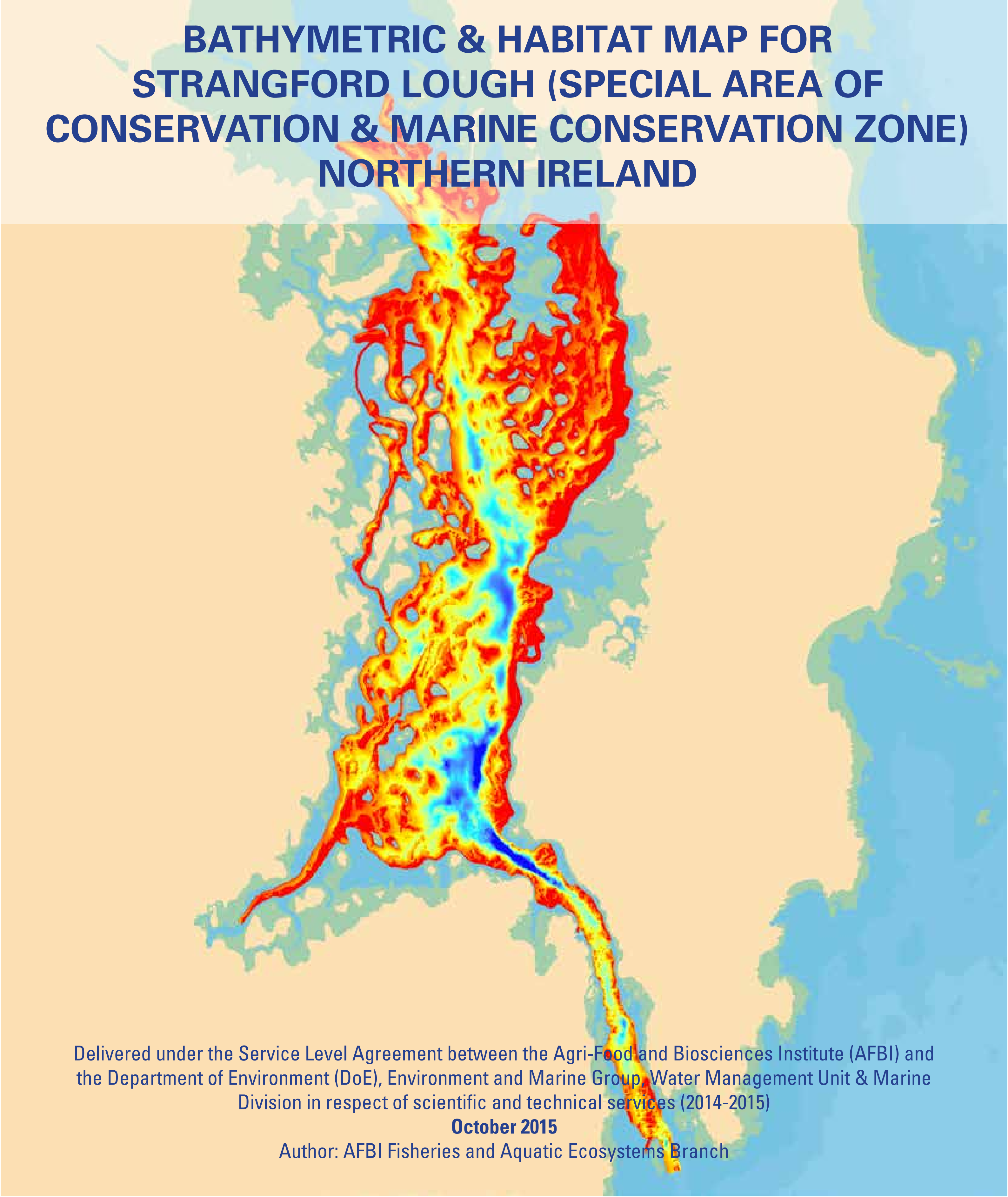
BATHYMETRIC & HABITAT MAP FOR STRANGFORD LOUGH (SPECIAL AREA OF CONSERVATION & MARINE CONSERVATION ZONE) NORTHERN IRELAND



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1. Introduction

Strangford Lough is probably the UKs most designated marine waterbody. It is a Special Area of Conservation, a Special Protection Area, OSPAR MPA, RAMSAR site, Area of Special Scientific Interest, Area of Outstanding Natural Beauty and Northern Ireland's first Marine Conservation Zone (replacing its status as a Marine Nature Reserve). It is a fully saline inland sea, sheltered from all wind directions resulting in an environment in which the predominant factor is water movement. The strength of the currents are co-associated with the substrate type (Erwin, 1986) as wind-generated waves have minimal impact on the seabed, however should prevailing wind directions show a prolonged shift this may cause some impact on seabed habitats, especially in shallower areas of the lough. This has resulted in a gradient of substrate types running from the deep entrance of the Lough in the south to the extensive mud and sand flats to the north. This gradient comprises bedrock through boulders, cobbles, gravels, mixed sediments, sands and muds and results in a wide range of specific habitats within a relatively small area. Within the central belt of the Lough in the area of muds and mixed sediments two unique types of biogenic reef complexes based on the horse mussel (*Modiolus modiolus*) were found. These biogenic reefs were the subject of much research in the 1970's and 80's and were widely regarded as unique and subsequently the main reason for Strangford's many designations. However, In the late 1980s and 1990s research emerged indicating that the *Modiolus* reefs in the Lough had been extensively damaged, most likely by commercial fishing through trawling and dredging. Despite restricting trawling and dredging to a southern zone of the Lough in 1993 and implementing a total ban on fishing within the Lough using these methods in 2003, the decline of the reefs has continued. As a result, the Ulster Wildlife Trust (UWT) has twice (in 2003 and 2011) made formal complaints to the European Commission (the Commission). The Department of the Environment (DOE) and Department of Agriculture and Rural Development (DARD) commissioned several research projects to assess the condition of features and the restoration potential of the reefs as a contribution to a formal restoration plan. As part of a joint study under a Service Level Agreement with the DOE, AFBI completed a multibeam echosounder (MBES) survey and compiled recent groundtruthing data from a range of sources to produce a high resolution bathymetric and habitat map for Strangford Lough. This map is key to the successful delivery of the current Strangford Lough revised restoration plan (DARD and DOE, 2015). The GIS products from this project will underpin future biogenic reef restoration activities within Strangford Lough. This habitat map can be considered as a revised baseline in order to determine extent and rate of recovery of the *Modiolus* reefs. It will also be used to map out the distribution and extent of those habitats which will be included in the MCZ designation citation.

