MERC Consultants
environmental and conservation services

Natura Impact Statement

For proposed maintenance dredging at Malahide Marina.

Client name	Malahide Marina Ltd
Client address	Malahide Marina, Malahide, Co. Dublin
Project description	Maintenance dredging of marina.
Project size	20,188 m^2
Report Version	2.1
Report date	14/3/2018

Report prepared by: *MERC Consultants Ltd. Loughaunbeg, Inverin, Co. Galway.*

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1. Introduction

1.1 Overview

Malahide Marina have proposed a project for the maintenance dredging of an area of 20,188 m^2 within the confines of the existing marina at Malahide, Co. Dublin (Figure 1.1). The marina is excluded from, but surrounded by, Malahide Estuary Special Area of Conservation (Site code: 000205) and Malahide Estuary Special Protection Area (Site code: 004025). A number of additional Natura 2000 sites are located within a 15km radius of the proposed project site.

Following a review of the proposed project, Screening for Appropriate Assessment, under Regulation 42 of the European Communities (Birds and Natural Habitats) Regulations 2011, and following the guidelines of *Assessment of plans and projects significantly affecting Natura 2000 sites* - Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC was conducted and is presented in section 6 of this report. The screening identified potential risks to the conservation objectives of Malahide Estuary SAC, Malahide Estuary SPA and additional European sites based on the proposed scope of works, without mitigation. The screening report concluded that; as the likely level of impact was uncertain a Natura Impact Statement (NIS) should be prepared.

A Natura Impact Statement was subsequently prepared and is presented as section 7 of this report. The NIS proposed measures to mitigate the potential impacts identified at the screening stage to ensure that the proposed project, individually or in combination with other plans or projects, would not have a significant effect on, or adversely affect the integrity of, a European Site.

1.2 Legislation

All EU Member States are obliged to establish a network of sites of conservation importance known as the Natura 2000 network. The network is made up of Special Areas of Conservation (SAC's) established under the EU Habitats Directive (92/43/EEC) and Special Protection Areas (SPA's) established under the EU Birds Directive (79/409/EEC). Under Article 6 (3) of the Habitats Directive, Member States are required to consider the potential effects of any project or plan on the conservation objectives of an SAC or SPA before a decision can be made to allow that project or plan to proceed.

Appropriate Assessment (AA) is the process whereby the potential impacts of a project or plan is assessed in terms of the site/s conservation objectives. The first step in the process is to conduct AA screening to determine, on the basis of a preliminary assessment and objective criteria, whether the project or plan, alone or in combination with other projects or plans could have significant effects on the conservation objectives of a Natura 2000 site. Where significant effects are likely, uncertain or unknown at the screening stage a Natura Impact Statement is required to enable a consent authority to carry out an appropriate assessment.

1.3 Statement of Authority

This report was prepared by Louise Scally, MERC Consultants Ltd.

Dr. Louise Scally MCIEEM

Dr Louise Scally (MSc., PhD) is a professional ecologist with a wide range of experience in the field of conservation biology, marine ecology and botanical taxonomy. She completed a M.Sc. in ecology and taxonomy at the Botany Department Trinity College Dublin in 1989 and a Ph.D. in taxonomy also at the Botany Department of Trinity College Dublin in 2001.

She has conducted field surveys for a range of habitats over the last 15 years for private and public sector clients including the National Parks and Wildlife Service, the Marine Institute, Bord Iascaigh Mhara, Inland Fisheries Ireland and the Environmental Protection Agency.

She was a scientific team member of MERC consultant's Marine habitat mapping surveys carried out in a number of Special Area of Conservation from 2005-2010 for the National Parks and Wildlife Service and was the Project Manager and scientific team leader for the 2009 to 2011 programme of marine surveys conducted by MERC Consultants on behalf of the Marine Institute for their current programme of Appropriate Assessment of designated sites. She is currently a scientific team member of MERC consultant's marine monitoring project of SAC's for the 2016 to 2018 Article 17 reporting period.

In addition to her scientific expertise she has an in-depth knowledge of Irish and European Environmental legislation and policy. In 2011 she prepared the text describing Activities Requiring Consent (ARCs) for inclusion in a handbook detailing the regulatory framework for all developments within designated sites in Ireland on behalf of the National Parks and Wildlife Service. She has also produced numerous Conservation Management Plans for the same department. To-date she has conducted in excess of 60 ecological reports in support of Appropriate Assessment under Article 6(3) of the EU Habitats Directive.

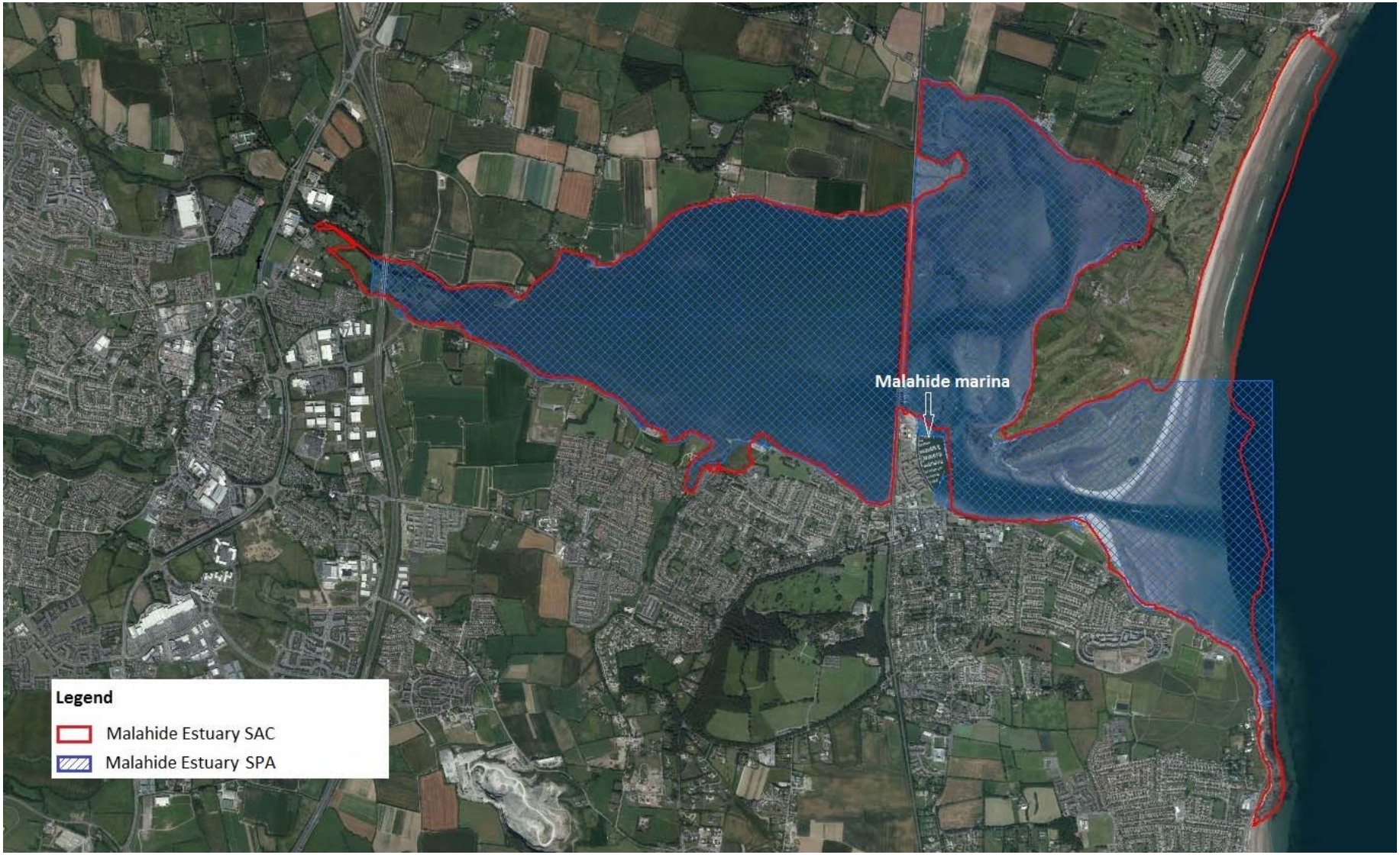

Figure 1.1 Malahide marina relative to Malahide Estuary SAC and Malahide Estuary SPA. **Bing Maps Aerial** - © 2018 Microsoft Corporation © 2018 DigitalGlobe ©CNES (2018) Distribution Airbus DS.

2. Project Description and Construction methods

2.1 Description of the proposed development

The proposed project is required for maintenance dredging of Malahide Marina, Co. Dublin to restore the marina depths to their original levels. Since its construction in 1991 sediments have continually washed into the marina area and gradually settled out, particularly in the eastern section of the marina adjacent to the rock armour on the landward side (figures 2.1 and 2.2). The current levels of siltation within the marina have affected safe navigation and caused distortion of some of the pontoons. Dredging of the area to remove the settled sediments was previously carried out in 1996, however sediment levels have increased gradually since that time and further maintenance dredging is now required.

It is proposed that a total of 40,000 m^3 of sediment is removed from the marina area by a water injection dredging process. It is proposed that the project be completed over a ten year period with a total of 20,000 m^3 being removed in 2018, a further 10,000 m^3 in 2022 and the remaining 10,000 m^3 in 2027.

Figure 2.1. Sediment settlement adjacent to pontoons at Malahide Marina. Image taken February 2017.

Figure 2.2. Sediment settlement adjacent to pontoons at Malahide Marina. Image taken March 2018.

2.2 Construction Methods

The method of dredging proposed is “water injection dredging”. This is a process whereby the sediment layer is mobilised by injecting water into the sediment creating a fluidised layer that initially acts as a density current. This fluid layer, flowing primarily under the influence of gravity, will tend to travel to the deepest point within the estuary system. Waterman Moylan Consulting engineers conducted a sediment transportation prediction impact study (Moylan, 2006) to assess the likely settlement of sediments mobilised by injection dredging within the marina area. This report has concluded that sediment settlement would be within the area known as the “short deeps” (figure 2.3).

The water injection dredging system operates by moving a jet bar over the surface of the seabed while the nozzles inject large volumes of water at low pressure into the sediment layer. The density of the sediment layer is lowered until it shows fluid behaviour. The fluidised sediment layer is then transported horizontally in the lower part of the water column away from the dredged areas. The hydrostatic pressure difference, the gradient of the seabed and the tidal and current flows are the main driving forces for this natural horizontal transport. In most cases the fluidised sediment will finally re-enter the water column in a high energy environment where it will be mixed with other naturally occurring sediment particles. From there on the sediment continues its natural route towards its original destination.

Figure 2.3. Area known as the "short deeps" where sediment settlement is predicted. **Bing Maps Aerial** - © 2018 Microsoft Corporation © 2018 DigitalGlobe ©CNES (2018) Distribution Airbus DS.

3. Appropriate Assessment Methods

3.1 Guidance

This document has been prepared having regard to the following guidance documents:

- European Commission (2000) *Managing Natura 2000 sites. The provisions of Article 6 of the 'Habitats Directive' 92/43/EEC*. Office for Official Publications of the European Communities, Luxembourg.
- European Commission (2001) *Assessment of plans and projects significantly affecting Natura 2000 sites. Methodological guidance on the provision of Article 6 (3) and (4) of the Habitats Directive 92/443/EEC*. Office for Official Publications of the European Communities, Luxembourg.
- Department of Environment Heritage and Local Government (DoEHLG) (2008) *Circular Letter SEA 1/08 & NPWS 1/08 Appropriate Assessment of Land Use Plans.*
- Department of Environment, Heritage and Local Government (DoEHLG) (2010) *Appropriate Assessment of Plans and Projects in Ireland. Guidance for Planning Authorities.*
- Scottish Natural Heritage (2012) *Habitats Regulations Appraisal of Plans: Guidance for Plan-Making Bodies in Scotland. Version 2.0. August 2012.*
- Scottish Natural Heritage (2012) *Habitats Regulations Appraisal (HRA) Advice Sheet: Screening general policies and applying simple mitigation measures.*
- Scott Wilson, Levett-Therivel Sustainability Consultants, Treweek Environmental Consultants and Land Use Consultants (2006) *Appropriate Assessment of Plans.*

3.2 Methods

The following actions were taken in the preparation of this report.

- A desk study was undertaken to map the proposed project site in the context of all Natura 2000 sites with the potential to be impacted by the proposed project. This included examining all available GIS mapped layers within the vicinity (15 km radius) of the proposed project site (e.g. NPWS marine community mapping, salt marsh maps, coastal habitat maps, aerial imagery etc.).
- The available information on the two designated sites adjacent to the proposed project (together with additional Natura 2000 sites within a 15km radius of the proposed project), was examined. A full list of the literature consulted is provided in section 8 of this report.
- The project plan, construction methods and scope of works were then examined in detail.
- A review of the conservation objectives, including the attributes, measures and target for each of the features of interest where available (or by reference to similar sites where not available) for which each SAC or SPA was selected, was undertaken.
- Field based site surveys were undertaken to assess the current distribution and condition of all habitats and species for which Malahide Estuary SAC is designated.

- The potential for impacts, relative to the scope of works provided, was assessed and documented.
- Consultation with a range of experts in Ireland and the UK in relation to the impacts and control of marine alien invasive species, particularly *Didemnum vexillum*, was undertaken.
- Appropriate Assessment Screening was undertaken.
- Following the completion of the Appropriate Assessment Screening additional specialist field and experimental work was undertaken to assist in the preparation of the Natura Impact Statement.
- A Natura Impact Statement was prepared.

4. Natura 2000 sites and Protected Species

According to the guidance for the Appropriate Assessment of Plans and Projects in Ireland (Department of the Environment, Heritage and Local Government, 2009) an examination of all Natura 2000 sites that might be affected by a project or plan should be identified and considered. It is currently recommended that any Natura 2000 site within a distance of 15km is considered for a plan and this figure derives from UK guidance (Scott Wilson, 2013). For projects, the distance could be much less than 15km, and in some cases less that 100m, but this must be evaluated on a case-by-case basis with reference to the nature, size and location of the project, and the sensitivities of the ecological receptors, and the potential for in-combination effects.

While this report deals with a project (the maintenance dredging of Malahide Marina) it was considered prudent to also list, examine and consider the qualifying interests and conservation objectives of other Natura 2000 sites within a 15km radius of the proposed project to fully examine any possibility for in-combination effects of the proposed project on the conservation objectives of these sites. These sites and their relative distance from the proposed project site are listed in table 4.1 and shown in figure 4.1. The features of interest for each of the sites are provided in table 4.2.

Table 4.1 Designated sites within a 15km radius of the proposed project site.

Site Designation	Site code	Site name	Distance from the proposed project (km)
SAC	000205	Malahide Estuary SAC	Immediately adjacent
SAC	000208	Rogerstown Estuary SAC	4.7
SAC	000199	Baldoyle Bay SAC	4.0
SAC	003000	Rockabill to Dalkey Island SAC	5.3
SAC	002193	Ireland's Eye SAC	7.5
SAC	000204	Lambay Island SAC	8.6
SAC	000202	Howth Head SAC	9.4
SAC	000206	North Dublin Bay SAC	7.6
SAC	000210	South Dublin Bay SAC	12.6
SPA	004025	Malahide Estuary SPA	Immediately adjacent
SPA	004015	Rogerstown Estuary SPA	4.7
SPA	004016	Baldoyle Bay SPA	4.0
SPA	004117	Ireland's Eye SPA	7.2
SPA	004069	Lambay Island SPA	8.6
SPA	004113	Howth Head Coast SPA	9.8
SPA	004006	North Bull Island SPA	7.6
SPA	004024	South Dublin Bay and River Tolka Estuary SPA	10.8
SPA	004122	Skerries Islands SPA	13.2
SPA	004014	Rockabill SPA	13.8

A mapping review of the sites listed in table 4.1 in relation to the proposed project site was conducted. This review included an examination of features which had the potential to provide a corridor, or other method of connectivity, between the project site and the conservation objectives of the designated sites within a 15km radius.

