea	*Neomysis integer*	22
		Praunus flexuosus	23
	Isopoda	*Jaera nordmanni*	24
		Jaera albifrons	25
		Asellus sp (R.L.)	26
	Amphipoda	*Allomelita pellucida*	27
		Melita palmata	28
		Gammarus duebeni	29
		Gammarus salinus	30
		Gammarus indet.	
	Decapoda	*Palaemon elegans*	31
		Palaemonetes varians	32
		Crangon crangon	33
		Carcinus maenas	34
	Ostracoda	*Cyprideis torosa* (R.L.)	35
Acarina		Indet	36

Table 2.1.2 contd/. - Flora and fauna recorded in Lough Atalia and Renmore Lough (based on Oliver, 2007; Sotillo et al., 2011 and AQUAFACT surveys)

Flora and fauna recorded in Lough Atalia and Renmore Lough (based on Oliver, 2007; Sotillo *et al.*, 2011 and AQUAFACT surveys)			
Phylum	**Division/Class**	**Species**	
Insecta	Diptera	Chironomidae indet.	37
	Odonata	Zygoptera (R.L.)	38
	Coleoptera	Dytiscidae (R.L.)	39
Mollusca	Pulmonata	*Peringia* (*Hydrobia*) *ulvae*	40
	Gastropoda	*Ecrobia (Hydrobia) ventrosa* (R.L.)	41
Bryozoa	Gymnolaemata	*Bowerbankia gracilis*	42
		Alcyonidium gelatinosum	43
Pisces	Osteichthyes	*Chelon labrosus*	44
		Platichthys flesus	45
		Pomatoschistus microps	46
		Gasterosteus aculeatus (R.L.)	47
		Antherina presbyter	48
		Anguilla anguilla (R.L.)	49

Table 2.1.2 contd/. - Flora and fauna recorded in Lough Atalia and Renmore Lough (based on Oliver, 2007; Sotillo et al., 2011 and AQUAFACT surveys)

A benthic survey using a 0.025 m^2 grab and a 1 mm mesh was undertaken to quantitatively assess the sea bed fauna and sediments in Lough Atalia. 2 grabs were taken for faunal identification at the 10 sites shown in Figure 2.1.10 below and a further sample was taken for grain size and organic carbon content. During the field work when samples were being collected, except for Station 1, there was a strong smell of hydrogen sulphide from all samples collected and the sediment was black. Both these features indicate anoxic, sedimentary conditions.

Figure 2.1.10 - Benthic grab station location map for Lough Atalia

The faunal analyses returned exceptionally low numbers of taxa and numbers of individuals with only 8 species being recorded at 4 stations. The following 7 species (and their densities) were recorded at Station 1: *Jaera nordmanni* (15), *Allomelita pellucida* (4), *Gammarus* sp (8), *Gammarus salinus* (13), Oligochaeta (3), *Pygospio elegans* (1) and *Polydora ciliata* (4). Station 3 returned only two specimens of *Melita palmata* and Station 5 and 9 returned only 1 specimen each of *Gammarus salinus*. Stations 2, 4, 6, 7, 8 and 10 had no fauna at all.

Table 2.1.3 shows the results of the analyses of grain size (as percentages) and organic carbon (right hand column as %) from the same 10 stations. Station 1 had by far the highest amount of coarse sediment with almost 70% being gravel. All other stations were characterised by low amounts of coarse sediment and high percentages of fine, very fine and silt clays. Organic carbon levels ranges from 10.05 at Station 1 to 18.96 at Station 2. The mean value was 14.89.

Results of granulometric (%) and organic carbon (LOI%) analyses on 10 sediment samples collected in Lough Atalia.								
Station	Gravel	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt-Clay	Organic Carbon
1	69.2	7.1	8.2	9.4	3.3	1.5	1.3	10.05
2	0.5	1.9	7	15	20.1	20.4	35	18.96
3	1	3.9	7.2	13.2	17	11.7	45.9	16.02
4	0.2	1.5	7.6	15.9	15.8	13.4	45.5	18.14
5	0.5	1	4.7	9	16.2	21.5	47.2	13.87
6	1	3.5	5.2	8.9	14.4	10.6	56.4	11.57
7	1.2	1	3.6	8.9	13.4	9.2	62.8	13.55
8	0	0	0.4	0.7	14.3	16.6	68.1	13.33
9	0.7	1.8	6.8	14.6	16.6	8.5	50.9	17.64
10	0.6	3.6	10.2	14.5	15.1	15.1	40.9	15.81

Table 2.1.3 - Results of granulometric (%) and organic carbon (LOI%) analyses on 10 sediment samples collected in Lough Atalia

Aquatic fauna from Renmore Lough was surveyed on 4th and 12th October 2011. Twelve invertebrate and three vertebrate taxa were recorded. Many taxa such as *Hediste diversicolor*, Chironomidae, *Ecrobia* (*Hydrobia*) *ventrosa*, *Anguilla anguilla* and *Gasterosteus aculeatus* are commonly occurring lagoonal species. Healy (2003) considers *Ecrobia ventrosa* and *Ruppia* sp. as characteristic lagoonal species. The former was present at all three stations in this survey, while the latter was recorded by Oliver (2007). *Palaemon varians* while also found in estuaries, is considered by Oliver (2007) be a characteristic lagoonal species. Other taxa such as *Hediste diversicolor, Palaemon varians* and Chironomidae are common marine or estuarine species which tolerate large salinity ranges. The Crustacea showed the most taxa present while there was only one species of mollusc, *i.e. E. ventrosa*, recorded.

Using the JNCC marine habitat classification, the above assemblage most closely fits the "sublittoral mud in low or reduced salinity (lagoons)" or SS.SMU.SMuLS grouping with the exception of *Arenicola marina, Heterochaeta costata* and *Corophium costata* which were not recorded in either water body.

In the Conservation Objectives for Galway Bay cSAC, the conservation status of Lough Atalia was assessed as 'Unfavourable- Bad' with problems of eutrophication and pollution, the threat of urbanisation, dumping and silting up. A major problem is the water quality at the site (NPWS, 2013).

A three dimensional mathematical model study (see Appendix 7.2 [Vol. 2C – Appendices to EIS] for full report) that was carried out to determine possible changes in salinity due to the construction of the proposed harbour extension predicted that:

- the present range of salinities which vary from 0 to 30 psu, within Lough Atalia will not change,
- the cumulative annual frequency of zero salinity occurring at the southern part of the lagoon *i.e.* close to the mouth, will increase from 7 to 18 hours over an average year and,
- the median salinity will reduce by 1.29 psu from the present value.

The model outputs can be seen in Figures 2.1.11 – 2.1.14 below for 90 (28.5 cumec (m^3/sec), 50 (82 cumec), 10 (200cumec) and 1 (272cumec) percentile flow of the River Corrib over a Neap – Spring cycle. Please note that the scale varies due to the values predicted by the output of the model *e.g.* Figure 2.1.14 the range is from 0 to 5. (*N.B.* Percentile flow is the percentage of time that the flow is greater or equal to a specific flow).

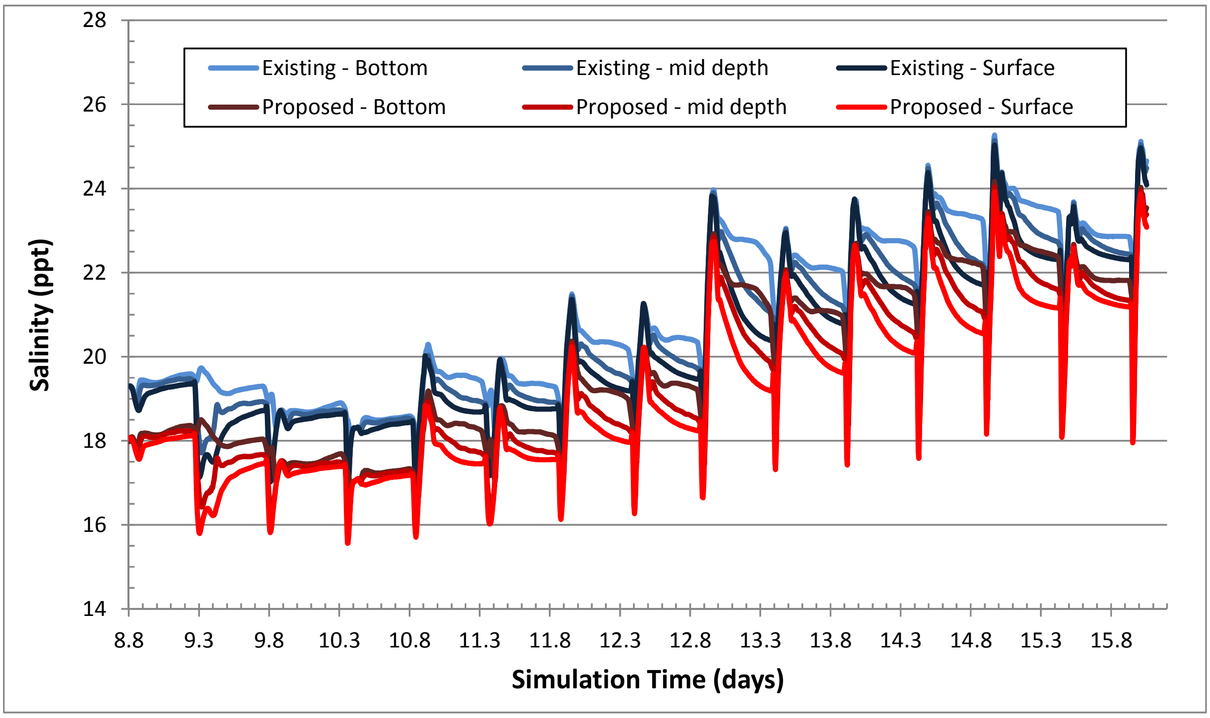


Figure 2.1.11 - Time series output of salinities at one location (St. 9) in Lough Atalia existing and proposed cases Neap to Spring tide under 90-percentile flow (28.5 cumec)

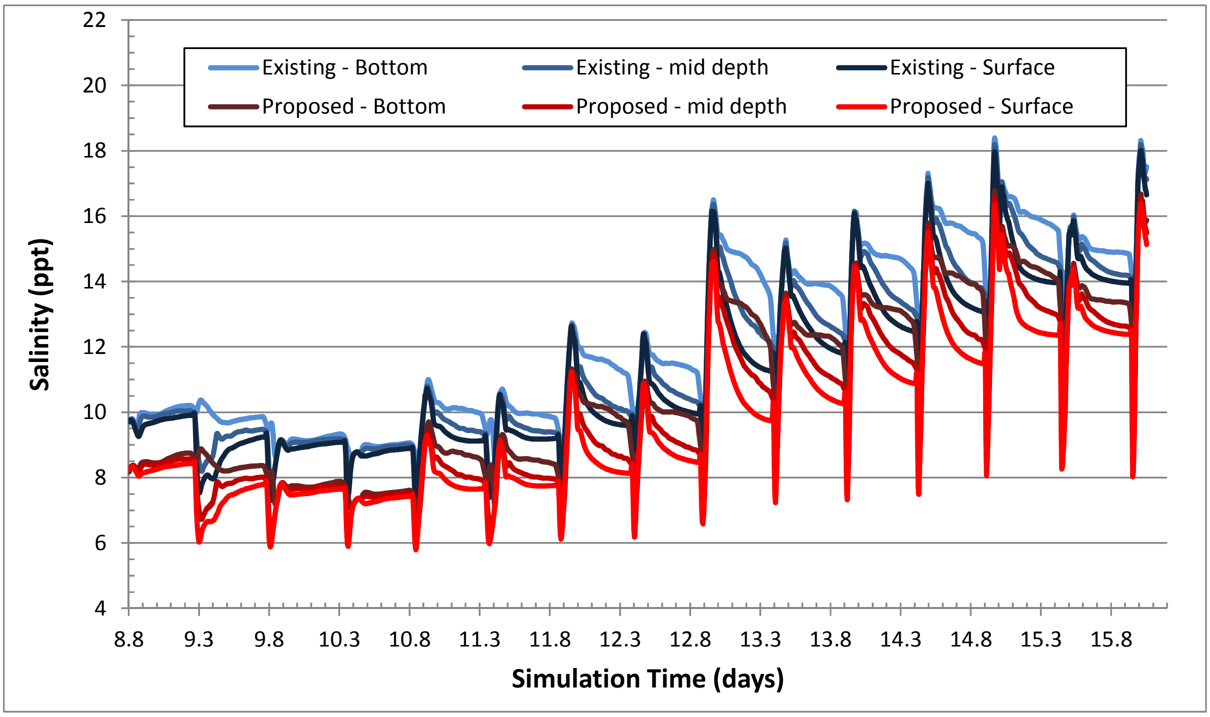


Figure 2.1.12 - Time series output of salinities at one location (St. 9) in Lough Atalia existing and proposed cases Neap to Spring tide under 50-percentile flow (82 cumec)

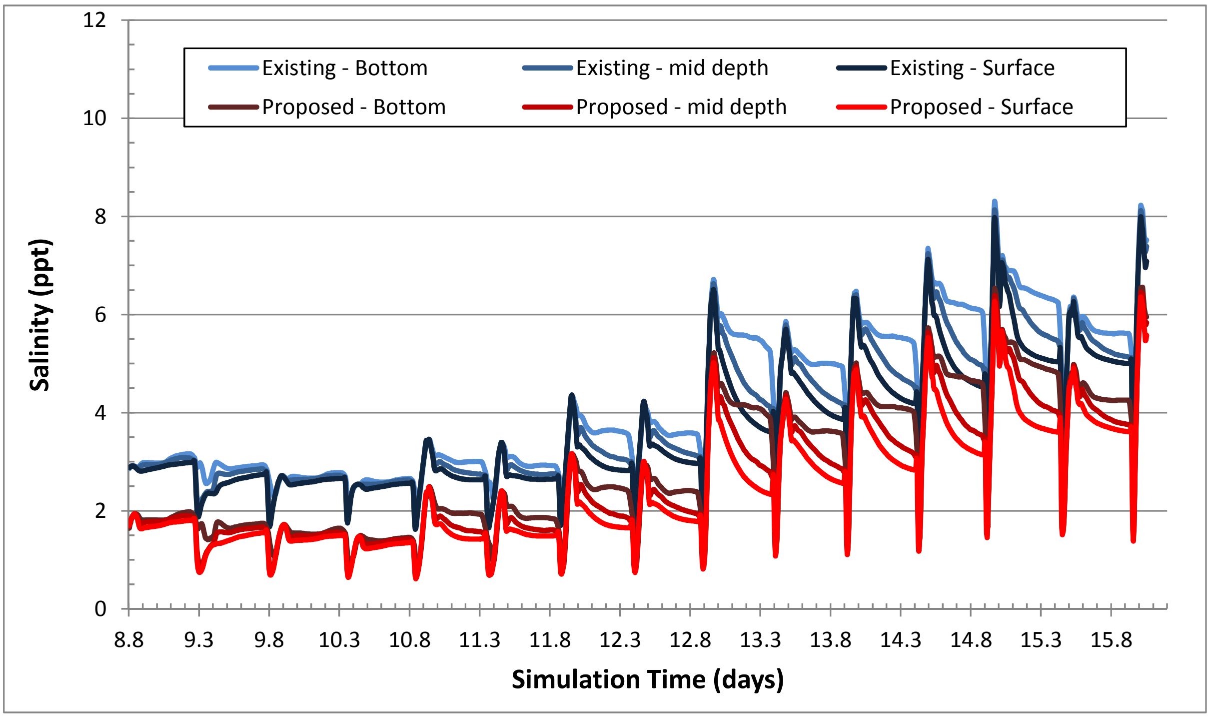


Figure 2.1.13 - Time series output of salinities at one location (St. 9) in Lough Atalia existing and proposed cases Neap to Spring tide under 10-percentile flow (200 cumec)

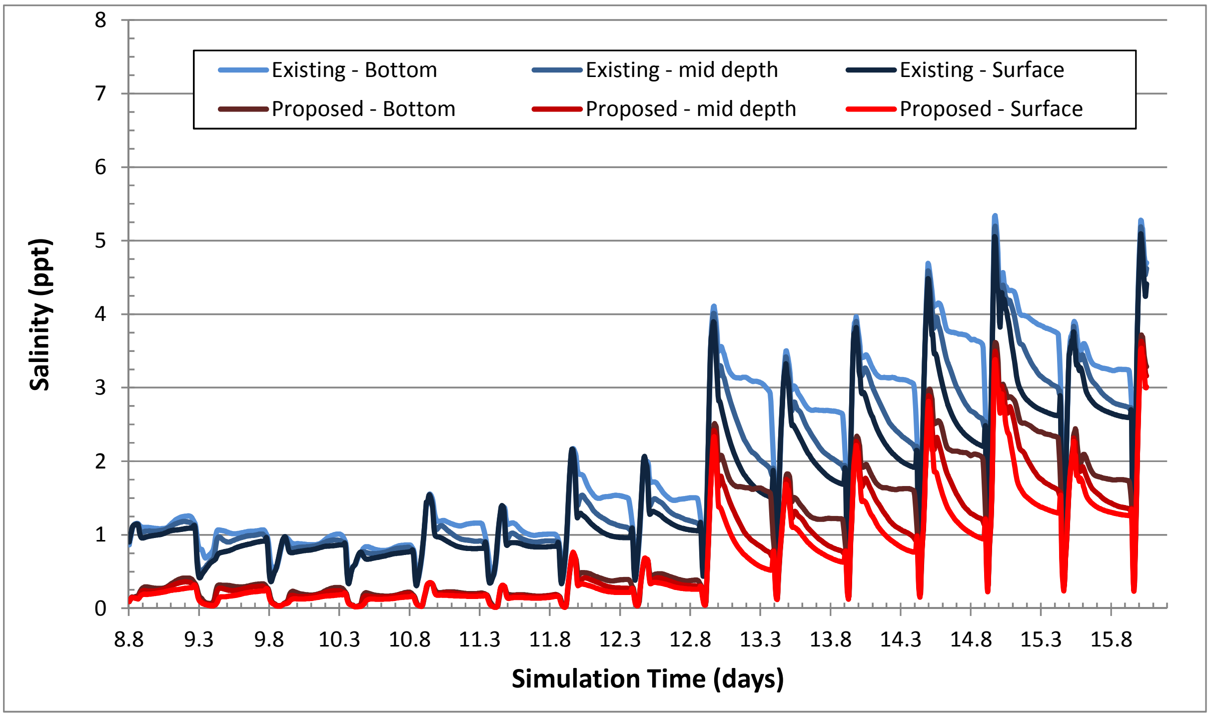


Figure 2.1.14 - Time series output of salinities at one location (St. 9) in Lough Atalia existing and proposed cases Neap to Spring tide under 1-percentile flow (272 cumec)

2.1.8 Potential impacts from the proposed development on floral and faunal species.

In order to determine if the predicted change in salinity could affect the resident flora and fauna recorded in both Lough Atalia and Renmore Lough, the salinity ranges which each species can tolerate was examined and the individual species are discussed below. It should be noted that some of these studies were laboratory-based experiments and species were tested under constant salinity levels for extended periods of time and not under the highly variable salinity levels that occur on each tide and under different River Corrib flow conditions. For information purposes, the practical salinity unit is presented in Table 2.1.4 below.

Practical Salinity Unit for Different Ranges of Salinity		
Salinity Term	**PSU**	**Common Term**
Freshwater	<0.5	Freshwater
Oligohaline	0.51 - 5	
Mesohaline	5.1 -18	Brackish
Polyhaline	18.1 - 30	
Poikilohaline	0 - 35	Poikilohaline
Euryhaline	30.1 - 40	Marine

Table 2.1.4 - Practical salinity scale for different ranges of salinity

The evolution of lagoonal communities appears to relate to the intrinsic variation in salinity within lagoons, both in time (short term) and space (Bamber *et al.,* 2001). In addition, a large number of lagoonal species are closely related to fully marine rather than estuarine or freshwater species, are essentially sublittoral and are tolerant of a wide range of salinity (for example 10 – 45 psu) (Bamber *et al.,* 2001).

de Wit (2011) uses the term poikilohaline for water that ranges from 0 – 35 psu and both Lough Atalia and Renmore Lough fit this category. These terms are used in the following section which examines the salinity tolerances of the species recorded and some other Irish lagoon characteristic species.

Salinity values recorded in Lough Atalia extend the tolerance ranges for many taxa and these are noted in the species' commentary where these apply. N.B. References can be found in Appendix 7.2. [Vol. 2C – Appendices to EIS]

1. *Chaetomorpha linum*

There is some doubt about the taxonomic status of the unattached lagoonal form of this species and it was recorded by Hatch & Healy (1998) as *C. mediterranea* (NPWS, 2012). It is a common, characteristic alga of semi-isolated Irish lagoons, recorded at 49 of the 87 (56.3%) lagoons surveyed (Oliver, 2005). It is considered a poikilohaline species.

2. *Enteromorpha sp*.

Studies on *Enteromorpha intestinalis* (Martins *et al*., 1999) showed that its growth varies along a bell-shaped curve with salinity and that the optimum salinity range for growth is 18–22 psu. *E. intestinalis* showed the lowest growth rates at extreme low salinity values (≤ 3 psu) and for salinity ≤ 1 psu, the alga died. Growth rates at salinities lower than 5 psu and higher than 25 psu were also low, when compared with growth between salinity of 15 and 20 psu, where *E. intestinalis* showed the highest growth rates. It is considered an oligo to polyhaline species.

3. *Ulva lactuca*

Taylor *et al.* (2001) showed that *Ulva lactuca* showed a wide tolerance to salinity, exhibiting growth in 3.4 to 34 psu. It is considered an oligo to polyhaline species.

4. *Fucus serratus (*Serrated wrack)

Fucus serratus can tolerate salinities from 18 – 40 psu (Jackson, 2008). Being intertidal and subject to precipitation, *Fucus serratus* is exposed to a broad range of salinities. This species is able to compensate for these changes in salinity by adjusting internal ion concentrations. Its occurrence in Lough Atalia extends its known salinity tolerance range. It is considered a meso to euryhaline species.

5. *Fucus spiralis (*Spiral wrack*)*

Fucus spiralis can tolerate salinity from 10 – 40 psu (White, 2008a). *F. spiralis* can experimentally tolerate salinities of 3 to 34 psu, but it is only found in estuaries down to 10 psu. Its occurrence in Lough Atalia extends its known salinity tolerance range. It is considered a meso to euryhaline species.

6. *Fucus vesiculosus (*Bladder wrack)

Fucus vesiculosus can tolerate salinity from 11 – 40 psu (White, 2008b). *F. vesiculosus* tolerates a wide range of salinities as evidenced by its penetration into the Baltic. Being an intertidal species, it must withstand occasional conditions of hyposalinity during winter precipitation and hypersalinity during the summer. In the UK, the species tolerates salinity down to 11 psu, below which it is replaced by *Fucus ceranoides* (Suryono & Hardy, 1997). Its occurrence in Lough Atalia extends its known salinity tolerance range. It is considered a meso to euryhaline species.

7. *Pelvetia canaliculata (*Channel wrack*)*

Pelvetia canaliculata can tolerate salinity from 18 – 40 psu (White, 2008c). It must be able to withstand wide variations in salinity because it is usually emerged for long periods of time, during which it will be drenched in freshwater from rainfall. Its occurrence in Lough Atalia extends its known salinity tolerance range. It is considered a meso to euryhaline species.

8. *Ceramium sp.*

Ceramium sp. can tolerate salinity levels from <18 to 40 psu (Hiscock and Pizzolla, 2007). *Ceramium virgatum* occurs over a very wide range of salinities. The species penetrates almost to the innermost part of Hardanger Fjord in Norway where it experiences very low salinity values and large salinity fluctuations due to the influence of snowmelt in spring (Jorde & Klavestad, 1963). Its occurrence in Lough Atalia extends its known salinity tolerance range. It is considered a meso to euryhaline species.

9. *Chondrus crispus*

Chondrus crispus can tolerate salinities from 18 – 40 psu (Rayment & Pizzola, 2008). Mathieson & Burns (1971) recorded maximum photosynthesis of *Chondrus crispus* in culture at 24 psu, but rates were comparable at 8, 16 and 32 psu. Photosynthesis continued up to 60 psu. Bird *et al.* (1979) recorded growth of Canadian *Chondrus crispus* in culture between 10 and 50 psu, with a maximum at 30 psu. The species would therefore appear to be extremely tolerant of a wide range of salinity conditions. Its occurrence in Lough Atalia extends its known salinity tolerance range. It is considered a poikilohaline species.

10. *Vaucheria* sp.

The genus *Vaucheria* belongs to the class Xanthophyceae (yellow green algae). Christensen, (1987) cultured this genus in salinities ranging from 0 – 60 psu. It is therefore considered a poikilohaline genus.

11. *Ruppia* sp.

Certain species of *Ruppia* (*R. maritima*) grow in soft sediments in sheltered shallow coastal waters from full salinity to nearly fresh water but mainly occur in brackish waters of lagoonal habitats, lochs, estuaries, creeks and pools in salt marshes, wetlands, ditches and lakes (Tyler-Walters, 2001). de Wit (2011) notes that *Ruppia* typically occurs in meso to polyhaline conditions.

12. *Cordylophora caspia*

Cordylophora caspia can survive 0 – 35 psu as resistant stages grow between 0.2 - 30 psu, reproduce between 0.2 to 20 psu and possesses the ability to ionically regulate (Kinne, 1971). In nature, well developed colonies are usually found in water of 2 -12 psu where tidal influence is considerable or between 2 - 6 psu where conditions are constant (Arndt, 1989). It is considered a poikilohaline species.

13. Nematoda

Nematodes are very common species occurring throughout the marine environment. Foster (1998) working on 4 species of intertidal nematode species demonstrated that they all have a capacity to exist in salinities ranging through 3.33, 16.6, 33.33 and 66.66 psu. Nematodes are considered as oligo – to euryhaline species.

14. *Hediste (Nereis) diversicolor*

Hediste diversicolor is a euryhaline species able to tolerate a range of salinities from full sea water down to 5 psu or less (Barnes, 1994). Low salinities (< 8 psu) can have an adverse effect on reproduction (Ozoh & Jones, 1990; Smith 1964). It is considered an oligo to euryhaline species.

15. *Polydora ciliata*

Polydora ciliata is widely distributed around Britain and Ireland. It is a euryhaline species inhabiting both fully marine and estuarine habitats. Gulliksen (1977) found that in an area of the western Baltic Sea, where bottom salinity was between 11.1 and 15 psu, *P. ciliata* was abundant. It is otherwise predominantly found in habitats with salinity range from 18 – 35 psu. Its occurrence in Lough Atalia extends its known salinity tolerance range. It is considered a meso to euryhaline species.

16. *Pygospio elegans*

Pygospio elegans is common in both marine and brackish waters especially the latter where high abundances have been found at salinities as low as 2 psu (Hempel, 1957). However, according to The Assessment of Climate Change for the Baltic Sea Basin (2008), *P. elegans* was estimated to have a lower tolerance of 7 psu. Other studies (Van Colen *et al.* 2010) have recorded *P. elegans* in salinity ranges from 16 to 27 psu in the tidal mud flats of Paulinapolder, the Netherlands. Its occurrence in Lough Atalia extends its known salinity tolerance range. It is considered as a meso to polyhaline species.

17. *Nais sp*.

Members of the genus *Nais* are usually found in low salinity or fresh water environments (Worsfield, 2003). It is considered to be an oligo to mesohaline taxon.

18. *Heterochaeta costata*

Verdonschot (1981) and Verdonschot *et al.* (1982) showed that *Heterochaeta costata* preferred shallow water brackish waters avoiding areas of usually euryhaline salinity. However, Casellato & Poja (1984) regularly recorded *H. costata* at salinities reaching up to 30 psu. It is considered as a meso to polyhaline species.

19. *Elminius modestus*

Austrominius (Elminus) modestus displays its greatest activity, measured as cirral and valve movement, when submerged in salinity concentrations close to that of the sea 33.5 psu (Davenport 1976, Foster 1970) and stops all activity outside of the range 17 – 53 psu (Foster 1970). Barnes & Barnes (1974) reported that embryos of *A. modestus* can fully develop and hatch into functioning nauplii at salinities of 21.4 – 42.8 psu at 20 °C. This compares to the salinity level, 21 psu, at which Cawthorne & Davenport (1980) found a cessation of larval release. Once released however, the larvae can survive at salinities as low as 9 psu (Cawthorne & Davenport 1980). Dassuncao (2009) showed that the larvae can survive salinities of 20 psu up to that of sea water at ~35 psu in a wide range of temperatures (~9°C -24°C). Outside of this range, *A. modestus* will most likely be able to still breed in salinities as low as 16 psu, and possibly lower if not maintained for an extended period of time. It is considered as a meso to euryhaline species.

20. *Nitokra spinipes*

N. spinipes is typically benthic and estuarine (de Sousa *et al.,* 2012) in areas with salinity varying between 0.5 and 30 psu (Wulff, 1972; Lotufo & Abessa, 2002). It is considered as a poikilohaline species.

21. Cyclopoida

Small planktonic animals of the subclass Copepoda, Cyclopoida occur in marine, brackish and freshwater environments (Boxshall *et al.* 2012). They are considered as meso to polyhaline species.

22. *Neomysis integer*

Neomysis integer can tolerate salinities from <18 – 30 psu (Budd, 2008b). *N. integer* is a euryhaline species which typically occurs in brackish water habitats and occasionally in freshwater habitats but more rarely in fully marine conditions. *N. integer* adapted successfully to the transition from brackish lagoon to freshwater lagoon in the case of Loch Mor Barvas, Isle of Lewis, Scotland (Barnes, 1994). In laboratory experiments, Kuhlman (1984) reported the lowest salinity tolerance of the species to be lower than 5 psu, and in other studies, it is suggested that *N. integer* tolerates salinities down to 0.5 psu (Koepcke & Kausch, 1996; Barnes, 1994). It is considered as a meso to polyhaline species.

23. *Praunus flexuosus*

A salinity tolerance range of 2–33 psu has been demonstrated, over which the body tissues experience the range 11–28 psu (McCluskey & Heard, 1971).It is considered as an oligo to polyhaline species.

24.*Jaera albifrons*

This species favours sheltered areas and estuarine environments. A study conducted by Jones (1972) showed that *J. albifrons* has very good survival rate in dilute seawater. It is considered as a meso to polyhaline species.

25. *Jaera nordmanni*

Jaera nordmanni was proposed as a characteristic lagoonal species for Ireland by Oliver and Healy (1998). This isopod was recorded at 24 of the 87 lagoons surveyed (27.6%) and may occur at others where it was not recorded due to the fact that only adult males are easily identified. This species may occur in freshwater, as in L. Errol, Cape Clear, Co. Cork. It has been described in England (Barnes 1994, Hayward and Ryland 1995) as occurring in streams flowing down the shoreline on south and west coasts only. All records in Ireland are from West Cork to Donegal. It is considered as an oligo to polyhaline species.

26. *Asellus sp*.

Asellus is found in rivers, streams and standing water particularly where there are plenty of stones under which it hides although not where the water is strongly acidic. *Asellus* is relatively tolerant of a range of pollutants and has been used as an indicator of water quality (Whitton, 1982).This is a freshwater to oligohaline species.

27*. Allomelita pellucida*

Allomelita pellucida is an intertidal species which can be found in brackish waters usually living as a part of interstitial or epibenthic communities of soft sediments (Hosie, 2008). It is considered as an oligo to mesohaline species.

28. *Melita palmata*

M. palmata is a common and abundant inhabitant of brackish, lagoon and estuarine environments along the European coasts of the Atlantic (Lincoln, 1979). *M. palmata* is usually observed where the influence of fresh water is stronger, for example, lagoons and river mouths due to its tolerance to a wide range of salinities (Karaman, 1982). It is considered as an oligo to mesohaline species.

29. *Gammarus duebeni*

A brackish-water species with wide salinity tolerance: found on rocky shores in pools near to high water with freshwater influence, in estuaries amongst vegetation and in freshwater streams and lakes (Bousfield, 1973). Bettison and Davenport (1976) studied salinity preferences of gammarid amphipods. They showed that *Gammarus duebeni* showed little avoidance of any particular sea water concentration. It is considered as an oligo to polyhaline species.

30. *Gammarus salinus*

This is a euryhaline species and is tolerant of salinities as low as 2 psu and as high as 30 psu, but it is most abundant at 10 psu. Bulnheim (1984) recorded the respiratory response of *Gammarus salinus* in response to an acute salinity change, from 30 to 10 psu, respiration rate moderately increased after an initial shock like response and initially specimens were quiescent as they acclimated to the decreased salinity but recovered within 24 hours. It is considered as an oligo to polyhaline species.

31. *Palaemon elegans*

Yazdani *et al.* (2010) showed that more than 50% of prawns survived at 1 to 30 psu salinity range, while above and below this range, less than 50% survived within 24 hours. Salinities between 8–18 psu were found to be the optimum range for *P. elegans*. It is considered as an oligo to mesohaline species.

32. *Palaemonetes varians*

This is a decapod crustacean and is listed as a characteristic lagoonal species in the U.K. by Barnes (1989) and Bamber (1997), but apparently is no longer regarded as such (NPWS, 2012). Although found in estuaries, this species appears to be far more characteristic of lagoons in Ireland, found in 64 of the 87 lagoons surveyed (73.6%) and may require a lagoonal environment for reproduction. It is considered as an oligo to polyhaline species.

33. *Crangon crangon*

Neal (2008) and McClusky *et al*. (1982) recorded that *Crangon crangon* can tolerate salinities of 7-40 psu and can survive extremes if previously acclimated to the high or low end of its tolerance. For example, individuals acclimated to 40 psu survived 50 psu for 38 hours in comparison 16 hours by those previously acclimated to 7 psu (McClusky *et al*., 1982). Lloyd & Yonge (1947) found that *Crangon crangon* can tolerate salinities of 7-40 psu and can survive fresh water for up to 8 hours. Its occurrence in Lough Atalia extends its known salinity tolerance range. It is considered as a meso to euryhaline species.

34. *Carcinus maenas*

Carcinus maenas can tolerant salinities between 4 - 40 psu (Neal & Pizzola, 2008; Crothers, 1968; Ameyaw-Akumfi & Naylor, 1987) and has a preference for 27-40 psu. It is considered as a meso to polyhaline species.

35. *Cyprideis torosa*

The ostracod *Cyprideis torosa* is a well known and characteristic inhabitant of many brackish water areas throughout Europe. It can be described as a tolerant species to salinity change. Heip (1976) investigated the community structure of *C. torosa* in a brackish water ecosystem with a salinity of 15 psu. This increased to 22 psu over time with no apparent change to the community. Its occurrence in Lough Atalia extends its known salinity tolerance range. It is a meso to polyhaline species.

36. Acarina

Acarines are extremely diverse. They live in practically every habitat and include freshwater, marine and terrestrial species. Some species can tolerate moderate salinity but do not occur in highly saline waters (Harvey, 1998).They are an oligo to mesohaline species.

37. Chironomidae

The family *Chironomidae* occur in all the types of freshwater habitat (streams, rivers, lakes and ponds), many are terrestrial or semi-terrestrial and some are marine. A study conducted by Bervoets *et al.* (1996) showed that a species belonging to *Chironomidae* (*Chironomus* *ripariusl*) had appeared to be very tolerant to an increase in salinity. It is considered as a meso to polyhaline family.

38. *Zygoptera* (larvae)

There are 20 families of Zygoptera and about 2,500 species. They are found to have an aquatic larval stage. There are a few truly marine species, several that live in brackish water, and many that survive in arid regions where the larvae can develop quickly in the warm waters of temporary ponds before they dry up (Brooks, 2000). They considered as meso to polyhaline species.

39. Dytiscidae

Dysticids or diving beetles, live in fresh to oligohaline water.

40. *Peringia (Hydrobia) ulvae*

Peringia (Hydrobia) ulvae has a salinity tolerance from <18 – 40 psu (Jackson, 2000). The species is found in a wide range of salinities. Its occurrence in Lough Atalia extends its known salinity tolerance range. It is considered as a meso to polyhaline species.

41. *Ecrobia (Hydrobia) ventrosa*

This is a gastropod mollusc commonly found in brackish lagoons and ditches and generally not on the open coast (NPWS, 2012). It was recorded at 18 of the 87 (20.7%) lagoons surveyed up to 2006. de Wit (2011) states that *E. ventrosa* occurs in lower salinity waters than its congener *E. ulvae.* It is considered as an oligo to polyhaline species.

42. *Bowerbankia gracilis*

Typical habitats for this species include seagrasses, drift algae, oyster reef, dock, pilings, breakwaters, and man-made debris. *Bowerbankia gracilis* has been collected in areas of the Indian River Lagoon where salinity was below 30 psu and is generally considered to be euryhaline (Winston 1995). Nair (1992) studied the tolerance of *B. gracilis* in varying salinities where zooids exposed to the highest salinity (37.5 psu) were initially very active but the activity declined slowly, reaching a mortality rate of 40% by the end of the experiment. In 35 psu, colonies were active during the first 13 hours and at the end of the experiment the survival rate declined to 90%. In 30 and 25 psu, colonies were very active and healthy throughout the duration of the experiment, showing 100% survival. Zooids in 20 and 15 psu were active during the first few hours followed by a decline in survival rate. The mortality rate of zooids in 10 psu increased during the first hour, reaching 40% after 4 hours, with no active zooids in the colony. In 7.5 psu, the zooids were very inactive even in the initial hours and the percentage surviving after 24 hours declined to 15%. In 3.75 psu, mortality reached 90% within 30 minutes and at the end of 5^{th} hour the specimens were found protruded with distorted tentacles.

43. *Alcyonidium gelatinosum*

Alcyonidium gelatinosum occurs commonly on the undersides of rocks and *Fucus serratus* plants in the intertidal zone and on bedrock down into the shallow sublittoral. *A. gelatinosum* has been recorded in salinities up to 29 – 32 psu (Oliver, 2005). Its occurrence in Lough Atalia extends its known salinity tolerance range. It is a polyhaline species.

44. *Chelon labrosus* (Thicklip Grey Mullet*)*

Grey mullet are often stocked in brackish coastal lagoons to improve fish yield (Ravagnan, 1992) and are introduced into freshwater lakes and reservoirs to create new fisheries (Ben Tuvia *et al.* 1992). Cardona *et al.* (2008) reported that *C. labrosus* dominated (in Mediterranean estuaries) the assemblage where salinity levels were lower than 13 psu. Hotos & Vlahos (1998) carried out experiments on *C. labrosus* fry which revealed that the fry could tolerate salinities up to 40 psu, 20% mortality occurred at 45 psu and 100% mortality above 70 psu. Therefore the range for *C. labrosus* is taken to be <13 to 40 psu. *C. labrosus* can be seen near Wolf Tone Bridge along the River Corrib. It is an oligo to euryhaline species.

45. *Platichthys flesus* (European flounder)

Platichthys flesus is usually found on muddy seabeds from the low shore to depths exceeding 50 m. The European flounder can also be found in estuaries (Pizzolla 2005). Lundgreen *et al*. (2008) studied *P. flesus* and its physiological mechanisms involved in acclimation to variable salinity and oxygen levels and their interaction. The fish were acclimated for 2 weeks to freshwater (1 psu), brackish water (11 psu) or full strength seawater (35 psu). Results showed that gill pace and blood did not change in relation to salinity and remained stable. They can be regularly seen in the River Corrib near Wolf Tone Bridge. It is considered as a meso to polyhaline species.

46. *Pomatoschistus microps* (Common Goby)

Pomatoschistus microps has been recorded in salinities as low as 4 psu (Barnes, 1994) and has been noted to tolerate salinities from about 8 to 80 psu (Riley, 2003). Its occurrence in Lough Atalia extends its known salinity tolerance range. It is an oligo to euryhaline species.

47. *Gasterosteus aculeatus* (Three-spined Stickleback)

They are common in estuaries and coastal lagoons around Britain and Ireland and in fully marine conditions from the northern Irish Sea and North Sea northwards. Described as an anadromous species, *G. aculeatus* may inhabit marine or freshwater environments (Tyler-Walters 2003). It is an oligo to euryhaline species.

48. *Atherina presbyter* (Sand Smelt)

The highest abundances of *A. presbyter* recorded by Pombo *et al.* (2005) were at salinity levels of between 28.0 and 32.0 psu. It is a polyhaline species.

49. *Anguilla anguilla* (European Eel)

The species is catadromous, living in fresh water but migrates to marine waters to breed (Freyhof & Kottelat, 2010) and it is therefore tolerant of salinity levels from freshwater to euryhaline conditions.

2.1.9 Conclusions

Biological communities of coastal lagoons are derived from:-

1. Marine species that can tolerate dilution of seawater,

2. Freshwater species that can tolerate a measure of salinity and

3. A group of brackish water species that are “distinctly more characteristic of lagoonal habitats than of estuaries or salt marshes” (Oliver, 2005).

The latter are referred to as lagoonal specialists and are broadly equivalent to the category of species inhabiting ‘blocked brackish water’ in the Netherlands and elsewhere (Verhoeven 1980a) and the species characterising ‘brackish lentic communities’ in Denmark (Muus 1967). Lists of lagoonal specialists have been compiled in the U.K. *e.g.* Barnes 1989a; Davidson *et al*. 1991; Bamber *et al* .1992b; Smith & Laffoley 1992; Downie 1996; JNCC, 1996; Bamber *et al*. 2001b have varied in content as species have been added or deleted, depending on the opinion of various authors. Healy (2003) lists Irish characteristic lagoonal species.

According to de Wit (2011) , species which inhabit lagoons have evolved to survive wide ranging salinity levels and this author goes on to state that because of the high fluctuations in salinity, biodiversity is lower than is found in more moderately fluctuating coastal environments. Wijeratne *et al.* (2004) working in Chilaw Lagoon, west coast of Sri Lanka, note that salinities in the lagoon are strongly influenced by seasonal variations in river discharge and vary from zero to 35 psu. Newton and Mudge who worked in Portugal on the Ria Formosa recorded somewhat similar variations in salinity with a low of 13 and a maximum of 36.5 psu. Natural England (2010) in a report on UK lagoons notes that salinities can vary from 0 to 40 psu and also comments that significant variation in salinity will be the norm in coastal saline lagoons over distances of centimetres and within time spans of minutes. It appears therefore that the natural variations recorded in Lough Atalia and Renmore Lough are typical of similar systems all around the world and that such variation relates to the flow of the River Corrib, the tidal cycle and the stage of the tide.

Natural England lists a number of lagoonal specialist taxa that are protected under the UK Wildlife and Countryside Act. These are *Lamprothamnium papulosum, Cara canescens, Clavopsella navis, Edwardsia ivelli, Nematostella vectnensis, Victorella pavida, Armandia cirrhosa, Alkmaria rominjii, Gammarus insensibilis* and *Tenellia adspersa.* None of these taxa have been recorded from either Lough Atalia or Renmore Lough.

A review of species and where they occur in Lough Atalia clearly shows that the bed of the Lough is very species poor with six of the ten sites surveyed returning no fauna and two of the remaining four only returning 1 species each. The station nearest the open sea returned 7 species. The more biologically diverse area is the intertidal zone. However, as noted in Oliver (2007), Lough Atalia is of no conservation value.

Research from a wide range of sources within this document has outlined the tolerances capable of the species found within Lough Atalia and Renmore Lough. All fauna listed have been shown to exhibit levels of resilience towards salinity change well within the temporary changes predicted by the mathematical model output. Indeed, salinities recorded in Lough

Atalia extend the tolerance ranges for many taxa by quite an amount. The mathematical model predicts that the current cumulative annual 7 hours of zero psu may extend to 18 hours at the southern part of the lagoon over the period of a year. The impact of additional temporary, seasonal and spatially restricted decreases in salinity to 0 psu within parts of the ecosystems will not affect their status or their ecological functioning.

Galway Harbour Company

Galway Harbour Extension

Appendices to NIS Addendum / Errata

Appendix No. 2.2 – Benthic Fauna

[From Chapter 7 of the EIS – Pages 7-38 to 7-71]

2.2 BENTHIC FAUNA

2.2.1 Benthic Fauna – Intertidal Survey

2.2.1.1 Methodology

The intertidal survey was carried out over low water on the 6th July 2004 and the same areas were revisited on August 13th 2011 (see Figure 2.2.1). During Phase I of the GHEP development 7.55 ha of foreshore were reclaimed and as a result, the top of the surveyed shore consists of a high revetment wall of large boulders. Observations of the flora and fauna of the foreshore and any bird species present were recorded from the western boundary along the Lough Atalia Channel to the eastern boundary at Renmore Beach. Algal and invertebrate densities were determined *in situ* and are given after each of the species recorded. Algal density is represented by % cover, while abundance of invertebrates uses the SACFOR abundance scale *i.e.* S = Superabundant, A = Abundant, C = Common, F = Frequent, O = Occasional, R = Rare. P = Present, is used when no meaningful abundance can be assigned *i.e.* when species are incidentally collected with other species.

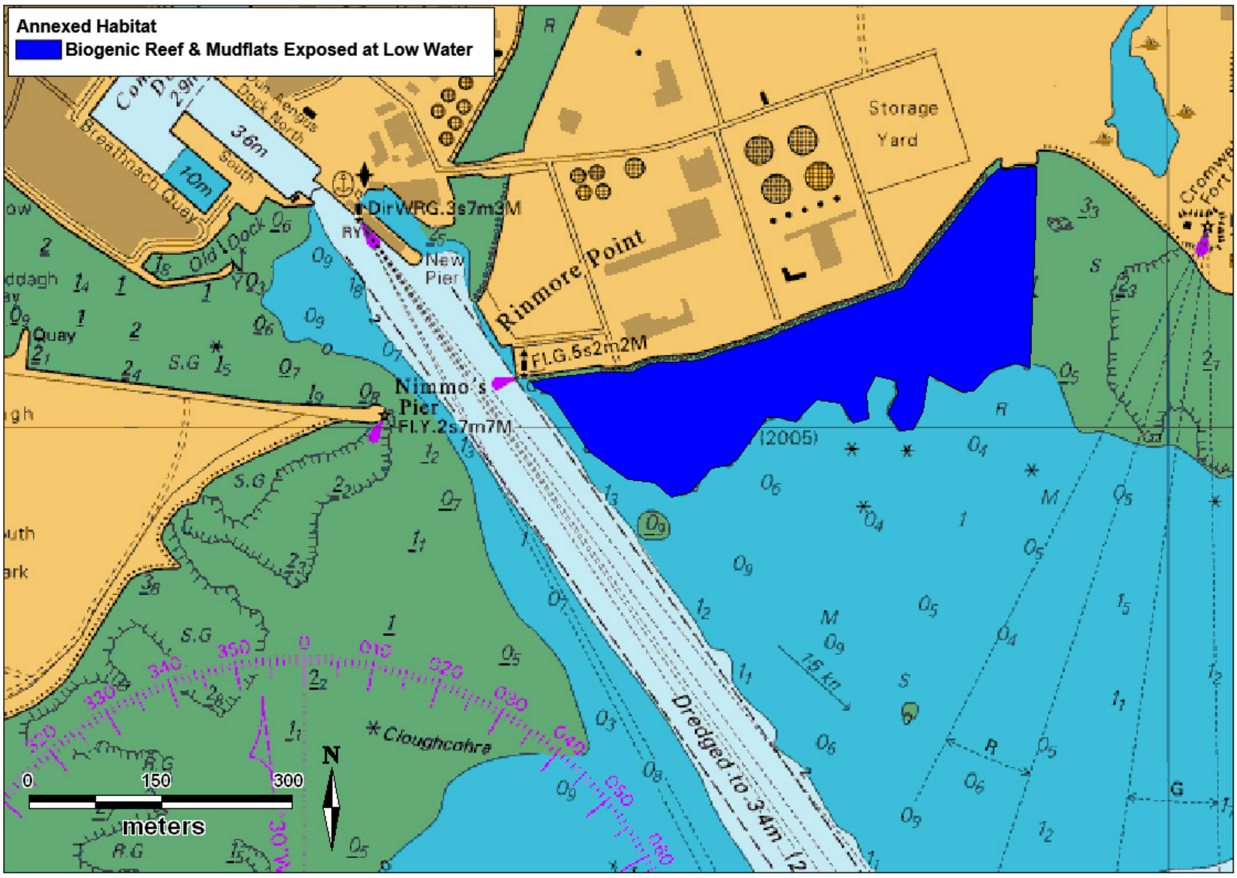


Figure 2.2.1 - Habitat map of annexed marine habitats in and around the proposed development

2.2.1.2 Results

The intertidal area can generally be described as a sheltered shore with the whole of the eulittoral being covered in seaweeds. Small patches of lichen (*Caloplaca, Verrucaria*) and *Pelvetia canaliculata* (*ca* 5%) were observed on rocks above high water and in the upper shore respectively. *Fucus spiralis* (*ca* 20%) was present close to the top of the shore while *Fucus vesiculosus* (*ca* 30%) and *Fucus ceranoides* (*ca* 10%), were present from the top of the shore to the mid shore. *Ascophyllum nodosum* (80%) covered the bulk of the mid-eulittoral along with *Polysiphonia lanosa*. Patches of *Chondrus crispus* were noted throughout the mid shore and *Ulva* sp. (formerly *Enteromorpha*) was observed on the boulders of the revetment wall and down the shore. *Ulva lactuca* was observed on the lower shore. *Fucus serratus* (*ca* 30%) was noted low down on the shore nearest the water's edge. The substrate along the western boundary consisted predominantly of gravels and pebbles with boulders scattered throughout. The shore extended to 20 m along this boundary.

Faunal species were generally low in number and densities. Those observed were mostly recorded toward the lower shore and included the periwinkles *Littorina littorea* (O) and *Littorina obtusata* (P), the barnacle *Semibalanus balanoides* (C) and the bivalves *Mytilus edulis* (C) and *Cerastoderma edule* (O). Crustacean species observed consisted of *Corophium* sp. (C) and the brown shrimp *Crangon crangon* (C). *Arenicola marina* casts (*ca* 10 m^2) were noted at low water. Mussels occur in aggregations which can be described as biogenic reefs and represent an Annex 1 habitat as described within the EU Habitats Directive.

2.2.2 Benthic Fauna & Sediments – Subtidal Survey

2.2.2.1 Station locations

In the initial sedimentological survey of the existing Galway Harbour Inner Dock in November 2000, four stations were sampled within the docks for grain size and heavy metals and a fifth sample was collected from the layby (behind the Harbour Master's office – see Figure 2.2.2) for grain size, heavy metals, organochlorine pesticides and PCB's, as requested by ABP.

In a further survey in 2004, 22 stations shown in Figure 2.2.3 below were sampled for sedimentological analysis and for macrofauna. Sediment probings were carried out at 12 No. pre-selected locations [as shown on Figure 2.2.4] to assess the depth of sediment in the area under consideration for the development.

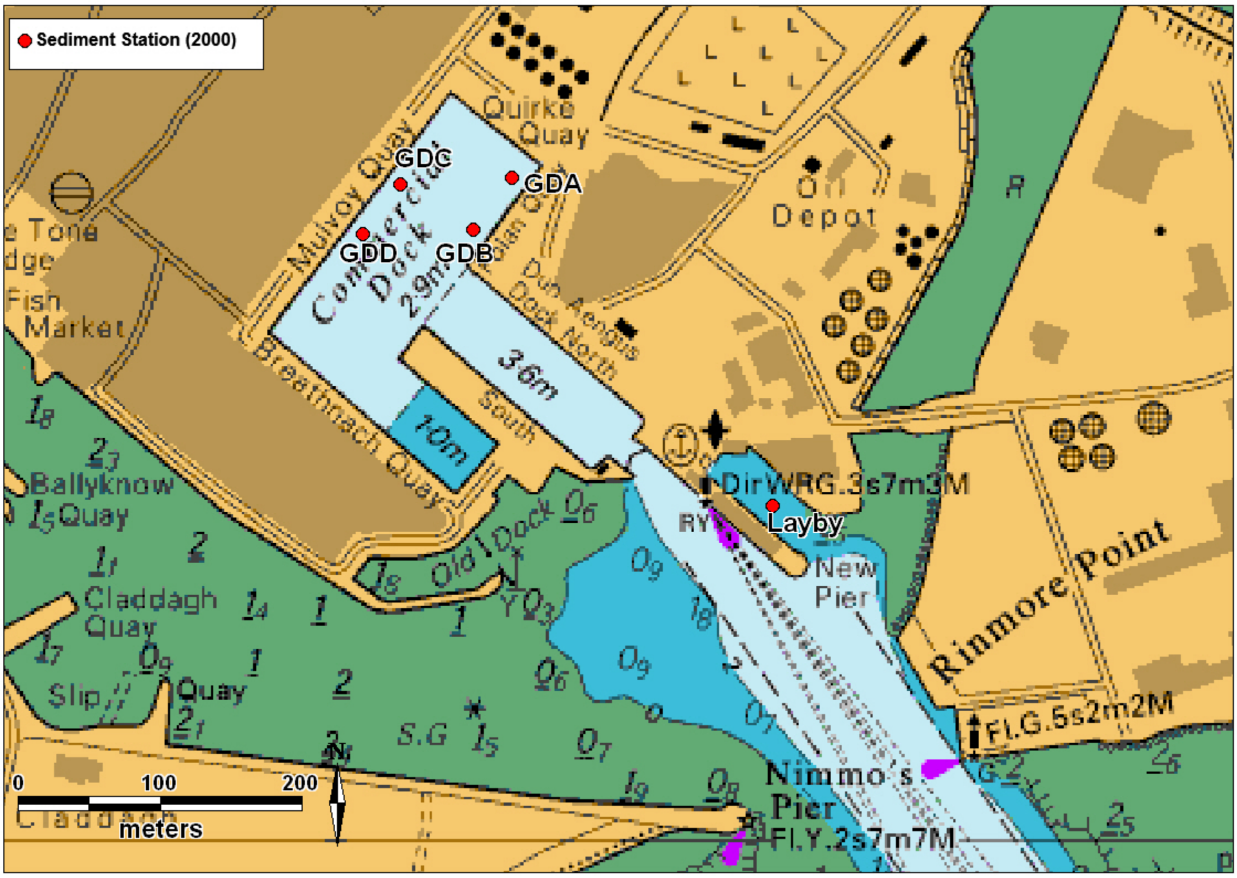


Figure 2.2.2 - Sediment stations sampled in 2000 in the docks and layby

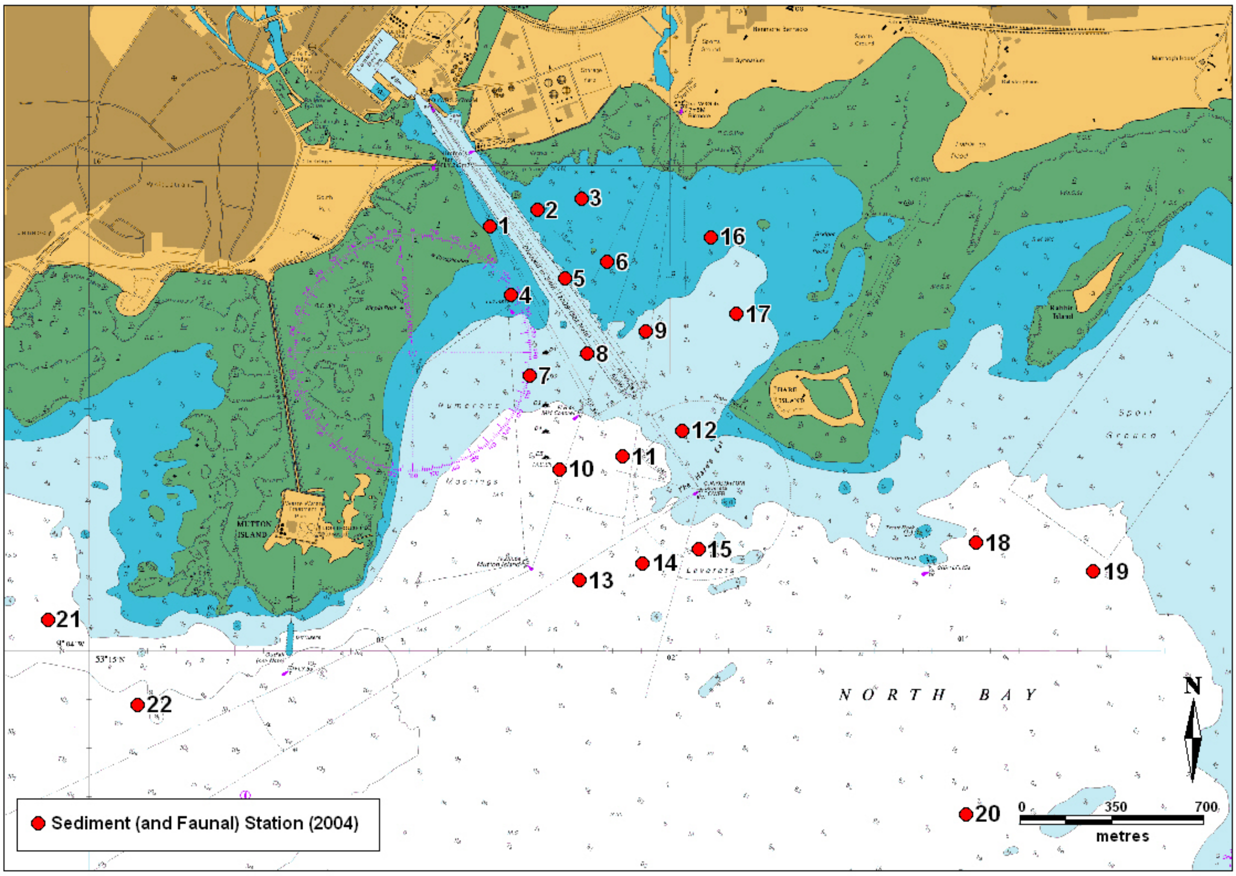


Figure 2.2.3 - Sediment (and faunal) stations sampled in 2004

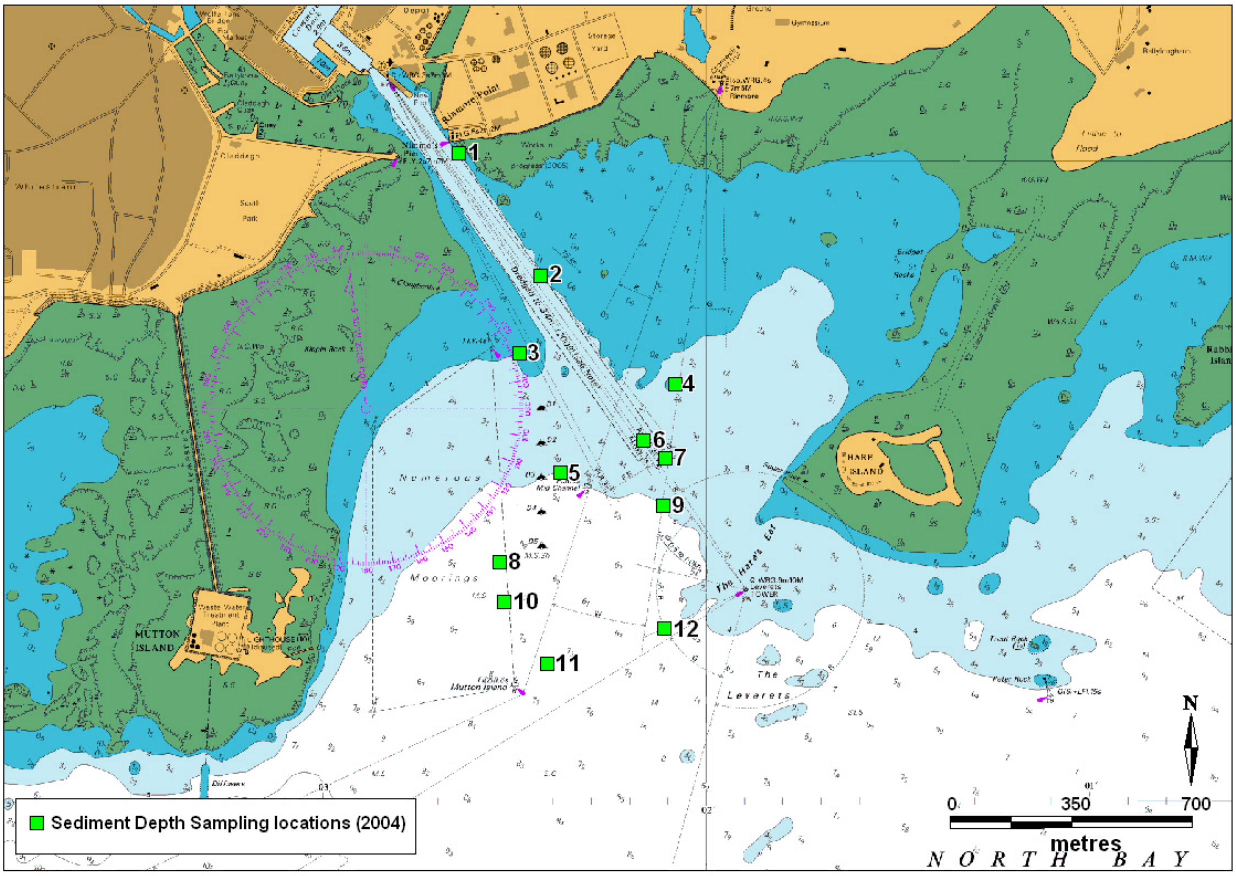


Figure 2.2.4 - Sediment depth sampling locations, 2004

Because of the many iterations in design and layout of the new structure, it was decided to carry out an additional benthic survey for sediment type and macrofauna in February 2010 using the same field, laboratory and statistical methodologies as for the previous survey. Figure 2.2.5 shows the location of the additional 12 stations.

