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THE MONITORING AND ASSESSMENT OF SIX EU HABITATS DIRECTIVE ANNEX I MARINE HABITATS

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An Roinn Cultúir, Oidhreachta agus Gaeltachta
Department of Culture, Heritage and the Gaeltacht

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Front cover, small photographs from top row:

Coastal heath, Howth Head, Co. Dublin, Maurice Eakin; **Red Squirrel** *Sciurus vulgaris*, Eddie Dunne, NPWS Image Library; **Marsh Fritillary** *Euphydryas aurinia*, Brian Nelson; **Puffin** *Fratercula arctica*, Mike Brown, NPWS Image Library; **Long Range and Upper Lake**, Killarney National Park, NPWS Image Library; **Limestone pavement**, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott; **Barn Owl** *Tyto alba*, Mike Brown, NPWS Image Library; **A deep water fly trap anemone** *Phelliactis* sp., Yvonne Leahy; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson

Main photograph:

A Kelp park, Nick Pfeiffer

The monitoring and assessment of six EU Habitats Directive Annex I Marine Habitats

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Contents

Executive Summary

This report presents details of a monitoring survey to assess the conservation status of six marine Annex I habitats conducted between 2016 and 2018. This included *Sandbanks which are slightly covered by sea water all the time* [1110], *Estuaries* [1130], *Mudflats and sandflats not covered by seawater at low tide* [1140], *Large shallow inlets and bays* [1160], *Reefs* [1170] and *Submerged or partially submerged sea caves* [8330].

The conservation status of *Sandbanks which are slightly covered by sea water all the time*, *Reefs*[1] and *Submerged or partially submerged sea caves* was assessed as Favourable. The conservation status of *Estuaries* and *Mudflats and sandflats not covered by seawater at low tide* was assessed as Unfavourable-Inadequate while *Large shallow inlets and bays* was assessed as Unfavourable-Bad.

The principle reason for the failure of a site to meet Favourable conservation status was an increase in fine sediments, a reduction in the extent or abundance of an area mapped for one or more keystone communities, and/or an increase in invasive alien species (IAS).

The main pressures acting on the sites were agriculture, commercial forestry, urbanisation (resulting in effluent discharge and storm water run-off) and aquaculture, together with the in-combination effects of these pressures. Future threats are considered to be those arising from the continuation of the aforementioned pressures and the development of windfarm infrastructure.

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[1] The Annex I habitat of Reefs within this report only refers to coastal reef unless otherwise stated.

1 Introduction

This report presents national conservation assessments for six marine habitats listed in Annex I of Council Directive 92/43/EEC of 21 May 1992 on the Conservation of natural habitats and of wild fauna and flora, commonly known as the 'Habitats Directive'. The habitats were surveyed between 2016 and 2018 (Table 1).

Table 1 Marine Annex I habitats surveyed.

Annex I habitat	Habitat code
Sandbanks which are slightly covered by sea water all the time	1110
Estuaries	1130
Mudflats and sandflats not covered by seawater at low tide	1140
Large shallow inlets and bays	1160
Reefs	1170
Submerged or partially submerged sea caves	8330

A total of 23 sites (encompassing 29 Special Areas of Conservation (SACs), 16 Special Protection Areas (SPAs) and nine areas outside of the Natura 2000 network), were surveyed during the period (Table 2 and Figure 1). This sample is considered to be representative of the total national resource. Roaringwater Bay and Islands SAC (000101) was surveyed as part of a pilot project in 2014 and the results of this survey were included in the overall conservation assessment.

Site reports describing the results and analyses of the data collected during field surveys are provided as a separate report (Scally *et al.*, in prep.). The data derived were used to assess change in habitat *Area*, *Structure & functions* and *Future prospects* of each site assessed. A national conservation status assessment and audit trail for each habitat was prepared by reference to the individual site assessments.

The Annex I habitat *Large shallow inlets and bays* is a large physiographic feature that may wholly or partially incorporate other Annex I habitats including, for example, *Reefs* and *Submerged or partially submerged sea caves*. Similarly, *Estuaries* may also include additional Annex I habitats, e.g. *Mudflats and sandflats not covered by seawater at low tide*. Annex I habitats contained within a larger physiographic feature have been assessed separately.

Table 2 Sites surveyed between 2016 and 2018. Sites with no codes relate to areas outside of the Natura 2000 network

Sampling site	Site code	Site Name	Sampling site	Site code	Site Name
1	002158	Kenmare River SAC	12	001482	Clew Bay Complex SAC
2	000343	Castlemaine Harbour SAC		-	Outer Clew Bay
	004029	Castlemaine Harbour SPA	13	000472	Broadhaven Bay SAC
	-	Dingle Bay		000470	Mullet/Blacksod Bay Complex SAC
3	00268	Galway Bay Complex SAC		004037	Blacksod Bay/Broadhaven SPA
	004031	Inner Galway Bay SPA	14	004032	Dungarvan Harbour SPA
4	002262	Valencia Harbour/Portmagee Channel SAC	15	000197	West of Ardara/Maas Road SAC
5	000455	Dundalk Bay SAC		-	Gweebarra Bay
	004026	Dundalk Bay SPA	16	002047	Tralee Bay and Magharees Peninsula, West to Cloghane SAC
	-	Greater Dundalk Bay		002261	Magharee Islands SAC
6	002170	Blackwater River (Cork/Waterford) SAC		004188	Tralee Bay Complex SPA
	004028	Blackwater Estuary SPA		-	Outer Tralee Bay
	000077	Ballymacoda (Clonpriest and Pillmore) SAC	17	002162	River Barrow and River Nore SAC
	004023	Ballymacoda Estuary SPA		-	Outer Harbour
	-	Outer Youghal Bay	18	001058	Great Island Channel SAC
7	002287	Lough Swilly SAC		004030	Cork Harbour SPA
	004075	Lough Swilly SPA	19	000206	North Dublin Bay SAC
	-	Outer Lough Swilly		004006	North Bull Island SPA
8	002111	Kilkieran Bay and Islands SAC		000210	South Dublin Bay SAC
9	000697	Bannow Bay SAC	20	002165	Lower River Shannon SAC
	004033	Bannow Bay SPA		004077	River Shannon and River Fergus Estuaries SPA
	000764	Hook Head SAC	21	000133	Donegal Bay (Murvagh) SAC
10	002159	Mulroy Bay SAC		004151	Donegal Bay SPA
	-	Outer Mulroy Bay	22	002999	Hempton's Turbot Bank SAC
11	000781	Slaney River Valley SAC	23	002265	Kingstown Bay SAC
	000710	Raven Point Nature Reserve SAC			
	000781	Wexford Harbour and Slobs SPA			
	004019	The Raven SPA			
	002161	Long Bank SPA			

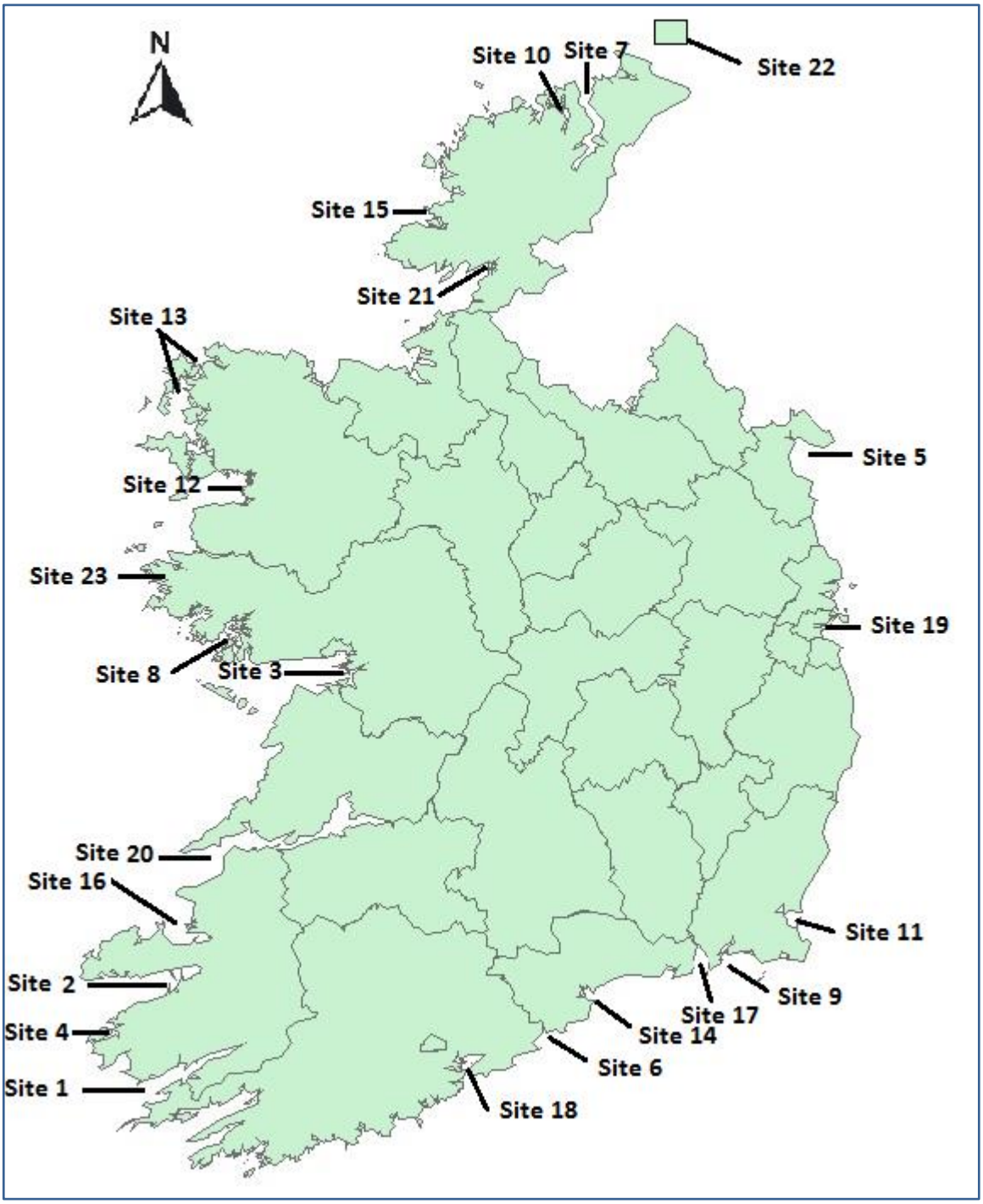

Figure 1 Location of monitoring sites.

2 Methods

2.1 Background

Extensive baseline surveys of Ireland's marine Natura 2000 sites were undertaken between 2009 and 2011 under a programme of benthic sampling carried out on behalf of the Marine Institute in collaboration with the National Parks and Wildlife Service (APEM, 2011a,b, Aquafact, 2007, 2008, 2010a,c,e,f,g, 2011a,c,e,i, 2012, ASU, 2007, 2010a,b, 2011, ERM, 2009, MERC 2012a-2012d, 2013, RPS 2009, 2011).

Certain sensitive species, e.g. *Zostera* spp. and maërl, were mapped in specific dive surveys carried out between 2005 and 2009 (MERC 2005, 2006, 2007a,b, 2008a,b, 2009).

Further sampling of soft sediment benthic habitats was carried out between 2009 and 2017 as part of a national programme of data collection for a variety of purposes, including compliance with the Habitats Directive and Water Framework Directive.

These data have been used to identify a variety of Marine Community Types (MCTs) found within Irish benthic habitats. At a number of sites, examination of the available data identified a range of biological communities whose species composition overlapped significantly. Such biological communities are grouped together into what experts consider are sufficiently stable units (i.e. a complex) for which conservation targets can be set. They occur where an area possesses similar abiotic features, but records a number of biological communities that are not regarded as being sufficiently stable and/or distinct temporally or spatially to become the focus of conservation efforts.

The data derived from the aforementioned surveys have provided the baseline information used to develop site-specific conservation objectives for the Annex I habitats within which these MCTs occur.

The methods described in Section 2.2 were designed to complement the baseline surveys described above so that change, should it have occurred, could be measured and assessed against the attributes and targets set for each conservation objective.

In general, surveys were repeated for each MCT that had been previously identified. In the case of *Reefs* and *Submerged or partially submerged sea caves*, baseline data against which to measure change were deficient (Aquafact, 2010b,d, 2011b,d,f,h,j, MERC, 2010, 2012e). In such cases, surveys were designed and conducted to improve on the existing baseline with the aim of providing the basis for the assessment of the conservation status of these habitats in the future.

2.2 Field Survey methods

2.2.1 Subtidal sediments

Subtidal sediments were sampled by selecting approximately three stations from each of the MCTs in a site as defined in the site specific conservation objectives guidance document (Appendix 1). Samples were collected using a 0.1 m^2 Day grab. Following removal of a sub-sample for particle size distribution and organic content analysis, the remaining sediment was sieved at 1 mm mesh size and preserved for macrofaunal identification. Ancillary *in situ* environmental data including station positions, observations and associated imagery were gathered at each sampling location (Table 3).

Table 3 Ancillary *in situ* environmental data collected at each subtidal station.

Attribute	Description
Easting (ITM)	Easting of station position in ITM
Northing (ITM)	Northing of station position in ITM
Date	Date sample was collected
Location	SAC or SPA site name
Time	Time sample was collected
Depth (m)	Depth in meters Below Chart Datum
Field description	Brief description of sediment type and any notable features
Exposure	Exposed, sheltered etc.
Sediment description	General sediment description using the Folk nomenclature (Folk, 1954)
Layering (cm)	Depth of any layering observed
Smell	e.g. odour of hydrogen sulphide
Colour	General
Sea State	Beaufort scale
Company name	Name of company collecting the sample
Sampler type	Day Grab or other
Sieve Size	Mesh size of sieve (1 mm)
Grab depth (cm)	Depth of the sample retrieved within the Day grab
Notes	Impacts and activities observed

2.2.2 Intertidal sediments

Three intertidal stations were sampled from each MCT, as defined in the site specific conservation objectives guidance document, from agreed locations within the site (Appendix 1).

At each station 5 x 0.01 m² cores were taken to a depth of 20 cm for benthic faunal analysis at 1 mm mesh size. A separate sub-sample was also collected for particle size distribution and organic content analysis. The remaining sediment was preserved for macrofaunal identification. Ancillary *in situ* environmental observations including station positions (Table 4) and associated imagery were gathered at each sampling location.

Core samples for each station were kept separate (not pooled) at the identification and statistical analysis stage.

Table 4 Ancillary *in situ* environmental data collected at each intertidal station.

Attribute	Description
Easting (ITM)	Easting of station position in ITM
Northing (ITM)	Northing of station position in ITM
Date	Date sample was collected
Location	SAC or SPA site name
Time	Time sample was collected
Time of Low water	Time of low water on the sampling date
Height of Low water	Height of low water on the sampling date
Sediment type	Sand, mud, muddy sand etc.
Area description	Description of notable features, laminations, erosion, deposition etc.
Redox Layer	Presence or absence of Redox layer and depth if recorded.
Sampler type	0.01 m^2 core or other
Sieve Size	Mesh size of sieve (1 mm)
Notes	Impacts and activities observed

2.2.3 Keystone Communities

Keystone communities are key contributors to the overall biodiversity in a site and also have low functional redundancy. As such, any disturbance to these communities has the potential to lead to significant ecosystem change within a site.