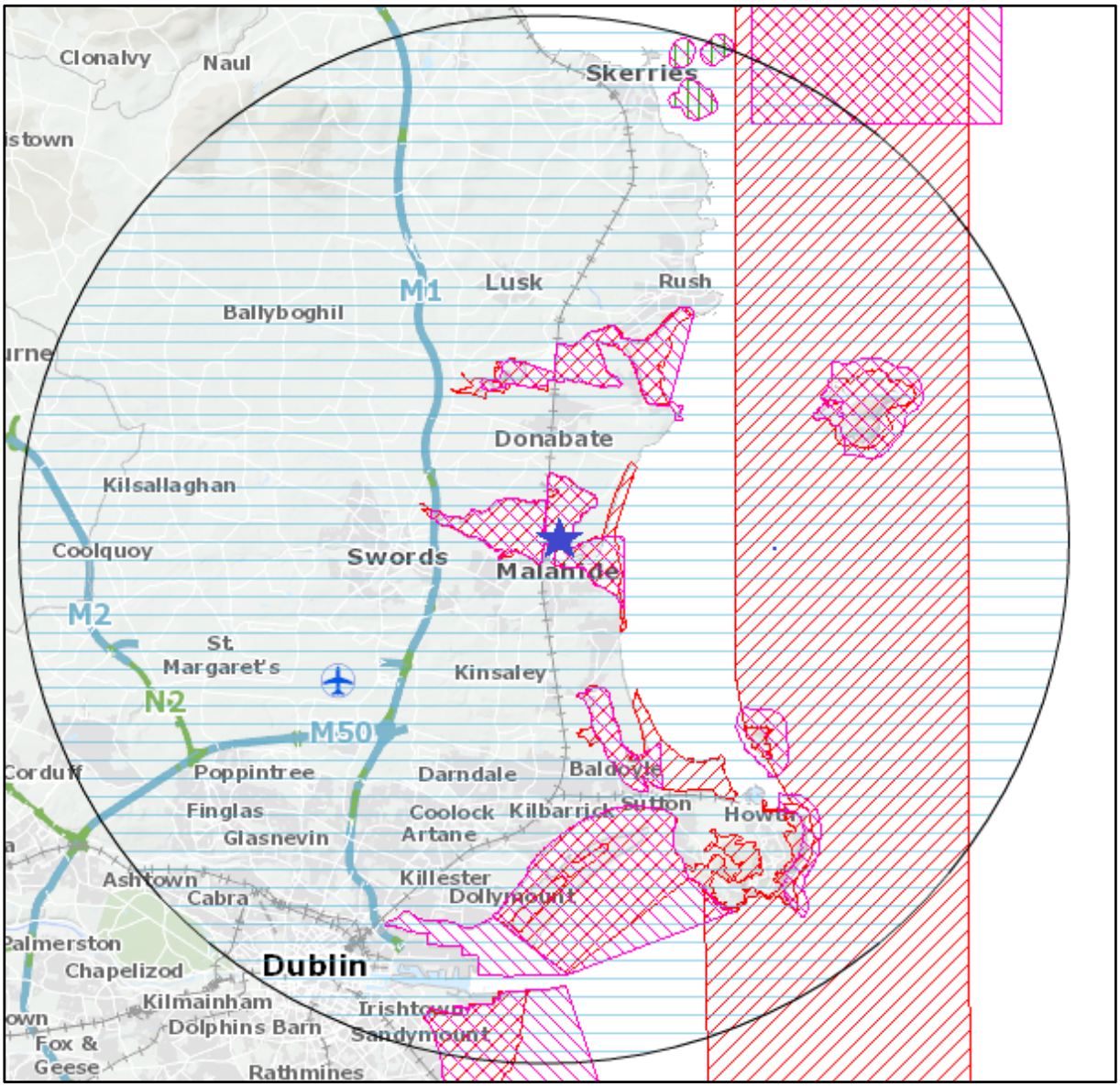

Figure 4.1. Designated sites within 15km radius of the project site. ©NPWS map viewer. February 2018. Proposed project location ★

Table 4.2. Features of interest for all sites within a 15km radius of the proposed project site.

Site code	Site name	Feature of interest
000205	Malahide Estuary SAC	• Mudflats and sandflats not covered by seawater at low tide [1140] • Salicornia and other annuals colonising mud and sand [1310] • Spartina swards (Spartinion maritimae) [1320] • Atlantic salt meadows (Glauco-Puccinellietalia maritimae) [1330] • Mediterranean salt meadows (Juncetalia maritimi) [1410] • Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120] • Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]
000208	Rogerstown Estuary SAC	• Estuaries [1130] • Mudflats and sandflats not covered by seawater at low tide [1140] • Salicornia and other annuals colonising mud and sand [1310] • Atlantic salt meadows (Glauco-Puccinellietalia maritimae) [1330] • Mediterranean salt meadows (Juncetalia maritimi) [1410] • Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120] • Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]
000199	Baldoyle Bay SAC	• Mudflats and sandflats not covered by seawater at low tide [1140] • Salicornia and other annuals colonising mud and sand [1310] • Atlantic salt meadows (Glauco-Puccinellietalia maritimae) [1330] • Mediterranean salt meadows (Juncetalia maritimi) [1410]
003000	Rockabill to Dalkey Island SAC	• Reefs [1170] • Phocoena phocoena (Harbour Porpoise) [1351]
002193	Ireland's Eye SAC	• Perennial vegetation of stony banks [1220] • Vegetated sea cliffs of the Atlantic and Baltic coasts [1230]
000204	Lambay Island SAC	• Reefs [1170] • Vegetated sea cliffs of the Atlantic and Baltic coasts [1230] • Halichoerus grypus (Grey Seal) [1364] • Phoca vitulina (Harbour Seal) [1365]
000202	Howth Head SAC	• Vegetated sea cliffs of the Atlantic and Baltic coasts [1230] • European dry heaths [4030]

000206	North Dublin Bay SAC	• Mudflats and sandflats not covered by seawater at low tide [1140] • Annual vegetation of drift lines [1210] • Salicornia and other annuals colonising mud and sand [1310] • Atlantic salt meadows (Glauco-Puccinellietalia maritimae) [1330] • Mediterranean salt meadows (Juncetalia maritimi) [1410] • Embryonic shifting dunes [2110] • Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120] • Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130] • Humid dune slacks [2190] • Petalophyllum ralfsii (Petalwort) [1395]
000210	South Dublin Bay SAC	• Mudflats and sandflats not covered by seawater at low tide [1140] • Annual vegetation of drift lines [1210] • Salicornia and other annuals colonising mud and sand [1310] • Embryonic shifting dunes [2110]
004025	Malahide Estuary SPA	• Great Crested Grebe (Podiceps cristatus) [A005] • Light-bellied Brent Goose (Branta bernicla hrota) [A046] • Shelduck (Tadorna tadorna) [A048] • Pintail (Anas acuta) [A054] • Goldeneye (Bucephala clangula) [A067] • Red-breasted Merganser (Mergus serrator) [A069] • Oystercatcher (Haematopus ostralegus) [A130] • Golden Plover (Pluvialis apricaria) [A140] • Grey Plover (Pluvialis squatarola) [A141] • Knot (Calidris canutus) [A143] • Dunlin (Calidris alpina) [A149] • Black-tailed Godwit (Limosa limosa) [A156] • Bar-tailed Godwit (Limosa lapponica) [A157] • Redshank (Tringa totanus) [A162] • Wetland and Waterbirds [A999]

004015	Rogerstown Estuary SPA	• Greylag Goose (Anser anser) [A043] • Light-bellied Brent Goose (Branta bernicla hrota) [A046] • Shelduck (Tadorna tadorna) [A048] • Shoveler (Anas clypeata) [A056] • Oystercatcher (Haematopus ostralegus) [A130] • Ringed Plover (Charadrius hiaticula) [A137] • Grey Plover (Pluvialis squatarola) [A141] • Knot (Calidris canutus) [A143] • Dunlin (Calidris alpina) [A149] • Black-tailed Godwit (Limosa limosa) [A156] • Redshank (Tringa totanus) [A162] • Wetland and Waterbirds [A999]
004016	Baldoyle Bay SPA	• Light-bellied Brent Goose (Branta bernicla hrota) [A046] • Shelduck (Tadorna tadorna) [A048] • Ringed Plover (Charadrius hiaticula) [A137] • Golden Plover (Pluvialis apricaria) [A140] • Grey Plover (Pluvialis squatarola) [A141] • Bar-tailed Godwit (Limosa lapponica) [A157] • Wetland and Waterbirds [A999]
004117	Ireland's Eye SPA	• Cormorant (Phalacrocorax carbo) [A017] • Herring Gull (Larus argentatus) [A184] • Kittiwake (Rissa tridactyla) [A188] • Guillemot (Uria aalge) [A199] • Razorbill (Alca torda) [A200

004069	Lambay Island SPA	• Fulmar (Fulmarus glacialis) [A009] • Cormorant (Phalacrocorax carbo) [A017] • Shag (Phalacrocorax aristotelis) [A018] • Greylag Goose (Anser anser) [A043] • Lesser Black-backed Gull (Larus fuscus) [A183] • Herring Gull (Larus argentatus) [A184] • Kittiwake (Rissa tridactyla) [A188] • Guillemot (Uria aalge) [A199] • Razorbill (Alca torda) [A200] • Puffin (Fratercula arctica) [A204
004113	Howth Head Coast SPA	• Kittiwake (Rissa tridactyla) [A188]
004006	North Bull Island SPA	• Light-bellied Brent Goose (Branta bernicla hrota) [A046] • Shelduck (Tadorna tadorna) [A048] • Teal (Anas crecca) [A052] • Pintail (Anas acuta) [A054] • Shoveler (Anas clypeata) [A056] • Oystercatcher (Haematopus ostralegus) [A130] • Golden Plover (Pluvialis apricaria) [A140] • Grey Plover (Pluvialis squatarola) [A141] • Knot (Calidris canutus) [A143] • Sanderling (Calidris alba) [A144] • Dunlin (Calidris alpina) [A149] • Black-tailed Godwit (Limosa limosa) [A156] • Bar-tailed Godwit (Limosa lapponica) [A157] • Curlew (Numenius arquata) [A160] • Redshank (Tringa totanus) [A162] • Turnstone (Arenaria interpres) [A169] • Black-headed Gull (Chroicocephalus ridibundus) [A179] • Wetland and Waterbirds [A999]

004024	South Dublin Bay and River Tolka Estuary SPA	• Light-bellied Brent Goose (Branta bernicla hrota) [A046] • Oystercatcher (Haematopus ostralegus) [A130] • Ringed Plover (Charadrius hiaticula) [A137] • Grey Plover (Pluvialis squatarola) [A141] • Knot (Calidris canutus) [A143] • Sanderling (Calidris alba) [A144] • Dunlin (Calidris alpina) [A149] • Bar-tailed Godwit (Limosa lapponica) [A157] • Redshank (Tringa totanus) [A162] • Black-headed Gull (Chroicocephalus ridibundus) [A179] • Roseate Tern (Sterna dougallii) [A192] • Common Tern (Sterna hirundo) [A193] • Arctic Tern (Sterna paradisaea) [A194] • Wetland and Waterbirds [A999]
004122	Skerries Islands SPA	• Cormorant (Phalacrocorax carbo) [A017] • Shag (Phalacrocorax aristotelis) [A018] • Light-bellied Brent Goose (Branta bernicla hrota) [A046] • Purple Sandpiper (Calidris maritima) [A148] • Turnstone (Arenaria interpres) [A169] • Herring Gull (Larus argentatus) [A184]
004014	Rockabill SPA	• Purple Sandpiper (Calidris maritima) [A148] • Roseate Tern (Sterna dougallii) [A192] • Common Tern (Sterna hirundo) [A193] • Arctic Tern (Sterna paradisaea) [A194]

5. The Receiving Environment

5.1 Site overview

Construction of Malahide marina commenced in 1991. The marina is located adjacent to the village of Malahide, Co. Dublin on the southern side of River Broadmeadow estuary immediately east of a viaduct which spans the estuary between Donabate and Malahide. The marina and adjacent housing development was constructed through a landfill and coastal-infill scheme of the existing estuary. A harbour wall, constructed of rock armour, was built along the western side of the marina. While the inner section of the marina was constructed using a layer of artificial matting overlaid with gravel.

The seaward section of the estuary is restricted from the inner estuary by a large sand spit, known as 'the island'. The outer section of the estuary drains almost completely at low tide, leaving only a narrow channel suitable for navigation through the centre.

To the west of the viaduct the estuary remains covered at low water except for at the extreme head where a small pocket of Estuarine sandy mud with Chironomidae and *Hediste diversicolor* community complex adjacent to patches of Atlantic salt meadow and isolated Spartina swards occur.

The general environment in the vicinity of the proposed project is comprised of intertidal mudflats and sandflats, and sand dunes. The urban centre of Malahide is located to the south of the estuary, while the northern side of the estuary is characterised by improved agricultural grassland mainly used for arable farming.

The marina is surrounded by, but excluded out of, Malahide Estuary SAC and Malahide Estuary SPA. Malahide Estuary SAC is characterised by intertidal sand and mud flats, which, in the context of its proximity to the city of Dublin are of relatively good quality. The sand and mudflats provide important foraging habitat for wintering water birds for which the area is designated as an SPA. Salt marshes, particularly Atlantic salt meadows and Salicornia flats are also well represented within the site. Sand dune systems, including significant areas of both shifting and fixed dunes, occur towards the east of the site, although the majority of this habitat is managed as a golf course. Blue mussel (*Mytilus edulis*) and eel grass (*Zostera noltii*) communities both occur within the site.

5.2 Habitats

A review of the aerial imagery, designated site boundaries and NPWS mapping was undertaken to obtain an overview of the project site. This was followed up by a site survey to assess the ecology of the site and adjacent area in the context of the proposed project. Site surveys were undertaken in January 2017 and February 2018 from both land and sea and are described in section 5.2.1 to 5.2.4. The area covered by the characterising community types are shown in figures 5.1, 5.2 and 5.3

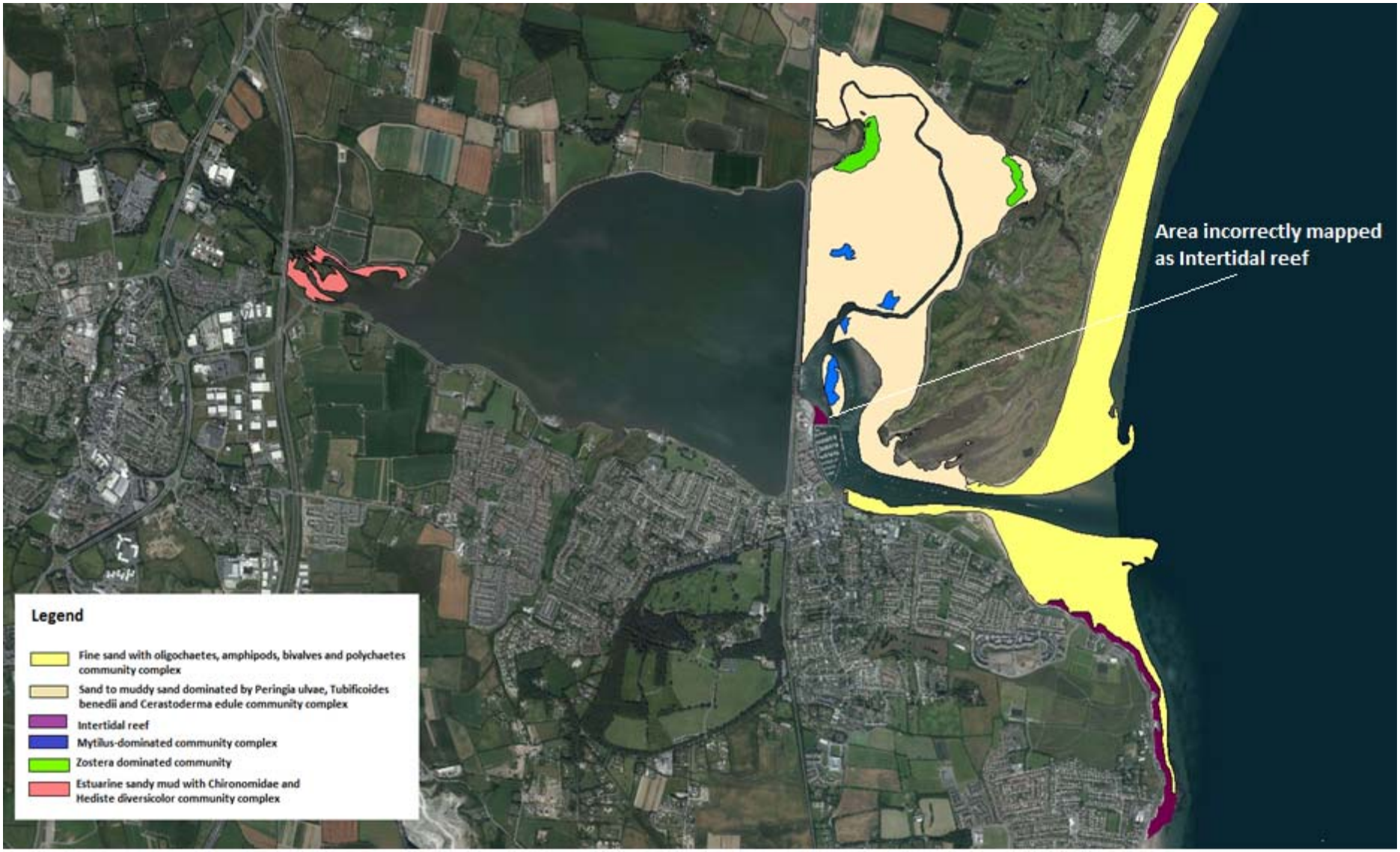

Figure 5.1 Marine Community types recorded within Malahide Estuary SAC. Source NPWS 2016. **Bing Maps Aerial** - © 2018 Microsoft Corporation © 2018 DigitalGlobe ©CNES (2018) Distribution Airbus DS

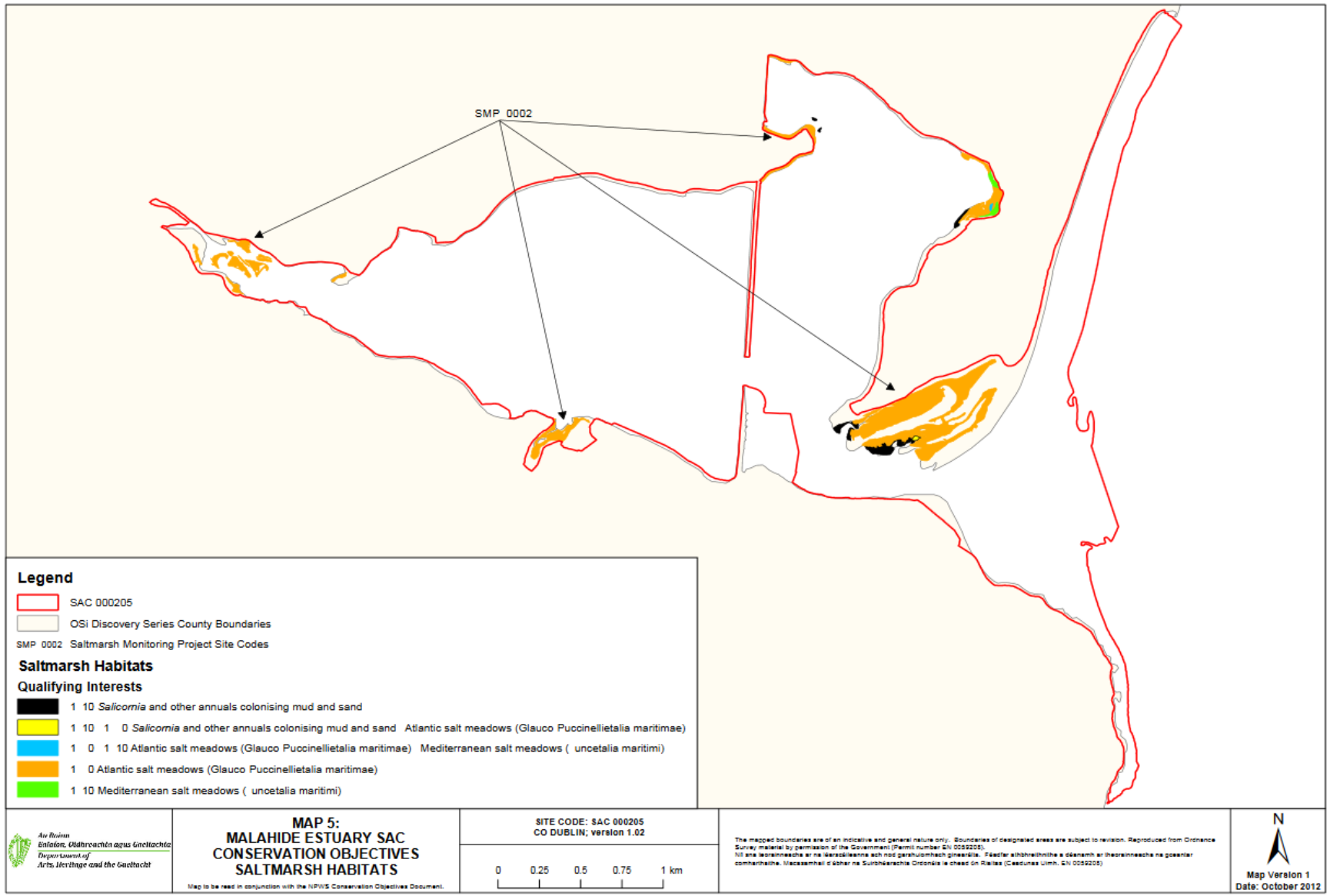

Figure 5.2 Saltmarsh habitats recorded within Malahide Estuary SAC (NPWS 2013).