Knowledge of the distribution and extent of benthic habitats and associated marine life is fundamental to marine resource management, and an integrated approach to marine stewardship. In 1998, the Oslo and Paris Commission (OSPAR) recognised the need to assess which marine habitats required protection, through the production of an inventory of habitats. This added to those habitats specified for protection and sensitive management under the EC Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora). Furthermore, the DOE is empowered by the Marine Act (Northern Ireland) 2013 to identify and

designate Marine Conservation Zones (MCZs) based on nationally important marine features. It is important through mapping exercises such as this project to be able to identify the location and extent of these features within Northern Ireland's waters. The Department has collaborated with experts in other Departments and academic institutions to review a wide range of International and National lists of marine habitats and species.
These conservation lists (outlined below) were amalgamated to identify marine features of nature conservation importance in Northern Irish waters, Priority Marine Features (PMFs) This is to ensure the range of representative, threatened, rare or declining species and habitats are protected. From this, the PMF Habitats, PMF Limited/low mobility species and PMF Highly mobile species lists were developed. The OSPAR list of Threatened and/or Declining Species and Habitats (OSPAR T&D):

- The UK Biodiversity Action Plan list (UK BAP);
- Northern Ireland List of Priority Habitats and Species (NI Priority);
- Species of Conservation Concern (SOCC), and
- Nationally Important Marine Features (NIMF).

DOE conducted a comprehensive criterion based review of all habitats and species on the PMF lists to identify the pMCZ features (Table 1 below describes the pMCZ Habitats). These will underpin the MCZ designation process and be used to identify areas of search.

Table 1. pMCZ Habitats. This list describes the broad scale habitats (based on EUNIS Level 2 & 3 classification system) and their corresponding finer sub-scale habitats contained for which marine protected areas are considered an appropriate conservation measure. These pMCZ Habitats will be used in the early stages of the MCZ development, underpinning the initial selection of search locations.

pMCZ Habitat	Examples of component (sub-scale) habitats
Deep sea bed	Cold water coral reefs
Low energy circalittoral (subtidal) rock	• Estuarine rocky habitats
Sublittoral (subtidal) biogenic reefs	• Horse Mussel (*Modiolus modiolus*) beds • Blue Mussel (*Mytilus edulis*) beds • Brittlestar beds
Sublittoral (subtidal) muds	• Mud habitats in deep water • Sea-pen and burrowing megafauna communities • Blue Mussel (*Mytilus edulis*) beds
Sublittoral (subtidal) sand	• Circalittoral sand and gravel communities • Tide-swept channels • Native oyster (*Ostrea edulis*) beds
Sublittoral (subtidal) mixed sediments	• Brittlestar beds

Identified pMCZ features also feed into assessments needed under the Marine Strategy Framework Directive (MSFD - Directive 2008/56/EC on establishing a framework for community action in the field of marine environmental policy) in order to achieve Good Environmental Status (GES).

1.1 Strangford Lough

Strangford Lough was designated as a Special Area of Conservation (SAC) under the 1992 EC Habitats Directive, including the following specific subtidal habitat features:

- Reefs, including the sub-features:
  - *Modiolus modiolus* biogenic reef;
  - Subtidal rock and boulder communities;
  - Subtidal rocky reef communities.
- Large shallow inlets/lays and coastal lagoons

From these features, the following attributes require assessment as part of SAC monitoring and management undertaken by the Department of the Environment, in order to ensure the features and sub-features are maintained in favourable condition (allowing for natural change):

- Extent of the feature and sub-features;
- The presence of a selection of characteristic biotopes at sites chosen to indicate the distribution and extent of each sub-feature;
- Species composition of selected biotopes at monitoring sites;
- Distribution of *Modiolus* beds;
- Extent and percentage cover of *Modiolus* beds;
- Structure of *Modiolus* beds;
- Species index of *Modiolus* beds;
- Water clarity;
- Water salinity and temperature;
- Nutrient status.

Strangford Lough was also a Marine Nature Reserve (MNR) established under Article 20 of The Nature Conservation and Amenity Lands (NI) Order 1985 (NCALO).
It imposed an obligation on the Secretary of State for Northern Ireland to manage a designated Marine Nature Reserve for the purpose of:

- Conserving marine flora, fauna or features of geological, physiographical or other scientific or special interest in the area; or
- Providing, under suitable conditions and control, special opportunities for the study of, and research into, matters relating to marine flora and fauna and the physical conditions in which they live, or for the study of features of geological, physiographical or other scientific or special interest in the area.