A range of keystone communities occur around the coasts of Ireland and the sampling and analysis methods that were employed differed depending on species being surveyed. The methods employed for each keystone community type are documented below.

For the survey of *Zostera*, maërl, *Pachycerianthus multiplicatus* and *Serpula vermicularis* communities, drop down video combined with diver ground-truthing was employed. These communities were extensively surveyed by a combination of diver transects and bottom viewers in Irish SACs between 2006 and 2009. During the current project a significant proportion of previously mapped polygons for each of these communities was resurveyed. At each polygon surveyed a Cathx Ocean® 4K dropdown video camera combined with RedHen Systems® spatial encoding was used to resurvey the polygons. One or more video transects through the polygons were carried out. The number of transects conducted through each polygon varied depending on the size of the polygon. In small polygons, typically those less than 20 ha, a single transect through the polygon was conducted. In larger polygons additional transects were carried out to ensure the full extent of the community was surveyed.

Video surveys were supplemented by diver surveys using SCUBA by a team of marine ecologists. Dive surveys were carried out within the relevant communities in three different areas within each site that was surveyed. During dive surveys stills images of the surveyed area were recorded and species lists of the epifauna and their relative abundance on a SACFOR (**S**uperabundant, **A**bundant, **C**ommon, **F**requent, **O**ccasional, **R**are) scale were prepared. Distinguishing epifauna (i.e. those species recorded at an abundance of Frequent to Superabundant) were identified. Observations were also made on any impacts or disturbing activities seen within the surveyed area. This information was used to assist in the analysis and interpretation of the video transects.

Following field surveys, the data from all video surveys was reviewed by examining the video footage in ESRI ArcGIS Full Motion Video® as an overlay on the mapped MCTs. Shapefiles of each of the surveyed video transects and locations of dive surveys were prepared in ESRI ArcGIS.

Zostera-dominated communities

Zostera-dominated communities are considered to be composed of *Zostera marina* and *Z. noltei* (collectively referred to as eelgrass). While taxonomic opinions differ, for the purpose of this project the only subtidal species of eelgrass found in Irish marine habitats is considered to be *Z. marina*, with *Z. noltei* occurring intertidally.

In the majority of sites where *Zostera noltei* was present it was surveyed by walking the perimeter of the bed during spring tides when the predicted tidal height at low water was less than 0.6 m. The boundary of the bed was recorded using Differential Global Positioning System (DGPS). A photographic record was made of each bed surveyed and observations on the health, density and any observed impacts were documented. In the case of Tralee Bay and Magharees Peninsula, West to Cloghane SAC (002070) and Mulroy Bay SAC (002159), *Z. noltei* was assessed by video survey at high water as described for *Z. marina* below.

During the current project over 80% of the previously mapped polygons for this community were revisited and surveyed using dropdown video supported by diver ground-truthing.

The condition of the *Zostera*-dominated community was assessed by examining the video footage and recording the following attributes for each transect:

- Shoot density on an AFOR (**A**bundant, **F**requent, **O**ccasional, **R**are) scale
- Presence of fragmentation (patchiness) within the eelgrass bed
- Evidence of physical damage e.g. exposed rhizomes
- Presence of siltation or epiphytes on the leaf blade
- Presence of invasive alien species
- Evidence of die back
- Presence of opportunistic species

The data derived from this analysis were compared to the attributes listed in the transect data for *Zostera*-dominated community polygons from previous surveys (MERC, 2006-2009). This provided a method to assess change in the *Structure & functions* of the *Zostera*-dominated community at a local level (polygon level) within each site. Table 5 provides a summary of the assessment criteria used.

The extent of the *Zostera*-dominated community was assessed by recording the presence or absence of *Z. marina* and/or *Z. noltei* along each video transect or walkover. In cases where either species was absent from a polygon where it had previously been shown to occur from the 2006-2009 surveys, the extent of the area of loss was measured in ArcGIS. In the case of polygons where a gross change in *Structure & functions*, e.g. a reduction in *Zostera* abundance, was only observed along part of a transect/s, an estimate of the total area of loss/change was made. This estimate was based on the length of the transect and the proportion of it where a gross change was observed. However in the majority of cases where a gross change was observed it applied to the entire transect and was therefore taken to represent the entire polygon. While this is not a totally accurate method of assessing the area of impact, based on expert judgement it was considered the most appropriate estimate.

Table 5 *Zostera*-dominated community complex assessment of *Structure & functions*.

Attribute	Assessment criteria	Target for pass
Physical quality indicators		
Shoot density	Gross change in abundance (AFOR) from previous survey results*	No gross change
Fragmentation	Gross change in abundance (AFOR) from previous survey results*	No gross change
Negative indicators		
Physical damage e.g. exposed rhizomes	Evidence of physical damage	A score of 2 (out of the 4 negative indictor attributes) or less for any combination of negative indicators.
Siltation or epiphytes on the leaf blade	Presence of siltation or cover of epiphytes on the leaf blade	
Invasive Alien Species (IAS)	Presence of IAS within the bed	
Opportunistic species	Superabundance or covering of smothering opportunistic species	
A fail in either the physical quality or negative indicator assessment results in an overall fail for the polygon.		

* Previous survey results refer to the surveys of sensitive subtidal communities carried out between 2006 and 2009 (MERC, 2006, 2007a, 2008a and 2009)

Maërl-dominated communities

During the current project, over 70% of the previously mapped polygons for this community were revisited and surveyed using dropdown video supported by diver ground-truthing.

The condition of the maërl-dominated community was assessed by examining the video footage and recording the following attributes for each transect:

- Percentage live to dead maërl
- Percentage cover of maërl
- Features of note (e.g. dunned maërl, banded maërl)
- Evidence of physical damage, e.g. dredge marks
- Presence of siltation/pseudofaeces
- Presence of algal cover over maërl beds
- Presence of invasive alien species
- Presence of opportunistic species

The data derived from this analysis were compared to the attributes listed in the transect data for the maërl-dominated community polygons from previous surveys (MERC, 2006-2009). This provided a method to assess change in the *Structure & functions* of the maërl-dominated community at a local level (polygon level) within each site. Table 6 provides a summary of the assessment criteria used.

The extent of the maërl-dominated community was assessed by recording the presence or absence of maërl along each video transect. In cases where maërl was absent from a polygon where it had previously been shown to occur the extent of the area of loss was measured in ArcGIS.

Table 6 Maërl-dominated community complex assessment of *Structure & functions*.

Attribute	Assessment criteria	Target for pass
	Physical quality indicators	
% Live : dead maërl	Gross change in ratio from previous survey results*	No gross change
Fragmentation	Gross change in cover (appearance of areas of sediment) from previous survey results*	No gross change
	Negative indicators	
Physical damage e.g. evidence of dredge marks	Evidence of physical damage	A score of 2 (out of the 5 negative indictor attributes) or less for any combination of negative indicators.
Siltation or pseudofaeces	Presence of siltation or cover of pseudofaeces over maërl	
Invasive Alien Species (IAS) Algal cover	Presence of IAS within the bed Presence of abundant/smothering macro-algal cover	
Opportunistic species	Superabundance or covering of smothering opportunistic species	
A fail in either the physical quality or negative indicator assessment results in an overall fail for the polygon.		

* Previous survey results refer to the surveys of sensitive subtidal communities carried out between 2006 and 2009 (MERC, 2006, 2007a, 2008a and 2009)

Serpula vermicularis-*dominated community complex*

The *Serpula vermicularis*-dominated community complex within Mullet/Blacksod Bay Complex SAC (000470) was surveyed by dropdown video transects through polygons previously mapped in 2008 by diver survey (MERC, 2008a).

The condition of the *Serpula vermicularis*-dominated community complex was assessed by examining the video footage and recording the following attributes for each transect:

- Presence of *Serpula vermicularis*
- Presence of aggregations of individuals forming biogenic reef structures
- Associated characteristic epifauna
- Evidence of impacts (e.g. dredge marks)
- Evidence of invasive alien species
- Evidence of opportunistic species

The data derived from this analysis were compared to the descriptions given in the 2008 survey carried out by diver surveys (MERC, 2008a) of the same polygons. This provided a method to assess change in the *Structure & functions* of the *Serpula vermicularis*-dominated community at a local level (polygon level) within each site. Table 7 provides a summary of the assessment criteria used.

The extent of the *Serpula vermicularis*-dominated community was assessed by recording the presence or absence of *Serpula vermicularis* along each video transect.

Table 7 *Serpula vermicularis*-dominated community complex assessment of *Structure & functions*.

Attribute	Assessment criteria	Target for pass
Physical quality indicators		
Serpula vermicularis 'Reef'	Gross change in presence from previous survey results*	No gross change
Characterising epifauna	Gross change in characterising species from previous survey results	No gross change
Negative indicators		
Physical damage e.g. evidence of dredge marks	Evidence of physical damage	A score of 2 (out of the 3 negative indictor attributes) or less for any combination of negative indicators.
Invasive Alien Species (IAS)	Presence of IAS within the bed	
Opportunistic species	Superabundance or covering of smothering opportunistic species	
A fail in either the physical quality or negative indicator assessment results in an overall fail for the polygon.		

* Previous survey results refer to surveys of sensitive subtidal communities carried out in 2008 (MERC, 2008a)

Pachycerianthus multiplicatus *community*

During the current survey the *Pachycerianthus multiplicatus* community within Kenmare River SAC (002158) and Kilkieran Bay and Islands SAC (002111) was surveyed by dropdown video transects through polygons previously mapped in 2006 and 2007. In these earlier surveys the community in Kenmare River SAC was mapped using a dropdown video while the community in Kilkieran Bay and Islands SAC was by diver survey.

The condition of the *Pachycerianthus multiplicatus* community was assessed by examining the video footage and recording the following attributes for each transect:

- Number of *Pachycerianthus multiplicatus* individuals recorded per transect
- Associated characteristic epifauna
- Evidence of impacts (e.g. dredge marks)
- Evidence of invasive alien species
- Evidence of opportunistic species

The data derived from this analysis were compared to the descriptions of the same polygons in the 2005 survey of *Pachycerianthus multiplicatus* carried out by diver surveys in Kilkieran Bay and Islands SAC (002111) (MERC, 2005) and within Kenmare River SAC (002158) in 2009 (MERC, 2009). This provided a method to assess change in the *Structure & functions* of the *P. multiplicatus* community at a local level (polygon level) within each site. Table 8 provides a summary of the assessment criteria used.

The extent of the *P. multiplicatus* community was assessed by recording the presence or absence of *P. multiplicatus* along each video transect.

Table 8 *Pachycerianthus multiplicatus* community assessment of *Structure & functions*.

Attribute	Assessment criteria	Target for pass
	Physical quality indicators	
Pachycerianthus multiplicatus	Gross change in presence from previous survey results*	No gross change
Characterising epifauna	Gross change in characterising species from previous survey results	No gross change
	Negative indicators	
Physical damage e.g. evidence of dredge marks	Evidence of physical damage	A score of 2 (out of the 3 negative indictor attributes) or less for any combination of negative indicators.
Invasive Alien Species (IAS)	Presence of IAS within the bed	
Opportunistic species	Superabundance opportunistic species	
A fail in either the physical quality or negative indicator assessment results in an overall fail for the polygon.		

* Previous survey results refer to the surveys of sensitive subtidal communities carried out in 2005 and 2009 (MERC, 2005, 2009).

Limaria hians-*associated community*

The *Limaria hians*-associated community within Mulroy Bay SAC (002159) was surveyed using SCUBA by a team of marine ecologists. Dives were conducted at a number of the stations previously surveyed by divers in 2008 (MERC, 2008a). Within Mulroy Bay this species is typically found under stones and among the holdfasts of kelp and, thus, precludes the use of video survey at this site as these areas are likely to be missed using a dropdown video system. Instead likely habitat niches for *L. hians* (under stones and within the holdfast of kelp plants) were searched by divers. Stills images of *L. hians* and the habitat and epifauna associated with its presence were recorded. Table 9 provides a summary of the assessment criteria used.

Table 9 *Limaria hians* associated community assessment of *Structure & functions*.

Attribute	Assessment criteria	Target for pass
	Physical quality indicators	
Limaria hians	Gross change in abundance from previous survey results*	No gross change
	Negative indicators	
Characterising epifauna	Evidence of gross change from previous survey results*	A score of 2 (out of the 3 negative indictor attributes) or less for any combination of negative indicators.
Invasive Alien Species (IAS)	Presence of IAS within the community	
Opportunistic species	Superabundance or covering of smothering opportunistic species	

* Previous survey results refer to the surveys of sensitive subtidal communities carried out in 2008 (MERC, 2008a).

Sabellaria spinulosa *community*

In Ireland, *Sabellaria spinulosa* is typically found as a biogenic reef forming species overlaying areas of intertidal boulders and/or bedrock. It is rarely found as a biogenic reef forming species without a solid substrate on which to form.

Sabellaria spinulosa was surveyed by walking the perimeter of the area where this species had previously been mapped. In all cases these were areas of intertidal geogenic reef on top of which colonies of *S. spinulosa* had formed.

Sites were surveyed during spring tides when the predicted tidal height was less than 0.4 m at low water. The boundary of the *Sabellaria spinulosa* reef was recorded with a DGPS. A photographic record of each area surveyed was made and observations on the structural integrity and thickness of the *S. spinulosa* over the underlying rock were made.

At sites where this species was not previously recorded but noted during the current survey of intertidal geogenic reef, the location and description of the general area was made but detailed mapping was not conducted.

Table 10 provides a summary of the assessment criteria used.

Table 10 *Sabellaria spinulosa* reef assessment of *Structure & functions*.

Attribute	Assessment criteria	Target for pass
	Physical quality indicators	
Sabellaria spinulosa reef	Gross change in area of previously mapped polygon (as per NPWS marine community mapping) where available	No gross change
	Negative indicators	
Physical damage (e.g. trampling)	Expert judgement	No negative indicators
Invasive Alien Species (IAS)	Presence of IAS within the community	

Mytilus*-dominated reef community*

The *Mytilus*-dominated reef community was surveyed by walking the perimeter of the area where this community had previously been mapped. Sites were surveyed during spring tides when the predicted tidal height was less than 0.4 m at low water. The boundary of the *Mytilus*-dominated reef community was recorded with a DGPS. A photographic record of each area surveyed was made, as were observations on the structural integrity and density of *M. edulis* within the community.

At one site (Tralee Bay and Magharees Peninsula, West to Cloghane SAC (002070)), the *Mytilus*-dominated reef community was surveyed at high water using a dropdown video camera with spatial encoding. At this site, transects through the previously mapped *Mytilus*-dominated reef community were conducted using a Cathx Ocean® 4K dropdown video camera combined with RedHen Systems® spatial encoding.

Following field surveys, the data from the video surveys were reviewed by examining the video footage in ESRI ArcGIS Full Motion Video® as an overlay on the mapped *Mytilus*-dominated reef community, thereby allowing the extent of the community to be re-assessed. Walkover survey data were compared

to previously mapped polygons in the same manner. Table 11 provides a summary of the assessment criteria used.