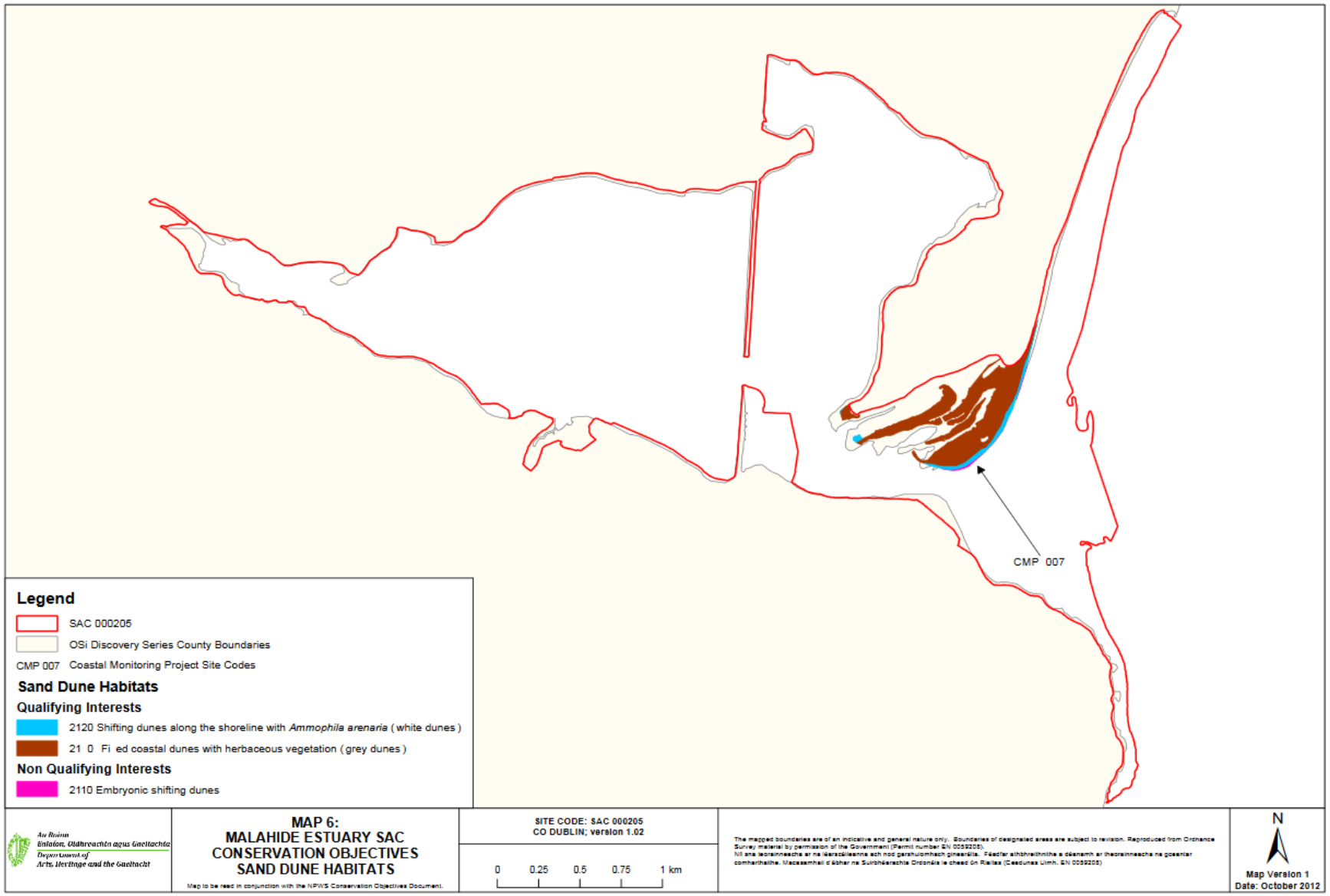

Figure 5.3 Sand Dune habitats recorded within Malahide Estuary SAC (NPWS 2013).

5.2.1 Sublittoral (subtidal) habitats

Sublittoral sediment

A narrow band of subtidal sediment occurs along the central navigation channel (figure 5.4) leading from the Irish Sea into Malahide marina to the east of the viaduct. A larger area of subtidal sediment also occurs on the western side of the viaduct. The channel to the east of the viaduct, which is comprised of a gradient of muddy sands and fine sands with broken shell, has been scoured as a result of the tidal regime within the estuary and extends for approximately 1.7 km from the mouth of the estuary to the entrance to the marina. This section includes the area known as the "short deeps" (see figure 2.1).

Figure 5.4. Subtidal navigable channel leading from the Irish Sea into Malahide Marina.

5.2.2 Littoral (intertidal) habitats

Littoral rock

Sections of intertidal reef occur in the exposed outer section of the site, south of Malahide. This area corresponds to the EU Habitats Directive Annex I habitat "Reefs" (EU habitat code: 1170).

The NPWS marine community mapping also indicates a discrete area of intertidal reef on the northern side of the marina. However, this is a mapping error, possibly as a result of using aerial imagery to identify intertidal habitats without adequate ground truthing. Site surveys of this area (conducted on a tide when the Low Water Height was 0.8 meters) confirm that the northern side of the marine remains subtidal except for a narrow band of silty sediment adjacent to an area of protective rock armour (Figure 5.5).

Figure 5.5 North side of marina adjacent to rock armour and mobile hoist. Image taken 40 minutes after low water at a tidal height of 0.8 meters

Littoral sediment

An extensive area of intertidal mudflats and sandflats occur within the Malahide Estuary and corresponds to the EU Habitats Directive Annex I habitat: Mudflats and sandflats not covered by seawater at low tide (EU habitat code: 1140). This area also includes the habitat "Wetlands" (EU Birds Directive habitat code A999).

This area comprises the majority of the area occupied by Malahide Estuary SAC to the east of the viaduct and is composed of five littoral sediment communities. These include:

- Fine sand with oligochaetes, amphipods, bivalves and polychaetes community complex.
- Sand to muddy sand dominated by *Peringia ulvae*, *Tubificoides benedii* and *Cerastoderma edule* community complex.
- Estuarine sandy mud with Chironomidae and *Hediste diversicolor* community complex.
- *Zostera* dominated community
- *Mytilus* dominated community

Detailed descriptions of these sediment communities are given in (NPWS, 2013a) and are described below.

The community complex "Fine sand with oligochaetes, amphipods, bivalves and polychaetes community complex" characterises the more exposed sections of the SAC along the eastern boundary of the site from the Martello Tower at Balcarrick in the north to Portmarnock in the south. The sediment of this community complex is largely that of fine sand (ranging from 74% to 88.9%) with negligible amounts of coarse material (<4%).

The community complex "Sand to muddy sand dominated by *Peringia ulvae*, *Tubificoides benedii* and *Cerastoderma edule* community complex" is present between the viaduct and the island. Belinstown stream transverses this area entering the estuary west of the Island. The substrate here is largely composed of fine material with silt-clay ranging from 2.2% to 59.7%, very fine sand from 3.2% to 32.9% and fine sand from 6.1% to 80%. Coarse material accounts for less than 7% of the sediment fractions.

The community complex "Estuarine sandy mud with Chironomidae and *Hediste diversicolor* community complex" occurs in a small area where the Ward and Broadmeadow Rivers enters the estuary. The sediment is largely that of sandy mud with silt-clay and very fine sand accounting for between 19.6% to 59.7% and 12.4% to 28.4% of the sediment fractions respectively. The remaining fractions range from 0.8% to 12.5% coarse sand, very coarse sand from 0.4% to 5.1%, medium sand from 1.6% to 27.7% and the fine sand fraction from 8.7% to21.9%.The proportion of gravel recorded is negligible (<1%).

Community complexes, such as those described above, are those considered to be unstable in nature with respect to their community composition and/or temporal or spatial distribution but with similar abiotic features. This allows biological communities to be grouped into sufficiently stable units (i.e. complexes) so that conservation targets can be set (NPWS 2013a).

Two *Zostera* dominated communities occur to the north of the site, one on Burrow Strand at Corballis and a second along the shore to the east of Kilcrea. *Zostera noltii* is a marine angiosperm with a limited distribution in Ireland and an important food source for certain water birds. Within Malahide Estuary SAC the coverage of *Zostera noltii* ranges from 60% in the more westerly bed at to 82% in the beds on Burrow Strand.

A *Mytilus* dominated community occurs between the viaduct and the spit at Malahide point. Here the bivalve, *Mytilus edulis* occurs in combination with patches of sandy mud and abundant epibionts such as the filamentous brown alga *Ectocarpus* sp.

5.2.3 Coastal habitats

Sand dune systems

A well-developed dune spit occurs on the northern side of the estuary, however, a golf links now occupies much of the area of the spit. Two dune types "Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)" (EU Habitat code: 2120) and "fixed coastal dunes with herbaceous vegetation (grey dunes)" (EU Habitat code: 2130) occur on the spit. The dune spit has a well-developed outer dune ridge dominated by Marram Grass (*Ammophila arenaria*) consistent with the white dunes, while the area behind them contains a more extensive area of grey dune.

The mobile dunes are experiencing some natural erosion along the north and eastern edge of the site and some accretion in the south. Erosion due to overuse of the dunes is also occurring and is affecting all areas

of the mobile and embryonic dunes, including those areas that are accreting (NPWS 2013b). The fixed dune is experiencing erosion caused by increasing recreational pressures especially in the north of the site, which is compounding the impacts of natural erosion. The absence of embryonic dunes along the eastern seaward edge of the spit would indicate that natural and human-induced erosion has impacted heavily on the frontline of the dunes.

Saltmarsh

The habitat "Salicornia and other annuals colonising mud and sand" occurs just below the sand dune system along the margin of the spit. This habitat is considered as a pioneer to saltmarsh vegetation and typically colonises intertidal mud and sandflats in areas protected from strong wave action. While considered to be a precursor to the development of more stable saltmarsh vegetation, it is unlikely to develop further at this location, due to the strong tidal action along this section of the spit.

"Spartina swards (Spartinion maritimae)". This habitat occurs in some of the more sheltered parts of the estuary in the Burrow strand area. It was originally listed as a qualifying Annex I habitat for Malahide Estuary SAC due to historical records of two rare forms of cordgrass– small cordgrass (*Spartina maritima*) and Townsend's cordgrass (*S. x townsendii)*. However as both forms are now considered to be alien and all stands of cordgrass in Ireland are now considered as common cordgrass (*S. anglica*) the significance of this habitat within Malahide Estuary is minor.

The habitat "Atlantic salt meadows (Glauco-Puccinellietalia maritimae)" occurs at a number of locations with the SAC. The main area occurs near the tip of the spit with smaller pockets occurring near Barrack Bridge, at the head of estuary near the entry of the Ward and Broad meadow Rivers and also along the northern fringes of the inner estuary

A small section of "Mediterranean salt meadows (Juncetalia maritimi)" occurs at Barrow Strand in the inner estuary surrounded by areas of Atlantic salt meadow.

The site is subject to erosion and accretion, as all coastlines naturally undergo a constant cycle of each. At Malahide estuary the erosion is due to both natural causes and from human interference. According to McCorry (2009), there are no indications of any major erosion of the saltmarsh at the site; erosion within the Atlantic Salt Meadow habitat is countered by accretion along the north side of the causeway.

5.2.4 Habitat for birds

The wetlands of northwest Europe are a vital resource for millions of northern and boreal nesting waterbird species that overwinter on these wetlands or visit them when migrating further south. To acknowledge the importance of Ireland's wetlands to wintering waterbirds the term Wetland & Waterbirds can be included as a Special Conservation Interest for a Special Protection Area that has been designated for wintering waterbirds, and is or contains a wetland site of significant importance to one or more of the species of Special Conservation Interest. The mudflat and sandflat area and its constituent community complexes form part of this food source/habitat for waterbird species. This includes the eel grass and mussel beds within the site which form an important food source. The east coast of Ireland in lower in marine wetland habitat complexity than the west of Ireland and in this context Malahide Estuary is of importance in maintaining the local biodiversity of the small number of wetland sites on the east coast of Ireland as a supporting habitat for waterbirds.

5.3 Species

The area surrounding Malahide marina is of importance for a number of species protected under Annex II of the EU Habitats Directive and Annex I of the EU Birds Directive and are described in section 5.3.1 to 5.3.3 below.

5.3.1 Vascular plants

Hairy violet (*Viola hirta*) is recorded as occurring within Malahide Estuary SAC. This plant is legally protected under the Flora Protection Order (Flora (Protection) Order, 1999 [SI 94/1999]) and is listed as Vulnerable in the Irish Red Data Book (Curtis & McGough, 1988). This softly-hairy perennial occurs on dry banks, rocky ground and scrub on limestone soils. It is very rare with a scattered distribution which includes sites on the Aran Islands and the south, west and east coasts of Ireland.

5.3.2 Mammals

Cetaceans and seals

Dedicated marine mammal surveys were not conducted during the course of field surveys. However, Harbour Porpoise (*Phocoena phocoena*) occur in the Irish Sea and also form a feature of interest for Rockabill to Dalkey Island SAC, located 5.25 km east of the project site. Grey Seal (*Halichoerus grypus*) and Harbour Seal (*Phoca vitulina*) also occur within the Irish Sea and form a feature of interest for Lambay Island SAC, located 8.6 km east of the proposed project site.

Other mammals

While Malahide estuary is within the current known distribution range for Otter (*Lutra lutra*) no evidence of this species was recorded during walkover surveys of the habitats surrounding the estuary (e.g. spraints, slides, foot prints or holts).

5.3.3 Birds

Malahide Estuary SPA is designated due to the presence of the following wintering waterbird species listed on Annex I and/or II of E.U. Birds Directive: Great Crested Grebe (*Podiceps cristatus*), Brent Goose (*Branta bernicla hrota*), Shelduck (*Tadorna tadorna*), Pintail (*Anas acuta*), Goldeneye (*Bucephala clangula*), Red-breasted Merganser (*Mergus serrator*), Oystercatcher (*Haematopus ostralegus*), Golden Plover (*Pluvialis apricaria*), Grey Plover (Pluvialis squatarola), Knot (*Calidris canutus*), Dunlin (*Calidris alpina alpina*), Black-tailed Godwit (*Limosa limosa*), Bar-tailed Godwit (*Limosa lapponica*) and Redshank (*Tringa totanus*). Under this SPA designation the wetland habitat is also protected as a source for the regularly-occurring migratory water birds that utilise it.

Malahide Estuary SPA is an important site for wintering waterfowl, providing both feeding and roosting areas. I-WeBS data (2010-2015) lists an internationally important population of the Light-bellied Brent Goose occurring at the site. According to Birdwatch Ireland (Birdwatch.ie) this species is Amber-listed as the majority winter at less than ten sites and the Irish population is internationally significant; the European population has been evaluated as Vulnerable as several important populations declined.

I-WeBS data (2010-2015) lists nationally important populations of the Black-tailed Godwit, Great Crested Grebe, Shelduck, Pintail, Goldeneye, Red-breasted Merganser, Oystercatcher, Grey plover, Lapwing, Greenshank, Little Grebe and the Gadwall.

According to ICUN, the Black-tailed Godwit is deemed Vulnerable in Europe and Near threatened globally, the species has undergone rapid declines in Europe and globally owing to changes in agricultural practices; the Oystercatcher, a widespread shorebird, is undergoing rapid population declines across the European part of its extremely large global range, globally its overall population trend is decreasing; the Lapwing is suspected to be decreasing at a moderately rapid rate; the Bar-tailed Godwit population is stable in Europe but declining and Near threatened Globally; the Curlew is undergoing rapid decline throughout Europe (Vulnerable) and globally (Near Threatened); and the EU population of the Dunlin is depleted.

A number of species that are listed on Annex I of the E.U. Birds Directive occur at the site i.e. Golden Plover, Dunlin, Bar-tailed Godwit, Red-throated Diver, Great Northern Diver and the Little Egret.