An Bord Pleanála, in its scoping document for the EIS recommended that sediment samples be collected off South Park, which has served as a municipal dump some decades previously, to determine any evidence of contaminants. Marine sediment samples were collected at South Park in May 2011 and the station location can also be seen in Figure 2.2.5.

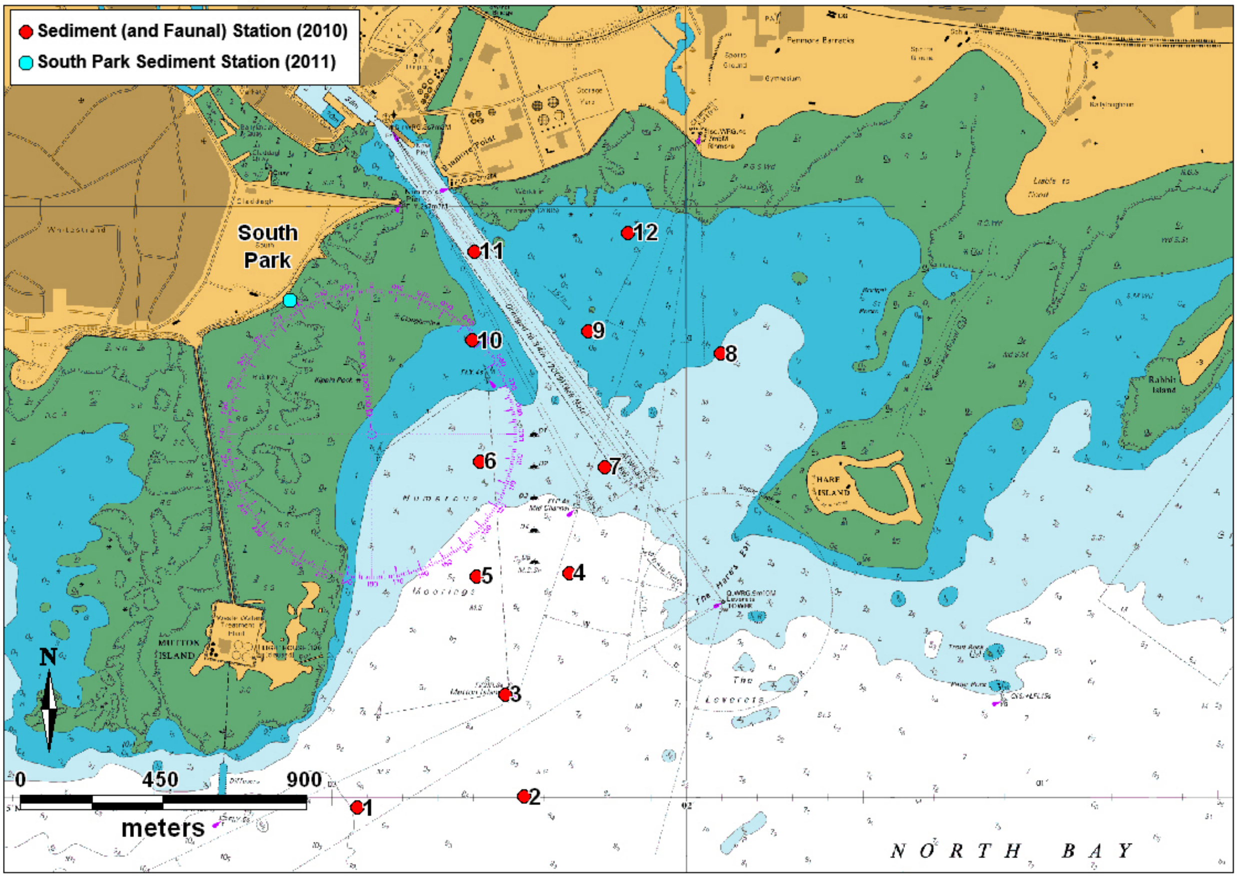


Figure 2.2.5 - Sediment and macrofauna stations sampled in 2010 and South Park sediment site sampled in May 2011

2.2.2.2 Methodology

2.2.2.2.1 Sedimentology

All sediment samples were collected using a van Veen grab sampler and each sediment sample was split into sub-samples for physical (sediment granulometry) and chemical (heavy metals, organics) characteristics. The granulometric and heavy metal samples were taken using a plastic spoon. The organic samples were taken using a metal spoon. All samples were frozen at -20°C pending analysis. Granulometric analysis was carried out by laser particle sizing. All chemical analyses were carried out by The Environmental Agency laboratory in Lllanelli, Wales and Complete Lab Solutions, Rosmuc, Co. Galway.

In order to assess the depth of sediment in the area under consideration for the development, AQUAFACT divers probed the sediments to refusal using a 4 metre probe. GPS was used to locate the new probing station positions.

2.2.2.2.2 Macrofauna

The following methodology was used in the two macrofaunal surveys. The first survey was carried out in July 2004 and comprised of 22 stations (see Figure 2.2.3), while the second was carried out in February 2010 and included of 12 stations (see Figure 2.2.4). Two replicate van Veen grab samples were taken at each station sampled. Measurements of sediment depth were taken in a diagonal transect across the grab surface using a clean plexiglass ruler. Data on each sample, *e.g.* station number, water depth, date, depth of sediment, smell, colour and visible macrofauna were logged in a field notebook. The faunal returns were sieved on a 1mm mesh sieve, stained with a vital dye, fixed with 10% buffered formalin and preserved in 70% alcohol. Samples were then sorted under a microscope (x 10 magnification), into five main groups: Polychaeta, Mollusca, Crustacea, Echinodermata and others. The taxa were then identified to species level where possible. All faunal nomenclature follows that of the World Register of Marine Species (WoRMS) website (http://www.marinespecies.org/) accessed on 17/08/2012.

All replicate data were combined to give a total for each station. A data matrix of all the faunal data was compiled and later used for statistical analyses. Faunal analysis was carried out using the PRIMER ® (Plymouth Routines in Multivariate Ecological Research) program.

Univariate statistics in the form of diversity indices were calculated. The following diversity indices were calculated:

1) Margalef's species richness index (D), (Margalef, 1958).

$$D = \frac{S-1}{\log_2 N}$$

where: N is the number of individuals

S is the number of species

2) Pielou's Evenness index (J), (Pielou, 1977).

$$J = \frac{H'(\text{observed})}{H'_{max}}$$

where: H'_{max} is the maximum possible diversity, which could be achieved if all

species were equally abundant (= $\log_2 S$)

3) Shannon-Wiener diversity index (H'), (Pielou, 1977).

$$H' = -\sum_{i=1}^{S} p_i(\log_2 p_i)$$

where: p_I is the proportion of the total count accounted for by the ith taxa

Species richness is a measure of the total number of species present for a given number of individuals. Evenness is a measure of how evenly the individuals are distributed among different species. The diversity index incorporates both of these parameters. Richness ranges from 0 (low richness) to 12 (high richness), evenness ranges from 0 (low evenness) to 1 (high evenness), diversity ranges from 0 (low diversity) to 5 (high diversity).

The PRIMER ® manual (Clarke & Warwick, 2001) was used to carry out multivariate analyses on the station-by-station faunal data. All species/abundance data were fourth root transformed and used to prepare a Bray-Curtis similarity matrix in PRIMER ®. The fourth root transformation was used in order to down-weigh the importance of the highly abundant species and allow the mid-range and rarer species to play a part in the similarity calculation. The similarity matrix was then used in classification/cluster analysis. The aim of this analysis was to find “natural groupings’ of samples, *i.e.* samples within a group that are more similar to each other, than they are similar to samples in different groups (Clarke & Warwick, loc. cit.). The PRIMER ® program CLUSTER carried out this analysis by successively fusing the samples into groups and the groups into larger clusters, beginning with the highest mutual similarities then gradually reducing the similarity level at which groups are formed. The result is represented graphically in a dendrogram, the x-axis representing the full set of samples and the y-axis representing similarity levels at which two samples/groups are said to have fused. SIMPROF (Similarity Profile) permutation tests were incorporated into the CLUSTER analysis to identify statistically significant evidence of genuine clusters in samples which are *a priori* unstructured.

The Bray-Curtis similarity matrix was also subjected to a non-metric multi-dimensional scaling (MDS) algorithm (Kruskal & Wish, 1978), using the PRIMER ® program MDS. This program produces an ordination, which is a map of the samples in two- or three-dimensions, whereby the placement of samples reflects the similarity of their biological communities rather than their simple geographical location (Clarke & Warwick, 2001). With regard to stress values, they give an indication of how well the multi-dimensional similarity matrix is represented by the two-dimensional plot. They are calculated by comparing the interpoint distances in the similarity matrix with the corresponding interpoint distances on the 2-d plot. Perfect or near perfect matches are rare in field data, especially in the absence of a single overriding forcing factor such as an organic enrichment gradient. Stress values increase not only with the reducing dimensionality (lack of clear forcing structure), but also with increasing quantity of data (it is a sum of the squares type regression coefficient).

Clarke and Warwick (*loc. cit*.) have provided a classification of the reliability of MDS plots based on stress values, having compiled simulation studies of stress value behaviour and archived empirical data. This classification generally holds well for 2-d ordinations of the type used in this study. Their classification is given below:

- Stress value < 0.05: Excellent representation of the data with no prospect of misinterpretation.
- Stress value < 0.10: Good representation, no real prospect of misinterpretation of overall structure, but very fine detail may be misleading in compact subgroups.
- Stress value < 0.20: This provides a useful 2-d picture, but detail may be misinterpreted particularly nearing 0.20.
- Stress value 0.20 to 0.30: This should be viewed with scepticism, particularly in the upper part of the range, and discarded for a small to moderate number of points such as < 50.
- Stress values > 0.30: The data points are close to being randomly distributed in the 2-d ordination and not representative of the underlying similarity matrix.

Each stress value must be interpreted both in terms of its absolute value and the number of data points. In the case of this study, the moderate number of data points indicates that the stress value can be interpreted more or less directly. While the above classification is arbitrary, it does provide a framework that has proved effective in this type of analysis.

The species, which were responsible for the grouping of samples in cluster and ordination analyses, were identified using the PRIMER programme SIMPER (Clarke & Warwick, 1994). This programme determined the percentage contribution of each species to the dissimilarity/similarity within and between each sample group.

2.2.2.2.3 Sediment Profile Imagery

In addition to the benthic sampling, replicate Sediment Profile Images (SPI) were taken of the seafloor at each of the 22 stations surveyed in 2004 (Figure 2.2.3) to aid with the description of current sea floor conditions. Operation and rationale of the SPI apparatus are outlined in Appendix 7.4. [Vol. 2C – Appendices to EIS]. A colour slide film (50 ASA) was used to capture the images, these were subsequently developed as diapositives and analysed using a dedicated image analyses system. The following parameters were measured from each image:

- sediment type expressed as major grain size mode;
- prism penetration depth which gives an indication of relative sediment compaction;
- Sediment Boundary Roughness (SBR) which indicates the degree the physical disturbance or biotic activity at the sediment water boundary;
- sediment apparent Redox Potential Discontinuity depth (aRPD);
- infaunal Successional Status (S.S);
- additional parameters such as the presence of a fine flocculent sediment layer, mud clasts faecal pellets, epifauna (surface living animals), infaunal borrows and tubes, microbial aggregations, outgassing of sediments (due to production of hydrogen sulphide and ammonia as by-products of anaerobic metabolism);

- calculation of a mean organism sediment index (OSI); and
- calculation of Benthic Habitat Quality (BHQ).

2.2.3 Results

2.2.3.1 Sedimentology

2.2.3.1.1 <u>Granulometry</u>

The grain size analysis results from the 4 samples collected from the existing inner docks and layby can be seen below in Table 2.2.1. Sediments in the layby were dominated by silt-clay (81.8%) and sediments within the docks ranged from sandy mud to muddy sand to muddy and sandy gravel.

Sediment grain size results from the docks and layby.					
Grain Size	GDA	GDB	GDC	GDD	Layby
Gravel % (>2000 µm)	<0.1	0.7	42	67.3	<0.1
Sand % (2000 – 63 µm)	38.6	75.4	24.9	21.8	19.2
Silt & Clay % (<63 µm)	61.4	23.9	32.7	10.9	81.8

Table 2.2.1 - Grain size results from the docks and layby

The sediment sampled at the 22 locations during the 2004 survey ranged from silt to medium sand, with very little coarse sand or gravel present. The majority of stations were dominated by very fine sand. The results of the quantitative granulometric analysis can be seen in Appendix 7.5. According to Folk (1954), sand and muddy sand were present in the survey area in 2004. Station 4 contained the highest percentage of silt material (44.62%), Station 19 contained the highest percentage of very fine sand (34.91%), Station 3 contained the highest percentage of fine sand (65.87%) and Station 21 contained the highest percentage of medium sand (42.82%). Gravel was not present at any station; however, Station 7 did have a high percentage of very coarse sand (28.59%).

The 2010 survey classified sediments as sandy mud, muddy sand, slightly gravelly sandy mud, slightly gravelly muddy sand and slightly gravelly sand according to Folk (1954). The majority of stations were dominated by silt-clay (S1 – S6, S8 and S11). The remaining stations were dominated by very fine sand (S7, S9, S10 and S12).

Station S6 contained the highest percentage of gravel (3%). Station S5 contained the highest percentage of very coarse sand (13.1%), coarse sand (12.3%) and medium sand (8.9%). Station S12 contained the highest percentage of fine sand (12.8%). Station S9 contained the highest percentage of very fine sand (75.4%) and station S3 contained the highest percentage of silt-clay (71%). Figure 2.2.6 shows these results in graphical form and the quantitative granulometric analysis results can be seen in Appendix 7.5.

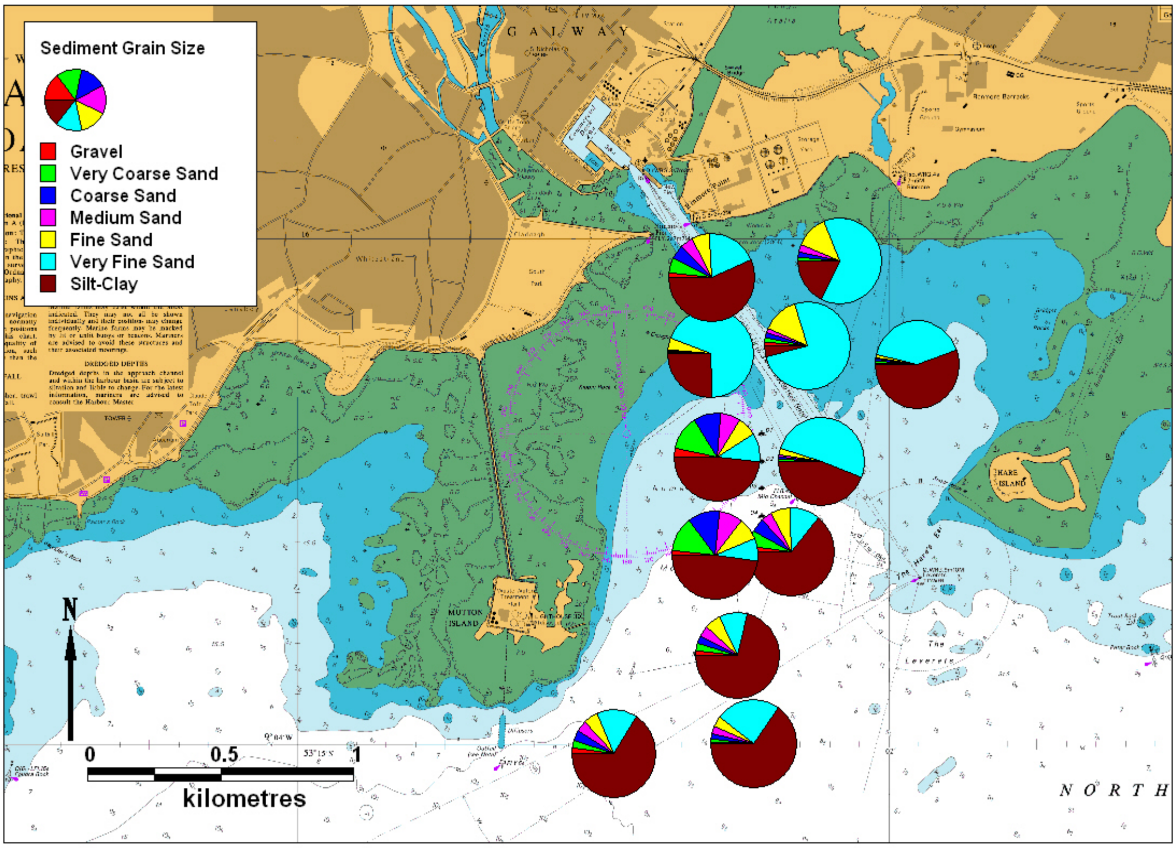


Figure 2.2.6 - Proportions of grain sizes in sediments surveyed in Galway Bay in 2010

Table 2.2.2 shows the refusal depths recorded in 2004 by divers at 12 locations (see Figure 2.2.4) in the proposed development area. The majority of the area is characterised by depths of at least 4 m with only 3 locations returning depths of 1.8 m or less.

Location of sediment sample stations and refusal depths				
Station	**Longitude**	**Latitude**	**Depth (m)**	**Comment**
1	09.02.649	53 16.014	1.7	Soft Mud over a gravel layer before rock
2	09 02.434	53 15.822	1.8	Soft Mud over rock
3	09 02.490	53 15.701	>4.0	Sandy muddy bottom over soft mud
4	09 02.084	53 15.652	>4.0	Sandy Shelly mud overlying soft mud
5	09 02.385	53 15.513	>4.0	Soft muddy bottom with intermittent stones
6	09 02.166	53 15.563	>4.0	Soft muddy bottom
7	09 02.109	53 15.536	>4.0	Soft muddy bottom
8	09 02.542	53 15.374	>4.0	Mud overlying gravel at 1m with underlying soft mud
9	09 02.117	53 15.462	>4.0	Soft mud interspersed with stones
10	09 02.530	53 15.312	>4.0	Soft mud interspersed with stones
11	09 02.419	53 15.215	>4.0	Uniform soft mud
12	09 02.114	53 15.269	0.75	Mud overlying coarse sand overlying rock

Table 2.2.2 - Location of sediment sampling stations and refusal depths.

2.2.3.1.2 Sediment Chemistry

The sediment chemistry results from the layby can be seen in Table 2.2.3 and Table 2.2.4 shows the heavy metal results from within the docks. The upper and lower proposed guidance values for sediment quality can also be seen in these tables (Cronin *et al.,* 2006). In the layby, all organochlorine pesticides were <0.01 μg/kg and all PCBs were <1 μg/kg and within guidance levels where available. Total organic carbon levels were high at 3.69% and of the metals, zinc had the highest concentration (717.4 mg/kg). Zinc exceeded the upper guidance level (Cronin *et al.,* 2006). Cadmium levels within the docks ranged from 0.9 (Station GDA) to 5.7 mg/kg (Station GDC). Copper levels ranged from 26 (GDA) to 117 mg/kg (GDC). Lead levels ranged from 167.5 (GDA) to 1088 mg/kg (GDC). Zinc levels ranged from 159.6 (GDA) to 886 mg/kg (GDC). Chromium levels ranged from 4.1 (GDA) to 14.4 mg/kg (GDC). Cadmium and copper levels exceeded the upper guidance level at Station GDC and lead and zinc exceeded the upper guidance level at Stations, GDB, GDC and GDD.

Sediment chemistry results from the layby				
Category	**Parameter**	**Layby**	**Lower Guidance Level***	**Upper Guidance Level***
Carbon	TOC %	3.69	n/a	n/a
	Carbonate (% as CO3)	20.4	n/a	n/a
Heavy Metals	Mercury (mg/kg)	0.33	0.2	0.7
	Arsenic (mg/kg)	9.99	9	70
	Cadmium (mg/kg)	1.11	0.7	4.2
	Copper (mg/kg)	53	40	110
	Lead (mg/kg)	89	60	218
	Zinc (mg/kg)	717.4	160	410
	Chromium (mg/kg)	17.3	120	370
	Nickel (mg/kg)	14.4	21	60
	Iron (%)	1.26	n/a	n/a
	Manganese (mg/kg)	187	n/a	n/a
	Inorganic Tin (mg/kg)	<0.1	n/a	n/a
	Dibutyl Tin (mg/kg)	<0.02	Σ TBT & DBT = 0.1	Σ TBT & DBT = 0.5
	Tributyl Tin (mg/kg)	<0.02		
Fats/Organic Solvents	Oil, Fats & Grease (mg/kg)	11100	n/a	n/a
	Naphthalene (mg/kg)	0.086	n/a	n/a
Organochlorine Pesticides (µg/kg)	Tecnazene	<0.01	n/a	n/a
	Trifluralin	<0.01	n/a	n/a
	Alpha-HCH (Lindane)	<0.01	n/a	n/a
	Hexachlorbenzene	<0.01	0.3	1
	Beta-HCH (Lindane)	<0.01	n/a	n/a
	Quintozene	<0.01	n/a	n/a
	Triallate	<0.01	n/a	n/a
	Chlorothalonil	<0.01	n/a	n/a
	Heptachlor	<0.01	n/a	n/a
	Aldrin	<0.01	n/a	n/a
	Triadimefon	<0.01	n/a	n/a
	Pendimethalin	<0.01	n/a	n/a

Table 2.2.3 - Sediment chemistry results from the layby.

Sediment chemistry results from the layby				
Category	**Parameter**	**Layby**	**Lower Guidance Level***	**Upper Guidance Level***
	Heptachlor epoxide	<0.01	n/a	n/a
	o,p-DDE	<0.01	n/a	n/a
	Endosulfan I	<0.01	n/a	n/a
	p,p-DDE	<0.01	n/a	n/a
	Dieldrin	<0.01	n/a	n/a
	p,p-TDE (DDD)	<0.01	n/a	n/a
	Endosulfan II	<0.01	n/a	n/a
	o,p-TDT (DDD)	<0.01	n/a	n/a
	o,p-DDT	<0.01	n/a	n/a
	p,p-DDT	<0.01	n/a	n/a
	Endosulfan Sulphate	<0.01	n/a	n/a
	o,p-Methoxychlor	<0.01	n/a	n/a
	p,p-Methoxychlor	<0.01	n/a	n/a
	Permethrin	<0.01	n/a	n/a
PCBs (μg/kg)	PCB Congener 28	<1	Individual congeners of ICES 7 = 1 Σ ICES 7 = 7	Individual congeners of ICES 7 = 180 Σ ICES 7 = 1260
	PCB Congener 52	<1		
	PCB Congener 101	<1		
	PCB Congener 118	<1		
	PCB Congener 153	<1		
	PCB Congener 138	<1		
	PCB Congener 180	<1		

Table 2.2.3 contd/. - Sediment chemistry results from the layby.

* = Proposed guidance values from Cronin *et al.*, 2006.

n/a = Guidance level not available

Heavy metal results from the docks						
Heavy Metal	GDA	GDB	GDC	GDD	Lower Guidance Level*	Upper Guidance Level*
Cadmium (mg/kg)	0.9	2.8	5.7	3.1	0.7	4.2
Copper (mg/kg)	26	62.8	117	75.2	40	110
Lead (mg/kg)	167.5	489.3	1088	591	60	218
Zinc (mg/kg)	159.6	465	886	492	160	410
Chromium (mg/kg)	4.1	10.1	14.4	13	120	370

Table 2.2.4 Metals results from the docks

* = Proposed guidance values from Cronin *et al.,* 2006.

The complete sedimentary log of data collected from the 22 stations sampled in 2004 is presented in Appendix 7.6. Organic carbon values ranged from <1.0 g/kg (<0.1%) (Station 6) to 52 g/kg (5.2%) (Station 7). A suite of heavy metals were analysed: Mercury, Vanadium, Titanium, Iron, Magnesium, Aluminium, Arsenic, Cadmium, Chromium, Copper, Lead, Manganese, Nickel and Zinc. Mercury concentrations ranged from 0.006 (Station 21) to 0.24 mg/kg (Station 2). Vanadium ranged from 6.7 (Station 10) to 44.5 mg/kg. (Station 7) Titanium ranged from 8.8 (Station 4) to 417 mg/kg (Station 3). Iron ranged from 3700 (S6) to 18,300 mg/kg (Station 7). Magnesium ranged from 4050 (Station 5) to 9520 mg/kg (Station 14). Aluminium ranged from 2280 (Station 6) to 14900 mg/kg (Station 11). Arsenic ranged from <0.1 (Station 5) to 9 mg/kg (Station 2). Cadmium ranged from 0.066 (Station 6) to 0.820 mg/kg (Station 7). Chromium ranged from 5.2 (Station 6) to 30.7 mg/kg (Station 7). Copper ranged from 2.6 (Station 21) to 28.6 mg/kg (Station 2). Lead ranged from 4.5 (Station 6) to 58.7 mg/kg (Station 2). Manganese ranged from 92.2 (Station 6) to 224 mg/kg (Station 7). Nickel ranged from 1.6 (Station 3) to 19.4 mg/kg (Station 7). Zinc ranged from 10.5 (Station 21) to 88.8 mg/kg (S2). All metals levels were lower than the upper guidance level and all (with the exception of Cadmium at one station [Station 7]) were lower than the lower guidance level also (Cronin *et al.,* 2006*).*

Tributyl tin ranged from <8 (Station 6 and Station 9) to 15.4 μg/kg (Station 5) (below the lower guidance level of Cronin *et al.* (2006)). Solids ranged from 46.2 (Station 7) to 80% (Station 21). Dieldrin, Endosulphan α, Endosulphan β and HCH γ values were <7.6 μg/kg at all stations. Permethrin values were <15.2 μg/kg at all stations. Acenaphthene values were <19 μg/kg at all stations. Acenapthylene values were < 20.9 μg/kg at all stations with the exception of stations 12, 13 and 19. Values at these stations were 47.2, 59.3 and 85.5 μg/kg respectively. Anthracene values were < 20 μg/kg at all stations except Stations 2 (28.4 μg/kg), 7 (20.8 μg/kg), 10 (27.2 μg/kg), 12 (31.4 μg/kg), 13 (27.6 μg/kg), 16 (51.1 μg/kg), 18 (38.8 μg/kg) and Station19 (66.2 μg/kg). Fluoranthene values ranged from < 20 μg/kg (Stations 3, 5-6, 9, 17 and 21) to a maximum of 270 μg/kg (Station 19). Fluorene values were < 20 μg/kg at all stations except Stations 2 (22.6 μg/kg), 16 (21.7 μg/kg), 18 (23.7 μg/kg) and Station 19 (33.2 μg/kg). Naphthalene values were < 19 μg/kg at all stations. Phenanthrene values ranged from < 20 μg/kg (stations 3-6, 9, 14-17, 20-22) to a maximum of 133.5 μg/kg (Station 18). Pyrene values ranged from <20 μg/kg (Stations 3, 5-6, 9, 14, 17, 21) to a maximum of 253.1 μg/kg (Station 19). Benz-[A]-Anthracene values ranged from <20 μg/kg (Stations 3, 5-6, 9, 14-17, 20-22) to 158.9 μg/kg (Station 19). Benzo (B) Fluoranthene values ranged from <20 μg/kg (Stations 1, 3, 5-6, 9, 14, 16-17, 20-22) to 143.5 μg/kg (Station 19). Benzo (K) Fluoranthene values ranged from < 20 μg/kg (Stations 1, 3, 5-6, 8-9, 14-17, 20-22) to 107.2 μg/kg (Station 19). Benzo (A) Pyrene values ranged from <20 μg/kg (Stations 1, 3, 5-6, 9, 14, 16-17, 20-22) to 212.2 μg/kg (Station 19). Benzo (E) Pyrene values ranged from <20 μg/kg (Stations 1, 3, 5-6, 9, 14-17, 20-22) to 131.1 μg/kg (Station 19). Benzo (Ghi) Perylene values ranged from <20 μg/kg (Stations 1, 3, 5-6, 8-9, 14-17, 20-22) to 117.3 μg/kg (Station 19). Chrysene values ranged from <20 μg/kg (Stations 1, 3, 5-6, 9, 14-17, 20-22) to 145.4 μg/kg (Station 19). Indeno-{1,2,3-CD]-Pyrene values ranged from <20 μg/kg (Stations 1, 3, 5-6, 9, 14, 16-17, 21-22) to 154.4 μg/kg (Station 19). Perylene values ranged from <20 μg/kg (Stations 1, 3, 5-6, 8-9, 12-17, 20-22) to 60.4 μg/kg (Station 19).

The values for the PCB Congeners 028, 052, 101, 118, 138, 153 and 180 were < 10 μg/kg at all stations with the exception of Station 8 where the values for congeners 138, 153 and 180 were 14.8, 12.8 and <20.1 μg/kg respectively. All PCBs and PAHs (Σ16 lower guidance of 4000 μg/kg) were below guidance levels (Cronin *et al.,* 2006).

Table 2.2.5 shows the results of the marine sediment samples collected from South Park in May 2011 and the lower and upper guidance levels of Cronin *et al.* (2006). All levels were below the lower guidance level of Cronin *et al.* (2006).

South Park marine sediment results					
Parameter	**Unit**	**Sample 1**	**Sample 2**	**Lower Guidance Level***	**Upper Guidance Level***
Arsenic (solids)	mg/kg	1.1	<1.0	9	70
Cadmium (solids)	mg/kg	<0.20	<0.20	0.7	4.2
Chromium (solids)	mg/kg	2.8	2.1	120	370
Copper (solids)	mg/kg	5.1	5.1	40	110
Extractable HC/DRO (C8-C40) Soil	mg/kg	<50	<50	1000	
Fats, Oils & Greases (soil)	mg/l	<5	<5		
Lead (solids)	mg/kg	2.1	5.3	60	218
Mercury (solids)	mg/kg	<0.35	<0.35	0.2	0.7
Nickel (solids)	mg/kg	<1.0	<1.0	21	60
PRO (C5-C12) Soil	mg/kg	<5	<5		
Zinc (solids)	mg/kg	18	16	160	410

Table 2.2.5 - Marine sediments analysed from South Park, May 2011

* = Proposed guidance values from Cronin *et al.,* 2006.

Further discussion on all of these results can be found in Section 2.2.4 Discussion.

2.2.3.2 Macrofauna (2004 Survey)

The taxonomic identification of the benthic infauna across all 22 stations (see Figure 2.2.3) sampled in the 2004 survey yielded a total count of 190 species, ascribed to 11 phyla. A complete listing of these species is provided in Appendix 7.3. Of the 190 species enumerated, 81 were polychaetes (segmented worms), 52 were crustaceans (crabs, shrimps, prawns), 37 were molluscs (mussels, cockles, snails *etc*.), 9 were echinoderms (brittlestars, sea cucumbers), 2 species were chelicerate (sea spiders), 1 species was a chordate (sea squirts and tunicates) and 1 species was a phoronid (horseshoe worm). Seven species were grouped as others; this group consisted of cnidarians (jellyfish, corals), nematodes (round worms), nemerteans and sipunculids (unsegmented worms). Numbers of species and numbers of individuals were generally low throughout the study area.

2.2.3.2.1 Univariate Analyses

Univariate statistical analyses were carried out on the station-by-station faunal data. The following parameters were calculated and can be seen in Table 2.2.6, species numbers, number of individuals, richness, evenness and diversity. Species numbers ranged from 2 (Station 2) to 54 (Station 21). Number of individuals ranged from 6 (Station 2) to 327 (Station 22). Richness ranged from 0.56 (Station 2) to 10.38 (Station 21). Evenness ranged from 0.33 (Station 7) to 0.9 (Station 11). Diversity ranged from 0.65 (Station 2) to 4.73 (Station 21).

Diversity indices for all faunal stations					
Station	No. species	No. individuals	Richness	Evenness	Diversity
1	11	37	2.77	0.75	2.58
2	2	6	0.56	0.65	0.65
3	26	257	4.51	0.63	2.95
4	12	25	3.42	0.81	2.90
5	35	93	7.50	0.89	4.55
6	12	26	3.38	0.75	2.70
7	6	105	1.07	0.33	0.85
8	13	30	3.53	0.85	3.15
9	12	28	3.30	0.83	2.98

Table 2.2.6 Diversity indices for all 22 stations sampled in the initial survey

Diversity indices for all faunal stations					
Station	No. species	No. individuals	Richness	Evenness	Diversity
10	16	58	3.69	0.86	3.44
11	17	44	4.23	0.90	3.67
12	24	55	5.74	0.86	3.93
13	45	228	8.10	0.86	4.70
14	25	169	4.68	0.72	3.36
15	22	158	4.15	0.81	3.63
16	12	30	3.23	0.81	2.91
17	16	56	3.73	0.82	3.29
18	30	114	6.12	0.83	4.08
19	20	72	4.44	0.80	3.47
20	25	103	5.18	0.84	3.89
21	54	165	10.38	0.82	4.73
22	38	327	6.39	0.76	4.00

Table 2.2.6 contd/. Diversity indices for all 22 stations sampled in the initial survey

2.2.3.2.2 <u>Multivariate Analyses</u>

The dendrogram and the MDS plot can be seen in Figures 2.2.7 and 2.2.8 respectively. SIMPROF analysis revealed 10 statistically significant groupings between the 22 stations (the red lines in the dendrogram connect the stations within a group and the black lines connect the different groups). It can be seen from these that stations 1, 2, 4 and 7 (Groups a, b, c and d) were not considered to be similar in biological make-up, not only to each other but also to any other stations.

Group a (Station 2) separated from all other stations at a similarity level of 6.49%. The reason for this separation was due to the very low faunal abundance level at this station. Only 2 species comprising 6 individuals were recorded: the bivalve *Kurtiella bidentata* (83.3% of the faunal abundance) and the polychaete *Ampharete* sp. (16.7% faunal abundance).

Group b (Station 7) separated from all the remaining groups at a similarity level of 9.2%. This was due to the fact that the polychaete *Phyllochaetopterus anglicus* was the only species recorded in appreciable numbers. This species accounted for 86.7% of the faunal abundance at this station.

Group c (Station 1) separated from all the remaining stations at a similarity level of 12.64%. This station contained 11 species and 37 individuals. Two species accounted for 65% of the faunal abundance at this station: the bivalve *Angulus fabula* (45.9% of the faunal abundance) and the polychaete *Spio* sp. (18.9% of the faunal abundance).

Group d (Station 4) separated from the remaining stations at a similarity level of 17.65%. This station contained 12 species and 25 individuals. Two species accounted for 60% of the faunal abundance at this station: the polychaete *Nephtys* sp. (32% of the faunal abundance) and the bivalve *Abra prismatica* (28% of the faunal abundance).

Group e (Stations 3, 5, 18 and 21) formed at a similarity level of 29.22%. SIMPER analysis revealed that these stations grouped together due to the presence of the bivalves *Venus casina* and *Abra alba,* the polychaetes *Nephtys* sp., the amphipod *Ampelisca brevicornis* and the bivalve *Thracia phaseolina.* This group contained 100 species comprising 629 individuals. *Thracia phaseolina* (20% faunal abundance) and *Crassicorophium crassicorne* (14.6% faunal abundance) were the main dominants of this group.

Group f (Stations 6, 9, 16 and 17) formed at a 35.19% similarity level. SIMPER analysis revealed that these stations grouped together due to the presence of *Ampelisca brevicornis, Nephtys* sp. and the polychaete *Melinna palmata.* This group contained 34 species comprising 140 individuals. *Ampelisca brevicornis* (37.1% faunal abundance) and *Melinna palmata* (9.3% faunal abundance) were the main dominants of this group.

Group g (Station 13) separated from the remaining stations at a similarity level of 38.13%. This station contained 45 species and 228 individuals. The top three dominant species at this station were: the bivalve *Kurtiella bidentata* (16.7% of the faunal abundance) and the polychaetes *Euclymene oerstedii* (10.5% of the faunal abundance) and *Melinna palmata* (7.9% of the faunal abundance).

Group h (Stations 10, 12, 14, 15 and 22) formed at a similarity level of 40.94%. SIMPER analysis revealed that these stations grouped together due to the presence of *Ampelisca brevicornis, Melinna palmata, Venus casina,* the bivalve *Nucula nucleus and Kurtiella bidentata.* This group contained 63 species comprising 767 individuals. *Kurtiella bidentata* (22% faunal abundance) and *Melinna palmata* (19% faunal abundance) were the main dominants of this group.

Group i (Stations 8 and 11) formed at a similarity level of 37.1%. SIMPER analysis revealed that these stations grouped together due to the presence of *Nephtys* sp., *Melinna palmata* and *Amphiura.* This group contained 24 species comprising 74 individuals. *Kurtiella bidentata* (13.5% faunal abundance), the polychaete *Notomastus latericeus* (10.8% faunal abundance) and *Melinna palmata* (10.8% faunal abundance) were the main dominants of this group.

Group j (Stations 19 and 20) formed at a similarity level of 34.34%. SIMPER analysis revealed that these stations grouped together due to the presence of *Ampelisca brevicornis*, *Nephtys* sp., *Nephtys kersivalensis* and the bivalves *Thyasira flexuosa* and *Abra nitida*. This group contained 37 species comprising 175 individuals. *Melinna palmata* (16.6% faunal abundance) and *Ampelisca brevicornis* (16% faunal abundance) were the main dominants of this group.

These delineations were also preserved in the MDS plot. The stress value of the MDS ordination is 0.18; this provides a useful 2d picture, but detail may be misinterpreted.

Table 2.2.7 shows the top 5 characterising/dominant species for each group. Where groups contained more than 1 station then the characterising species were determined from the SIMPER analyses and the characterising species from the groups that contained only 1 station were determined from the faunal abundance data. Sediment type according to Folk (1954) can also be seen in Table 2.2.7. Figure 2.2.9 shows the relative locations of the faunal groupings within the study area in 2004. An overall macrofaunal discussion can be found in Section 2.2.4.2 Macrofauna.

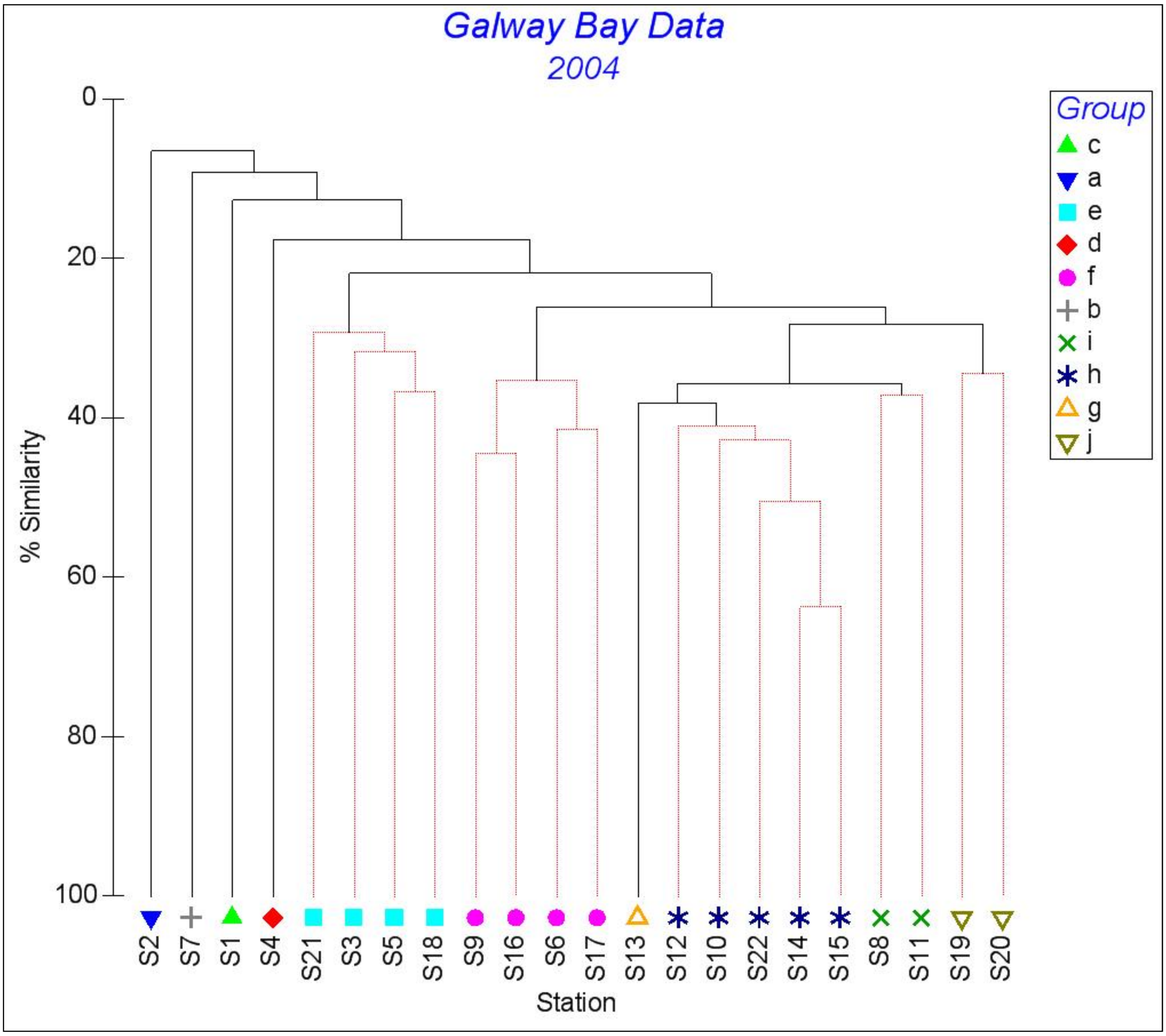


Figure 2.2.7 - Dendrogram of all 22 stations initially sampled in Galway Bay in 2004

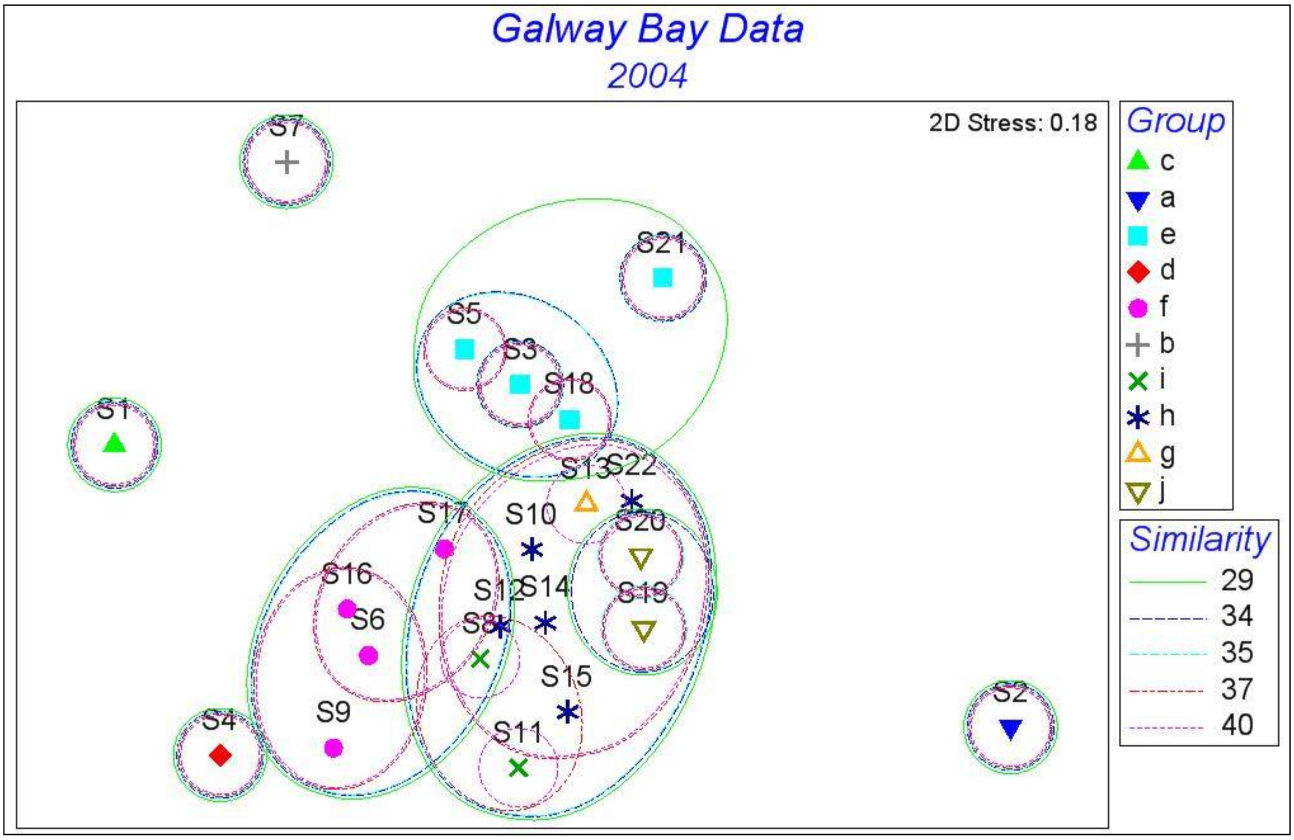


Figure 2.2.8 - MDS ordination of all 22 stations initially sampled in Galway Bay in 2004

Characterising/Dominant species for each faunal group									
Group	**Stations**	**Avg. Group Similarity**	**Species**	**Av. Abund**	**Av. Sim**	**Sim/SD***	**Contrib %**	**Cum %**	**Sediment Type#**
a	2	n/a	*Kurtiella bidentata*	n/a	n/a	n/a	83	83	Muddy sand
			Ampharete sp.	n/a	n/a	n/a	17	100	
b	7	n/a	*Phyllochaetopterus anglicus*	n/a	n/a	n/a	87	87	Muddy sand
			Abra alba	n/a	n/a	n/a	5	91	
			Nephtys assimilis	n/a	n/a	n/a	3	94	
			Philine aperta	n/a	n/a	n/a	3	97	
			Macoma balthica	n/a	n/a	n/a	2	99	
c	1	n/a	*Angulus fabula*	n/a	n/a	n/a	46	46	Sand
			Spio sp.	n/a	n/a	n/a	19	65	
			Eumida bahusiensis	n/a	n/a	n/a	5	70	
			Nephtys assimilis	n/a	n/a	n/a	5	76	
			Magelona mirabilis	n/a	n/a	n/a	5	81	
d	4	n/a	*Nephtys* sp.	n/a	n/a	n/a	32	32	Muddy sand
			Abra prismatica	n/a	n/a	n/a	28	60	
			Gattyana cirrosa	n/a	n/a	n/a	4	64	
			Eteone flava	n/a	n/a	n/a	4	68	
			Exogone hebes	n/a	n/a	n/a	4	72	
e	3, 5, 18, 21	31.27	*Thracia phaseolina*	2.13	3.7	3.19	11.83	11.83	Sand & Muddy sand
			Ampelisca brevicornis	1.51	3.08	3.61	9.86	21.69	
			Nephtys sp.	1.38	2.99	4.01	9.57	31.26	
			Venus casina	1.17	2.47	6.9	7.91	39.17	
			Abra alba	1.16	2.41	4.18	7.7	46.87	

Table 2.2.7 - Characterising/dominant species and community classification for the 10 faunal groups identified from the 2004 survey data

Characterising/Dominant species for each faunal group									
Group	**Stations**	**Avg. Group Similarity**	**Species**	**Av. Abund**	**Av. Sim**	**Sim/SD***	**Contrib %**	**Cum %**	**Sediment Type#**
f	6, 9, 16, 17	37.75	*Ampelisca brevicornis*	1.89	12.08	9.32	31.99	31.99	Sand & Muddy sand
			Melinna palmata	1.29	7.44	7.94	19.71	51.7	
			Nephtys sp.	1.25	7.44	8.04	19.71	71.4	
			Thracia phaseolina	0.8	3.2	0.9	8.49	79.89	
			Hyale pontica	0.5	1.23	0.41	3.26	83.15	
g	13	n/a	*Kurtiella bidentata*	n/a	n/a	n/a	17	17	Muddy sand
			Euclymene oerstedii	n/a	n/a	n/a	11	28	
			Melinna palmata	n/a	n/a	n/a	8	36	
			Abra nitida	n/a	n/a	n/a	6	42	
			Ampelisca brevicornis	n/a	n/a	n/a	5	47	
h	10, 12, 14, 15, 22	45.64	*Kurtiella bidentata*	2.21	5.38	3.49	11.79	11.79	Muddy sand
			Melinna palmata	2.15	5.24	4.58	11.49	23.28	
			Ampelisca brevicornis	1.55	4.17	6.08	9.15	32.42	
			Nucula nucleus	1.51	4.03	3.95	8.82	41.24	
			Venus casina	1.51	3.95	3.96	8.65	49.9	

Table 2.2.7 contd/. Characterising/dominant species and community classification for the 10 faunal groups identified from the 2004 survey data

Characterising/Dominant species for each faunal group									
Group	**Stations**	**Avg. Group Similarity**	**Species**	**Av. Abund**	**Av. Sim**	**Sim/SD***	**Contrib %**	**Cum %**	**Sediment Type#**
i	8, 11	37.1	*Nephtys* sp.	1.34	6.72	n/a	18.11	18.11	Muddy sand
			Melinna palmata	1.38	6.72	n/a	18.11	36.21	
			Amphiura filiformis	1.19	6.72	n/a	18.11	54.32	
			Notomastus latericeus	1.31	5.65	n/a	15.23	69.55	
			Ampelisca brevicornis	1.25	5.65	n/a	15.23	84.77	
j	19, 20	34.34	*Ampelisca brevicornis*	1.84	5.21	n/a	15.17	15.17	Muddy sand
			Nephtys sp.	1.49	4.93	n/a	14.35	29.52	
			Nephtys kersivalensis	1.47	4.58	n/a	13.35	42.87	
			Thyasira flexuosa	1.41	4.58	n/a	13.35	56.22	
			Abra nitida	1.41	4.58	n/a #	13.35	69.57	

Table 2.2.7 contd/. Characterising/dominant species and community classification for the 10 faunal groups identified from the 2004 survey data

* Cannot be calculated as the group only have 2 stations

n/a = Similarity percentages cannot be calculated on groups with only one station

According to Folk (1954) Classification

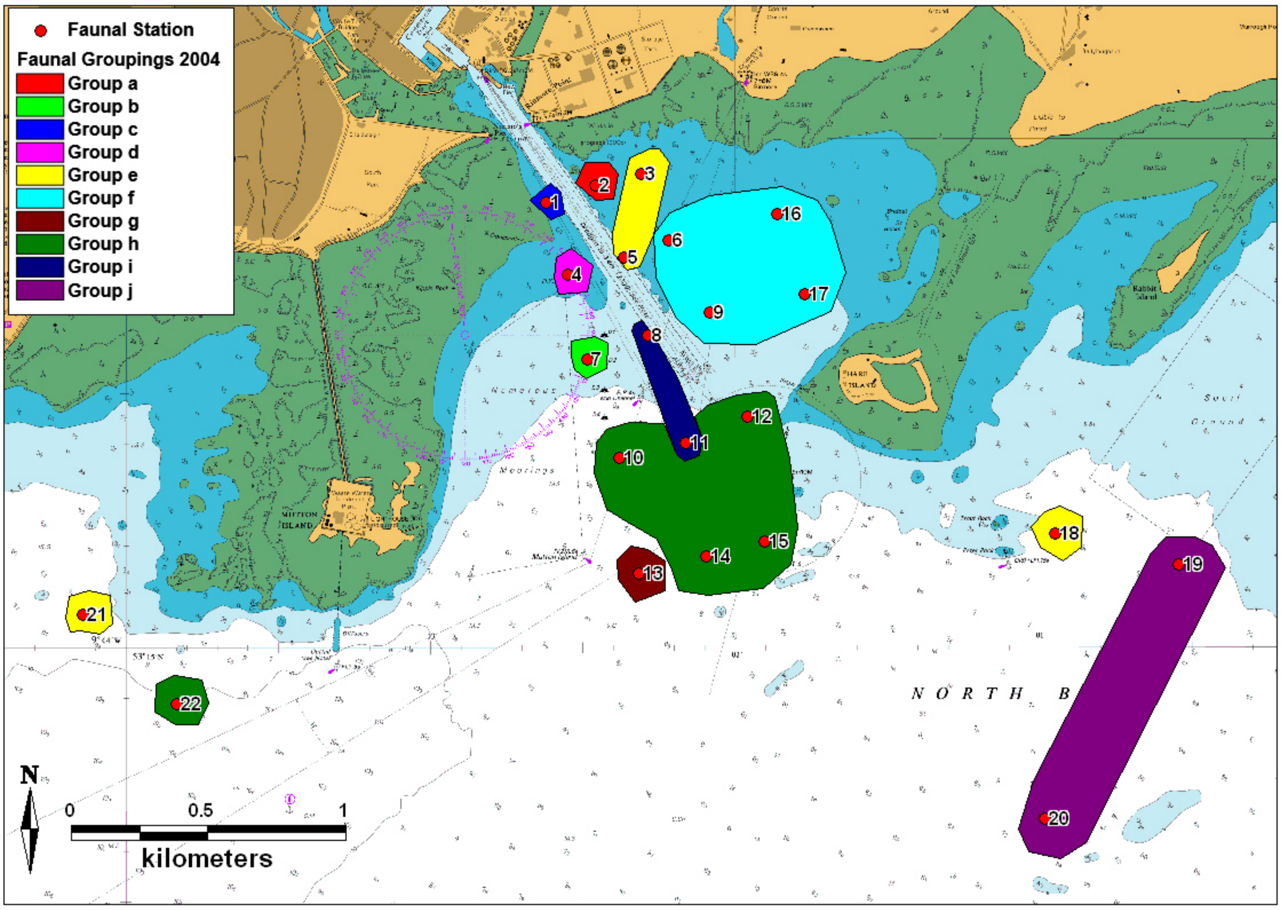


Figure 2.2.9 - Faunal groupings identified from the survey area in 2004

2.2.3.3 Macrofauna (2010 Survey)

The taxonomic identification of the benthic infauna across all 12 stations (see Figure 2.2.4) sampled in the vicinity of Galway Docks yielded a total count of 146 species comprising 2210 individuals, ascribed to 9 phyla. A complete listing of these species abundance is provided in Appendix 7.7.

Of the 146 species enumerated, 81 were annelids (segmented worms), 21 were crustaceans (crabs, shrimps, prawns), 30 were molluscs (mussels, cockles, snails *etc*.), 6 species were echinoderms (brittlestars, sea cucumbers), 2 species were cnidarians (corals, anemones, jellyfish *etc.*), 2 species were spiunculids (peanut worms), 2 species were chelicerates (sea spiders), 1 species was a phoronid (horseshoe worm) and 1 species was a nemertean.