Table 11 *Mytilus*-dominated reef community assessment of *Structure & functions*.

Attribute	Assessment criteria	Target for pass
	Physical quality indicators	
Mytilus-dominated reef community	Gross change in abundance of *Mytilus edulis* of previously mapped polygon (as per NPWS marine community mapping)	No gross change
	Negative indicators	
Physical damage (e.g. trampling)	Expert judgement	No negative indicators
Invasive Alien Species (IAS)	Presence of IAS within the community	

Barnea candida

The marine bivalve mollusc, *Barnea candida*, has previously been recorded from within Bannow Bay SAC and was also known to occur in Galway Bay SAC. This species typically burrows into soft substrates, such as soft rocks and peat, in the intertidal and shallow subtidal. In Bannow Bay SAC the site was surveyed by searching suitable substrates within the mapped polygon for this species. In Galway Bay Complex SAC suitable substrate at the location of previous records of *B. candida* were searched. Table 12 provides a summary of the assessment criteria used.

Table 12 *Barnea candida* assessment of *Structure & functions*.

Attribute	Assessment criteria	Target for pass
	Physical quality indicators	
Barnea candida	Presence of *Barnea candida*	Species present
	Negative indicators	
Habitat for the species	Presence of suitable habitat	Habitat for species present

2.2.4 Littoral hard substratum (Intertidal reef)

A number of MCTs are described for the intertidal component of the *Reefs* habitat [1170] and are listed in Appendix 2. Intertidal reef within transitional and coastal water bodies designated under the Water Framework Directive (WFD) is currently monitored in Ireland using the WFD rocky shore macroalgal species richness tool (WFD UK TAG, 2009). During the current project this tool was applied to the survey of intertidal reef MCTs at each monitoring site for which the Annex I habitat *Reefs* is listed as a qualifying interest.

The WFD rocky shore macroalgal species richness tool was designed as a method for assessing 'ecological status' in transitional and coastal waterbodies designated under the WFD. The tool is based on the assumption that taxonomic composition corresponds totally or nearly totally with undisturbed

conditions. Therefore there should be no detectable changes in macroalgal abundance due to anthropogenic activities.

The tool relies on recording and scoring a range of physical characteristics (Table 13) for a given area of intertidal reef and assessing the range of macroalgal species within that area against the diversity of the physical features recorded. The resulting score is taken as a proxy for the Ecological Quality Status (EQS) of the reef. In order to simplify and aid survey efficiency, the tool relies on recording only a limited number of specified macro algal species. Separate reduced species lists of macroalgae, tailored to reflect the commonly found species occurring around the coasts of England, Scotland, Wales, Northern Ireland and the Republic of Ireland have been prepared. Additional attributes associated with a shore, but not necessary for the calculation of the final EQS score, are also recorded (Table 13).

At each site within which *Reef*s [1170] was a qualifying feature a number of stations were selected. The number of stations surveyed within each site was selected to represent the range of exposures and aspects present. At a number of sites stations were selected at locations previously monitored by the Environmental Protection Agency (EPA) where previous survey data were already available.

The data gathered from each site were assessed using the Intertidal Coastal Waters Macroalgae – Rocky Shore Tool (WFD UK TAG, 2009).

Table 13 Physical attributes recorded at each shore surveyed to facilitate the calculation of EQS.

Attributes recorded to calculate a 'shore score' for EQS		
Shore descriptor	**Dominant shore type**	**Sub-habitat**
Non-anthropogenic turbidity	Rock ridges, outcrops, platforms	Wide shallow rock pools (more than 3 m wide and less than 50 cm deep)
Sand scour	Irregular rock	Large rock pools (more than 6 m long)
Chalk shore *	Boulders: large, medium, small	Deep rock pools (50% less than 100 cm deep)
	Steep or vertical rock	Basic rock pools
	Non-specific hard substrate	Large crevices
	Pebbles, stones, small rocks	Large overhangs and vertical rock
	Shingle, gravel	Other habitats (to be specified if found)
		Caves
Additional attributes recorded		
Ascophyllum	Impacts or activities occurring noted	
Barnacles	Limpets	
Chlorophyte	Mussels	
Fucoid	Periwinkles	
General shore description	Rhodophyta mosaics	

* Chalk shores do not occur in Ireland. However this descriptor is always scored as absent to facilitate the overall calculation to arrive at a shore descriptor score.

2.2.5 Sublittoral hard substratum (Subtidal reef)

Subtidal reef surveys were conducted by surveying three stations within each reef community complex documented for a site (Appendix 2). The presence and type of reef was also investigated at a number of locations within SACs where *Reefs* was not a qualifying interest and also in areas outside of the Natura 2000 network. At locations where reef had not been previously mapped (within and outside of the Natura 2000 network), the available mapping for the area, e.g. Admiralty maps, Light Detection and Ranging (LIDAR) data and aerial imagery, was reviewed in an attempt to identify potential reef areas. These areas were then surveyed by conducting dropdown video surveys at a number of locations within the areas identified as potential reef habitat.

Surveys were carried out by dropdown video surveys using a Cathx Ocean® 4K dropdown video camera combined with RedHen Systems® spatial encoding. Video surveys were supplemented by diver surveys on SCUBA. Dive surveys were carried out at a single station within each community complex. At each station all depth zones within the community complex were surveyed. Where dive surveys were conducted the distinguishing epifauna was recorded on a SACFOR scale and both wide angle and macro photographic stills images were gathered. Observations were also made of any impacts or disturbing activities within the surveyed area. This information was used to assist in the analysis of the video transects.

In *Laminaria*-dominated reef community complex, the height and density of the kelp was measured using a Biosonics MX single beam acoustic echo sounder mapping system. This system provides spatially referenced acoustic data on the height and density of kelp. Maps derived from these data were then created to obtain an overview of the characteristics of the kelp canopy.

Kelp height and density is considered to be an appropriate metric for partially assessing the *Structure & functions* of kelp communities. These data provide a baseline on which height and density can be measured in the future.

Following field surveys, the data from the video surveys were reviewed by examining the video footage in ESRI ArcGIS Full Motion Video® as an overlay on the mapped marine community complexes. All conspicuous epifauna were noted and assigned a score on the SACFOR scale.

Shapefiles of each of the surveyed video transects and locations of dive surveys were prepared in ESRI ArcGIS.

There is a paucity of data for Irish subtidal reef habitats, the main data source being the BioMar survey (Picton & Costello, 1997). The current survey has produced spatially referenced video and acoustic data together with additional diver-survey species inventories of the characterising flora, fauna and abundance/density of kelp. This archive of spatially referenced video, diver and acoustic data now provides an array of standard stations where change can be monitored in the future.

2.2.6 *Submerged or Partially Submerged Sea Caves* [8830]

MCTs have not been assigned to sea caves in Ireland. Only six sea caves have been surveyed in detail, four of these were surveyed in 2012 (MERC, 2012e) and two during the course of the current project. It is considered that the availability of detailed information required to assign MCTs is insufficient for this habitat. The surveys conducted during the course of this project have added to the existing baseline data for sea caves and will facilitate the identification of MCTs in the future.

The methods employed for the survey of the two sea caves assessed during the current project was based on the detailed methodology described in MERC (2012e). This involved a dive team, consisting of two surveyors, entering the cave through a seaward opening and laying a calibrated line along the cave bottom. The line was tied off to a secure anchor point at the mouth of the cave and once the dive team reached the back of the cave, the line was tied off to another secure anchoring point. This allowed the length of the cave (front to back) to be accurately measured. As the divers returned along the

distance line, which was left *in situ*, towards the mouth of the cave, they conducted transects across the width of the cave, again using a calibrated distance line to measure the width of the cave at staged intervals. As both of the caves surveyed were not fully submerged, the height of the cave (floor to roof) was estimated. The entry/exit line was left in place following the dive team's survey to be used by a second survey team as a safety, orientation and calibration line.

A second dive team, consisting of two surveyors entered the cave along the *in situ* distance line. This survey team conducted a survey of the characterising flora and fauna of the cave as they travelled from the entrance to the rear of the cave. The presence of the calibrated distance line allowed the surveyors to record the location of species within the cave and hence establish the location and extent of any zonation together with the type and variation in biotopes that occurred both along the floor of the cave and from base to sea level along the walls. Species abundance was recorded on a SACFOR scale (**S**uperabundant, **A**bundant, **C**ommon, **F**requent, **O**ccasional, and **R**are). Both wide angle and macro images of the species and habitats were noted.

The total surface area of rock habitat within each sea cave was estimated based on the length, width and height of the cave. In order to capture the additional surface area that is created by undulating surfaces, crevices, overhangs and by boulders that are within the cave system, a raising auxiliary to more accurately indicate the likely surface area of habitat within the cave was applied. Without more detailed surveys it was not possible to definitively suggest a suitable or appropriate auxiliary so this is based on the expert judgement of the survey team.

2.3 Data analysis

Multivariate analysis in PRIMER version 7, using the routines described below, was used to aid the identification of community complexes and changes in benthic communities of intertidal and subtidal sediment samples collected between the present and previous surveys.

Cluster Analysis: The technique used in the present study was group average clustering (Lance & Williams, 1967) - a hierarchical, agglomerative procedure based on a similarity matrix generated from square root transformed species/station data using the Bray-Curtis similarity coefficient. The results of the analysis are plotted as dendrograms. Analysis was undertaken using the CLUSTER program from the PRIMER version 7 statistical package.

Multi-Dimensional Scaling: The technique used in the present study was ordination by non-metric Multi-dimensional Scaling (Kruskal & Wish, 1978). This is based on the similarity matrix generated during cluster analysis (i.e. using the Bray-Curtis coefficient). The similarities between each pair of entities are used to produce a two dimensional map which ideally shows the inter-relationships present. Physical data can be superimposed on the resulting plot in the form of 'bubble' plots.

SIMPER: This technique was used to identify the species most responsible for similarities within each site or group and also those that contributed most to dissimilarities between groups. The output is given as percentage of similarity or dissimilarity and ranks those species that contribute most to this value.

Shade Plots: PRIMER version 7 contains new plotting routines which produce simple visualisations of the data matrix where the larger the entry (abundance) of a specific species for a specific replicate or site, the darker the shade of colour is plotted. White represents the absence of this species and the darkest marks the highest abundance. These can be used for various reasons but are extremely useful where statistical tests have demonstrated that a gradient structure exists between sites. In this way it can replace the SIMPER testing which identifies the species or group of species which contribute most to community composition of pre-defined clusters (from SIMPROF significance tests). SIMPER testing functions poorly when gradients exists between groups of samples and when clear clusters of samples do not exist. The shade plot function reduces the species set to the 50 most important contributors in terms of abundance.

BIOENV: The PRIMER version 7 program BIOENV was used to undertake a harmonic (weighted Spearman's) rank correlation between the similarity matrices derived from biological data and individual (or groups) of environmental variables. Values of correlation coefficient r lie within the range –1 to +1, with the extremes of this range indicating that the two sets of ranks are in either complete opposition or complete agreement. Values around zero correspond to the absence of any match between the two patterns, but typically r will be positive. Tables cannot be used to test the significance of the correlation, but values do provide an index of agreement between two matrices. Values over 0.8 are regarded as representing a very good match.

2.3.1 Data manipulation and transformations

Data transformation acts to weight the contributions of common and rare species for non-parametric, multivariate tests. During analysis, the appropriate transformation is decided by reference to the type of data, the purpose of the study and with the aid of the shade plot which illustrates the range of per species abundance. For the majority of sites the data will be subjected to a square root transformation prior to analyses. This is a moderate transformation that reduces the weighting of highly abundant species but does not place too much emphasis on the rarer ones and is appropriate where abundances range from 0-500. Where abundances ranged from 0-1000s, data were fourth root transformed.

For sites where encrusting and colonial species which are recorded qualitatively proved to be only a minor component of the macrofaunal communities, they were removed from the statistical analysis. However where encrusting or colonial species, e.g. maërl, which significantly contributed to a community complex were recorded these observations were discussed in the results section of the individual site report.

Environmental data (physical sediment properties) were normalised prior to BIO-ENV analysis.

Data from previous surveys were standardised to ensure significant differences were not identified due to differences in taxonomic resolution, naming or updating of literature. Notes on the manipulation of each of these previous datasets are provided in the results section as relevant to each site.

3 Conservation Assessment

In line with the guidelines for the assessment of the conservation status of EU Annex I habitats (Evans & Arvela, 2011), each of the six habitats was evaluated by conducting a separate assessment of its *Range*, *Area*, *Structure & functions* and *Future prospects* and combining these parameters to reach an overall assessment of that habitat.

3.1 *Range*

Within the current reporting period it is considered that *Range* has not changed for any of the six Annex I habitats included in this report. This is due to the largely physical nature of the habitats and the absence of any pressures or threats that could lead to a significant alteration in their *Range*. Therefore it has not been considered further in this report.

3.2 *Area*

In the case of the six Annex I habitats assessed, significant loss of *Area* over the reporting period is highly unlikely due to the largely physical nature of the habitats. It is reasoned that other than natural impacts, such as erosion, there are no pressures or threats that could lead to any significant alteration in habitat *Area*. While factors such as accretion or loss of *Mudflats and sandflats not covered by seawater at low tide* as a result of sedimentation and/or dredging could occur within a reporting period we are not aware of any such incidents occurring.

An exception is in the case of the Annex I habitat *Sandbanks which are slightly covered by seawater all the time* [1110]. This habitat has a degree of inherent mobility due to its susceptibility to alteration depending on sediment type, hydrogeographical factors and weather conditions. However as changes in the extent of this habitat are likely due to natural impacts, change in extent of *Area* is not considered a negative.

3.3 *Structure & functions*

In developing the site specific conservation objectives it was recognised that conservation units would need to be set at a level where change could be discerned over and above natural variation. These ecological units or complexes, Marine Community Types (MCT), were considered the most stable and significant entities upon which conservation objectives could be set and against which sectorial pressures might be assessed. However it is recognised that there is considerable variation in biological communities within these conservation units.

Structure & functions for each site was dependent on the individual MCTs, sediment composition, keystone species, negative species and unique communities for which targets had been set in the site specific conservation objectives. These parameters were the same *for Sandbanks which are slightly covered by seawater all the time* [1110], *Estuaries* [1130], M*udflats and sandflats not covered by seawater at low tide* [1140] and *Large shallow inlets and bays* [1160].

Such variation in subtidal MCTs is problematic given that sampling takes place remotely. The number of samples required to take this variability into account is prohibitively expensive and time consuming.

Table 14 Site level assessment of *Structure & functions* based on individual indicators and targets.