5.4 Invasive Alien Species (IAS)

A colonial tunicate, later identified as the colonial ascidian, *Didemnum vexillum* was first recorded at Malahide marina in 2005 (Minchin and Sides, 2006). The species was found attached to the immersed sections of the pontoons, ropes and chains and the hulls of fouled pleasure craft. *D. vexillum* is an aggressive and rapidly spreading invasive alien species. Where a suitable substrate is present e.g. rocks, shells, pontoons and pilings, it can overgrow these surfaces ultimately forming large sheet like colonies and extensive pendulous (overhanging) masses. It also has the ability to overgrow other sessile organisms e.g. sponges, hydroids, oysters and even itself. While the abundance of *D. vexillum* within Malahide marina has varied considerably since its first recorded appearance is 2005, the species is still known to be present at the site.

No other invasive alien species were recorded or are reported for this site.

6. Appropriate Assessment Screening

6.1 Consideration of Conservation Objectives

A site-specific conservation objective aims to define favourable conservation condition for a particular habitat or species at that site.

The conservation status of a natural habitat will be taken as favourable when:

- Its natural range and areas it covers within that range are stable or increasing.
- The specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future.
- The conservation status of its typical species is favourable.

The conservation status of a species is defined as the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within the territory of the member states. The conservation status of a species will be taken as favourable when:

- Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
- The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- There is, and will probably continue to be, as sufficiently large habitat to maintain its populations on a long-term basis.

The site specific conservation objectives have been designed to provide metrics (attributes, measures and targets) against which the favourable conservation status (as outlined above) can be measured. This section identifies potential drivers and impacts; direct and secondary, as a result of the proposed project on the site specific conservation objectives of Malahide Estuary SAC, Malahide Estuary SPA and other sites identified within a 15 km radius of the proposed project site (table 4.1) which have a direct or indirect connectivity to it.

An explanation of the potential for impact as a result of the proposed project, without mitigation, is outlined in section 6.2. A summary of potential impacts on the conservation objectives of all European sites within a 15km radius is provided in table 6.1

6.2 Potential Impacts

Based on the description of the proposed project, the project construction methodology described in section 2 and the ecology of the receiving environment described in section 5 a summary of potential impacts on the receiving environment that may arise as a consequence of the proposed project are presented below.

Potential impacts associated with Injection dredging:

- Mobilisation of sediments and the resulting potential to smother susceptible species.
- Dispersion of alien invasive species.
- Noise disturbance to susceptible species.

As the proposed project is located outside of any European site the main potential impacts are likely to be indirect impacts associated with potential indirect habitat loss, damage of habitats and their associated communities and loss or damage to a foraging resource for birds utilising the adjacent intertidal habitats and disturbance. Details of the potential impacts are provided below.

These potential impacts are considered under their potential to cause:

- Direct habitat loss
- Disturbance to the structure and function of marine habitats and associated communities.
- Disturbance to Marine Mammals
- Damage and disturbance to coastal habitats and associated species
- Impacts on Water quality
- Hydrological changes
- Indirect habitat loss
- Impacts on birds
- Impacts on wetland habitats for birds

Details of the potential impacts identified are provided below and an analysis of the likelihood of these potential impacts leading to a negative impact on the conservation objectives of the aforementioned European sites is provided below and summerised in table 6.1.

6.2.1 Direct Habitat loss

No direct habitat loss will occur within Malahide Estuary SAC or any European site. The project is confined to dredging an area of the marina which is excluded out of the SAC. Dredging will remove sediments that have been deposited in the marina since it was last dredged in 1996 and overlie an area of artificial substrate of matting and gravel installed when the marine was originally created in 1991. Therefore no direct habitat loss will occur within the SAC area.

6.2.2 Disturbance to the structure and function of marine habitats and associated communities.

The risk of disturbance to the structure and function of marine habitats and associated communities is associated with the deposition of sediment downstream of the marina within the SAC area. There is potential for temporary habitat change through deposition of fine silts over an area of intertidal mudflats and sandflats and subsequent potential for an alteration to the existing community complexes.

Sediment mobilised as a result of dredging could have the potential to impact on species susceptible to smothering. This is likely to be localised within the receiving environment due to the dynamics of flow within Malahide Estuary. The only subtidal area with the potential to be impacted by sediment mobilisation is the channel leading from Malahide Marina to the Irish Sea to the east. The sediments in this area are comprised of sand and no communities of conservation importance are recorded from this area. Surrounding the subtidal channel, a large area of intertidal mudflat and sandflat occurs. This area contains *M. edulis* and *Zostera* dominated communities which form part of the conservation objectives for Malahide Estuary SAC.

M. edulis is considered very tolerant of a range of physical and chemical conditions. As a result, blue mussel beds were considered to be 'Not sensitive' to changes in temperature, salinity, de-oxygenation, nutrient and organic enrichment, and substratum type, at the benchmark level of pressure (Mainwaring *et al* 2014). *Mytilus edulis* occurs in areas of high suspended particulate matter (SPM) and therefore a level of siltation is expected from the settling of SPM. An indirect effect of increased turbidity and reduced light penetration may be reduced phytoplankton productivity which could reduce the food availability for *M. edulis* (Tyler-Walters 2008). However, as *M. edulis* uses a variety of food sources and food is brought in from other areas with currents and tides, the effect is likely to be minimal. This species and the biotopes it forms are therefore not sensitive to changes in water clarity that refer to light penetration. *M. edulis* are often found in areas with high levels of turbidity. For example, the average suspended particulate matter (SPM) concentration at Hastings Shingle Bank was 15 -20mg/l in June 2005, reaching 50mg/l in windier (force 4) conditions, although a concentration of 200mg/l was recorded at this site during gales (Last *et al* 2011).

Both *Zostera angustifolia* and *Zostera noltii* are documented as occurring within Malahide Estuary SAC, in an area approximately 1.5km north of the proposed project. While some taxonomists dispute the distinction between *Z. angustifolia* and other *Zostera* species (e.g. *Z. marina*), *Zostera angustifolia* has been classified as an intertidal plant found from mid- to low-tide mark, usually in poorly-draining muddy sediments. The species is typically found in conditions of variable salinity, often in estuaries. *Z. noltii* occurs higher on the shore than then other *Zostera angustifolia*, typically on mixtures of sand and mud.

Regardless of any taxonomic confusion, both plants flourish best where the local sediments are closely balanced between the forces of erosion and accretion. Excessive sedimentation can be harmful as it tends to smother the plants. Highly turbid water also inhibits growth by reducing the amount of light available for photosynthesis (Davison and Hughes, 1998)

Sediment mobilised as a result of dredging will settle in the area of the “short deeps” and from there be dispersed out to sea by the natural process that created these deep pockets originally. Therefore there is no potential for sediment to settle out on habitats and species within the intertidal area e.g. eel grass beds and mussel beds and thereby result in an indirect habitat loss and/or a change to the structure and function of these communities.

Mobilisation of the sediment and movement of the fixed structures (pontoons, and chains) within the marina area during dredging operations has the potential to facilitate dispersion of the invasive alien species, *Didemnum vexillum,* which is known to occur in the marina area. The spread of *D. vexillum* has the potential to impact on the Mussel (*Mytilus edulis*) community within Malahide Estuary SAC. This could occur if *D. vexillum* fragments were mobilised during dredging and settled on the mussel community. Mobilisation of *D. vexillum* within the sediment also has the potential to lead to settlement further down-stream of the marina should a suitable substrate be present.

The colonial tunicate, *Didemnum vexillum* is an aggressive and rapidly spreading colonial tunicate species. Where a suitable substrate is present e.g. rocks, shells, pontoons and pilings, it can overgrow these surfaces ultimately forming large sheet like colonies and extensive pendulous (overhanging) masses. It also has the ability to overgrow other sessile organisms e.g. sponges, hydroids, oysters and even itself. It is considered to have originated in the Northwest Pacific, possibly Japan, but has been reported in several parts of the world including New Zealand, North America, and Europe. *Didemnum vexillum* has the potential to cause significant economic damage to fisheries and aquaculture. It can also have negative ecological impacts and in some areas its rapid expansion has reduced the abundance of previously established benthic species.

In Ireland it was first recorded at Malahide Marina in 2005, where it had attached to the immersed surface of the pontoons, ropes, chains and on the hulls of fouled pleasure craft (Minchin and Sides, 2007). It is also known to occur on the west coast of Ireland in Galway Bay and Clew Bay and at Carlingford Lough and Strangford Lough in Northern Ireland (GB Non-native Species Secretariat, 2017).

In other parts of the world, e.g. east and west coasts of North America, the species was first reported in the 1980's and subsequently (2007) reported to be undergoing a population explosion (Bullard *et al*, 2007). Attempts to eradicate *D. vexillum* at Holyhead marina, Wales in recent years have failed to eradicate the species. Further UK studies have suggested that while eradication may be achievable it is likely that this will be only be on a limited scale and technically difficult to achieve (Laing *et al*, 2007).

D. vexillum can spread by either sexual or asexual reproduction. In the case of sexual reproduction larvae are brooded within the tunic and when released swim for a short period before finding and attaching to a suitable substrate. The larval stage is only of a few hours duration (Kott, 2002). The short duration of the larval phase means that dispersal through this method is likely to be localised in scale. This is considered to be the reason for the localised colonisation of the marina and one other location within Holyhead harbour despite a healthy and abundant adult population (GB Non-native Species Secretariat, 2017).

Asexual reproduction occurs by budding to expand colony size. Optimal asexual growth occurs at temperatures between 14-18°C, although growth can occur between 11°C and 25°C. Rapid growth through budding of zooids can produce large mats or pendulous growths. Fragments of colonies can reattach and grow, and serve to spread the species to new locations.

Other factors including salinity and temperature and suitable available habitat restrict the reproduction and spread of the species.

In 2009 the GB *D. vexillum* Working Group was set up to help coordinate and advise on the response to *D. vexillum* in Great Britain. As it was not considered feasible to fully eradicate this species from GB, the group agreed to produce recommendations to help reduce its rate of spread and re-invasion. This group identified the main pathways for spread as: recreational boating, fisheries and aquaculture, ship recycling, marine industries (oil, gas, renewable and dredging), shipping - ballast water and biofouling (GB *D. vexillum* Working Group, 2009).

6.2.3 Disturbance to Marine Mammals

The Grey seal (*Halichoerus grypus*) and Harbour seal (*Phoca vitulina*), breed around all shorelines of Ireland and use the coastal and offshore waters in their daily lives for foraging, transit between terrestrial resting places (known as haul-out sites), and other behaviours linked to their annual life cycles (e.g., social behaviour, territoriality).

In addition, Twenty-four species of cetacean (i.e., whales, dolphins and porpoises) have been recorded from Ireland, 18 of which are more commonly observed, while the remaining six species have rarely been recorded and are currently classed as vagrant (i.e., species well outside their normal natural range). Some species can occur close to shore, and may be found within enclosed bays, harbours and estuaries. Others (e.g., Blue whale, Sperm whale, Humpback whale) may be highly migratory and show a preference for deeper water offshore habitats, or travel hundreds or thousands of kilometres between winter breeding and summer foraging locations, occupying Irish waters during part of their annual cycle (NPWS, 2014).

Malahide Estuary SAC is not designated for marine mammals. The nearest site/s designated for marine mammals are Lambay Island SAC (Grey seal and Harbour seal) and Rockabill to Dalkey Island SAC (Harbour porpoise). These site are 8.6 km and 5.3 km respectively east of the proposed project site. However, with due consideration of the wide ranging nature of most marine mammals and their protection under the Under the Wildlife (Amendment) Act 1976-2005 and additional legislation (EU Habitats Directive) the potential for disturbance for marine mammals is considered here.

Noise levels associated with dredging activities are not expected to be significantly elevated over typical background levels associated with Malahide Marina as a mixed urban and recreational boating/water sports environment. The deck noise associated with injection dredging is less than 81db. Measurement of underwater noise as a result of dredging has demonstrated that dredgers are marginally louder while dredging than shipping traffic. De Jong *et al*. (2010) measured underwater sounds produced by seven trailing suction hopper dredgers (TSHDs) during the construction of a 2,000 hectare harbour extension of the Port of Rotterdam. The results showed that dredging itself did not produce louder sounds than those produced by the dredger during transit when dredging over sand (as will be a similar case at Malahide i.e. soft sediment).

However, according to NPWS guidance, coastal dredging operations can be detected by marine mammals at received levels exceeding ambient sound more than 10km from shore. While sound exposure levels from such operations are thought to be below that expected to cause injury to a marine mammal, they have the potential to cause lower level disturbance, such as masking or behavioural impacts. As the dredging activity will occur within a fixed area for a period of a number of

days it has the potential to introduce continuous anthropogenic sound at levels that may impact upon marine mammal individuals and/or local populations (NPWS, 2014).

Therefore, it is considered that injection dredging has the potential to impact on marine mammals entering the estuary or utilising the marine waters within a 10km radius of the proposed project site.

6.2.4 Damage and disturbance to coastal habitats and associated species

There is no potential for any disturbance to the coastal habitats and associated species (Salicornia and other annuals colonising mud and sand [1310), Spartina swards (Spartinion maritimae) [1320], Atlantic salt meadows (Glauco-Puccinellietalia maritimae) [1330], Mediterranean salt meadows (Juncetalia maritimi) [1410], Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120], and Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]) for which the Malahide estuary, or any European site, is designated.

The project will be confined to the marina area and there is no requirement to access or transverse the coastal habitats at any point. The dredging of silt from within the marina area will not have the potential to impact on coastal (including mudflat) habitats due to the particularly strong tidal streams in the area which are predicted to carry suspended sediment along the mid-section of the main channel. The habitat supporting both Salicornia and other annuals colonising mud and sand and Spartina swards (Spartinion maritimae) is also considered to be outside of the zone of influence of the proposed project.

6.2.5 Impacts on Water quality

The sediment being dredged is comprised of fine silt which has been washed into the marina area. Analysis of the sediment has shown that the dredged sediment will consist of clayey silt with a low sand content. Accordingly, it will readily assimilate into this existing sediment pool, following initial settlement without adversely affecting its physical composition or ecological function.

The results of sediment analysis found that the mobilised sediments in all cases contain values below the lower Irish action levels for the full suite of parameters examined under the Marne Institute requirements for analysis of dredged spoil (Cronin *et al*., 2006), with the exception of nickel and arsenic at a number of sites. For these two parameters however, it is believed that the action levels for both these elements may be too conservative because of naturally high background levels and an absence of background Irish sedimentation concentration data when criteria were initially applied (Marine Institute, 2010). This report recommends that appropriate assessment criteria for sediments that facilitate normalisation, for instance to take grain size into account, are urgently required.

While there will be increased turbidity arising from the dredging works this will be temporary in nature and is a naturally occurring feature of estuarine environments with no potential to give rise to negative ecological effects.

6.2.6 Hydrological changes

There is no potential for hydrological change as a result of the proposed dredging. Deposition of sediments dredged from the marina area are predicted to temporarily settle in the area known as the short deeps approximately 1 km downstream of the marina. From this area they will be dispersed out to sea by the natural process that created these deep pockets originally.

6.2.7 Indirect habitat loss

No potential for indirect habitat loss has been identified as a result of the proposed project.

6.2.8 Impacts of birds

The intertidal mudflats and sandflats surrounding Malahide marina, within Malahide Estuary SPA provide important feeding and roosting areas for a range of wintering waterfowl. The inner estuary to the west of the marina is of lagoonal nature and is of particular value as it increases the diversity of birds which occur. Any impact to the structure and function of the intertidal mudflats and sandflats and the marine communities that they support has the potential to impact the feeding resource of the bird species which utilise the area. Impacts to the structure and function of this habitat are described under the heading of "Disturbance to the structure and function of marine habitats and associated communities" above. Based on the analysis of the potential impact of the proposed project on the structure and function of *Mytilus edulis* communities through the spread of the invasive alien species, *Didemnum vexillum,* an impact on wetland habitats (EU habitat code: A999) for birds could occur.

Noise disturbance to birds as a result of the injection dredging process is considered to be not significant. The deck level noise associated with injection dredging is <81 db. The area is already disturbed by recreational boat traffic and surrounded by a built up area. Therefore the noise level as a result of injection dredging is not above ambient noise levels and waterbirds utilising the area will have been habituated.

6.3 Assessment of Potential Impacts on the conservation objectives of European sites

Feature of interest with potential for impact	Activity	Potential impact/s	Likelihood of impact occurring (in absence of mitigation) and possible impact duration
Malahide Estuary SAC			
Mud flats and sandflats not covered by seawater at low tide [1140]	Injection dredging, movement of pier structures e.g. chains.	Mobilisation of sediments leading to the spread of the invasive alien species *D. vexillum* resulting in smothering of the *Mytilus edulis* community if settlement occurred on this community. Spread of *D. vexillum* downstream of the marina if suitable substrate was available.	Probable (>50% and <95% chance of occurring) Long term (15-60 years) Unlikely (>5% and <50% chance of occurring) Long term (15-60 years)
Rogerstown Estuary SAC			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site.			
Baldoyle Bay SAC			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site.			
Rockabill to Dalkey Island SAC			
Phocoena phocoena (Harbour Porpoise) [1351]	Injection dredging	Disturbance due to noise from dredging activities	Unlikely (>5% and <50% chance of occurring) Short term (0-1 years)
Ireland's Eye SAC			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site.			
Lambay Island SAC			
Halichoerus grypus (Grey Seal) [1364] *Phoca vitulina* (Harbour Seal) [1365]	Injection dredging	Disturbance due to noise from dredging activities	Unlikely (>5% and <50% chance of occurring) Short term (0-1 years)
Howth Head SAC			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site.			