Strangford Lough was automatically designated as Northern Ireland's first MCZ under the introduction of the Marine Act (Northern Ireland) 2013. As a result of this Act the previous Marine Nature Reserve Designation under the NCALO has been revoked.
As part of the re-designation of Strangford Lough as an MCZ, an assessment of the up-to-date distribution and extent of habitats within the subtidal area of the lough is required.

1.1.1 Morphology

Strangford Lough is a large marine inlet on the County Down coast of Northern Ireland. It is approximately 31km long and its main body varies in width from 4-7km. The Lough opens into the Irish Sea through a constricted channel known as 'the Narrows', which is 8km in length and at its narrowest 0.5km wide. The Lough has a complex bathymetry with numerous islands and submerged drumlins known as 'pladdies'. Average depth is between 14-30m, but varies greatly throughout the lough.

1.1.2 Geology

The Lough emerged from under the melting ice-sheets of the Ice Age 10-12 million years ago. There is a Y-shaped deeper channel (possibly an old river-valley or geological fault-line) up to 66 m deep which extends from the Narrows up to the central portion of the Lough. The underlying rock is largely Silurian. The surface of the seabed and shore of the Lough ranges from bedrock in areas with strong currents to fine mud in sheltered waters.

1.1.3 Hydrography

High tidal ranges at the entrance and the large volume of water stored inside the basin of the main lough give rise to strong flows, reportedly ~3.5 m/s in the Narrows (Brown, 1990), and a multitude of islands and rocky outcrops add to considerable complexity in the flow patterns. Current speeds are generally far lower within the main lough, although local complexity can increase flow at a finer scale.

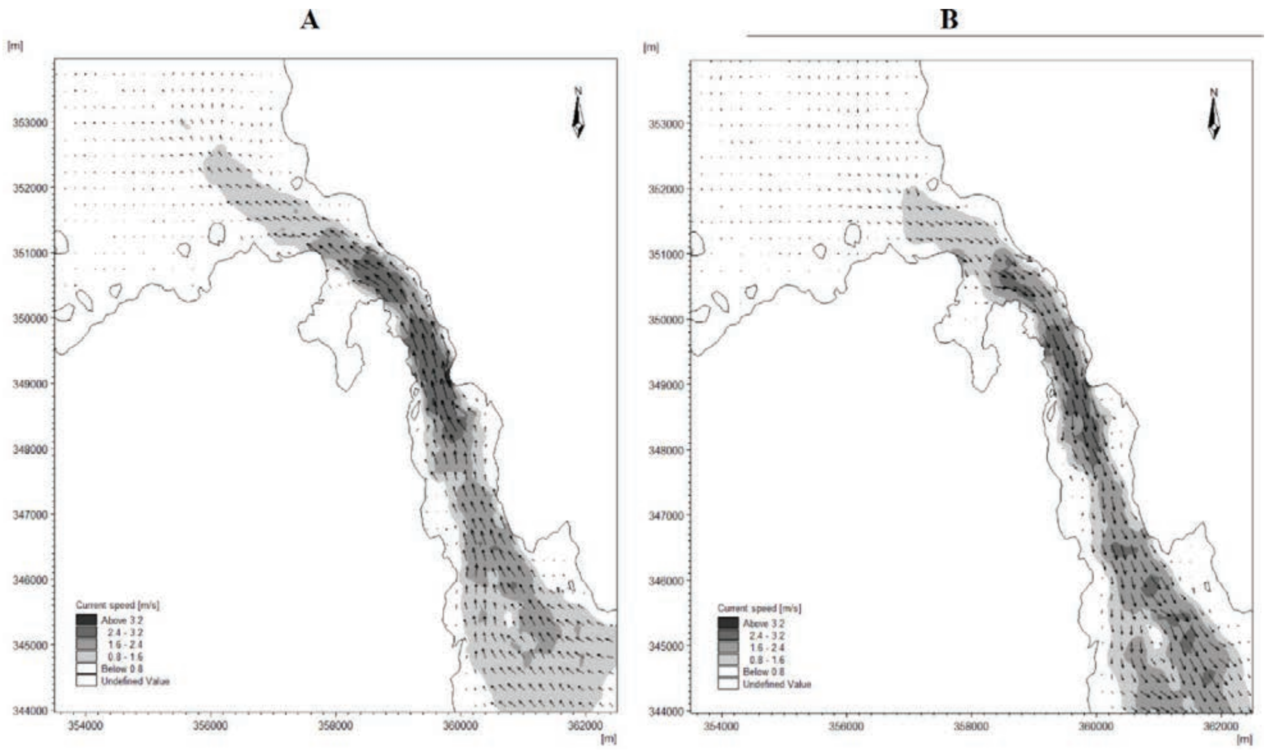

Figure 1. Depth averaged maximum flow during (A) flood tide, and (B) ebb tide in the Narrows. Taken from Kregting & Elsäeßer (2014).

1.2 Project aims

The aim of this project is to utilise high resolution acoustic data (multibeam sonar) to facilitate development of an up-to-date subtidal habitat map for Strangford Lough, including the Narrows. In particular, efforts will be focussed on using existing data for biotope classification and identification, ensuring that these records are representative of the current status of the lough.