2.2.3.3.1 <u>Univariate Analyses</u>

Univariate statistical analyses were carried out on the combined replicate station-by-station faunal data. The following parameters were calculated and can be seen in Table 2.2.8; species numbers, number of individuals, richness, evenness and diversity. Species numbers ranged from 10 (S6) to 67 (S7). Number of individuals ranged from 15 (S6) to 620 (S2). Richness ranged from 3.32 (S6) to 11.26 (S7). Evenness ranged from 0.56 (S11) to 0.95 (S5). Diversity ranged from 2.2 (S11) to 5.08 (S7).

Diversity indices for all faunal stations					
Station	No. Species	No. Individuals	Richness	Evenness	Diversity
S1	56	299	9.65	0.82	4.75
S2	66	620	10.11	0.58	3.49
S3	50	269	8.76	0.83	4.69
S4	30	128	5.98	0.73	3.58
S5	13	20	4.01	0.95	3.51
S6	10	15	3.32	0.94	3.11
S7	67	351	11.26	0.84	5.08
S8	40	133	7.97	0.84	4.45
S9	22	140	4.25	0.72	3.21
S10	26	114	5.28	0.64	3.00
S11	15	58	3.45	0.56	2.20
S12	21	63	4.83	0.89	3.9

Table 2.2.8 - Diversity indices for the 12 stations sampled in the vicinity of Galway Docks, 2010

2.2.3.3.2 Multivariate Analyses

The dendrogram and the MDS plot can be seen in Figures 2.2.10 and 2.2.11 respectively. SIMPROF analysis revealed 6 statistically significant groupings between the 12 stations (the red lines in the dendrogram connect the stations within a group and the black lines connect the different groups).

It is clear from these figures that S11 (Group I) separated away from all other stations at a similarity level of 12.14%. This was due to the fact that the polychaete *Capitella* sp was the only species recorded in any appreciable numbers. The presence of a dense *Capitella* population has classically been associated with organically enriched and physically disturbed habitats in the marine environment (Warren, 1977; Pearson & Rosenberg, 1978). This is typical of what one would expect in a navigational channel which is disturbed by dredging activity on an infrequent basis.

The remaining stations were 18.19% similar to each other (Groups II, III, IV, V and VI). Group II consisted of stations S5 and S6. These stations were 34.63% similar to each other. SIMPER analysis revealed that these stations grouped together due to the presence of the bivalve *Thyasira flexuosa,* the polychaetes *Scoloplos armiger* and *Spiochaetopterus typicus* and the bivalve *Abra alba* at each station. These two stations had poor species diversity and abundance and in total they contained 19 species comprised of 35 individuals. *Thyasira flexuosa* (20% of the abundance), *Spiochaetopterus typicus* (11.4% of the abundance) and *Scoloplos armiger* (8.6% of the abundance) were the dominant species in this group.

Group III consisted of station S4. This group separated from Groups VI and V at a 38.42% level of similarity. Three species were responsible for 85% of the faunal abundance at this station: *Scoloplos armiger* (37.6% of the faunal abundance), *Thyasira flexuosa* (32.3% of the faunal abundance) and the bivalve *Kurtiella bidentata* (15.1% of the faunal abundance). In total, this station contained 30 species and 128 individuals.

Group IV consisted of station S7. This group separated from Group V at a 47.88% level of similarity. Five species accounted for approximately 50% of the faunal abundance at this station: the polychaetes *Mediomastus fragilis* (14.3% of faunal abundance), *Pholoe inornata* (13.7% of faunal abundance), *Pomatoceros* sp. (7.5% of faunal abundance) and *Pomatoceros triqueter* (7.2% of faunal abundance) and the crustacean *Tanaopsis graciloides* (4.2% of faunal abundance). In total, this station contained 67 species and 351 individuals.

Group V consisted of stations S1, S2 and S3, and had a total group similarity of 61.23%.. SIMPER analysis revealed that these stations grouped together due to the presence of *Thyasira flexuosa,* the polychaetes *Pholoe inornata* and *Melinna palmata,* the ophiuroid *Amphiura filiformis* and the bivaleve *Kurtiella bidentata.* The top four dominant species in this group were the molluscs *Turritella communis* (34.2%) and *Thyasira flexuosa* (15.4%), the polychaete *Pholoe inornata* (10.4%) and the bivalve mollusc *Kurtiella bidentata* (8.2%).

Group IV consisted of stations S8, S9, S10 and S12 and had a total group similarity of 38.25%. SIMPER analysis revealed that these stations grouped together due to the presence of the polychaetes *Scoloplos armiger, Spiophanes bombyx, Nephtys hombergii* and the mollusc *Tellina* sp. The top four dominant species in this group were the molluscs *Tellina* sp. (17.3%), the oligochaete *Tubificoides pseudogaster* agg. (14.2%), the amphipod *Crassicorophium crassicorne* (7.1%) and the polychaete *Pygospio elegans* (6.4%).

These delineations were also preserved in the MDS plot. The stress value of the MDS ordination is 0.08; this results in a good representation of the data with no real prospect of misinterpretation of overall structure, but very fine detail may be misleading in compact subgroups.

Table 2.2.9 shows the top 5 characterising/dominant species for each group. Where groups contained more than 1 station then the characterising species were determined from the SIMPER analyses and the characterising species from the groups that contained only 1 station were determined from the faunal abundance data. Sediment type according to Folk (1954) can also be seen in Table 2.2.9. Figure 2.2.12 shows the relative locations of the faunal groupings within the study area in 2010.

The results of the two macrobenthic infaunal quantitative surveys were similar indicating that any change in benthic conditions in the area is at a low rate. The univariate statistics indicate that faunal diversity and numbers of species are low. This is to be expected in an area that has been subjected to pressures including enrichment from untreated sewage, port channel maintenance operations and fluctuating salinities. An overall macrofaunal discussion can be found in Section 2.2.4.2.

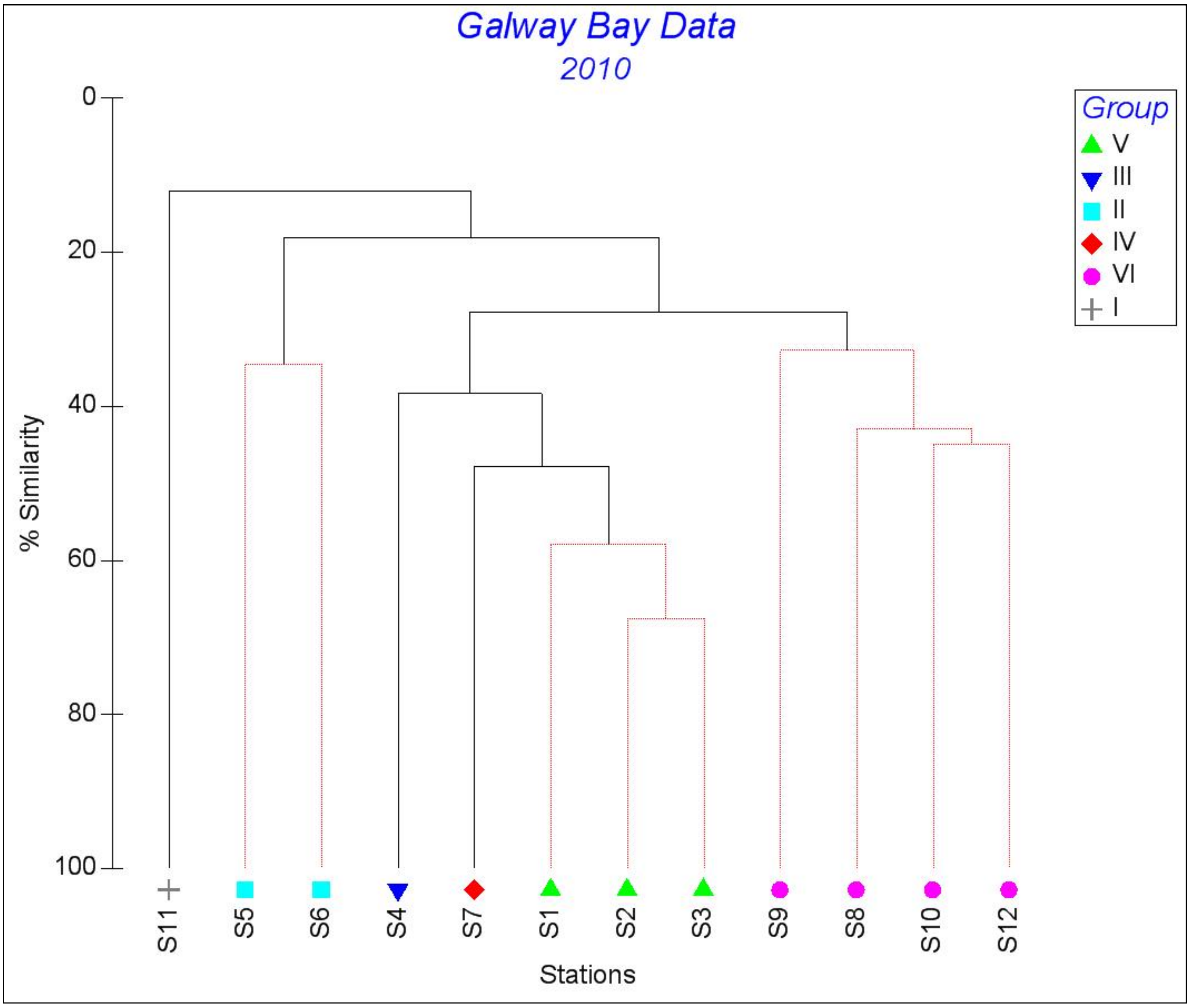


Figure 2.2.10 - Dendrogram showing each station from the 12 stations sampled in the vicinity of Galway Docks, 2010

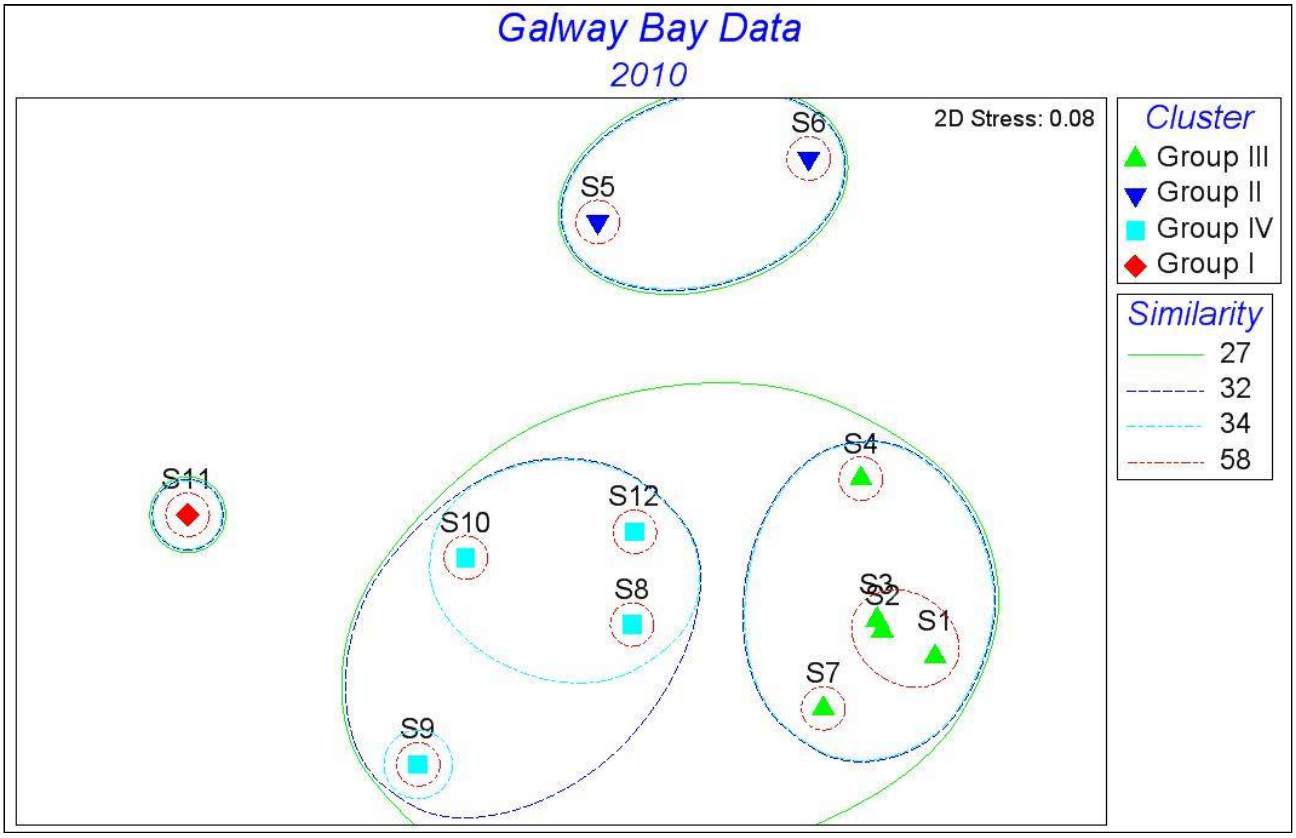


Figure 2.2.11 - MDS ordination showing each station from the 12 stations sampled in the vicinity of Galway Docks, 2010

Characterising/dominant species for each faunal group									
Group	Stations	Avg. Group Similarity	Species	Av. Abund	Av. Sim	Sim/SD*	Contrib %	Cum %	Sediment Type#
I	11	n/a	*Mediomastus fragilis*	n/a	n/a	n/a	65.5	65.52	Slightly Gravelly Sandy Mud
			Spio filicornis	n/a	n/a	n/a	5.2	70.69	
			Nephtys cirrosa	n/a	n/a	n/a	3.4	74.14	
			Spionidae sp.	n/a	n/a	n/a	3.4	77.59	
			Pygospio elegans	n/a	n/a	n/a	3.4	81.03	
II	5, 6	34.63	*Thyasira flexuosa*	1.37	10.56	n/a	30.49	30.49	Slightly Gravelly Muddy Sand
			Scoloplos armiger	1.09	8.02	n/a	23.17	53.66	
			Spiochaetopterus typicus	1.16	8.02	n/a	23.17	76.83	
			Abra alba	1	8.02	n/a	23.17	100.00	
III	4	n/a	*Scoloplos armiger*	n/a	n/a	n/a	37.6	37.63	Slightly Gravelly Sandy Mud
			Thyasira flexuosa	n/a	n/a	n/a	32.3	69.89	
			Kurtiella bidentata	n/a	n/a	n/a	15.1	84.95	
			Nephtys sp. (juv)	n/a	n/a	n/a	7.5	92.47	
			Terebellides stroemii	n/a	n/a	n/a	4.3	96.77	
IV	7	n/a	*Mediomastus fragilis*	n/a	n/a	n/a	14.3	14.33	Muddy Sand
			Pholoe inornata	n/a	n/a	n/a	13.7	28.01	
			Pomatoceros sp.	n/a	n/a	n/a	7.5	35.50	
			Pomatoceros triqueter	n/a	n/a	n/a	7.2	42.67	
			Tanaopsis graciloides	n/a	n/a	n/a	4.2	46.91	

Table 2.2.9 Characterising/dominant species and community classification for the 6 faunal groups identified from the 2010 survey data

Characterising/dominant species for each faunal group									
Group	**Stations**	**Avg. Group Similarity**	**Species**	**Av. Abund**	**Av. Sim**	**Sim/SD***	**Contrib %**	**Cum %**	**Sediment Type#**
V	1, 2, 3	61.23	*Thyasira flexuosa*	2.44	2.62	3.67	4.29	4.29	Slightly Gravelly Sandy Mud & Sandy Mud
			Pholoe inornata	2.26	2.6	25.1	4.25	8.54	
			Melinna palmata	1.92	2.4	13.67	3.92	12.46	
			Amphiura filiformis	1.85	2.33	24.75	3.8	16.26	
			Kurtiella bidentata	2.08	2.27	9.08	3.7	19.96	
VI	8, 9, 10, 12	38.25	*Tellina* sp.	1.85	4.24	3.95	11.08	11.08	Slightly Gravelly Sand, Sandy Mud & Muddy Sand
			Nephtys hombergii	1.4	3.75	4.23	9.8	20.89	
			Spiophanes bombyx	1.27	3.37	5.61	8.81	29.69	
			Scoloplos armiger	1.23	3.12	6.51	8.15	37.84	
			Tubificoides pseudogaster agg.	1.36	2.17	0.85	5.67	43.51	

* Cannot be calculated as the group only have 2 stations
n/a = Similarity percentages cannot be calculated on groups with only one station
According to Folk (1954) Classification

Table 2.2.9 contd/. Characterising/dominant species and community classification for the 6 faunal groups identified from the 2010 survey data

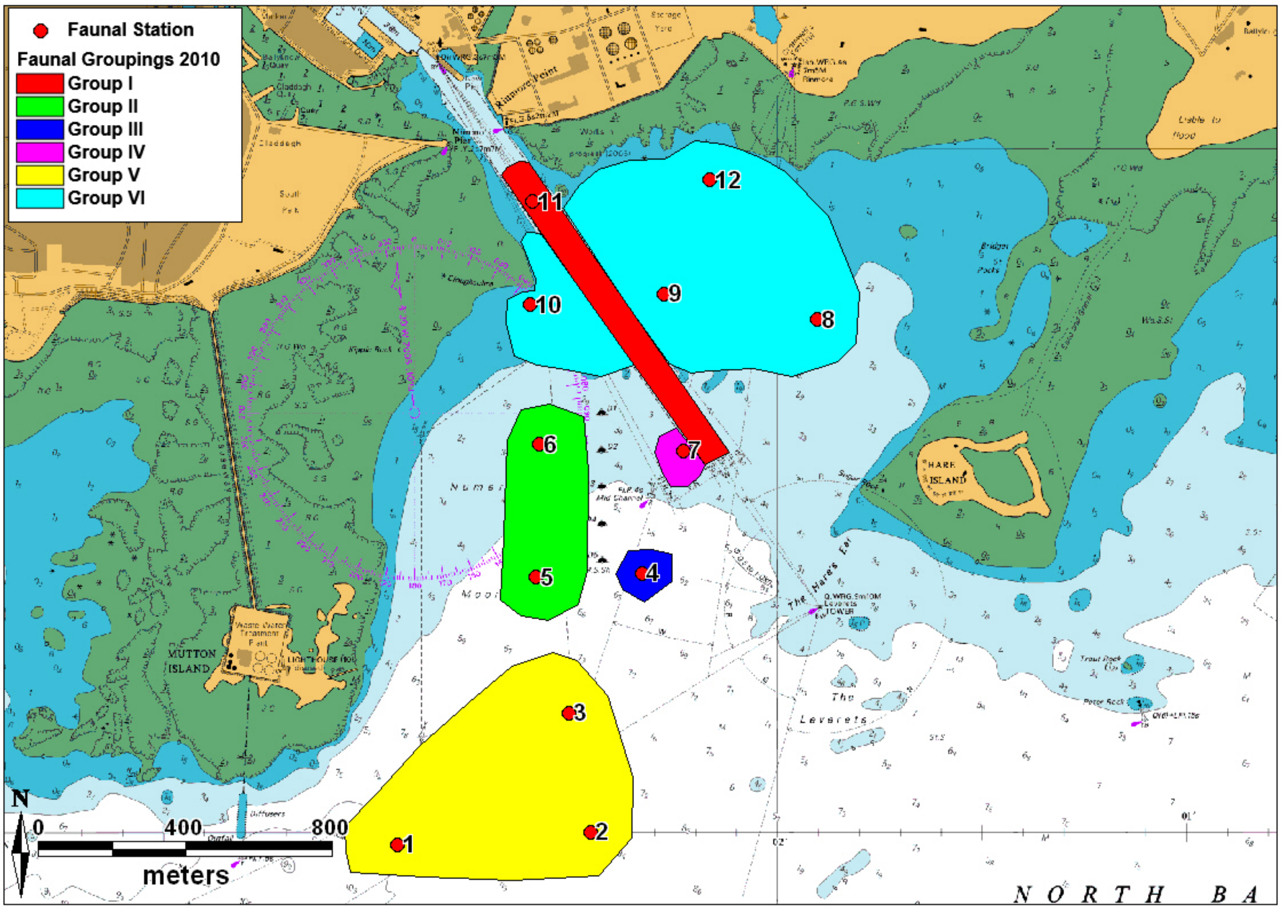


Figure 2.2.12 - Faunal groupings identified from the survey area in 2010

2.2.3.4 Sediment Profile Imagery (SPI)

The results of the analyses on the images collected at the 22 sites in 2004 (see Figure 2.2.3) are presented in Table 2.2.10.

2.2.3.4.1 Major mode

Fine sediments dominate the area surveyed. Of the 22 stations samples, 15 (Stations 1, 4, 7, 9, 11 – 20 and 22 had their major modes represented by the 3 –2 phi fraction which is muddy sand. 1 site, Station 10 had its mode at 4 phi . The remaining stations had modes that included the phi range of 2 - 1 which is fine sand.

Mean values for SPI analyses							
Station	Major Mode (phi)	Mean Penetration (cm)	S.B.R. (cm)	Mean Redox (cm)	S.S.[1]	OSI[2]	BHQ[3]
1	3 – 2	6.245	0.97	4.88	II	2	5
2	2 – 1	3.65	1.07	2	II	-1	4
3	2 – 1	4.05	1.32	>4.05	II	4.3	6
4	3 – 2	13.61	0.77	4.45	I	-0.3	2.3
5	2	5.97	9.42	1.57	I-II	-2	1.3
6	2 – 1	3.14	0.89	2.8	II	-0.5	2.5
7	4-3/3-2	>21 (op)	-	2	I	-1	2
8	2 – 1	14.16	1.23	4.37	II	4.3	6.7
9	3-2/2-1	12.23	1.02	5.07	II	2	5
10	4/4-3	17.96	1.9	2.5	I	-1	2.5
11	3 - 2	>21 (op)	-	1.5	I	-2	4.7
12	3 – 2	20.72	0.60	3.6	II	5	4
13	3 – 2	16.71	0.84	3.88	II-III	3.7	4
14	3 – 2	18.5	1.09	1.01	II	6	6
15	3 – 2	11.73	0.91	4.17	II	1.3	3
16	2-3/3-2	8.67	0.70	4.85	II	4	5
17	2-1/3-2	10.07	0.69	4.875	II	4.3	5.3
18	3 – 2	12.63	3.65	2	Azoic – II	- 6	2
19	3 – 2	18.09	1.46	4.9	I-II	-1.3	2
20	1-0/3-2	16.04	0.68	3.45	I on III	1	2
21	2 - 1	2.62	2.09	>2.62	II	0	3
22	3 - 2	17.13	0.92	3.24	I-II	1.3	3

Table 2.2.10 - Mean values for SPI analyses on samples collected in inner Galway Bay

[1] Ranges from 0 to III, [2] Ranges from -6 to +11, [3] Ranges from 0 to +15

- indicates that analysis was not possible, op = over penetration

2.2.3.4.2 Mean penetration

Mean penetration ranges from 2.62 at Station 21 to a maximum of 20.72 at Station 12. Over penetration occurred at 2 stations (Stations 7 and 11). Fifteen stations (Stations 4, 7, 8 – 15, 17 – 20 and 22) returned mean penetrations of greater than 10cm.

2.2.3.4.3 Surface boundary roughness

Surface boundary roughness (SBR) was lowest at Station 17 (0.69) and greatest at Station 5 (9.42). Most values were lower than 2.

2.2.3.4.4 Mean Redox discontinuity

The redox discontinuity was shallowest at Station 14 (1.01cm) and deepest at Station 9 (5.09). Fourteen stations (Station 1, 3, 4, 8, 9, 12, 13, 15 – 20 and 22) had redox discontinuities of 3 cm or deeper.

2.2.3.4.5 Successional Stage

The successional stage ranged from Azoic to Stage II-III,

2.2.3.4.6 Organism Sediment Index

The Organism Sediment Index varied from -2 at Stations 5 and 11 19 to 6 at Station 14.

2.2.3.4.7 Benthic Habitat Quality

Benthic Habitat Quality varied from 1.3 at Station 5 to 6.7 at Station 8.

2.2.4 Discussion

2.2.4.1 Sedimentology

2.2.4.1.1 Granulometry

Sediments in the layby were dominated by silt-clay (81.8%) and sediments within the docks ranged from sandy mud to muddy sand to muddy and sandy gravel.

The sediments returned from the proposed development area were predominately fine sands and silt-clay. The navigation channel is periodically dredged (*ca* every 10 years), due to the accumulation of sand, silt and clay through the natural process of sedimentation. It is to be expected that these sites would be dominated by sand and silt. The findings of sand and silt in this area are consistent with those from previous workers (Shin, 1981; Shin et al., 1982; O'Connor *et al*., 1993; Roche, 2004).

With regard to sedimentation rates and build up of material, as there will be at most only the same amount of sediment coming in from the river/sea, the rate will be at most the same as it is at present. In fact with the Mutton Island causeway in place, the expected increase in current velocities anticipated due to the new structure (See Chapter 8 of EIS) and the decommissioning of the sewage pipes in the Corrib River and off South Park, the sediment loadings will be somewhat less than in previous years. This in turn suggests a slower build-up of material within the proposed development area over time than is the case at present.

Information from the Harbour Master indicates that maintenance dredging occurs *ca* every 10 years *i.e.* when the channel has filled in to *ca* +50 cm over the last dredging episode. As suspended sediment loadings will be lower and current velocities will be higher, it is predicted that maintenance dredging may only be required every 15 years.

2.2.4.1.2 Sediment Chemistry

Organic carbon contents of inshore and estuarine sediments, as estimated by loss on ignition, are generally highly correlated with the fine silt-clay fraction (Marine Institute, 1999). This correlation can be clearly seen in the results of the present survey. Organic carbon values greater than 20 g/kg (2%) (Stations 2, 4, 7, 10, 11, 20 and the layby station) corresponded with those stations that were predominately composed of silt-clay sediments. The maximum organic carbon content value recorded was 52 g/kg (5.2%) at Station 7. Values in this region are not considered to be excessively high or uncommon for this area.

The mercury levels recorded in this area were consistent with previously recorded values of <1 mg/kg (ppm) (Roche, 2004) and are all below the lower guidance level of 0.2 mg/kg (Cronin e*t al.,* 2006).

Cadmium, arsenic and nickel were consistent with previous findings and were not found in elevated concentrations (>1 mg/kg, >10 mg/kg and >25 mg/kg respectively) at any station. Cadmium levels exceed the upper guidance level within the dock area only. All other Cadmium levels throughout the study area were all below the lower guidance level of Cronin *et al.* (2006) with one exception. Lead, zinc and copper were within their expected ranges (>50 mg/kg, >80 mg/kg and >20 mg/kg respectively) at all stations with the exception of Stations 2 and 7. Values were slightly elevated at these stations. It is thought that elevated concentrations of lead and zinc in this area are the result of the bulk shipping of these metals [powered oxide] from the docks in past times. Zinc, lead and copper exceed the upper guidance level within the dock area and zinc levels exceeded the upper guidance level in the layby. All were below the lower guidance level in the wider study area. Iron and manganese levels were consistent with previously recorded values (Roche, 2004) for this area. Aluminium values were within the expected range of 5.7% (57,000 mg/kg) obtained from the Irish Sea (CEFAS, 2000) (No data from Galway Bay was available for comparison)

Regarding levels of PAH's, all were significantly lower than the lower guidance level of 4000 μg/kg (for all 16 PAHs). Regarding chlorinated pesticides, very little references material can be found from Irish marine sediments, with the exception of dieldrin. The Marine Institute (1999) reported levels of greater than 0.5 μg/kg as being measurable. Results in this survey ranged from <4.2 to <7.6 μg/kg. It is possible that the analytical procedure used in this analysis could not attain a lower detection limit to reveal more precise concentrations. All PCB's had levels <10 μg/kg, these levels are well below the upper guidance levl of 180 μg/kg of Cronin *et al.* (2006). TBT values recorded from the Galway Bay area were below the expected value recorded by the Marine Institute (1999) >800 μg/kg (0.8 mg/kg). Levels were well below the lower guidance level of 0.1 mg/kg {100 μg/kg}.

In order to look at the effects of the remobilisation of contaminants from deeper sediments, results of bore hole surveys carried out by Causeway Geotech Ltd. (see Appendix 6.2) were examined. The following results were recorded (see Appendix 7.6). The levels of arsenic ranged from a minimum concentration of 3.9 mg/kg in BH03 (depth 0.5-1.5 m) to a maximum of 18 mg/kg in BH02 (depth 2.0-2.5 m). These levels were within the guidance levels of Cronin *et al.* (2006). The levels of cadmium ranged from a minimum value of <0.10 mg/kg in BH01, BH02 (1.5-2.0 and 2.0-2.5 m), BH03, BH05 (5.5-6 m), BH06 (0.5-1.0 m), BH07 and BH08 to a maximum of 0.35 mg/kg in BH05 (depth 0.5-1 m). These levels were below the lower guidance level of Cronin *et al.* (2006). Chromium ranged from a minimum of <5.0 mg/kg in BH03 (depth 0.5-1.5 m) to a maximum of 38 mg/kg in BH06 (depth 6.5-7.0 m). These levels were below the lower guidance level of Cronin *et al.* (2006). Copper ranged from a minimum of <5.0 mg/kg in BH03 (0.5-1.5 m and 3.5-4.0 m), BH04 (0.5-1.0 m), BH05 (0.5-1.0 m) and BH06 (0.5-1.0 m and 1.5-2.0 m) to a maximum of 32 mg/kg in BH06 (6.5-7.0 m). These levels were below the lower guidance level of Cronin *et al.* (2006). Lead ranged from a minimum of <5.0 mg/kg in BH03 (0.5-1.5 m and 3.5-4.0 m), BH04 (0.5-1.0 m), BH05 (0.5-1.0 m) and BH06 (0.5-1.0 m) to a maximum of 31 mg/kg in BH06 (6.5-7.0 m). These levels were below the lower guidance level of Cronin *et al.* (2006). The levels of mercury were recorded at <0.10 mg/kg in all samples. These levels were below the lower guidance level of Cronin *et al.* (2006). The levels of nickel ranged from <5.0 mg/kg in BH03 (0.5-1.5 m and 3.5-4.0 m) and BH06 (0.5-1.0 m) to a maximum of 37 mg/kg in BH06 (6.5-7.0 m). These levels were within the guidance levels of Cronin *et al.* (2006). Selenium levels ranged from <0.2 mg/kg in BH02 (2.0-2.5 m), BH03 (7.5-8.0 m) and BH07 (1.5-2.0 m) to 0.74 mg/kg in

BH04 (4.5-5.0 m). Zinc ranged from a minimum of 10.0 mg/kg in BH06 (0.5-1.0 m) to a maximum of 83 mg/kg in BH01 (1.5-2.0 m). These levels were below the lower guidance level of Cronin *et al.* (2006).

Boron levels ranged from 1 to 6.9 mg/kg in BH05 (5.5-6.0 m) and BH03 (0.5-1.5 m) respectively. Total and free cyanide was <0.50 mg/kg in all samples. Sulphur levels ranged from 0.11 to 0.96 mg/kg in BH02 at depths of 2.0-2.5 m and 0.5-1.0 m respectively. Sulfide levels ranged from 3.9 to 10 mg/kg in BH07 (0.5-1.0 m) and BH03 (7.5-8.0 m) respectively. Sulfate as SO_4 ranged from 3500 to 24000 mg/kg in samples BH02 (2.0-2.5 m) and BH05 (8.5-9.0 m) respectively. Thiocyanate levels were <5.0 mg/kg in all samples except in BH02 (2.0-2.5 m) and BH03 (7.5-8.0 m) in which they were 15 and 18 mg/kg respectively. Hexavalent chromium was <0.5 mg/kg in all samples.

Acenaphthene, acenapthylene, anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(g,h,)perylene, dibenzo(a,h)anthracene, fluorine, indeno(1,2,3-cd)pyrene and naphthalene values were < 0.1 mg/kg at all stations. Phenanthrene and fluoranthene values were <0.1 mg/kg in all samples except BH01 (0-0.5m) at which it was 0.2 mg/kg. Benzo(a)anthracene, chrysene and pyrene levels were <0.1 mg/kg in all samples except BH01 (0-0.5 m) in which it was 0.1 mg/kg. Levels of total PAHs (polycyclic aromatic hydrocarbons) was <2 mg/kg in all samples. All PAH levels were below the lower guidance level of Cronin *et al.* (2006).

The level of total petroleum hydrocarbons (TPH) was <10 mg/kg in all samples. TPH aliphatic >C5-C6, TPH aliphatic >C6-C8, TPH aliphatic >C8-C10, TPH aromatic >C5-C7, TPH aromatic >C7-C8 and TPH aromatic >C8-C10 levels were <0.1 mg/kg in all samples. The level of TPH aliphatic >C10-C12, TPH aliphatic >C12-C16, TPH aliphatic >C16-C21, TPH aliphatic >C21-C35, TPH aliphatic >C35-C44, TPH aromatic >C10-C12, TPH aromatic >C12-C16 and TPH aromatic >C35-C44 was <1 mg/kg in all samples. TPH aromatic >C16-C21 and TPH aromatic >C21-C35 levels were <1 in all samples except BH01 (1.5-2 m) in which they were 2.0 and 1.8 mg/kg respectively. All hydrocarbons were below the lower guidance level of Cronin *et al.* (2006).

The level of catechols, phenol, cresols, xylenols, nephthols and trimethyl phenols was <0.05 mg/kg in all samples. Total phenols level was <0.3 mg/kg in all samples.

Boelens, 1999 (Fig. 4.2.11, Ireland's Marine and Coastal Areas and Adjacent Seas and associated text) was used as establishing background levels for heavy metals. Arsenic levels ranged from 3.9 mg/kg to a maximum concentration of 18 mg/kg in the Causeway Geotech Ltd. survey. Seven of the 21 samples have a value above >10 mg/kg which is considered an elevated level, but all have levels below the maximum concentration of 20 mg/kg. Cadmium levels were found to reach a maximum value 0.35 mg/kg, and lie below accepted levels of >1.0 mg/kg . Levels of chromium found are below the estimated background level of 30 mg/kg in all samples except in one which has a value of 38 mg/kg. However, this value is below the maximum level of 40 mg/kg. Copper levels are considered elevated above 20 mg/kg, and four samples from the Causeway Geotech Ltd. survey have a concentration above these with a maximum of 32 mg/kg. These values are less than the maximum concentrations of >100 mg/kg found by Boelens (1999). Lead levels were detected to a maximum of 31 mg/kg which is below what is considered elevated levels of >50 mg/kg. Mercury concentrations of <.0.1 mg/kg found in all samples are below the detectable limit, and these are lower an elevated concentration of 0.1 -0.9 mg/kg. All except three of the samples show a nickel concentration in line with that found by Boelens (1999) of <25 mg/kg. The maximum level of nickel detected was 37 mg/kg which is below the maximum concentration of 40 mg/kg found by the same author. Zinc levels detected in the sediment samples were all below the concentration of >80 mg/kg which is considered to be elevated, except one sample in which a level of 83 mg/kg was detected. However, this is much lower than the high concentrations of zinc of >250 mg/kg.

These results indicate that there are no reasons to suggest that mobilisation of deep sediments will impact on water or sediment quality during the dredging operations.

All traces of metals in the samples taken at South Park were found to be extremely low. Arsenic levels were found to be very low, at 1.1 mg/kg or less, and far below what is considered to be an elevated degree of >10 mg/kg (Boelens, 1999) and well below Cronin *et al.* (2006) lower guidance levels. Cadmium concentrations were recorded at <0.20 mg/kg in both samples, and well below an elevated threshold of >1 mg/kg and well below Cronin *et al.* (2006) lower guidance levels. Levels of chromium were recorded at a maximum value of 2.8 mg/kg and much lower than the estimated background level of >30 mg/kg and well below Cronin *et al.* (2006) lower guidance levels. Copper was detected at a concentration of 5.1 mg/kg in both samples, well below elevated levels of >20 mg/kg and well below Cronin *et al.* (2006) lower guidance levels. Lead levels were recorded at a minimum of 2.1 mg/kg and a maximum of 5.3 mg/kg, and were very low when compared to potential elevated concentrations of >50 mg/kg and well below Cronin *et al.* (2006) lower guidance levels. Mercury was detected at levels <0.35 mg/kg, and according to Boelens 1999 (Fig. 4.2.11, Ireland's Marine and Coastal Areas and Adjacent Seas), this may indicate a medium concentration but still below elevated levels of >1.0 mg/kg and within Cronin *et al.* (2006) guidance levels. Nickel was barely detectable, with concentrations recorded at <1.0 mg/kg (values of >25 mg/kg are considered elevated) and well below Cronin *et al.* (2006) lower guidance levels. Zinc concentrations ranged between 16 and 18 mg/kg and were also very low when compared to elevated levels of >80 mg/kg and well below Cronin *et al.* (2006) lower guidance levels.

Extractable HC/DRO (C8-C40) (diesel hydrocarbons) tests found concentrations of <50 mg/kg, while PRO (C5-C12) (petroleum hydrocarbons) tests returned levels of <5 mg/kg in both samples, which are considered low (Complete Lab Solutions, *pers. comm*.). Extractable hydrocarbon levels are well below Cronin *et al.* (2006) lower guidance levels. Fats, oils and greases were recorded at values of <5 mg/l and these are considered to be low concentrations.

In general, the analyses indicate that there is nothing unexpected in the sediment having regard to its location at the mouth of a river / harbour and that any disturbance of those sediments will not impact on the water quality and hence aquatic life in the location.

These results do not indicate any long term or residual contaminant leakage or seepage from the historical municipal dump at Southpark.

2.2.4.2 Macrofauna

The construction of the proposed harbour extension will involve the infilling of *ca* 27ha including breakwaters and dredging of *ca* 46.5 ha of intertidal and subtidal habitat which include Annex 1 habitats as listed in the EU Habitats Directive and include biogenic reefs (mussels beds). The only annexed habitat is the intertidal area which covers an area of *ca* 5.9 ha. In the present study the dominating macrofaunal subtidal species were the bivalve *Kurtiella bidentata,* the tube-dwelling polychaete *Melinna palmata,* the amphipod *Ampelisca brevicornis* and the bivalve mollusc *Thracia phaseolina*. Other dominants included the polychaete *Phyllochaetopterus anglicus*, the amphipod *Crassicorophium crassicorne*, the polychaetes *Nephtys* spp. and *Euclymene oerstedii*, the bivalves *Angulus fabula, Venus casina* and *Thyasira flexuosa*, the gastropod *Turitella communis* and the ophiuroid *Amphiura filiformis*. These species are quite common for this area and are typical of species that inhabit muddy sand areas. Their characteristics identify them with previously recorded communities in the area: the *Melinna palmata* association reported by Keegan *et al.* (1976), Groups A and C recorded by Shin *et al*. (1982) and is an equivalent to the *Telinna fabula* sub-community described by Spärck (1935).

The groupings identified by the CLUSTER analysis represented slight variations of the above community between stations, but overall the faunal assemblage of the area is homogenous. *Kurtiella bidentata* is a common species in this area and *Melinna palmata* is tolerant to organic enrichment. These species are typical of the study area, which is a shallow, moderately exposed site and the species inhabiting it are adapted to on-going natural stresses and disturbances (*i.e.* fluctuations in salinity, strong waves, tides and storms, periodic high turbidity). No unusual species were observed during the present study.

Adult mussels form feeding resources for invertebrate species such as carnivorous gastropods and star fish and bird species such as Oystercatcher and Hooded Crow while postlarvae and juveniles are a food resource for a wide range of benthic invertebrates. However, as the mussel beds that will be lost due to the construction of the harbour extension represent < 0.1% of the total area of this habitat in the bay, its loss is regarded as being insignificant.

2.2.4.3 Sediment Profile Imagery

The most important SPI parameters that describe the status of the sea floor are the mean redox depth, the successional stage and the organism sediment index (OSI). Typically, redox values of 0.5 cm or less are characteristic of heavily organically enriched sediments. No such low values were recorded and as noted above, 13 of the 22 stations had redox depths of 3 cm or greater. This indicates that the sea floor in the general area is relatively well oxygenated. With regard to the successional stage, the lowest value of “Azoic”was recorded from one image recovered from Station 18. The next lowest, Stage I, was recorded at three sites (Stations 7, 10 and 11), Stage I-II at three sites (Stations 5, 13 and 22) while the majority of stations (12) had values of I – II. Station 13 returned a value of II-III while Station 20 returned I in III. These are plotted in Figure 2.2.13 below. OSI can range from -6 to +11 and Table 7.17 above shows that this value ranges from - 6 at Station 18 to a maximum of +6 at Station 14. BHQ values can range from 0 - +15 and again, Table 7.17 above shows values range from 1.3 at Station 5 to 6.7 at Station 8. All these values indicate that the area of Galway Bay where it is proposed to build the harbour extension is of low to medium quality.

Figure 2.2.13 shows the successional sere determined for each station.

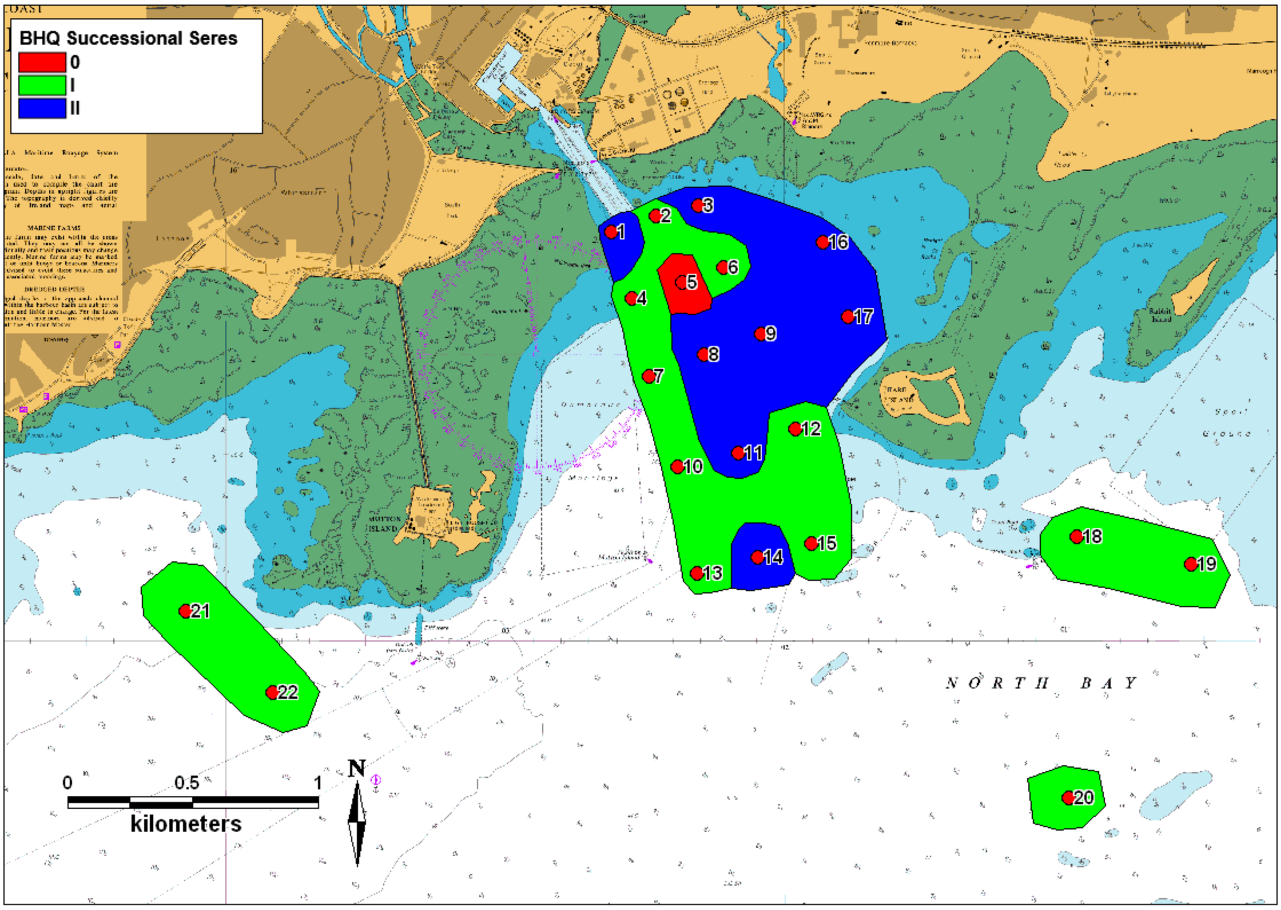


Figure 2.2.13 - Successional seres in the vicinity of the proposed development site

Galway Harbour Company

Galway Harbour Extension

Appendices to NIS Addendum / Errata

Appendix No. 2.3 – Salmon Smolt Tracking and Fish Predation Surveys

[From Chapter 7 of the EIS – Pages 7-79 to 7-97]

2.3 SALMON SMOLT TRACKING AND FISH PREDATION SURVEYS

2.3.1 Field Surveys - Salmon Smolt Tracking

Salmon smolt tracking was carried out in 2010 to determine the routes or patterns of descending Atlantic Salmon smolts (*Salmo salar)* running to the sea from Lough Corrib and to assist in the assessment of the potential effects of the proposed development.

2.3.1.1 Materials and Methods

For the purposes of the smolt tagging study, 10 single-channel acoustic receivers and 100 acoustic tags were procured. Key stages in the proposed work were as follows:

- Tag ranging – test range for the transmitter receiver combination in the environmental conditions specific to the study area.
- Receiver deployments – plot out locations for the 10 receivers based on the results of the range tests. Deploy receivers at these locations
- Fish capture & tagging – surgically implant acoustic tags into wild Atlantic Salmon smolts captured at the Inland Fisheries smolt trap downstream of the Corrib Weir.
- Fish releases – release fish in batches to continue downstream to Galway Bay over a range of lighting and tidal conditions
- Data retrieval & analysis – recover data from the acoustic receivers to allow analysis and interpretation of results.

Tag Ranging

Range testing of the acoustic tags to be used during the study was carried out from a rigid inflatable boat (RIB) in the proposed study area in Galway Bay on 09th April 2010. Weather was clear and dry with a light southeasterly breeze blowing. The sea had a slight surface chop. The tags used for the study were Thelma Biotel 7.3 mm ID transmitters, the receivers were Vemco VR2W single channel receivers. The dates and times on:

- a laptop used for receiver downloads,
- the Vemco VR2W receiver and
- a GPS unit

were checked for synchronicity.

For the purpose of range testing, a single receiver was deployed on the seafloor using SCUBA equipment. A perforated metal rod was hammered vertically into the seabed leaving 0.75 to 1.5 m of bar protruding. The Vemco VR2W receiver was then attached to this protruding section of bar using cable ties and rope.

The location of the receiver's position was logged using GPS. A Thelma Biotel 7.3 mm tag was activated and inserted into a dead fish that was secured to a weighted line. This set up allowed the tagged fish to be suspended in the water column at a particular depth while varying its distance from the receiver. Seafloor depth in the survey area varied between approximately 3 m and 11 m – range tests were carried out with the tagged fish suspended at 2 m and a second run of range tests were conducted with the tagged fish suspended at 5 m depth. The tagged fish was lowered to the required test depth and notes made of the distance from the receivers' location and the time. On downloading the receiver log for the duration of the test, the approximate maximum range at which the tag was detected at each depth run was noted by matching up the hand-written time/range log with tag detections on the receiver log. Maximum detection ranges recorded were 235 m and 243 m at 8 m and 5 m depth, respectively.

Receiver Deployments – Listening Stations

Ten Vemco VR2W receivers (see Figure 2.3.1) were deployed on the seabed as described in the previous section at ten stations in the study area. Based on the results of range tests in the field, listening stations were plotted (using MapInfo Professional) with a 220 m reception radius on each receiver (see Figure 2.3.15). One receiver (#1) was placed in Lough Atalia, in the deeper portion of the Lough, upstream of the railway bridge. A second receiver (#2) was placed just outside the harbour entrance covering the gap between Rinmore Point and Nimmo's Pier, and the area immediately beyond this. This receiver (#2) was placed to allow the detection of each tagged smolt as it exited the Claddagh basin area, and also to determine if it remained in this area, or returned to this area after its first transit through this receiver's range. A cordon of receivers (#s 3-8) was deployed in an arc stretching between the head just south of Renmore Barracks and Mutton Island in order to detect tagged smolts exiting and entering this area during the course of the study period. A small overlap in receiver range was included to ensure that no 'deaf' areas existed between adjoining listening stations that might allow smolts to exit this area without being detected.

Two receivers (#s 9 and 10) were deployed in the North Channel area, between Black Rock and Grey Rock.

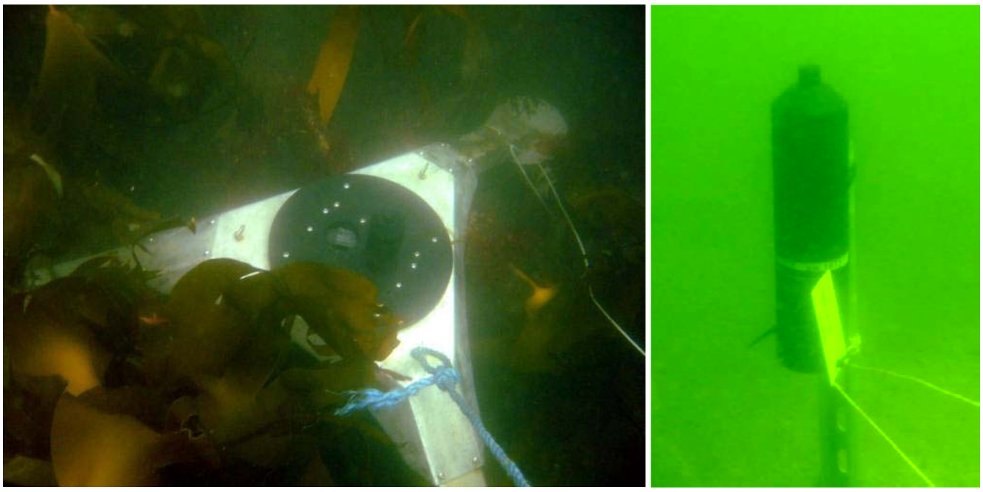


Figure 2.3.1 - Tripod mount used at rocky receiver Station 10 (left), vertical steel rod mount used at sandy/muddy receiver Stations 1-9 (right)

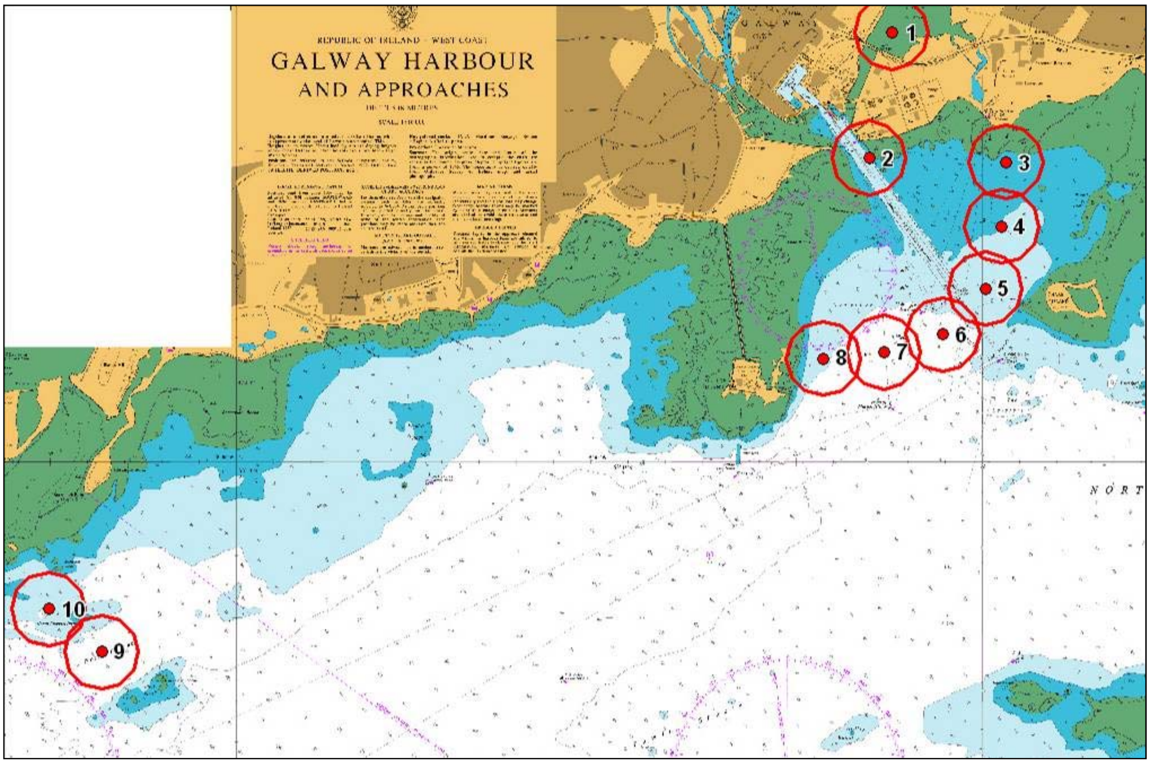


Figure 2.3.2 - Locations of 10 acoustic receivers deployed in Galway Bay, April 21st & April 22nd 2010

Fish tagging – surgical insertion

Prior to tagging, all tags were magnetically activated (27th April, 2010) and checked for proper functioning. Two tags out of a batch of 100 were found to be non-functional. Acoustic ID transmitter tags were sequentially numbered from 201-300. Fish were captured at the Inland Fisheries Ireland smolt trap (see 2.3.3) and transferred to a laboratory at Inland

Fisheries Ireland, Kings Island, Galway for surgical implantation of Thelma Biotel 7.3 mm acoustic ID transmitters. Where possible, larger fish were chosen for tag implantation due to the greater ease of handling larger fish during surgery.

Figure 2.3.3 - Location of the Inland Fisheries Ireland smolt trap, downstream of the main weir on the River Corrib, Galway. Inset shows detail of the trap viewed from the eastern bank

After anaesthetisation, each fish was weighed and its fork length measured. Tags were sterilised before insertion. A latero-ventral incision was made behind the pectoral fins and a tag was inserted into the peritoneal cavity. Two interrupted sutures were then tied to prevent tag extrusion (see Figures 2.3.3 and 2.3.5). Fish were returned to small tanks of oxygenated water for revival from the anaesthetic. Once revived they were transferred to large holding tanks at Inland Fisheries Irelands Nun's Island facility for recovery from surgery.

Figure 2.3.4 - Left: tag insertion surgery underway; Right: smolts in large recovery tank

Figure 2.3.5 - Post-surgery view of Salmon smolt with sutured tag insertion wound

Fish were handled as gently as possible during all procedures to minimise stress, skin damage and scale loss. Three holding tanks were used to keep tagged fish in post-surgery recovery. These tanks were filled with fresh river water on the morning of tagging. Tanks were flushed out, rinsed and re-filled with fresh river water before both sets of releases. The water in each tank was oxygenated (O_2 was supplied to each tank from an Oxygen tank via diffuser attached to an O_2 cylinder). Moribund fish and mortalities were removed as soon as they were identified to reduce stress to other fish in the tanks. Acoustic tags were recovered from any dead fish for re-use. Fish were tagged on two separate days – 27th April, 2010 and 07th May, 2010. In all, 94 tagged smolts were released.

Due to the relatively large number of tags used in a relatively small study area, it was decided to release tagged fish in small batches over a number of days in an attempt to reduce the number of transmission “collisions”. “Collisions" happen when two or more tags transmit all or part of their pulse train at the same time. When this happens, the pings overlap and neither transmission can be detected by the receiver. Although collisions are inevitable, tags are designed to transmit in such a way as to eliminate the possibility of any two tags *continuously* colliding with each other.

Fish Tagged on 27th April – Released during daylight hours

A total of 51 fish were tagged on 27th April 2010. These were released into the lower river Corrib at Nun’s Island in three batches during hours of daylight as detailed in Table 2.3.1.

Batch release of smolts 28th/29th April 2010			
Release Details	**Tank 1**	**Tank 2**	**Tank 3**
Release date	28th April, 2010	28th April 2010	29th April 2010
Release time	16:45-16:54	11:07-11:17	09:11-09:24
Number released	19 fish	18 fish	14 fish
Non Detections	2	6	2

Table 2.3.1 - Batch release of smolts 28th/29th April 2010

Fish were removed from the large holding tanks as gently as possible using a fine mesh pond net. As fish were removed from the large holding tanks, they were transferred to a 10 litre bucket containing fresh river water. This was gently lowered into the river once 3-5 smolts had been captured and allowed to submerge. The bucket was recovered once all of the fish had swam free.

Fish Tagged on 07th May – Released during daylight hours

A total of 43 fish were tagged on 07th May 2010. These were released into the lower river Corrib at Nun's Island in three batches during hours of darkness as detailed in Table 2.3.2.

Batch release of smolts 7th/8th/9th May 2010			
Release Details	**Tank 1**	**Tank 2**	**Tank 3**
Release date	07th May, 2010	09th May 2010	08th May 2010
Release time	23:25-23:30	23:30-23:35	23:25-23:31
Number released	14 fish	15 fish	14 fish
Non Detections	1	1	2

Table 2.3.2 Batch release of smolts on 7th/8th/9th May 2010

Data Retrieval – Receiver Recovery

Data were downloaded from all receivers on 04th May 2010. On this date all receivers were recovered using SCUBA equipment and data were downloaded on site to a ruggedised laptop computer. Meters 2-10 were immediately re-deployed after data download. Meter 1 was recovered from the water and brought back to the office. It was redeployed on 09th May 2010. The final recovery of all receivers was carried out on the 27th May 2010. All ten receivers were returned to the lab and the final data downloads made.