North Dublin Bay SAC			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site.			
South Dublin Bay SAC			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site.			
Malahide Estuary SPA			
Wetland and waterbirds	Injection dredging	Smothering of *Mytilus edulis* community due to spread of Invasive alien species.	Unlikely (>5% and <50% chance of occurring) Short term (0-1 years)
Rogerstown Estuary SPA			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site. While the east coast SPA's provide a discrete network of interconnected sites for a number of water birds these sites are too far distant from the proposed project site for noise disturbance to lead to any impact.			
Baldoyle Bay SPA No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site.			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site. While the east coast SPA's provide a discrete network of interconnected sites for a number of water birds these sites are too far distant from the proposed project site for noise disturbance to lead to any impact.			
Irelands Eye SPA			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site. While the east coast SPA's provide a discrete network of interconnected sites for a number of water birds these sites are too far distant from the proposed project site for noise disturbance to lead to any impact.			
Lambay Island SPA			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site. While the east coast SPA's provide a discrete network of interconnected sites for a number of water birds these sites are too far distant from the proposed project site for noise disturbance to lead to any impact.			
Howth head Coast SPA			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site. While the east coast SPA's provide a discrete network of interconnected sites for a number of water birds these sites are too far distant from the proposed project site for noise disturbance to lead to any impact.			
North Bull Island SPA			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site. While the east coast SPA's provide a discrete network of interconnected sites for a number of water birds these sites are too far distant from the proposed project site for noise disturbance to lead to any impact.			

South Dublin Bay and River Tolka Estuary SPA			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site. While the east coast SPA's provide a discrete network of interconnected sites for a number of water birds these sites are too far distant from the proposed project site for noise disturbance to lead to any impact.			
Skerries Islands SPA			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site. While the east coast SPA's provide a discrete network of interconnected sites for a number of water birds these sites are too far distant from the proposed project site for noise disturbance to lead to any impact.			
Rockabill SPA			
No potential for impact on any habitat or species which forms a feature of interest for the site and therefore no potential for impact on any of the conservation objectives for this site. Rockabill island is an important site for breeding terns. However, it is considered that this SPA is too far distant for any disturbance from the proposed project to impact the tern or purple sandpiper species for which this site is designated.			
Wider area of Irish sea (outside of European sites)			
All marine mammals listed under the EU Habitats Directive and Wildlife (Amendment) Act 1976-2005	Injection dredging	Disturbance due to noise from dredging activities	Unlikely (>5% and <50% chance of occurring) Short term (0-1 years)

6.4 Analysis of potential in-combination impacts

Although the proposed project is located outside of any European site, Appropriate Assessment requires that potential in-combination impacts be considered. Other projects or plans with the potential to increase overall or specific project related impacts, to a level where these could be significant in the context of the conservation objectives of the site, need to be considered and evaluated.

Accordingly, this report has reviewed the potential of other projects, plans, activities and environmental factors to impact the site and thereby raise the prospect of additional impacts on the conservation objectives of any European site.

The Appropriate Assessment Screening has considered that the following impacts are potentially associated with injection dredging:

- Mobilisation of sediments and the resulting potential to smother susceptible species.
- Dispersion of alien invasive species.
- Noise disturbance to susceptible species.

The potential impact mechanisms have been evaluated according to the potential for these to give rise to or cause:

- Direct habitat loss
- Disturbance to the structure and function of marine habitats and associated communities.
- Disturbance to Marine Mammals
- Damage and disturbance to coastal habitats and associated species
- Impacts on Water quality
- Hydrological changes
- Indirect habitat loss
- Impacts on birds
- Impacts on wetland habitats for birds

AA guidelines indicate that consideration of in-combination impacts should include *ex situ* and *in situ* projects/developments. As these may change over time and in order to provide clarity the following potential projects/developments or sources of impact have been considered:

- Local area developments around the Malahide Estuary and in the marine area to the east of the project site.
- Climate change.

The Fingal Development Plan 2017-2023 has been reviewed as part of this NIS. The plan does not yet have a specific Local Area Plan for the Malahide area, however there are Local Area Development Plans for Donabate-Portrane (Map 7) and Swords (Map 8). Details of all zoning and proposed developments in these two LAP's have been reviewed. Malahide-Portmarnock development plans going forward are covered by Map 9. The proposed development activity for the area surrounding Malahide Estuary is detailed in the plans and relevant maps provided by the Fingal Development Plan 2017-2023 (maps

and plans are not reproduced here due to copyright restrictions but are available at the relevant links provided). A summary of the map based local objectives for each of the three maps (Maps 7, 8 and 9) is available here.

The proposed plans and developments for the area ensure that practically all of the land immediately adjoining Malahide estuary is earmarked as Greenbelt, High Amenity or Open Space. As such, the permissible activities in these areas are restricted and are further defined in the plan. No significant developments that are considered likely to have significant impacts on their own or to contribute to creating in-combination effects will likely be permitted going forward.

While some land area to the south of Portrane has been designated for housing development under the Portrane LAP, a significant buffer remains between the area and the designated site and any proposed developments will only be consented after appropriate evaluation (NIS) considering the requirements for AA.

The "Broadmeadow Way" cycling and pedestrian route that is proposed to run alongside the existing rail viaduct (to the west of Malahide Marina) is likely to be proceed during the near term. It is a long-standing objective of the Fingal County Development Plan to develop a Fingal Coastal Way. The Broadmeadow Way will be a critical link in the proposed coastal route as it spans the Malahide Estuary, thereby linking two peninsulas. The overall length of the trail is approximately 6km. The Broadmeadow Way has been designed to best practice and will have a high amenity value and will bring significant benefits for the locality as well as the greater area. It will benefit both commuters and recreational users. The proposed trail will connect to other proposed cycle/pedestrian routes and will link to public transport. Fingal County Council has undertaken a comprehensive study on a number of feasible route options, from which a preferred route has been selected.

The project has been subject to a detailed planning and consenting process and construction of the route will not impact on the estuary or introduce greater levels of disturbance as the principal use of the rail bridge at the moment is for rail commuter and Dublin-Belfast line rail traffic. Consequently it is not considered that the completion of the Broadmeadow way will contribute to in-combination effects of the proposed injection dredging project.

Climate change is likely to have an ongoing impact on the Malahide Estuary site as it will on most or all other parts of the coastal environment in the future. It remains impossible to predict the eventual outcome of climate change such as may be realised in changes to the intertidal and subtidal foreshores through alternated bathymetry, hydrology, sea level, tidal currents, water exchange or ecological geography of the coast. Mechanisms by which climate change could impact the site include one-off dramatic weather events or through longer-term shifts in climate leading to large scale physical and eco-geographical impacts that may have severe localised effects.

In the context of the proposed project, the plausible outcomes of predicted climate change are for significant sea level rise in the future. Such changes are likely to lead to dramatic physical changes in the coast with consequent widespread ecological changes. In this context, the potential in-combination impacts of the proposed dredging project considered together with the likely future gross changes resulting from climate change means suggest that the dredging will not contribute measurably

or significantly to the overall level of climate change related impact. Therefore no in-combination with climate change impact is considered likely for any of the indicators referred to previously as a consequence of the completion of the dredging project.

No additional impacts or activities have been identified that could lead to an in-combination impact of the proposed project on any European site.

6.5 Appropriate Assessment Screening Statement

The potential for impacts on the conservation objectives of Malahide Marina SAC, Malahide Marina SPA and all additional European sites within a 15km radius of the proposed project have been identified as:

- The potential for the spread of the Invasive Alien Species, *Didemnum vexillum* into Malahide Estuary SAC and Malahide Estuary SPA leading to smothering of the *Mytilus edulis* dominated community as a result of colonisation by *D. vexillum* and as a potential vector for further spread of this species to other habitats outside of the marina area.
- Disturbance to marine mammals.

The aforementioned impacts have the potential to negatively impact the conservation objectives of Malahide Marina SAC, Malahide Marina SPA and additional European Sites with a 15km radius of the proposed project site and therefore a Natura Impact Statement is required.

7. Natura Impact Statement.

7.1 Mitigation

7.1.1 Control of the spread of *D. vexillum*

Following the preparation of the Appropriate Assessment screening, Malahide Marina contracted the Marine ecology group, School of Biology and Environmental Science, University College Dublin to further examine the potential for injection dredging to lead to the spread of *D. vexillum* (Brooks *et al* 2018).

This project aimed to a) understand if the growth and asexual reproduction (through fragmentation) of *D. vexillum* varies seasonally at Malahide marina and b) test the viability and attachment potential of fragments of *D. vexillum* on a range of different substrates in both lab and field conditions. The study was conducted at Malahide marina from April 2017 until mid-January 2018.

This study has demonstrated that fragments of *D. vexillum* were only found below pontoons/breakwaters in high energy current flow areas on the spring and summer sampling dates. The report notes that for both the laboratory and field experiments, fragment mortality and reduced viability of fragments occurs rapidly over a relatively short time-frame. In particular, the findings from the laboratory experiment show that high levels of fragment mortality and reduced viability within seven days of initiation of the experiment While in the field experiment, due to adverse conditions, fragment mortality and viability rates over shorter periods could not be established. Final sampling by one month after initiation, revealed that nearly all fragments across all substrate types had total mortality, with the remaining two fragments clearly unviable. Taken together these findings are consistent with evidence from the literature and expert opinion on the potential for fragment survival particularly on sediment which is the predominant substrate in the Malahide marina (Brooks *et al* 2018).

The results of this study (Appendix 1) have concluded that:

"*Based on our findings, water injection dredging at Malahide marina should ideally take place during the winter months December/January when colonies are reduced in cover and potential for fragmentation. This time period would also fall outside the one month period examined in the field experiment portion of our study to ensure the mortality of any potential fragments on the benthos from the peak period of growth (and reproduction). Thus greatly reducing any potential for resuspension during the water injection dredging procedure. In fact, given that the procedure occurs in low energy areas resuspension of fragments in these areas will not occur based on our finding that no fragments occurred on the benthos in those locations during the November and January sampling dates. Equally, fragments that may have survived in high energy areas will be covered by sediment during the procedure and therefore this will potentially further reduce survival and transport of D. vexillum away from the marina. That said based on our findings there was no evidence of fragment accumulation in those areas during that time period.*

To strengthen our findings from the monitoring study and ensure that fragment accumulation (and potential transport of fragments) is reduced, we will continue our monitoring study of D. vexillum during the licence application and the water injection dredging period if required". (Brooks *et al* 2018).

In consideration of the results of this study, it is our opinion that provided all injection dredging is carried out between December and January on any given year the potential for the spread of *D. vexillum* is highly unlikely.

Therefore the following mitigation is proposed:

- Injection dredging is conducted between December 1st and January 31st in any given year.

7.1.2 Noise disturbance to marine mammals

While the levels of noise resulting from injection dredging are considered to be below that expected to cause injury to a marine mammal, they have the potential to cause lower level disturbance, such as masking or behavioural impacts. Therefore, it is considered prudent that a marine mammal observer (MMO) is present during dredging operations. This will avoid any disturbance or harm to marine mammals that may be present in the immediate vicinity of the proposed project site, or wider area, during dredging operations.

Therefore the following mitigation is proposed:

- A qualified and experienced marine mammal observer (MMO), independent of the dredging contractor, shall be appointed to monitor for marine mammals and to log all relevant events using standardised data forms.
- The MMO shall advise the Works Superintendent with a previously agreed timeframe prior to scheduled activity if environmental conditions, e.g. sea state, light, visibility, are insufficient for effective visual monitoring. In such conditions, injection dredging (or other activity of concern) shall be postponed until acceptable conditions prevail.
- In the event of suitable environmental conditions, a clear on-site communication signal shall be agreed between the MMO and the Works Superintendent as to whether the relevant activity may or may not proceed, or resume following a break (see below). Injection dredging shall only proceed on positive confirmation with the MMO, which must be recorded by the MMO.
- The MMO shall conduct pre-dredging start-up constant effort at least 30 minutes before the sound-producing activity is due to commence, continuing monitoring during and for 30 minutes following the activity. Sound-producing activity shall not commence until at least 30 minutes have elapsed with no marine mammal detections by the on-site MMO.
- Operations shall not commence if marine mammals are detected within a 200m radial distance of the intended sound source, i.e. within the Monitored Zone.
- Once begun, the activity may continue if weather conditions deteriorate or if marine mammals enter the 200m-radius Monitored Zone following start-up. If there is a break in injection

dredging activity for a period greater than 30 minutes then all monitoring measures shall recommence as for start-up.

- Full reporting on MMO operations and mitigation undertaken should be provided to the Department of Arts, Heritage and the Gaeltacht to facilitate reporting under Article 17 of the EU Habitats Directive and future improvements to guidance.

7.1.3 Monitoring

It is proposed that ongoing monitoring of *D. vexillum* is conducted within Malahide marina and the surrounding estuary to include the *Mytilus edulis* community over the course of the next 11 years (up to 2028). This will provide an early warning system in the unlikely event that *D. vexillum* has established outside of its existing known range within the marina. The proposal includes provision for monitoring one year following the final proposed dredging operation in 2027.

7.2 Analysis of the proposed project on the conservation objectives of European sites following mitigation

7.2.1 Control of the spread of *D. vexillum*

Mitigation to avoid the spread of *D. vexillum* has been proposed through limiting injection dredging operations to the months of December and January. This is the period which research has indicated the species is unlikely to be viable.

The mussel beds within Malahide Estuary SAC are outside of the predicted settlement area of any sediment mobilised. The proposed dredging period of December/January has further reduced the possibility of viable fragments of *D. vexillum* establishing a new colony on mussel beds or other suitable hard substrate (e.g. shell, rock, discarded debris) within the flow path of the mobilised sediment.

Provided this mitigation is adhered we are of the opinion that the spread of *D. vexillum* as a result of the proposed project is highly unlikely on the grounds of best scientific advice.

7.2.2 Noise disturbance to marine mammals

Mitigation to avoid disturbance to all marine mammals with the potential to access the area adjacent to the proposed project and a wider (approximately 10 km radius) has been proposed through the presence of a MMO.

Provided this mitigation is adhered we are of the opinion that no negative impacts on any marine mammal will occur as a result of the proposed project.

7.2.3 Monitoring

The Centre for Agriculture and Biosciences International (CABI) have reviewed the relevant literature related to the control and spread of *D. vexillum* (CABI, 2017) and concluded that establishing monitoring programs is likely the most effective management strategy. CABI note that eradication techniques are likely to unsuccessful at a regional scale but may be possible at a small scale.

Monitoring of the site for the presence of *D. vexillum* has been proposed for an eleven year period (during and after the project phase of activity). This will provide an early warning system to identify any spread of this species following injection dredging operations and allow early action to be taken.

Provided this mitigation is adhered we are of the opinion that the unlikely spread of *D. vexillum* will be noted at the earliest opportunity and appropriate action taken.

Table 7.2 Summary of assessment of mitigation on the conservation objectives of the features of interest within all SAC's and SPA's considered to be within the zone of influence of the proposed project with the potential to be impacted.

Malahide Estuary SAC		
Attribute	**Target**	**Analysis of the effects on the attribute as a consequence of the project**
Habitat/species for which the site is designated: Mudflats and sandflats not covered by seawater at low tide [1140]		
Habitat area	The permanent habitat area is stable or increasing, subject to natural processes.	**No impact.** The permanent habitat will not be impacted.
Community extent	Maintain the extent of the *Zostera*-dominated community and the *Mytilus edulis*-dominated community complex, subject to natural processes.	**No impact**. The area occupied by the *Zostera*-dominated community and the *Mytilus edulis*-dominated community complex will not be impacted by the proposed project. Sediment mobilised as a result of injection dredging will settle out in the area of the "Short deeps" and not result in any smothering of the species which form these community complexes. As dredging will take place during the months of December/January the spread of *D. vexillum* has been mitigated. We are therefore of the opinion that the project will not lead to the spread of *D. vexillum* onto *Mytilus edulis* communities which would be considered to provide a suitable substrate for *D. vexillum.* The habitat that supports the *Zostera* dominated community does not have the potential to support *D. vexillum.*
Community structure: *Zostera* density	Conserve the high quality of the *Zostera*-dominated community, subject to natural processes	**No impact**. The area occupied by the *Zostera*-dominated community will not be impacted by the proposed project. Smothering as a result of sediment mobilisation will not occur as the *Zostera* dominated community is outside of the zone of influence of the mobilised sediment. Any sediment mobilised will settle out in the area of the "Short deeps" and will also be of a temporary nature (days). Therefore we are of the opinion that sediment settlement on *Zostera noltii* beds will not occur and no impact will result to the density of *Zostera noltii* beds within Malahide Estuary SAC.
Community structure: *Mytilus edulis* density	Conserve the high quality of the *Mytilus edulis*-dominated community, subject to natural processes	**No impact.** As dredging will take place during the months of December/January the spread of *D. vexillum* has been mitigated. We are therefore of the opinion that provided injection dredging takes place during December/January that the project will not lead to the spread of *D. vexillum* onto *Mytilus edulis* communities which would be considered to provide a suitable substrate for *D. vexillum.* Therefore we are of the opinion that no impact of the density of *Mytilus edulis* will occur.
Community distribution	Conserve the following community types in a natural condition: Fine sand with oligochaetes, amphipods, bivalves and polychaetes	**No significant impact.** The injection dredging process will lead to mobilisation of fine sediments that will be short lived in duration (days) and will be mobilised in the direction of the prevailing currents, as demonstrated by the available models, into the subtidal "short

	community complex; Estuarine sandy mud with Chironomidae and *Hediste diversicolor* community complex; and Sand to muddy sand with *Peringia ulvae*, *Tubificoides benedii* and *Cerastoderma edule* community complex.	deeps" area. Therefore sediment settlement on the community distribution of the constituent communities of intertidal mudflats and sandflats will not occur.
Habitat/species for which the site is designated: Salicornia and other annuals colonising mud and sand [1310]		
No impact. This habitat is considered to be outside of the zone of influence of the proposed project (see rationale provided in section 6.2.4)		
Habitat/species for which the site is designated: Spartina swards (Spartinion maritimae) [1320]		
No impact. This habitat is considered to be outside of the zone of influence of the proposed project (see rationale provided in section 6.2.4)		
Habitat/species for which the site is designated: Atlantic salt meadows (Glauco-Puccinellietalia maritimae) [1330]		
No impact. This habitat is considered to be outside of the zone of influence of the proposed project (see rationale provided in section 6.2.4)		
Habitat/species for which the site is designated: Mediterranean salt meadows (Juncetalia maritimi) [1410]		
No impact. This habitat is considered to be outside of the zone of influence of the proposed project (see rationale provided in section 6.2.4)		
Habitat/species for which the site is designated: Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120]		
No impact. This habitat is considered to be outside of the zone of influence of the proposed project (see rationale provided in section 6.2.4)		
Habitat/species for which the site is designated: Fixed coastal dunes with herbaceous vegetation (grey dunes) [2030]		
No impact. This habitat is considered to be outside of the zone of influence of the proposed project (see rationale provided in section 6.2.4)		
Rogerstown Estuary SAC		
No impact. All of the features of interest for which this site is designated are considered to be outside of the zone of influence of the proposed project and therefore no potential impacts on the conservation objectives of this site have been identified.		
Baldoyle Bay SAC		
No impact. All of the features of interest for which this site is designated are considered to be outside of the zone of influence of the proposed project and therefore no potential impacts on the conservation objectives of this site have been identified.		