Indicator	Target	Notes	Assessment
Number of MCTs	The number of MCTs in a site should remain as specified in the conservation objectives	Any change from this should be taken as a fail unless the change can be attributed to improving environmental conditions or natural processes or a likely artefact of sampling*	*Favourable* = all community types listed in the site specific guidance document are present
			Unfavourable-Inadequate = increase or decrease in MCTs present
			Unfavourable-Bad = ≤50% of MCTs are present
Negative species	No increase in numbers of negative indicator species	Increase in presence and/or abundance of group IV or V species (Ambi Index**) in stations within the MCTs	*Favourable* = absent from ≥75% of stations
			Unfavourable-Inadequate = absent from 74-51% of stations
			Unfavourable-Bad = absent from ≤50% of stations
Sediment	No significant change in the proportion of grain size classes	Change in the proportion of grain size classes that would result in change in the classification of the sediment type. Other than through Natural process***.	*Favourable* = ≥75% of stations with no change
			Unfavourable-Inadequate = 74-51% of stations with no change
			Unfavourable-Bad = ≤50% of stations with no change
Keystone communities	Area of the keystone communities	A change, other than through natural processes, in the area of these communities as defined in the conservation objectives	*Favourable* = ≥90% of area shows no change
			Unfavourable-Inadequate = 90-76% of area shows no change
			Unfavourable-Bad = ≤75% of area shows no change
	Quality of the keystone communities	A change in quality elements, other than through natural processes, of these communities as defined in the conservation objectives	*Favourable* = >90% with no change
			Inadequate = 90-76% with no change
			Unfavourable-Bad = ≤75% show no change

* As described in the text below sampling artefacts can arise due to the physiographic structure of a site and location of sampling stations.

** Ambi Index: AZTI marine biotic index. (Borja *et al*., 2000 & 2003).

***Storm events can lead to coarsening of the sediment composition while deposition is associated with an increase in the proportion of fine particles (Huisman *et al*., 2016).

Table 15 Overall site level assessment of *Structure & functions*. MCT is Marine Community Types.

Attribute	Favourable	Inadequate	Bad
Structure & functions	All attributes stable	Loss of a single sediment MCT (unless due to an artefact of sampling) Or Significant change in sediment grain size classes other than through natural processes Or Increase in numbers of negative indicator species Or Any decline in area of Keystone communities Or Reduction in quality of Keystone communities	Loss of more than a single MCT (unless due to an artefact of sampling) Or Loss of Keystone community Or Any combination of three or more attributes classed as 'Inadequate'

In some cases the pressure responsible for a negative assessment for *Structure & functions* was unknown. For example an MCT may not have occurred or a sediment grain size class may have changed. On some occasions it was not clear if this was as a result of the current or previous sampling strategy or natural variation. In such cases the possible reasons for the negative assessment were explored and reported.

In the case of *Reefs* and *Submerged or partially submerged sea caves* there were insufficient baseline data available against which an assessment of *Structure & functions* could be made. Therefore best expert judgement based on the presence of pressures and threats and an overview of the distinguishing species and habitat was used to assess *Structure & functions* of these habitats. Furthermore the data gathered during the course of the current field surveys have provided a baseline to allow attributes and targets for the *Structure & functions* of *Reefs* to be set so that change can be measured in the future. In the case of *Submerged or partially submerged sea caves*, further field survey is required to capture the full physical, spatial and temporal variability of this habitat and its distinguishing species to allow attributes and targets to be established so that future change could to be measured.

3.4 *Future prospects*

For each site, *Future prospects* were assessed by considering the current and likely future trend in *Area* and *Structure & functions*. *Area* was always considered to be stable for the six marine habitats assessed and therefore the assessment focused on *Structure & functions* based on current pressures on the habitat and perceived future threats. Observed pressures included obvious recorded pressures, e.g. physical damage to the habitat as a result of dredging, and credible indirect pressures, e.g. nutrient enrichment.

The in-combination effects of multiple possible pressures were also explored. Two elements were applied to the assessment (1) examination of the current *Structure & functions* in the absence of any indicators that there was likely to be improvement in *Structure & functions* in the medium term (next 6 years) and (2) consideration of the observed pressures and likely future threats with the potential to lead to an negative impact on the *Structure & functions* of the site. The assessment of future threats was based on observed current pressures in the absence of mitigation, in conjunction with expert judgement.

Range was not considered in the assessment, as in the case of all six marine habitats assessed, it is considered to be stable in the long term (100s of years).

An assessment of Unfavourable-Bad for any one of the indicators results in an overall fail (Unfavourable-Bad) for *Future prospects*. An assessment of Unfavourable-Inadequate for both indicators results in an overall assessment of Unfavourable-Bad.

Table 16 Overall site level assessment of *Future prospects* for each habitat.

Indicator	Target	Assessment
Number of negative pressures (by intensity)	No pressures resulting in a current or projected failure of *Area* or *Structure & functions*	Favourable: Pressures not impacting on current or future status and/or measures deemed adequate to secure Favourable *Area* and *Structure & functions*
		Unfavourable-Inadequate: any other combination
		Unfavourable-Bad: Pressures causing a serious decline in current or future status and/or measures deemed inadequate to address impacts
Threats	No threats identified	Favourable: No threats identified
		Unfavourable-Inadequate: Potential for threat to lead to indirect localised negative impact within the next 12 years
		Unfavourable-Bad: Potential for threat to lead to large scale, direct negative impact within the next 12 years

At a national level assessment of *Future prospects* was evaluated by considering future trends and likely future status of the habitat *Range*, *Area* and *Structure & functions*. Future trends are dependent on threats which will have a negative impact on a habitat but which may be balanced by conservation measures designed to mitigate these threats. This parameter was assessed for each habitat by evaluating the overall site based threats recorded for each site and scaling this to a national level.

Table 17 Assessment of *Future prospects*. FCS is Favourable conservation status

Current status of Attribute	Future trend	Future status	*Future prospects*
At/above FCS	Increasing	Above FCS	Favourable
At/above FCS	Stable	Equal to or above FCS	Favourable
At FCS	Decreasing	Below FCS	Unfavourable-Inadequate
Below FCS	Increasing	Equal to or above FCS	Unfavourable-Inadequate
Unknown	Unknown	Unknown	Unknown
Below FCS	Stable	Below FCS	Unfavourable-Bad
Below FCS	Decreasing	Below FCS	Unfavourable-Bad

3.5 Overall site assessment

For each site the overall assessment of each habitat was based on a combination of *Area*, *Structure & functions* and *Future prospects*. *Range* was not considered in the site assessment. For a site to be considered at Favourable conservation status all attributes must have achieved a rating of Favourable. If any single attribute was rated as Unfavourable-Bad the overall site assessment was scored as Unfavourable-Bad. Any other combination gave a rating of Unfavourable-Inadequate.

4 Results

This section provides the results of the conservation assessment for each of the six Annex I habitats surveyed. The detailed analysis is provided in the site-by-site assessments and associated project deliverables (Scally *et al.*, in prep.).

4.1 *Sandbanks which are slightly covered by sea water all the time* [1110]

The Annex I habitat *Sandbanks which are slightly covered by sea water all the time* consists of sandbanks which are permanently submerged. They are elevated, elongated, rounded or irregular topographic features and are predominantly surrounded by deeper water. They consist mainly of sandy sediments, but larger grain sizes, including boulders and cobbles, or smaller grain sizes, including mud, may also be present on a sandbank. Banks where sandy sediments occur in a layer over hard substrata are classed as sandbanks if the associated biota are dependent on the sand rather than on the underlying hard substrata (European Commission, 2013).

This habitat is mainly found along the east coast of Ireland but also occurs in the Shannon Estuary and off the Donegal coast (Figure 2).

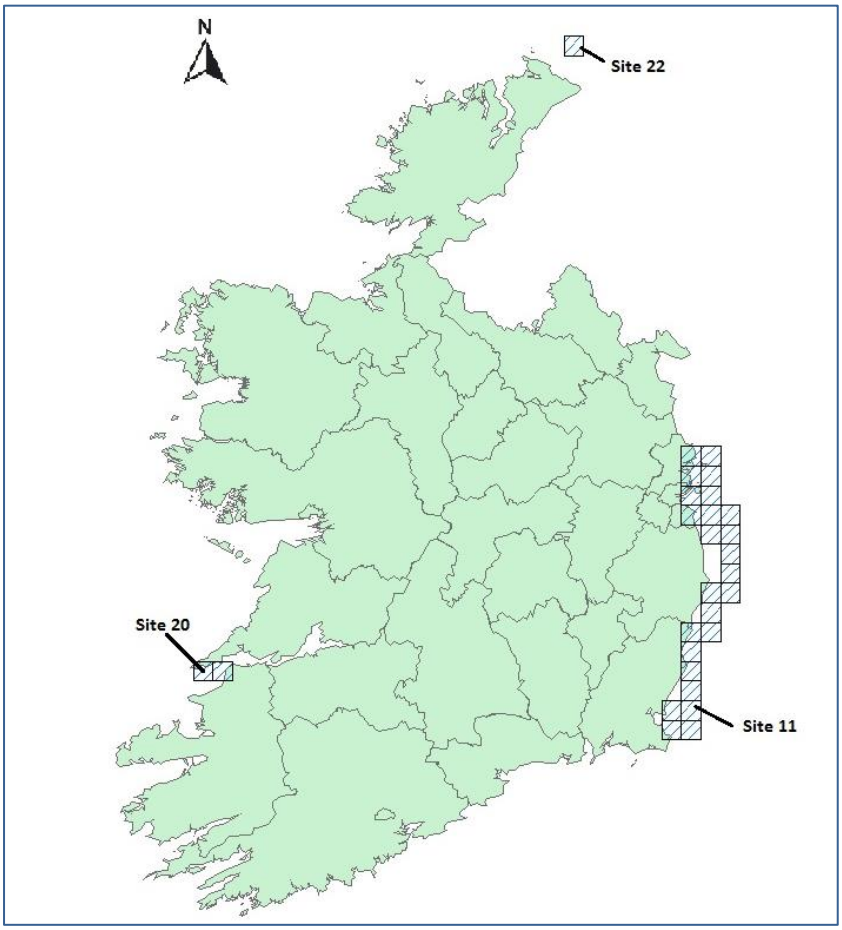

Figure 2 Location of monitoring sites for *Sandbanks not covered by seawater all the time* [1110] overlaid on the national distribution map (NPWS, 2019) for the habitat.

The overall conservation status of the habitat has been assessed as Favourable.

28% of the total resource of Sandbanks which are slightly covered by seawater all the time were surveyed within four SACs (Table 18) during the current reporting period. This habitat is comprised of a low number of sublittoral soft sediment communities with a limited range of species and sediment types. No changes in any of the indicators used (change to number of MCTs, change to sediment composition and presence of negative indicator species) were identified at any of the stations sampled.

No pressures have been identified that are currently acting on the sites. Potential threats to the habitat are considered to include the potential impacts of wind energy infrastructure in the vicinity of the habitat. Benthic dredging from commercial fishing vessels is also considered a potential threat.

Table 18 presents a summary of the individual site conservation assessments. The results of the national conservation assessment for the habitat are provided in Table 19.

Table 18 Conservation status assessment for each site for the habitat Sandbanks which are slightly covered by seawater all the time [1110]. 'Fav' is Favourable.

SAC Name	Habitat area within the SAC (km²)	*Area*	*Structure & functions*	*Future prospects*	Overall site assessment
Long Bank SAC (002161)	13.19	Fav	Fav	Fav	Fav
Blackwater Bank SAC (002953)	34.88	Fav	Fav	Fav	Fav
Lower River Shannon SAC (002165)	13.53	Fav	Fav	Fav	Fav
Hempton's Turbot Bank SAC (002999)	7.08	Fav	Fav	Fav	Fav

Table 19 Conservation assessment: Sandbanks which are slightly covered by sea water all of the time [1110]

Attribute	National conservation assessment
Area of national resource (247 km²)	Favourable
Structure & functions	Favourable
Future prospects	Favourable
Overall	Favourable

4.2 *Estuaries* [1130]

The Annex I habitat *Estuaries* consist of the downstream part of a river valley, subject to the tide and extending from the limit of brackish waters. *Estuaries* are coastal inlets where, unlike *'Large shallow inlets and bays*' there is generally a substantial freshwater influence. The mixing of freshwater and sea water and the reduced current flows in the shelter of the estuary lead to deposition of fine sediments often forming extensive intertidal sand and mud flats. Where the tidal currents are faster than flood tides most sediments deposit to form a delta at the mouth of the estuary (European Commission, 2013).

Estuaries are widespread around the coast of Ireland occurring in every county and constituting a qualifying interest for many marine SACs (Figure 3). During the current reporting period *Estuaries* were surveyed in 20 SACs around the coast of Ireland.

The overall conservation status of the habitat has been assessed as Unfavourable-Inadequate.

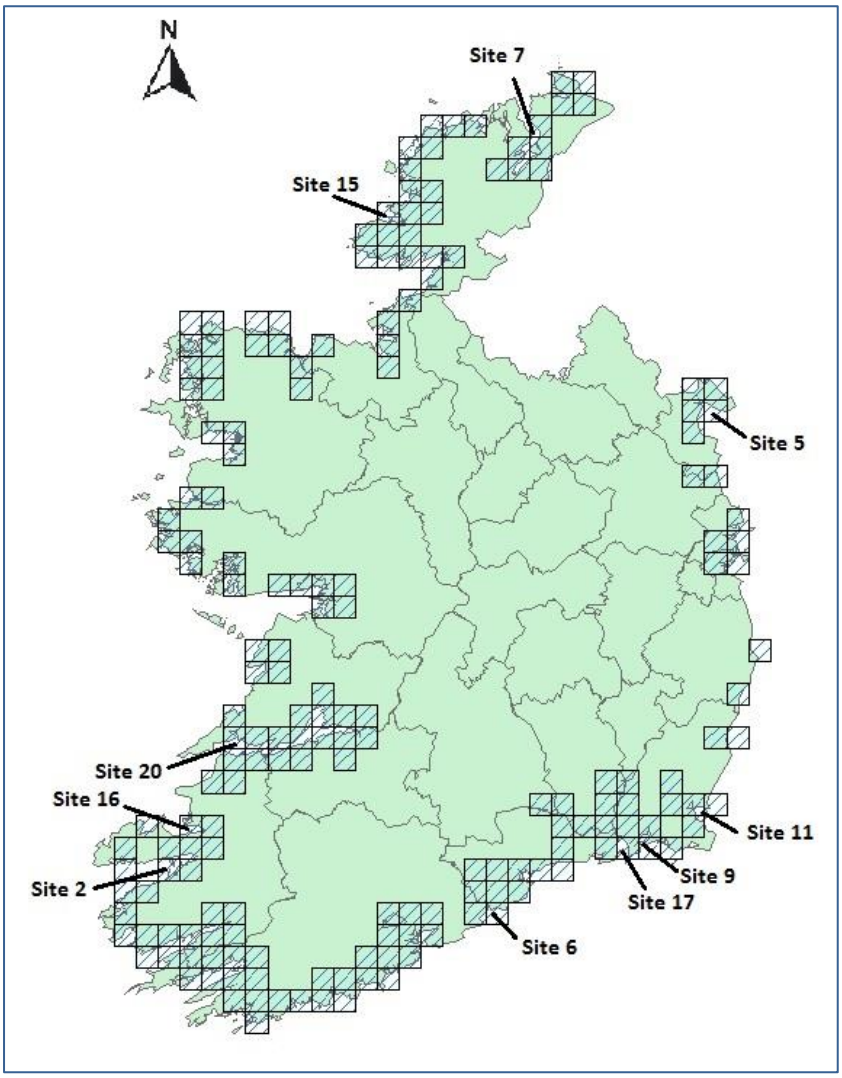

Figure 3 Location of monitoring sites for *Estuaries* [1130] overlaid on the national distribution map (NPWS, 2019) for the habitat.