2.3.1.1.1 Salmon Smolt Tracking Results

Tag Detections

Of the 94 tagged fish released, 80 were detected post-release by the ten acoustic receivers deployed in the study area while 14 No. i.e. 204, 219, 220, 229, 230, 232, 260, 265, 266, 281, 282, 287, 288 and 289 were not detected following release. Tag detections were picked up by nine out of the ten receivers deployed. No detections were made at Station 10 (in the North Channel/Black Rock area). Table 2.3.3 gives an overview of the number of tagged fish detected at each station during the current study.

Number of tags detected at each station	
Station	**Number of tags detected**
1	3
2	77
3	12
4	19
5	24
6	23
7	25
8	15
9	2
10	0

Table 2.3.3 Total number of tags detected at each station after fish releases.

Of the 80 tagged fish detected following release, 77 were detected at Station 2 (the receiver located outside the harbour mouth). Tag 214 was only detected at Station 1 (the Lough Atalia receiver). A total of 3 tags were detected at stations other than Station 2 but not at Station 2 (Tags 214, 224 & 225) – *i.e.* these fish exited the Claddagh Basin without being picked up by the receiver whose range spanned the harbour mouth.

The tagged fish can be divided into two main groups for which behaviour can be deduced following release:

Fish that remain in the Corrib/Claddagh Basin for a variable length of time following release, are detected at Station 2, proceed to swim from Station 2 to one or more of the outer stations and then are not detected again during the study period. This may be best visualised in the plot below (Figure 2.3.6).

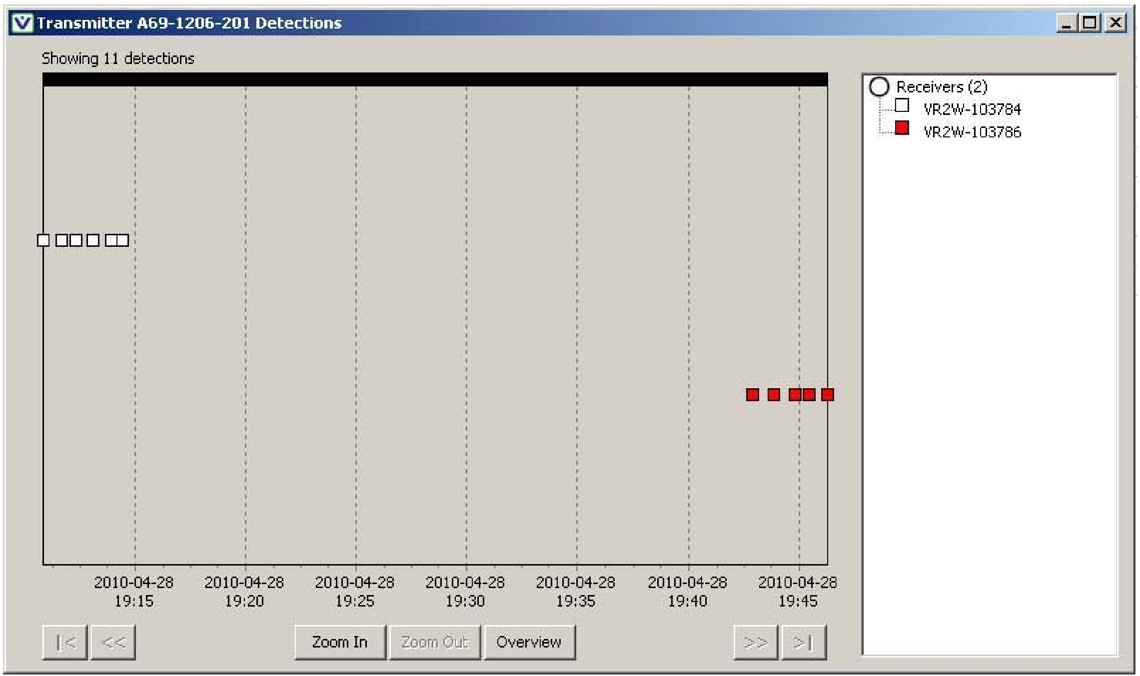


Figure 2.3.6 - Detection pattern of fish exhibiting 'transit' behaviour as represented in the Vemco VUE (software) plotted detections window for Tag 201. The x-axis is time, the y-axis splits detections between various receivers by which the tag was picked up

These fish spent a short amount of time at Station 2 (detections shown by white boxes) and made the transit to Station 4 within about 27 minutes. The fish spent approximately five minutes within range of Station 4 and were not detected again during the study period. A total of 58 out of the 80 tags detected (73%) showed this pattern of detections.

- Fish whose behaviour does not follow the above pattern. These fish are generally detected at the listening stations over a much longer period (weeks) of time than those exhibiting the simple transit behaviour. This group may include fish that have been eaten by predators (seals, porpoises, dolphins, birds). The Vemco VUE plot below (Figure 2.3.7) shows an example of the pattern of detections seen for this type of tag.

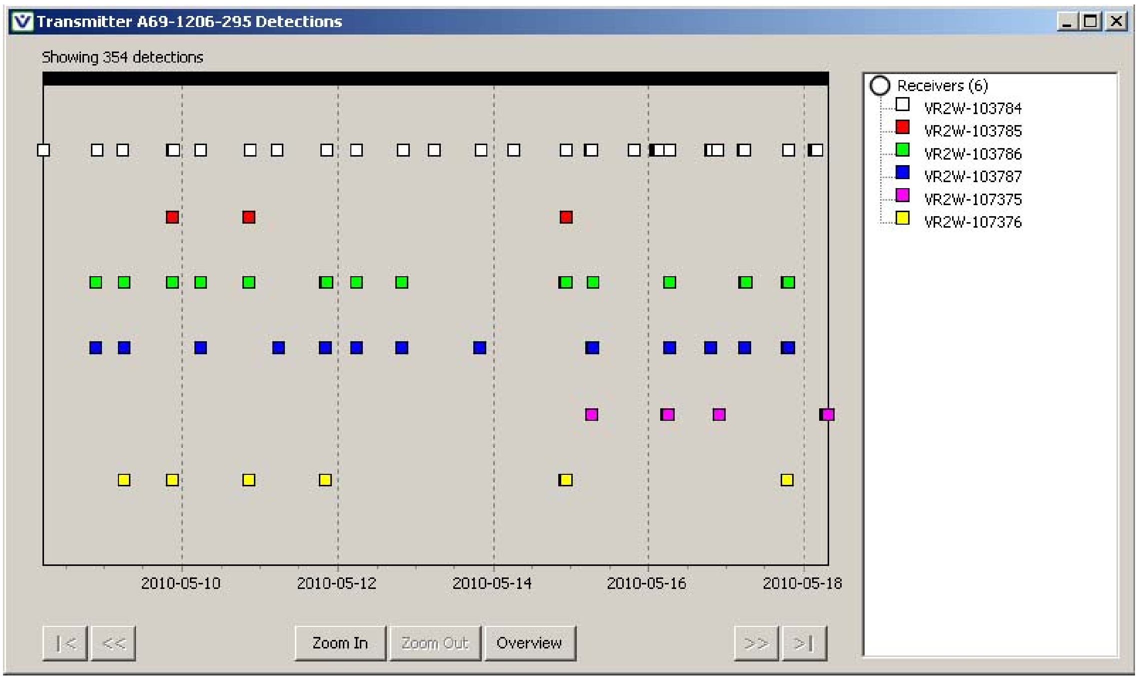


Figure 2.3.7 - Detection pattern of fish exhibiting 'aberrant' behaviour as represented in the Vemco VUE (software) plotted detections window for Tag 295. The x-axis is time, the y-axis splits detections between various receivers by which the tag was picked up

This plot covers a time period of approximately ten days (as opposed to approximately 35 minutes for the previous plot). The tag (# 295) was detected at Station 2 just outside the Harbour mouth (white boxes) fairly continuously over the ten day period covered by the plot. It was detected at Station 1 (in Lough Atalia) over the final three days during which detections were recorded for this tag. It was also detected at intervals at stations 3, 4, 5 and 6 during this time. A total of 10 out of the 80 tags detected (approximately 13%) showed this type of pattern of detections.

2.3.1.1.2 Tag detections

Figure 2.3.8 shows the time taken by the 77 fish detected at Station 2 to reach that station following their release at Nun's Island (*i.e.* their residence time in the River Corrib/ Claddagh Basin following release). The yellow horizontal lines mark intervals of 24 hours – five days. A total of 52 fish (67.5%) made the journey in 24 hours or less. A further 10 fish (cumulative 80.5%) were detected at Station 2 within 48 hours (1-2 days), a further 5 (87% cumulative) within 72 hours (2-3 days), an additional 5 (93.5% cumulative) within 96 hours (4-5 days) and the remaining 5 fish were detected in range of station 2 more than 4 days after their release time.

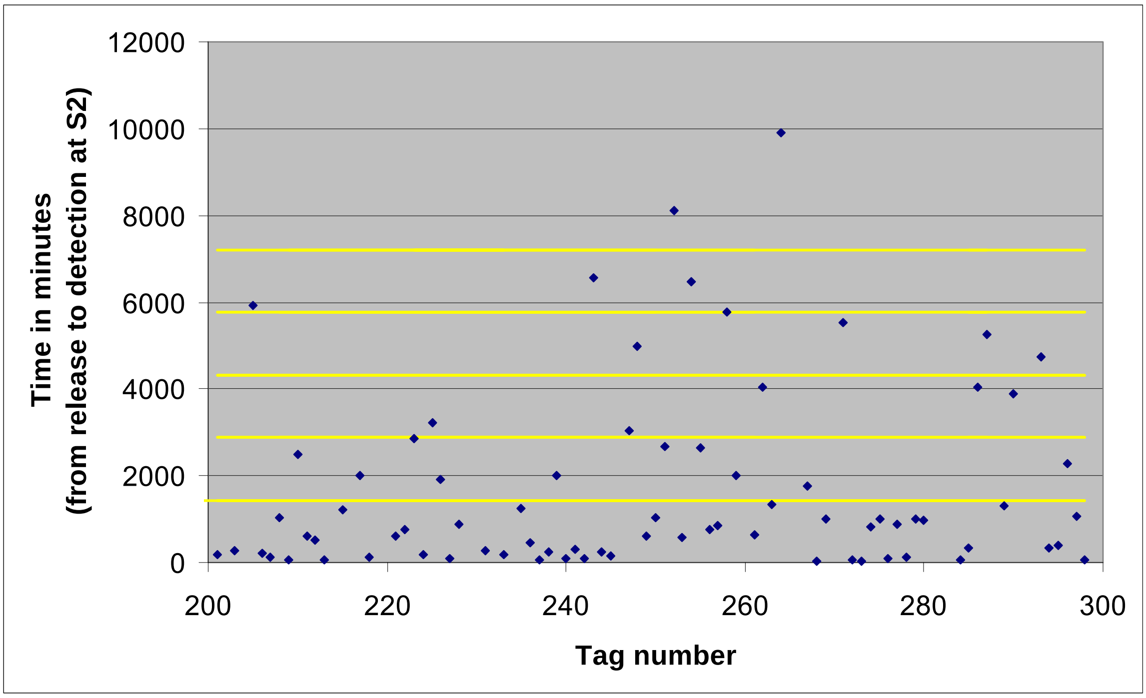


Figure 2.3.8 - Time taken by fish released at Nun's Island to reach Station 2 (77 tags detected). Yellow horizontal lines mark successive intervals of 24 hours following tag release – a total of five days are marked

Corrib/Claddagh Basins – Tag Detection Patterns

Tags detected post-release fell into two main categories (see Figure 2.3.9) in terms of tag detection patterns:

- Fish that were detected at Station 2, subsequently detected at one or more of the outer stations, generally within a reasonably short time frame (minutes to hours), and then not detected again during the study period (58 tags – 72.5% of detected tags)
- Fish that did not conform to the above pattern and were detected at many stations or at a single station only over a period of several days during the study period (10 tags – 12.5% of detected tags).

Two further groups of tags (Figure 2.3.9) were noted:

- Tags that were detected only at Station 2 (approximately 15% of detected tags)
- A single tag that was detected only at Station 7

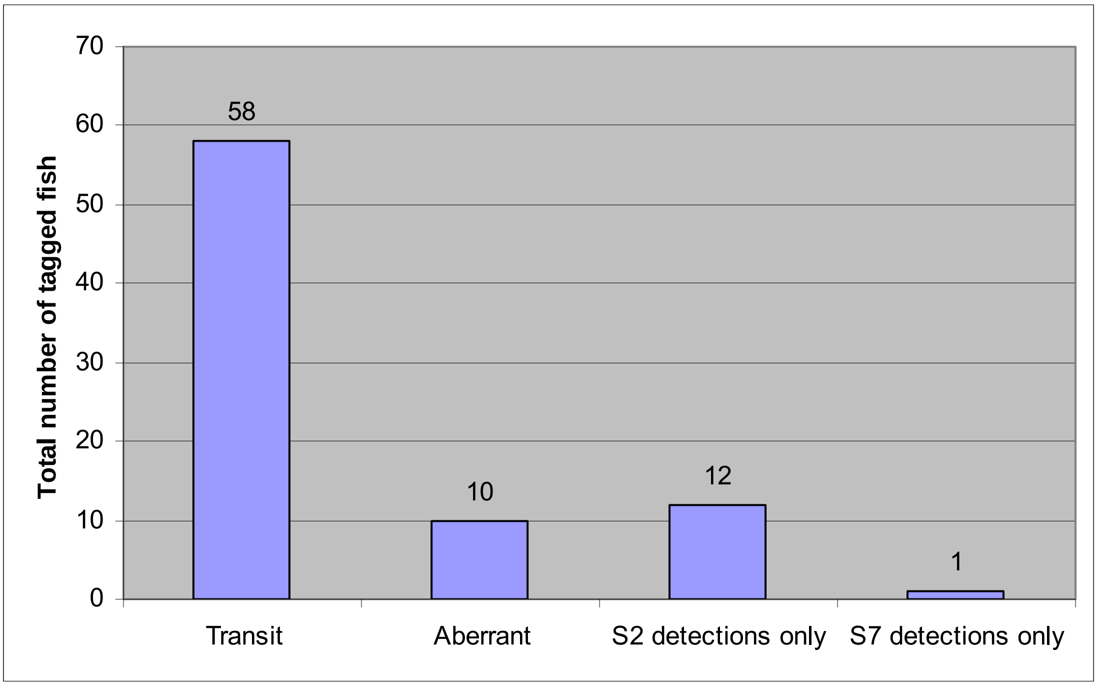


Figure 2.3.9 - Number of fish falling into various tag detection pattern categories

Galway Harbour Outer Receivers – Tag Transit Times

Figure 2.3.10 shows a plot of the time taken for fish to swim between Station 2 and the cordon of outer Stations (Stations 3-8). This represents a distance of approximately 1.25 – 1.75 km. Times were calculated by calculating the difference in minutes between the time of first detection of each tag at Station 2 and the time of final detection of the tag at the outer receiver stations (the lower yellow horizontal line in Figure 2.3.10 represents 1 hour, whilst the upper yellow horizontal line represents 1 day). The majority of transit times for tagged fish are clustered either side of the 1 hour mark, with a relatively much smaller number of fish taking substantially longer than this.

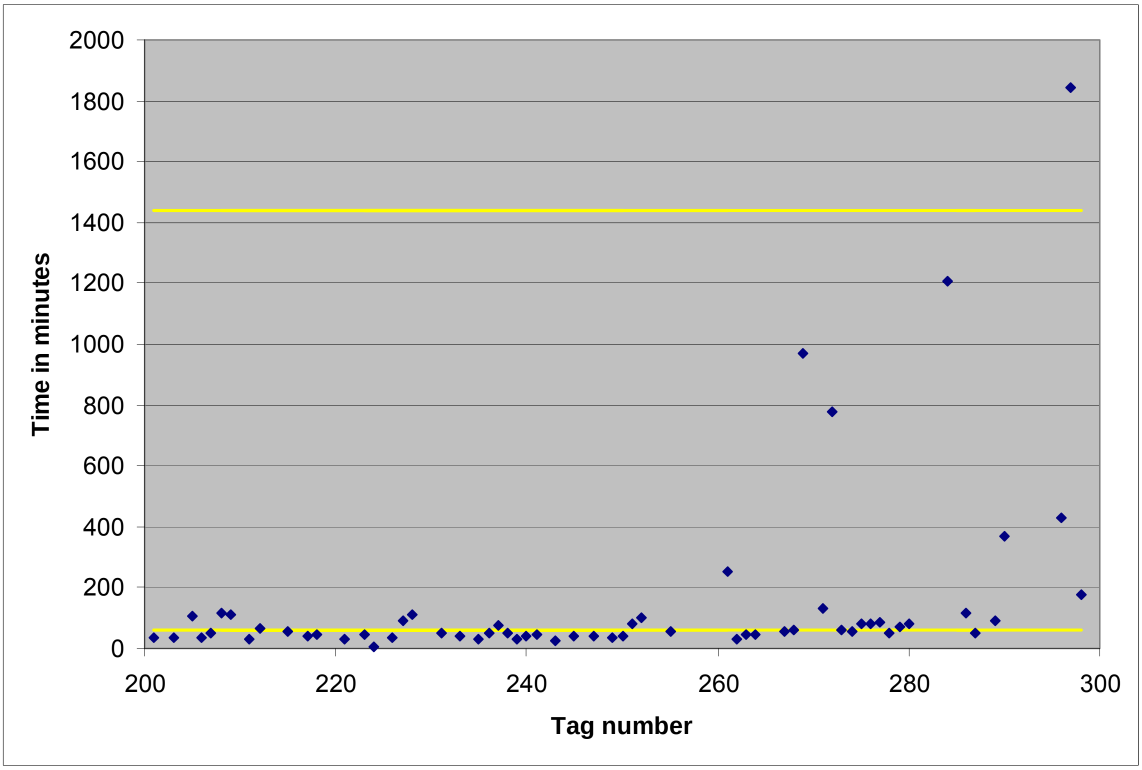


Figure 2.3.10 - Time taken for fish to swim between Station 2 and the outer stations. Time of first detection at Station 2 was taken as the start point and time of final detection at the outer station as the end of the duration of this transit time (the lower yellow)

ExistingTag Detections

Figure 2.3.11 shows the total number of tag detections at each receiver located along the outer cordon of stations in Galway Bay (Stations 3-8) during the smolt tracking period, and at Station 9 in the outer bay for tags displaying the more common 'transit type' behaviour recorded during the current study. Some tags were detected at more than one station on their exit of the harbour area – for example a fish may have swam between Station 7 and 8 and, due to the range overlap of the receivers, been detected simultaneously at both. This accounts for the total of transiting tag detections being greater than the total number of post release tags detected during the study.

Figure 2.3.11 gives a good indication of the areas most used by descending tagged salmon smolts in exiting the harbour during the current study. A total of 35 tags were detected between Stations 3, 4 and 5. A total of 54 tags were detected between stations 6, 7 and 8. A total of 2 tags were detected at Station 9 – one of the outer bay receiver stations between Black Rock and Grey Rock in the North Channel area.

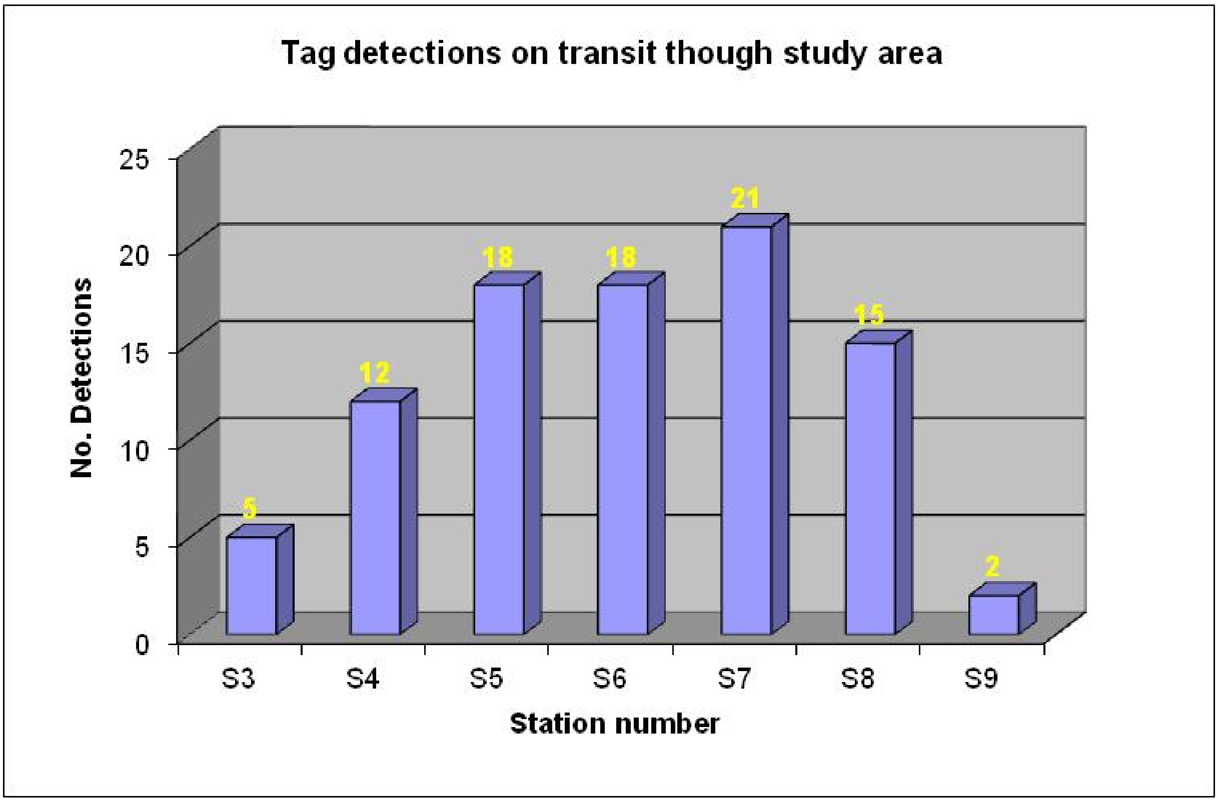


Figure 2.3.11 - Numbers of tagged fish exiting the study area detected at each receiver

2.3.1.1.3 Discussion

Tag Detections

A total of 80 tags out of the 94 released were detected during the study period. The fact that 14 tags were *not* detected may be attributed to a number of potential causes:

- Malfunction of 14 tags.
- Extended residence time - the tagged fish may have remained in the Corrib/Claddagh Basin throughout the duration of the study period and not come into range of the Station 2 receiver.
- Predation - the tagged fish may have been eaten by a predator and been removed from the study area before reaching the Station 2 receiver.
- Tag extrusion – the tag may have been extruded through the insertion wound and deposited on the river bed or bed of the Claddagh Basin before the fish reached the ranged of the Station 2 receiver.
- Tag collisions - "Collisions" happen when two or more tags transmit all or part of their pulse train at the same time. With such a large number of tags in such a small area, some collisions are almost inevitable. In an attempt to reduce this problem during the

current study, tagged fish were released in batches over a number of days (instead of releasing all fish in a tagged group simultaneously).

The 3 tags that were detected at stations other than Station 2 but not at Station 2 are likely to be attributable to tag collisions. Tag 214 was detected only at Station 1 (the Lough Atalia receiver) over a period of approximately four days.

First Detection – Corrib/Claddagh Basin Residence Times

The longest residence time for a tagged fish in the Corrib/Claddagh Basin was approximately one week following its release. However, most of the tagged fish released into the river proceeded to move towards the sea in a shorter time than this. Just over two thirds of tagged fish released into the river began their seaward movement in 24 hours or less. A total of 80.5% of released fish had been detected at Station 2 within 48 hours.

Note: All of these fish had undergone surgery, post surgery recovery and had been subjected to handling. In addition, each fish was carrying a relatively large, actively pinging foreign body (an acoustic tag) in its peritoneal cavity upon release. The effect of this treatment on fish behaviour is unknown. We can only assume that tagged fish behaviour roughly approximates to untagged fish behaviour.

Corrib/Claddagh Basin – Tag Detection Patterns

Of the two main categories identified in terms of tag detection patterns, it is assumed that the behaviour exhibited by those fish undertaking a relatively fast transit from Station 2 to one or more of the outer stations (72.5% of detected tags) represents 'normal' behaviour for descending Atlantic salmon smolts in the Corrib system. The pattern of tag detections seen in the 10 fish assigned to the 'Aberrant' group is assumed not to be representative of 'normal' migratory behaviour for Atlantic salmon. Some of these detection patterns may be attributable to a tagged fish having been eaten by a predator (with the tag continuing to transmit from inside the predators digestive tract) or to the effects of the tagging process and the presence of the tag on behaviour of the fish. It is also possible that the behaviour of these fish may represent the true behaviour of a small proportion of the migrating population.

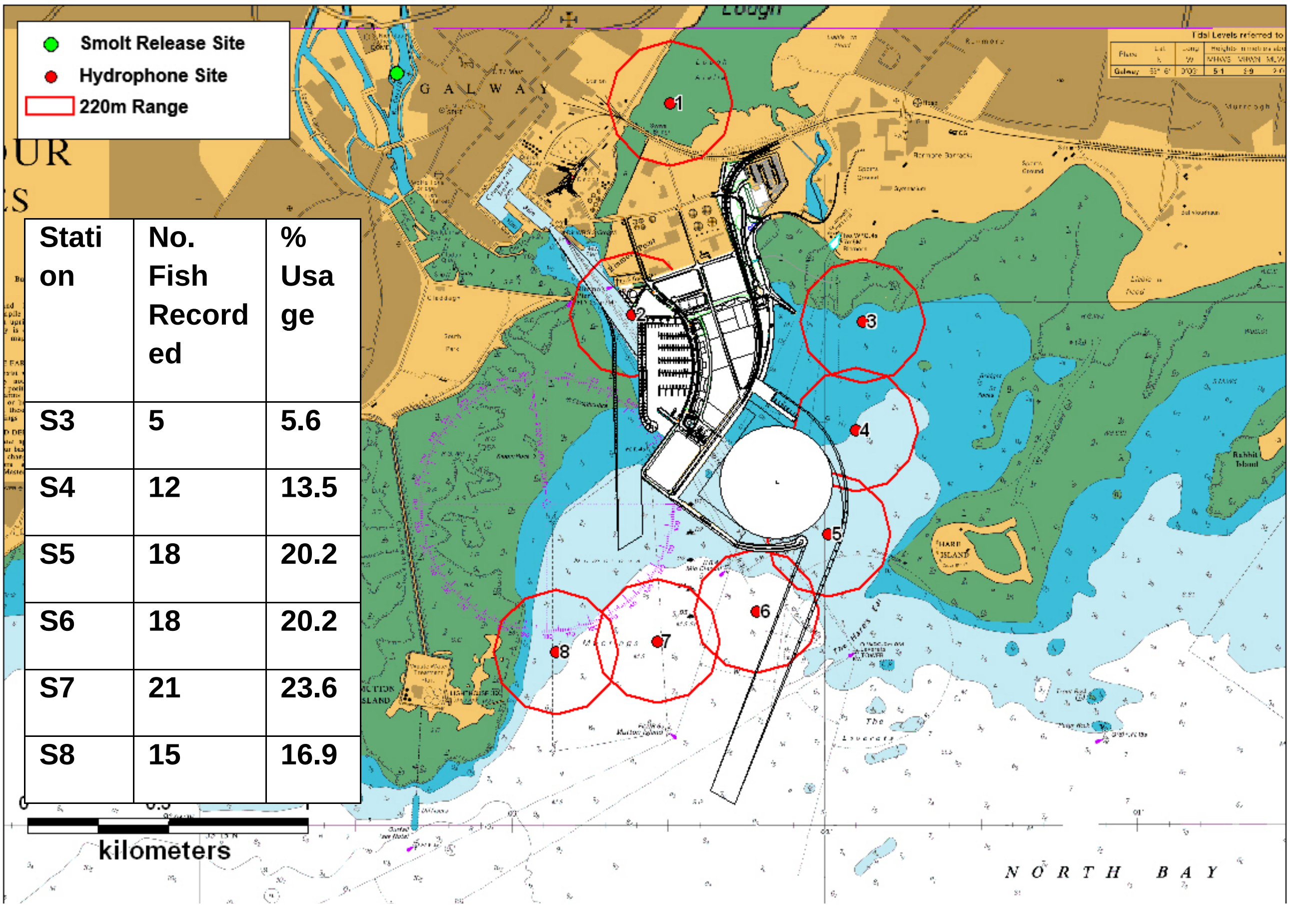
Galway Harbour Outer Receivers – Tag Transit Times

Of those fish exhibiting 'normal' behaviour, the majority (approximately 87%) made the journey between Station 2 (the inner harbour mouth station) and the outer cordon of harbour receivers within, or around, one hour. A relatively much smaller number (approximately 13% of the total) of fish took substantially longer than this with only one fish taking longer than 24 hours.

Smolt Exit Paths – Proposed Development Footprint

The number of individual tags detected at each receiver in the outer cordon of receivers in the current study are shown in Figure 2.3.11. This gives a good indication of the paths taken by fish exiting the harbour area. Figure 2.3.12 below shows the approximate footprint of the proposed harbour development in relation to the locations of the inner bay cordon of acoustic receivers. The proposed structure would lie in the path taken by fish that, during the current study, exited the inner harbour area using the corridor covered by receivers S3, S4, S5, S6 and part of S7. This represents between approximately 60% and 83% of exiting individual tag detections. In effect, with the new pier structure in place, all descending smolts would now be concentrated into an area through which, prior to its construction, somewhere between 40% and 60% of descending individual tag detections were recorded. All fish will now pass between the area where S6, S7 and S8 were located.

Salmon smolt migration behaviour, once they reach the sea, is thought to be regulated by the track of the river plume in which they swim (Ford, Gargan and Rogers, Western Regional Fisheries Board, *pers. comm*.) and it is thought that swimming depths are in the top *ca* 2 m of sea (O'Farrell, *pers. comm*.). Thorstad *et al.,* (2004) reported that fish swam in directions that were independent of current flow. Based on the information presented (see Chapter 8 of the EIS for salinity modelling) on the track of the River Corrib plume and how variable it can be based on flow rate and prevailing wind and tidal conditions, smolts may swim out into the open sea in any direction between a line defined by the Mutton Island causeway to the west and the new pier to the east. Once the fish pass Mutton Island they can then swim westwards along the north shore of Galway Bay and swim out northwestwards to their feeding grounds in the North East Atlantic.



Station	No. Fish Recorded	% Usage
S3	5	5.6
S4	12	13.5
S5	18	20.2
S6	18	20.2
S7	21	23.6
S8	15	16.9

Figure 2.3.12 - Approximate footprint of the proposed harbour development at Galway in relation to the locations of the inner bay receiver stations

2.3.1.2 Timetable of important fisheries events

Based on the data collated regarding various significant fish and fishery species, the following calendar (Table 2.3.4) has been drawn up to show the annual timing of the various fish migratory movements in to and out of the River Corrib and of the spawning season for Shrimp.

Timing of important fishing events												
Event	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Downstream Salmon smolt run			•	•	•							
Upstream Spring salmon run	•	•	•	•	•							
Upstream grilse run					•	•	•	•	•	•		
Upstream Sea Lamprey run					•	•						
Upstream elver run				•	•							
Downstream silver eel run	•									•	•	•
Shrimp spawning				•								

Table 2.3.4 Timing of Important Fisheries Events, River Corrib/Inner Galway Bay.

2.3.1.3 Fish Predation Surveys

2.3.1.3.1 Introduction

Cormorants (*Phalacrocorax carbo*) are common fish predators and occur in both marine and freshwater habitats. There is a breeding colony on Deer Island in Inner Galway Bay off the Clare coast (see Figure 2.3.13) and in April 2010, the colony was estimated at 110 occupied nests.

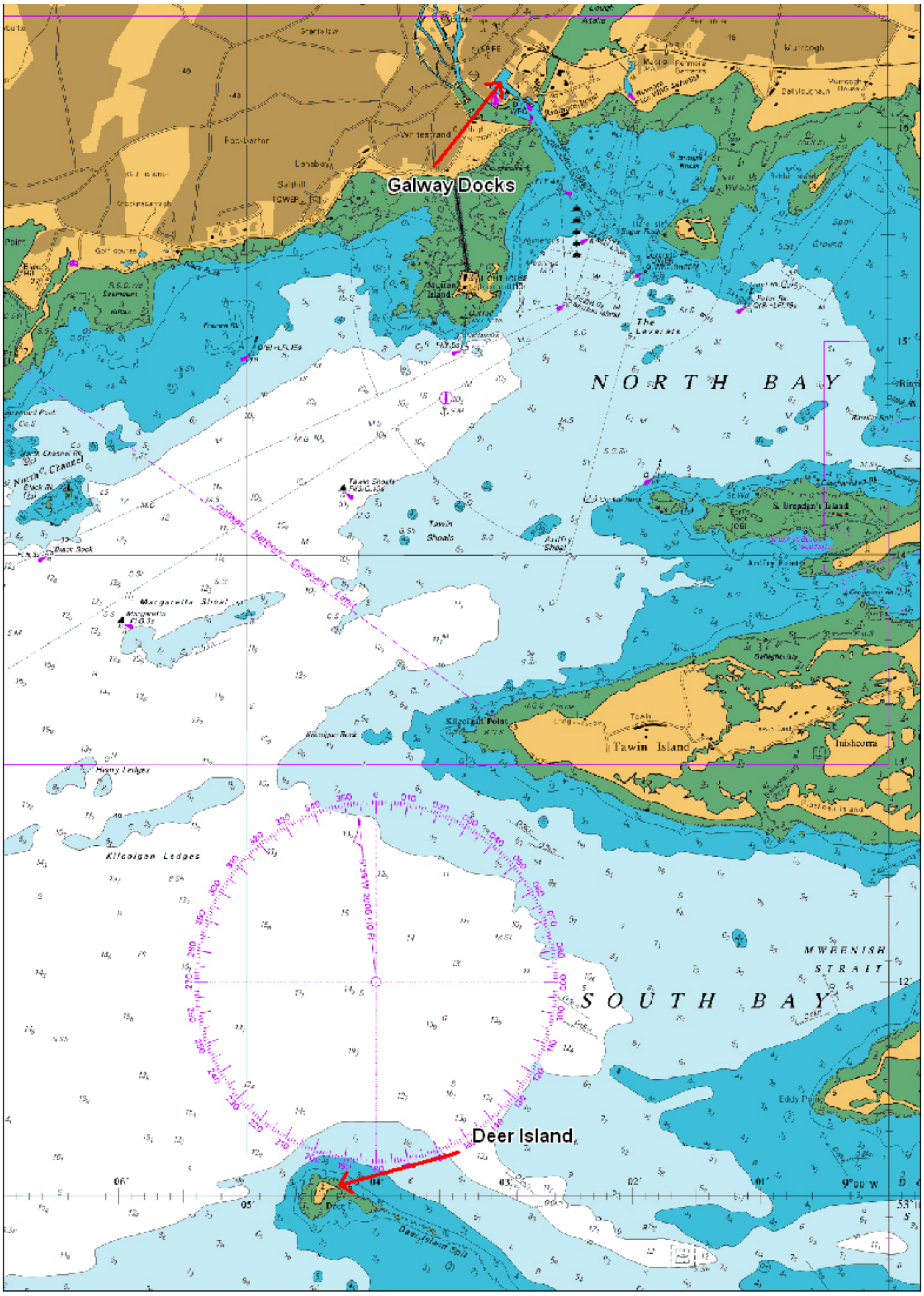


Figure 2.3.13 - Location of Deer Island in relation to Galway Docks

Cormorants have been identified as significant predators on Salmon smolts in certain fisheries (*e.g.* the River Bann) as the fish depart their mother rivers and head for marine feeding grounds. The migration period for Salmon smolts on the Corrib is well established and data on numbers of smolts running down the River Corrib for a number of years were reviewed.

Inland Fisheries Ireland (IFI) had concerns that the proposed development could impact smolt numbers by restricting the fish to a smaller area of sea water than they have access to at present and thereby increase likely contact with predators such as Cormorants and seals. A study was under taken to address this issue.

2.3.1.3.2 Methodology

The study took the form of the following elements:

1. Make regular observations in the vicinity of the proposed development area to record numbers of Cormorants and to observe birds to try to determine what they were feeding on. The opportunity was taken to make observations on numbers of seals present at the same time in the same area.
2. Visit the colony at Deer Island to estimate numbers of birds/nests.

2.3.1.3.3 Results

Numbers of Cormorants and Seals at the site

Figure 2.3.14 show the numbers of Cormorants recorded in the vicinity of the proposed development site during the period February '09 – May '13. Observations were made with x10 binoculars from the end on Nimmo's Pier and the duration of each observation period was 15 minutes. Observations were made between the layby and the new slipway within the Galway Enterprise Park and broad scale sweeps were made between the slip, Hare Island and Mutton Island in calmer weather. Maximum numbers (+50) were recorded between October 2010 to mid-January 2011 when there was a shoal of Spratt in the area while no birds were recorded on a number of dates throughout the survey period. Salmon smolts migrate out of the Corrib system during the months of March and April and Figure 2.3.15 is a graph of smolt numbers that went to sea during the Spring months of 2010 and 2011. Comparison of the cormorant and the smolt numbers shows no correlation with periods of smolt migration through the area and indicate that in the Corrib Estuary, cormorants are not a significant predator on salmon smolts. From the observations made of birds overflying the area, it appears that Cormorants have a greater preference for feeding within Lough Corrib than in the estuary.

The length of each cormorant dive into water was *ca* 45 seconds and positive identification of prey items proved difficult with the only definite identification being Eel.

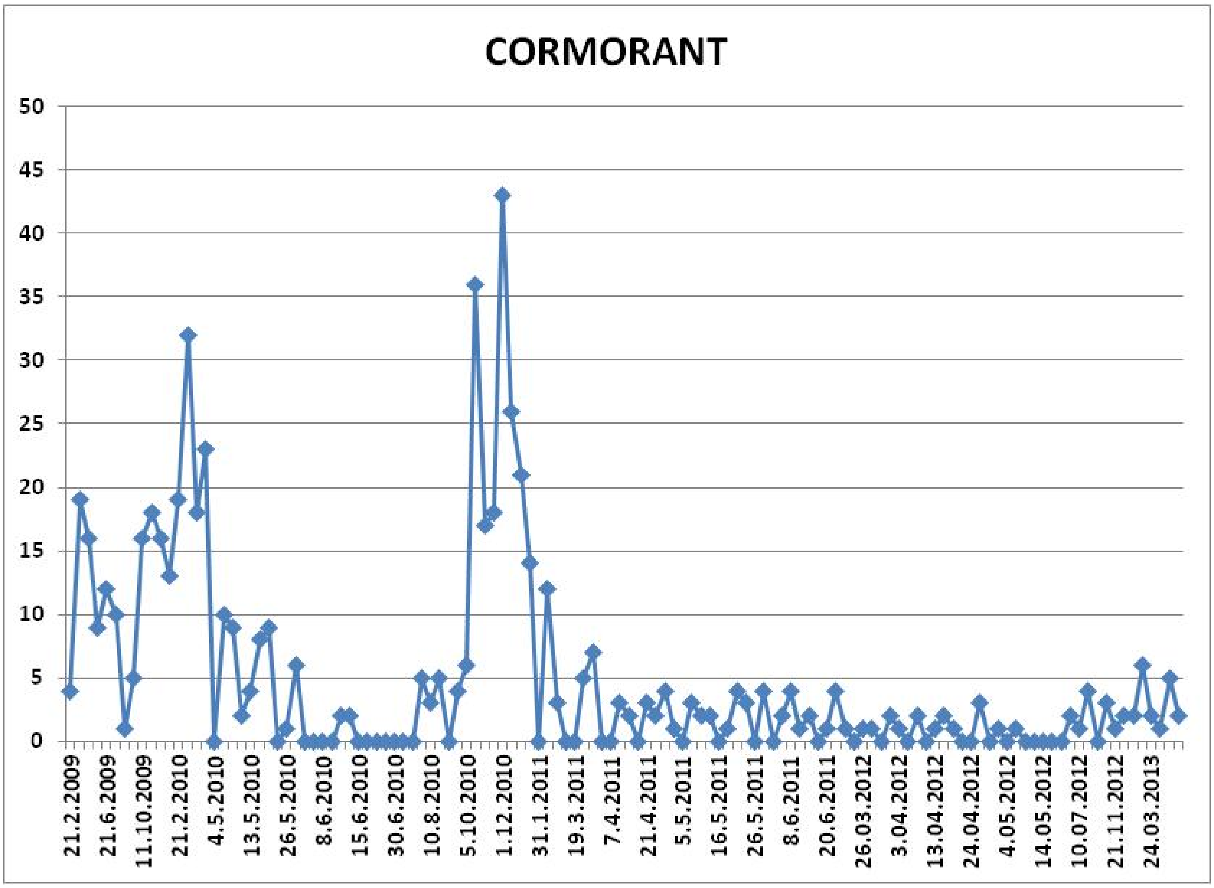


Figure 2.3.14 - Graph showing cormorant numbers around the proposed development area between February 2009 and May 2013

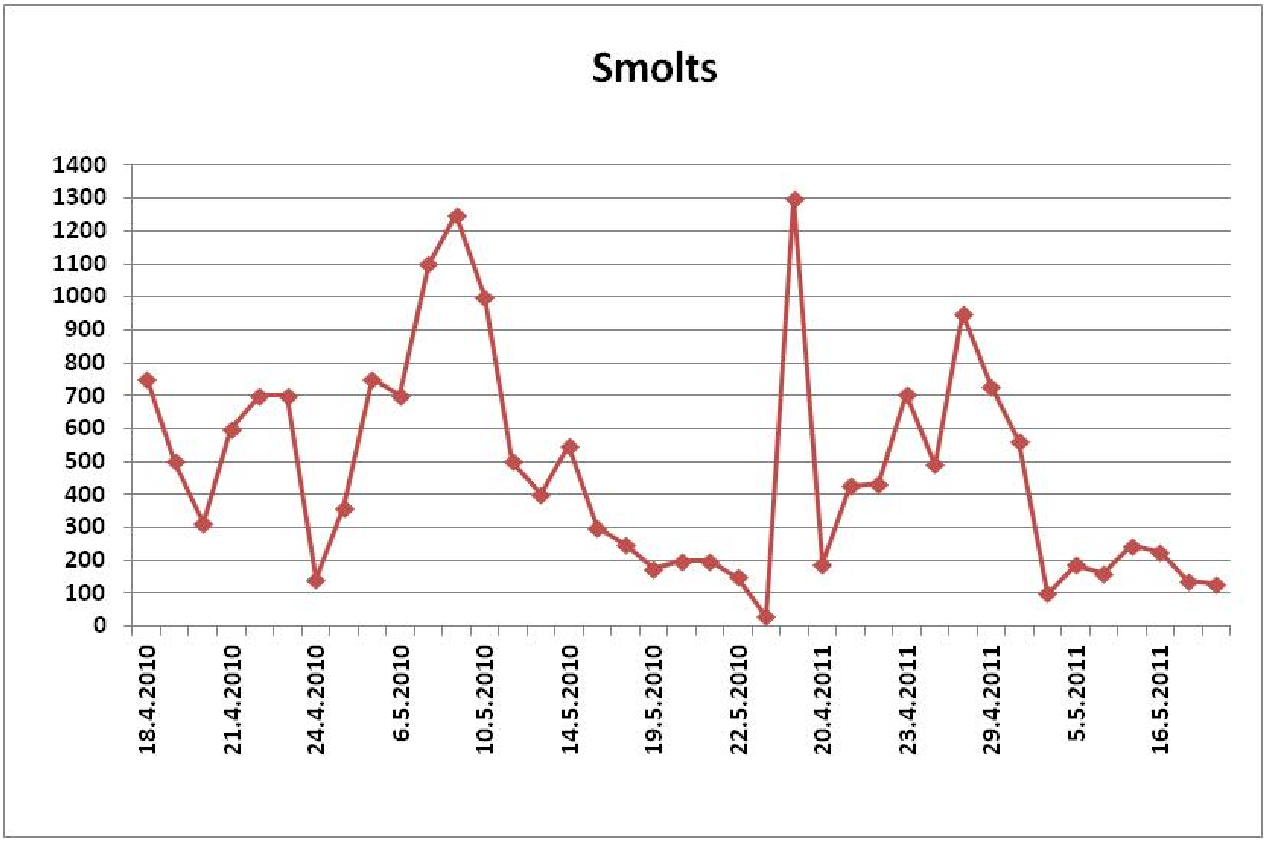


Figure 2.3.15 - Smolt migration numbers for 2010 and 2011

Salmon smolt migration numbers, recorded during April and May 2010/2011, can be seen in Figure 2.3.15. In 2010 the peak number of 1250 smolts was recorded on 8 May. 1301 smolts was the highest number recorded in 2011, being recorded earlier in the year on 19th April.

Figure 2.3.16 is a graphical representation of Seal numbers observed off Nimmo's Pier. The same field methodology as for sea Cormorants described above was used. When making the observations both at the mouth of the Corrib and during the sweeps between the Galway Enterprise Park, Hare and Mutton Islands, the observers also checked for cetaceans. A single dolphin was occasionally observed to the west of Hare Island. A picture of numerous seals photographed on December 1st 2010 is shown in Photo 5 of Appendix 7.14 [Vol. 2C – Appendices to EIS]. As for Cormorants, maximum numbers coincided with the presence of shoaling Spratt between the period October 2010 to January 2011.Outside this period, seal numbers were low at the site and no seals were observed on several occasions. Comparison of the seal and the smolt numbers shows no correlation with periods of smolt migration through the area and indicates that in the Corrib Estuary, seals are not a significant predator on Salmon smolts.

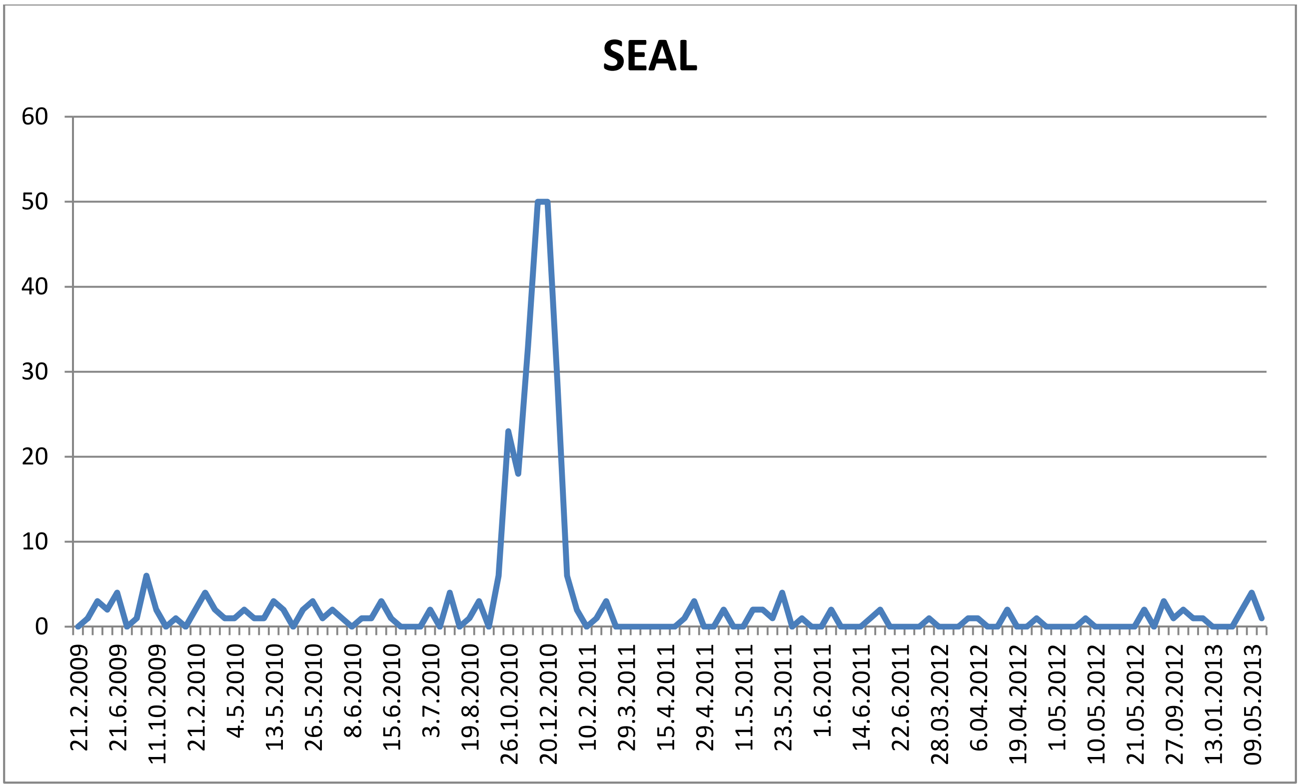


Figure 2.3.16 - Graph showing seal numbers around the proposed development area between February 2009 and May 2013

Visit to Deer Island

Deer Island was visited in June 2010 when the weather was sunny and calm. The colony occupies the western section of the island and the nests occur from the upper splash zone to the highest part of the island (see photos in Appendix 7.13) [Vol. 2C – Appendices to EIS]. The population was estimated at *ca* 300 birds and 100 nests.

Cormorants retain hard parts of prey items in their stomachs: items such as fish bones, decapods carapaces and nereid jaws do not pass into the gut; this is to prevent damage to the intestine. These hard parts are regurgitated by the adult around the nest as a small, mucous enwrapped package. Regurgitates were present throughout the colony as rainfall levels during the preceding week had been extremely low (regurgitates are known to break up when exposed to rainfall). No microscopic analyses of the regurgitates was attempted but eel, perch and swimming crab were identified during examination by eye.

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Appendix No. 2.4 – Otter

[From Chapter 7 of the EIS – Pages 7-108 to 7-113]

2.4 OTTER

2.4.1 Desk Study - Otter Records

Although not strictly a marine mammal, Otter (*Lutra lutra*) are often found on the coast as well as in lakes and rivers. Otter is listed in Annexes II and IV of the EU Habitats Directive and is a qualifying interest of the Galway Bay Complex cSAC. The species is shy and mainly nocturnal, but there have been many records of Otter in even the most densely-populated towns and cities of Ireland (Chapman & Chapman, 1982; Hayden & Harrington, 2000; Sleeman & Moore, 2005). Otter have been recorded relatively frequently in Lough Atalia and in the general area bounded by Mutton Island, the River Corrib mouth and the mouth of the Lough Atalia channel.

There have been a number of recorded sightings in the Galway Harbour area in recent years (per Galway Branch, BirdWatch Ireland and records available via the National Biodiversity Data Centre, NBDC) as outlined in Table 2.4.1, below.

Number	Site	Date
2	Lough Atalia	23rd of November 2003
1	Lough Atalia	29th of September 2004
1	Nimmo's Pier	30th of October 2004
1	Mutton Island	17th of December 2004
1	Nimmo's Pier	9th of November 2005
1	Mutton Island	10th of January 2008
1	Nimmo's Pier	20th of December 2011
1	Mutton Island Causeway	15th of June 2012 *
1	Nimmo's Pier	10th of September 2012
1	Rinmore Point	29th of September 2012 *
1	Mutton Island Causeway	19th of July 2013 *

Table 2.4.1 Records of Otter from Inner Galway Bay.
*** per NBDC**
Otter Site Survey Results

The foreshore at the current Galway Harbour Park was surveyed for Otter at low tide on the 22nd of May 2011. There is a small amount of open shore at low tide that is a mixture of rocks, shell shingle and mud. On the landward side is the rock walling of the harbour park. Figure 2.4.1 (below) shows the character of this area.

Figure 2.4.1 - Foreshore at the Galway Harbour Park at low tide, 22.05.2011

No Otter were recorded during the site visit. The search of the foreshore did not reveal any signs of Otter (*e.g.* spraints, fish remains, couches or holts). The rock walling in this area varies between four and five m high and tide marks show that approximately the lower 3 m of same is inundated at high tide.

Otter often rest among rocks or seaweed at the coast and there is potential for individuals to do so in the area around the site of the proposed development (indeed they have been known to rest on the causeway to Mutton Island). The rock walling at the current harbour park foreshore consists of large boulders and there are large gaps and spaces between them. The nature of this rock walling (*i.e.* with open, draughty spaces unfilled by soil or sediment) and the fact that most of it is inundated by the sea at high tide means that its potential as a site for a regularly used holt (particularly a natal holt) is low.

Otter were recorded four times during survey work in the area of the site. One (probably an adult male) was recorded (for 12 minutes) during a cetacean watch on the 15th of December, feeding on Mutton Island. Another sighting was made (during surveys for seals in Lough Atalia) of one individual in the outflow channel of Lough Atalia on the 2nd of February 2012. Four Otter were observed (over a period of four hours and 32 minutes) on the 5th of February 2012 in the area of water from in front of Renmore Beach, along the front of the existing harbour park at Rinmore Point to the mouth of the River Corrib. This observation was made during one of the bird survey vantage point watches from near Rinmore point. The observer interpreted the observation to involve an adult male and female (possibly courting) and two younger animals (possibly the female's cubs from the year before). The area around Renmore Lough (*i.e.* behind the boulder ridge at the top of Renmore beach and around the lough) was investigated for signs of an Otter holt on the 7th of February 2012. A number of animal tracks were found close to the lough and Otter spraint was observed at multiple locations in the area. However, no signs of a holt were discovered and it seems likely that the Otter recorded in the area on the 5th of February were holting elsewhere. Finally, Otter were recorded by AQUAFACT staff in the port area on several dates in 2012 and 2013 up to time of going to print.