2. Methodology

2.1 Multibeam echosounder (MBES) data acquisition and processing

2.1.1 Main Lough

DOE commissioned AFBI to conduct a MBES survey of Strangford Lough in 2012. MBES data were collected aboard the DARD fisheries protection vessel *Banrion Uladh*. Soundings were collected with a Kongsberg EM3002 (dual head MBES configuration), attitude and navigation with a Seapath 200 and GPS height with a Hemisphere R320 GPS. Sound velocity profiles were collected with an YSI Castaway CTD.
Soundings were processed in CARIS HIPS and SIPS software, to reduce artefacts and derive the bathymetry to 2m horizontal resolution, and backscatter to 1m resolution. PPP in POSPAC (GNSSPOS) was used to improve the GPS height and generate the tidal corrections needed to de-tide the data. The VORF model (UKHO) was used to reduce all GPS heights to Chart Datum.

2.1.2 The Narrows

MBES data were collected aboard the DARD fisheries protection vessel *Banrion Uladh* in 2013. Soundings were collected with a Kongsberg EM3002 (dual head MBES configuration), attitude and navigation with a Seapath 200. Sound velocity profiles were collected with an YSI Castaway CTD.
Soundings were processed in CARIS HIPS and SIPS software, to reduce artefacts and derive the bathymetry to 1m horizontal resolution, and backscatter to 0.5m resolution. Data were de-tided using a tide file in CARIS produced using predicted tide data from the software 'TotalTide'.

2.1.3. Multibeam data integration

The bathymetric data from both surveys were initially merged to 2m horizontal resolution in ArcGIS 10.1, and filtered using neighbourhood focal statistics with a circular search of 5m, to reduce artefacts.
There were substantial differences between the backscatter datasets which meant that mosaicing or merging these datasets would not improve subsequent analysis.
Following cluster analysis of bathymetric and backscatter derivatives, it was decided to treat each survey area separately to reduce the impact of the backscatter differences in the whole lough area.

2.2. Multibeam data post-processing

The bathymetric data were post-processed to yield the following derivatives using the Spatial Analyst toolset in ArcGIS 10.1 and Benthic Terrain Modeller (Wright *et al.,* 2012) extension:

1) Slope angle
2) Aspect – northness and eastness
3) Terrain ruggedness
4) Benthic position index

'Terrain ruggedness' may be defined as the ratio between the surface area and the planar area of each cell in the input bathymetric dataset; it is a measure of terrain complexity. 'Benthic Position Index (BPI)' may be defined as a measure of where a referenced location is relative to the locations surrounding it, and allows the identification and mapping of crests and troughs at specific (user defined) scales. The use of BPI in habitat mapping is discussed in depth by Verfaillie *et al.*(2007). In this study, BPI grid files were generated over a range of scales, with the search radius of 10m to 100m yielding the most useful information when examined in conjunction with other datasets including ground-truthing information. This broad-scale BPI is used in subsequent analysis to produce the final habitat maps.

The backscatter data (one dataset for the Main Lough, one dataset for the Narrows) were segmented using the 'Isocluster unsupervised classification' routine in ArcGIS 10.1.

The backscatter data from the Narrows was particularly problematic due to influence of tide on the data, which results in artefacts running along survey tracks which masked the overall ground-type distribution patterns in the cluster map that could be seen by eye in the backscatter imagery. It was therefore decided not to use the backscatter image in supervised or unsupervised analysis, but instead to use it for manual interpretation in the Narrows.

The cleaner backscatter data in the Main Lough reduced the number of artefacts that are amplified in the clustering process. It was therefore decided to incorporate the backscatter cluster map in further analysis.

2.3. Ground-truthing data collation

All data were analysed and assigned to UK MNCR biotope categories, following guidelines published by Connor *et al*., 2004. Where possible, data were ascribed to biotope or sub-biotope categories (MNCR Levels 5 and 6, respectively), however in some cases it was only possible to assign data to MNCR Level 4 (Biotope complex) due to a paucity of biota or substratum data, or due to poor video footage quality (poor visibility). MNCR biotopes are all incorporated within the EUNIS classification, and both the MNCR codes and their sister EUNIS codes will be referred to together in the Results section.

2.3.1. Historic diver survey records (CEDaR)

Subtidal biotope records were requested from CEDaR for the entire lough, which included all historic records from the 1970s to 2013. Where available, sediment descriptions were also included. The datasets were presented in ArcGIS10.1, and based upon consultation with DOE

scientific staff, a decision was made to use all records for hard substrata (bedrock, boulders – biotope codes “IR” (infralittoral rock) and “CR” (circalittoral rock)) that were not from wreck sites (where biotopes were recorded on the wrecks rather than surrounding areas), and where biotopes were recorded to a minimum of MNCR Level 4 (biotope complex). 107 records were included within this dataset.
Due to documented ongoing changes in the lough over the past decade (Roberts *et al.,* 2011, Geraldi *et al.,* 2014), which primarily appear to have affected community composition and structure in sediment substrata, it was deemed inappropriate to use older records from diver surveys on sediment substratum sites. However, due to a paucity of recent dive records on softer substrata in the southern part of the lough, and in the Narrows, it was decided to extract records south of a line running east-west at the southern tip of Limestone Pladdy. This region of the lough appears to have shown less change than the region to the north (J. Breen, pers. comm.). Once these had been extracted, records were selected that had biotope information recorded to a minimum of MNCR Level 4 (biotope complex). 91 records were utilised from this dataset.

All diver survey data provides the dive start point as a location (latitude and longitude, in WGS 1984 datum). Due to lack of information about distance covered during a dive, biotopes are associated only with this start point location.