Of the total resource of *Estuaries* within 11 SACs (Table 20) 59.8% was surveyed during the current reporting period, 69.31% of the *Area* surveyed was assessed as Unfavourable-Inadequate.

The overall site based conservation assessment was recorded as Unfavourable-Inadequate at three sites (Lough Swilly SAC, Dundalk Bay SAC and Lower River Shannon SAC), the remaining eight sites were assessed as Favourable. Thus 76.6% of the area surveyed is assessed as Unfavourable-Inadequate; this represents only 27.3% of the sites surveyed. The size of estuaries in Ireland varies greatly from the 3 ha Easky Estuary in Co. Sligo to the Lower River Shannon Estuary of 242 km^2. Therefore the Lower River Shannon SAC dominates the assessment. Given that the majority of sites (73%) across the country were assessed as Favourable a National assessment of Favourable was deemed to better represent conditions at a site level.

Lough Swilly SAC failed to reach Favourable conservation status due to an increase in negative indicator species. Two SACs (Dundalk Bay SAC and Lower River Shannon SAC) failed to meet Favourable conservation status due to changes in the sediment composition in one MCT within each site. In each of these cases, an increase in the proportion of fine sediment grain size classes was recorded (Scally *et al*., in prep.).

It is considered highly probable that the pressures are acting on these sites are causing increased sediment input and/or sediment mobilisation. Agriculture, maintenance dredging and urbanisation are considered to be the most likely contributing factors to the increased sediment input and resulting changes recorded in MCTs. The source of the majority of these impacts is outside of the SAC network.

Table 20 presents a summary of the individual site conservation assessments. The results of the national conservation assessment for the habitat are provided in Table 21.

Table 20 Conservation status assessment for the habitat *Estuaries* [1130] within each site monitored. 'Fav' is Favourable. 'U-I' is Unfavourable-Inadequate.

SAC Name	Habitat area within the SAC (km²)	*Area*	*Structure & functions*	*Future prospects*	Overall site assessment
Castlemaine Harbour SAC (000343)	56.96	Fav	Fav	Fav	Fav
Dundalk Bay SAC (000455)	27.99	Fav	U-I	Fav	U-I
Blackwater River (Cork/Waterford) SAC (002165)	12.08	Fav	Fav	Fav	Fav
Ballymacoda (Clonpriest and Pillmore) SAC (002999)	1.60	Fav	Fav	Fav	Fav
Lough Swilly SAC (002287)	61.18	Fav	Fav	U-I	U-I
Bannow Bay SAC (000697)	0.34	Fav	Fav	Fav	Fav
Slaney River Valley SAC (000781)	19.05	Fav	Fav	Fav	Fav
West of Ardara/Maas Road SAC (000781)	15.30	Fav	Fav	Fav	Fav
Tralee Bay and Magharees Peninsula, West to Cloghane SAC (002047)	3.06	Fav	Fav	Fav	Fav
River Barrow and River Nore SAC (002162)	38.56	Fav	Fav	Fav	Fav
Lower River Shannon SAC (002165)	242.73	Fav	U-I	Fav	U-I

Table 21 Conservation assessment: *Estuaries* [1130]

Attribute	National conservation assessment
Area of national resource (801 km²)	Favourable
Structure & functions	Unfavourable-Bad
Future prospects	Unfavourable-Inadequate
Overall	Unfavourable-Inadequate

4.3 *Mudflats and sandflats not covered by seawater at low tide* [1140]

The Annex I habitat *Mudflats and sandflats not covered by seawater at low tide* is characterised by sands and muds of the coasts of the oceans, their connected seas and associated lagoons, not covered by sea water at low tide, devoid of vascular plants (with the exception of eelgrasses), usually coated by blue algae and diatoms. They are of particular importance as feeding grounds for wildfowl and waders. In Ireland this habitat is normally associated with *Large shallow inlets and bays* and *Estuaries* (European Commission, 2013).

Mudflats and sandflats not covered by seawater at low tide are widespread around the coast of Ireland occurring in sheltered areas generally in association with *Large shallow inlets and bays* and *Estuaries* (Figure 4). They constitute a qualifying interest for many marine SACs. During the current reporting period this habitat was surveyed in 22 SACs around the coast of Ireland.

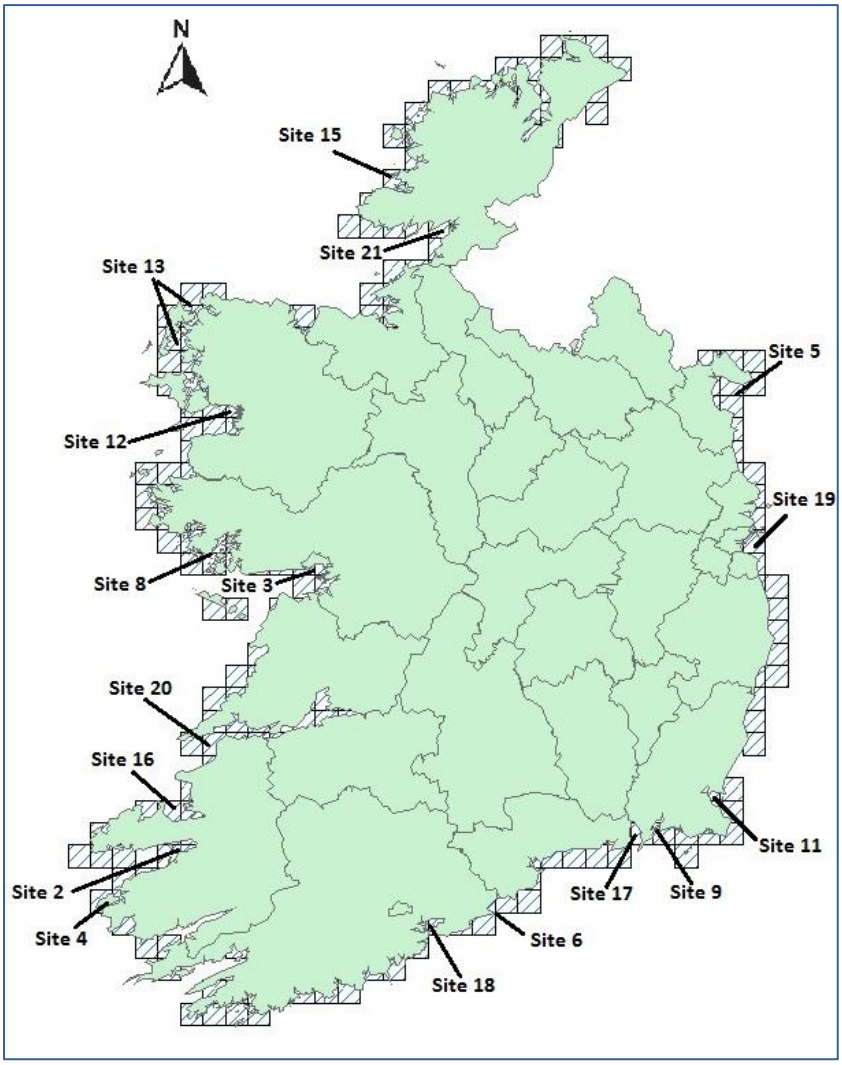

Figure 4 Location of monitoring sites for *Mudflats and sandflats not covered by seawater at low tide* [1140] overlaid on the national distribution map (NPWS, 2019) for the habitat.

The overall conservation status of *Mudflats and sandflats not covered by seawater at low tide* has been assessed as Unfavourable-Inadequate.

Of the total resources of *Mudflats and sandflats not covered by seawater at low tide* within 21 SACs (Table 22) 49% was surveyed during the current reporting period. Three sites (Castlemaine Harbour SAC, Dundalk Bay SAC and Lower River Shannon SAC) were assessed as Unfavourable-Inadequate, the remaining 18 sites were assessed as Favourable. The area assessed as Unfavourable-Inadequate represents 56% and as such is regarded as Bad (DG Environment, 2017). However the number of sites assessed as Favourable is 86%. Therefore for this habitat the more accurate assessment of *Structure & functions* was deemed to be Unfavourable-Inadequate.

Table 22 Conservation status assessment for the habitat *Mudflats and sandflats not covered by seawater at low tide* [1140] within each site monitored. 'Fav' is Favourable. 'U-I' is Unfavourable-Inadequate.

	Habitat area within the SAC (km²)	***Area***	***Structure & functions***	***Future prospects***	**Overall site assessment**
Castlemaine Harbour SAC (000343)	42.87	Fav	Fav	U-I	U-I
Galway Bay Complex SAC (000268)	7.44	Fav	Fav	Fav	Fav
Valentia Harbour/Portmagee Channel SAC (002262)	1.23	Fav	Fav	Fav	Fav
Dundalk Bay SAC (000455)	43.75	Fav	U-I	Fav	U-I
Blackwater River (Cork/Waterford) SAC (002165)	2.84	Fav	Fav	Fav	Fav
Ballymacoda (Clonpriest and Pillmore) SAC (002999)	3.02	Fav	Fav	Fav	Fav
Kilkieran Bay and Islands SAC (002111)	1.80	Fav	Fav	Fav	Fav
Bannow Bay SAC (000697)	8.93	Fav	Fav	Fav	Fav
Slaney River Valley SAC (000781)	10.27	Fav	Fav	Fav	Fav
Raven Point Nature Reserve SAC (000710)	0.73	Fav	Fav	Fav	Fav
Clew Bay Complex SAC (001482)	12.77	Fav	Fav	Fav	Fav
Broadhaven Bay SAC (000472)	4.95	Fav	Fav	Fav	Fav
Mullet/Blacksod Bay Complex SAC (000470)	14.28	Fav	Fav	Fav	Fav
West of Ardara/Maas Road SAC (000197)	12.59	Fav	Fav	Fav	Fav
Tralee Bay and Magharees Peninsula, West to Cloghane SAC (002047)	16.85	Fav	Fav	Fav	Fav
River Barrow and River Nore SAC (002162)	9.26	Fav	Fav	Fav	Fav
Great Island Channel SAC (001058)	7.23	Fav	Fav	Fav	Fav
North Dublin Bay SAC (000206)	5.78	Fav	Fav	Fav	Fav
South Dublin Bay SAC (000210)	7.20	Fav	Fav	Fav	Fav
Lower River Shannon SAC (002165)	88.08	Fav	U-I	Fav	U-I
Donegal Bay (Murvagh) SAC (000133)	10.69	Fav	Fav	Fav	Fav

The majority of SACs surveyed (18 of the 21 sites surveyed) were assessed as being at Favourable conservation status. However, 174 km² of the total national resource of *Sandflats and mudflats not covered by seawater at low tide* is located within the three sites which failed to meet Favourable conservation

status, and so this was a significant factor in the overall failure of the habitat to meet Favourable conservation status.

The principal reason for the failure of the habitat to meet Favourable conservation status was a change in sediment composition (Dundalk Bay SAC and Lower River Shannon SAC) and an increase in alien invasive species (Castlemaine Harbour SAC) (Scally *et al.*, in prep.).

Mudflats are vulnerable to increased sediment loads, resulting from activities upstream of rivers, entering a bay. The most likely cause of these increased sediment loads is considered to be a combination of the discharge of untreated effluent and intensive agriculture. Maintenance dredging to facilitate navigation is also considered to be a factor in increased sedimentation (e.g. Dundalk Bay SAC). The encroachment of the invasive alien species *Spartina anglica* on *Zostera noltei* beds is the principal reason for the failure of Castlemaine Harbour SAC to meet Favourable conservation status.

Table 22 presents a summary of the individual site conservation assessments. The results of the national conservation assessment for the habitat are provided in Table 23.

Table 23 Conservation assessment: *Mudflats and sandflats not covered by seawater at low tide* [1140].

Attribute	National conservation assessment
Area (638 km²)	Favourable
Structure & functions	Unfavourable-Bad
Future prospects	Unfavourable-Inadequate
Overall	Unfavourable-Inadequate

4.4 *Large shallow inlets and bays* [1160]

The Annex I habitat *Large shallow inlets and bays* is characterised by large indentations of the coast where, in contrast to *Estuaries*, the influence of freshwater is generally limited. These shallow indentations are generally sheltered from wave action and contain a great diversity of sediments and substrates with a well-developed zonation of benthic communities. These communities have generally a high biodiversity (EU Commission, 2013). As this habitat generally comprises a large physiographic feature it may wholly or partially incorporate other Annex I habitats including, for example, *Reefs* and *Submerged or partially submerged sea caves*.

In Ireland, *Large shallow inlets and bays* occur around all coasts of Ireland and vary substantially in size, exposure and the number of additional Annex I habitats which they incorporate (Figure 5). During the current reporting period this habitat was surveyed in 20 SACs around the coast of Ireland.

The overall conservation status of *Large shallow inlets and bays* has been assessed as Unfavourable-Bad.

36.9% of the total resource of *Large shallow inlets and bays* within 14 SACs (Table 24) were surveyed during the current reporting period and 63.2% were assessed as Unfavourable-Bad.

A change in sediment composition, resulting in an increased proportion of fine grain size class was recorded at three of the SACs surveyed.

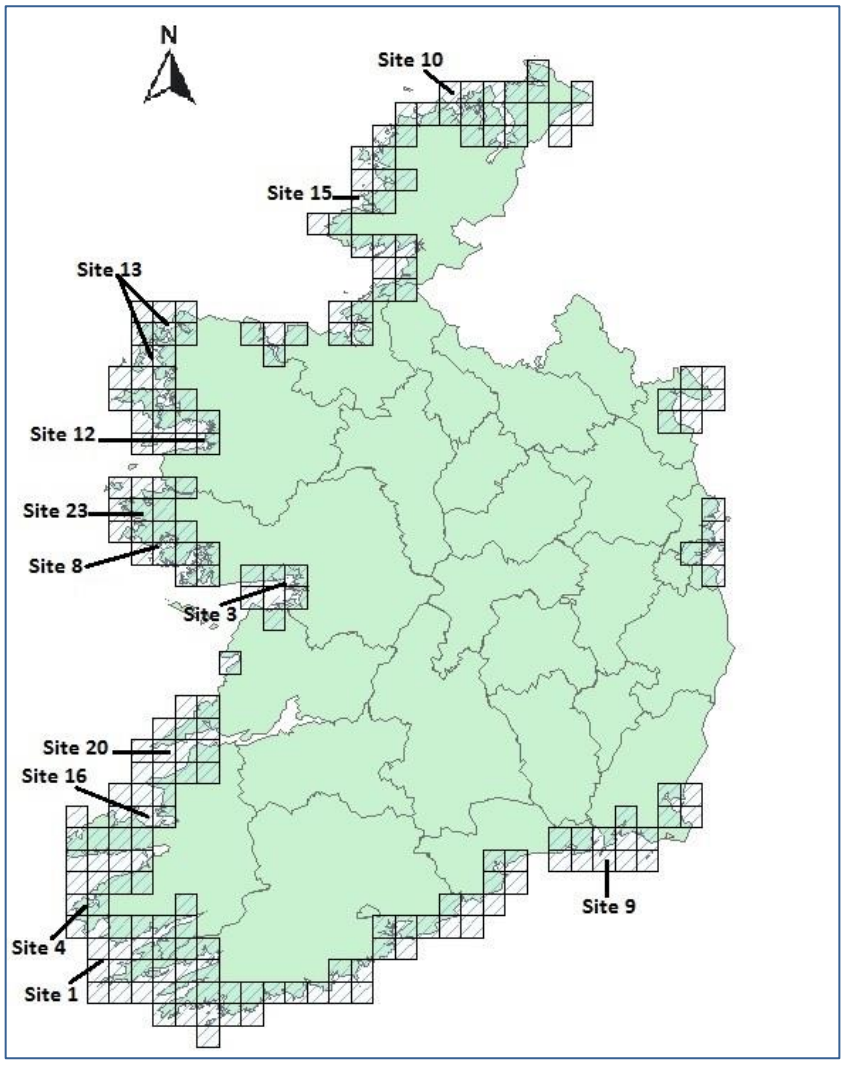

Figure 5 Location of monitoring sites for *Large shallow inlets and bays* [1160] overlaid on the national distribution map (NPWS, 2019) for the habitat.