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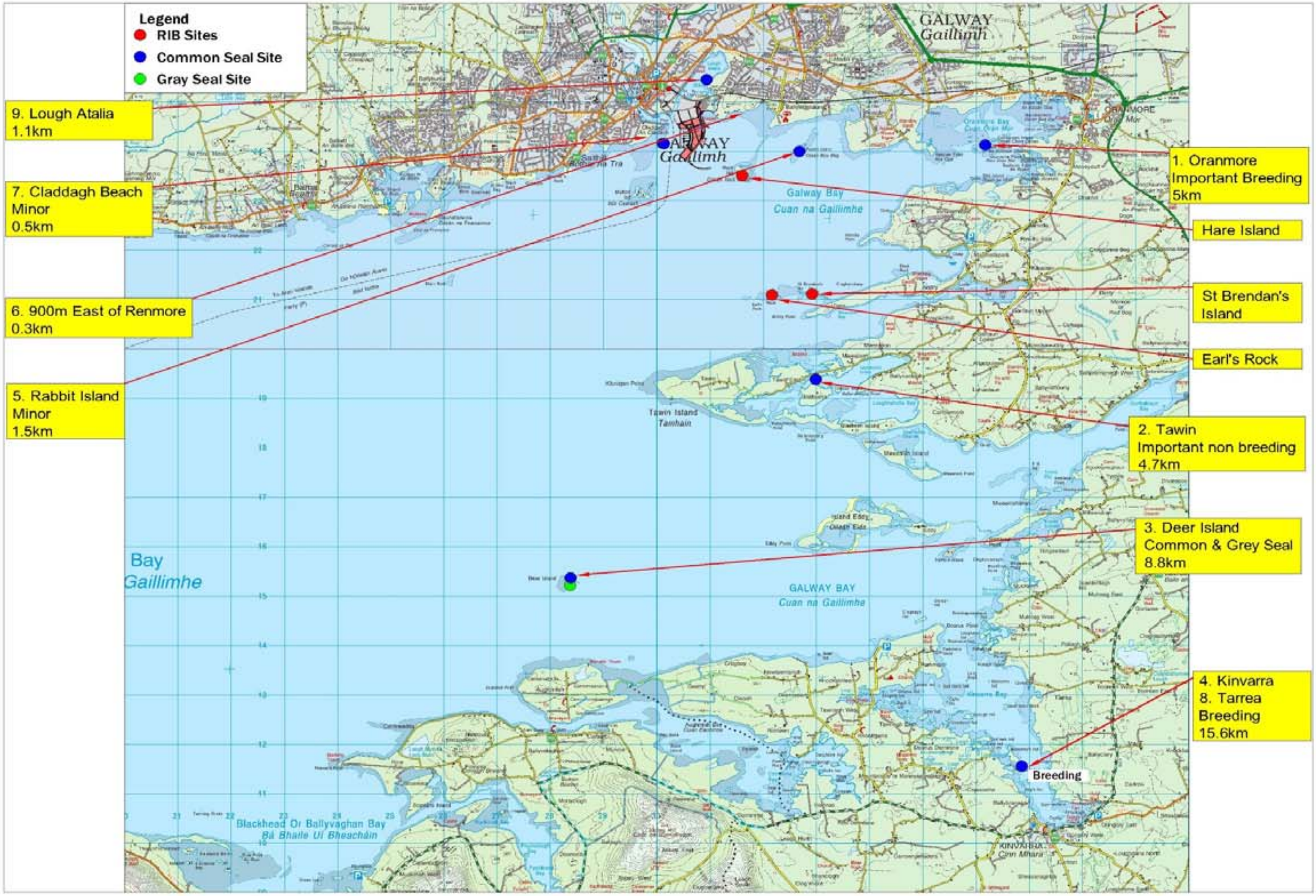
Appendix No. 2.5 – Seal Survey Raw Data

[From Chapter 7 of the EIS – Pages 7-38 to 7-71]



NIS Addendum / Errara Appendix 2.5

Figure 2 - Harbour Seal haul out locations and distance by sea to Development. Range of Vision generally 2km from land (Hare Island, Earl's Rock and St Brendan's Island viewed from RIB)

Seal Observations - Aquafact, Nimmo's Pier

2009		2010			2011		2012		2013		2014	
21.2.2009	0	24.1.2010	0		6.1.2011	29	23.03.2012	0	13.01.2013	0	26.01.2014	1
29.3.2009	1	21.2.2010	2		19.1.2011	6	26.03.2012	0	03.02.2013	0	09.02.2014	1
26.4.2009	3	28.3.2010	4		31.1.2011	2	27.03.2012	1	24.03.2013	0	23.02.2014	3
24.5.2009	2	31.3.2010	2		10.2.2011	0	28.03.2012	0	17.04.2013	2	09.03.2014	2
21.6.2009	4	18.4.2010	1		28.2.2011	1	29.03.2012	0	09.05.2013	4	16.03.2014	1
19.7.2009	0	4.5.2010	1		11.3.2011	3	3.04.2012	0	16.06.2013	1	05.04.2014	0
30.8.2009	1	5.5.2010	2		19.3.2011	0	4.04.2012	1	14.07.2013	2	13.04.2014	2
27.9.2009	6	6.5.2010	1		29.3.2011	0	6.04.2012	1	28.07.2013	0	27.04.2014	1
11.10.2009	2	11.5.2010	1		5.4.2011	0	11.04.2012	0	17.08.2013	1	11.05.2014	2
22.11.2009	0	13.5.2010	3		6.4.2011	0	13.04.2012	0	31.08.2013	3	24.05.2014	0
13.12.2009	1	19.5.2010	2		7.4.2011	0	16.04.2012	2	08.09.2013	1	08.06.2014	1
		21.5.2010	0		15.4.2011	0	19.04.2012	0	14.09.2013	2	22.06.2014	3
		25.5.2010	2		18.4.2011	0	23.04.2012	0	06.10.2013	1	05.07.2014	1
		26.5.2010	3		21.4.2011	1	24.04.2012	1	27.10.2013	1	16.08.2014	0
		27.5.2010	1	grey seal	27.4.2011	3	30.04.2012	0	16.11.2013	0		
		31.5.2010	2		29.4.2011	0	1.05.2012	0	01.12.2013	0		
		1.6.2010	1	grey seal	3.5.2011	0	2.05.2012	0	14.12.2013	3		
		8.6.2010	0		5.5.2011	2	4.05.2012	0				
		10.6.2010	1		10.5.2011	0	9.05.2012	1				
		11.6.2010	1		11.5.2011	0	10.05.2012	0				
		14.6.2010	3		13.5.2011	2	11.05.2012	0				
		15.6.2010	1		16.5.2011	2	14.05.2012	0				
		16.6.2010	0		18.5.2011	1	19.05.2012	0				
		20.6.2010	0		23.5.2011	4	21.05.2012	0				
		30.6.2010	0		25.5.2011	0	22.06.2012	2				
		3.7.2010	2		26.5.2011	1	10.07.2012	0				
		5.7.2010	0		30.5.2011	0	16.08.2012	3				
		14.7.2010	4		1.6.2011	0	27.09.2012	1				
		10.8.2010	0		6.6.2011	2	11.10.2012	2				
		19.8.2010	1		8.6.2011	0	21.11.2012	1				
		3.9.2010	3		13.6.2011	0	16.12.2012	1				
		21.9.010	0		14.6.2011	0						
		5.10.2010	6		16.6.2011	1						
		26.10.2010	23		20.6.2011	2						
		10.11.2010	18		21.6.2011	0						
		26.11.2010	33		22.6.2011	0						
		1.12.2010	50									
		20.12.2010	50									

Seal Observations - Chris Peppiatt, Current Galway Harbour Park

2011

	Common	HO Renmore	HO Rabbit
31.03.2011	1	0	0
17.04.2011	5	5	5
17.05.2011	1	0	1
15.06.2011	0	0	0
11.07.2011	1	0	0
11.08.2011	0	0	0
26.09.2011	0	0	0
12.10.2011	0	0	4
11.11.2011	0	1	0
03.12.2011	0	0	0
29.12.2011	1	0	0

2012

	Common	HO Renmore	HO Rabbit
01.01.2012	0	0	0
13.01.2012	1	1	0
20.01.2012	1	0	0
05.02.2012	1	0	0
28.02.2012	1	0	0
06.03.2012	1	0	0
25.03.2012	0	0	2
10.10.2012	1	0	0
30.10.2012	3	1	14
16.11.2012	2	0	2
27.11.2012	1	0	0
21.12.2012	1	0	0
27.12.2012	2	3	0

2013

	Common	HO Renmore	HO Rabbit
22.01.2013	0	0	0
02.02.2013	1	0	0
22.02.2012	1	0	0
25.02.2013	3	5	13
04.03.2013	1	0	0
14.03.2013	2	0	0

2014

	Common	HO Renmore	HO Rabbit
04.03.2014	1	3	0
08.04.2014	0	0	0
14.05.2014	1	0	0
14.06.2014	1	0	0
17.07.2014	2*	0	0
27.08.2014	0	0	0

* Fighting

HO Renmore = Renmore Barracks Haul Out M\313\246

HO Rabbit = Rabbit Island Haul Out M\326\239

Seal Observations - Chris Peppiatt, Mutton Island Lighthouse

2011

17.06.2011	1
15.07.2011	0
15.08.2011	0
22.09.2011	0
19.10.2011	0
10.11.2011	0
15.12.2011	0

2012

11.01.2012	0
07.02.2012	1
09.03.2012	0
10.04.2012	0
17.05.2012	0

Seal Observations - Marine Mammal Observer, John Olney - during site investigation works within development site

2012	No.	MM Type	Activity	Distance to Barge
11/03/2012	1	Adult common seal, possibly cow (size). Approx. 1.2m long.	Possibly feeding. Head briefly above water.	80m
12/03/2012	1	Adult common seal.	Swimming near harbour lock gates.	>500m
12/03/2012	3	Adult common seals, feeding.	Feeding. Heads occasionally briefly above water.	300m
12/03/2012	3	Adult common seals, heads occasionally above water.	Feeding. Heads occasionally briefly above water.	300m
12/03/2012	2	Adult common seals, feeding.	Feeding. Heads occasionally briefly above water.	250m
13/03/2012	1	Adult common seal.	Swimming near shoreline, head occasionally above water.	350m
13/03/2012	1	Adult common seal, only head visible.	Swimming, milling about shoreline.	350m
13/03/2012	1	Adult common seal, possibly male. Approx. 1.4m long.	Milling about barge, curious.	50m
14/03/2012	1	Adult common seal, possibly male. Approx. 1.4m long.	Milling about barge, curious.	20m
15/03/2012	1	Adult common seal, only head visible.	Possibly feeding. Head briefly above water.	250m
16/03/2012	1	Adult common seal, only head visible.	Swimming, head briefly above water.	250m
22/03/2012	2	Probable European otters, one measuring c.1m long	Swimming and playing along shoreline.	>100m

Galway Harbour Company

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Appendices to NIS Addendum / Errata

Appendix No. 2.6 – Kelp Report

- **Risk Assessment for All Marine Mammals [excluding Otter]**
- **Aquatic Habitat Use of the Harbour Seal**

REPORT

Additional risk assessment of the Galway Harbour Extension for all marine mammals (excluding otter), including a review of the aquatic habitat use of the harbour seal (*Phoca vitulina*).

Report commissioned by McCarthy Keville O'Sullivan Ltd. under the Galway Harbour Extension Project

Author: Kelp Marine Research
Contact: info@kelpmarineresearch.com
Date: October 2014
Version 3.1 (FINAL)

Table of Contents

1.

1. Background and Aim

The aim of this report is to provide 1) an additional risk assessment for all marine mammal species (excluding otter) and 2) a comprehensive desktop analysis of harbour seal aquatic habitat use, to support in the assessment of potential effects of the Galway Harbour Extension on marine mammals as part of the full risk assessment within the Environmental Impact Statement (EIS) for the Galway Harbour Extension Project by McCarthy Keville O'Sullivan Ltd.

Two species of pinnipeds, harbour seal and grey seal, and four species of cetaceans, harbour porpoise, common and bottlenose dolphin and minke whale, occur in the Galway Bay candidate Special Area of Conservation (cSAC). The site for the Galway Harbour Extension is listed as a cSAC for the harbour seal under European legislation.

This independent report serves only to extend information previously submitted in the EIS to the National Parks and Wildlife Service and An Bord Pleanala, as part of the Strategic Infrastructure Development (SID) application of the Galway Harbour Extension project (January 2014), specific to requests for further information and points of concern for marine mammals. This document is not a stand-alone report, or stand-alone risk assessment. The risk assessment and EIS of the Galway Harbour Extension, including marine mammals, remains under full responsibility of McCarthy Keville O'Sullivan Ltd.

The EIS and project planning documentation are available at: http://www.galwayharbourextension.com.

2. Risk assessment for all marine mammals (excluding otter)

2.1 Risk assessment procedure

The additional risk assessment of the Galway Harbour Extension conducted here, for all marine mammal species occurring in the Galway Bay cSAC, was executed following the National Parks and Wildlife Service guidelines as outlined in the report "*Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters*" (DAHG 2014; available at http://www.npws.ie).

All information provided in this report was derived from existing scientific literature and reports, including site-specific reports detailing survey, monitoring and acoustic recording and modelling results, executed for the Galway Harbour Extension Project, available at http://www.galwayharbourextension.com. No targeted surveys or observations of marine mammals were conducted in the area of proposed construction activities for the purpose of this report. The risk assessment provided here focuses primarily on potential impacts of the proposed construction activities in the marine habitat.

The risk assessment for marine mammals focuses on two main types of potential disturbances, physical hearing damage and changes in behaviour. Whereas a large body of effort to investigate the effects of noise in the marine environment has focused on the likelihood of physical (hearing) damage, it has become apparent that changes in behaviour and/or habitat-use resulting from sound exposure or construction activities are often equally, or more likely to translate to a negative effect at the population-level, given the apparent fitness consequences of these responses (e.g. Southall et al. 2007, de Ruiter et al. 2013). Mild to severe behavioural responses to anthropogenic disturbance, including changes in vocalisations, area avoidance and cessation of vital activities such as foraging have been recorded across a wide range of species, areas and types of disturbances (e.g. Goldbogen et al. 2013). The type and strength of behavioural responses can vary widely between and within species and between types of disturbances and are often highly context dependent, calling for case-by-case, in depth study of biological relevance and severity of effects (e.g. Goldbogen et al. 2013).

The risk assessment conducted here provides likelihoods of effects based on available published information. Due to the general lack of detailed knowledge of many aspects of seal and cetacean marine habitat use, behaviour and temporal presence in Ireland, including in the Galway Bay cSAC, it may be that specific dependencies of the species concerned could not be evaluated, and could therefore not be taken into account in the risk assessment. Most notably, knowledge on (spatio-temporal variation in) dependencies on specific marine sites is limited. In recent years, site-specific surveys carried out as part of the Environmental Impact Statement have been undertaken (Galway Harbour Company 2014), providing visual and acoustic information on the presence of cetacean and pinniped species near the area proposed for construction, adding to survey efforts undertaken in the Galway Bay cSAC (Cronin et al. 2004, O'Brien 2009, Duck & Morris 2013a,b).

2.2 Marine mammal species concerned

Harbour seal (*Phoca vitulina*)
Grey seal (*Halichoerus grypus*)
Harbour porpoise (*Phocoena phocoena*)
Bottlenose dolphin *(Tursiops truncatus)*
Short-beaked common dolphin *(Delphinus delphis)*
Minke whale (Balaenoptera acutorostrata)

2.3 Risk assessment

Assessment 1.

Do individuals/populations of marine mammal species occur within the proposed area?

The harbour seal is resident in the Galway Bay cSAC (NPWS 2013, Galway Harbour Company 2014). Harbour porpoises are frequently recorded in the Galway Bay cSAC and near the proposed area (84% of monitoring days between June 2011 and October 2013; O'Brien 2009, CH7 Galway Harbour Company 2014). Bottlenose dolphins used to be frequently recorded (Berrow et al. 2002), but seemed to be declining (O'Brien 2009). Short-beaked common dolphins, minke whales and grey seals are recorded infrequently in the proposed area (O'Brien 2009, Duck & Morris 2013a, b, Galway Harbour Company 2014). However, dolphins (bottlenose or common dolphins) were recorded acoustically on 32% of monitoring days between June 2011 and October 2013, suggesting a more regular presence of dolphins than was found from visual monitoring studies (CH7, Galway Harbour Company 2014).

Assessment 2.

Is the plan or project likely to result in death, injury or disturbance of individuals?

2A. Dredging

Dredging will be performed by two different types of vessels in the proposed project: Trail Suction Hopper Dredgers (TSHD), and backhoe dredgers. The type of substrate determines which vessel type will be used. As one type of dredging is noisier than the other, there are two sets of peak levels that have to be taken into account. Peak levels are 133-185 dB re 1 μPa and 143-195 dB re 1 μPa for TSHD and backhoe dredgers respectively (De Jong et al. 2011, Robinson et al. 2011, Appendix 10.2 Galway Harbour Company 2014). Permanent and Temporary hearing Threshold Shifts (PTS and TTS) can occur for both pinnipeds and cetaceans, if they venture too close to the sound source (Galway Harbour Company 2014). Unless individual animals would be very close to, or attracted by the dredging activities, (hearing) injury or death resulting from these activities is unlikely. The proposed mitigation measures would effectively mitigate against these effects (Table 1).

Seals

The intensity and duration of noise related to dredging is such that it can cause PTS, TTS and behavioural changes (Table 1). In harbour seals, behavioural changes such as area avoidance have been estimated to occur from sounds with an intensity of 55 dB above hearing threshold (Thompson et al. 2013). The peak frequency of dredging noise lies around 125 Hz, which is in the most sensitive part of harbour seal hearing range. Therefore, dredging has the potential to cause behavioural disturbance for the resident harbour seal. Auditory sensitivity levels for grey seals are estimated to be similar to those of the harbour seal. However, grey seals only occur infrequently in the harbour, and are therefore less likely to be affected (Table 1).

Bottlenose and common dolphin, and harbour porpoise

While limited information is available on the direct effects of dredging activities on dolphin and porpoise populations, dredging activities in a UK harbour resulted in an avoidance response of the bottlenose dolphins in the area (Pirotta et al. 2013). The bottlenose dolphins had begun exploiting Aberdeen Harbour as a foraging patch several years before the activities commenced. Dredging occurred several times over a period of several years, but the population did not seem to habituate. The fact that even in an area with regular disturbance, bottlenose dolphins still responded strongly to dredging suggests that it has a high disturbance potential for this species in certain areas or habitats. The mechanism behind the disturbance remains open for research, as it can either be caused by direct avoidance of the noise, be mediated by a change in prey behaviour or visibility, or a combination of the three (Pirotta et al. 2013). However, in contrast, construction work in Broadhaven Bay, Ireland (an area of generally low anthropogenic disturbance) could not be linked to any changes in population density for bottlenose dolphins, common dolphins and minke whales, whereas interannual population fluctuations were detected for harbour seals and grey seals (Anderwald et al. 2013).
Hearing sensitivities of short-beaked common dolphins and harbour porpoises are similar to those of bottlenose dolphins for the noise frequencies of dredging activities. Acoustic deterrence and/or area avoidance resulting from exposure to other types of sound (e.g. seismic

airgun shooting, wind turbines, pile driving) has been demonstrated for both common dolphins and harbour porpoises (Goold 1996, Tougaard et al. 2009, Brandt et al. 2012). However, shipping noise was modelled to have little impact on the population level of harbour porpoise in Danish waters (Nabe-Nielsen et al. 2014). Using a precautionary approach, it should be considered likely that dredging for the Galway Harbour Extension project may result in behavioural disturbance (e.g. temporal area avoidance) of bottlenose dolphins, common dolphins and harbour porpoises present in the area during these activities.

Minke whale

In minke whales, main hearing sensitivity is predicted to be between 30 Hz and 7.5 kHz, or between 100 Hz and 25 kHz, depending on location of the stimulus (Tubelli et al. 2012). Hence, they can hear well within the range of sound generated by dredging activities. As an added potential disturbance, minke whale vocalisations, typically low frequency sounds at 100-400 Hz (Mellinger et al. 2000), will be masked by dredging noise, which may hinder communication (Mellinger et al. 2000). A very strong response of an individual minke whale to playback of low-frequency sonar, at 1-2 kHz, suggested that this species can be heavily affected by anthropogenic noise (Kvadsheim et al. 2011). However, minke whales only occur infrequently in the Galway Bay cSAC (O'Brien 2009), and are unlikely to venture far into the bay. This makes the occurrence of behavioural disruption by the dredging activities unlikely.

2B. Pile driving

Since the construction of wind farms generally involves pile driving, a lot of documentation can be found on the effects of this sound source on marine mammals and fish alike (Carstensen et al. 2006, Bailey et al. 2010, Thompson et al. 2010, Brandt et al. 2012, Dähne et al. 2013, Kastelein et al. 2013). Because of its high intensity and pulse-like structure, pile driving noise is one of the most disturbing anthropogenic noises underwater to date. The intermittent temporal structure inhibits quick habituation (Neo et al. 2014), while the high intensity can cause TTS or and PTS (Southall et al. 2007).

Seals

For harbour seals, Thompson et al. (2013) simulated the construction of two piles in the Moray Firth, UK. Behavioural disturbance was modelled to start at 80 km from the sound source in open water. However, the amplitude of pile driving depends upon the diameter of the pile and the technique used to drive it into the ground. Since the piles used in the proposed project are smaller than average wind turbine piles, it is likely that the noise produced during the Galway Harbour Extension will be less. Furthermore, the shallow water depth in the Galway Bay cSAC, and the buffering effect caused by Mutton and Hare Island will result in a much smaller actual range of sound propagation, and hence disturbance. Impact levels have been predicted to be limited to the inner Galway Bay (EIS Appendix 10.3, Galway Harbour Company 2014). In addition, response of the harbour seal population could be affected by either habituation or sensitisation to the noise during actual construction activities (Götz & Janik 2010, Götz & Janik 2011). Pile driving can cause PTS and TTS when individual seals occur within 100 - 600 m from the sound source. The proposed mitigation measures will effectively mitigate against direct hearing injury, whereas behavioural disturbance remains likely for harbour seals (Table 1).

Harbour porpoise

The noise created by pile driving is sufficiently loud to be audible to harbour porpoises, and has been shown to deter this species for 9 to 70 hours within 20 km of a pile driving site in open waters (Tougaard et al. 2009, Brandt et al. 2012). Since generally more than one pile needs to be driven into the ground, depending on the time between two consecutive pile-driving events, harbour porpoises can be deterred from an area during the entire period of development (Brandt et al. 2012). On the other hand, Kastelein et al. (2013), when exposing a single individual to pile-driving sounds in a large pool, found that behavioural responses were limited to the time of playback. Afterwards, the individual would soon return to its baseline behaviour. The lack of long-term responses in this study could be due to the fact that the animal was held in captivity and could therefore not show avoidance behaviour of a particular site. Another study by Scheidat et al. (2011) on the effect of a wind farm construction in the North Sea showed that harbour porpoise occurrence actually increased after construction of the farm. However, no observations were conducted during construction, so it is unclear whether the site was abandoned at that time. Overall, pile driving can be considered to trigger strong short-term (avoidance) responses, which may change behaviour for multiple hours after sound exposure. Driving of multiple piles could therefore result in a carry-over effect, and deter harbour porpoises for longer periods of time, resulting in temporal loss of habitat during the period of construction. Close proximity to the pile driving activities could result in injury (TTS or PTS), but this risk is likely reduced by the tendency of harbour porpoises to avoid the area with pile driving activities. Mitigation actions, including 30 min pre construction watches and soft-start protocols will effectively reduce the likelihood of direct impact on harbour porpoise, but behavioural changes remain likely to occur.

Bottlenose and common dolphin, and minke whale

The response of mid- and low-frequency cetaceans (cetaceans whose auditory range is within 150 Hz-160 kHz (mid) and 7 Hz – 22 kHz (low) (Southall et al. 2007), in this case, short-beaked common dolphins, bottlenose dolphins and minke whales, to pile-driving sounds has been modelled by Bailey et al. (2010) for the construction of an offshore wind farm in the Moray Firth, UK. In the Moray Firth, behavioural response to pile driving was modelled to occur up to 50 km from the construction site located in open water. Goold (1996) studied the distribution of common dolphins in response to seismic airgun surveys in offshore waters using passive acoustic monitoring. During the survey, individuals tended to stay at least 10 km away from the surveying site. The acoustic spectrum of airgun noise is different from pile-driving sounds, but the temporal structure is quite similar. However, response ranges will differ per area, based on background noise levels and the acoustic properties of the abiotic environment. The piles used in the present project are of a smaller diameter and will therefore require less force (i.e. noise) to be driven into the ground. Furthermore, as stated above, the shallow water and buffering effect of Mutton and Hare Island on the underwater sound propagation will result in much smaller response ranges as opposed to open water environments. Based on the propagation models, the behavioural response range for mid- and low-frequency cetaceans is estimated to stay within the inner Galway Bay (EIS Appendix 10.3, Galway Harbour Company 2014). For cetaceans, behavioural disturbance by pile driving at medium to large distance is likely to occur, whereas injury (TTS or PTS) is possible when individuals occur at close range (19 - 100 m) from the pile driving activities. Proposed mitigation actions, including 30 min pre construction watches and soft-start protocols will effectively reduce the likelihood of direct impacts, but behavioural changes remain likely to occur (Table 1).

2C. General construction in the marine environment

General marine construction noise will consist of underwater blasting and deposition of quarry material. Deposition of quarry material can be compared acoustically to dredging sounds, since it will consist of relatively short, continuous broadband noise. Therefore, the behavioural responses as described in section 2A concerning dredging can be also applied here. Rock blasting will pose a heavier acoustic strain on the environment. Sound pressure levels for rock blasting during the Galway Harbour Extension are estimated to be 225 dB re 1 µPa at 1m.

Seals

The acoustic structure and sound levels of rock blasting are such that harbour seals will likely exhibit a startle response (Götz & Janik 2011). As repeated elicitation of the startle reflex can lead to sensitisation (Götz & Janik 2011), this would call for a minimisation of the number of blasts per day to avoid direct injury or deaths from seals in close proximity to the site. Blasting can cause TTS and PTS to seals within 50-160 m from the source (Table 1). Proposed mitigation actions will effectively reduce the likelihood of direct impacts, but behavioural changes remain likely to occur for animals present in the area (Table 1).

Bottlenose and common dolphin, harbour porpoise and minke whale

For all cetaceans, blasting sounds can invoke PTS or TTS, if animals venture too close to the site of explosion. Precise impact ranges can be calculated using the criteria set out by Southall et al. (2007), and will be in the range of 45-90 m for PTS and TTS, respectively (Table 1). Behavioural disturbance by blasting at medium to large distance is likely to occur. Proposed mitigation actions will effectively reduce the likelihood of direct impacts, but behavioural changes remain likely to occur for animals present in the area (Table 1).

2D. Shipping noise

As a relatively low-level, continuous sound source, shipping noise will not pose a physical threat to pinnipeds or any of the cetacean species concerned. Behavioural disturbance however, is possible, depending on the size and velocity of the vessels. In the case of the Galway Harbour Extension project, the size of vessels entering the harbour area will increase significantly post-construction. The new harbour will be able to hold 25.000 tonnes vessels, in contrast to the current 5.000 tonnes vessels (Galway Harbour Company 2014). At the same time, however, the number of vessels docking at the harbour will decrease from 180 to 107 vessels per year (medium scenario; Galway Harbour Company 2014), resulting in a reduction of disturbance events and possibly similar or less impact per ship if the larger ships are modern vessels carrying more silent engines.

Seals

Seal responses to shipping noise have received little study. In general, seals tend to dive when faced with disturbance, but in the case of underwater noise, a surfacing response might be expected (Harris et al. 2001). Sound pressure levels of low frequency sounds can decrease up to 7 dB closer to the water surface (Urik 1983, Green & Richardson 1988, Richardson et al. 1995). Australian fur seals respond to in-air motorboat noise above 75 dB re 20 µPa, by becoming more alert, or moving away (Tripovich et al. 2012). Conversely, Harris et al. (2001) showed that Arctic seals showed only localised avoidance responses to an approaching vessel doing seismic surveys, often remaining in areas with over 190 dB re 1 µPa noise levels. Of the Northwest coast of Co. Mayo, displacement of grey and harbour seals was correlated to increasing vessel abundance during the offshore construction of a pipeline in Broadhaven Bay, Ireland (Anderwald et al. 2013). Analysis of the vessel type showed that the negative correlation was more likely caused by increased levels of underwater noise, than by increased collision risk (Anderwald et al. 2013). A controlled behavioural response study was conducted to investigate the response of vessel approaches on harbour seal haul-out behaviour (Anderson et al. 2012). The study showed that harbour seals responded to approaching vessels at significant greater distances than to an approaching pedestrian. Seals were alerted by approaching vessels heading directly towards the animals at distances ranging from 560 to 850 m (Anderson et al. 2012). These patterns of response were consistent during pre-during and post breeding periods. Johnson and Acevedo-Gutierrez (2007) observed that harbour seals were less affected when powerboats and kayaks passed by, but did flee when powerboats were approaching within 400 m. This difference may relate to an approaching vessel possible blocking the direction of the seals escape route (Anderson et al. 2012). However, since these studies concern airborne noise, and vessels approaching seals directly, it is unlikely distances will be similar for underwater shipping noise. The current residency of harbour seals near the harbour suggests a level of tolerance to shipping noise. Higher short-term peak levels in vessel noise post-construction may elicit startle responses within seals, which could lead to area avoidance (Götz & Janik 2011). However, habituation to the noise may alter this response to some extent (Götz & Janik 2010).

Harbour porpoise

Very little conclusive information is available on the response of harbour porpoises to boat noise. The fact that harbour porpoises can currently be found in the Galway Bay cSAC suggests that current sound levels can be tolerated. On a population level, shipping noise has been modelled to have little impact for harbour porpoises (Nabe-Nielsen et al. 2014). On the other hand, studies by Amundin & Amundin (1973) and Polacheck & Thorpe (1990) show avoidance responses to shipping noise.

Bottlenose and common dolphins

Many studies, conducted across a wide range of areas and habitats have reported a broad range of behavioural changes in response to boat traffic, including population-level effects. Rako et al. (2013), for example, investigated the effect of leisure boat noise on a population of bottlenose dolphins in a Croatian archipelago, and found strong seasonal displacements of animals during periods of very high activity on the water. The results could not be explained by a change in prey abundance, and a strong correlation between vessel density and underwater noise suggests that both vessel presence and an increase in underwater noise could be the cause for the displacement. However, bottlenose dolphins did not adversely respond to increased shipping noise during construction activities in a nearby bay area, Broadhaven Bay, County Mayo (Anderwald et al. 2012). Leisure boat levels in the Galway Bay cSAC are lower than described in Rako et al. (2013), so the impact of boat traffic is expected to be lower. Furthermore, the number of ships entering the port yearly is estimated to decrease after the extension, which may help to reduce any impact.

Minke whale

In baleen whales, boat noise can cause changes in vocal behaviour (Miller et al. 2000). The acoustic properties of ship noise make it a masking sound for many baleen whale vocalisations, including those of minke whales. It may be that the future decrease in the number of ships entering the port will result in a decrease in masking time. Since the currently available information suggests that minke whales visit Galway Bay mainly during the summer months, and generally in very low numbers, masking of minke whale vocalisations during construction is deemed unlikely.

Behavioural effects of shipping noise have been shown for all species present in the Galway Bay cSAC, and short-term behavioural changes can be expected to occur for all species when present during and post construction (Table 1).

2E. Vessel collision

Both pinnipeds and cetaceans have been documented with mild to severe and lethal trauma after vessel collision (Moore et al. 2013). Distinctions can be made between blunt and sharp trauma, which are caused by rotating and non-rotating parts of the vessel, respectively (Moore et al. 2013). Different factors can affect the severity of the impact, such as vessel size and velocity, the angle at which collision takes place, and the anatomy of the body part that is hit (Laist et al. 2001, Vanderlaan & Taggart 2007, Moore et al. 2013). The likelihood of such collisions is thus far unclear, as frequency studies have only been conducted for species with very high incidences of collisions, such as right whales (Kraus et al. 2005).

Seals

Of the species here concerned, harbour seals will have the greatest likelihood of vessel-related injury (collision), since they are resident in the area and may be inquisitive towards vessels. In the UK, 27 stranded harbour seals with corkscrew motor injuries have been found since 2008 (SNCA 2012). Most observed lethal injuries were likely caused by seals being drawn through a ducted propeller such as a Kort nozzle or some types of Azimuth thrusters (Thompson et al. 2010). Since not all carcasses end up on the beach, actual number of deaths may be higher than currently reported. As a consequence, the effect on population levels cannot be estimated (SNCA 2012). However, it has been stated that the number of collisions generally does not pose a threat to a species on population level (Thompson et al. 2010, Weinrich et al. 2010). Possible mitigation measures include avoidance of the breeding season, and avoidance of certain engine types (SNCA 2014). Since no marine construction works will take place during the breeding season, the risk of vessel collision will be minimized during this vulnerable period. Given the absence of documentation of vessel collisions with harbour seals, and their general level of interaction with/presence in area with larger numbers of vessels, the likelihood of harbour seal trauma caused by vessel collision in the Galway Bay cSAC is expected to be limited, but increased during marine construction activities due to the increase in the number of vessels. However, the absence of documentation of vessel collisions with harbour seals may be due to the fact that these were not recorded and/or noticed. Grey seals rarely occur in the vicinity of the harbour and therefore the likelihood for this species to be injured by collision is considered small.

Harbour porpoise

The harbour porpoise is a frequently occurring species in the Galway Bay cSAC. It occurs in shallow coastal areas, where it hunts for prey using echolocation. The species is shy by nature, and generally will not venture closely to large vessels. Because of its habitat and prey choice, a harbour porpoise has a relatively high chance of coming into contact with humans. For example, the mortality caused by by-catch of harbour porpoises in commercial fishing gear is so large that population sustainability may suffer (Tregenza et al. 1997). However, documentation on trauma related to vessel collisions is scarce, and incidences seem lower than for by-catch. This could be explained by the shy nature of the species, or by inadequate documentation of collision-related injuries. It is believed that anthropogenic trauma from collision does not pose a major threat to small marine mammal species on the population level (Weinrich et al. 2010), which may be a reason for the lack of documentation. More documentation exists on vessel collision with large marine mammals such as whales (Laist et al. 2001, Weinrich et al. 2010; Silber et al. 2012), which is likely caused by the fact that such incidents are more easily noticed by the ship's crew.

Bottlenose and common dolphin
Documentation on bottlenose dolphin collision with vessels indicates that injuries may range from mild to severe (Moore et al. 2013). Incidences of collision are low, and will most likely occur during the presence of large numbers of vessels on the water. In the Sarasota Bay area, 4 cases of non-lethal strike injuries on bottlenose dolphins were reported in a time-span of 13 years (Wells et al. 1997). All were recorded immediately after a day with the highest vessel density of that particular year. Hence, the likelihood of bottlenose dolphin trauma caused by vessel collision in the Galway Bay cSAC will be limited, but increased during marine construction activities due to the increase in the number of vessels and their time spent actively operating in the area. Collisions between short-beaked common dolphins and vessels are scarcely documented, whereas they are often reported to bowride (actively associate with ship) without resulting injuries. It is possible that the lack of documentation is due to a low incidence of vessel-related trauma in common dolphins, however, it may also result from inadequate documentation. Since common dolphins may be attracted to boats, similar to bottlenose dolphins, the likelihood of collision could be similar to that of the bottlenose dolphin. Combined with the fact that common dolphin sightings in the Galway Bay cSAC are relatively rare, the risk of vessel collisions with common dolphins is expected to be limited.

Minke whale
Compared to other cetaceans, vessel related incidents with baleen whales have been recorded quite regularly. This is possibly due to the size of the animals, their behaviour, or simply due to the fact that a collision with a 20 m long animal is more easily noticed. Within the baleen whales, however, reports of collisions between ships and minke whales are relatively low in number. Since minke whales are also seen on only few occasions within the Galway Bay cSAC, the risk of vessel related injuries within the current project for this species is expected to be limited.

2E. Secondary impact due to localised disruption of normal ecological activity (e.g. via displacement or removal of prey species)

Seals
Secondary impacts of the Galway Harbour Extension on harbour seals, if any, are likely to be most prominent in the effect of marine construction noise on their prey. Several fish species can be affected by anthropogenic noise, and show distinctive responses based on the sound type. For example, Atlantic herring (*Clupea harrengus*) exhibits flight behaviour to engine noise, but not to low-frequency sonar (Doksæter et al. 2012). Strong pulsed sounds such as pile driving sounds can elicit behavioural responses in mackerel, causing them to change depth (Hawkins et al. 2014). If close, the blasts created by pile driving may be so intense that they cause physical trauma to the fish exposed (Halvorsen et al. 2012). The differences in behavioural response between sound type and fish species make it difficult to give an estimation of the likely effect on harbour seals, particularly given the general lack of information on prey species and foraging

behaviour in Irish waters and in the Galway Harbour cSAC. As the harbour seal is an opportunistic predator and may readily shift prey species between seasons if prey abundance changes (Brown & Mate 1983, Tollit et al. 1998, Thomas et al. 2011), it is likely to be generally resilient to changes in prey behaviour, if only part of the fish species strongly respond. However, harbour seals also display a high site-fidelity to their foraging area (Härkönen & Harding 2001). It is currently unclear what the flexibility of the species is when confronted with a change in quality of foraging area. If prey species shift their distribution, or become less abundant on the longer term due to the construction activities, this may impact the resident harbour seal population. This impact can result in a reduction in the overall energy budget of the population, resulting from lost or reduced foraging opportunities, and increased time and energy spent acquiring/searching for food in alternative, potentially less suitable, or more distant locations. Since grey seals only occasionally occur in the Galway Bay cSAC, secondary impact due to displacement or removal of prey species is unlikely to have an effect.

Harbour porpoise
Harbour porpoises are opportunistic predators and feed in both pelagic and demersal habitat (Santos & Pierce 2003). Known prey species comprise Atlantic herring, sandeel, sprat and members of the cod family (De Pierrepont et al. 2005). As mentioned before, Atlantic herring shows flight behaviour in response to engine noise. Likewise, avoidance reactions in cod were found during playback of trawler noise (Engås et al. 1995). Conversely, lesser sandeel distribution was not affected by the sound of seismic shooting (Hassel et al. 2004). Similar to the harbour seal, the impact of acoustic disturbance on harbour porpoise foraging success will therefore largely depend upon the relative abundance of different prey species, accessibility/proximity of alternative foraging locations, and preferred diet in the Galway Bay cSAC.

Bottlenose and common dolphin
Bottlenose dolphins in UK waters feed mostly on squid (*Loligo* sp.) and several cod species (De Pierrepont et al. 2005). Horse mackerel is also known as a prey species (De Pierrepont et al. 2005). Given the generally close proximity to shore of bottlenose dolphins in Irish waters, including in the Galway Bay cSAC (Oudejans et al. in press, O'Brien et al. 2009), this species likely forages mainly in inshore waters (< 5 km from shore). Fish species, most notably cod (*Gadus morhua*), can show anti-predatory responses to noise (Engås et al. 1995). Hence, the sound created by the proposed activities could disrupt the foraging efficiency of bottlenose dolphins in a similar way as described for the harbour seal. Squid can detect sound (Mooney et al. 2010), and were recently found to gain physical trauma from relatively low level (max. 175 dB re 1 µPa), low frequency sounds (André et al. 2011). Squid is generally distributed in deeper waters than found within the Galway Bay cSAC, and it is therefore unlikely that this species is affected within the proposed area. Short-beaked common dolphins are opportunistic feeders, and consume a variety of mackerel, sprat, squid, sardines, snipe fish, European hake, sand smelt, toothed goby and blue whiting (Pascoe 1986, Silva 1999). Most species are likely to occur in the Galway Bay cSAC (fishbase.org). The response to anthropogenic noise of most of those species remains unknown. However, as described above, both mackerel and squid can be affected. A goby species related to the toothed goby, however, which produces sound as a part of its sexual display, did not show a behavioural response after acoustic disturbance (Picciulin et al. 2010). As for the bottlenose dolphin, the severity of the secondary impact of the construction activities will therefore depend on the relative abundance of non-impacted prey. In addition, the general

more offshore distribution of the common dolphin will make the species less dependant on near shore waters for foraging than bottlenose dolphins.

Minke whale

Minke whales, feeding predominantly on fish, are infrequent visitors of the Galway Bay cSAC during summer months. They are therefore unlikely to be affected at the population level by changes in fish behaviour due to acoustic disturbance.

Assessment 3.

Is it possible to estimate the number of individuals of each species that are likely to be affected?

Harbour seal

The harbour seal is a resident species in the Galway Bay cSAC. The harbour seal population in the inner Galway Bay area consisted of 221 individuals in 2012 (Duck & Morris 2013b). The species was regularly recorded present in the water at different locations in the bay during multiple surveys for the Galway Harbour Extension Project (Galway Harbour Project 2014). Depending on their flexibility to choose alternative, non-impacted sites for functional activities that occur in the water such as mating and foraging, individuals residing at or near the harbour might be affected. Individuals residing in haul-outs at or near the harbour will likely be impacted by increased noise levels during their time in the water (e.g. during travel to and from the haul-out).

Grey seal

In two consecutive monitoring periods, only 8 grey seals were recorded in the vicinity of Galway harbour (Duck & Morris 2013a,b). Since the monitoring study was not focussing specifically on grey seals, this can be an underestimation. However, considering this low density, it is unlikely that a substantial number of individuals will be affected by the procedures.

Bottlenose dolphin

The coastal population of bottlenose dolphins conduct long-distance movements along the Irish west coast (O'Brien et al. 2009, Oudejans et al. 2010), utilising multiple areas for foraging and other life functions, within a large home range. Bottlenose dolphins were considered a regularly occurring species in the Galway Bay cSAC. However, surveys across several years have shown a decreasing trend in occurrence. Whereas between 1994 and 1999 bottlenose dolphins were the most sighted species from Fanore, on the south end of the Galway Bay cSAC (Berrow et al. 1996), surveys conducted from 2006 found only between 4-11% of sighted species to be bottlenose dolphins (0.3 groups per survey; O'Brien 2009). A recent cetacean survey did not record any dolphin species inside in the proposed development area (Galway Harbour Company 2014). An acoustic survey using one C-POD located of the south coast of Mutton Island recorded dolphin vocalisations on 32% of 804 monitoring days (Galway Harbour Company 2014). These vocalisations likely consisted of bottlenose or common dolphins, and indicate a more regular presence of dolphins than indicated by visual observations. Currently no abundance estimate is available for the population of coastal bottlenose dolphins in Irish waters, hence it is not possible to determine the number of individuals potentially affected by the development.

Harbour porpoise
The density of harbour porpoises in the outer part of Galway Bay in 2008 was estimated at 0.73 individuals per km^2 (Berrow et al. 2008), at a surface area of 547 km^2. More recently, acoustic monitoring in the inner bay using CPOD acoustics showed harbour porpoise presence 84% of monitoring days within 1 nm from the proposed area (Galway Harbour Company 2014). A dedicated cetacean survey recorded one sighting of two harbour porpoise approximately 800 m south of the proposed development (Galway Harbour Company 2014). The number of individuals affected depends on their distribution in the bay, and flexibility to choose alternative, non-impacted sites for functional activities such as resting and foraging.

Short-beaked common dolphins
Short-beaked common dolphins occur infrequently in the vicinity of the proposed area of development or in the Galway Harbour Bay cSAC (O'Brien 2009). Due to the sporadic sightings of this species, the number of individuals affected is estimated to be small.

Minke whale
This species occurs sporadically, and likely seasonally, in the proposed area. Given the current available information, it is estimated that the potential number of individuals affected is small.

2. Assessment 4.

Will individuals be disturbed at a sensitive location or sensitive time during their life cycle?

Harbour seal
The mating season of harbour seals takes place in the water near the end of the breeding season (Coltman et al. 1997, see 3.5 *Mating Behaviour*). In the Galway Bay cSAC, this is in June-July. Nursing of pups takes place in the water, during the breeding season, in May-July (Leopold et al. 1992). Since marine construction activities will cease during that period, this part of their life cycle is unlikely to be disrupted. The mating season is followed by the annual moulting season, which takes place in August-September (NWPS 2011). Most of the harbour seal population will be hauled out on shore in this period. Harbour seals increase their time foraging in the water in the winter (see section 3.3 *Foraging behaviour*). During this period, individuals may be more susceptible to disturbance from ongoing construction activities within the proposed area.

Harbour porpoise
The calving period of harbour porpoises takes place from May till July (Van Utrecht 1978, Verwey & Wolff 1983, Evans et al. 1986, Evans 1990, Kinze, 1990). In the North Sea, relatively high calf densities in certain areas suggested the presence of preferred calving grounds (Sonntag et al. 1999). These high calf densities have not been found for the Galway Bay cSAC (Berrow et al. 2008), but high proportions further south along the Irish coast suggest harbour porpoises along the Irish coast also have preferred calving grounds (Leopold et al. 1992, Sonntag et al. 1999). Since the main calving period takes place in summer, this will not be directly affected by anthropogenic disturbances due to marine construction activities.

Bottlenose dolphin

Reproduction in bottlenose dolphins is only partly seasonal, with females being able to give birth throughout the year (Urian et al. 1996). Populations at the same latitude can have distinctly different breeding seasons, so breeding is not related to day length, as it is in many other species. However, breeding mostly took place within the period March-August (Urian et al. 1996). In Ireland, young calves and newborn bottlenose dolphins have been observed throughout the year (Oudejans, unpublished data), so the period of calving could possibly be affected by the proposed marine activities in the Galway Bay cSAC. Bottlenose dolphin calves remain dependant on their mothers for several years, and the majority of groups will be partly composed of dependant young animals throughout the year. Some records exist of cetacean mother-calf separations following severe disruption or disturbance, resulting from high intensity sounds sources (e.g. killer whales; Miller et al. 2012). These separations are considered highly stressful, and may be lethal for the calf. Hence, while these occurrences would be rare (also given the low number of animals recorded), the risk involved in these rare occurrences is very high. The same may apply for common dolphin and harbour porpoise. The proposed mitigation measures, including 30 min pre-construction monitoring and soft start procedures, will effectively mitigate against these possible effects.

Short-beaked common dolphin

Conception in short-beaked common dolphins is estimated to take place in July-August (Westgate et al. 2006). Gestation takes about a year, so giving birth occurs in the same period. It is unclear whether common dolphins give birth in special calving grounds. It is assumed therefore, that dolphins that are present in the Galway Bay cSAC during that July-August, may also mate and give birth there. These activities therefore can potentially be interrupted by construction activities. However, occurrences of common dolphins in the Galway Bay cSAC have been rare. Hence, for groups present in the bay during the breeding period, breeding activities could potentially be affected. However, given the limited number of common dolphin sightings in the Galway Bay cSAC, and near the area proposed for construction, this is unlikely to occur and the number of animals potentially affected is estimated to be low.

Minke whale

Minke whale breeding grounds are currently unknown, but are believed to lie in waters of the North Atlantic Ocean near the equator (Víkingsson & Heide-Jørgensen 2005). It is unclear when the minke whale breeding season takes place, but since this is not likely to occur near the Galway Bay cSAC, minke whale breeding activities are unlikely to be affected by the construction activities.

Assessment 5.

Are the impacts likely to focus on a particular section of the species' population, e.g., adults vs. juveniles, males vs. females?

Seals

Harbour seals show large intraspecific differences in foraging behaviour (see 3.3 *Foraging Behaviour*). Differences related to size and sex have been recorded in the Moray Firth, Scotland

(Thompson et al. 1998). Males and large individuals venture out further to search for food than females. In other locations, however, juveniles were found to conduct larger movements than adults (Lowry et al. 2001). As one of the resting sites of harbour seals is located in the vicinity of Galway Harbour, this means that females, and most notably pupping and nursing females, are more likely to be affected by the proposed activities than males. Since very low numbers of grey seals are sighted in the proposed area, disturbance due to the construction activities is unlikely to impact a specific section of the population.

Harbour porpoise
Limited information is currently available on the harbour porpoise population structure. Harbour porpoises in the Galway Bay live in groups of two individuals, on average (Berrow et al. 2008). Of the population about 7% of individuals consists of juveniles, which is similar to the ratio found in other coastal waters of Ireland. Differences between males and females and juveniles in habitat-use have so far not been investigated.

Bottlenose dolphins
The social structure of bottlenose dolphins is a fission fusion society (Connor et al. 2000). This entails that group formations may change on a day-to-day basis, and group composition frequently changes. Aggregations and groups of animals are generally composed of mixed age- and sex-classes. Therefore, outside of the generally larger sensitivity of mother-calf pairs, it does not appear that any particular section of the species' population might be more affected than others.

Short-beaked common dolphin
Short-beaked common dolphins live in large aggregations of mixed sex- and age-classes. Therefore, outside of the generally larger sensitivity of mother-calf pairs, it does not appear that any particular section of the species' population might be more affected than others.

Minke whale
There is insufficient information available to consider different impacts on a particular section of the population of minke whales visiting the Galway Bay cSAC.

Assessment 6.

Will the plan or project cause displacement from key functional areas, e.g., for breeding, foraging, resting or migration?

Harbour seal
Harbour seals forage mainly within coastal waters and are a resident species of the Galway Bay cSAC. As a non-migratory species, they may have specific preferred areas for foraging. The quality of a foraging site is based on distance to the haul-out site, prey abundance and bathymetry. Individuals are known to generally forage within 50 km of their haul-out site, staying in the same area for over a decade (Bjørge et al. 1995, Härkönen & Harding 2001). Preferential foraging areas are generally within 20 km from the haul-out site (Tollit et al. 1998, Härkönen & Harding 2001, Grigg et al. 2009). Furthermore, harbour seals will choose areas with a long-term stable high prey abundance (Grigg et al. 2009). The high site-fidelity for both

foraging and resting classifies harbour seals as central-place foragers (Orians & Pearson 1979, Thompson et al. 1998, Grigg et al. 2009).

If situated in the area of construction activities, harbour seals might not be able to use their preferred foraging location during these works. However, no preferred foraging areas have been identified from land-based surveys within the proposed area (Galway Harbour Company 2014). Furthermore, changes in prey distribution due to the acoustic disturbance could cause a deterioration of the quality of the patch. The effects of any impacts on foraging sites will depend on the availability of other suitable foraging areas in the area, and the increased time and energy spent acquiring/searching for food in alternative, potentially less suitable, or more distant locations. Harbour seals are known to be a flexible species, as can be concluded from their opportunistic prey selection and seasonal change of prey choice (Brown & Mate 1983, Tollit et al. 1998). Given the presence of alternative foraging opportunities, these characteristics make the species generally resilient to changes in the environment relating to food abundance.

Grey seal
Grey seals occur infrequently in the area (O'Brien 2009). Grey seals generally conduct large offshore movements and individuals tagged on the Blasket Islands, Co. Kerry, did not utilize the inner Galway Bay, despite individuals travelling multiple times up and down the west coast passing Galway Bay (Jessops et al. 2013). Hence, it is therefore unlikely the developed area comprises important habitat for the species.

Harbour porpoise
Harbour porpoises are currently the most frequently recorded cetacean species in the Galway Bay cSAC (O'Brien 2009). Given the general lack of knowledge on the fine-scale habitat use including foraging and mating/breeding areas, currently insufficient information exists to conclude whether construction activities would result in displacement from key functional areas.

Bottlenose dolphin
The population of bottlenose dolphins that frequents the Galway Bay cSAC is likely to be part of a coastal population that travels along the entire west coast of Ireland. It is possible that the Galway Bay cSAC is used as a part of their coastal habitat (Oudejans et al. in review). If the area is used as a migratory corridor, increased noise levels might cause the population to venture further offshore.

Short-beaked common dolphin
Short-beaked common dolphins occur occasionally in the area (O'Brien 2009). Generally, insufficient scientific information exists to conclude whether construction activities would result in displacement from a key functional area for this species. In Ireland, the common dolphin is mainly distributed in offshore waters and waters covering the coastal shelf (Wall et al. 2013). As such, the shallow waters of the proposed site likely do not comprise important habitat for this species.

Minke whale
Minke whales occur infrequently in the area (O'Brien 2009). Given the low number of sightings, it can be assumed the area does not comprise of important habitat for this species.

Assessment 7.

How quickly is the affected population likely to recover once the plan or project has ceased?

Seals

The marine development work will be interrupted for several months (April-July) every year, which will give all species time to recover from the disturbances. The recovery period will be most important for harbour seals, since they reside in the area permanently, which increases their levels of disturbance and decreases possibility for recovery during development. Stress levels may be elevated for some time after cessation of activities, but will likely have returned to normal at the start of the breeding season in June (Tougaard et al. 2009). Habituation in seals occurs quickly when exposed to non-startling, long-duration sounds (Götz and Janik 2010), such as shipping and dredging noise. Sounds with a short rise-time can elicit startle-reflexes, to which seals will sensitize if exposed multiple times in a row (Götz and Janik 2011). These sounds, i.e. blasting and pile-driving, have the potential of causing long-term behavioural effects, impact individual fitness and decrease longevity (Götz and Janik 2011). Therefore, the within-project recovery of seals will depend upon the presence of pile-driving or blasting activities during the winter construction periods. A study investigating harbour seal movements after completion of two wind farms in the Danish Wadden Sea, indicated no significant long-term effect of the operational wind farms on seal behaviour (McConnell et al. 2013). Short-term displacement effects were reported during the construction and operation of a wind farm in the Wadden Sea, Denmark (Edren et al. 2010). Here, no long-term effects were found, and harbour seals continued to use the area, and population increased in accordance with an increase observed in other areas (Edren et al. 2010). In contrast, longer-term displacement of seals was recorded in Broadhaven Bay, Ireland during an offshore construction of a pipeline (Anderwald et al. 2013). Current post-construction monitoring will enable to determine long-term effects and identify if seals return to pre-construction levels. After completion of the project, the population might return to pre-construction distribution ranges within a few months (Tougaard et al. 2009). Based on the currently available information, with grey seals only sighted occasionally in the Galway Bay cSAC, the proposed activities are not expected to cause an impact at population-level.

Harbour porpoise

Knowledge of harbour porpoise population structure and disturbance effects on population level are currently limited. Short term responses have been reported during the construction of a windfarm, where harbour porpoise activity was reduced between 24 and 70 h after pile driving activities (Brandt et al. 2012). Studies of long-term responses of harbour porpoises to acoustic disturbance have shown conflicting results. Teilmann and Carstensen (2012) studied the effects of the construction of an offshore wind farm in the Baltic, and found that ten years after construction population numbers were still not up to their previous level. On the other hand, Scheidat et al. (2011) found that harbour porpoise presence in the Dutch North Sea actually increased during and after the construction of the wind farm. This phenomenon was explained by the fact that previously the site was on a busy travel pathway for commercial shipping, which was rerouted for the windfarm. Furthermore, the two areas probably differed in significance for the respective populations, which would influence the necessity of return: In the Baltic, harbour porpoise presence had been infrequent already before construction, suggesting the area was relatively unimportant for the population. Galway Bay is currently an urbanised but relatively undisturbed marine area, and harbour porpoise sightings are common. The probability and speed of recovery after the construction period will therefore depend on the relationship between the relative importance of the area for harbour porpoises and area quality post-construction.

Bottlenose and common dolphin, and minke whale

The relatively small number of sightings of bottlenose dolphins, common dolphins and minke whales in the Galway Bay cSAC suggest that impacts on animals of these species frequenting the bay will not lead to population-level effects (Table 1). However, in general, information on population sizes, habitat-use and behaviour in Irish waters is limited, and conclusive evidence for the likelihood of population-level effects resulting from the project is currently unavailable.

Table 1. ***Summary of the likelihood of physical hearing and behavioural effects on individual marine mammals exposed to noise from five types of marine construction activities for the Galway Harbour Extension Project: 1a) Dredging Backhoe; 1b) Dredging TSHD; 1c) Pile driving; 1d) Blasting and 1e) Shipping noise in the absence (no mitigation) and presence (mitigation) of proposed mitigation measures.*** *Physical hearing effects include Permanent Threshold Shift (PTS) and Temporal Threshold Shift (TTS). Species' specific threshold levels for effects (SPL(peak)/SEL threshold) are published data from Southall et al. (2007). The impact zone (m) from source states the maximum distance or estimated range category from the source at which either SEL or SPL threshold levels are exceeded. Impact zones were calculated using received sound levels quantified in Appendix 10.2 of the EIS (Galway Harbour Company 2014), using a precautionary approach. For all sound types other than single pulses, threshold levels for behavioural effects (*) are not included, but are assumed to occur more commonly at levels below PTS/TTS threshold levels (Southall et al. 2007), and are defined as Medium (0 - 2500 m), and Large (>2500 m; Appendix 10.2 Galway Harbour Company 2014). Definitions: Likely: The likelihood of occurrence of the impact is high; Unlikely: The likelihood of occurrence of the impact is low; Possible: The impact is likely if animals are present in the area (for occasional- infrequently recorded species). Abbreviations: Trail Suction Hopper Dredgers (TSHD), Sound Pressure Level (SPL), Sound Exposure Level (SEL), Does not occur (d.n.o.). Not available (N/A), Behaviour (Beh.).*

1a) BACKHOE DREDGING					
Species	Acoustic impact	SPL(peak)/SEL threshold	Impact zone (m)	Impact (no mitigation)	Impact (mitigation)
Harbour seal	PTS	218/203	8	Likely	Unlikely
	TTS	212/183	80	Likely	Unlikely
	Beh. effect	*	Large	Likely	Likely
Grey seal	PTS	218/203	8	Possible	Unlikely
	TTS	212/183	80	Possible	Unlikely
	Beh. Change	*	Large	Possible	Possible
Bottlenose dolphin	PTS	230/215	2	Unlikely	Unlikely
	TTS	224/195	15	Unlikely	Unlikely
	Beh. effect	*	Large	Likely	Likely
Common dolphin	PTS	230/215	2	Unlikely	Unlikely
	TTS	224/195	15	Unlikely	Unlikely
	Beh. effect	*	Large	Likely	Likely
Harbour porpoise	PTS	230/215	1	Unlikely	Unlikely
	TTS	224/195	15	Likely	Unlikely
	Beh. effect	*	Large	Likely	Likely
Minke whale	PTS	230/215	N/A	Unlikely	Unlikely
	TTS	224/195	N/A	Unlikely	Unlikely
	Beh. effect	*	N/A	Unlikely	Unlikely

1b) TSHD DREDGING					
Species	Acoustic impact	SPL(peak)/SEL threshold	Impact zone (m)	Impact (no mitigation)	Impact (mitigation)
Harbour seal	PTS	218/203	10	Likely	Unlikely
	TTS	212/183	100	Likely	Unlikely
	Beh. effect	100	Large	Likely	Likely
Grey seal	PTS	218/203	10	Possible	Unlikely
	TTS	212/183	100	Possible	Unlikely
	Beh. effect	*	Large	Possible	Possible
Bottlenose dolphin	PTS	230/215	2	Unlikely	Unlikely
	TTS	224/195	20	Unlikely	Unlikely
	Beh. effect	*	Large	Likely	Likely
Common dolphin	PTS	230/215	2	Unlikely	Unlikely
	TTS	224/195	20	Unlikely	Unlikely
	Beh. effect	*	Large	Likely	Likely
Harbour porpoise	PTS	230/215	9	Unlikely	Unlikely
	TTS	224/195	90	Likely	Unlikely
	Beh. effect	*	Large	Likely	Likely
Minke whale	PTS	230/215	N/A	Unlikely	Unlikely
	TTS	224/195	N/A	Unlikely	Unlikely
	Beh. effect	*	N/A	Unlikely	Unlikely

1c) PILE DRIVING					
Species	Acoustic impact	SPL(peak)/SEL threshold	Impact zone (m)	Impact (no mitigation)	Impact (mitigation)
Harbour seal	PTS	218/186	100	Likely	Unlikely
	TTS	212/171	600	Likely	Unlikely
	Beh. effect	212/171	Large	Likely	Likely
Grey seal	PTS	218/186	100	Possible	Unlikely
	TTS	212/171	600	Possible	Unlikely
	Beh. effect	212/171	Large	Likely	Likely
Bottlenose dolphin	PTS	230/198	17	Possible	Unlikely
	TTS	224/183	100	Possible	Unlikely
	Beh. effect	224/183	Large	Likely	Likely
Common dolphin	PTS	230/198	17	Possible	Unlikely
	TTS	224/183	100	Possible	Unlikely
	Beh. effect	224/183	Large	Likely	Likely
Harbour porpoise	PTS	230/198	16	Likely	Unlikely
	TTS	224/183	90	Likely	Unlikely
	Beh. effect	224/183	Large	Likely	Likely
Minke whale	PTS	230/198	N/A	Unlikely	Unlikely
	TTS	224/183	N/A	Unlikely	Unlikely
	Beh. effect	224/183	N/A	Unlikely	Unlikely

1d) BLASTING					
Species	Acoustic impact	SPL(peak)/SEL threshold	Impact zone (m)	Impact (no mitigation)	Impact (mitigation)
Harbour seal	PTS	218/186	50	Likely	Unlikely
	TTS	212/171	160	Likely	Unlikely
	Beh. effect	212/171	Large	Likely	Likely
Grey seal	PTS	218/186	50	Possible	Unlikely
	TTS	212/171	160	Possible	Unlikely
	Beh. effect	212/171	Large	Likely	Likely
Bottlenose dolphin	PTS	230/198	45	Possible	Unlikely
	TTS	224/183	90	Possible	Unlikely
	Beh. effect	224/183	Large	Likely	Likely
Common dolphin	PTS	230/198	45	Possible	Unlikely
	TTS	224/183	90	Possible	Unlikely
	Beh. effect	224/183	Large	Likely	Likely
Harbour porpoise	PTS	230/198	45	Likely	Unlikely
	TTS	224/183	90	Likely	Unlikely
	Beh. effect	224/183	Large	Likely	Likely
Minke whale	PTS	230/198	N/A	Unlikely	Unlikely
	TTS	224/183	N/A	Unlikely	Unlikely
	Beh. effect	224/183	N/A	Unlikely	Unlikely

1e) SHIPPING NOISE				
Species	Acoustic impact	SPL(peak)/SEL threshold	Impact zone (m)	Impact (no mitigation)
Harbour seal	PTS	218/203	d.n.o.	Unlikely
	TTS	212/183	3	Possible
	Beh. effect	*	Large	Likely
Grey seal	PTS	218/203	d.n.o.	Unlikely
	TTS	212/183	3	Possible
	Beh. effect	*	Large	Possible
Bottlenose dolphin	PTS	230/215	d.n.o.	Unlikely
	TTS	224/195	d.n.o.	Unlikely
	Beh. effect	*	Medium	Possible
Common dolphin	PTS	230/215	d.n.o.	Unlikely
	TTS	224/195	d.n.o.	Unlikely
	Beh. effect	*	Medium	Possible
Harbour porpoise	PTS	230/215	d.n.o.	Unlikely
	TTS	224/195	d.n.o.	Unlikely
	Beh. effect	*	Large	Likely
Minke whale	PTS	230/215	N/A	Unlikely
	TTS	224/195	N/A	Unlikely
	Beh. effect	*	N/A	Unlikely

2.3 Mitigation

Mitigation measures as proposed in the EIS (Galway Harbour Company 2014) are likely to minimise strong and direct effects of the construction activities, thereby also mitigating population-level effects resulting from those effects. Harbour seals, grey seals, bottlenose dolphins, short-beaked common dolphins, harbour porpoises and minke whales have all been observed in the area of the proposed activities. Due to differences in abundance, behaviour and life-strategy, some species are more likely to be affected by the construction activities than others. In light of the possible impacts of the proposed activities, qualified marine mammal observers should conduct visual observations before and during developmental work in the water, and all activities will be put to a halt or postponed if the situation so requires. Mitigation measures should be performed as described in detail in "The Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters" by the Department of Arts, Heritage and Gaeltacht (DAHG 2014). All construction activities (see 4.3.1. NPWS 2014), that may impose an impact on marine mammals should adhere to these technical guidelines. A brief summary of the main topics of the guidelines are provided below:

- One or more qualified marine mammal observer(s) (MMO) conduct monitoring in the "monitored zone" or exclusion zone for a minimum of 30 min (pre-start monitoring) before the start of construction activity (pile driving, dredging, drilling and blasting), and when construction activities cease for more than 30 min.
- Construction activities shall start only after confirmation given by the MMO, and will not commence if marine mammals are detected within a 500 - 1,000 m radial distance of the sound source, depending on activity type (see DAHG 2014).
- Ramp-up (soft start) mitigation procedures should be implemented for all pile driving and geophysical surveys undertaken, and only commence after confirmation given by the MMO.
- Marine mammal observers will provide daily reports including the monitoring and construction operations, mitigation measures undertaken, and description of any observed reaction by marine mammals, using the standard operation forms for Coastal/Marine works.
- Daily reports are to be submitted to the relevant regulatory authority within 30 days after completion of the operations.