2.3.2. 2008 MRRG ROV videos

Some biotope information relating in particular to *Modiolus modiolus* biotope categories was recorded from the MRRG ROV surveys, along with limited biota and sediment information, available in spreadsheet format. In order to fully utilise these data for biotope distribution mapping, all the ROV footage itself was examined and biotopes assigned.
The start point of each ROV dip was recorded (latitude and longitude, in WGS 1984 datum), and therefore the biotope identified was assigned to this start point. Where more than one biotope was identified from one “dip”, the first biotope encountered only was associated with the start point. In many cases, a mosaic of biotopes was observed, in heterogeneous sediments, and therefore these were recorded jointly associated with the start point location. Field of view was small on this ROV system, and therefore each tow’s footage was reviewed in its entirety to get a better impression of the substratum composition prior to biotope assignment.
105 records were utilised from this dataset.

2.3.3. 2011 AFBI drop frame footage for inspecting aquaculture sites

The AFBI drop frame video footage from nine tows was analysed to deduce biotope complexes and biotopes, where appropriate. Start and end of tow positions were recorded and biotopes assigned to such transects. For ease of analysis positions were taken every one- two minutes; biotopes were assigned to these positions as “spot samples”. This resulted in 96 samples across the transects.

2.3.4. 2011 NERC drop-down video survey (the Narrows)

A number of drop down video tows were completed by Envision Ltd. as part of the NERC "FLOWBEC" project (http://noc.ac.uk/project/flowbec). These surveys concentrated in the Narrows, particularly around the Seagen site. Footage was not available for this project, however the footage was analysed by a team led by Dr. Robert Kennedy at NUI Galway. Permission to access these data were kindly granted by Dr. Graham Savidge, of QUB (co-investigated for FLOWBEC). The data provides biota scored from the SACFOR semi-quantitative scaling system, in short video segments, then averaged for the entire transect and assigned to a calculated midpoint of each transect. For each transect midpoint there was also a descriptor for bottom type, depth and a modelled value for mean current speed. This produced, in total, 163 records, or 'samples'.

In order to deduce biotopes from these data, the samples data were analysed within PRIMER (the analysis results are available upon request). Dr. Kennedy's team had ascribed arbitrary values relating to the SACFOR scale, with rare = 1 to superabundant = 6. The SIMPROF routine (with a 1% significance level) was used to identify factors which in turn were plotted using multi-dimensional scaling to examine grouping of the infaunal communities from the samples. SIMPER was then used to extract the species responsible for the similarity of each community group. These "characterising species" were then used to classify the samples into biotopes using the MNCR classification. In some cases it was clear from the bottom type description that heterogeneous substrata were found, and the characterising species corresponded to more than one biotope or biotope complex. In such cases, a mosaic of biotopes or biotope complexes was ascribed to one 'sample'.

2.3.5. 2012 AFBI aquaculture inspection surveys

The AFBI drop frame video footage from 17 tows was analysed to deduce biotope complexes and biotopes, where appropriate. Start and end of tow positions were recorded and biotopes assigned to such transects. If a different biotope was noted within the tow, the position of this new biotope was recorded, using the positional overlay from the video, thereby breaking the tows into "sections". Using the start and end positions of these sections, a total of 50 records were utilised.

2.3.6. 2012 AFBI diver video from inspection of mooring chain impacts

Five diver inspection videos were made available, which could be treated each as single locations (diver entry position). The field of view of the video footage was very small but from viewing all footage it was possible to deduce biotope information. This added a further five records for the project.

2.3.7. 2012 DOE Spatial Grab Sampling Survey

Data were analysed from 76 grab samples (DOE Marine Division) taken in 2012 (for sediment particle size analysis (PSA) and infauna). Sediment PSA data were analysed using Gradistat, and infaunal data were pre-treated to remove species with no records and biomass data were square root transformed prior to analysis within PRIMER (analysis results are available upon request). SIMPROF routine (with a 1% significance level) was used to identify factors which in turn were plotted using multi-dimensional scaling to examine grouping of the infaunal communities from the samples. SIMPER was then used to extract the species responsible for the similarity of each community group. These “characterising species” were then used to classify the samples into biotopes using the MNCR classification.

Biotopes have been assigned to all 76 samples, and photographs of each sample used to help corroborate the biotopes. In one case the biotope that fits the characterising species most closely is unlikely to be found within a lough (as it is an offshore sand biotope); this may be due to the limited data available and issue of “fit” within the existing MNCR classification scheme. As such the records of offshore sand are treated with caution in the final mapping.

2.3.8. 2013 AFBI drop frame footage from Nephrops areas

The AFBI drop frame video footage from six tows was analysed to deduce biotope complexes and biotopes, where appropriate. Start and end of tow positions were recorded and biotopes assigned to such transects. Visibility was fairly poor restricting discrimination of smaller sized species, and therefore biotope complex level was usually the highest level possible to discriminate.

2.3.9. 2013 Envision Ltd. (for Royal Haskoning) drop frame video footage from an impact area around the Seagen marine current turbine in Strangford Narrows

A drop frame towed video survey was completed at 26 sites in the vicinity of the Seagen turbine. The footages was analysed by Envision Mapping Ltd. with biotope complexes and biotopes ascribed to each site. The start and end positions of the tows were provided along with the biotope information, which was utilised in this project. Stills from the video footage deemed to be representative of each ascribed biotope were also available in the report (Envision Mapping Ltd., 2013).