Significant changes were documented in the areas that had previously recorded for eelgrass beds in surveys carried out between 2005 and 2009 (MERC, 2005, 2006, 2007a, 2008a, 2009). In some SACs, the loss of entire eelgrass beds in certain parts of a site was recorded. This occurred in Mulroy Bay SAC, Valentia Harbour/Portmagee Channel SAC, Clew Bay Complex SAC and Mullet/ Blacksod Bay Complex SAC. In these and other SACs, a significant decrease in the abundance of eelgrass shoots within a bed since the previous baseline survey was also recorded. An increase in negative indicators, e.g. epiphytic algal cover on eelgrass leaves, the presence of opportunistic species and invasive alien species (in particular the brown seaweed *Sargassum muticum*) was also recorded in many of the eelgrass beds surveyed.

In Blacksod Bay, the *Serpula vermicularis*-dominated community complex which, in a 2008 survey, had been recorded as being comprised of large aggregations of biogenic reef formed by *S. vermicularis,* in June 2018 was found to consist of broken tubes of *S. vermicularis.* Very few living aggregations were still present resulting in the area of this keystone community being severely impacted. The cause of this impact is physical damage due to benthic dredging. Physical damage to maërl thalli in the maërl beds adjacent to the *Serpula vermicularis*-dominated community complex was also observed.

Significant negative impacts were recorded in the maërl community, which contains the rare *Lithothamnion dentatum* species, within Roaringwater Bay SAC. Here, pseudofaeces deposition and/or

extensive algal cover was recorded over the maërl beds in the vicinity of mussel longlines. Within the maërl beds in the immediate vicinity of the mussel longlines the opportunistic ascidian *Ascidiella aspersa* was also recorded as 'Abundant'.

A total of 0.29 ha or 23.99% of the total known national resource of the unique marine community type for the rare burrowing worm anemone *Edwardsia delapiae* within Valentia Harbour/Portmagee Channel SAC has been lost. It should be noted that this is the type locality of this species and until recently the only site in the world in which it had been recorded (it has recently been recorded in a site in Scotland, Paul Kay *pers. comm.*). This is an indirect result of the impact of the construction of a floating breakwater over this MCT, leading to a negative change in the sediment which is a crucial requirement of this species.

Minor increases in the habitat for *Pachycerianthus multiplicatus* were recorded in Kenmare River SAC and Kilkieran Bay & Islands SAC. However these increases are considered to be the result of increased survey effort rather than an increase in species distribution. No significant increase in the extent of the area of other keystone species was recorded.

Table 24 presents a summary of the individual site conservation assessments. The results of the national conservation assessment for the habitat are provided in Table 25.

Table 24 Conservation assessment for the habitat *Large shallow inlets and bays* [1160] within each site monitored. 'Fav' is Favourable. 'U-I' is Unfavourable-Inadequate. 'U-B' is Unfavourable-Bad

SAC Name	Habitat area within the SAC (km²)	*Area*	*Structure & functions*	*Future prospects*	Overall site assessment
Kenmare River SAC (002158)	393.22	Fav	U-I	U-B	U-B
Galway Bay Complex SAC (000268)	108.25	Fav	Fav	Fav	Fav
Valentia Harbour/Portmagee Channel SAC (002262)	26.29	Fav	U-B	U-B	U-B
Kilkieran Bay and Islands SAC (002111)	187.60	Fav	Fav	U-I	U-I
Hook Head SAC (000764)	52.44	Fav	Fav	Fav	Fav
Mulroy Bay SAC (002159)	31.70	Fav	U-B	U-B	U-B
Clew Bay Complex SAC (001482)	101.89	Fav	U-B	U-B	U-B
Broadhaven Bay SAC (000472)	86.74	Fav	U-I	U-B	U-B
Mullet/Blacksod Bay Complex SAC (000470)	111.69	Fav	U-B	U-B	U-B
West of Ardara/Maas Road SAC (000197)	6.88	Fav	Fav	Fav	Fav
Tralee Bay and Magharees Peninsula, West to Cloghane SAC (002047)	101.30	Fav	Fav	Fav	Fav
Lower River Shannon SAC (002165)	352.82	Fav	Fav	Fav	Fav
Kingstown Bay SAC (002265)	0.75	Fav	U-B	U-B	U-B
Roaringwater Bay and Islands SAC* (000101)	128.09	Fav	U-I	U-I	U-B

* Surveyed for the 1160 habitat in 2014 (MERC, 2014a).

Table 25 Conservation assessment: *Large shallow inlets and bays* [1160]

Attribute	National conservation assessment
Area (4,570 km²)	Favourable
Structure & functions	Unfavourable-Bad
Future prospects	Unfavourable-Inadequate
Overall	Unfavourable-Bad

4.5 *Reefs* [1170]

The Annex I habitat *Reefs* can be either biogenic concretions or of geogenic origin. They are hard compact substrata on solid and soft bottoms which arise from the sea floor in the sublittoral and littoral zone. *Reefs* may support a zonation of benthic communities of algae and animal species as well as concretions and corallogenic concretions (European Commission, 2013). In Ireland, the majority of *Reefs* habitat is geogenic, meaning they are characterised by a substrate formed of bedrock, boulders or cobble. In the inshore area, this geogenic substrate normally supports a diverse range of flora and fauna including kelp forests (Figure 6). Geogenic reefs occur both subtidally and within the intertidal zone and are generally found in association with the Annex I habitat Large shallow inlets and bays. Biogenic reefs, while less common, are also found around all coasts of Ireland. These include intertidal biogenic reefs formed by the mussel (*Mytilus edulis*) and the honeycomb worm (*Sabellaria spinulosa*), and subtidal reefs formed by the polychaete worm *Serpula vermicularis*. Biogenic reefs usually support a diverse range of associated epifauna and are an important keystone community.

Reefs habitat from 13 SACs around the Irish coast was surveyed (Figure 6). *Reefs* habitat in the offshore (Figure 7) was not surveyed as part of this project.

Limited data were available by which to assess the *Structure & functions* of sublittoral reef. However during the present reporting period, 618 km² of inshore reef habitat, representing the range of inshore reef communities in Ireland, has been surveyed using a method which has resulted in a permanent record of reef physical and ecological structure and, where present, kelp canopy height and structure. This has provided a baseline against which to measure change in the future.

A number of factors make sublittoral geogenic reef unlikely to be vulnerable to change in *Area,* foremost being the hard rock substrates from which they are formed. Therefore, other than minor alteration of the rock face due to the effects of natural erosion, habitat loss is highly unlikely.

The main pressures on intertidal reef habitat is the increase in invasive alien species and the harvesting of marine algae. In sublittoral reef habitats, the most significant pressures observed in the course of this survey were those associated with lost fishing gear and the use of tangle nets. The mechanical harvesting of kelp has the potential to lead to direct and indirect impacts on infralittoral reef habitats in the future.

Of note were a significant increase in the area of intertidal biogenic formed by *Sabellaria spinulosa* at a number of locations within Lough Swilly SAC from which it had not previously been recorded, and a significant increase in *Mytilus edulis* reef within Cork Harbour SPA.

Notwithstanding the lack of detailed baseline information on intertidal and inshore sublittoral *Reefs*, their conservation status has been assessed as Favourable.

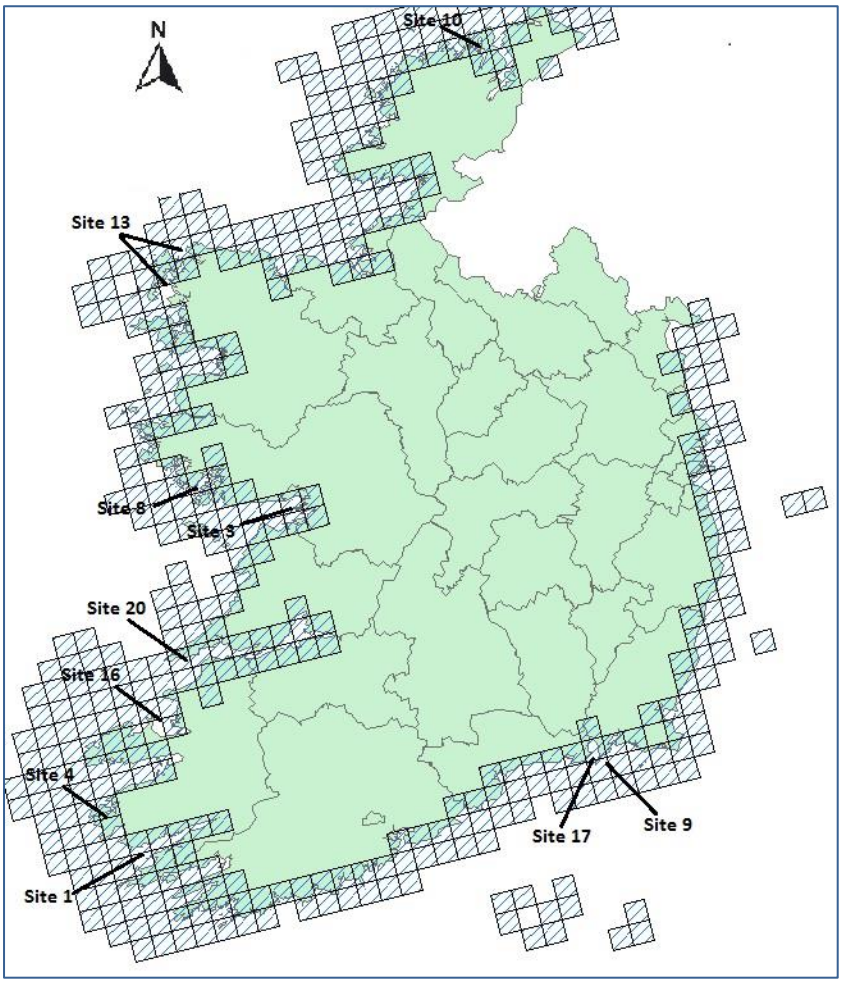

Figure 6 Location of monitoring sites for *Reefs* [1170] overlaid on the national distribution map (NPWS, 2019) for the inshore extent of the habitat.

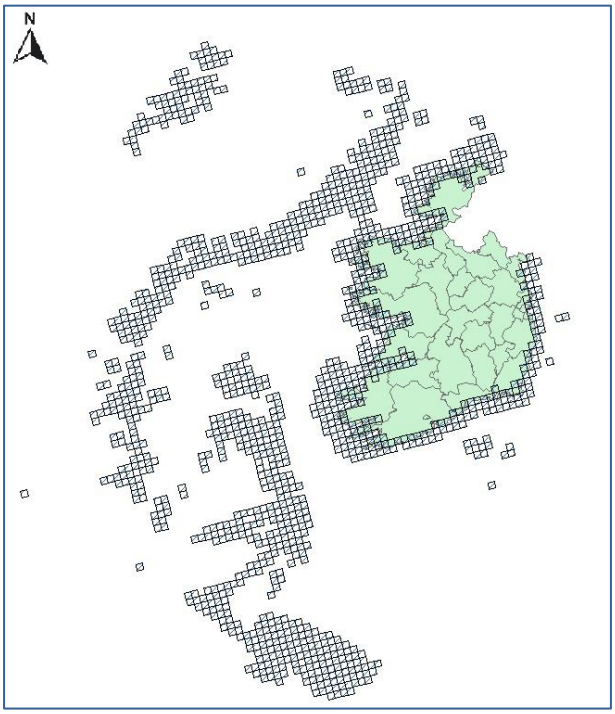

Figure 7 National distribution map (NPWS, 2019) of full extent of *Reefs* [1170] habitat.

Table 26 presents a summary of the individual site conservation assessments for inshore reef habitats. The results of the national conservation assessment for inshore reef habitat are provided in Table 27.

Table 26 Conservation assessment for the habitat *Reefs* [1170] within each site monitored* 'Fav' is Favourable. 'U-I' is Unfavourable-Inadequate. 'U-B' is Unfavourable-Bad

SAC Name	Habitat area within the SAC (km²)	*Area*	*Structure & functions*	*Future prospects*	Overall site assessment
Kenmare River SAC (002158)	91.96	Fav	Fav	Fav	Fav
Galway Bay Complex SAC (000268)	27.73	Fav	U-B	U-B	U-B
Valentia Harbour/Portmagee Channel SAC (002262)	9.53	Fav	Fav	Fav	Fav
Kilkieran Bay and Islands SAC (002111)	90.84	Fav	Fav	Fav	Fav
Hook Head SAC (000764)	105.34	Fav	Fav	Fav	Fav
Mulroy Bay SAC (002159)	0.43	Fav	Fav	Fav	Fav
Broadhaven Bay SAC (000472)	11.03	Fav	Fav	Fav	Fav
Mullet/Blacksod Bay Complex SAC (000470)	15.31	Fav	U-I	U-I	U-I
Tralee Bay and Magharees Peninsula, West to Cloghane SAC (002047)	28.56	Fav	Fav	Fav	Fav
Magharee Islands SAC (002261)	23.37	Fav	Fav	Fav	Fav
River Barrow and River Nore SAC (002162)	0.20	Fav	Fav	Fav	Fav
Lower River Shannon SAC (002165)	214.21	Fav	Fav	Fav	Fav
Roaringwater Bay and Islands SAC** (000101)	34.97	Fav	Fav	Fav	Fav

* This table only provides data for inshore reef communities.

** Roaringwater Bay and Islands SAC was surveyed in 2014 (MERC, 2014a).

Table 27 Conservation assessment: *Reefs* (for inshore reef communities only)

Attribute	National conservation assessment
Area (32,188 km²)*	Favourable
Structure & functions	Favourable
Future prospects	Favourable
Overall	Favourable

* This figure includes both inshore and offshore *Reefs* area

4.6 *Submerged or partially submerged sea caves* [8330]

The Annex I habitat *Submerged or partially submerged sea caves* are caves situated under the sea or opened to it, at least at high tide, including partially submerged sea caves. Their bottom and sides harbour communities of marine invertebrates and algae (EU Commission, 2013). Sea caves occur around all coasts of Ireland (Figure 6). Due to the logistics involved in the survey of sea caves, few have been fully surveyed. Identification of the extent of the habitat within its range is hindered as some sea caves are fully submerged; these caves are only known as a result of exploration by SCUBA divers. Sea caves with an entrance above the high water mark are better known but still under-recorded.