Next to direct monitoring during the construction activities, we recommend that dedicated research is undertaken in the Galway Bay cSAC, with a focus on the area affected by the construction activities, investigating:

1) Distribution and abundance of all marine mammals species prior, during and post-construction, including mark-recapture studies and ongoing acoustic monitoring.
2) Behavioural patterns and aquatic habitat-use of all marine mammals species prior, during and post-construction, including on-animal data loggers.
3) Prey species presence and abundance prior, during and post-construction.
4) Marine mammal responses to construction activities.

2.4 Summary

Two pinniped and four cetacean species occur in Galway Bay cSAC and the greater Galway Bay. Based on current available information, the harbour seal is resident in the area, harbour porpoises are frequently sighted, bottlenose dolphins and common dolphins are infrequently sighted but regularly recorded acoustically, and minke whales and grey seals are infrequently present.

Given the scale of the development and associated loss of marine habitat resulting from the project, significant impacts on marine life in the cSAC area cannot be ruled out. These activities have the potential of disturbing the marine mammals in the area, both physically and behaviourally. Dredging, pile driving, blasting, general construction in the marine environment and shipping will likely cause acoustic disturbance, while physical presence of vessels may increase the risk to collision. Acoustic disturbance in close proximity to the animals can cause temporary or permanent hearing threshold shifts and may lead to behavioural changes at larger distances. However, the proposed mitigation actions are likely to effectively reduce and minimise the risk of direct physical (hearing) injuries (PTS, TTS) and behavioural changes caused by underwater noise or collisions. Secondary impacts, by changes in prey abundance and distribution, may also occur.

In general, the current knowledge of fine-scale habitat use in Irish waters is insufficient to determine if marine mammals will be deterred from key functional areas, and to what extent essential parts of their life cycle might be affected. Of the marine mammal species present in the Galway Bay cSAC, harbour seals and harbour porpoises have the highest probability to be affected by the construction works, due to their residency/frequent occurrence in the Galway Bay cSAC, and, in case of the harbour seal, use of the area for essential life functions (foraging, nursing, breeding, mating, resting and moulting). Of these essential life functions, the terrestrial activities (terrestrial resting, breeding and moulting, not assessed here), are not directly affected by the marine construction works. These activities constitute of three of the five conservation objectives for harbour seals in the Galway Bay cSAC (NPWS 2013). The remaining two conservation objectives (access to suitable habitat and disturbance) will potentially be affected due to either direct or indirect effects of the construction activities. Marine mammals either are unlikely to be affected at a population level (grey seal, minke whale, common dolphin, bottlenose dolphin), or are likely to recover from any impacts of the construction activities (harbour seal, harbour porpoise). Here, the probability and speed of recovery will depend on the relative importance of the area for the species, behavioural characteristics and area quality post-construction. Proposed mitigation measures are likely to minimise strong and direct effects in close proximity to the construction activities for all marine mammals.

3. Aquatic habitat use of the harbour seal (*Phoca vitulina*)

3.1 Introduction

Harbour seals are one of the most widespread pinniped species, distributed from temperate to polar regions throughout the coastal waters of the Northern Hemisphere (Thompson & Härkönen 2008). In Ireland, the harbour seal inhabits bays, rivers, estuaries and intertidal areas, primarily along the western Atlantic coast (Cronin et al. 2004, Ó Cadhla et al. 2007, Duck & Morris 2013a, b). Adult males are up to 1.9 m long and weigh 70-150 kg. Females reach 1.7 m in length and 60-110 kg in weight. At birth, pups are 65-100 cm long and weigh 8-12 kg (Burns 2002).

Harbour seals require both terrestrial and marine habitat. The terrestrial habitat use includes periods of resting, breeding/nursing and moulting behaviour, while access to sea is required for obtaining food and for nursing and mating. The terrestrial localities, generally referred to as haul-out sites, are often used by the same individuals over consecutive years (Thompson et al. 1998, Cronin et al. 2009). However, shifts in preferred haul-out sites have been known to occur within an SAC (Cordes et al. 2011).

The high site-fidelity for both foraging and resting behaviours classifies harbour seals as central-place foragers (Orians & Pearson 1979) and offers the opportunity for the identification of key habitat and the development of Special Areas of Conservation for this species (Thompson et al. 1997, Cunningham et al. 2008). The dependence on terrestrial habitat for resting, moulting and rearing pups has provided opportunities to conduct large-scale population assessments, identifying population growth and decline in different regions worldwide (Lonergan et al. 2007).

In Ireland, national harbour seal censuses were conducted in 2003 (Cronin et al. 2004) and in 2011-2012 (Duck & Morris 2013a, b). These recorded an 18% increase in the overall number of harbour seals between 2003 and 2012, from a total of 2955 to 3489 individuals (Cronin et al. 2004, Duck & Morris 2013b). These estimates could not be corrected for the proportion of animals at sea at the time of the survey and hence likely underestimate the total number of individuals (e.g. due to age- and sex related differences in haul-out behaviour; Thompson et al. 1989, Härkönen et al. 1999).

Harbour seal in the Galway Bay cSAC
The harbour seal is a resident species of the Galway Bay cSAC and the species has been incorporated in the conservations objective target statement of the SAC (NPWS 2013). The inner Galway Bay is home to a significant population of harbour seals within Irish coastal waters (Duck & Morris 2013a, b). The area includes a number of haul-out, breeding and moulting sites for the species (NPWS 2013). Between 2003 and 2011, the number of harbour seals in the inner Galway Bay increased from 200 to 248 individuals (Duck & Morris 2013a, b). On a larger regional scale, harbour seals increased from 467 individuals in 2003, to 886 in 2011/12 in County Galway, an increase of 75% (Duck & Morris 2013b). Opposed to the terrestrial habitat use, relatively little is known about the aquatic habitat use of harbour seals in the Galway Bay cSAC.

During fish predation surveys 50 harbour seals were recorded foraging on sprat (Galway Harbour Company 2014). In addition, available water depth, habitat type, prey presence and proximity to haul-out sites suggest the Galway Bay cSAC likely functions as a foraging area for harbour seals.

3.2 Diving behaviour

The diving and foraging behaviour of harbour seals have been studied using a variety of electronic recorders, including time-depth (TDR) and satellite dive recorders. By combining dive profiles, stomach temperature, telemetry and swim speed recordings, these studies have allowed the allocation of function to different dive types (e.g. Lesage et al. 1999). No studies using TDR or other recorders of diving behaviour have been conducted with harbour seals in the Galway Bay cSAC. Hence, no specific or detailed data is available on the diving behaviour of the harbour seal in the area.

Dive types

Harbour seal dives typically fall into one of two broad categories: deep foraging dives referred to as "square" or "U-shaped" dives, and "V-shaped" dives, which are often more shallow (Schreer et al. 2001). The remaining dives are a variation of these two shapes. The U-shaped dive is the most common dive type exhibited by the harbour seal (Baechler et al. 2001, Eguchi et al. 2005, Wilson et al. 2014).

U-shaped or square-shaped dives are typically considered foraging dives based on the increased proportion of time spent at depth (Wilson et al. 2014). These dives are often longer in duration and have a greater mean depth than V-shaped dives (Lesage et al 1999, Schreer et al. 2001, Eguchi et al. 2005). However, male harbour seals conducted U-shaped dives while travelling within their home range (Baechler et al. 2001) and as part of mating behaviour (Hanggi & Schusterman 1994), indicating this dive type is not solely linked to foraging. V-shaped dives consist of more shallow dives, which are generally shorter in duration than U shaped dives, and are associated with travelling, predator avoidance and exploration behaviour (Lesage et al. 1999, Schreer et al. 2001). The reduction in drag during V-shaped dives enables more efficient travelling, while potentially increasing the chances to encounter prey (Williams & Kooyman 1985). Harbour seals in St Lawrence conducted both U- and V-shaped dives during foraging behaviour, which may suggest that dive types represent different foraging strategies (Lesage et al. 1999). Wiggles in the dive profile have been observed in both U- and V-shaped dives and likely refer to patchy prey distribution (Wilson et al. 2014). Harbour seals typically conduct consecutive foraging dives within a dive bout, with only a small percentage of foraging dives conducted outside of these bouts (Wilson et al. 2014).

The proportion of U- and V-shaped dives changes with age, season and age-class. Adult males conduct more U-shaped dives than females (Baechler et al. 2001). The proportion of U-shaped by male harbour seals declined from 63 to 45% between premating and mating periods, indicating a behavioural change and alteration of aquatic habitat use in this period (Baechler et al. 2001). Subsequently, the proportion of V-shaped dives significantly increased during the mating season. Adult females altered their diving behaviour during periods of lactation: U-shaped dives increased significantly from early to late lactation, whereas the number of V-shaped dives decreased (Baechler et al. 2001). During the breeding season, both male and female harbour seals shifted towards more V-shaped dives (Wilson et al. 2014). Suckling pups showed an increase in U-shaped dives, and subsequent decline in V-shape dives between the early and late lactation period (Baechler et al. 2001). Weaned pups showed an increase of U-shaped dives over the first month post weaning, while the proportion of V-shaped dives significantly decreased (Baechler et al. 2001).

Diurnal patterns

Several studies reported diurnal dive patterns of harbour seals. In St Lawrence, harbour seals conducted U-shape dives with an average depth of 20 m during daylight whereas dives occurred in shallower waters (~8 m) at twilight and during the night (Lesage et al. 1999). A greater percentage of V-shaped dives was exhibited at night during the breeding season in San Juan Islands, along the US Pacific coast (Wilson et al. 2014). Harbour seals in Prince William Sound spent more time in-water and diving at night between September and April (80%) compared to 50% in July (Frost et al. 2001). Similar night time diving behaviour was reported for individuals in the Moray Firth, which was thought to reflect the diurnal behaviour of vertically migrating prey, which becomes more accessible at night (Thompson et al. 1989).

Time-in-water

Harbour seals generally haul out on sandbanks and rocky shorelines that become available during low tide (Schneider & Payne 1983, Pauli & Terhune 1987, Cronin et al. 2009). Some populations also use high tide haul-out sites (London et al. 2012). In general, seals spend most of their time in the water: 61%-93% in Moray Firth, Scotland (Thompson et al. 1998), 76%-93% in the Dutch Wadden Sea (Ries et al. 1997) and 68%-75% in Monterey Bay, US (Frost et al. 2001). Males and females spend a similar percentage of time in the water (Thompson et al. 1998). In the water, harbour seals spend most of their time foraging (e.g. 76% of the time in Moray Firth; Thompson et al. 1998). Multi day foraging trips are common, and appear to be conducted by both male, female and juvenile seals (Thompson et al. 1998, Lowry et al. 2001, Sharples et al. 2012, Wilson et al. 2014).

Time-in-water shows fluctuations on both daily and seasonal scales. In Ireland, harbour seals spent the most time at sea during the winter months and remained the most time ashore post-moulting in October (Cronin et al. 2009). This pattern is consistently reported in other studies (Frost et al. 2001). Terrestrial habitat use increases during the breeding and moulting season when harbour seals spend approximately 60% of their time on the haul-out site and 40% in the water (Yochem et al. 1987, Thompson et al. 1989). Frost et al. (2010) suggested that prey may become more abundant in near shore waters in summer, resulting in seals spending less time in the water. Subsequently, a deeper mean dive depth was recorded during winter months compared to summer months, which suggests that prey becomes less accessible in shallow waters during this period (Frost et al. 2001). Harbour seals in Prince William Sound spent the least time in the water diving in the morning (0300- 0900), which increased throughout the day and was highest at night (2100-0300; Frost et al. 2001).

Diving depth

Harbour seals prefer water depths ranging from 4 to 100 m depth (Bjørge et al. 1995, Lesage et al. 1999, Lesage et al 1999, Frost et al. 2001, Bailey et al. 2014). For example harbour seals in Prince William Sound have nearby access to waters >200 m deep, while the majority of their foraging dives are confined to waters 20-100m deep (Frost et al. 2001). The at-sea distribution of harbour seals in the Moray Firth was related to water depth and seabed slope (Bailey et al. 2014). Here, harbour seals showed a preference for foraging in water depth between 10 and 50 m, and tended not to use waters less than 10 m deep (Tollit et al. 1998). In contrast, in the St. Lawrence estuary in eastern Canada, fifty-four percent of the total dives of harbour seals were found to be in water less than 4 m deep (Lesage et al. 1999).

Diving and foraging strategies of harbour seals are tailored to their local habitat and hence differ within a heterogeneous marine landscape. Regional patterns in dive depth were identified as part of a large-scale study of harbour seal behaviour around Britain. Based on a large dataset including data from all main harbour seal haul-out sites, Sharples and colleagues (2012) found large regional variation in dive patterns coinciding with habitat type and available water depth surrounding the haul-out sites. Typically, individuals inhabiting the more shallow waters along the British east coast conducted longer distance foraging trips than seals inhabiting the deeper waters north and west coast of Scotland (Sharples et al. 2012). In addition, regional patterns showed a relation between maximum depth during foraging and accessible habitat (Sharples et al. 2012).

3.3 Foraging behaviour

Sensory detection of prey

Harbour seals use their whiskers to detect water movement and accurately follow hydrodynamic trails generated by fish, which enables long distance prey location (Dehnhardt et al. 1998, 2001). Seals maximally reduce the whiskers' basic noise by means of undulating the surface structure of the hair. This optimizes its signal to noise ratio and enhances its sensory performance (Miersch et al. 2011). In theory, a hydrodynamic trail of a fish (e.g. herring), might be detectable for a seal up to 180 m away (Dehnhard et al. 2001). Using its extraordinarily well-developed vibrissae, seals are capable of foraging at night and in murky waters, besides using vision to search and catch prey during daytime. As all other pinnipeds (and cetaceans), the harbour seal is considered to be functionally colour blind (Peich et al. 2001). The sensitivity of the eyes however, is high, and seals are probably able to orient visually even at great depth (Levenson & Schusterman 1999).

Diet

Harbour seals are opportunistic and catholic feeders (Harkonen 1987, Pierce & Santos 2003, Andersen et al. 2004, Kavanagh et al. 2010). Within the northeast Atlantic, they feed mainly on teleost fish species (Kavanagh et al. 2010). In the Moray Firth, harbour seals mainly foraged in waters between 10 and 50 m deep (Tollit et al. 1998). Mid-water dives recorded during foraging trips were thought to be encounters with pelagic prey (Tollit et al. 1998).

A relatively small number of species dominates the diet of harbour seals, but seasonal shifts in diet are seen in many areas, associated with seasonal fluctuations in prey availability (Brown and Mate 1983, Tollit et al. 1998). The diet of harbour seals in the Moray Firth consists primarily of bottom associated prey species (Tollit & Thompson 1996), including sand eel, lesser octopus, whiting, cod and flounder. Similar diets were recorded in Scotland (Pierce et al. 1991), Sweden (Harkonen 1987) and Iceland. Sand-eels consisted of the main prey during the summer months both in Scottish and Baltic coastal waters, gadoids contributed to the diet in winter, while cephalopods were mostly recorded in summer, coinciding with seasonal prey availability in coastal waters (Tollit and Thompson 1996, Tollit et al. 1998). Harbour seals along the Irish west coast hunt on a wide variety of prey, with a few dominant prey species (sole, sand eel and Trisopterus species) representing the majority (47%) of the diet biomass (Kavanagh et al. 2010). Harbour seals in Puget Sound, US, inhabiting rocky-reef sites, foraged on bottom dwelling species (Lance et al. 2012). A large part of their diet consisted of vertically migrating schooling fish including herring, Pacific hake and salmon (Lance et al. 2012).

Foraging strategy

The foraging behaviour of a harbour seal varies with season, species and locality. They are opportunistic predators, changing their foraging tactics depending on the behaviour and distribution of the prey species (Middlemas et al. 2006, Thomas et al. 2011), which correlate with habitat and sediment type (Payne et al. 1989). Seasonal differences in diet composition as well as inter-annual variations found within haul-out sites, further stipulate the ecological flexibility of the harbour seal diet. This opportunistic character is illustrated by a rare observation of a foraging event within the Galway Bay cSAC, whereby numerous harbour seals were feeding on a large shoal of sprat (Galway Harbour Company 2014).

In general, optimal foraging conditions are influenced by i) local bathymetry, ii) the ability to maximise foraging time, iii) and the availability of prey. Analysis of foraging behaviour using time depth recorders (TDRs) showed that harbour seals generally forage at or near the seabed (e.g. Harkonen 1987, Bjorge et al. 1995). Telemetric studies identified that the species forages within 50 km of haul-out sites, and primarily within 10-20 km (Tollit et al. 1998, Thompson et al. 1998, Cunningham et al. 2008, Wilson et al. 2014). In many areas, harbour seals exhibit two foraging strategies (Thompson et al. 1998, Grigg et al. 2009). In one strategy, harbour seals make short, daily trips to and from foraging areas near the haul-out site; in the alternative strategy, harbour seals make longer foraging trips to more distant foraging areas, often lasting for a number of days and followed by extended haul-out period. Grigg and colleagues (2009) reported a spatial overlap between harbour seal distribution at sea and distribution of prey within San-Francisco Bay. This overlap was found to be more accurate within 10 km and declined with increasing distance from the haul-out site. Furthermore, Grigg and colleagues (2009) revealed that harbour seals often return to the same foraging area, showing that they are able to identify foraging areas over long time scales. Similar preferences for and repeated usage of foraging areas were recorded in the Moray Firth (Thompson et al. 1994, Cordes et al. 2011, Bailey et al. 2014).

Recordings of foraging trip durations in the Moray Firth showed that over 70% of the harbour seals made foraging trips longer than 24 h. Similar trip duration was observed in south-west Scotland (25 h) and in north-west Scotland (35 h; Cunningham et al. 2009) and for individual seals along the Irish west coast (Cronin et al. 2009). In the Moray Firth, a positive relation was found between the length and the body mass of an individual and the duration and length of the foraging trip: larger males conducted the longest foraging trips (Thompson et al. 1998). No such correlation was found between forage trip distance and body mass during a study along the Scottish west coast (Cunningham et al 2008). Foraging behaviour of adult females changes during the breeding season (Thompson et al. 1994). During pre-pupping period, adult females conducted regular foraging trips. During the pupping period, long distance foraging trips ceased, and females remained within 2 km from the haul-out site, indicating a reduction in home range during this period. 10-24 days after the pupping period, long distance foraging trips resumed (Thompson et al. 1994).

Sex- and age-class specific foraging behaviour

Studies on harbour seals in the Moray Firth found a correlation between body mass, dive duration and dive depth, indicating larger adult seals conducted deeper and longer dives (Tollit et al. 1998). This likely results in a reduction in intraspecific competition for food resources in inshore areas. Here, both foraging range and foraging-trip duration were observed to be relatively short for the body size of females compared to males (Thompson et al. 1998). Thompson et al. (1998) furthermore suggested that harbour seals would forage as far as possible within the energy and time budget, which is constrained by their body-size. A positive relationship between body mass and dive duration of long dives was also reported for harbour seals in Monterey, California (Eguchi et al. 2005). In contrast, no body mass relationship was apparent for harbour seals along the Scottish west coast (Cunningham et al. 2008). The authors argued that food availability requirements for all individuals, regardless of sex or size, were accessible within easy range of the haul-out cluster throughout the year. Similarly, no body mass-dive correlation, or sex-related differences in at-sea movements were recorded in harbour seals inhabiting Prince William Sound (Lowry et al. 2001). In Prince William Sound, where the bathymetry is highly variable and a large range of water depths is available to seals within a few kilometres from their haul-out site, harbour seals prefer water depths between 20-100 m (Lowry et al. 2001). Interestingly, the horizontal foraging ranges of seals were found to be fairly similar to those for harbour seals in other areas (Lowry et al. 2001).

Pup foraging

Harbour seal pups are exceptional among phocids due to their ability to swim and enter the water soon after birth (Bowen et al. 1999). Pups perform dives associated with foraging before weaning (Jorgensen et al. 2001), and may accompany their mother at sea during foraging trips (Bowen et al. 1999). As a result, harbour seal pup development contains a large aquatic component. Studies using stomach temperature telemetry identified that pups primarily nurse in water (Schreer et al. 2010) and ingest approximately two-third (68%) of the milk when in water (Sauve et al. 2014). Accordingly, female harbour seals undertook foraging trips beyond the first week of lactation (Thompson et al. 1994).

3.4 Movement patterns

Range

Harbour seals are capable of travelling long distances, covering several hundreds of kilometres during foraging trips (Lowry et al. 2001). Several studies have investigated foraging behaviour and movements of harbour seals using VHF radio-telemetry (e.g. Allen 1988, Thompson et al. 1989, Thompson & Miller 1990, Bjørge, et al. 1995). Individual harbour seals foraged within 50 km of haul-out sites, with the majority of individuals remaining within 10-20 km from the haul-out site. More accurate satellite telemetry studies in recent years confirmed these small-scale movement patterns within coastal waters (Cunningham et al. 2008), while simultaneously identified offshore trips formed a larger component of the harbour seal movement patterns than previously described (Sharples et al. 2012, Peterson et al. 2012).

Several studies identified individual harbour seals to conduct multi-day foraging trips that covered several hundreds of kilometres from the haul-out location (Lowry et al. 2001, Cunningham et al. 2008, Cronin et al. 2009). Analysis of behavioural data of 118 tagged harbour seals in seven core regions around Britain showed a high variability between individual at-sea movements (Sharples et al. 2012). The results furthermore revealed that the observed variations in trip duration and distance travelled could not be explained by differences in size, sex and body condition of the tagged individuals, but concluded that foraging variability was best supported by habitat and environmental constrains at a regional level. In addition to the haul-out fidelity and adjacent movement in coastal waters, the study identified a more pronounced offshore component in the movement pattern of the harbour seal than previously identified, and wide-ranging movements into offshore waters were observed in all colonies along the British coasts (Sharples et al. 2012). Similarly, a high number of tagged adult males in Paddila Bay, near Vancouver Island, Canada, conducted long distance movements >100 km (Peterson et al. 2012). Preferential use of certain habitats or response to spatio-temporal changes in prey density may explain such movements (Peterson et al. 2012).

Age- and sex-specific variation in movement patterns

Individual variation in movement patterns was evident in most studies. In the Moray Firth, adult male seals conducted longer foraging trips and covered larger distances than females (Thompson et al. 1998). In contrast, Lowry et al. (2001) found that juvenile harbour seals in Prince William Sound (PWS) travelled larger distances, moved between more spread out haul-out locations, and ranged further offshore during foraging trips than adult seals. The average distance from haul-out sites of the smaller juvenile harbour seals in PWS was almost twice as far as for adults. Juvenile dispersal, emigration and establishment of new haul out sites are possible reasons for long-range movements of harbour seals (Burns 2002).

Home range

Thompson and colleagues (1998) reported that the mean foraging range, and hence the home range for adult males was larger than that for females. In contrast, females in Prince William Sound exhibited larger home ranges than males, and home range size variations showed large variations over the year (Lowry et al. 2001). Furthermore, juveniles were found to maintain a greater home range, and travelling longer distances between haul-out sites than adult seals in Prince William Sound (Lowry et al. 2001). Seasonal variation in home range size is linked to behavioural patterns during breeding and moulting. Female home range declined with the onset of pupping when females remained within 2 km from the haul-out site (Thompson et al. 1994). In Prince William Sound, both male and female harbour seals showed a similar decline in home range during the breeding season, however, male home range size showed more variation (Lowry et al. 2001).

Site fidelity

Intensive short-term studies have shown that harbour seals display high levels of site-fidelity over periods of months to years (Härkönen & Heide-Jørgensen 1990, Thompson et al. 1997). Observations in many regions have shown that harbour seal pupping sites are used consistently in successive years (Lonergan et al. 2007). Satellite derived telemetry data collected during two years revealed that harbour seals in southeast Scotland spent 39% of time within 10 km of haul-out sites between November and June (Sharples et al. 2009). Along the southwest coast of Scotland, individual seals used on average 13 haul-out locations (range 6-29, Cunningham et al.

2008). The number of sites was positively correlated with the duration of tag deployment, suggesting individuals do visit more haul out locations over time. The seals used different haul-out sites in the autumn/winter (October to February) compared to spring/summer (March to July) (Cunningham et al 2008). The distances between these seasonal haul-out sites ranged between 40 and 130 km. In addition, almost half of the identified haul-out sites were not used for return trips and described as transient sites, while only a small number of haul-out sites showed a high level of individuals returning back (Cunningham et al. 2008). Cordes and colleagues (2011) described changes in the long-term pattern of haul-out use in the Special Area of Conservation in the Moray Firth, Scotland, showing considerable inter-annual variability in both abundance and the relative importance of areas within the SAC, and nearby areas (Cordes et al. 2011). Over a 20 year period, the harbour seal distribution shifted from the SAC to a nearby estuary, resulting in a drastic decline in mother pup pairs within the SAC. The foraging areas used by females remained broadly the same during both periods, hence the redistribution was thought to be caused by a decline in the quality of the haul-out, rather than a change in foraging behaviour (Cordes et al. 2011).

3.5 Mating behaviour

The mating structure of the harbour seal is described as a lek-system in which males aggregate and display to attract females (Bradbury 1981). During the mating period, male seals use multiple tactics to acquire access to females (e.g. Hayes et al. 2004, Boness et al. 2006). Mating behaviour of the harbour seal occurs mainly in the water (Van Parijs et al. 1997). The mating season has been described to start directly after the suckling period, at end of lactation (Thompson et al. 1994, Van Parijs et al. 1997). At the start of the mating period, males spend more time in the water and the size of the home range decreases, in order to increase their chances of encountering females (Boness et al. 2006, Cunningham et al. 2008). Male seals change their diving behaviour and show an increase in short shallow dives (Van Parijs, et al. 1997). These shorter dives form part of an underwater display behaviour, during which males produce simple stereotyped broadband roar vocalizations for the purpose of attracting females and competing with other males (Van Parijs et al. 1997, Bjørgesæter et al. 2004, Boness et al. 2006). Various acoustic vocalisation behaviours have been identified including single male display, and aggregations of multiple males (Hayes et al. 2004). This display behaviour may occur near haul-out sites, in foraging areas, and on transit between both sites (Van Parijs et al. 2000a, Hayes et al. 2004). Male seals established different acoustic and display based territories, through which females freely travelled (Hayes et al. 2004). Acoustic evidence indicated that areas were occupied by single males (Van Parijs et al. 2000b). Site-fidelity to territories was found to last at least 2-4 years (Van Parijs et al. 2000b, Hayes et al. 2004). Female harbour seals choose males based on the display and vocal display (Hanggi and Schusterman 1994, Boness et al. 2006).

3.6 Anthropogenic impacts

The type and the severity of a behavioural response as a result from an anthropogenic disturbance are variable and dependent on multiple abiotic (e.g. type of disturbance, the frequency of occurrence, time of day), and biotic factors (e.g. behavioural state, group size, habituation; Bejder et al. 2009). Biological disturbance due to anthropogenic noise has been receiving more and more scientific attention over the past decade. Leading in this field is the information on cetaceans, as they are known to rely heavily on sound and feature on most agreements of species protection. Pinnipeds have been somewhat less studied, possibly because they forage by sight and sense rather than sound (Schusterman et al. 2000). Currently however, there remains a large uncertainty about the extent to which predicted noise levels may impact individual seals (Thompson et al. 2013), illustrated by the preliminary nature of the noise exposure criteria developed by Southall et al. (2007). Nevertheless, it is recognized that acoustic disturbance is an important issue in pinniped conservation, because of the relatively high sensitivity of these animals to low frequency sounds, which constitute most anthropogenic noise. For example, disturbance of foraging behaviour is predicted to lead to increased competition for food, greater energetic cost of foraging, or reduced foraging opportunities, which likely will cause a reduction in an individual seal's overall energy balance followed by a decline in reproductive success and consequences and population-level (Thompson et al. 2013).

Direct effects

Both pinnipeds and cetaceans have been documented with mild to severe and lethal trauma after vessel collision (Moore et al. 2013). Distinctions can be made between blunt and sharp trauma, which are caused by rotating and non-rotating parts of the vessel, respectively (Moore et al. 2013). Different factors can affect the severity of the impact, such as vessel size and velocity, the angle at which collision takes place, and the anatomy of the body part that is hit (Laist et al. 2001, Vanderlaan & Taggart 2007, Moore et al. 2013). The likelihood of such collisions is thus far unclear, as frequency studies have only been conducted for species with very high incidences of collisions, such as right whales (Kraus et al. 2005). It has been stated that the number of collisions generally does not pose a threat to a species on population level (Weinrich et al. 2010), but quantitative reports on this matter have yet to be written.
Seals can taste the water, when opening the mouth, and their eyes are continuously exposed to whatever dissolved irritants there may be in the water. Such chemical pollution, irritating or even harmful to the seals could potentially be present during construction.

Direct disturbance and/or injury due to sound and intensified motorised vessel/plant/construction activities

Few studies have investigated the effect of disturbance on harbour seal behaviour. A controlled behavioural response study was conducted to investigate the anthropogenic impact on harbour seal haul-out behaviour (Anderson et al. 2012). The study, conducted within a seal reserve in Denmark during the breeding season, recorded the flight initiation for two stimuli: an approaching vessel and a pedestrian. The results showed that harbour seal decision-making was strongly influenced by the fleeing of neighbouring seals and seals became alert at greater distances with increasing group size. Furthermore, harbour seals responded to boat disturbance at significant greater distances than to an approaching pedestrian. Seals were alerted by approaching vessels at distances ranging between 560 to 850 m, and a flight response was initiated at distances ranging between 510 to 830 m (Anderson et al. 2012). For pedestrian approaches distances were shorter and ranged between 200 to 425, and 165 to 260m respectively. These patterns of response were consistent during pre-during and post breeding periods.

Johnson and Acevedo-Gutierrez (2007) observed that harbour seals were less affected when powerboats and kayaks passed by, but did flee when powerboats were approaching within 400 m. This difference may relate to an approaching vessel possibly blocking the direction of the seal's escape route (Anderson et al. 2012). During the breeding period, harbour seals may be very reluctant to flee completely from the haul-out site on approaching boats, and harbour seals returned significantly sooner to the haul-out site than for non-breeding period (Anderson et al. 2012). This reluctance to leave has been reported in other harbour seal populations (Henry & Hammill 2001). Interestingly, seals did not return until sunset irrespective of disturbance type when disturbances occurred outside the breeding season (Anderson et al. 2012). In addition, indirect effects, such as disturbed birds may cause an increased alert response by seals at a larger distance.

Grigg and colleagues (2012) identified that anthropogenic activity had a relative low influence on the aquatic distribution of seals in San Francisco Bay. Harbour seal distribution was primarily determined by high prey abundance and distance from the haul-out site. In fact, seals were found closer than expected to human activity, which included fishing activity, other (boat) activity and outflow locations. Harbour seals in Hood Canal, Washington, altered their haul-out pattern to coincide with peaks in anthropogenic activity. During periods of high human interactions in the summer, harbour seals were less likely to haul-out during the day, but instead hauled out more during night-time (London et al. 2012). In autumn and winter, when interaction rate was low, this shift was reversed.

Harbour seals may interact with fisheries, especially in coastal waters (Cosgrove et al. 2013). Cronin and colleagues (2014) conducted a review of fisheries interactions between harbour seal and fisheries in Irish waters. Grey seal interactions were found to be significant in inshore waters (<12 nautical miles from shore), and especially with static-net (or passive) fisheries (e.g. gill/tangle nets), which have increased following the driftnet ban in 2006. While little direct evidence is available, Cronin et al. (2014) assumed given the inshore distribution of the harbour seal, interactions are likely to be comparable between grey and harbour seals in Irish waters.

In Ireland, the use of pingers, or seal scarers, at salmon farms was effective, but only in the short term. Seals soon became habituated to the devices, which then were perceived to act as attractants (Cronin et al. 2014). Acoustic Deterrent Devices (ADD) were effectively used to reduce seal movements up Scottish rivers in which interactions between salmon rod and seals occurred (Graham et al. 2009). However multiple studies have reported the short effectiveness of acoustic deterrent devices with seals (Jacobs & Terhune 2002, Götz & Janik, 2013). In these cases, animals may tolerate or habituate to high noise levels (i.e. as the result of food motivation) and consecutively may suffer hearing damage, further reducing the responsiveness to ADDs (Götz & Janik, 2013). An additional side-effect of ADDs is that they may have an ecological effect on other marine species, in particular the harbour porpoise. New methods are currently developed that use selectively inflicted startle responses in harbour seals by using a frequency range that is sensitive to harbour seal, but less sensitive for non-target species including the harbour porpoise (Götz & Janik, 2014). The use of ADDs and pingers have the potential to be used as a conservation measure. During construction of offshore windpark in Denmark, seal scarers were used to keep seals and harbour porpoise away from the construction site, in order to prevent them from severe noise impact (see further below: Edrén et al. 2004). Likewise, Tougaard et al. (2006) found acoustic deterring devices (Aquamark 100, Lofitek seal scarer) to be efficient in order to deter seals and harbour porpoise out to safe distances, during piling, and anchoring of vessels during wind farm construction.

Industrial development
Long-term displacement of seals was recorded in Broadhaven Bay, Ireland during an offshore construction of a pipeline (Anderwald et al. 2013). The impact of the industrial construction resulted in a negative correlation between vessel number and seal abundance. Based on analysis of the vessel type, the authors stated that the observed decline was more likely caused by increased levels of underwater noise, than by increased collision risk. In recent years, the construction of offshore wind farms have resulted in an increase of studies investigating the effect of industrial developments on marine mammals. Koschinski and colleagues (2003) examined the reactions of harbour porpoise and harbour seal to playbacks of simulated noise from an offshore wind turbine (30 and 800 Hz peak source levels of 128 dB (re 1 $\mu Pa^2 Hz^{-1}$ at 1 m) at 80 and 160 Hz (1/3-octave centre frequencies). Underwater recordings were modified to simulate a 2 MW and used during a controlled playback scenario monitoring seal behaviour. The results showed harbour seals reacted at a distance of 200 m from the underwater speaker by making fewer surfacings. Madsen et al. (2006) criticised the research set-up and argued that the procedure introduced high frequency noise artefacts, to which species may have reacted instead of to the low frequency.

Short-term displacement effects were reported during the construction and operation of a wind farm in the Wadden sea, Denmark (Edren et al. 2010). Here, sheet pile driving during the construction phase caused a 10 to 60% reduction in the number of seals hauled-out on a sand bank approximately 10 km away, compared to periods with no pile-driving. Simultaneously with the pile driving, a seal deterrent (189 dB re 1 _Pa at 10–15 kHz) and porpoise pingers (145 dB re 1 _Pa at 20–160 kHz) were deployed from the pile driving platform and activated 30 min prior to pile driving at the turbine foundation to limit the number of seals and porpoises exposed to physically damaging noise. After the construction period, seals continued to use the haul-out site and abundance increased similar as recorded in nearby sites, indicating no long-term effects (Edren et al. 2010). During the construction phase, sound levels were not measured and seal behaviour in water was not monitored. Therefore, it remains unknown whether the seals reacted to under-water noise by leaving the general area, or reacted to airborne sound by remaining in the water.

Harbour seal movement patterns using satellite tags, showed scattered presence of harbour seals around the construction site during baseline and construction periods and a more consistent presence during operation of the wind farm (Teilmann et al. 2006). Unfortunately, the accuracy of the positions retrieved from satellite transmitters were found to be insufficient to conclude with certainty on the degree to which construction of the wind farm has affected seal movement patterns. After completion of two wind farms in the Danish Wadden sea, a study investigating harbour seal movements indicated no significant long-term effect of the operational wind farms on seal behaviour (McConnell et al. 2013). Seal dive and movement patterns showed individual seals moved inside and outside the wind farms within close proximity to individual wind farm towers. Operational noise from wind turbines at sites in Denmark and Sweden, was reported to be measurable only above ambient noise at frequencies below 500Hz, resulting in audibility for harbour seals from <100m to several kilometres (Tougaard et al. 2009). The authors concluded that operational sound levels may cause behavioural effects of harbour seals up to distances of a few hundred meters, while it was not thought to mask important biological sounds. Aerial counts of harbour seals during moulting in August, before and during the construction of the Øresund bridge, did not observe a reduction in the number of seals lying on rocks within 1.5 km of the bridge, although there was a tendency to use rocks further away from the work than previously (Heide-Jørgensen & Teilmann 1999). To assess population-level impacts of a proposed wind farm construction on harbour seals using the Dornoch Firth and Morrich More SAC, Moray Firth, Thompson et al. (2013) developed a framework model. Based on the spatial overlap of received sound levels and seal distribution, in combination with estimates of the impacts of noise exposure, the impact assessment model predicted a potentially large number of seals being either displaced or experiencing PTS. However, the population modelling used within the framework showed these short term effects did not result in long-term changes to the viability of this population, and identified immediate recovery after the construction phase (Thompson et al. 2013). Despite the fact that the framework benefited from a long history of research on the Moray Firth harbour seal population, it was recognized that the impact assessment incorporated a considerable level of uncertainty.

3.7 Discussion and conclusions

The harbour seal occurs in estuarine, coastal and offshore waters and utilises aquatic habitat for foraging, mating, nursing and breeding. The species is widely distributed and shows large flexibility in habitat use. Generally, harbour seals forage in waters up to 100 m depth, at 10 to 50 km from their haul-out sites. Harbour seals mainly forage within 10 to 20 km from their haul-out sites, but offshore trips (20 - >50 km) form an important part of their foraging strategy. Furthermore, harbour seals can show site-fidelity to specific foraging areas.

Potentially strong variation in diving behaviour, habitat use, ranging patterns, diet and foraging strategies between age- and sex classes exists, and may render certain individuals more sensitive to disturbance, or to changes in their habitat. In addition, these differences between age- and sex-classes generally vary between areas, for example depending on prey availability or habitat-type. Most studies show large individual variation, which reduces the extent to which individual behaviour can be used to predict population level effects. With the exception of mothers with nursing calves, it is therefore not possible to conclude which part of the population in the Galway Bay cSAC may be more or less vulnerable to the proposed construction activities. Nursing calves may accompany their mothers on foraging trips and are often nursed in the water. Ranging patterns during pupping, and of nursing mothers and calves, are more limited than those of the other life stages in the population, restricted to the areas more proximate to haul-outs. This spatial restriction will render them more vulnerable to disturbance from the marine construction activities associated to the Galway Harbour Extension.

Information on the aquatic habitat use of harbour seals in Ireland remains limited. However, the proximity to harbour seal haul-outs, the presence of water depths preferred for foraging (10 – 100 m), and of suitable habitat types and prey species in the area, in combination with observations of foraging harbour seals, suggest that the area can be used for foraging. In addition, it is furthermore likely that areas in proximity to the haul-outs are used for mating, nursing and during breeding, or as a travelling corridor by individuals in the Galway Bay cSAC.

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Galway Harbour Company

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Appendices to NIS Addendum / Errata

Appendix No. 2.7 – Bird Survey Data

Bird Count Data - 2012/2013

Development site survey details, 2012-2013

Date	Start Time	Finish Time	Duration	High tide	Low tide	Description	Sea state	Cloud	Wind	Temp	Visibility (km)	Rain
10.10.2012	10:00	18:00	8 hours	13:12	20:19	High tide mid, falling later	1	100%	E, Beaufort 0-1	11	2 +	None
30.10.2012	09:00	17:00	8 hours	17:25	10:56	Low tide early; high late	1; 2-3	30%	NW, SW later, Beaufort 1-2; 3-4	9	5 +	None
16.11.2012	08:30	16:30	8 hours	18:45	12:12	Low mid, rising later	1-2	100%	SSW, Beaufort 2	9	5 +	Occ. Drizzle
27.11.2012	09:00	17:00	8 hours	17:45	11:15	Low mid, rising later	1	100%	SW, Beaufort 1-2	6	5 +	None
21.12.2012	08:00	16:00	8 hours	11:25	17:19	High tide mid, falling later	1-2	100%	SW, later SE; Beaufort 1-2; 2-3	7	5 +	None
27.12.2012	08:00	16:00	8 hours	16:46	10:21	Low tide early; nearly high before end	0	25%	SW, Beaufort 0-1	7	2	None
22.01.2013	08:00	16:00	8 hours	14:08	07:41	Low start; high 2 hr before end	1	50%	E, Beaufort 1-2	0-3	2 +	None
02.02.2013	09:00	17:00	8 hours	08:53	14:55	High start; low 2 hr before end	0-1	0%	W, Beaufort 1-2	5	5 +	None
22.02.2013	09:00	17:00	8 hours	15:34	08:59	Low tide start; high tide before end	1-2	100%	E, Beaufort 1-2	3	5 +	None
25.02.2013	09:00	17:00	8 hours	17:22	10:53	Low tide early; nearly full end	1	0%	E, Beaufort 1	3	5 +	None
04.03.2013	09:00	17:00	8 hours	09:39	15:23	High tide start; Low tide end	1	100%	ESE, Beaufort 1	5	3 +	None
14.03.2013	09:00	17:00	8 hours	18:57	12:24	Low tide mid; rising later	1-2	60-75%	W, Beaufort 1 start; 2/3 end	9	3 +	One short shower

Development site marine counts, 2012-2013

Species	10 Oct 2012	30 Oct 2012	16 Nov 2012	27 Nov 2012	21 Dec 2012	27 Dec 2012	22 Jan 2013	02 Feb 2013	22 Feb 2013	25 Feb 2013	04 March 2013	14 March 2013
Black-headed Gull	**10 (0)**	**6 (0)**	**10 (0)**	**0**	**15 (0)**	**0**	**1 (1)**	**12 (0)**	**2 (0)**	**22 (15)**	**10 (0)**	**0**
Brent Goose	**17 (0)**	**7 (0)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2 (0)**	**17 (0)**	**0**
Common Gull	**19 (0)**	**0**	**4 (0)**	**10 (10)**	**15 (0)**	**10 (0)**	**2 (1)**	**8 (0)**	**0**	**8 (8)**	**0**	**0**
Red-breasted Merganser	**1 (0)**	**0**	**4 (0)**	**3 (1)**	**2 (2)**	**0**	**2 (0)**	**3 (0)**	**2 (0)**	**1 (0)**	**1 (0)**	**5 (0)**
Cormorant	**7 (5)**	**20 (1)**	**2 (2)**	**1 (1)**	**1 (1)**	**0**	**2 (1)**	**1 (1)**	**4 (2)**	**2 (0)**	**23 (2)**	**8 (2)**
Great Northern Diver	**0**	**2 (1)**	**5 (4)**	**2 (2)**	**6 (3)**	**6 (4)**	**3 (1)**	**9 (4)**	**4 (3)**	**7 (3)**	**10 (10)**	**8 (4)**
Wigeon	**0**	**0**	**0**	**0**	**0**	**0**	**1 (0)**	**0**	**3 (0)**	**4 (0)**	**2 (0)**	**2 (0)**
Great-crested Grebe	1 (1)	0	1 (0)	0	1 (1)	1 (0)	1 (1)	1 (0)	0	2 (0)	3 (0)	0
Shag	2 (1)	56 (56)	7 (5)	0	4 (3)	4 (1)	0	17 (3)	24 (12)	10 (0)	19 (19)	12 (2)
Great Black-backed Gull	2 (2)	1 (0)	1 (0)	0	2 (2)	0	0	2 (0)	0	3 (3)	2 (0)	1 (0)
Herring Gull	1 (0)	4 (0)	12 (0)	0	1 (1)	6 (0)	1 (1)	15 (0)	0	19 (12)	7 (1)	3 (0)
Mute Swan	6 (0)	0	2 (0)	0	0	2 (0)	0	4 (0)	1 (0)	2 (0)	2 (0)	2 (0)
Red-throated Diver	0	1 (0)	0	0	0	0	0	0	0	0	0	1 (0)
Razorbill	0	4 (2)	0	0	0	2 (0)	0	0	0	0	0	2 (0)
Common Scoter	0	2 (0)	0	0	0	0	0	0	0	0	0	0
Common Guillemot	0	0	0	0	0	6 (0)	0	0	0	0	0	0
Black Guillemot	0	0	0	0	0	0	0	0	0	0	0	1 (0)

Development site shore counts, 2012-2013

Species	10 Oct 2012	30 Oct 2012	16 Nov 2012	27 Nov 2012	21 Dec 2012	27 Dec 2012	22 Jan 2013	02 Feb 2013	22 Feb 2013	25 Feb 2013	04 March 2013	14 March 2013
Black-headed Gull	**0**	**7 (7)**	**1 (0)**	**1 (1)**	**0**	**1 (0)**	**0**	**2 (0)**	**0**	**1 (0)**	**0**	**0**
Common Gull	**0**	**1 (0)**	**0**	**0**	**0**	**1 (0)**	**0**	**2 (0)**	**0**	**1 (0)**	**0**	**0**
Cormorant	**0**	**6 (0)**	**2 (0)**	**0**	**0**	**2 (1)**	**0**	**0**	**0**	**0**	**0**	**1 (0)**
Grey Heron	**2 (1)**	**2 (1)**	**2 (1)**	**1 (1)**	**1 (0)**	**2 (2)**	**0**	**2 (0)**	**0**	**1 (1)**	**0**	**0**
Wigeon	**0**	**0**	**3 (0)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2 (0)**	**2 (0)**
Turnstone	**0**	**1 (1)**	**7 (0)**	**0**	**1 (0)**	**4 (1)**	**0**	**7 (0)**	**5 (5)**	**2 (2)**	**6 (0)**	**1 (0)**
Curlew	**0**	**0**	**3 (1)**	**0**	**0**	**0**	**0**	**1 (0)**	**2 (2)**	**2 (0)**	**1 (0)**	**2 (0)**
Redshank	**0**	**1 (1)**	**0**	**0**	**0**	**1 (1)**	**0**	**1 (0)**	**0**	**1 (0)**	**1 (0)**	**1 (0)**
Shag	0	10 (7)	0	1 (1)	1 (0)	2 (1)	0	3 (0)	1 (1)	1 (1)	0	0
Herring Gull	1 (0)	2 (1)	2 (0)	0	1 (0)	0	0	8 (0)	0	2 (2)	0	2 (0)
Oystercatcher	0	0	5 (1)	0	0	4 (2)	0	2 (0)	3 (3)	5 (2)	1 (0)	3 (1)
Greenshank	0	1 (1)	0	0	0	1 (0)	0	0	1 (1)	1 (1)	1 (0)	0

Bearna Comparison Site Survey Details, 2012-2013

Date	Start Time	Finish Time	Duration	High tide	Low tide	Description	Sea	Cloud	Wind	Temp	Visibility (km)	Rain
12-Oct-12	10:00	18:00	8 hours	13:49		High tide mid, falling later	2	50%	SW, Beaufort 3-4	-	5 +	None
31-Oct-12	09:00	17:00	8 hours	18:02	11:30	Low tide mid, rising later	1	75%	W, Beaufort 1-2	7	5 +	None
17-Nov-12	08:30	16:30	8 hours		12:59	Low tide mid, rising later	1-2	25%	WSW, Beaufort 2-3	-	5 +	None
28-Nov-12	09:00	17:00	8 hours	18:34	12:01	Low tide mid, rising later	2-3	33%	SW, Beaufort 3-4	9	5 +	None
22-Dec-12	08:00	16:00	8 hours	12:31	18:31	High tide mid, falling later	2-3	100%	SW, Beaufort 3-4	5	2-3	Showers
29-Dec-12	08:00	16:00	8 hours	18:02	11:35	Low tide mid, rising later	2-3	30%	SW, Beaufort 3-4	8	5	None
23-Jan-13	09:00	17:00	8 hours	15:08	08:39	Low start; high later, falling again	1-2	60%	SW, Beaufort 2-3	3	5 +	Showers later
03-Feb-13	09:00	17:00	8 hours	09:48	15:47	High start, low later, falling again	1-2	100%	SW, Beaufort 3-4	8	2 +	Occ. drizzle
23-Feb-13	08:30	16:30	8 hours	16:11	09:39	Low early; high at end	0-1	100%	E, Beaufort 0-1	2-5	5 +	None
23-Feb-13	09:00	17:00	8 hours	17:56	11:27	Low mid; almost high end.	1	100%	E, Beaufort 1-2	4	5 +	None
04-Mar-13	09:00	17:00	8 hours	10:42	16:30	Low early; high end.	1	33%	E, Beaufort 1	8-9	3 +	None
15-Mar-13	09:00	17:00	8 hours	07:18	12:58	Falling early; low mid; rising at end	2	50%	W, Beaufort 3	8	3 +	None

Bearna Comparison Site Marine Counts

Species	12 Oct 2012	31 Oct 2012	17 Nov 2012	28 Nov 2012	22 Dec 2012	29 Dec 2012	23 Jan 2013	03 Feb 2013	23 Feb 2013	26 Feb 2013	05 March 2013	15 March 2013
Black-headed Gull	**71 (71)**	**4 (0)**	**2 (0)**	**1 (0)**	**0**	**0**	**0**	**0**	**3 (0)**	**0**	**1 (0)**	**0**
Brent Goose	**4 (0)**	**0**	**1 (0)**	**0**	**0**	**0**	**0**	**0**	**0**	**4 (4)**	**23 (0)**	**1 (0)**
Common Gull	**20 (0)**	**4 (1)**	**0**	**0**	**0**	**0**	**0**	**0**	**10 (0)**	**0**	**1 (0)**	**0**
Red-breasted Merganser	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2 (2)**	**4 (0)**	**9 (0)**	**0**
Cormorant	**16 (16)**	**1 (0)**	**2 (0)**	**1 (1)**	**0**	**1 (0)**	**1 (0)**	**0**	**5 (0)**	**5 (3)**	**2 (1)**	**2 (1)**
Great Northern Diver	**0**	**6 (6)**	**3 (0)**	**0 (0)**	**6 (6)**	**6 (6)**	**2 (2)**	**5 (4)**	**25 (13)**	**20 (17)**	**13 (10)**	**7 (5)**
Teal	**0**	**0**	**0**	**5 (0)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Great-crested Grebe	1 (0)	0	0	0	0	0	0	0	0	0	0	0
Shag	45 (43)	22 (22)	15 (10)	3 (3)	3 (3)	3 (3)	6 (4)	11 (7)	46 (33)	25 (15)	39 (15)	12 (12)
Great Black-backed Gull	11 (0)	5 (0)		0	0	0	0	0	4 (0)	0	1 (0)	0
Herring Gull	410 (12)	21 (15)	2 (0)	0	0	0	0	0	12 (0)	0	4 (0)	2 (0)
Red-throated Diver	1 (1)	0	0	0	0	0	2 (0)	1 (0)	1 (0)	1 (0)	1 (0)	1 (0)
Mute Swan	2 (2)	0	0	0	0	0	0	0	0	0	0	0
Mallard	12 (11)	2 (0)	17 (0)	5 (0)	0	16 (2)	7 (7)	1 (0)	2 (2)	4 (0)	2 (0)	0
Common Scoter	0	1 (1)	0		0	0	0	0	0	0	0	0
Razorbill	45 (2)	0	1 (0)	1 (0)	0	1 (1)	12 (0)	0	2 (0)	2 (0)	9 (0)	5 (0)
Common Guillemot	11 (0)	0	0	0	0	0	0	0	0	0	2 (0)	0
Black Guillemot	0	0	0	0	0	0	0	0	0	1 (0)	0	0
Gannet	1 (1)	0	0	0	0	0	0	0	0	0	0	0

Bearna Comparison Site Shore Counts

Species	12 Oct 2012	31 Oct 2012	17 Nov 2012	28 Nov 2012	22 Dec 2012	29 Dec 2012	23 Jan 2013	03 Feb 2013	23 Feb 2013	26 Feb 2013	05 March 2013	15 March 2013
Cormorant	**11 (11)**	**3 (0)**	**7 (7)**	**0**	**0**	**0**	**1 (1)**	**0**	**1 (1)**	**5 (0)**	**0**	**1 (0)**
Grey Heron	**15 (0)**	**2 (1)**	**4 (4)**	**0**	**0**	**2 (0)**	**0**	**0**	**1 (0)**	**2 (2)**	**0**	**6 (0)**
Black-headed Gull	**63 (22)**	**5 (0)**	**6 (6)**	**10 (10)**	**0**	**10 (10)**	**65 (23)**	**0**	**1 (0)**	**7 (3)**	**0**	**3 (3)**
Common Gull	**29 (1)**	**6 (6)**	**3 (0)**	**10 (10)**	**0**	**1 (1)**	**13 (1)**	**1 (0)**	**14 (14)**	**15 (12)**	**3 (0)**	**8 (8)**
Sandwich Tern	**4 (0)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Brent Goose	**0**	**0**	**1 (0)**	**23 (23)**	**0**	**0**	**14 (12)**	**0**	**39 (28)**	**20 (0)**	**23 (7)**	**21 (4)**
Teal	**0**	**0**	**0**	**3 (3)**	**0**	**0**	**0**	**0**	**0**	**0**	**1 (0)**	**0**
Bar-tailed Godwit	**4 (4)**	**5 (0)**	**4 (1)**	**13 (0)**	**12 (12)**	**12 (12)**	**4 (1)**	**25 (0)**	**21 (21)**	**20 (16)**	**6 (3)**	**16 (0)**
Redshank	**4 (1)**	**1 (1)**	**1 (0)**	**2 (0)**	**0**	**2 (2)**	**4 (4)**	**0**	**3 (1)**	**1 (0)**	**4 (0)**	**1 (0)**
Dunlin	**0**	**0**	**0**	**4 (0)**	**0**	**0**	**0**	**0**	**30 (30)**	**51 (49)**	**0**	**9 (0)**
Curlew	**4 (2)**	**3 (2)**	**5 (1)**	**2 (1)**	**2 (2)**	**5 (3)**	**3 (2)**	**5 (3)**	**4 (4)**	**2 (2)**	**5 (3)**	**5 (2)**
Turnstone	**30 (0)**	**11 (11)**	**5 (5)**	**3 (0)**	**0**	**0**	**4 (2)**	**25 (0)**	**0**	**3 (0)**	**21 (0)**	**1 (0)**
Ringed Plover	**0**	**1 (0)**	**0**	**3 (3)**	**0**	**0**	**1 (1)**	**0**	**2 (0)**	**4 (0)**	**2 (0)**	**0**
Shag	131 (56)	3 (1)	24 (24)	0	0	1 (1)	5 (5)	0	11 (3)	17 (11)	15 (5)	7 (0)
Little Egret	1 (0)	1 (0)	0	0	0	1 (0)	0	2 (0)	1 (1)	0	0	0
Great Black-backed Gull	18 (14)	3 (3)	4 (4)	1 (0)	0	0	0	0	4 (2)	2 (2)	1 (0)	2 (0)
Herring Gull	160 (3)	12 (12)	10 (10)	1 (1)	0	4 (4)	5 (2)	4 (1)	11 (9)	10 (3)	1 (0)	24 (1)
Mallard	2 (2)	6 (4)	4 (3)	6 (5)	0	3 (3)	6 (1)	0	2 (0)	2 (2)	1 (0)	0
Purple Sandpiper	0	1 (0)	0	0	0	0	0	0	0	0	0	0
Greenshank	1 (1)	3 (3)	1 (0)	0	0	0	2 (2)	2 (0)	2 (0)	1 (1)	1 (0)	1 (0)
Oystercatcher	16 (2)	11 (8)	13 (7)	7 (2)	8 (8)	6 (4)	14 (14)	11 (6)	9 (4)	9 (5)	26 (4)	7 (0)
Snipe	0	0	0	0	0	0	1 (1)	0	1 (0)	0	0	0
Grey Plover	0	0	0	0	0	0	1 (1)	1 (0)	0	1 (0)	0	0