Rockabill to Dalkey Island SAC		
Habitat/species for which the site is designated: *Phocoena phocoena* (Harbour Porpoise) [1351]		
Access to suitable habitat	Number of artificial barriers	**No impact.** No artificial barriers will be constructed at any time as a result of the proposed project.
Disturbance	Level of impact	**No impact.** Human activity at the marina and surrounding area is already significant due to the urban location of the site and current recreational activities. No increase in this activity as a result of the proposed project will occur. Noise disturbance due to injection dredging is considered to be low. The presence of a Marine Mammal observer during dredging operations will mitigate any potential, but unlikely, additional noise disturbance as a result of the proposed project.
Habitat/species for which the site is designated: Reefs [1170]		
No impact. Reefs within this site are considered to be outside of the zone of influence of the proposed project and therefore no potential impacts on the conservation objectives of Reefs have been identified.		
Ireland's Eye SAC		
No impact. All of the features of interest for which this site is designated are considered to be outside of the zone of influence of the proposed project and therefore no potential impacts on the conservation objectives of this site have been identified.		
Lambay Island SAC		
Habitat/species for which the site is designated: *Halichoerus grypus* (Grey seal) [1364]		
Access to suitable habitat	Number of artificial barriers	**No impact.** No artificial barriers will be constructed at any time as a result of the proposed project
Breeding behaviour	Breeding sites	**No impact.** The proposed project is too far distant from the breeding sites for this species to lead to any impacts on this attribute and target.
Moulting behaviour	Moult haul-out sites	**No impact.** The proposed project is too far distant from the moult haul-out sites for this species to lead to any impacts on this attribute and target.
Resting behaviour	Resting haul-out sites	**No impact.** The proposed project is too far distant from the resting haul-out sites for this species to lead to any impacts on this attribute and target.
Disturbance	Level of impact	**No impact.** Human activity at the marina and surrounding area is already significant due to the urban location of the site and current recreational activities. No increase in this activity as a result of the proposed project will occur. Noise disturbance due to injection dredging is considered to be low. The presence of a Marine Mammal observer during dredging operations

		will mitigate any potential, but unlikely, additional noise disturbance on Grey seal which may range between this SAC and the vicinity of the proposed project site.
Habitat/species for which the site is designated: *Phoca vitulina* (Harbour Seal) [1365]		
Access to suitable habitat	Number of artificial barriers	**No impact.** No artificial barriers will be constructed at any time as a result of the proposed project
Breeding behaviour	Breeding sites	**No impact.** The proposed project is too far distant from the breeding sites for this species to lead to any impacts on this attribute and target.
Moulting behaviour	Moult haul-out sites	**No impact.** The proposed project is too far distant from the moult haul-out sites for this species to lead to any impacts on this attribute and target.
Resting behaviour	Resting haul-out sites	**No impact.** The proposed project is too far distant from the resting haul-out sites for this species to lead to any impacts on this attribute and target.
Disturbance	Level of impact	**No impact.** Human activity at the marina and surrounding area is already significant due to the urban location of the site and current recreational activities. No increase in this activity as a result of the proposed project will occur. Noise disturbance due to injection dredging is considered to be low. The presence of a Marine Mammal observer during dredging operations will mitigate any potential, but unlikely, additional noise disturbance as a result of the proposed project.
Habitat/species for which the site is designated: Reefs [1170]		
No impact. Reefs within this site are considered to be outside of the zone of influence of the proposed project and therefore no potential impacts on the conservation objectives of Reefs have been identified.		
Habitat/species for which the site is designated: Vegetated sea cliffs of the Atlantic and Baltic coasts [1230]		
No impact. Vegetated sea cliffs of the Atlantic and Baltic coasts within this site are considered to be outside of the zone of influence of the proposed project and therefore no potential impacts on the conservation objectives of Vegetated sea cliffs of the Atlantic and Baltic coasts have been identified.		
Howth Head SAC		
No impact. All of the features of interest for which this site is designated are considered to be outside of the zone of influence of the proposed project and therefore no potential impacts on the conservation objectives of this site have been identified.		
North Dublin Bay SAC		
No impact. All of the features of interest for which this site is designated are considered to be outside of the zone of influence of the proposed project and therefore no potential impacts on the conservation objectives of this site have been identified.		

South Dublin Bay SAC
No impact. All of the features of interest for which this site is designated are considered to be outside of the zone of influence of the proposed project and therefore no potential impacts on the conservation objectives of this site have been identified.
Malahide Estuary SPA
No potential for impact on any habitat or species which forms a feature of interest for this site and therefore no potential for impact on any of the conservation objectives for this site.
Rogerstown Estuary SPA
No potential for impact on any habitat or species which forms a feature of interest for this site and therefore no potential for impact on any of the conservation objectives for this site.
Baldoyle Bay SPA
No potential for impact on any habitat or species which forms a feature of interest for this site and therefore no potential for impact on any of the conservation objectives for this site.
Ireland's Eye SPA
No potential for impact on any habitat or species which forms a feature of interest for this site and therefore no potential for impact on any of the conservation objectives for this site.
Lambay Island SPA
No potential for impact on any habitat or species which forms a feature of interest for this site and therefore no potential for impact on any of the conservation objectives for this site
Howth Head Coast SPA
No potential for impact on any habitat or species which forms a feature of interest for this site and therefore no potential for impact on any of the conservation objectives for this site
North Bull Island SPA
No potential for impact on any habitat or species which forms a feature of interest for this site and therefore no potential for impact on any of the conservation objectives for this site

South Dublin Bay and River Tolka Estuary SPA
No potential for impact on any habitat or species which forms a feature of interest for this site and therefore no potential for impact on any of the conservation objectives for this site
Skerries Islands SPA
No potential for impact on any habitat or species which forms a feature of interest for this site and therefore no potential for impact on any of the conservation objectives for this site
Rockabill SPA
No potential for impact on any habitat or species which forms a feature of interest for this site and therefore no potential for impact on any of the conservation objectives for this site

7.3 Residual impacts

It is concluded that provided the project is implemented in accordance with the detailed scope of work (section 2) and the mitigation measures detailed in section 7, that residual impacts on the Conservation objectives of the European sites within a 15km radius of the proposed project will not occur.

7.4 Natura Impact Statement

This NIS contains an examination and analysis of the potential significant effects on **the *features of interest and conservation objectives*** of Malahide Estuary SAC, Malahide Estuary SPA and additional European sites within a 15km radius of the proposed project

All potential impacts on the features of interest, as specified in the detailed conservation objectives for each habitat or species for which these sites are selected have been addressed. This will ensure that the following overarching conservation objectives are reached:

> **(1) To maintain or restore the favourable conservation condition of the Annex I habitat(s) and/or the Annex II species for which each SAC has been selected**.
>
> **(2) To maintain or restore the favourable conservation condition of the bird species listed as Special Conservation Interests for each SPA**.

The NIS therefore concludes that, provided the mitigation measures described in this document are fully implemented ***no significant adverse impacts are expected on the Features of Interest and Conservation Objectives of any of the aforementioned Natura 2000 sites either alone or in combination with other projects or plans***.

It is further concluded that there is no requirement to proceed to Stage 3 (Assessment of Alternative Solutions).

8. References

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Appendix 1

Testing the likelihood of the invasive tunicate *Didemnum vexillum* dispersal via proposed water-injection dredging at Malahide Marina

Paul Brooks, Jennifer Coughlan & Tasman Crowe
School of Biology and Environmental Science, UCD
Final report - March 2018

Didemnum vexillum (Kott 2002) is an invasive colonial tunicate or Ascidian, its origin is unknown but it is believed to have originated from somewhere in the Pacific Northwest (Kott 2002; Lambert 2009). Concern over the potential for *D. vexillum* to become invasive stems from ecological traits that it shares with other invasive species, including the ability to overgrow benthic organisms, high reproductive and population growth rates, ability to spread by colony fragmentation, tolerance to a wide range of environmental conditions and the apparent scarcity of predators (Daley & Scavia 2008). Like many invasive ascidians this species has experienced recent range expansions due to human-mediated transportation, such as the unintentional transport on the hulls of recreational and commercial ships (Wasson et al. 2001; Lambert 2009). *D. vexillum* is a strong spatial competitor and once established it may persist and become the most dominant member of the new community (Lambert 2009). In some cases, it is known to reduce the abundance of previously established benthic species and cause significant changes in benthic community structure (Castilla *et al*. 2004; Lambert 2009). It was found in Ireland for the first time on pontoons and leisure craft at Malahide marina (Minchin and Sides 2006; Minchin 2007) and since been reported at a number of sites around the country (Minchin 2007; Griffith *et al.* 2009).

Like all colonial ascidians, *D. vexillum* reproduces sexually and broods its larvae, however it is purported that larval dispersal capacity is limited as competency is only minutes to a few hours max (Mather 2002). However, this species can also form new colonies asexually through fragmentation (Bullard et al 2007). This is particularly true when in its rope-like or tendril growth form; long flaccid lobes containing larvae brooded within the colony tissue extend from the central portion of attached colonies that easily break off (Bullard *et al* 2007). Coutts (2002) noted that colonies that had fallen off of contaminated barges in Marlborough Sounds in New Zealand eventually died off if they landed on muddy or sandy bottoms. Furthermore, deposition of sediment particles can interfere with the feeding and respiration functions of invertebrate communities, and can lead to smothering if sufficient water currents do not re-suspend and export sediments, in particular fine material such as mud or silt (Lohrer

et al. 2006; Maldonado et al. 2008). This die-off observed on soft sub-strata may also be linked to the fact that there is generally a lack of hard substrata (living or otherwise) found in sedimentary habitats (e.g. rocks, mussels, barnacles, encrusting polychaetes, etc.). More recent experimental work conducted in both lab and field trials found that tendril reattachment was successful in lab trials only but only one of 80 tendrils at two sites in the field reattached to substrate. In addition tendrils deployed at both sites were degraded within 24 – 50 h after deployment and in general disappeared completely 6 days after deployment, which the authors attributed to the presence of a gastropod predator observed at field sites (Stefaniak & Whitlatch 2014). Equally, it has been suggested that colonies growing on live marine animals seem to be more resistant to the cold, than those growing on rocks, stones and plants (Gittenberger 2007). Hence, depauperate sedimentary habitats would have a reduced chance of facilitating dispersal. One study (Hopkins et al. 2011) reports that the low energy currents at three sites in New Zealand (Nelson, Picton and Waikawa), had associated high rates of mortality on plates transplanted with invasive biofouling species (including *D. vexillum*). In particular plates orientated upwards were covered by a 2 to 3mm layer of sediment at the completion of a 1-month experiment had contributed greatly to the observed mortality rates. In addition, sediment-related mortality was also observed on caged plates deployed upwards at two other sites, suggesting that even relatively low levels of sedimentation can have a significant effect on survival (Hopkins et al. 2011). Other research has shown that covering of *D. vexillum* in dredge material (70% silt/clay, 20% sand, 10% small cobble) was found to be completely successful in eliminating colonies (Coutts 2006; Coutts & Forrest 2007). As with many invasive species dispersal vectors play a major role in there spread, Herborg *et al*. (2009) evaluated a range of dispersal vectors for *D. vexillum* across a large spatial scale in Canada. Of the potential dispersal vectors included in the study, the authors found that natural larval dispersal and drift of adult colonies were predicted to have a moderate risk when compared to other vectors such as transportation on vessel hulls, aquaculture transfers and commercial fishing. However, the authors report that this may vary depending on local environmental conditions and/or seasonality.

It is widely reported that there are direct links between expansive growth of this species and temperature/seasonality (Bullard *et al* 2007; Daley & Scavia 2008; Fletcher *et al*. 2013). In summer months, in other temperate areas, fragmentation when colonies of *D. vexillum* are at their highest growth rates (rope-like growth forms) resulted in rapid recolonisation through asexual reproduction of fragments but this only occurred on hard substrata (Bullard *et al* 2007). In winter months, expanded colonies die back and are reduced to basal overwintering patches with little reproductive capabilities (Satoh 1994; Daley & Scavia 2008). Furthermore, it has been suggested that colony growth and

reproduction occurs at water temperatures between 10 – 25 ^{o}C with optimisation of both occurring between 15 and 20 ^{o}C (McCarthy *et al* 2007; Daley & Scavia 2008). In Europe, its optimal growing temperatures appears to be between 14 and 18 degrees C, with decreases at warmer and colder temperatures and massive die-off at temperatures below 5 degrees (Gittenberger 2007). In terms of seasonal variation in growth rates of *D. vexillum*, observations over a 28 month period in the United States show that colonies began growing by asexual budding when water temperature reached 8 to 12 °C in the spring, and continued accumulating biomass through the summer, however colonies began to degenerate again when water temperatures declined relatively rapidly to 15 °C in late autumn or early winter (Valentine et al 2007). In other places, the length of the reproductive season has been shown to vary, from 3.5 to 5 months in the Northern hemisphere (Valentine *et al* 2009; Sorte & Stachowicz 2011) and up to 9 months in the Southern hemisphere (Fletcher et al. 2013). However, this is known to be very much dependent on local conditions such as size of existing population, temperature variation over seasons and preceding years, and other environmental factors such as depth, salinity, etc (Valentine *et al* 2009; Sorte & Stachowicz 2011; Fletcher *et al.* 2013).

Experimental work which tested survivability of fragments at varying depths (0.5 – 4m) and salinity (High; 26 -30, Medium; 15-28 and Low; 10 - 26) at three sites, showed that fragment biomass was greatly reduced at depths of 4m in comparison to shallower depths at all three sites. Additionally, fragments placed in medium and low salinity sites had reduced survivability and dramatically reduced growth rates in comparison to fragments in high salinity sites, with fragments in medium/low salinity sites appearing pale, bulbous and decaying (Bullard & Whitlatch 2009). In contrast, more recent work comparing stress resistance of *D. vexillum* with another invasive tunicate sourced in the Irish Sea suggests that *D. vexillum* was more tolerant of low salinity than previously envisaged (Gröner *et al.* 2011). Although, this was a short term lab experiment, such ambiguity would warrant further study in more natural conditions. Indeed, it has been suggested that lack of success in eradication programs of *D. vexillum* was most likely due to failure to observe such seasonal patterns and local conditions (Fletcher *et al* 2013).

As such the overall aim of this study is to a) understand the growth and asexual reproduction (through fragmentation) of *D. vexillum* varies seasonally at Malahide marina and b) test the viability and attachment potential of fragments of *D. vexillum* on a range of different substrates in both lab and field conditions.

Methodology:

Study was conducted at Malahide marina, located in the Broadmeadow estuary in North County Dublin, from late April 2017 until mid-January 2018.

Figure 1. Malahide marina

Monitoring

Malahide marina in North County Dublin (Figure 1) has proposed to use water injection dredging to remove sediment which has accumulated in low flow areas of the marina. As part of the licensing application and to ensure minimum environmental impact and decreased risk of the spread of this invasive, we monitored and experimentally tested the likelihood of *D. vexillum* spreading during the water injection dredging process.

Firstly, we monitored the seasonal growth patterns of *D. vexillum* at the marina by using a survey at the marina, at six locations around the marina on the breakwaters/pontoons (Figure 2), 4 quadrats (0.5 X 0.5 m) were used to record the extent (percentage cover) of this species at three time-points (April, June & November). These sampling dates were chosen to match closely with the expected growth and dieback patterns previously recorded for *D. vexillum* at Malahide marina (O'Brien & Crowe, unpublished data). Due to a reduction in complete die-back during the study, monitoring was extended with the addition of a further time-point in January 2018.

In addition, at each location the amount of *D. vexillum* fragments on the subtidal sediment was evaluated in three random areas at each time point by scraping the top 30mm of sediment in a 0.4 X

1m strip using a surber net. Collected sediment was then sieved on site and the number of fragments recorded.

Experimental work plan

The aim of these experiments is test the viability of fragments of *D. vexillum* on different substrates. Understanding the viability of fragments over a given time period should guide when the appropriate time to implement the water injection dredging method to minimise the potential transport of viable fragments of *D. vexillum* to new locations in the marina or the wider environment. This was tested using a combination of both field and laboratory experiments ran simultaneously during peak growth periods at Malahide marina. The field experiment consisted of subtidal plots where fragments were placed on trays with different substrates (sediment, natural rock, mussel shells & concrete) in three replicated locations of both high energy (in the tidal race) and low energy (outside the tidal race) water flow areas around the marina (Figure 2). Viability and attachment potential of fragments to the different substrates was evaluated at different sampling points- 2 days, 1 week, 2 weeks and 1 month after initiation, to establish if an appropriate time frame for dredging after die-back of *D. vexillum* growth patterns (reduction of asexual fragmentation in colonies). Communication with leading experts on *D. vexillum*, suggests that fragments on sediment are most likely to be only viable for a number of days/weeks at most (John Bishop; Ashley Coutts, personal communications – see Appendix). In addition, a more controlled experiment tested the same factor (Substrate - sediment, natural rock, mussel shells & concrete) in the laboratory. Previous work on *D. vexillum*'s ability to attach to substrates has only been tested in the lab and may not be truly indicative of how this occurs in the field. In the field, other parameters such as flow rates, natural sedimentation, changes in salinity, fluctuation in water temperature, predation rates could all influence survivability and attachment rates. So a combinational approach of both lab and field experiments was deemed to be a more suitable approach to addressing our overarching questions.