2.3.10. Summarising biotope information

Each ground-truthing dataset was converted into a separate shapefile within ArcGIS, with locations associated with level 4 and higher level biotopes where adequate information supported such biotope discrimination. In many cases it was necessary to attribute more than one biotope to a location, due to a mosaic effect in heterogeneous ground. However, it is useful to summarise these data to allow general spatial patterns to be discerned and for ease of mapping (reducing the number of categories possible). Therefore the individual ground-truthing datasets were merged together in a master spreadsheet, and following a review of the information a “summary biotope” and “summary substratum” were assigned for each ground-truthing location. In some cases there was a lack of substratum information and therefore these records lack a description. Where possible, mosaics of more than one biotope were summarised to one "dominant" biotope, but where data did not permit this (where mosaics consisted of even proportions of biotopes or biotope complexes) the mosaic was upheld.

This summary of ground-truthing information was added to the ArcGIS project and converted into a shapefile, which was symbolised with (a) the summary biotope, and (b) the summary substratum.

2.4. Data integration and analysis

A number of approaches were trialled to classify the multibeam data (bathymetry, bathymetric derivatives and backscatter) and incorporate the biotope ground-truthing data:

(1) A supervised classification approach: Signature files were created from the ground-truthing data, using (a) un-buffered locations, and (b) buffered by 10m locations. Examination of the signature files revealed a considerable overlap between each biotope category, which results in difficulties classifying the multibeam data and a high rate of "miss classification".

(2) An unsupervised classification approach:

The ISO Cluster technique organises the data in the input raster into a user-defined number of groups in order to produce signatures which are then used to classify the data using the Maximum Likelihood Classification function. The number of iterations for the clustering procedure was set to 200, as it was found that higher numbers of iterations had a negligible effect on the clustering results with significant increases in computing time. The number of classes, and the choice of input data layers, was based on an iterative approach following manual examination of the datasets, and ranged from 6 to 12. The final cluster number chosen for the main lough was eight, and the final cluster number for the Narrows was also coincidentally eight. In the case of the main Lough, the input data layers for cluster analysis that gave the most ecologically coherent results (in terms of compatibility with the ground-truthing) were the backscatter cluster map, the broad BPI, terrain ruggedness and depth, and in the case of the Narrows, these were broad BPI, terrain ruggedness and depth.

Following the generation of each cluster map, the ArcGIS tool "extract by…" was used to extract the cluster number beneath each ground-truthing location, and the resulting table was then examined to determine the "majority" cluster number for each biotope category. This biotope category was then manually assigned to the relevant cluster. Where more than one biotope category could be assigned to a cluster number, the cluster was attributed by the range of biotopes as a mosaic, e.g. "biotopeX/biotopeY/biotopeZ". In some cases this led to more than four biotopes being attributed to each cluster number.

(3) An unsupervised classification approach with manual interpretation/editing: This follows the same steps as (2) above, with the difference that the whole lough was examined in detail by selecting polygons by each biotope category found within the ground-truthing dataset, and where individual polygons contained distinct combinations of biotopes these were re-attributed accordingly, so long as the multibeam data supported this (in particular from

interpretation of the backscatter data). This resulted in a final product that more closely corresponds (spatially) to the ground-truthing, but has a greater range of biotope mosaic categories. In some cases the polygons were also manually edited to fit geomorphological features more closely (and to reduce the impact of any data artefacts which are amplified in the auto-classification processes). This was particularly required in the Narrows map, due to a number of persistent artefacts that are likely due to the strong tidal conditions/upwelling etc. that affect the acoustic response and result in along-track artefacts.

2.5. Confidence assessment

Accuracy assessment was undertaken by comparing the ground-truthing biotope complexes (MNCR Level 4) with the mapped polygons (also classified at biotope complexes). The percentage of agreement was calculated for each map (main lough and the Narrows). Due to the use of mosaics, agreement was given if an example of the biotope complex in the ground-truthing samples was also in the polygon classification.

In addition to the accuracy assessment, a confidence assessment was completed following the MESH method (MESH, 2007).

3. Results

3.1. Multibeam data

Cleaned bathymetry was produced for both the main lough (2m horizontal resolution) and the Narrows (1m horizontal resolution), as shown in Figures 3.1 and 3.2 below. Maximum depths attained were -68.9m and -73.5m respectively (to Chart Datum, which approximates Lowest Astronomical Tide (LAT)).