Bird Count Data - 2014

Development site survey details, 2014

Date	Start Time	Finish Time	Duration	High tide	Low tide	Description	Sea	Cloud	Wind	Temp	Visibility (km)	Rain
04-Mar-14	08:00	16:00	8 hours	07:00	12:48	High start, low mid, rising at end.	1	100%	SW, Beaufort 0-1	9-10	3 +	None
08-Apr-14	12:00	20:00	8 hours	12:26	19:10	High start, through low, rising at end	2	50%	W, Beaufort 3	6-11	3 +	None
14-May-14	08:30	16:30	8 hours	17:52	11:26	Low mid, rising towards end	1	100%	W, Beaufort 1	13	5 +	None
14-Jun-14	08:45	16:45	8 hours	18:58	12:28	Low mid, rising towards end	0-1	100%	SW, Beaufort 0-1	16-20	3 +	None
17-Jul-14	09:00	17:00	8 hours	09:39	15:25	Rising start, high early, low and then rising at end	0-1	100%	SE, Beaufort 0-1	17	4-5	Light between 10:00 & 10:30
27-Aug-14	07:00	15:00	8 hours	07:12	12:43	High start, low mid, rising at end.	2-3	100%	E, Beaufort 3; then SE 4	16	3-5 +	Some after 14:00
27-Sep-14	11:00	19:00	8 hours	19:54	13:25	Falling start, low mid, nearly high by end	2	50-100%	SW, Beaufort 2	18-20	3 +	None

Development site marine counts, 2014

Species	04 Mar 2014	08 Apr 2014	14 May 2014	14 Jun 2014	17 Jul 2014	27-Aug-2014	27-Sep-2014
Black-headed Gull	**15 (0)**	**0**	**0**	**4 (0)**	**10(0)**	**0**	**0**
Common Gull	**2 (0)**	**0**	**0**	**0**	**0**	**0**	**0**
Red-breasted Merganser	**11 (3)**	**0**	**0**	**0**	**0**	**0**	**0**
Wigeon	**3 (0)**	**0**	**0**	**0**	**0**	**0**	**0**
Cormorant	**1 (0)**	**3 (3)**	**5 (0)**	**2 (0)**	**3(1)**	**2(0)**	**3(2)**
Great Northern Diver	**10 (6)**	**6 (6)**	**8 (5)**	**1 (1)**	**0**	**0**	**0**
Sandwich Tern	**0**	**6 (0)**	**6 (4)**	**2 (2)**	**2(0)**	**11(5)**	**4(1)**
Common Tern	**0**	**0**	**10 (8)**	**14 (2)**	**12(9)**	**10(4)**	**2(0)**
Shag	17 (6)	5 (4)	0	0	0	0	1(0)
Great Black-backed Gull	5 (0)	0	2 (0)	0	3(0)	1(0)	1(0)
Herring Gull	33 (0)	4 (0)	5 (0)	1 (0)	0	0	10(0)
Mute Swan	3 (0)	2 (0)	1 (0)	3 (0)	2(0)	0	1(0)
Mallard	0	0	1 (0)	0	0	0	0
Scaup	2 (0)	0	0	0	0	0	0
Manx Shearwater	0	28 (0)	0	0	0	0	0
Razorbill	0	2 (1)	0	0	0	0	0
Common Guillemot	1 (0)	4 (4)	1 (1)	0	0	0	0
Gannet	0	0	0	0	0	2(0)	0

Development site shore counts, 2014

Species	04 Mar 2014	08 Apr 2014	14 May 2014	14 Jun 2014	17 Jul 2014	27-Aug-2014	27-Sep-2014
Black-headed Gull	**7 (0)**	**0**	**0**	**0**	**0**	**4(0)**	**1(0)**
Common Gull	**2 (0)**	**0**	**0**	**0**	**0**	**0**	**0**
Common Tern	**0**	**0**	**1 (0)**	**0**	**0**	**0**	**0**
Cormorant	**1 (0)**	**0**	**0**	**0**	**0**	**0**	**2(0)**
Grey Heron	**2 (0)**	**0**	**1 (1)**	**1 (1)**	**1(0)**	**1(0)**	**1(0)**
Brent Goose	**0**	**2 (0)**	**0**	**0**	**0**	**0**	**0**
Turnstone	**10 (0)**	**0**	**0**	**0**	**0**	**0**	**3(0)**
Curlew	**3 (0)**	**0**	**0**	**0**	**0**	**1(0)**	**4(0)**
Ringed Plover	**0**	**0**	**1 (0)**	**0**	**0**	**0**	**0**
Redshank	**1 (0)**	**0**	**0**	**0**	**0**	**1(0)**	**2(0)**
Little Egret	0	0	1 (0)	0	0	0	0
Shag	1 (0)	0	0	0	0	0	1(0)
Mallard	0	1 (0)	0	0	0	0	0
Herring Gull	3 (0)	1 (0)	1 (0)	3 (0)	1(0)	8(0)	29(0)
Great Black-backed Gull	0	0	1 (0)	0	0	0	1(0)
Oystercatcher	3 (0)	0	0	0	0	1(0)	5(0)
Greenshank	1 (0)	0	0	0	0	1(0)	0

Bearna Comparison Site Survey Details, 2014

Date	Start Time	Finish Time	Duration	High tide	Low tide	Description	Sea	Cloud	Wind	Temp	Visibility (km)	Rain
05-Mar-14	09:00	17:00	8 hours	07:42	13:27	High early, then through low, rising at end	3	100%	SW, Beaufort 4	10	3 +	None
05-Apr-14	10:00	18:00	8 hours	09:44	15:24	High early, then through low, rising at end	1	100%	SW, Beaufort 0; 1-2	14-15	2 +	Shower @ 16:30
13-May-14	08:00	16:00	8 hours	17:15	10:52	Low mid, rising towards end	1	50%	NW, then W; Beaufort 2-3	10-12	3 +	Two light showers
13-Jun-14	08:00	16:00	8 hours	18:11	11:44	Low mid, rising towards end	2	80-100%	SW, Beaufort 3-4	16-18	2 early, 5 later	Some early drizzle
16-Jul-14	08:00	16:00	8 hours	08:49	14:35	Rising start, high early, low and then rising at end	2-3	50-80%	SW, Beaufort 3-4	20	3 +	Two short showers
26-Aug-14	07:00	15:00	8 hours	18:52	12:11	High early, low mid, rising at end	1-2	100%	NE, Beaufort 3	17-18	5 +	None
26-Sep-14	10:00	18:00	8 hours	19:27	12:50	Falling start, low mid, nearly high by end	1-2	15%	W, Beaufort 2-3	16-18	5 +	One short shower early

Bearna Comparison Site Marine Counts, 2014

Species	05 Mar 2014	05 Apr 2014	13 May 2014	13 Jun 2014	16 Jul 2014	26 Aug 2014	26 Sep 2014
Black-headed Gull	**2 (0)**	**1 (0)**	**3 (0)**	**0**	**0**	**0**	**18(10)**
Common Gull	**0**	**10 (0)**	**0**	**0**	**0**	**0**	**2(1)**
Cormorant	**2 (0)**	**3 (0)**	**2 (1)**	**1 (0)**	**1(0)**	**7(3)**	**2(2)**
Great Northern Diver	**7 (6)**	**39 (4)**	**5 (2)**	**1 (0)**	**0**	**0**	**0**
Sandwich Tern	**0**	**2 (0)**	**9 (0)**	**14 (0)**	**8(3)**	**9(5)**	**7(2)**
Common Tern	**0**	**0**	**13 (2)**	**1 (0)**	**3(2)**	**2(0)**	**0**
Red-throated Diver	1 (0)	9 (0)	0	0	0	0	0
Shag	12 (8)	16 (11)	2 (0)	0	0	8(6)	0
Great Black-backed Gull	0	2 (0)	0	0	1(0)	0	1(0)
Herring Gull	0	10 (0)	0	0	0	0	2(1)
KIttiwake	0	0	0	0	0	2(0)	0
Sabine's Gull	0	0	0	0	0	1(0)	0
Arctic Skua	0	0	1 (0)	0	0	0	0
Mallard	0	2 (0)	0	0	0	5(0)	5(0)
Manx Shearwater	0	1 (0)	0	30 (15)	120(51)	1(0)	0
Balearic Shearwater	0	0	0	0	1(0)	0	0
Storm Petrel	0	0	0	0	1(0)	0	0
Razorbill	0	30 (0)	2 (0)	5 (2)	4(0)	16(4)	5(5)
Common Guillemot	0	15 (0)	4 (0)	2 (0)	0	0	0
Black Guillemot	0	2 (0)	1 (0)	0	0	0	0
Gannet	0	0	0	3 (0)	1(0)	4(0)	1(0)

Bearna Comparison Site Shore Counts, 2014

Species	05 Mar 2014	05 Apr 2014	13 May 2014	13 Jun 2014	16 Jul 2014	26 Aug 2014	26 Sep 2014
Cormorant	**0**	**2 (0)**	**6 (0)**	**3 (1)**	**1(0)**	**0**	**3(0)**
Grey Heron	**0**	**2 (0)**	**2 (1)**	**2 (0)**	**1(0)**	**2(0)**	**6(3)**
Black-headed Gull	**0**	**0**	**17 (2)**	**2 (0)**	**14(0)**	**2(0)**	**15(0)**
Common Gull	**7 (0)**	**3 (0)**	**15 (1)**	**1 (0)**	**2(0)**	**28(4)**	**34(34)**
Common Tern	**0**	**0**	**23 (0)**	**0**	**0**	**0**	**0**
Sandwich Tern	**0**	**4 (0)**	**1 (0)**	**0**	**0**	**1(0)**	**23(18)**
Brent Goose	**6 (0)**	**25 (0)**	**0**	**0**	**0**	**0**	**0**
Teal	**1 (0)**	**0**	**0**	**0**	**0**	**0**	**2(0)**
Bar-tailed Godwit	**11 (0)**	**0**	**0**	**0**	**0**	**2(0)**	**2(0)**
Redshank	**1 (0)**	**0**	**0**	**0**	**5(0)**	**3(0)**	**3(1)**
Dunlin	**200 (0)**	**3 (0)**	**0**	**0**	**0**	**0**	**14(0)**
Curlew	**3 (0)**	**0**	**0**	**4 (4)**	**7(0)**	**2(0)**	**4(2)**
Turnstone	**1 (0)**	**1 (0)**	**0**	**0**	**0**	**5(0)**	**9(0)**
Ringed Plover	**0**	**1 (0)**	**0**	**0**	**0**	**0**	**0**
Shag	2 (0)	3 (0)	4 (1)	0	0	5(0)	0
Little Egret	2 (0)	1 (0)	0	1 (0)	0	2(0)	2(0)
Great Black-backed Gull	1 (0)	1 (0)	1 (1)	2 (0)	3(0)	16(0)	3(3)
Lesser Black-backed Gull	0	0	0	0	2(0)	2(0)	0
Herring Gull	0	2 (0)	5 (0)	6 (0)	3(0)	49(4)	21(13)
Mallard	1 (0)	0	4 (0)	0	0	6(0)	1(1)
Purple Sandpiper	0	1 (0)	0	0	0	0	0
Greenshank	1 (0)	2 (0)	0	0	0	1(0)	3(0)
Oystercatcher	5 (0)	9 (4)	5 (2)	7 (0)	1(0)	8(5)	14(13)
Whimbrel	0	0	1 (1)	0	0	1(0)	0
Sanderling	0	6 (0)	0	0	0	0	1(0)
Common Sandpiper	0	0	0	0	0	2(0)	0

Galway Harbour Company

Galway Harbour Extension

Appendices to NIS Addendum / Errata

Appendix No. 2.8 – Bird Species Profiles
By Dr. Chris Peppiatt

Bird Species Profiles
By
Dr. Chris Peppiatt

A detailed desk study of national and international publications was undertaken for each of the species and is presented below. In addition, waterbird monitoring of the GHE count area has been carried out through monthly counts from March 2011 – March 2012 (as presented in the EIS and NIS) in addition to October 2012 – March 2013 and from March – September 2014. The full data set is presented in Appendix 2.7 and is presented as ***additional information*** to that which was included within the EIS and NIS. Therefore, the interpretations of the data and maximum counts differ from the information originally presented and the information below should be considered ***to supersede*** the information presented in the NIS and EIS. Each count involved an eight hour watch from a vantage point at the northern edge of the GHE development site. Maximum counts of all species were recorded for each 30 minute interval during these counts. Some counts also recorded bird numbers in the adjacent intertidal areas at Renmore Beach and the eastern end of Nimmo's Pier – South Park Shore. It is considered that the full data set is sufficient to characterise the birds at the site.

Species Profiles
These species profiles, prepared by Dr. Chris Peppiatt, with input from Dr. Tom Gittings, include general reviews of species ecology, Irish status and distribution, occurrence within Inner Galway Bay; detailed assessment of their occurrence within and adjacent to the development site; and a review of their sensitivities to potential impacts. The profiles cover 14 of the 20 SCI species: Light-bellied Brent Goose, Wigeon, Red-breasted Merganser, Great Northern Diver, Cormorant, Grey Heron, Bar-tailed Godwit, Curlew, Redshank, Turnstone, Black-headed Gull, Common Gull, Sandwich Tern and Common Tern.

The remaining six SCI species (Teal, Shoveler, Ringed Plover, Golden Plover, Lapwing, and Dunlin) have never, or only very rarely been recorded within the development site and it is considered that the habitat conditions are unsuitable for these species. Two of these species (Ringed Plover and Dunlin) have been recorded in adjacent areas, but only occurred irregularly and in very small numbers, so any potential disturbance impacts are not considered likely to be significant.

(i) Black-headed Gull (*Chroicocephalus ridibundus*)

Background Information

Species Habits and Preferences

This species forms nesting colonies on the margins of lakes, lagoons, slow-flowing rivers, deltas, estuaries and on tussocky marshes, but may also nest on the upper zones of saltmarshes, coastal dunes and offshore islands in more coastal areas. The species will also utilise artificial sites such as sewage ponds, gravel- and clay-pits, ponds, canals and floodlands and may nest on the dry ground of heather moors, sand-dunes and beaches. During the winter the species is most common in coastal habitats and tidal inshore waters, showing a preference for inlets or estuaries with sandy or muddy beaches, and generally avoiding rocky or exposed coastlines. It may also occur inland during this season, frequenting ploughed fields, moist grasslands, urban parks, sewage farms, refuse tips, reservoirs, lakes, turloughs, ponds and ornamental waters. Roosting often occurs on inland lakes and reservoirs. Black-headed Gulls roost communally at night and may commute long distances between foraging areas and their nocturnal roosts. Irish wintering distribution is widespread, both inland and at the coast. Black-headed Gull can forage in a variety of ways and is a member of the surface swimmer, water column diver (shallow; maximum depth one metre), intertidal walker (out of water), intertidal walker (in water) and terrestrial walker trophic guilds. A wide range of prey items are taken including insects (beetles, flies, dragonflies, grasshoppers and crickets, mayflies, stoneflies, caddisflies), oligochaete and polychaete (at coast) worms, slugs, marine and freshwater molluscs, small fish, amphibians, carrion and items from rubbish dumps. Generally breeding birds forage at maximum distances of 12-30 kilometres from the colony. Birds are fully mature after two years and the oldest recorded individual was 32 years ten months old.

The birds that breed in Ireland are part of the W Europe/W Europe W Mediterranean West Africa population that breeds in north and west Europe and south Greenland and winters in south and west Europe. The size of this breeding population is estimated at 3.7 to 4.8 million individuals. The population trend is currently stable and the European population has been assessed as secure. Birds are present in Ireland during the whole year, with resident birds being joined by numbers of wintering visitors from northern and eastern Europe. Black-headed Gull is red-listed in BoCCI 2014-2019 (Colhoun and Cummins, 2013) due to the severe decline in its breeding population, which was approximately 14,000 AON when surveyed for the Seabird 2000 project during the period 1998-2002 (Mitchell *et al*., 2004). There is no estimate available of the size of the Irish wintering population. Irish birds are generally resident, although dispersal has been noted to continental Europe. Worldwide, there are six flyway populations of Black-headed Gull, breeding in eastern Europe, Russia, Kamchatka, central Asia, China, North-east U.S.A. and South-east Canada. Wintering populations are also found in the Mediterranean, North and East Africa, Central, South and South-east Asia, Japan, Korea, China and North-east U.S.A.

Species Sensitivities

The species is susceptible to avian influenza and avian botulism so may be threatened by future outbreaks of these diseases. It may also be threatened by future coastal oil spills and has suffered local population declines in the past as a result of egg collecting. In some areas of its breeding range the species may also suffer from reduced reproductive successes due to contamination with chemical pollutants. In Ireland, it is thought that breeding declines may be due to predation at colonies by American Mink.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the overall European breeding range of Black-headed Gull will be reduced and shifted northwards by the late 21st century. Most of the southern half of the present breeding distribution (including the Republic of Ireland, Wales and much of southern England) is predicted to become unsuitable for the species, while only limited northward extension of suitable areas is predicted, to Northernmost Norway and Russia, Novaya Zemyla and Svalbard. It is difficult to predict what these changes might have on the Irish wintering population of Black-headed Gull were they to occur; due to the wide-ranging nature of this species it is probable that birds would still winter around the Irish coast, although the numbers doing so could decline.

Black-headed Gull is relatively tolerant of human disturbance. Furness *et al*. (2012) gave Black-headed Gull a low vulnerability score for disturbance by ship traffic and this species habitually occurs in close proximity to human activity. However, the species may be more sensitive to disturbance at its breeding colonies, and, in winter, at large nocturnal roosts.

Population size and distribution within Inner Galway Bay

During the period from winter 2001/02 to 2008/09 the peak I-WeBS count in the Inner Galway Bay SPA varied between 1,230 and 3,153, with a mean of 2,148 for the period from 2004-2008 (Boland and Crowe, 2012). The Inner Galway Bay wintering population has been assessed as being in favourable condition with an increase of 8% between 1994/5-2007/08 (NPWS, 2013).

Black-headed Gulls occur throughout Inner Galway Bay. In the BWS low tide counts, the main concentrations occurred along the northern shore of the bay, possibly reflecting the proximity to Galway Docks and other urban feeding habitats. The locations of the nocturnal roost sites are not known.

Black-headed Gulls can utilise a wide range of habitats for foraging and roosting. In the BWS low tide counts, the majority of birds occurred in intertidal habitats (mean of 62% of the total counts, and 79% of the counts of foraging birds, with smaller numbers in subtidal habitat (25%, 19%). The numbers recorded in supratidal/terrestrial habitat were low (13%, 2%), but this reflected the definition of the subsites and large numbers of the species feed in fields, etc. around Inner Galway Bay.

Site Specific Comments Re. Habits, Preferences and Sensitivities

Black-headed Gull has been regularly recorded in the development study area (as recorded in the NIS and EIS), with maxima of 69 birds using the site for foraging during the period from March 2011 to March 2012 (recorded on seven out of 18 watches; mean peak count of 5 birds, next largest count 12 birds and all other counts either zero or less than ten birds), 23 birds during the period from October 2012 to March 2013 (recorded on eleven out of twelve watches; mean peak count of 8 birds) and 22 birds during the period from April to June 2014 (recorded on two out of four watches, mean peak count of seven birds). The mean total counts within the GHE count area in the two winter seasons monitored were 7.3 (2011/12) and 8.4 (2012/13), compared to maximum counts of 69 (2011/12) and 24 (2012/13).

Whilst in the study area they have been observed to forage on the shoreline, to feed from the surface of the water and to rest briefly on the water. Birds regularly rest on buoys within the marine part of the study area. True roosting behaviour was not observed within the development site study area, either on the foreshore or on the water. Unlike the pattern observed in the BWS low tide counts, the majority of birds observed in the GHE counts were in the subtidal zone.

Black-headed Gull was also regularly recorded in adjacent areas. Large numbers can occur in Nimmo’s Pier-South Park Shore (mean 132, range 0-300, across the 2011/12 and 2012/13 winters), while numbers in Renmore Beach are low (mean of 3, range 0-7, across the 2011/12 and 2012/13 winters).

(ii) Cormorant (*Phalacrocorax carbo*)

Background Information

Species Habits and Preferences

The species breeds in a wide variety of habitats in coastal and inland areas. Along the coast it may breed on cliff ledges from just above high water to 100 metres, although often undisturbed islands are used, where (as at Deer Island) the nests can be on flat ground. Breeding sites can also be inland on lake islands, where nesting may be on the ground or on trees (which are usually killed by the birds' guano after a few years, but can still be used until they become unstable). Breeding colonies may number a few hundred to over a thousand nests. Throughout the year birds may forage along the coast, close inland to water depths of 30-35 metres, in estuaries, lagoons and in shallow inland waters like lakes and ponds, rivers and reservoirs. Roosting is at the breeding colony during the breeding season. Outside the breeding season, Cormorants roost communally, often in large groups close to their foraging areas on rocks and sandbanks, at nocturnal roost sites on small islands, steep cliffs and in groups of trees surrounded by water, and may commute considerable distances to and from these roosts. During the day, they may roost in smaller groups on rocks and sandbanks close to their foraging areas.

Cormorant is a member of the water column diver (deeper) trophic guild. It is a specialist predator that feeds mostly by diving from the surface for prey. Cormorant often forage alone, but there are sometimes large feeding flocks of up to several hundred birds. Such flock-feeding is associated with schooling prey and (in some areas) with shallow, often turbid, water; the flock move slowly forwards with ranks of birds diving almost synchronously in successive waves, driving fish before them towards the surface. In clear waters they may use visual pursuit-diving after individual prey but in turbid waters probably forage by disturbing prey from the substrate or from hiding places which are grabbed at short range. Foraging occurs mainly during the day. Prey items are usually benthic fish over bare or vegetated substrates, although schooling fish like Sandeels are also taken and individuals shift flexibly between benthic and pelagic foraging. The maximum dive depth is 30-35 metres, although on average probably more usually around ten metres.

Cormorants generally prefer waters less than 10 m deep for foraging (Skov et al., 1995, quoted by Kober et al., 2010; Seabird Wikispace). Prey items comprise mainly fish of less than 20 centimetres in length, but fish up to 75 centimetres or 1.5 kilograms are occasionally taken. Marine prey includes: Sandeels, Sprat, Herring, Whiting, Cod, Saithe, Pollack, Dab, Plaice, Butterfish, blennies, Eel and crabs. Recorded foraging distances from the breeding colony are varied, with a maximum claimed of 50 kilometres, a mean of maximum foraging distances of approximately 30 kilometres and a mean of approximately 10 kilometres. In general it is safe to say that the majority of birds forage within 15 kilometres of the colony during the breeding season. Birds are fully mature after two to four years, typical lifespan is 15 years and the oldest recorded individual was 22 years old.

The birds that breed in Ireland are mainly sedentary, with dispersal of birds from breeding areas at other times of year. The Irish population is North-west European population of the subspecies *P. c. carbo*. The size of this breeding population is estimated at about 120,000 individuals. The population trend is currently increasing. The All-Ireland breeding population is approximately 5,180 AON (Seabird 2000). The all-Ireland wintering population is estimated at 11,920 birds (Crowe and Holt, 2013). Worldwide, there are also breeding populations in Iceland, Greenland, north-eastern North America, right across the mid latitudes of Russia to the Pacific, Japan, India, China, Australia, New Zealand, the north-western Atlantic coast of Africa, southern Africa and central Africa.

Species Sensitivities

Breeding birds are very loyal to traditional nest sites, even if they experience persecution there. Cormorant can be vulnerable to drowning after entanglement is fishing nets. This species is also often the target of the animosity of fishing and fishery management interests and they can then experience (illegal) persecution. Although hunted for food in the Middle East, this does not occur in the range of the Irish population. Pollution and changes to/depletion of fish stocks are also important threats.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the overall breeding range of Cormorant will remain similar to the situation at present, although there may be slight shift to the North, including in Ireland, Britain and continental Europe, with a predicted expansion in Iceland.

Cormorant feed by diving in the sea and often rest close to water. Thus they are vulnerable to oil spills, both in the sense of direct oiling of the birds and due to contamination of and/or shortage of suitable prey in the aftermath of a spill.

There appears to be little published evidence about the sensitivity of Cormorants to human disturbance. Furness *et al*. (2012) gave Cormorant a high vulnerability score for disturbance by ship traffic, referring to “moderate distance flush”. However, in Cork Harbour, Cormorants regularly feed within, and around, the shipping channel at the mouth of the harbour (Roches Point) and do not flush when ships pass (T. Gittings, personal observations). Cormorants regularly feed in the upper reaches of estuaries, close to harbours and docks, and in small waterbodies in close proximity to human activity. Inner Galway Bay is the sixth most important site in the Republic of Ireland for wintering Cormorants (Boland and Crowe, 2012).

Population size and distribution within Inner Galway Bay

During winter the SPA regularly supports 1% or more of the all-Ireland population of Cormorant. The mean peak number of this species within the SPA during the baseline period (1995/96 – 1999/00) was 266 individuals, compared to 263 individuals in recent years (2005/06-2008/09). The Inner Galway Bay wintering population has been assessed as being in favourable condition with an increase of 43% between 1994/5-2007/08, compared to a national increase of 32% over the same period (NPWS, 2013).

The site is also selected for its breeding population of Cormorant. There is a single colony, located at Deer Island in the south-western part of the SPA. In 2000, as part of the Seabird 2000 survey, 200 pairs of Cormorant (based on apparently occupied nests, AON) were estimated on Deer Island; exceeding the All-Ireland 1% threshold and making the site of national importance for this species. In 2010, 128 AON were recorded (Alyn Walsh, NPWS, pers. comm.).

The breeding colony at Deer Island may also be used as a nocturnal roost site during winter. The locations of other nocturnal roost sites in Inner Galway Bay are not known.

The distribution of foraging Cormorants in summer is not known. However, as the entire area of Inner Galway Bay is within the potential foraging range of the Deer Island colony, it may be reasonable to assume that birds are more or less uniformly distributed throughout suitable subtidal habitat (as in winter).

Site Specific Comments Re. Habits, Preferences and Sensitivities
Cormorant has been regularly recorded in the development study area (as recorded in the NIS and EIS), with maxima of 6 birds using the site for foraging during the period from March 2011 to March

2012 and 23 birds during the period from October 2012 to March 2013 and 5 birds during the period from April to June 2014. The mean total counts within the GHE count area in the two winter seasons monitored were 2.8 (2011/12) and 6.8 (2012/13).

Whilst in the study area they have been observed to dive for prey regularly. The whole of the marine area of the study area is foraging habitat for this species, therefore. Small numbers of birds (maxima 6, 2 and 3 for the periods mentioned above) use intertidal rocks and marine buoys within the study area as daytime resting/roosting places. However, these are mainly short term resting places and there is no nocturnal roost within the proposed development area.

The colony site on Deer Island is 8.5 kilometres from the site of the proposed development.

(iii) Common Gull (*Larus canus*)

Background Information

Species Habits and Preferences

This species nests on the ground in a wide variety of situations, including, islands, cliffs, shingle banks and bogs. Rooftop nesting is known from Scotland and continental Europe. In Ireland breeding is on the coast and inland on islands on large lakes in the west. Nesting is usually colonial, but there can be anything from a few to several hundred nests. Outside of the breeding season it occupies similar habitats to when breeding, but also occurs more frequently along the coast on estuaries with low salinities, sandy beaches and estuarine mudflats. Common Gulls roost communally at night and may commute long distances between foraging areas and their nocturnal roosts. Irish wintering distribution is widespread, both inland and at the coast. Common Gull can forage in a variety of ways and it is a member of the surface swimmer, water column diver (shallow; maximum depth one metre), intertidal walker (out of water), intertidal walker (in water) and terrestrial walker trophic guilds. Foraging can be intertidal on rocky and muddy shores, from marine and fresh water bodies, on wet grassland, by following the plough and at rubbish dumps. Scavenging discards from fishing boats has been recorded as an important food source. A wide range of prey items are taken including earthworms, insects (craneflies, moth adults and larvae), aquatic and terrestrial invertebrates (e.g. planktonic crustaceans, crayfish and molluscs), small fish, frogs, young birds and small mammals. During the spring the species will also take agricultural grain and often scavenges. There is little information available about the typical foraging ranges from breeding colonies, but one study reported a maximum range of 50 kilometres and a mean maximum range of 25 kilometres from the colony (Thaxter *et al*., 2012). Birds are fully mature after 2-3 years. The average lifespan is 18 years and the oldest recorded individual was 33 years six months old.

The birds that breed in Ireland are part of the Northwest and Central Europe/Atlantic coast and Mediterranean flyway population that breeds in Iceland, Ireland, Britain and continental Europe east to the White Sea and winters across Europe to north Africa. The size of this breeding population is estimated at 1.2 to 2.25 million individuals. The population trend is considered to be possibly declining/depleted. Birds are present in Ireland during the whole year, with resident birds being joined by numbers of wintering visitors from central and northern Scotland, Scandinavia and the Baltic. Common Gull is amber-listed in BoCCI 2014-2019 (Colhoun and Cummins, 2013) due to a moderate decline in its breeding population and the concentration of the breeding population in a small number of sites. The Irish breeding population is approximately 1,600 AON (Mitchell *et al*., 2004). Irish birds are generally resident, although dispersal has been noted to continental Europe. Worldwide, there are four flyway populations of four subspecies of Common Gull, which breed in Russia, Siberia, Alaska and Canada. Wintering populations are also found in the Black and Caspian seas, East and South-east Asia, Canada and U.S.A.

Species Sensitivities

In north and west Europe the species is threatened at breeding colonies by predation from introduced ground predators such as American Mink, and by disturbance from tourism, angling and research activities during the laying period. Inland populations breeding in colonies near rivers are also vulnerable to mass outbreaks of black flies (Simuliidae). The species is also threatened by the transformation and loss of its breeding habitats through land reclamation, drainage, afforestation (e.g. with conifers) and dam construction. In its wintering range the species is potentially threatened by the activities of fisheries (e.g. reductions in fishing effort, increases in net mesh sizes and exploitation of formerly non-commercial fish species) and their effects on competition for prey resources. Other threats to wintering sites include land reclamation and drainage. Egg collecting from colonies occurs in Germany, Scotland, the Russian Federation and Poland, and the species is shot in the Russian Federation.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the overall European breeding range of Common Gull will be reduced in extent by almost half and shifted northwards by the late 21st century. Most of the southern half of the present breeding range (including the Ireland, Wales, southern and central England and much of central continental Europe) is predicted to become unsuitable for the species, while only limited northward extension of suitable areas is predicted, to Northern Russia, Iceland, Novaya Zemyla and Svalbard. It is difficult to predict what these changes might have on the Irish wintering population of Common Gull (although it is obvious that 1,600 pairs of resident birds would be missing) were they to occur; due to the wide-ranging nature of this species it is probable that birds would still winter around the Irish coast, although the numbers doing so could decline.

Common Gull is relatively tolerant of human disturbance. Furness *et al*. (2012) gave Common Gull a low vulnerability score for disturbance by ship traffic and this species habitually occurs in close proximity to human activity. However, the species may be more sensitive to disturbance at its breeding colonies, and, in winter, at large nocturnal roosts.

Population size and distribution within Inner Galway Bay

During the period from winter 2001/02 to 2008/09 the peak I-WeBS count in the Inner Galway Bay SPA varied between 913 and 2,886, with a mean of 1,312 for the period from 2004-2008 (Boland and Crowe, 2012). The Inner Galway Bay wintering population has been assessed as being in favourable condition with an increase of 21% between 1994/5-2007/08 (NPWS, 2013).
In the BWS low tide counts, on average, over half the total count occurred on the southern shore of the bay between Aughinish Island and Kinvarra Bay. There was also a concentration along the northern shore of the bay, possibly reflecting the proximity to Galway Docks and other urban feeding habitats.

Common Gulls can utilise a wide range of habitats for foraging and roosting. In the BWS low tide counts, the majority of birds occurred in intertidal habitats (mean of 58% of the total counts, and 71% of the counts of foraging birds, with smaller numbers in subtidal habitat (20%, 17%). The numbers recorded in supratidal/terrestrial habitat were low (8%, 12%), but this reflected the definition of the subsites and large numbers of the species feed in fields, etc. around Inner Galway Bay.

Site Specific Comments Re. Habits, Preferences and Sensitivities

Common Gull has been regularly recorded in the development study area (as recorded in the NIS and EIS), with maxima of 7 birds using the site for foraging during the period from March 2011 to March 2012 (recorded on seven out of 18 watches; mean count of 1 bird), 19 birds during the period from October 2012 to March 2013 (recorded on nine out of twelve watches; mean count of 7 birds) and 4 birds during the period from April to June 2014 (recorded on one out of four watches, mean count of one bird). Whilst in the study area Common Gull have been observed to forage on the shoreline, to feed from the surface of the water and to rest briefly on the water. True roosting behaviour was not observed within the development site study area, either on the foreshore or on the water. Unlike the general pattern observed across Inner Galway Bay in the BWS counts (see above), the majority of birds in the GHE counts occurred in the subtidal zone.

Common Gull was also regularly recorded in adjacent areas. Large numbers can occur in Nimmo's Pier-South Park Shore (mean 13, range 0-30, across the 2011/12 and 2012/13 winters), while numbers in Renmore Beach are low (mean of 1, range 0-3, across the 2011/12 and 2012/13 winters).

During the period from winter 2001/02 to 2008/09 the peak I-WeBS count in the Inner Galway Bay SPA varied between 913 and 2,886, with a mean of 1,312 for the period from 2004-2008 (Boland and Crowe, 2012).

(iv) Common Tern (*Sterna hirundo*)

Background Information

Species Habits and Preferences

The species breeds in a wide variety of habitats in coastal and inland areas from sea-level to altitudes of 4,000 metres or more. Along the coast it shows a preference for nesting on flat rock surfaces on inshore islands, open shingle and sandy beaches, dunes and spits, vegetated inter-dune areas, sandy, rocky, shell-strewn or well-vegetated islands in estuaries and coastal lagoons, saltmarshes, mainland peninsulas and grassy plateaus on coastal cliff tops. Inland it may nest in similar habitats including sand or shingle lakes shores, shingle banks in rivers, sandy, rocky, shell-strewn or well-vegetated islands in lakes and rivers, sand- or gravel-pits, marshes and reservoirs. During winter it inhabits sheltered coastal waters, estuaries and large rivers, occupying harbours, jetties, piers, beaches and coastal wetlands (i.e. lagoons, rivers, lakes, swamps and saltworks, mangroves and saltmarshes). During winter roosting occurs on un-vegetated sandy beaches, shores of estuaries or lagoons, sandbars and rocky shores.

Birds are present in Ireland during passage periods (April-May and August-September-October) and the breeding season (April to July). Common Tern is a member of the water column diver (shallow) trophic guild. It is a specialist predator that feeds mostly by plunge diving for prey (often preceded by hovering), but also by 'contact-dipping', where the bill only is dipped into the water to catch prey from the surface. The maximum dive depth is 1-2 metres. Prey items comprise mainly small fish. Marine prey includes: Herring, Sandeels, Sprat, Anchovy, Whiting, Cod, Hake, Haddock, Saithe, Mackerel, Sea Lamprey. Freshwater prey can include: Perch, Bream, Rudd, Salmon, Trout and Eel. Also taken are shrimps, crabs, water beetle larvae, caddis flies, small squid and polychaete worms. Detection of active prey is visual and birds roost on rocks or islands (i.e. at the nesting colony during the breeding season) at night. Recorded foraging distances from the breeding colony are varied, with a maximum claimed of 37 kilometres, a mean (of maximum foraging distances) of approximately 15 kilometres and a mean (of mean foraging distances) of 8.67 km; in general it is safe to say that the majority of birds forage within 20 kilometres of the colony during the breeding season (seabird wikispace). Birds are fully mature after three-four years, average lifespan is 12 years and the oldest recorded individual was 33 years old.

The birds that breed in Ireland are part of the southern and western Europe breeding population that winters mainly off the western seaboard of Africa, with smaller numbers wintering off Portugal and Spain. The size of this breeding population is estimated at about 160,000 – 200,000 individuals. The

population trend is currently stable and the European population has been assessed as secure, although Common Tern is listed on Annex 1 of the Birds Directive (79/409/EEC). This population breeds in Ireland, Britain, France, Netherlands, Norway, Sweden, Denmark, Italy, Spain and Greece. Wintering is mainly off western and southern African coasts. The Irish breeding population is approximately 4,200 pairs (Seabird 2000). Worldwide, there are also breeding populations around the Baltic, across Russia from the west to the Pacific, down into China and across North America.
Species Sensitivities

Breeding birds are very sensitive to human disturbance at their nest sites, but can nest in urban environments. In Leith Docks (Edinburgh), Jennings et al. (2014) reported that "the birds are tolerant of routine human activities in the docks and that they have become well habituated to breeding in this urban environment" (Merne, 2004; Jennings et al., 2012a). Similarly, a Common Tern colony has been established for many years in Dublin Port (Merne, 2004), while, in Cork Harbour, Common Terns have nested on an island in a small golf course lake at Ringaskiddy.

Common Terns appear to be sensitive to disturbance within a zone of around 100-150 m around their breeding colonies. Carney and Sydeman (1999) quote two studies that reported flush distances of 142 m and 80 m for Common Tern colonies approached by humans. Burger (1998) studied the effects of motorboats and personal watercraft (jet skis, etc.) on a Common Tern colony. She found that the personal watercraft caused more disturbance than the motor boats, the factors that affected the terns were the distance from the colony, whether the boat was in an established channel, and the speed of the craft, and she recommended that personal watercraft should not be within 100 m of colonies.

Foraging Common Terns are more tolerant of human disturbance and Furness *et al*. (2012) gave Common Tern a low vulnerability score for disturbance by ship traffic, referencing "slight avoidance at short range". In Irish coastal waters they often feed in very close proximity to human activity. For example in Galway Bay, they regularly feed in the mouth of the Corrib inside Nimmo's Pier.

Common Terns are also sensitive to loss of breeding sites due to erosion, wind-blown sand or overgrowth of vegetation and to nest predation by predators. Common Terns wintering off West Africa are hunted by snaring. Pollution and changes to/depletion of fish stocks are also important threats.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the overall breeding range of Common Tern will remain similar to the situation at present, although it may become patchier in Ireland, Britain and eastern Europe, while it is predicted that Iceland may be colonised by breeding birds.

Common Tern feed by diving into the sea and often rest close to water. Thus they are vulnerable to oil spills, both in the sense of direct oiling of the birds and due to contamination of and/or shortage of suitable prey in the aftermath of a spill.

Population size and distribution within Inner Galway Bay

In 1995, as part of the All-Ireland Tern survey, 98 pairs (apparently occupied nests, AON) of Common Tern were recorded in Ballyvaghan Bay in Co. Clare. The colony site in Ballyvaghan Bay was described as Green Island but, according to Lysaght (2002), the Ballyvaughan colony was at Gall Island, and "it is likely that the 1995 survey misidentified the island". The Seabird 2000 Survey recorded 46 pairs (AON) of Common Tern on Mutton Island in Co. Galway in 2001. Both counts exceed the All-Ireland 1% threshold for this species. The colony at Mutton Island was abandoned in 2003 and 2004. During the years 2005 to 2013 inclusive the Mutton island colony switched sites to nearby Rabbit Island, where it was estimated that there were 50 pairs being present in 2010 and 35-

50 pairs in 2011. The Rabbit Island colony continued to be occupied up to 2013. In the 2014 breeding season the Common Tern colony that had been using Rabbit Island returned to the original site on the north-east corner of Mutton Island and it is estimated that there were 50-75 pairs (i.e. still above the All-Ireland 1% threshold); according to staff at Mutton Island, some terns may have also been nesting on Mutton Island in 2013. The old colony site in Ballyvaghan Bay was not occupied in the 2014 breeding season, and there are no records indicating occupation of this colony since the 1990s. Small numbers of Common Tern share the Sandwich Tern and Black-headed Gull colony in Coranroo Bay; it is estimated that 10 pairs were present during the 2014 breeding season. The above pattern of local movement of colonies is typical for this species: Jennings et al. (2012b) described how numbers at individual colonies are strongly affected particularly by local influences of predation, whereas numbers in the region as a whole are more strongly influenced by food supply.

The distribution of foraging Common Terns within Inner Galway Bay is not known. The mean foraging range of Common Terns is 8.67 km, while the majority of birds forage within 20 kilometres of their breeding colony (seabird wikispace). The mean foraging range probably represents the core foraging area, while the area between the mean foraging range and the maximum foraging range can be thought of as a buffer zone, exploited by lower numbers of birds less intensively. Therefore, if these foraging range figures are representative of the Inner Galway Bay population, the core foraging range for the Common Terns from the Rabbit Island/Mutton Island colony is likely to be along the northern and eastern shores of the bay. The southern shore being exploited less intensively by these birds, but is likely to be the core foraging range for the Corranroo Bay colony. Within these areas, Common Terns can feed in all subtidal habitat (and have been observed feeding out in the middle of the bay) and in intertidal habitat at high tide. Based on the seabird wikispace foraging range data, it is around 70% of the core foraging ranges of the Mutton Island colony, and 90% of the core foraging ranges of the Rabbit Island and Corranroo Bay are contained within the Inner Galway Bay SPA.

Site Specific Comments Re. Habits, Preferences and Sensitivities

Common Tern has been regularly recorded in the development study area (as recorded in the NIS and EIS), with maxima of 4 birds using the site for foraging during summer 2011 and 14 birds during the period from April to June 2014. Whilst in the study area they have been observed to plunge dive for prey regularly. The whole of the marine area of the study area is foraging habitat for this species, therefore. One bird was observed resting briefly on rocks within the study area in May 2014 and birds regularly rest on buoys within the marine part of the study area during the summer months.

Common Tern probably regularly feed in the adjacent section of shoreline to the west of the GHE site, including in the mouth of the Corrib at Nimmo’s Pier and along the Nimmo's Pier-South Park Shore. On 28 June 2014, around 30-40 Common Terns were feeding in the latter area at low tide.

The colony site on Mutton Island is about one kilometre from the nearest part of the proposed development as built and approximately 300 metres from the proposed dredging zone of influence, and c. 300 m from the shipping channel. The colony site at Rabbit Island is approximately 1.9 kilometres from the site of the proposed development. The colony in Coranroo Bay is 12 kilometres from the site of the proposed development. The abandoned colony site in Ballyvaghan Bay is 15 kilometres from the site of the proposed development.

(v) Curlew (*Numenius arquata*)

Background Information

Species Habits and Preferences

This wader species breeds on coastal saltmarshes, inland wet grasslands with short swards (including cultivated meadows), grassy marshes, cutover bog, swampy heathlands and swampy moors. During the winter the distribution in Ireland is wide-ranging, including both coastal and inland sites on habitats that include rocky shores, muddy estuaries and inlets, sandbanks, saltmarshes, beaches, lagoons, lakes, turloughs and areas of wet grassland (including agricultural and amenity grasslands). Roosting is communal in areas like saltmarshes and sand banks. This species is a member of the intertidal walker (out of water) trophic guild. Foraging is mainly by pecking from the surface and by probing with the long, decurved bill into the substrate. Food items taken at the coast are chiefly polychaete worms, bivalves, crustaceans (amphipods, shrimps, crabs) and occasional small fish. Birds are mature after two years and the oldest known ringed individual was 31 years six months old.

The Europe/Europe North & West Africa population of Curlew breeds in western, central and northern Europe (including Ireland), east to the Ural mountains. The size of this population has been estimated at 700,000 – one million individuals and the trend is considered to be declining. This flyway population winters in western Europe (including Ireland), the Mediterranean, and North-west Africa, east to the Persian Gulf. The size of the Irish wintering population is estimated at 35,320 (Crowe and Holt, 2013); the resident population is swelled by wintering breeders from Scotland, northern England and Scandinavia. The Irish breeding population is widespread in distribution, but may have declined to as few as 200 pairs. Curlew has been red-listed in BoCCI 2014-2019 due to severe declines in its breeding and wintering populations (Colhoun and Cummins, 2013). Worldwide, there are five flyway populations of Curlew. In addition to the areas already mentioned, breeding occurs in south-eastern Europe, Siberia and Kazakhstan. Wintering populations are also found in South-west, southern and South-east Asia and eastern and southern Africa.

Species Sensitivities

The species is threatened by the loss and fragmentation of moorland habitats as a result of afforestation and of marginal grassland habitats as a result of agricultural intensification and improvement (e.g. drainage, inorganic fertilisation and reseeding). The species also suffers from high egg and chick mortalities (due to mechanical mowing) and higher predation rates if nesting on improved grasslands. Conversely populations in the central Asians steppes have declined following abandonment of farmland and subsequent increases in the height of vegetation, rendering large areas unsuitable for nesting. It has also suffered population declines as a result of hunting, and is susceptible to avian influenza so may be threatened by future outbreaks of the virus. Wintering populations are threatened by disturbance on intertidal mudflats (e.g. from construction work and foot-traffic), development on high-tide roosting sites, pollution and the flooding of estuarine mudflats and saltmarshes as a result of tidal barrage construction. The species is also threatened by the degradation of migration staging areas owing to land reclamation, pollution, human disturbance and reduced river flows. Local populations of this species have also declined owing to hunting pressures.

Curlew is relatively sensitive to human disturbance compared to other species. This reflects its large body size, as generally disturbance sensitivity increases with body size, and its status as a quarry species (Laursen et al., 2005). While it has been recently removed from the quarry species list in Ireland, it is likely that it will take a period of time for this to affect its disturbance sensitivity. Also, its continued status as a quarry species elsewhere along its migration route may affect its behaviour in Ireland as the higher disturbance sensitivity in quarry species may persist in migratory species even when they are in areas where they are not hunted (Burger and Gochfield, 1991, cited by Laursen et al., 2005). In various disturbance experiments in open tidal flats in North Sea coastal sites, Curlew showed escape distances (the distance at which they responded to disturbance) of 102-455 m (see Introductory Report). However, escape distances may be much lower in in enclosed coastal habitats and/or where background levels of human activity are higher and an escape distance of 38 m was reported for a rocky shore site in Northern Ireland (Fitzpatrick and Bouchez, 1998).

Wintering Curlew feed at the coastline, often on the waterline. They are vulnerable to oil spills that can (when they reach shore) coat the foraging habitat, oil birds and kill/contaminate prey.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the breeding range of European populations of Curlew will be reduced in extent by more than 40% and shifted north-eastwards by the latter part of the 21st century. It is predicted that Curlew will become extinct as a breeding bird in most of the Republic of Ireland, southern and central England and Wales. It is also predicted that areas in southern Scandinavia and western/central Europe will become unsuitable for the species' needs and that these losses will not be offset by the possible colonisation of Svalbard, Novaya Zemyla and Iceland. It is not possible to predict exactly what the effect of changing breeding distribution would be on the wintering distribution of the species, but it is quite possible that the Irish wintering population may be reduced in both numbers and the extent of its distribution.

Population size and distribution within Inner Galway Bay

During the period from winter 2001/02 to 2008/09 (Boland and Crowe, 2012) the peak count in the Inner Galway Bay SPA varied between 442 and 987 (mean of 674). The conservation condition Inner Galway Bay Curlew population has been assessed as favourable, with an increase of 10.6% over the period 1994/95-2008/09, compared to a national decrease of -25.7% over the same period (NPWS, 2013). Inner Galway Bay is the twelfth most important site in the Republic of Ireland for Curlew (Boland and Crowe, 2012).

Wintering Curlew in Ireland often utilise terrestrial habitats. However, the numbers of Curlew recorded in the supratidal/terrestrial zone during the BWS counts of Inner Galway Bay were very low (around 1% of the total count). These low percentages do not necessarily reflect the actual usage of these habitats around Galway Bay, but, instead, probably reflect the focus of the survey on recording waterbird distribution in the tidal zones.

Site Specific Comments Re. Habits, Preferences and Sensitivities

Curlew have been recorded in the development study area (as recorded in the NIS and EIS), but somewhat irregularly and in very low numbers. Whilst in the study area they have been observed to forage in the intertidal zone of the site of the proposed development. The whole of the intertidal area of the study area is foraging habitat for this species, therefore. Count maxima of 3 birds using the proposed development site for foraging during the period from March 2011 to March 2012 (mean 0.75, recorded on 5 out of 12 counts during the winter period), 3 birds during the period from October 2012 to March 2013 (mean 0.9, recorded on 6 out of 12 counts) and 3 birds during the period from April to June 2014 were recorded.

Curlew also occur in the adjacent intertidal area to the west (Nimmo's Pier-South Park Shore), again somewhat irregularly and in very low numbers (1-2 birds in five out of 13 counts during the 2011/12 and 2013/14 winters). Curlew were not recorded in the adjacent intertidal area to the east (Renmore Beach).

(vi) Grey Heron (*Ardea cinerea*)

Background Information

Species Habits and Preferences

Grey Heron nest colonially, usually in tall trees, but also in low trees and bushes and sometimes on the ground on marine or lake islands. Foraging takes place in a wide variety of freshwater and marine aquatic habitats, including ponds, lakes, reservoirs, canals, rivers, streams, ditches, estuaries, lagoons and any kind of open coastal shoreline. This species is often found both breeding and foraging at suitable sites in urban areas. Foraging birds feed on land or in shallow water, where they wade or stand still (either singly or in loosely associated groups). Prey items are caught by grabbing or stabbing with the bill and they are usually killed before swallowing. Foraging takes place mostly during daylight. This species is a member of the intertidal walker (in water) trophic guild. Food items are chiefly fish, amphibians, small mammals, insects and reptiles, also occasionally crustaceans, molluscs, worms and birds. Birds are mature after one year. The average expected lifespan is five years, but the oldest recorded ringed bird was 25 years and four months old.

Although birds in Ireland and Britain are mainly sedentary, rather than migratory, the northern and western European population of Grey Heron is estimated at 263,000 – 286,000 individuals and is considered to be increasing. The All-Ireland wintering population is estimated at 2,500 birds (Crowe and Holt, 2013) distributed across the whole island. The Irish and British populations of Grey Heron are the sole non-migratory populations. There is dispersal up to 150 kilometres from natal heronries. However, there is some recorded movement between Britain and Ireland and the Irish population is increased during winter by migrants from Norway.

Worldwide, Grey Heron are distributed right across Europe (as far north as Norway and Sweden, but not in Iceland; they are much more thinly distributed around the Mediterranean), across central Asia and down into India, China and South-east Asia, Japan, southern and eastern Africa and Madagascar.

Species Sensitivities

In Europe the species was heavily persecuted in the nineteenth century due to its consumption of fish, which resulted in competition with fishermen and fish farmers Timber harvesting is a threat throughout much of the species range by removing trees used by nesting colonies and/or disturbing nearby colonies. The species is also susceptible to avian influenza and avian botulism, so may be threatened by future outbreaks of these diseases. Individual site populations may be threatened by loss of or damage to foraging habitat or roosting sites.

Grey Heron are generally relatively tolerant of human disturbance. They feed in a wide range of habitats, including small ponds and watercourses, often in close proximity to human activity.
It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the breeding range of the Grey Heron in Europe will shift northwards by the latter part of the 21st century. These authors predict that breeding will increase in Fenno-Scandinavia and that Iceland will be colonised, while declines are predicted in the south of the current breeding range in the Mediterranean. Although there may be some small-scale reduction in breeding distribution, the situation in Ireland and Britain was predicted to remain very much the same as it is at present. If the Irish and British breeding populations continue to be sedentary (as at present), it may be that the distribution and numbers recorded will also remain similar to as at present.

Grey Heron feed along the coastline, including in shallow water. They are thus very vulnerable to oil spills that can oil the birds and kill/contaminate prey.

Population size and distribution within Inner Galway Bay

According to the Conservation Objectives Supporting Document (NPWS, 2013) the SPA regularly site regularly supports 1% or more of the all-Ireland population of Grey Heron during winter. The mean peak number of this species within the SPA during the baseline period (1995/96 – 1999/00) was 102 individuals. During the period from winter 2001/02 to 2008/09 the peak count in the Inner Galway Bay SPA varied between 87 and 174 (mean of 130). The conservation condition of the Inner Galway Bay Grey Heron population has been assessed as favourable, with an increase of 52.4% over the period 1994/95-2008/09, compared to a national increase of 29.2% over the same period (NPWS, 2013). Inner Galway Bay is the most important site in the Republic of Ireland for Grey Heron (Boland and Crowe, 2012).

Grey Heron can utilise a wide range of habitats for foraging and roosting. In the BWS low tide counts, the majority of birds occurred in intertidal habitats (mean of 64% of the total counts, and 70% of the counts of foraging birds, with smaller numbers in subtidal habitat (24%, 28%). The numbers recorded in supratidal/terrestrial habitat were low (12%, 2%), but this reflected the definition of the subsites and it is likely that larger numbers of the species feed in small non-tidal wetlands, ditches, etc. around Inner Galway Bay.

The subtidal habitat suitable for foraging by Grey Heron will be limited to shallow subtidal waters in which the birds can wade. The tidal zone between the mean low tide and the lowest astronomical tide can be considered to be a reasonable approximation of the distribution at low tide of suitable Grey Heron subtidal foraging habitat. The distribution of heronries around Inner Galway Bay is presented in Figure NIS(A) 2.4 below.

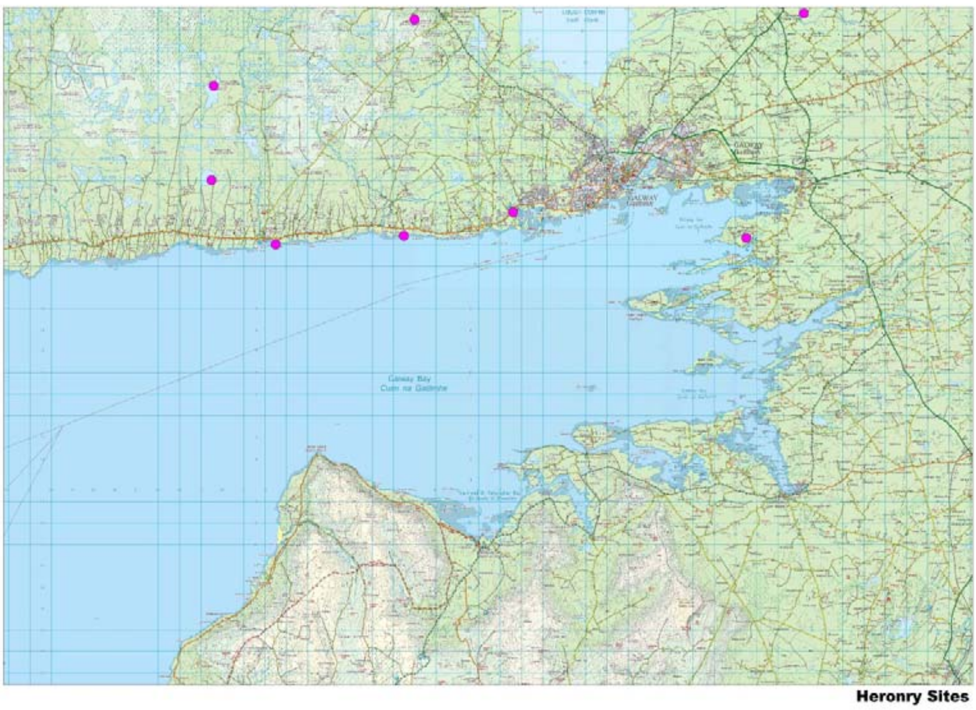

Figure NIS(A) Error! No text of specified style in document.**.1 Heronries around Inner Galway Bay**

Site Specific Comments Re. Habits, Preferences and Sensitivities

Grey Heron have been regularly recorded in the development study area (as recorded in the NIS and EIS). Whilst in the study area they have been observed to forage along the shoreline and in shallow water in the intertidal zone (i.e. walking/wading in water). The whole of the intertidal marine area of the study area is foraging habitat for this species, therefore. Roosting behaviour has not been observed at the development site study area. Count maxima of 2 birds using the proposed development site for foraging during the period from March 2011 to March 2012 (mean 0.8, recorded on 8 out of 12 counts during the winter period), 2 birds during the period from October 2012 to March 2013 (mean 1.1, recorded on 9 out of 13 counts during the winter period) and 2 birds during the period from April to June 2014 were recorded. It should be noted that Grey Heron was recorded at the development site study area on 23 out of 34 long watches that have currently been carried out at the site. This species does not occur at the site of the proposed development at or close to high tide, when there is no exposed foreshore on which it can forage.
Grey also occur in the adjacent intertidal area to the west (Nimmo's Pier-South Park Shore), but irregularly and in very low numbers (1-3 birds in two out of 13 counts during the 2011/12 and 2013/14 winters). Grey Heron were recorded on a single count in the adjacent intertidal area to the east (Renmore Beach).

(vii) Great Northern Diver (*Gavia immer*)

Background Information

Species Habits and Preferences

This species breeds on freshwater lakes, but is mainly found in coastal marine areas during winter (i.e. when it is present in Ireland). It is a specialist predator that swims on the surface of the water and (as the common name suggests) dives beneath it to capture prey, being a member of the water column diver (deeper) trophic guild. When searching for prey, the bird regularly dips its bill and forehead below the water surface before diving silently from there. Diving depths of up to 70 metres have been reported, although it is thought that the majority of dives are to within ten metres of the surface. The average dive time has been quoted as 42 seconds. Fish up to 28 cm in length (including species found in Galway Bay like Haddock, Whiting, Herring, Sprat, Sandeel and Sea Trout) are the main food, although crustaceans (including crabs and shrimp) and molluscs are also commonly taken. Detection of active prey is visual and birds roost on the water at night. Birds are mature after two years and the oldest recorded individual (ringing recovery) was 7 years and 10 months old.

The best wintering habitat types for this species would be shallow marine waters with an ample supply of small/medium-sized fish, crustaceans and molluscs. Off the south-eastern United States, Haney (1990) found Great Northern Divers to prefer the 0-19 m depth zone, but to be frequent in the 20-39 m depth zone (28% of observations) and occurred up to 100 km offshore (to the edge of continental shelf). Warden (2010) reported that 33% of the bycatch occurred at depths of 15-35 m (compared to 52% of the landings). From data in Wilson et al. (2006), Lewis et al (2008) and Lewis et al (2009) a mean of 29% (s.d. 32%, n = 10) of observations of Great Northern Divers were below the 20 m depth contour in aerial transects of c. 10-50 km length around the Scottish coast. Therefore, published data indicates that Great Northern Divers prefer depths of less than 20 m, but can regularly occur in depths of up to around 30-40 m.