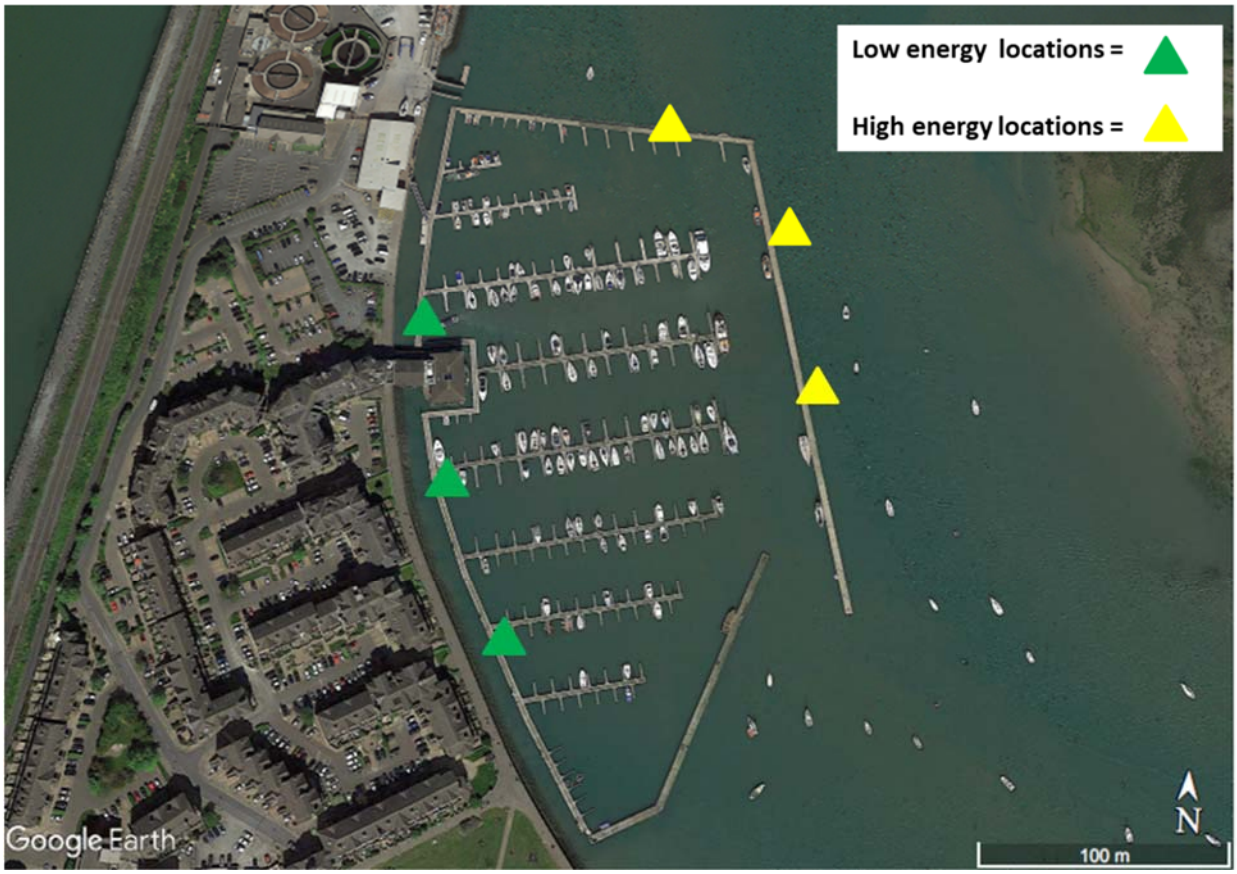

Figure 2. Map of Malahide marina showing six locations used to monitor *D. vexillum* at the marina. The six locations were also used during the field experiment to place experimental substrate treatments. Green triangles denote low current flow areas (Low energy) and yellow triangles denote high current flow areas (High energy).

Data analysis

Monitoring

Data collected during the monitoring study were analysed using ANOVA (Analysis of Variance) in WinGMAV5 (Underwood *et al.,* 1998).The factors and levels used were Current flow (Low energy & High energy), which was a fixed factor, in addition the factor Location (6 levels: 1, 2, 3, 4, 5 & 6), which was random and nested. Cochran's test was then used to test for homogeneity of variance, when Cochran's test was significant data were transformed. When terms in ANOVAs were significant Student Newman Keuls (SNK) tests were used to determine post-hoc comparisons between levels of significant terms.

Lab & Field experiments

For both the laboratory and field experiments Chi-squared tests of association using 2 x 4 contingency tables were used to analyse both viability and mortality data. Viability data had the following factors; Viability with 2 levels/categories - Viable/Unviable and the factor Substrate with 4 levels/categories – Concrete/Mussel shells/Stone/Sediment (n = 12 for both the lab & field experiments). Mortality data from the final sampling dates of both lab (Day 7) and field experiments (Day 30) had the following

factors; Mortality with 2 levels/categories - Live/Dead and the factor Substrate with 4 levels/categories – Concrete/Mussel shells/Stone/Sediment (n = 12 for treatments in the lab experiment & n = 9 for treatments in the field experiment). For the field experiment, individual Chi-squared tests of association using 2 x 4 contingency tables were used to analyse mortality data from across both current flow areas – Low & High energy. Data from three locations was pooled for each substrate in both current flow areas (n = 27 for each substrate).

Results

Monitoring

Number of fragments found on the benthos varied both spatially and temporally. On the first sampling date (April 2017), at two of the six locations there was an average of 0.33 fragments per location found but there was no significant differences amongst locations or between current flow areas (n=3). On the second sampling date (June 2017) again fragments were only found at two locations but with an average of one fragment per location (n= 3). On both dates fragments were significantly higher in number in high energy flow areas in comparison to low energy areas where no fragments occurred (Figure 3a & b, Table 1, SNK: High > Low, $p < 0.01$). On subsequent sampling dates (November 2017 & January 2018), however, no fragments were found on the benthos at any of the six locations around the marina and subsequently no analyses could be conducted (Figure 3c & d, Table 1c & d).

Table 1. Analyses of the number of *D. vexillum* fragments data recorded on the benthos at each of six locations beneath pontoons in Malahide marina for both low & high energy current flow areas sampled at four time-points between April 2017 and January 2018 (*n* = 3).

a) April

Source of variation	df	MS	F	*p*	
Current flow = Cu	1	0.222222	4	0.116117	
Location(Cu)	4	0.055556	0.5	0.736486	
RES	18	0.111111			

b) June

	df	MS	F	p	
Current flow = Cu	1	2	4	0.116117	
Location(Cu)	4	0.5	4.89098E+15	**0**	***
RES	18	0			

c) November

	df	MS	F	p
Current flow = Cu	1			
Location(Cu)	4		**No Test**	
RES	18			

d) January

	df	MS	F	*p*
Current flow = Cu	1			
Location(Cu)	4		**No Test**	
RES	18			

*** denotes significance $p < 0.001$

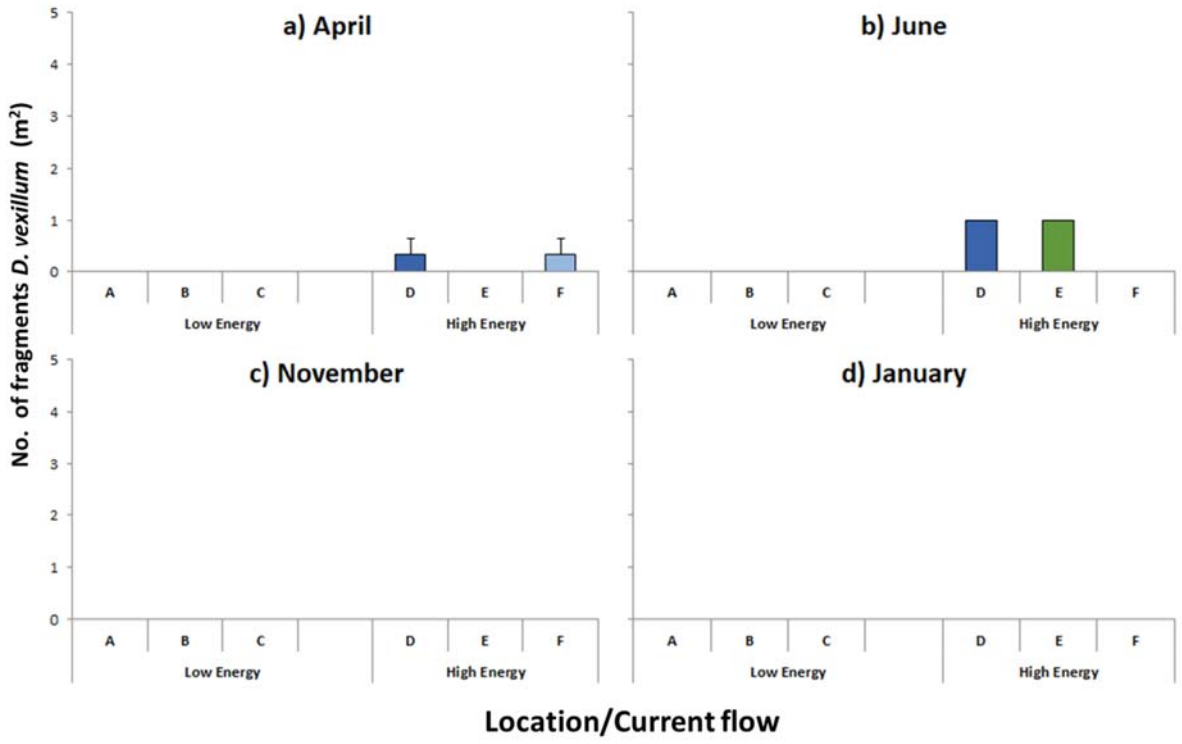

Figure 3. Number of *D. vexillum* fragments recorded on the benthos at each of six locations beneath pontoons in Malahide marina for both low & high energy current flow areas sampled at four timepoints between April 2017 and January 2018 (*n* = 3).

Percentage cover of *D. vexillum* in high energy current flows at all time points were significantly greater than low energy current flows (Figure 4a, b, c & d, Table 1 a, b, c & d, SNK; High > Low, $p < 0.01$). However, there was no significant variation amongst locations in each current flow (Figure 4 & Table 2). In general, the percentage cover was highest on the summer sampling date in June but reduced dramatically during the autumn and winter sampling dates (Figure 4). Colonies of *D. vexillum* remaining at these time-points appeared pale at all locations in the marina when compared visually to colonies sampled at peak growth periods (June 2017).

Table 2 Analyses of percentage cover data of *D. vexillum* recorded in quadrats at each of six locations on pontoons/breakwaters for both low & high energy current flow areas at Malahide marina, sampled at four time-points a) April 2017, b) June 2017, c) November 2017 and d) January 2018 (*n* = 4).

a) April

Source of variation	df	MS	F	*p*	
Current flow = Cu	1	2604.167	100	0.0006	***
Location(Cu)	4	26.0417	1.44	0.2608	
RES	18	18.0556			

b) June

	df	MS	F	*p*	
Current flow = Cu	1	7632.667	313.67	0.0001	***
Location(Cu)	4	24.3333	0.65	0.6321	
RES	18	37.25			

c) November

	df	MS	F	*p*	
Current flow = Cu	1	937.5	45	0.0026	**
Location(Cu)	4	20.8333	0.88	0.4941	
RES	18	23.6111			

d) January

	df	MS	F	*p*	
Current flow = Cu	1	1354.341	87.83	0.0007	***
Location(Cu)	4	15.4204	0.64	0.6417	
RES	18	24.1474			

** denotes significance $p < 0.01$ *** denotes significance $p < 0.001$

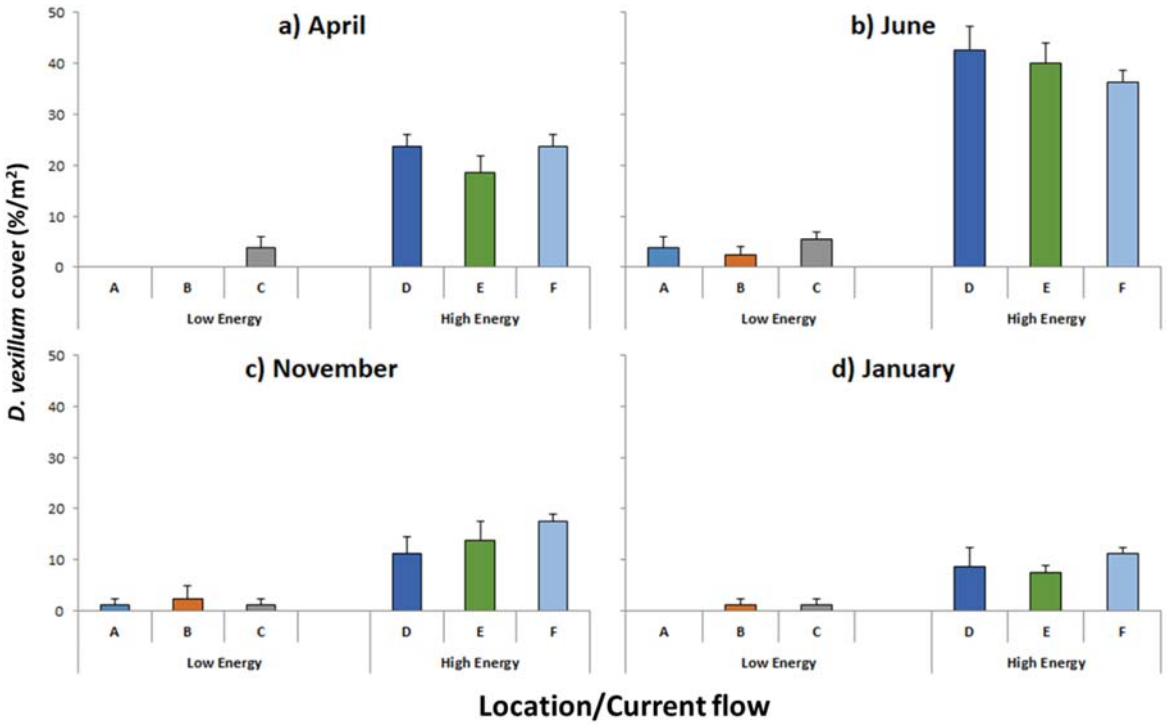

Figure 4. Percentage cover of D. vexillum recorded in quadrats at each of six locations on pontoons/breakwaters for both low & high energy current flow areas at Malahide marina, sampled at four time-points between April 2017 and January 2018 (*n* = 4).

Lab experiment

After four days in the lab experiment viability of all fragments was reduced across all substrates. In particular, 92 % of fragments (*n* = 12) on the substrates; concrete, mussel shells and sediment, showed reduced viability – appearing bleached and pale in coloration. On the stone substrate this was somewhat reduced at 83 %. There was no significant difference between substrate treatments (X^2 = 0.67, df = 2, p = 0.8802) but the number of unviable fragments was significantly higher than viable fragments (Figure 5a). By day seven, all fragments remaining, across all substrates showed reduced viability, appearing very pale and bleached (Figure 5b, X^2 = No test as number of viable fragments was zero).

Fragment mortality (fragments appeared totally decomposed) on day seven of the lab experiment was 42 % on the substrates concrete and stone. On mussel shells this was higher with 67% mortality recorded. On the final substrate – sediment, fragment mortalities were 92 % (*n* = 12). In particular, there was a significant association between fragment mortality and substrate type (X^2 = 8.62, df = 2, p < 0.05) with significantly higher mortality of fragments on the substrates mussel shells and sediment in comparison to the other two substrate treatments (Figure 6).

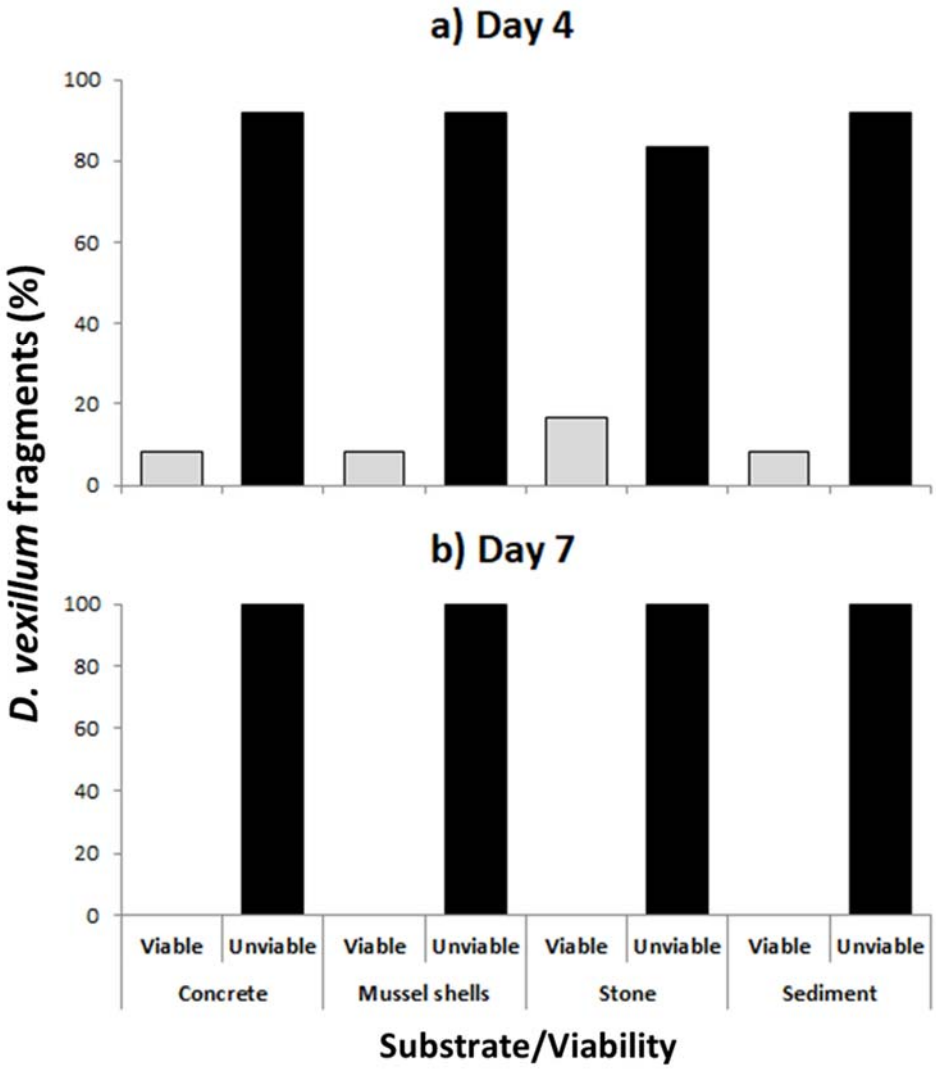

Figure 5 Viability of *D. vexillum* fragments placed on four experimental substrate treatments during the laboratory experiment, viability of fragments was sampled twice on a) four days and b) seven days after initiation. All treatments were replicated (*n* = 12).