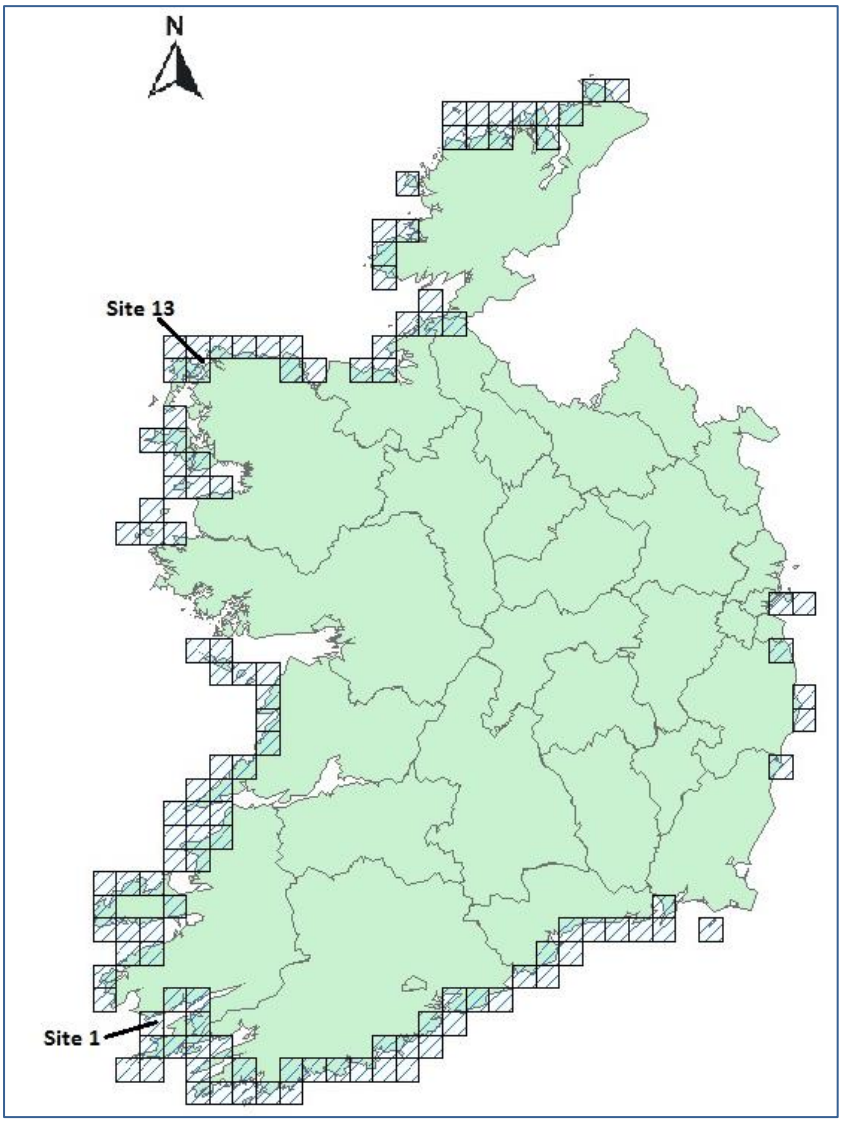

Figure 8 Location of monitoring sites for *Submerged or partially submerged sea caves* [8330] overlaid on the national distribution map (NPWS, 2019).

Those sea caves that have been surveyed have been shown to support an extremely diverse and species-rich faunal community. In general, sea caves are an extension of the adjacent geogenic reef habitat as they host a similar range of sublittoral fauna. However due to the light-limiting nature of sea caves and the physical structure, with floor, wall and roof niches, they have been shown to host a far greater diversity and often more unique faunal community to that of adjacent reef habitat.

During the current reporting period, two sea caves were surveyed; one in Kenmare River SAC and a second in Broadhaven Bay SAC.

The overall conservation status of the habitat was assessed as Favourable. The results of the assessment are provided in Table 27.

Sea caves remain one of the most challenging habitats to survey and therefore an assessment of their conservation status is difficult. It is likely that a very large number of sea caves around the Irish coast are completely submerged and unknown. Without considerable exploration, it is unlikely that the full extent of the national resource will ever be known.

Of the known sea caves, which are generally those that are partially submerged, there are insufficient baseline data upon which to fully describe the habitat or its typical species and communities. In Irish waters, only a small sub-sample (six caves) has been surveyed in detail to date. This sample is not considered large enough to accurately assess their *Structure & functions* or extrapolate the likely total *Area* of the habitat.

A number of factors make sea caves unlikely to be vulnerable to change. Foremost, all sea caves in Ireland are formed from hard rock. Therefore, other than minor alteration of the rock face due to the effects of natural erosion, loss of area is highly improbable.

The inaccessible nature of sea caves also makes them less vulnerable to anthropogenic impacts. No pressures or threats have been identified with a ranking of medium or higher for this habitat.

Notwithstanding the lack of detailed baseline information for *Submerged or partially submerged sea caves*, their conservation status has been assessed as Favourable. This is based on the clear lack of pressures on the sea caves surveyed to date and the lack of any future threats which could impact on their conservation status.

Table 28 presents a summary of the individual site conservation assessments for *Submerged or partially submerged sea caves*. The results of the national conservation assessment are provided in Table 29.

Table 28 Conservation assessment for the habitat *Submerged or partially submerged sea caves* [8330] within each site monitored. 'Fav' is Favourable.

SAC Name	Habitat area within the SAC	*Area*	*Structure & functions*	*Future prospects*	Overall site assessment
Kenmare River SAC (002158)	Unknown	Fav	Fav	Fav	Fav
Broadhaven Bay SAC (000472)	Unknown	Fav	Fav	Fav	Fav

Table 29 Conservation assessment: *Submerged or partially submerged sea caves* [8330]

Attribute	National conservation assessment
Area (Unknown)	Favourable
Structure & functions	Favourable
Future prospects	Favourable
Overall	Favourable

5 Discussion

The discussion that follows outlines the rationale for the conservation status assessments of the six Annex I marine habitats assessed during the 2013-2018 reporting period. Because Annex I marine habitats each correspond directly to geographical features (*e.g. Large shallow inlets and bays*, *Estuaries*, *Mudflats and sandflats not covered by seawater at low tide*), the *Range* and *Area* of each habitat was considered to be stable and unlikely to have changed significantly during the monitoring cycle. Accordingly, the following discussion focuses on the *Structure & functions* criterion for each Annex I habitat.

5.1 *Sandbanks which are slightly covered by sea water all the time* [1110]

Sandbanks which are slightly covered by sea water all the time are limited in their distribution around the coast of Ireland. The habitat is distributed mainly along the east coast of Ireland with additional sandbanks also occurring in the Shannon Estuary and off the north Donegal coast (Figure 2). In the current reporting period, 69 km^2 of the total national resource of 247 km^2 was sampled to assess the conservation status of this habitat. This represents 28% of the total national resource for this habitat. The sandbanks of the east coast and Shannon Estuary are comprised of a low number of sublittoral Marine Community Types which have a limited range of species and sediment types. The Hempton's Turbot Bank (Co. Donegal) on the other hand is largely comprised of cobble and highly mobile shell material.

The habitat has been assessed as being at Favourable conservation status and no pressures have been identified. However, it is considered to be threatened by the likely increase in applications for offshore windfarm developments, especially off the east coast of Ireland. Potential impacts associated with benthic dredging for fishing, while currently not observed to constitute a pressure on this habitat, remain a threat.

5.2 *Estuaries* [1130]

Estuaries occur widely on all coasts of Ireland (Figure 3). However, the size of individual estuaries varies greatly from the 0.03 km^2 Easky Estuary in Co. Sligo to the Lower River Shannon Estuary which measures 242 km^2. Encompassing 37% of the national resource, the Lower River Shannon is by far the largest estuary in Ireland.

The overall conservation status of *Estuaries* has been assessed as Unfavourable-Inadequate. The principal reason for the failure of the habitat to achieve a Favourable conservation status assessment is a significant change in observed sediment composition at stations sampled as part of the monitoring programme. The large area of the total national resource of the *Estuaries* habitat within Lower River Shannon SAC, where a change in sediment composition was recorded, was a significant factor in the overall failure of this habitat to meet Favourable conservation status.

It is considered highly likely that the recorded changes in sedimentology have resulted from increased rates of sedimentation. Estuaries surrounded by urban settlements are vulnerable to the impact of run-off from storm water and may also be impacted by on-going discharge of inadequately treated waste water. Without adequate mitigations, estuaries adjacent to and/or down-stream of areas of changing land use, arterial drainage schemes, aggregate extraction and intensification of agriculture and/or commercial forestry operations are likely to be impacted by sedimentary materials. These materials are generated through these activities and in many cases are transported downstream and are ultimately deposited in the *Estuaries*.

Two of the sites (Lower River Shannon SAC and Dundalk Bay SAC) which failed to achieve Favourable conservation status were adjacent to or downstream of catchments that included large urban centres. In

the case of the Lower River Shannon, the area where the greatest change in sedimentology was recorded is located downstream of a large urban settlement (Ennis). Ennis is currently without adequate wastewater treatment facilitates. Much of the wastewater emanating from the town is discharged into the Fergus River and ultimately enters the Lower Shannon Estuary. Meanwhile, Dundalk Bay is subject to the impacts of maintenance dredging in addition to run-off from a large urban centre (Dundalk town). While it was not possible to directly attribute negative changes recorded to any particular activity or combination of activities, both the Lower River Shannon and Dundalk Bay are receptors of runoff from very significant geographical catchments. In this context, these estuaries receive waters that may carry sediments over long distances and which are associated with the range of activities described above. It is considered likely that agriculture, in combination with changing land use and urbanisation, has played a significant role in the negative assessment for the habitat at these sites.

The presence of the non-native Pacific oyster *Magallana gigas* (syn. *Crassostrea gigas*) and the non-native barnacle *Austrominius modestus* (syn. *Elminius modestus*) were the reason for the failure of Lough Swilly SAC to reach Favourable conservation status. It is considered likely that deliberate and accidental introductions through aquaculture activity are the origin of this impact.

5.3 *Mudflats and sandflats not covered by seawater at low tide* [1140]

Mudflats and sandflats not covered by seawater at low tide are present on all coasts of Ireland (Figure 4). 313 km^2, of the total national resource of 638 km^2, were surveyed during the current reporting period to assess the conservation status of this habitat. These 313 km^2 occurred within 21 SACs around the coast of Ireland. The habitat has been assessed as Unfavourable-Inadequate.

Three sites failed to achieve Favourable conservation status (Castlemaine Harbour SAC, Dundalk Bay SAC and Lower River Shannon SAC). Collectively, these sites represent 27% of the national resource for this habitat. An increase in fine surficial sediments was recorded through sampling at Dundalk Bay SAC and Lower River Shannon SAC. The origin/s for the recorded increases in the fine sediment component of surficial sediments within this habitat are likely to be similar those previously described for *Estuaries* [1130].

Whilst previously recorded at Castlemaine Harbour SAC, an increase in the invasive alien species *Spartina anglica* within and surrounding the *Zostera noltei* beds at Inch Spit and inner Castlemaine Harbour is considered a significant and growing threat.

5.4 *Large shallow inlets and bays* [1160]

During the current reporting period, 1,690 km^2 of the total resource of 4,570 km^2 of *Large shallow inlets and bays* within 14 SACs around the coast of Ireland were surveyed to assess conservation status of this habitat. It has been assessed as Unfavourable-Bad.

The main explanation for the failure of this habitat to achieve Favourable conservation status is the significant change recorded in the *Area* and *Structure & functions* of keystone communities. Keystone communities are characterised by sensitive indicator species such as eelgrasses (*Zostera marina* and *Z. noltei*) and maërl, as well as a range of invertebrate species including burrowing species such as *Pachycerianthus multiplicatus* and reef-building species such as *Serpula vermicularis* and *Limaria hians*. Species selected as indicators usually have very specific habitat requirements and have known vulnerabilities, being less resilient to changes in environmental conditions than other species. Pressures on a habitat are likely to manifest as changes to the distribution and extent of indicator species and *Structure & functions* of keystone communities prior to wider impacts being more readily detectable.

At three of the sites, Roaringwater Bay SAC, Valencia Harbour/Portmagee Channel SAC and Blacksod Bay SAC, the cause of the impact on the keystone communities was clear.

In Roaringwater Bay SAC, significant negative impacts were recorded in the maërl community as a result of pseudofaeces deposition and/or extensive algal cover on the maërl beds; these beds included the rare *Lithothamnion dentatum* maërl species. This impact was caused by the presence of mussel longlines directly over the beds. A proliferation of opportunistic ascidian species *Ascidiella aspersa* was also recorded during sampling by diving; it formed an extensive community on the seabed adjacent to mussel lines.

In Valentia Harbour/Portmagee Channel SAC, a clear mechanism for the recorded change in the very vulnerable *Edwardsia delapiae*-associated community was identified during the monitoring surveys at this site. The loss of 24% of this community has most likely resulted from the construction of a floating breakwater over a significant proportion of the area associated with this community. Construction of the floating breakwater occurred in the intervening period between initial baseline surveys of this community in 2007 and the monitoring event that took place in 2017.

The breakwater is anchored to the seabed through a complex system of tensioners. These have become very heavily fouled with macroalgae, mussels (*Mytilus edulis*), the large anemone *Metridium senile*, ascidians and a wide range of other encrusting organisms. In addition, the extensive wetted surface area provided by the underside of the floating breakwater structures has become completely colonised and is host to a community that is dominated by mussels and a range of molluscan and algal species. An extensive community of crustaceans prey on the mussels growing on the surfaces of ropes and tensioners. Ranges of other aquatic and avian species also appear to have identified the breakwater as suitable habitat providing both shelter and rafting opportunities, as well as an abundant and renewable food source. As evidenced during sampling by diving, the seabed is now a largely continuous deep layer of mussel shell debris resulting from the predation of mussels. In addition, a seabed community of echinoderms was seen to prey on clumps of mussels that either fall off or are washed off ropes and floating structures and end up on the seabed. Furthermore, it is likely that settlement of mussel seed is occurring on the exposed shell debris that now litters the seabed over most of the area beneath and adjacent to the floating structures. In summary, the breakwater structures and its anchoring system has created an entirely new ecosystem in the area beneath and adjacent to the breakwater (out to a distance of up to 20 m) by providing settlement surface for a range of flora, as well as foraging opportunities and shelter for a wide range of fauna.

It is likely that the described impacts of the breakwater are compounded by changes in tidal water flows in and around the breakwater structures that are attributable to the floating breakwater. Fouling of tensioners and wetted surfaces has exacerbated the current shading effects of the breakwater and tidal flows appear to have (to an undetermined extent) been diverted away from the structure, leading to reduced tidal currents in and around the breakwater. This has likely facilitated colonisation of submerged surfaces as well as settlement of suspended solids and pseudofaeces from the suspended *Mytilus edulis* community.