The birds that winter in Irish waters are part of the European breeding population that comes from Iceland and Greenland. The wintering population is mainly present from September to May (with October to March being the important peak months), although a few birds are present in the SPA during May-June and the first birds of the autumn are usually seen in August. This species spends the majority of time on the water, but it is able to fly strongly (usually low over water, to a height of about ten metres, but higher over land) at speeds up to 110-120 km/h. It is thought that migration of the European breeding population may involve multiple flights with breaks spent on the sea. The size of the European breeding population is estimated at about 5,000 individuals, or 700-2,300 pairs. This estimate has remained the same through all five editions of Wetlands International's Waterbird Population Estimates (made in the years 1994, 1997, 2002, 2006 and 2012), so (as far as can be told) the flyway population is stable. The European wintering distribution is around the coasts of Ireland and Britain, the Norwegian coast and continental Atlantic coasts from the North Sea to the Bay of Biscay and as far as Atlantic Iberia (with some staying to winter around Iceland).

The Irish wintering distribution is effectively around the entire coastline, although the larger population size apparent on the west coast is to be expected, given that this side of the country is closer to Iceland and Greenland. The All-Ireland wintering population has been estimated as 1,340 birds (Crowe and Holt, 2013), but the authors note that this is a conservative estimate. The three sites in Ireland at which internationally important concentrations (50 or more individuals) have been recorded are Inner Galway Bay, Donegal Bay and Blacksod & Tullaghan Bays, Co. Mayo (Boland and Crowe, 2012). The record count is of 385 on the 25th of January 2009 in Inner Galway Bay. Although bays/estuaries are undoubtedly good sites for divers, they also offer more viewing opportunities for survey (c.f. open coastline) and are more sheltered, thus giving better sea conditions for detecting the birds. Sea state is very important for counting divers, with birds being difficult to count in conditions with significant waves, a factor which has been noted during I-W*e*BS counts in Inner Galway Bay and that has been commented on in literature (Suddaby, 2010). Since non-estuarine stretches of coastlines are only surveyed formally every nine years (the BWI NEWS survey) and birds can be foraging up to ten kilometres offshore, it is likely that Crowe and Holt were correct in treating the Irish wintering population estimate as conservative. In the third edition (Colhoun and Cummins, 2013) of the Birds of Conservation Concern in Ireland (BoCCI), Great Northern Diver was moved from the green list (low conservation concern) to the amber list (medium conservation concern) on the strength of the international importance (> 20% of flyway population) of the non-breeding population, although it seems that this change does not actually indicate a worsening of the conservation status of the Irish wintering population.

Species Sensitivities

Breeding birds are very sensitive to human disturbance at their nest sites (i.e. outside of Ireland). Nests are also commonly lost to predators and to flooding following water level fluctuations at breeding lakes. At North American breeding lake sites, birds have been negatively impacted by pollution (acid rain effects, mercury pollution), lead poisoning from lead fishing weights and type E botulism. It does not appear that this species is regularly hunted, although it has been noted that they may be occasionally so by the Inuit.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the breeding range of the Great Northern Diver in Iceland will be decreased and shifted north-eastwards, but that islands to the North (Jan Mayen, Bjørnøya and parts of Svalbard) may become suitable for breeding by the latter part of the 21st century. It is not clear what effect this northward shift of the breeding population would have on the wintering distribution of the species; it could be that the wintering distribution will also move further northwards (with unpredictable impacts on the Irish wintering population), but the birds are reputed to avoid ice, so this could limit northward shifting of wintering sites.

As birds that spend the vast majority of their time on or in the water, divers are highly vulnerable to oil spills.

There is evidence that divers can be disturbed by boats/shipping, both recreational and commercial. The potential negative impacts of such disturbance are as follows:

(1) Birds may avoid areas where ships are regularly present (e.g. shipping lanes), resulting in secondary habitat loss.
(2) Individual birds that are regularly disturbed (i.e. which lose foraging time and experience energy loss while fleeing ships) may experience fitness consequences, which at an extreme level could lead to mortality.

Borgmann (2010) reviewed human disturbance impacts on waterbirds and listed a case where Great Northern Diver exhibited an average flush distance (presumably to flight, rather than by swimming or diving) of 51 metres when disturbed by non-motorised boats whilst wintering off the U.S. coast.

Furness *et al*. (2012) mention that "*divers are especially sensitive to approaching boats more than 1 km*", quoting Schwemmer *et al*. (2011) as the authority for this statement. However, this statement does not appear in the paper by Schwemmer *et al*. (2011) that has been referenced in Furness *et al*. (2012). In the tabulated data supplementary to Furness *et al*. (2012) (which are available for online download), it is stated that Great Northern Diver are "apparently less sensitive than other diver species" (i.e. c.f. Red-throated and Black-throated divers, which are stated to have "*a very great flush distance*") to ship traffic disturbance, without a clear authority being given. In the same supplementary data, Topping and Petersen (2011) are quoted as stating that Great Northern Diver "fly from boats more than 1000m away". Forrester *et al*. (2007) is also listed as a reference in the supplementary data to Furness *et al*. (2012). Research has indicated that they are likely to be referring to a statement in Forrester *et al*. (2007) that Great Northern Diver "*rarely fly in winter*". A total of 14 Great Northern Divers were recorded during five studies at four offshore wind farm sites in the U.K.: Argyll Array, Humber Gateway, Gwynt Y Mor and Burbo Bank (Cook *et al*., 2012). Of these, none recorded Great Northern Divers flying within the generic collision risk zone, while Red-throated and Black-throated divers where regularly recorded flying, although it should be noted that 14 sightings is a small sample. Topping and Petersen (2011) actually state that "*Red-throated Divers are susceptible to human disturbances while in the marine environment. From ship-based bird surveys it is known that birds often flush at distances of about 1 km from an approaching ship*". Schwemmer *et al*. (2011) detail research that they carried out in the German North Sea in which they determined that Red-throated Diver (*Gavia stellata*) and Black-throated Diver (*Gavia arctica*) avoid active shipping lanes. In this study these two species were lumped together due to an inability to differentiate them during aerial surveys. They go on to suggest that, due to the recorded avoidance of shipping lanes, these two species are unlikely to habituate to shipping traffic. While Great Northern Diver can certainly be flushed to flight by approaching ships, it seems that there is a certain amount of confusion in the literature that is currently available. There is the suggestion that Great Northern Diver may be less sensitive to ship traffic disturbance than the other two species, but it appears that no authoritative studies have been carried out. Red-throated Diver appears to have been the subject of most survey work, due to concerns that have been raised about marine renewable energy projects (wind and wave) in the North Sea, where this species is by far the commonest diver.

Distribution within Inner Galway Bay

According to the supporting information document for the Inner Galway Bay SPA conservation objective (NPWS, 2013) the population change for Great Northern Diver (based on two five-year means, 1995/96 – 1999/00 and 2005/06 – 2009/10) was + 93%. The site conservation condition for this species was classified as favourable. There is no comparable all-Ireland trend with which the site trend can be compared.

For the I-WeBS period from 2007/08 to 2011/12, Great Northern Diver was recorded in 23 of the 25 I-WeBS subsites (the exceptions being Lough Atalia and a turlough site that lies near to the shoreline of the bay). During the 2009-2010 low tide baseline waterbird surveys, Great Northern Diver was recorded from 17 of the 31 sub-sites that were defined for the study. Foraging was recorded at all 17 sub-sites and roosting was also recorded in nine of these. In the area of the Inner Galway Bay SPA as a whole, I-WeBS counts have indicated that divers are more numerous around the southern coast than the northern coast.

Site Specific Comments Re. Habits, Preferences and Sensitivities

Great Northern Divers have been regularly recorded in the development study area (as recorded in the NIS and EIS). Whilst in the study area they have been observed to dive regularly and on some occasions have been observed to eat prey at the surface. The whole of the marine area of the study area is foraging habitat for this species, therefore. Great Northern Diver have been observed swimming within a few metres of the tide line, so the whole marine area up to the high water mark is potential habitat for this species. Birds have also been observed loafing/resting on the surface within the study area, so the whole marine area is also resting habitat. It is to be expected that birds also roost within the study area at night. There appear to be no available data on the effects of lighting on this species, i.e. as to the possibility that lighting may increase the available foraging period, or if lighting from shore may limit roosting in nearshore areas.

During two winters of observations at the proposed port extension study area (during which attention was paid during the passage of ships into and out of the port) Great Northern Diver was never observed to take flight because of boat/ship passage. Observed diver/ship interactions were comparatively few, probably not more than ten in total. Individuals were occasionally observed to swim away from approaching boats or to dive. Similarly, in Cork Harbour, Great Northern Divers regularly feed within, and around, the shipping channel at the mouth of the harbour (Roches Point) and do not flush when ships pass (T. Gittings, personal observations). In contrast, a Great Northern Diver has been observed to take flight (on a single occasion) at the rapid approach of a RIB within the study area for the proposed compensation/SPA extension site (west of Silver Strand beach, up to and just to the west of Bearna Pier). Furthermore, such flushing behaviour was noted on a number of times when the observer was travelling across the bay from the harbour in a fast RIB whilst on the way to count hauled-out seals at low tide. In any case, Great Northern Divers within the study area categorically do not flush when vessels approach to within a distance of one kilometre or more. Even given the statement by Schwemmer *et al*. (2011) that they consider Red-throated and Black-throated Divers are unlikely to become habituated to fast or intense shipping activity, it seems that this may be the case for Great Northern Diver in the Galway harbour area if their average flushing distance is in any way close to that stated for the other two species.

The key to the severity of shipping disturbance to divers may be due to the speed at which the vessels are travelling. Ships entering or leaving the harbour along the harbour channel are always travelling slowly, as are traditional fishing vessels and yachts. RIBs travel more quickly along the channel, but even in this case not as fast as they do when crossing open stretches of water where no channel discipline is required. Observations made by Schwemmer *et al*. (2011) were for Red-throated and Black-throated divers (congeners, but different species from the Great Northern) that may have differing sensitivities to shipping. Their observations (i.e. that divers avoid shipping lanes) were made in the German North Sea in area where shipping was described as ‘intense’ and ‘channelled’. There were no details of the average speed and size of these ships, but it might be that their speed is the key factor in causing the avoidance of the shipping lanes by divers.

(viii) Light-bellied Brent Goose (*Branta bernicla hrota*)

Background Information

Species Habits and Preferences

This migratory wildfowl species nests in small, loose colonies on tundra with pools. In winter (i.e. when they are present in Ireland) they are found in estuaries and large sheltered coastal bays. Foraging takes the form of grazing on saltmarshes, foreshores and (in some places) on improved and amenity grasslands. Brent geese will feed in shallow water and upend to reach food. This species is a member of both the surface swimmer and intertidal walker (out of water) trophic guilds. In winter the birds can be in small flocks (10-30 birds), or in larger flocks of hundreds or even a few thousand. Roosting in winter is communal and can be on land in open areas, or on islands or sand bars. This species is vegetarian and the main food types are Eelgrasses (in autumn and early winter), saltmarsh grasses, marine green algae like *Ulva* and *Enteromorpha,* saltmarsh plants like Sea Aster, Arrowgrass and Glassworts and other grass species on sown agricultural and amenity grassland close to the coast. Birds are mature after two to three years. Wild birds can live until their twenties.

The flyway population of the *hrota* subspecies of Brent Goose that breeds in the east Canadian high Arctic winters mostly in Ireland. Wintering birds are present mainly from September to April (peak period October to March), arriving at Strangford Lough in autumn before spreading across Ireland. The size of this flyway population is estimated at 40,000 individuals; it has continued to show an increase since the early 1990s.

The All-Ireland wintering population comprises the vast majority of the 40,000 flyway population, with an estimated number of 36,380 (Crowe and Holt, 2013). Light-bellied Brent Goose is amber-listed in BoCCI 2014-2019 (Colhoun and Cummins, 2013) due to the concentration of the wintering population in a small number of sites and its international importance. Worldwide, there are seven populations of Brent Goose of three or four recognised subspecies. Breeding is circumpolar, occurring Greenland, high Arctic Canada, Alaska, central to Pacific high Arctic Russia, Svalbard and Franz Josef Land. Wintering birds from these populations are found on the Pacific and Atlantic coasts of North America, Britain, France, Netherlands, Denmark, Japan and Korea.

Species Sensitivities

This species is lightly hunted in Canada and Greenland. It is thought that they may be occasionally subject to illegal hunting in Ireland during the winter. However, hunting pressure on this species is not considered to be heavy. Brent Geese are relatively tolerant of human disturbance (e.g. walkers) in comparison to other species. In its winter range the species may be persecuted by farmers, as in recent years it has increasingly taken to grazing on cultivated grasslands and winter cereal fields near the coast. The species may also be threatened in the future by reductions in food supplies following the return of a disease of Eelgrass (*Zostera marina*), an important food in autumn and early winter. The nesting success of breeding pairs in Svalbard is greatly reduced as a result of Arctic Fox predation. The species is susceptible to avian influenza so may be threatened by future outbreaks of the virus. Individual site populations may be threatened by loss of or damage to foraging habitat or roosting sites.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the breeding range of the Brent Goose in Europe will diminish by the latter part of the 21st century. These authors predict that breeding, which currently occurs in Svalbard and Franz Josef Land, will be restricted to the latter archipelago. A northward shift in the east Canadian Arctic breeding population (which winters in

Ireland) is predicted by other sources. It is not clear what effects this shift of the breeding population would have on the wintering distribution of the species.

Brent Geese feed along the coastline, including in shallow water. They are thus very vulnerable to oil spills that can oil the birds and kill/contaminate plant food.

Population size and distribution within Inner Galway Bay

According to the Conservation Objectives Supporting Document (NPWS, 2013) the SPA regularly supports 1% or more of the biogeographical population of Light-bellied Brent Goose. The mean peak number of this species within the SPA during the baseline period (1995/96 – 1999/00) was 676 individuals. During the period from winter 2001/02 to 2008/09 the peak count in the Inner Galway Bay SPA varied between 729 and 1,457 (mean of 1,110). The conservation condition Inner Galway Bay Curlew population has been assessed as favourable, with an increase of 135% over the period 1994/95-2008/09, compared to a national increase of 58% over the same period (NPWS, 2013). Inner Galway Bay is the eighth most important site in the Republic of Ireland for Curlew (Boland and Crowe, 2012).

The subsite distribution of Light-bellied Brent Goose in Inner Galway Bay does not show any strong patterns of association with the distribution of suitable tidal zones or biotopes. Light-bellied Brent Goose tend to feed on concentrated food resources, often in the supratidal or terrestrial zone and the large-scale distribution of these birds may have been affected by the proximity of suitable supratidal/terrestrial foraging habitat.

Light-bellied Brent Goose can utilise a wide range of habitats for foraging and roosting. In the BWS low tide counts, the majority of birds occurred in subtidal habitats (mean of 59% of the total counts, and 59% of the counts of foraging birds, with substantial numbers in intertidal habitat (30%, 29%). The numbers recorded in supratidal/terrestrial habitat were low (11%, 12%), but this may have reflected the focus of the count subsites on tidal habitats. Although this species is well-known for using agricultural or amenity grasslands (sometimes not immediately adjacent to the sea), they are generally coastal in Galway Bay. They do use amenity grasslands close to the sea at South Park and the Galway Golf Club at Salthill; other supratidal habitats used in Galway Bay (e.g. saltmarsh in Oranmore Bay, in the Tawin area and close to Lough Muree) are covered by I-WeBS/BWS.

The subtidal habitat suitable for foraging by Light-bellied Brent Goose will be limited to shallow subtidal waters as Light-bellied Brent Goose generally do not feed in waters of greater than 0.5 m depth. The tidal zone between the mean low tide and the lowest astronomical tide can be considered to be a reasonable approximation of the distribution at low tide of suitable Light-bellied Brent Goose subtidal foraging habitat.

Site Specific Comments Re. Habits, Preferences and Sensitivities

Brent Geese have been recorded, somewhat irregularly, in the development study area (as recorded in the NIS and EIS). Whilst in the study area they have been observed to forage along the shoreline and in shallow water in the intertidal zone (i.e. walking/wading in water and swimming at up-ending depths). The whole of the intertidal marine area of the study area is foraging habitat for this species, therefore. Although Brent Geese will rest on deeper water, they have not been observed to do so at the development site study area and roosting behaviour has not been observed. Count maxima of 16 birds using the proposed development site for foraging during the period from March 2011 to March 2012 (mean 2.2, recorded on 3 out of 12 counts during the winter period), 17 birds during the period from October 2012 to March 2013 (mean 3.6, recorded on 4 out of 12 counts during the winter period) and 2 birds during the period from April to June 2014 were recorded.

Brent Geese also occur in the adjacent intertidal areas, again somewhat irregularly. In the area to the west (Nimmo's Pier-South Park Shore) 1-41 birds were recorded in four out of 13 winter counts. In the area to the east (Renmore Beach), 2 birds were recorded one one out of 10 winter counts.

(ix) Bar-tailed Godwit (*Limosa lapponica*)

Background Information

Species Habits and Preferences

This wading bird species nests on the ground in areas of tundra and bog in the continental low Arctic and into high Arctic regions. Outside the breeding season Bar-tailed Godwit are almost entirely coastal in distribution, showing a pronounced preference for sheltered bays or estuaries, or shores free of rock, gravel or shingle and providing plenty of tidal movement over fine sand or muddy sand. This species is a member of the intertidal walker (out of water) trophic guild and feeds mainly in flocks at the tide edge or by water margins and in water up to 15 centimetres deep. Roosting and resting occurs on beaches, except at high spring tides, where it may occur in slightly more elevated areas, including grassland close to the sea. Much of the foraging is by probing while walking, inserting the long bill to moderate depths or full length with the head rotating slightly. Also uses shallow probes, a rapid ‘stitching’ action (consisting of a rapid series of shallow probes close together) and will also pick food from the surface. The major food groups taken at the coast are lugworms, ragworms, small crustaceans, small molluscs and occasionally small fish like Sandeels.

The Northern and Western European wintering population of Bar-tailed Godwit breeds in high Arctic Scandinavia, North Russia, the White Sea and Kanin. Worldwide, there are five flyway populations of the various recognised subspecies of Bar-tailed Godwit. In addition to the breeding sites already mentioned, breeding occurs across high Arctic Siberia to the Pacific and into West Alaska. Birds are mature after two years. While the average lifespan is only 5 years, the oldest known individual was over 24 years old.

The size of the Northern and Western European wintering population has been estimated at 120,000 individuals and the trend is increasing. The European wintering distribution includes Ireland, Britain, continental Europe from France to Germany, Atlantic Iberia, in scattered parts of the western Mediterranean and North-west Africa. Worldwide, wintering populations are also found in West, West-central and South-west Africa, Madagascar, the Red Sea and Middle East, India, South-east Asia and Australasia. Bird shave been tracked migrating from New Zealand to the Yellow Sea in China; at over 10,000 kilometres this is the longest known non-stop flight made by any bird species.

Species Sensitivities

The species is threatened by the degradation of foraging sites due to land reclamation, pollution, human disturbance, reduced river flows and in some areas the invasion of mudflats and coastal saltmarshes by mangroves (owing to sea-level rise and increased sedimentation and nutrient loads at the coast from uncontrolled development and soil erosion in upstream catchment areas). In Ireland it is also possible that the invasion of estuarine mud by colonising *Spartina* grass (not present in Galway Bay) may be the cause of habitat degradation. The species is also susceptible to avian influenza so may be threatened by future outbreaks of the virus. There is also evidence of subsistence hunting of Bar-tailed Godwit in Alaska and China.

Bar-tailed Godwit feed at the coastline, often on the waterline. They are vulnerable to oil spills that can (when they reach shore) coat the foraging habitat, oil birds and kill/contaminate prey.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the breeding range of the flyway population of Bar-tailed Godwit will be reduced by 75% and shifted north-eastwards (to southern Novaya Zemyla and extreme North-east European Russia) by the latter part of the 21st century. Thus, it is predicted that the breeding range of the Irish wintering population will be drastically reduced and will be further from Ireland (although birds from other flyway populations currently migrate much further distances than that between Ireland and the predicted new breeding range of the wintering population). It is not possible to predict exactly what the effect of this would be on the wintering distribution of the species, but it seems quite possible both that the size of the flyway population may be reduced and that birds may not migrate as far as Ireland to winter, so it is quite possible that the Irish wintering population will be reduced in both size and distribution.

Site Specific Comments Re. Habits, Preferences and Sensitivities

During surveys at the proposed development site Bar-tailed Godwit was not recorded within the study area at the proposed development site. These on-site surveys have so far comprised long watches on 34 different dates (18 watches between March 2011 and March 2012; 12 watches between October 2012 and March 2013; four watches between March 2014 and June 2014), giving a total of 212 hours of watches. This total included 25 watches (170 hours) over the October to March winter season when Bar-tailed Godwit would have been most to likely to be in the area, but also included cover over the breeding season and during passage.

According to the Conservation Objectives Supporting Document (NPWS, 2013) the SPA regularly supports 1% or more of the all-Ireland population of Bar-tailed Godwit during winter. The mean peak number of this Annex I species within the SPA during the baseline period (1995/96 – 1999/00) was 447 individuals. During the period from winter 2001/02 to 2008/09 (Boland and Crowe, 2012) the peak count in the Inner Galway Bay SPA varied between 207 and 796 (mean of 447).

(x) Redshank (*Tringa totanus*)

Background Information

Species Habits and Preferences

The wader species breeds on coastal saltmarshes, inland wet grasslands with short swards (including cultivated meadows), grassy marshes, cutover bog, swampy heathlands and swampy moors. On passage the species may frequent inland flooded grasslands and the silty shores of rivers and lakes, but during the winter it is largely coastal, occupying rocky, muddy and sandy beaches, saltmarshes, tidal mudflats, saline and freshwater coastal lagoons and tidal estuaries. In Ireland the breeding distribution is mostly limited to Connemara, the Shannon Estuary, Mullet Peninsula, Donegal and birds in the Midlands nesting on cutover bog. The Irish winter distribution is mainly coastal, with smaller numbers on inland lakes and turloughs. This species is a member of the intertidal walker (out of water) trophic guild. Foraging during daylight is mainly by pecking from the surface and probing into the substrate, with prey or the burrows of prey located by sight. Foraging at night, in turbid shallow water or when birds are forced together into high densities is by touch and can involve the open bill being moved rapidly from side to side in mud until prey is located. Food items taken at the coast are chiefly polychaete worms, gastropod snails, bivalves and crustaceans (amphipods, shrimps, crabs). Birds are mature after one year and the oldest known ringed individual was 17 years old.

The Iceland & Faroes/Western Europe population of Redshank breeds in Iceland and the Faroe Islands. The size of this population has been estimated at 150,000 - 400,000 individuals and the trend is considered to be possibly increasing. This flyway population winters in Ireland, Britain, other North Sea coasts and North-west France. The size of the Irish wintering population is estimated at

29,520 (Crowe and Holt, 2013). The small Irish breeding population is part of the Britain & Ireland/Britain-Ireland-France population of Redshank, which also breeds in Britain and winters Ireland, Britain and North-west France. The size of this population is estimated at 95,000 – 135,000 birds and the trend is declining. Redshank is red-listed in BoCCI 2014-2019 (Colhoun and Cummins, 2013) due to the severe decline of the Irish breeding population and the wintering population also qualifies for amber-listing. During passage periods migrating individuals from other flyway populations may also be present in Ireland. Worldwide, there are nine flyway populations of Redshank. In addition to the areas already mentioned, breeding occurs in Fenno-Scandinavia, the Baltic, most of central Europe, Russia, Siberia, Mongolia, China, India and Tibet. Wintering populations are also found in the Mediterranean, Asia Minor, South-east Asia, India, Sri Lanka, East Africa and the Middle East.

Species Sensitivities

The species is threatened by the loss of breeding and wintering habitats through agricultural intensification, wetland drainage, flood control, afforestation, land reclamation, industrial development, encroachment of *Spartina* spp. on mudflats, improvement of marginal grasslands (e.g. by drainage, inorganic fertilising and re-seeding), coastal barrage construction, and heavy grazing (e.g. of saltmarshes). The species is also threatened by disturbance on intertidal mudflats from construction work (UK) and foot-traffic on footpaths. It is vulnerable to severe cold periods on its Western European wintering grounds and suffers from nest predation by introduced predators (e.g. European Hedgehog) on some islands. The species is also susceptible to avian influenza so may be threatened by future outbreaks of the virus.

Redshank generally show moderate sensitivity to human disturbance. In various disturbance experiments in open tidal flats in North Sea coastal sites, Redshank showed escape distances (the distance at which they responded to disturbance) of 82-137 m (see Introductory Report). However, escape distances may be much lower in in enclosed coastal habitats and/or where background levels of human activity are higher and an escape distance of 37 m was reported for a rocky shore site in Northern Ireland (Fitzpatrick and Boucher, 1998).

Wintering Redshank feed at the coastline, often on the waterline. They are vulnerable to oil spills that can (when they reach shore) coat the foraging habitat, oil birds and kill/contaminate prey.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the breeding range of European populations of Dunlin will be reduced in extent and shifted north-eastwards by the latter part of the 21st century. It is predicted that Redshank will become extinct as breeding bird in the Republic of Ireland, southern and central England and Wales. It is also predicted that areas in southern Scandinavia and central Europe will become unsuitable for the species' needs and that these losses will not be offset by increases in Svalbard, Novaya Zemyla and North-west Russia. However, it is also predicted that Iceland and the Faeroe Islands (where the bulk of the birds that winter in Ireland breed) will remain suitable for the species' needs. It is not possible to predict exactly what the effect of changing breeding distribution would be on the wintering distribution of the species, but it is quite possible that the Irish wintering population will remain stable (unless, which seems unlikely, the winter climate of Iceland warms to the extent that breeding birds are able to winter there also).

Population size and distribution within Inner Galway Bay

During the period from winter 2001/02 to 2008/09 (Boland and Crowe, 2012) the peak count in the Inner Galway Bay SPA varied between 671 and 1,091 (mean of 910). The conservation condition Inner Galway Bay Curlew population has been assessed as favourable, with an increase of 81% over the period 1994/95-2008/09, compared to a national increase of 22.7% over the same period

(NPWS, 2013). Inner Galway Bay is the ninth most important site in the Republic of Ireland for Redshank (Boland and Crowe, 2012).

Site Specific Comments Re. Habits, Preferences and Sensitivities

Redshank have been regularly recorded in the development study area (as recorded in the NIS and EIS). Whilst in the study area they have been observed to forage in the intertidal zone of the site of the proposed development. The whole of the intertidal area of the study area is foraging habitat for this species, therefore. Count maxima of 1 bird using the proposed development site for foraging during the period from March 2011 to March 2012 (mean 0.5, recorded on 6 out of 12 counts during the winter period), 1 bird during the period from October 2012 to March 2013 (mean 0.5, recorded on 6 out of 12 counts) and 1 bird during the period from April to June 2014 were recorded.

Redshank also occur in the adjacent intertidal area to the west (Nimmo's Pier-South Park Shore), somewhat irregularly and in very low numbers (1-3 birds in seven out of 13 counts during the 2011/12 and 2013/14 winters). Redshank were not recorded in the adjacent intertidal area to the east (Renmore Beach).

(xi) Red-breasted Merganser (*Mergus serrator*)

Background Information

Species Habits and Preferences

This duck species nests on sheltered lakes and large rivers, also along the coast, on islands and sea-loughs. In winter they are found exclusively in brackish and marine waters, particularly in shallow protected estuaries, bays, lagoons and also offshore. Red-breasted Merganser is a member of the water column diver (shallow) trophic guild. Foraging occurs during the daytime and is by diving from the water surface; birds forage with head and eyes immersed to search for food and subsequently dive to capture it. This species prefers shallow waters to about 5 metres in depth and most dives are within 3-5 metres of the surface. Foraging can be by single birds, pairs, or by larger flocks, sometimes cooperatively. Marine food items taken include: Cod, Herring, Butterfish, sandeels, Sprat, blennies, sticklebacks, Hake, crustaceans (prawns, shrimps and crab) and molluscs. In winter the birds are generally found in small flocks. Birds are mature after two to three years. The oldest recorded individual (ringing recovery) was 9 years and four months old.

Breeding in Ireland occurs mainly in the North and West, in Northern Ireland, Donegal, Mayo, Galway, Kerry and west Cork. Wintering occurs around the majority of the Irish coast. The Irish wintering population includes local breeding birds that move to the coast, but also birds from Icelandic breeding population and probably some from East Greenland also. This wintering population is part of the North-west and central European flyway population, which breeds in North and North-west Europe, Iceland and East Greenland. Wintering birds in Ireland are mainly present from September to May (with October to March being the important peak months). The size of this flyway population is estimated at about 170,000 individuals. This flyway population is considered to be currently secure.

The Irish wintering distribution is effectively around the entire coastline. The All-Ireland wintering population has been estimated at 2,130 (Crowe and Holt, 2013). Worldwide, there are also breeding populations in North-east Europe, Siberia, China, West and South-east Greenland, Alaska, Canada and adjoining areas in the U.S.A. Wintering birds from these populations are found off the Atlantic and Pacific coasts of North America, the Gulf of Mexico, East Mediterranean, Black Sea, South-east, South-west and Central Asia and the South-west coast of Greenland.

Species Sensitivities

The species is subject to persecution and may be shot by anglers and fish-farmers who consider that it threatens fish stocks. It is also threatened by accidental entanglement and drowning in fishing nets. Alterations to its breeding habitats by dam construction and deforestation, and habitat degradation from water pollution are other major threats to the species. It is also considered vulnerable to nest predation by ground predators (e.g. American Mink) and would (like any marine coastal species) be vulnerable to the effects of oil pollution.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the breeding range of the Red-breasted Merganser in Europe is predicted to be shifted northwards by the latter part of the 21st century. These authors predict the extinction of this species as a breeding bird in Ireland, a shift northwards in Britain to the extreme north of Scotland only, a reduction of breeding range in North-west Russia, Finland and Scandinavia, but a colonisation of Svalbard and Novaya Zemlya. It is not clear what effects this shift of the breeding population would have on the wintering distribution of the species; it could be that the wintering distribution will also move further northwards (with unpredictable impacts on the Irish wintering population).

Red-breasted Merganser frequently occur in enclosed estuarine waters in relatively close proximity to moderate levels of human activity: e.g., in Cork Harbour their main area of occurrence is in the North Channel, where they occur in the middle of the channel 200-300 m from a road (used as an informal amenity walking route) running along the southern shore. However, there appears to be little specific research evidence about their response to human disturbance. Avocet Research Associates (2007) report the results of research carried out in San Francisco Bay where Red-breasted Merganser were experimentally disturbed by kayaks. The mean response distance was 28 m, and they recommended a buffer distance of 219 m (to include the upper end of the 95% confidence limit plus an extra 40 m) to avoid disturbance. Knapton et al. (2000) reported flight distances[1] of 746-939 m, and flight times of 33-51 seconds, for diving ducks (including Red-breasted Merganser) in response to disturbance by boats on an Ontario lake.

Red-breasted Merganser feed by diving beneath the water for prey. They are thus very vulnerable to oil spills that can oil the birds and kill/contaminate prey.

Population size and distribution within Inner Galway Bay

According to the Conservation Objectives Supporting Document (NPWS, 2013) the SPA regularly supports 1% or more of the all-Ireland population of Red-breasted Merganser during winter. The mean peak number of this species within the SPA during the baseline period (1995/96 – 1999/00) was 249 individuals. During the period from winter 2001/02 to 2008/09 the peak count in the Inner Galway Bay SPA varied between 156 and 335 (mean of 215). The conservation condition of the Inner Galway Bay Red-breasted Merganser population has been assessed as intermediate (unfavourable), with a decrease of 4.1% over the period 1994/95-2008/09, compared to a national decrease of 11% over the same period (NPWS, 2013). Inner Galway Bay is the most important site in the Republic of Ireland for Red-breasted Merganser (Boland and Crowe, 2012).

Site Specific Comments Re. Habits, Preferences and Sensitivities

Red-breasted Merganser have been recorded, somewhat irregularly, in the development study area (as recorded in the NIS and EIS). Whilst in the study area they have been observed to forage by diving within the marine area of the site of the proposed development. However, the other section of the GHE count area (including the proposed entrance channel to the commercial port) is deep

[1] The distance flown in response to disturbance

subtidal habitat (greater than 5 m depth) and is, therefore, unlikely to be very suitable foraging habitat for this species. Red-breasted Merganser were not observed within the intertidal portion of the development area. Count maxima of 3 birds using the proposed development site for foraging during the period from March 2011 to March 2012 (mean 0.5, recorded on 3 out of 12 counts during the winter period), 5 birds during the period from October 2012 to March 2013 using the proposed development site for foraging during the period from March 2011 to March 2012 (mean 2, recorded on 10 out of 12 counts during the winter period) and 11 birds during the period from April to June 2014 were recorded.

(xii) Sandwich Tern (*Sterna sandvicensis*)

Background Information

Species Habits and Preferences

This species breeds in colonies mainly on marine inshore islands, sand spits, shingle beaches and (occasionally in Ireland) on islands in freshwater lakes. During winter it is mainly found in coastal marine areas during winter. Birds are present in Ireland during passage periods and the breeding season, mainly between March and September-October. In recent years a small number (maximum number recorded has been eight) of individuals have also wintered in Galway Bay. Sandwich Tern is a member of the water column diver (shallow) trophic guild. It is a specialist predator that feeds mostly by plunge diving for prey, but will also snatch prey in flight from just below the water surface or skims low over the waves to catch small fish emerging from the water. The maximum dive depth is 1.5-2 metres. Prey items comprise mainly marine fish about 10 cm in length; in the Atlantic these are mainly Sandeels, but Herring, Sardines, Anchovies, Sprat, Whiting, sticklebacks and Cod are also taken, as are shrimps, squid and ragworms. Detection of active prey is visual and birds roost on rocks or islands (i.e. at the nesting colony during the breeding season) at night. Recorded foraging distances from the breeding colony are varied, with a maximum claimed of 70 kilometres and a mean of approximately 15 kilometres; in general it is safe to say that the majority of birds forage within 20 kilometres of the colony during the breeding season. Birds are fully mature after three-four years and the oldest recorded individual (ringing recovery) was 27 years and 3 months old.

The birds that breed in Ireland are part of the Western Europe breeding population that winters mainly off West African coasts and in the Mediterranean. The size of the European breeding population is estimated at about 166,000 – 171, 000 individuals. The population trend is currently stable, although the European population has been assessed as depleted, due to a moderate historical decline, and Sandwich Tern is listed on Annex 1 of the Birds Directive (79/409/EEC). This population breeds on Atlantic coasts (Ireland, Britain, France, Netherlands, Germany, Sweden, Denmark and the Baltic), in the Mediterranean (France, Spain and Italy) and in the Black and Caspian seas. Wintering is mainly off West African coasts (Mauretania, Ghana, Senegal, Sierra Leone, Liberia, Côte D'Ivoire), but occurs down as far as South Africa. The Irish breeding population is approximately 3,700 AON (apparently occupied nests, or pairs). Worldwide, there are also breeding populations in southern U.S.A., Caribbean islands, Gulf of Mexico and Caribbean Mexico and South America).

Species Sensitivities

Breeding birds are very sensitive to human disturbance at their nest sites. Foraging Sandwich Terns are more tolerant of human disturbance and Furness *et al*. (2012) gave Sandwich Tern a low vulnerability score for disturbance by ship traffic, referencing "slight avoidance at short range". In Irish coastal waters they often feed in very close proximity to human activity.

Sandwich Terns are also to loss of breeding sites due to erosion, wind-blown sand or overgrowth of vegetation and to nest predation by predators. Sandwich Terns wintering off West Africa are hunted.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the breeding range of Sandwich Tern in Ireland and Britain will remain similar to as at present. Overall, a slight breeding distribution shift to the north is predicted, with the possibility that breeding may start to occur in Iceland, but that there will be a decline on continental Atlantic coasts from France to Germany and in the Black Sea.

Sandwich Tern feed by diving into the sea and often rest close to water. Thus they are vulnerable to oil spills, both in the sense of direct oiling of the birds and due to contamination of and/or shortage of suitable prey in the aftermath of a spill.

Population size and distribution within Inner Galway Bay

In 1995, as part of the All-Ireland Tern survey, the breeding population of Sandwich Tern in Inner Galway Bay was surveyed and 81 pairs (based on apparently occupied nests) were recorded. This exceeds the All-Ireland 1% threshold for this Annex I species. In 2014 the breeding colony on an island in Coranroo Bay was still extant and the size of the breeding population was estimated at 50 to 75 pairs, still exceeding the all-Ireland 1% threshold.

The distribution of foraging Sandwich Terns within Inner Galway Bay is not known. The mean foraging range of Common Terns is 14.7 km, while the majority of birds forage within 20 kilometres of their breeding colony (seabird wikispace). The mean foraging range probably represents the core foraging area, while the area between the mean foraging range and the maximum foraging range can be thought of as a buffer zone, exploited by lower numbers of birds less intensively. Therefore, if these foraging range figures are representative of the Inner Galway Bay population, the core foraging range for the Sandwich Tern colony includes the entire SPA, and extends outside the SPA to near Black Head on the southern shore. Within these areas, Sandwich Terns can feed in all subtidal habitat (and have been observed feeding out in the middle of the bay) and in intertidal habitat at high tide. Based on the seabird wikispace foraging range data, around 60% of the core foraging ranges is contained within the Inner Galway Bay SPA.

Site Specific Comments Re. Habits, Preferences and Sensitivities

The Sandwich Tern breeding colony is approximately 12 kilometres from the site of the proposed development and is not close to any of the shipping routes, areas likely to be used by recreational boating, etc.

Sandwich Tern has been regularly recorded in the development study area (as recorded in the NIS and EIS), with maxima of 13 birds using the site for foraging during summer 2011 and 6 birds during the period from April to June 2014. Whilst in the study area they have been observed to plunge dive for prey regularly. The whole of the marine area of the study area is foraging habitat for this species, therefore. This species has not been observed resting within the study area, although they do regularly rest on exposed muddy sand near to Nimmo’s Pier and on rocks between Nimmo’s Pier and the Mutton Island causeway.

(xiii) Turnstone (*Arenaria interpres*)

Background Information

Species Habits and Preferences

This wading bird species nests on the ground in open sites, usually on a slight ridge or hummock, or in a rock fissure, usually close to the coast, but sometimes a few kilometres inland. In winter (i.e. when present in Ireland) the distribution is around the shoreline of the coast, with shores that are stony, rocky, or covered with seaweed preferred, as well as sea-walls, breakwaters, harbours and jetties. Turnstone is a member of the intertidal walker (out of water) trophic guild. The commonest feeding technique (which gives the bird its common name) is to overturn objects (e.g. stones, seaweed) with the bill and forehead while searching for prey. Other feeding techniques include rolling up mats of seaweed, searching in cracks between rocks and probing into sediment with the bill. Food items taken include flies, wasps, ants, butterflies and moths, beetles, spiders, crustaceans (amphipods, barnacles, crabs and isopods), molluscs (winkles, mussels and limpets), worms, brittlestars, urchins, small fish (sticklebacks) and plant seeds. Will scavenge dead animals washed up on the shoreline (seals, whales, man, sheep and wolf have been recorded), eat discarded human foodstuffs (e.g. spilt grain, bread, chips) and also steal the contents of unguarded birds' eggs. In winter the birds are generally found in small loose flocks (of less than ten to 20-30 individuals), although larger groups may be found at particularly attractive feeding areas, or at roosts. Flocks will typically forage energetically and actively in one area before flying of together to another feeding site along the shoreline. Birds are mature after two years and the average lifespan is nine years. The oldest recorded individual (ringing recovery) was 19 years and eight months old.

The birds that winter in Ireland breed in North-eastern Canada and North and east Greenland. The wintering population is mainly present from September to May (with October to March being the important peak months). The size of this population is estimated at about 100,000 to 200,000 individuals. The current trend is tentatively considered to be increasing after declines in previous years. The wintering distribution is around the coasts western Europe and North-west Africa.

The Irish wintering distribution is effectively around the entire coastline. The All-Ireland wintering population has been estimated at 9,630 (Crowe and Holt, 2013). Since non-estuarine stretches of coastlines are only surveyed formally every nine years (the BWI NEWS survey) and rocky coastlines are a preferred habitat for this species, estimates of populations size and population trends based on I-W*e*BS data (this survey covers only a very small proportion of non-estuarine wetlands) should be treated with caution. Worldwide, there are also breeding populations in Fenno-Scandinavia, Northwest Russia, the high Russian Arctic, west and central Siberia, low Arctic Canada and Alaska. Wintering birds from these populations are found in South and Central America, southern U.S.A., Africa, Madagascar, the Middle East, India, South-east Asia, Australia and New Zealand.

Species Sensitivities

Breeding birds are vulnerable to nest predation (i.e. outside of Ireland). Other threats include habitat loss and pollution.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the breeding range of the Turnstone in Scandinavia and North-west Russia will be reduced and shifted slightly northwards by the latter part of the 21st century. Presumably, this northward shift will also occur in Canada and Greenland. It is not clear what effects this shift of the breeding population would have on the wintering distribution of the species; it could be that the wintering distribution will also move further northwards (with unpredictable impacts on the Irish wintering population).

Turnstone feed at the coastline, often on the waterline. They are vulnerable to oil spills that can (when they reach shore) coat the foraging habitat, oiling the birds and kill/contaminate prey.

Population size and distribution within Inner Galway Bay

According to the Conservation Objectives Supporting Document (NPWS, 2013) the SPA regularly supports 1% or more of the all-Ireland population of Turnstone during winter. The mean peak number of this species within the SPA during the baseline period (1995/96 – 1999/00) was 182 individuals. During the period from winter 2001/02 to 2008/09 the peak count in the Inner Galway Bay SPA varied between 217 and 372. However, due to the difficulties of counting Turnstone, the I-WeBS counts are likely to be significant underestimates of the true population size within Inner Galway Bay. The conservation condition of the Inner Galway Bay Turnstone population has been assessed as favourable, with an increase of 105% over the period 1994/95-2008/09, compared to a national trend of 16% over the same period (NPWS, 2013). Inner Galway Bay is the third most important site in Ireland for Turnstone (Boland and Crowe, 2012).

Over the twelve I-WeBS seasons (37 counts) from 2002/03 to 2013/14, Turnstone was recorded in 24 of the 25 I-WeBS sub-sites used (the exception being the Ahapouleen wetland, a freshwater turlough site that lies near to the shoreline of the bay). During the 2009-2010 low tide baseline waterbird surveys, Turnstone was recorded from 26 of the 31 sub-sites that were defined for the study. Foraging was recorded at all 26 sub-sites and roosting was also recorded in 14 of these. For the five monthly counts from October 2009 to February 2010, the average SPA count was 287, with a maximum count of 466 in December 2009. In the area of the Inner Galway Bay SPA as a whole, I-WeBS counts and low tide baseline data have indicated that Turnstone are most numerous around the southern coast of the inner bay between Kinvara and Aughinish and in the centre of the bay in the Tawin Island area.

As Turnstone typically feed on rocky shores, their distribution within Inner Galway Bay might be expected to be correlated with the distribution of the fucoid-dominated community complex biotope. However, no such relationship was found in our analyses of subsite distribution. It may be that, in areas with large amounts of this biotope, the difficulties of detecting Turnstone in counts from fixed vantage points causes systematic undercounting, compared to areas with small amounts of the biotope.

Site Specific Comments Re. Habits, Preferences and Sensitivities

Turnstones have been regularly recorded in the development study area (as recorded in the NIS and EIS). Whilst in the study area they have been observed to forage actively on the shoreline. No high tide roosts have been observed within the development site study area. In most cases the birds observed foraged for a short period before flying off, either to the west or to the east. Turnstone do not regularly occur in the areas of intertidal habitat adjacent to the GHE site (Nimmo's Pier-South Park Shore and Renmore Beach).

The intertidal habitat within the study area is classified as the fucoid-dominated biotope and is suitable foraging habitat for the species. However, it has been fragmented due to the loss of the upper shore by the development of the GHEP and now exists as small patches of habitat, isolated from other areas of suitable habitat. This fragmented nature of the habitat is reflected in the behaviour of the birds only staying within the site for short periods of time as described above.

(xiv) Wigeon (*Anas penelope*)

Background Information

Species Habits and Preferences

This dabbling duck species nests on shallow freshwater marshes, on lake islands, or under tussocks adjacent to lakes and lagoons. In winter they occur on coastal marshes, freshwater and brackish lagoons, estuaries and bays. Many also winter on inland wetlands, lakes, rivers and turloughs. Wigeon is a member of the both the surface swimmer and intertidal walker (out of water) trophic guilds. This species is almost entirely vegetarian, foraging is by grazing on land while walking, on water, from the surface and under water by immersion of the head and neck. Wintering birds are gregarious and can feed during the day or night, depending on tidal state and disturbance. Food items taken include: *Zostera*, *Ruppia*, *Salicornia*, algae (e.g. *Enteromorpha*, *Ulva*) and grasses from the supratidal zone, as well as duckweeds, clover, horsetails and Fool's Watercress. Occasionally, some animal materials (i.e. cockles, other molluscs, crustaceans, amphibians and fish spawn) are taken. Birds are mature after one year. Although average life expectancy is only 1.6 years, the oldest recorded individual (ringing recovery) was 18 years and three months old.

The Irish breeding population is small at best; during the last breeding atlas survey pairs were present during the breeding season in nine 10-kilometre squares scattered across inland lowland wetlands, but breeding was not confirmed at any of these sites. The Irish wintering population is widespread and can be found at lowland wetlands both at the coast and inland. This wintering population includes birds from the Icelandic, Fenno-Scandinavian and Russian breeding populations and can fluctuate widely in number due to the severity of weather conditions both in continental Europe and in Ireland. Wintering birds are part of the Western Siberia & NE Europe/NW Europe flyway population, which breeds in western Siberia and northern Europe (including Iceland and very thinly in Ireland and Britain). Wintering birds in Ireland are mainly present from September to April (with October to March being the important peak months). The size of this flyway population is estimated at about 1.5 million individuals and the population trend is considered to be currently stable/secure. The All-Ireland wintering population has been estimated at 62,980 (Crowe and Holt, 2013) and Wigeon is red-listed in BoCCI 2014-2019 (Colhoun and Cummins, 2013) due to a severe decline in the wintering population. Worldwide, there are five flyway populations of Wigeon breeding across Siberia, into Mongolia and North-east China. Wintering birds from these populations are found in southern and central Asia, North-east Africa, the Black Sea and the Mediterranean.

Species Sensitivities

This species is susceptible to disturbance from freshwater recreational activities (e.g. walkers), pollution (including thallium contamination, petroleum pollution, wetland drainage, peat-extraction (e.g. in the Kaliningrad region of Russia), changing wetland management practices (decreased grazing and mowing in meadows leading to scrub over-growth) and the burning and mowing of reeds. Avian influenza virus (strain H5N1) is also a potential threat, as is poisoning from the ingestion of lead shot pellets. This species is hunted for sport (e.g. in Ireland and Britain), and although population numbers in an area decrease significantly after a period of shooting, there is no current evidence that such utilisation poses and immediate threat to the species, although hunting may increase the species sensitivity to disturbance impacts (see below). The eggs of this species used to be (and possibly still are) harvested in Iceland. This species is also hunted for commercial and recreational purposes in Gilan Province, northern Iran.

Wigeon generally show moderate-high sensitivity to human disturbance. In various disturbance experiments in open tidal flats in North Sea coastal sites, Wigeon showed escape distances (the distance at which they responded to disturbance) of 128-269 m (see Introductory Report). In controlled disturbance experiments in a restored freshwater wetland complex in Denmark (Bregnballe et al., 2009), escape distances were 190-205 m when views were unobstructed and 117 m (but note small sample size) when views were obstructed. Mathers et al (2000) reported observations of unplanned disturbances on Wigeon feeding on *Zostera* beds in Stangford Lough, Ireland. As the *Zostera* beds are spatially discrete and widely separated, the displacement costs are likely to be high. The EDs were reported in distance bands of 0-100 m, 100-250 m and > 250 m, and for flock sizes of 0-100 and > 100 birds. The median ED was in the 100-250 m band, but there were significant numbers of observations of birds showing both small EDs (< 100 m) and large EDs (> 250 m). It should be noted that, as this was not a controlled study, the distribution of potential disturbances was not necessarily equal across the distance bands.

It has been predicted (Huntley *et al*., 2007) that, as a result of climate change, the breeding range of the Wigeon in Europe is predicted to be shifted northwards by the latter part of the 21st century. These authors predict the extinction of this species as a breeding bird in Ireland, England and Wales, a reduction of the breeding range in Iceland (slight), southern Scandinavia and Russia, but a colonisation of Svalbard and Novaya Zemlya. It is not clear what effects this shift of the breeding population would have on the wintering distribution of the species; it could be that the wintering distribution will also move further northwards (with unpredictable impacts on the Irish wintering population), but winter visitors from Iceland (swelled by birds from the east during bad weather on the continent) would still be expected.

Population size and distribution within Inner Galway Bay

During the period from winter 2001/02 to 2008/09 the peak count in the Inner Galway Bay SPA varied between 1,138 and 2,185, with a mean of 1,828 (Boland and Crowe, 2012). The conservation condition Inner Galway Bay Curlew population has been assessed as favourable, with an increase of 17.6% over the period 1994/95-2008/09, compared to a national decrease of -20.2% over the same period (NPWS, 2013). Inner Galway Bay is the tenth most important site in the Republic of Ireland for Wigeon (Boland and Crowe, 2012).

The subsite distribution of Wigeon in Inner Galway Bay does not show any strong patterns of association with the distribution of suitable tidal zones or biotopes. Wigeon tend to feed on concentrated food resources, often in the supratidal or terrestrial zone and the large-scale distribution of these birds may have been affected by the proximity of suitable supratidal/terrestrial foraging habitat.

Wigeon can utilise a wide range of habitats for foraging and roosting. In the BWS low tide counts, the majority of birds occurred in subtidal habitats (mean of 56% of the total counts, and 59% of the counts of foraging birds, with substantial numbers in intertidal habitat (40%, 38%). The numbers recorded in supratidal/terrestrial habitat were low (4%, 3%), but this may have reflected the focus of the count subsites on tidal habitats. As with Brent Goose, most of the supratidal habitats used by this species in Inner Galway Bay are covered by I-WeBS/BWS.

The subtidal habitat suitable for foraging by Wigeon will be limited to shallow subtidal waters as Wigeon generally do not feed in waters of greater than 0.5 m depth (Kirby et al., 2000). The tidal zone between the mean low tide and the lowest astronomical tide can be considered to be a reasonable approximation of the distribution at low tide of suitable Wigeon subtidal foraging habitat.

Site Specific Comments Re. Habits, Preferences and Sensitivities

Wigeon have been recorded, somewhat irregularly, in the development study area (as recorded in the NIS and EIS). Within the study area they have been observed to forage on the foreshore (almost certainly on marine algae) and in the shallow water immediately adjacent to it. The foraging habitat for this species in the proposed development site are the intertidal and shallow subtidal zones, therefore. Count maxima of 12 birds using the proposed development site for foraging during the period from March 2011 to March 2012 (mean 1.8, recorded on 3 out of 12 counts during the winter period), 4 birds during the period from October 2012 to March 2013 (mean 0.8, recorded on 4 out of 12 counts during the winter period) and 3 birds during the period from April to June 2014 were recorded. The pattern of usage of the site appears to be seasonal, with all the records in later winter/spring. Roosting behaviour was not recorded at the site of the proposed development.

Wigeon also occur in the adjacent intertidal areas, again somewhat irregularly and in very low numbers. In the area to the west (Nimmo's Pier-South Park Shore) 1-10 birds were recorded in five out of 13 counts during the 2011/12 and 2013/14 winters. In the area to the east, 1-2 birds were recorded in two out of 10 counts during the 2011/12 and 2013/14 winters.

Galway Harbour Company

Galway Harbour Extension

Appendices to NIS Addendum / Errata

Appendix No. 2.9 – Lough Corrib SPA CSI's

Name	SCI Selection Criterion	Present Inner Galway Bay SPA and/or at Harbour Extension Site	Breeding birds from Lough Corrib likely to visit Inner Galway Bay SPA during summer?	Likelihood of impact on conservation status of Lough Corrib SCI?
Greenland White-fronted Goose *Anser albifrons flavirostris*	Wintering	No - Occasionally birds fly through Inner Galway Bay SPA, but no flock regularly uses the bay.	n/a	None
Gadwall *Anas strepera*	Wintering	Yes - Very low numbers (e.g. 2-6 birds recorded in Lough Atalia, occasionally similar numbers at Dunguire Bay, Kinvara).	n/a	None
Shoveler *Anas clypeata*	Wintering	Yes, but not recorded at the harbour extension site.	n/a	None
Pochard *Aythya ferina*	Wintering	No - Effectively no, but occasionally recorded in the lagoon at Lough Muree and also occasionally at the Ahapouleen wetland, which is part of the Galway Bay Complex SAC (but not Inner Galway Bay SPA) and part of the Galway Bay I-WeBS count.	n/a	None
Tufted Duck *Aythya fuligula*	Wintering	No - Occasionally recorded at the Ahapouleen wetland, which is part of the Galway Bay Complex SAC (but not Inner Galway Bay SPA) and part of the Galway Bay I-WeBS count.	n/a	None
Common Scoter *Melanitta nigra*	Breeding	Yes, but rarely recorded at site of the proposed development. Two birds were recorded at the development site study area on the 30th October 2012 (i.e. recorded during one survey out of 37 at the site). Scoter are regularly recorded during the Inner Galway Bay I-WeBS count. The numbers involved are usually not more than 50 birds, although occasional counts of over 100 are recorded. Flocks (rather than odd birds) are always recorded on the southern side of the bay between Kinvara and Rinn. It is not known if breeders from the small population in Lough Corrib winter locally, although this may occur. However, even the modest numbers recorded on the southern side of Galway Bay are much too large to comprise only local breeders and the majority (or all) of these flocks must be made up of foreign breeders (possibly from Russia).		None

Hen Harrier *Circus cyaneus*	Post breeding/roost	Effectively no, but occasional records of birds flying through the Inner Galway Bay SPA.		None
Coot *Fulica atra*	Wintering	Effectively no, but recorded in Lough Atalia once a few years ago and regular at Ahapouleen wetland, which is part of Galway Bay Complex SAC and also part of the Galway Bay I-WeBS count.	n/a	None
Golden Plover *Pluvialis apricaria*	Wintering	Yes, but not recorded at the harbour extension site.	n/a	None
Black-headed Gull *Chroicocephalus ridibundus*	Breeding	Recorded at site of proposed development.	Possible. In a recent (2007) survey, almost all of the Black-headed Gull breeding on Lough Corrib were on the upper lake at Taney Island, 26 kilometres North-west of the harbour site.	Unlikely, breeders from Lough Corrib may visit Galway Bay during the breeding season (indeed probably do on occasion). Available data often vary widely, but 30 kilometres has been quoted as a rule of thumb maximum foraging distance from the colony for this species. However, even though the harbour site is within the foraging range of the nearest Black-headed Gull colony, they will spend the vast majority of their time foraging much closer to the colony. There is no necessity for birds that may be travelling from Lough Corrib to Galway Bay to follow the lake and River Corrib down through Galway City to the vicinity of the river mouth, so they may not actually forage in the vicinity of the harbour when and if they do visit the bay for long-range foraging. The area of the footprint of the site of the proposed development is a small proportion of the available foraging habitat (i.e. Lough Corrib, River Corrib, Lough Mask and Galway Bay) that is available within range of the breeding colony.
Common Gull *Larus canus*	Breeding	Recorded at site of proposed development.	Possible. In a recent (2007) survey, the largest and closest Common Gull colony on Lough Corrib was in the lower lough at Walsh's Island, 13 kilometres North-northwest of the harbour site.	Unlikely, breeders from Lough Corrib may visit Galway Bay during the breeding season (indeed probably do on occasion). Available data often vary widely, but 25-50 kilometres has been quoted as a maximum foraging distance from the colony for this species. However, even though the harbour site is within the foraging range of the nearest Common Gull colony, they will spend the vast majority of their time foraging much closer to the colony. There is no necessity for birds that may be travelling from Lough Corrib to Galway Bay to follow the lake and River Corrib down through Galway City to the vicinity of the river

				mouth, so they may not actually forage in the vicinity of the harbour when and if they do visit the bay for long-range foraging. The area of the footprint of the site of the proposed development is a small proportion of the available foraging habitat (i.e. Lough Corrib, River Corrib, Lough Mask and Galway Bay) that is available within range of the breeding colony.
Common Tern *Sterna hirundo*	Breeding	Recorded at site of proposed development.	Possible. In a recent (2007) survey, the largest and closest Common Tern colony on Lough Corrib was in the lower lough on an islet beside Walsh's Island, 13 kilometres North-northwest of the harbour site.	Unlikely, breeders from Lough Corrib may visit Galway Bay during the breeding season (indeed probably do on occasion). Available data often vary widely, but 20 kilometres has been quoted as an average maximum foraging distance from the colony for this species. However, even though the harbour site is within the foraging range of the nearest Common Tern colony, they will spend the vast majority of their time foraging much closer to the colony. There is no necessity for birds that may be travelling from Lough Corrib to Galway Bay to follow the lake and River Corrib down through Galway City to the vicinity of the river mouth, so they may not actually forage in the vicinity of the harbour when and if they do visit the bay for long-range foraging. The area of the footprint of the site of the proposed development is a small proportion of the available foraging habitat (i.e. Lough Corrib, River Corrib and Galway Bay) that is available within range of the breeding colony.
Arctic Tern *Sterna paradisea*	Breeding	No - This species is a breeding SCI for SPAs in the Aran Islands and on Connemara marine islands. It is rarely recorded in the Inner Galway Bay SPA, but there are problems of differentiation from Common Tern at distance. There are no Arctic Tern breeding in Inner Galway Bay. Not recorded as part of surveys at the site of proposed development.		None