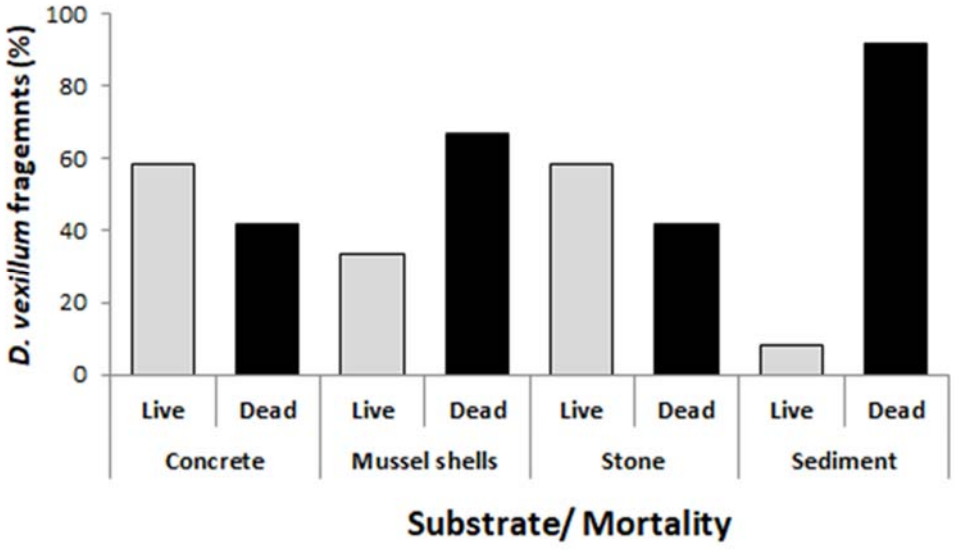

Figure 6 Mortality rates of *D. vexillum* fragments placed on four experimental substrate treatments during the laboratory experiment, mortality of fragments was sampled seven days after initiation. All treatments were replicated (*n* = 12).

Field experiment

Viability of fragments on the first three sampling dates (2 days, one week & two weeks) could not be fully established due to poor visibility for divers, but fragments that were observed at various locations across both current flow sites across all substrates types appeared pale and bleached on all sampling dates (data not shown).

After one month, on the final sampling date mortality rates across all four substrates tested was 100% (Figure 7a & b, X^2 = No test as number of live fragments was zero). In particular, there was no remaining evidence of fragments at all locations, across all substrates in both high and low energy sites with the exception of two pale white unviable fragments at one location in the high energy area (Figure 7c & d) recorded on two different substrates (stone & sediment).

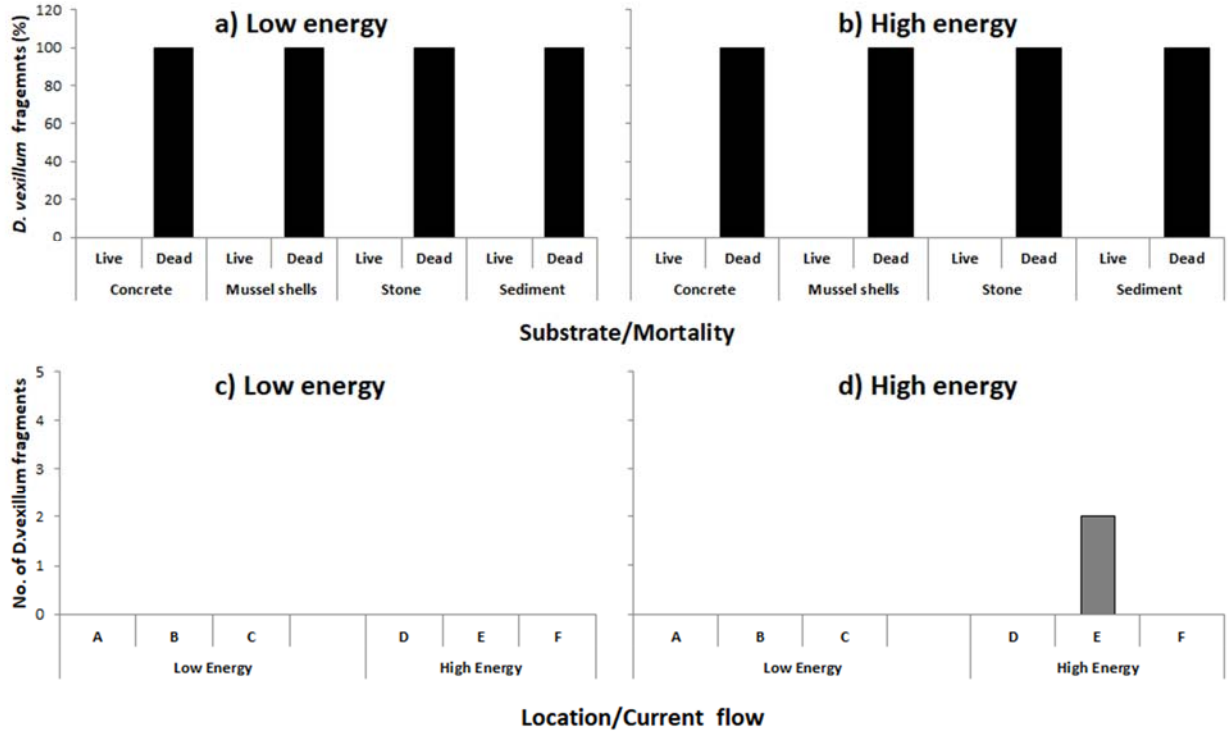

Figure 7. Mortality data of *D. vexillum* fragments on four experimental substrate treatments in both a) Low energy and b) High energy current flow areas sampled on day 30 of the field experiment (*n* = 27 for each substrate). Also shown are the number of fragments found in locations in both c) Low energy and d) High energy current flow areas (*n* = 9 for each location).

Discussion/Conclusions

The overall aim of this study was to a) understand the growth and asexual reproduction (through fragmentation) of *D. vexillum* varies seasonally at Malahide marina and b) test the viability and

attachment potential of fragments of *D. vexillum* on a range of different substrates in both lab and field conditions.

Our findings for growth rates of *D. vexillum* show that the peak period for growth at Malahide marina is during the summer, when percentage cover in quadrats peaked (with an mean of ~ 37 +/- 3.5 %) in high energy current flow locations. In contrast, the lowest growth rates occurred in January for both high energy (~ 9.2 +/- 1.35 %) and low energy (~ 0.8 +/- 0.5 %) areas (Figure 4). Equally, those findings for growth of *D. vexillum* were reflected in the findings for the number of fragments found on the benthos throughout the study period (Figure 3). In fact, fragments were only found below pontoons/breakwaters in high energy current flow areas on the spring and summer sampling dates (April & June, Figure 3a & b).

Our expectation based on field observations over the past few years and evidence from the literature on *D. vexillum* growth patterns in other locations was that total die-back would have occurred during late autumn/winter; due to the link with water temperature and growth for this species (Valentine et al 2007; McCarthy *et al* 2007; Daley & Scavia 2008), however, this was not the case. In fact, monthly sea surface temperatures (sst) for Malahide for 2017 appear to fall within the historical sst range (see Appendix: Figures A1 & A2). As such, there may have been other factors that may have influenced the patterns found in the current study and require further testing. Nonetheless our findings clearly show a trend towards a reduction in growth patterns throughout the year consistent with expectations.

In terms of our findings for the lab and field experiments, we clearly show that fragment mortality and reduced viability of fragments occurs rapidly over a relatively short time-frame. In particular, the findings from the lab experiment show that high levels of fragment mortality and reduced viability within seven days of initiation of the experiment (Figure 5 & Figure 6). In the field experiment, due to adverse conditions, fragment mortality and viability rates over shorter periods could not be established. That said, final sampling by one month after initiation, reveals that nearly all fragments across all substrate types had total mortality, with the remaining two fragments clearly unviable (Figure 7). Taken together these findings are consistent with evidence from the literature and expert opinion on the potential for fragment survival particularly on sediment which is the predominant substrate in the Malahide marina (see Coutts 2006; Coutts & Forrest 2007; John Bishop; Ashley Coutts, personal communications – see Appendix). In the field fragment mortality/viability may also have been influenced by high levels of sediment deposition. During all sampling dates there was distinct sediment loading in the water column at the marina which hampered diving and data acquisition. In addition,

observations on the final sampling date found sediment accumulation on trays used for experimental treatments was very evident. In fact, sediment covering of *D. vexillum* colonies has been shown to dramatically increase mortality rates (Hopkins *et al* 2011). In terms of attachment potential for lab and field experiments, no fragments at any period appeared to adhere to any of the substrates treatments over the observed time (personal observation).

In conclusion, based on our findings, water injection dredging at Malahide marina should ideally take place during the winter months December/January when colonies are reduced in cover and potential for fragmentation. This time period would also fall outside the one month period examined in the field experiment portion of our study to ensure the mortality of any potential fragments on the benthos from the peak period of growth (and reproduction). Thus greatly reducing any potential for resuspension during the water injection dredging procedure. In fact, given that the procedure occurs in low energy areas resuspension of fragments in these areas will not occur based on our finding that no fragments occurred on the benthos in those locations during the November and January sampling dates. Equally, fragments that may have survived in high energy areas will be covered by sediment during the procedure and therefore this will potentially further reduce survival and transport of *D. vexillum* away from the marina. That said based on our findings there was no evidence of fragment accumulation in those areas during that time period.

To strengthen our findings from the monitoring study and ensure that fragment accumulation (and potential transport of fragments) is reduced, we will continue our monitoring study of *D. vexillum* during the licence application and the water injection dredging period if required.

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Appendices

Expert opinions:

Response from John Bishop

> *A resting overwintering phase has been described in Didemnum spp., but I'm not sure it's very relevant to survival after falling onto a silty bottom ……*
>
> *Jessica Marks described the regression of the zooidal thoraces in colonies from northern Norway (Artic/ sub-Arctic), and the formation of a glossy pellicle over the upper surface of the colonies, which were growing on rock. Brooded larvae were still present in this stage (didemnid*

larvae are commonly brooded in the colony tunic) and resulting larvae would possibly be released upon the sloughing of the pellicle and return to the active phase after the winter. These observations have only been published in brief in a taxonomic paper, with reference to a second paper 'in press' discussing the resting stage and zooid replacement /regeneration in more detail, but as far as I can tell this was never published. I do have the MS somewhere. Jessica mentions also seeing the same thing in Maine in one of the species she studied.

The taxonomic paper is:

Marks, J.A., 1996. Three sibling species of didemnid ascidians from northern Norway: Didemnum albidum (Verril, 1871), Didemnum polare (Hartmeyer, 1903), and Didemnum romssae sp.nov. Canadian Journal of Zoology 74, 357-379.

No such observations have been published for D. vexillum as far as I know, but we have seen a very similar phenomenon in Dvex that we were trying to culture. (We must have made it very unhappy!)

Since this trick only involves the sealing off of the upper surface, how much it would help a free piece rather than an attached colony is debatable. Conceivably pieces might round off to become 'all upper surface' and develop a continuous pellicle, but this has not been described.

As far as I'm aware, no resistant dispersive propagule (analogous to, say, a statocyst) is known in didemnids nor, I think in any ascidians.

Response from Ashley Coutts

I'm afraid I did not monitor the rate of tendril decay underneath the Steel Mariner barge. However, I did note that it appeared a bacteria developed in the tendrils on the muddy substrate. It was grey/white in colour. I suspect this decayed started within a couple of weeks.

Sea surface temperatures for Malahide marina

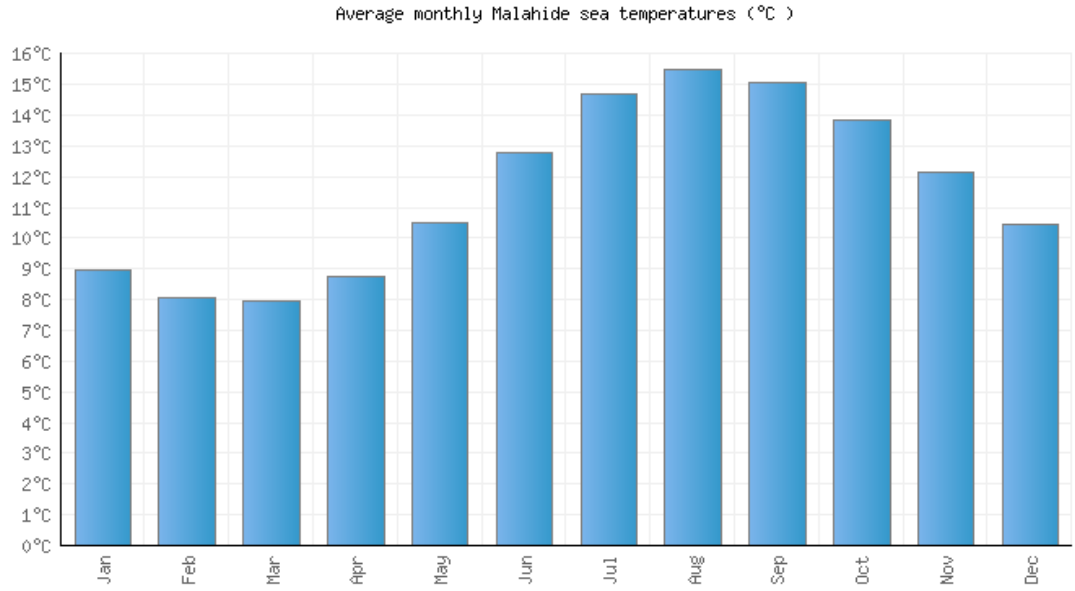

Figure A1 Sea surface temperatures (sst) for Malahide marina for Jan – Dec 2017 (Data source: https://www.seatemperature.org/europe/ireland/malahide.htm - data is derived based on NOAA global sst satellite data).

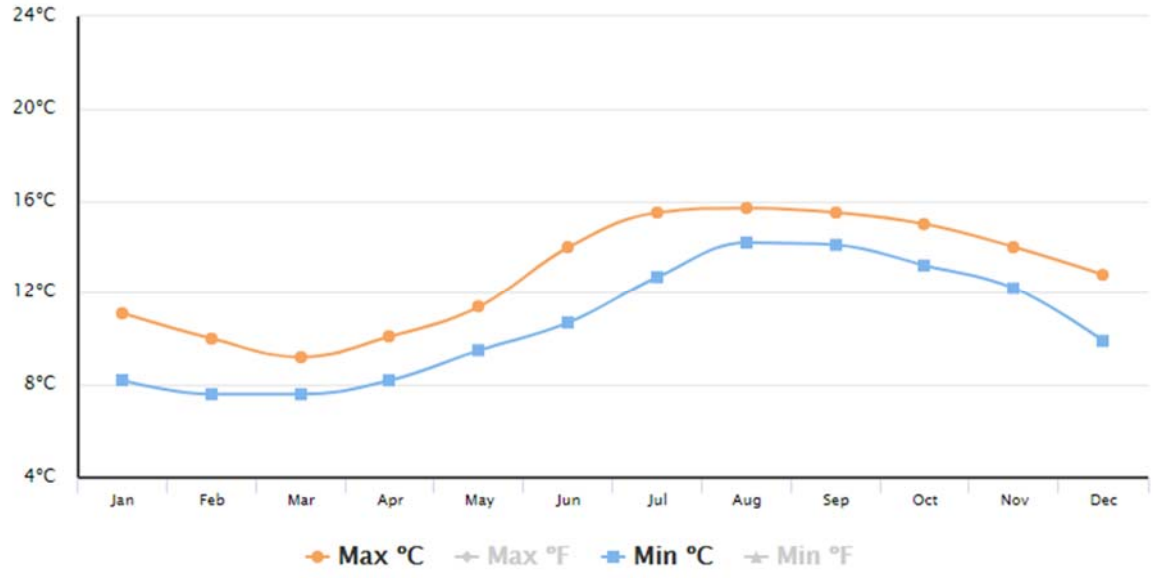

Figure A2 Calculated Mean Max and Mean Min Sea surface temperatures (sst) for Malahide marina. Data is calculated from multiple years of historical data (Data source: https://www.seatemperature.org/europe/ireland/malahide.htm - data is derived based on NOAA global sst satellite data).