The seabed characteristics have changed from a muddy sand with a patchy veneer of pea-sized gravel to a muddy, shell debris and pseudofaeces-dominated sediment. The associated fauna has also changed with a noticeable loss of the burrowing component of the previously-recorded seabed community. The location, which had been characterised by a fauna rich in anemones, including *Edwardsia delapiae,* is now characterised by mussel shell debris and vertical lines of *Mytilus edulis* and the ascidians *Ascidiella aspersa* and *Phallusia mammillata* extending out from the breakwater.

In Blacksod Bay, the *Serpula vermicularis*-dominated community complex has been effectively lost due to benthic bivalve dredging. Physical damage to maërl thalli was also observed in the maërl beds adjacent to and co-incident with the *Serpula vermicularis*-dominated community complex.

At other sites, the primary reason for the failure of the *Large shallow inlets and bays* habitat to meet Favourable conservation status was the significant decreases in the abundance of *Zostera marina*. This occurred in six of 14 SACs surveyed and ranged from a gross negative change in abundance to a total loss of an area of eelgrass.

Epiphytic algal cover on eelgrass leaves was noted in the majority of sites where a decrease in the abundance of *Zostera marina* was recorded. In these sites, die-back was frequently observed. Die-back occurs naturally during the winter months and is characterised by variable proportions of blackened and/or dead leaf blades. During the current project, it was observed in the months of April to August. Such unseasonal occurrence of die-back is generally indicative of significant pressure as a result of changes in environmental parameters. The presence of microalgae as an epiphyte on the leaf blades was not recorded in the 2005 to 2009 surveys to the extent that was observed during the 2017-2018 surveys. Microalgae on *Z. marina* leaf blades is associated with nutrient enrichment (e.g. Coleman & Burkholder, 1994, Borum, 1985, Short *et al*., 1995). An over-abundance of leaf epiphytes can contribute to a light attenuation at the leaf surface, thereby reducing the photosynthetic capacity of the plant. Nutrient enrichment can also lead to a proliferation of free-living macroalgae. At one site (Mulroy Bay SAC), entire beds of *Z. marina* had been replaced by dense mats of the bloom-forming macro-algae *Chaetomorpha linum*. This species is well known to proliferate in areas of nutrient enrichment (McGlathery, 2001).

Anecdotal information has indicated that a widespread loss of eelgrass beds occurred across Europe during the summer of 2018. This has been attributed to the exceedingly high summer temperatures in Europe during this period and is the subject of current research. However, it should be noted that the loss of the eelgrass beds in Mulroy Bay SAC was recorded during surveys carried out in mid-April 2018 - prior to the high summer temperatures. The majority of the other sites where a negative impact was recorded were surveyed during May and June of 2018 when die-back was already well progressed. Therefore, the high temperatures of the summer of 2018 are not considered to have contributed to the impacts observed.

The exact cause of decline in eelgrass beds at most sites is unknown. The major pressures and threats on the *Large shallow inlets and bays* habitat have been identified as agriculture, forestry, aquaculture, fisheries and waste-water treatment and disposal. It is likely that the cause of decline or loss of the eelgrass beds is site-specific and most likely due an in-combination effect of one or more of the main pressures.

The presence of the invasive alien species *Sargassum muticum* was recorded widely during this current monitoring programme. Its establishment in eelgrass beds and maërl beds has the potential to lead to significant ecosystem change in the future as it has been observed to result in significant shading of eelgrass beds. This leads to light attenuation with consequent impacts on growth rates and the ability of eelgrass beds to regenerate. Excessive growth of *S. muticum* can also lead to changes in water flow over eelgrass beds by slowing down or diverting the flow of water, potentially leading to localised changes in the seabed through increased rates of siltation.

5.5 *Reefs* [1170]

During the current reporting period, 618 km^2 of inshore reef habitat within 12 SACs around the coast of Ireland were surveyed to assess its conservation status. The overall assessment of the Status of this habitat, which includes the offshore resource, has been assessed as Unfavourable-inadequate. It should be noted that when considering the inshore *Reefs* habitat alone, it was assessed as being in Favourable conservation status.

The available information for sublittoral inshore reefs made it difficult to assess *Structure & functions*, as there were limited data against which change could be measured. However, pressures on the habitat were considered to be low and no obvious impacts were noted at the majority of sites surveyed. The lack of obvious pressures was used as a proxy against which to assess *Structure & functions*. In the case of intertidal reefs, data were available for a number of sites from previous monitoring conducted under the Water Framework Directive and therefore comparison with these data was possible.

The current project has provided a dataset of spatially encoded data for reef physical and ecological structure and kelp canopy height and structure. This has provided a baseline against which to measure change in the future.

5.6 *Submerged or partially submerged sea caves* [8330]

Two sea caves were surveyed in detail during the course of this project. The overall assessment of the conservation status for this habitat is Favourable.

Sea caves remain one of the most challenging habitats to survey and therefore an assessment of their conservation status is difficult. It is likely that a very large number of sea caves around the Irish coast are completely submerged and unknown. Without considerable exploration it is unlikely that the full extent of the national resource will ever be known. Of the known sea caves, generally those that are partially submerged, there are insufficient baseline data upon which to fully describe the habitat or its typical species and communities. Along with the two sea caves sampled as part of this current work a further four caves have been surveyed in 2012 (MERC, 2012e). This represent a small sub-sample of this habitat that has been surveyed in detail and is not considered large enough to accurately assess their *Structure & functions* or extrapolate the likely total *Area* of the habitat.

However, a number of factors make sea caves unlikely to be vulnerable to change. Foremost, all sea caves in Ireland are formed from geogenic hard rock habitats. Therefore, other than minor alteration of the rock face due to the effects of natural erosion, habitat loss is highly unlikely. The inaccessible nature of sea caves, on the seaward side of cliff faces, also makes them less vulnerable to anthropogenic impacts.

Notwithstanding the lack of detailed baseline information for *Submerged or partially submerged sea caves*, their conservation status has been assessed as Favourable. This is based on the clear lack of pressures on the sea caves surveyed to date and the lack of any future threats which could impact on their conservations status.

5.7 Conclusion

The conservation status of the *Sandbanks which are slightly covered by sea water all the time* is Favourable while that of *Reefs* is Unfavourable-Inadequate. The status of the latter habitat is heavily influenced by the fact that the proportion of the resource in the offshore far exceeds that of the inshore.

The conservation status of *Estuaries* and *Mudflats and sandflats not covered by sea water at low tide* has been assessed as Unfavourable-Inadequate and that of *Large shallow inlets and bays* has been assessed as Unfavourable-Bad. The latter represents a decline in status from the previous reporting period. These habitats are most vulnerable to anthropogenic activities occurring both within and outside of the SAC network. The major pressures and threats on the *Large shallow inlets and bays* habitat have been identified as agriculture, forestry, aquaculture, fisheries and waste-water treatment and disposal. The probable cause for the deterioration of this habitat is liable to be site specific and is most likely due an in-combination effect of one or more of the main pressures.

Aquaculture has been identified as the cause of direct smothering of rare and vulnerable maërl species at Roaringwater Bay SAC. Fishing (by mechanical dredging) is highly likely to be the single cause of the recorded destruction of the *Serpula vermicularis* community at Mullet/Blacksod Bay Complex SAC. Indirect habitat loss due to the construction of a floating breakwater has resulted in the effective habitat loss of the *Edwardsia delapiae*-associated habitat at Valentia Harbour/Portmagee Channel SAC. Significant increases in the invasive alien species *Sargassum muticum* in the majority of sites surveyed has impacted eelgrass communities and has the potential to lead to gross habitat change and significant ecosystem wide impacts in the future.

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Appendix 1 Sediment Marine Community Types sampled within each SAC

Site	Marine Community type					
Kenmare River SAC	Intertidal mobile sand community complex	Muddy fine sands dominated by polychaetes and *Amphiura filiformis* community complex	Fine to medium sand with crustaceans and polychaetes community complex	Coarse sediment dominated by polychaetes community complex		
Castlemaine Harbour SAC	Intertidal muddy fine sand Community Complex	Intertidal sand with *Nephtys cirrosa* community	Fine to muddy fine sand with polychaetes community complex	Mixed sediment community complex	Fine sand with *Donax vittatus* and polychaetes community	
Galway Bay Complex SAC	Intertidal muddy fine sand Community Complex	Intertidal sand community complex	Fine to medium sand with bivalves community complex	Sandy mud to mixed sediment community complex	Mixed sediment dominated by Mytilidae community complex	
Valencia Harbour/Portmagee Channel SAC	Intertidal sand with nematodes and polychaetes community complex	Medium to fine sand with *Nephtys cirrosa* and *Spiophanes bombyx* community complex	Coarse sediment with *Pisione remota* community complex	Sandy mud to mixed sediment with *Melinna palmata* community complex	Mixed sediment with *Chaetozone gibber* community complex	
Dundalk Bay SAC	Muddy fine sand community	Fine sand community complex	Gravel dominated by polychaetes community			
Lough Swilly SAC	Fine sand community complex	Intertidal mixed sediment with polychaetes	Subtidal mixed sediment with polychaetes and bivalves	Muddy fine sand with *Thyasira flexuosa*	Mud community complex	*Ostrea edulis* dominated community
Kilkieran Bay & Islands SAC	Intertidal sand with polychaetes community complex	Mixed sediment dominated by polychaetes community complex	Sand with nemerteans and crustaceans community complex	Deep water sand dominated by bivalves and polychaetes community complex		

Site	Marine Community type			
Bannow Bay SAC	Fine sands with *Pygospio elegans* and *Corophium volutator* community complex	Intertidal sand dominated by polychaetes community complex	Sand with *Chaetozone christei* and *Tellina* sp. community complex	Coarse sediment with *Pisidia longicornis* and epibenthic fauna community complex
Hook Head SAC	Sand with *Chaetozone christiei* and *Tellina* sp. community	Coarse sediment with *Pisidia longicornis* and epibenthic fauna community complex		
Mulroy Bay SAC	Sand dominated by *Nephtys cirrosa* and *Bathyporeia* sp. community complex	Gravel to mixed sediment with nematodes community complex	Gravelly sand with bivalves, polychaetes and nemerteans community complex	
Slaney River Valley SAC	Estuarine muds dominated by polychaetes and crustaceans community complex	Sand dominated by polychaetes community complex	Mixed sediment community complex	Fine sand with *Spiophanes bombyx* community complex
Raven Point Nature Reserve SAC	Sand dominated by polychaetes community complex	Estuarine muds dominated by polychaetes and crustaceans community complex	Mixed sediment community complex	Fine sand with *Spiophanes bombyx* community complex
Clew Bay Complex SAC	Sandy mud with polychaetes and bivalves community complex	Fine sand dominated by *Nephtys cirrosa* community	Intertidal sandy mud with *Tubificoides benedii* and *Pygospio elegans* community complex	
Broadhaven Bay SAC	Coarse sediment to sandy mud with *Pygospio elegans* community complex	Sand with *Angulus tenuis* community complex	Sand to coarse sediment with crustaceans and *Polyophthalmus pictus* community complex	Subtidal sand with polychaetes community complex

Site	Marine Community type				
Mullet/Blacksod Bay Complex SAC	Mobile sand with *Bathyporeia guilliamsoniana* community	Sand with *Angulus tenuis* and *Pygospio elegans* community complex	Sand with *Gastrosaccus spinifer* community complex	Fine sand with *Angulus fabula* community complex	
West of Ardara/Maas Road SAC	Sand with amphipods, polychaetes and *Tellina tenuis* community complex	Estuarine sand with oligochaetes community complex			
Tralee Bay & Magharees Peninsula, West to Cloghane SAC	Sand to sandy mud with polychaetes and bivalves community complex	Sand with *Nephtys cirrosa* community complex	Mixed sediment with crustaceans, bivalves and polychaetes community complex	*Ostrea edulis*-dominated community	
River Barrow & River Nore SAC	Muddy estuarine community complex	Sand to muddy fine sand community complex	Fine sand with *Fabulina fabula* community		
Great Island Channel SAC	Mixed sediment to sandy mud with polychaetes and oligochaetes community complex				
North Dublin Bay SAC	Fine sand to sandy mud with *Pygospio elegans* and *Crangon crangon* community complex	Fine sand with *Spio martinensis* community complex	*Mytilus edulis*-dominated community		
South Dublin Bay SAC	Fine sands with *Angulus tenuis* community complex	Fine sand to sandy mud with *Pygospio elegans* and *Crangon crangon* community complex	Fine sand with *Spio martinensis* community complex		
Lower River Shannon SAC	Intertidal sand with *Scolelepis squamata* and *Pontocrates* spp. community	Intertidal sand to mixed sediment with polychaetes, molluscs and crustaceans community complex	Estuarine subtidal muddy sand to mixed sediment with gammarids community complex	Subtidal sand to mixed sediment with *Nucula nucleus* community complex	Subtidal sand to mixed sediment with *Nephtys* spp. community complex

Site	Marine Community type		
Donegal Bay (Murvagh) SAC	Estuarine fine sands dominated by polychaetes and oligochaetes community complex	Intertidal muddy sand to sand dominated by polychaetes, bivalves and crustaceans community complex	Subtidal fine sand with polychaetes and bivalves community complex
Hempton's Turbot Bank SAC	Coarse sediment with platyhelminthes, nematodes and polychaetes community		
Kingstown Bay SAC	Subtidal sand with amphipods and polychaetes community		

Appendix 2 Reef Marine Community Types sampled within each SAC

Site	Marine Community type				
Kenmare River SAC	Intertidal reef community complex	*Laminaria*-dominated community complex	Subtidal reef with echinoderms and faunal turf community complex		
Galway Bay Complex SAC	*Mytilus*-dominated reef community	Fucoid-dominated community complex	*Laminaria*-dominated community complex	Shallow sponge-dominated reef community complex	
Valencia Harbour/Portmagee Channel SAC	*Fucus*-dominated intertidal reef community complex	*Laminaria*-dominated community	Echinoderm-dominated reef community complex		
Kilkieran Bay and Islands SAC	Intertidal reef community complex	Subtidal sponge and ascidian community complex	Deep water faunal crust and sponge community complex	Exposed to moderately exposed subtidal reef community complex	*Laminaria*-dominated community complex
Hook Head SAC	Exposed to moderately exposed intertidal reef community complex	Echinoderm and sponge dominated community complex	*Laminaria*-dominated community		
Mulroy Bay SAC	*Laminaria*-dominated community complex	Reef community complex			
Broadhaven Bay SAC	Fucoid-dominated reef community complex	Subtidal reef community complex			
Mullet/Blacksod Bay Complex SAC	Intertidal reef community complex	Sheltered subtidal reef community complex	*Laminaria*-dominated community complex		
Tralee Bay and Magharees Peninsula, West to Cloghane SAC	Intertidal reef community complex	Subtidal reef community complex	*Laminaria*-dominated reef community complex		
Magharee Islands SAC	Intertidal reef community complex	*Laminaria*-dominated community complex	Subtidal reef community complex		
River Barrow and River Nore SAC	*Sabellaria spinulosa* reef				
Lower River Shannon SAC	Fucoid-dominated intertidal reef community complex	Mixed subtidal reef community complex	Faunal turf-dominated subtidal reef community	Anemone-dominated subtidal reef community	*Laminaria*-dominated community complex