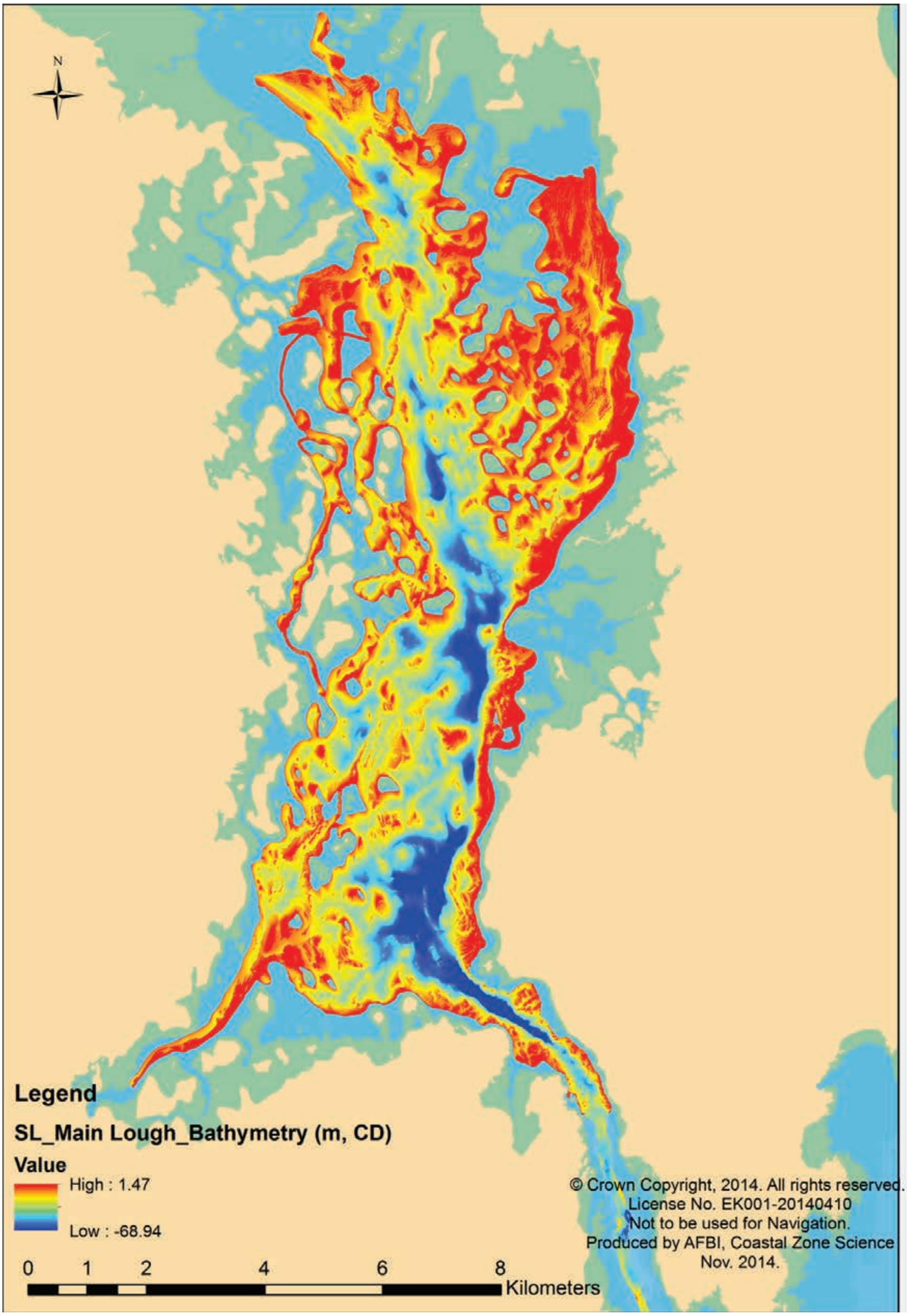

Figure 3.1. Multibeam bathymetry for the main Lough.

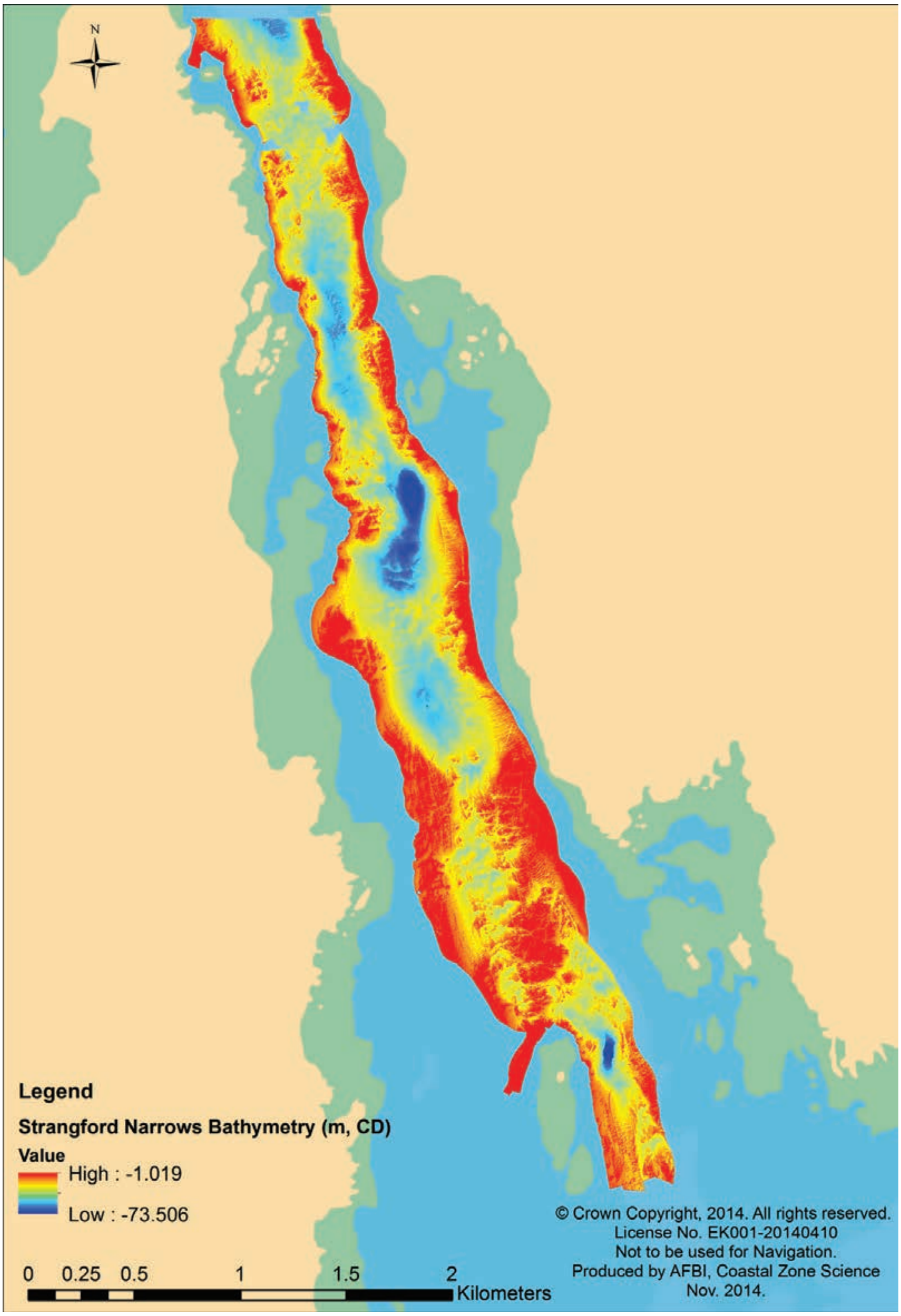

Figure 3.2. Multibeam bathymetry for the Narrows

Backscatter data were mosaiced for both areas, as show in Figures 3.3 and 3.4 below. The softest ground (resulting in low backscatter values, but represented as high image values for best graphic representation) is found in the north of the lough, and toward the Quoile estuary. The middle channel of the lough shows a heterogeneous backscatter pattern, with highest reflectance towards and in the Narrows, as seen in outcropping bedrock areas or boulderfields.

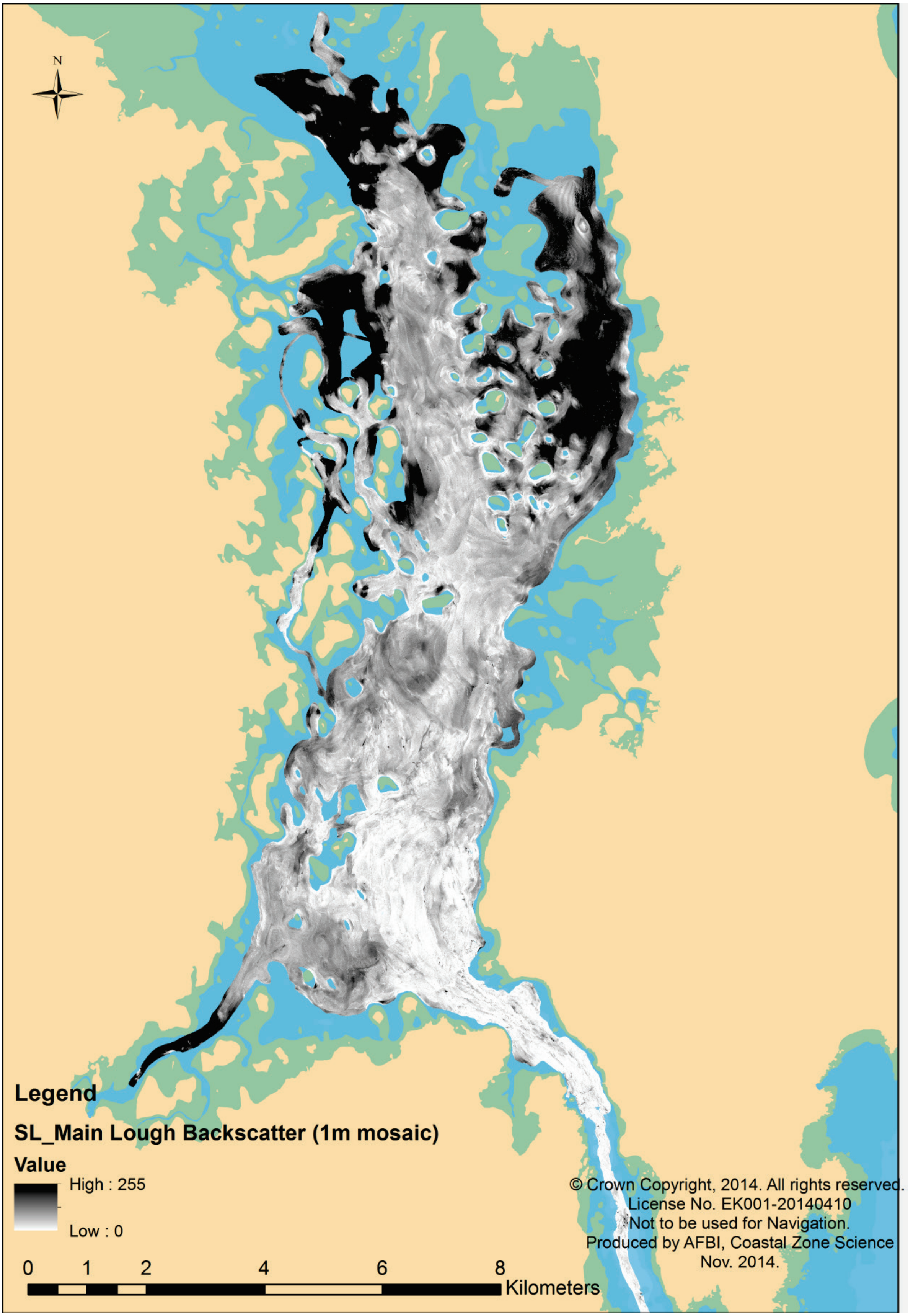

Figure 3.3 Multibeam backscatter mosaic for the main lough. Low image values = high reflectivity (coarser or harder ground), high image values = lower reflectivity (softer ground).

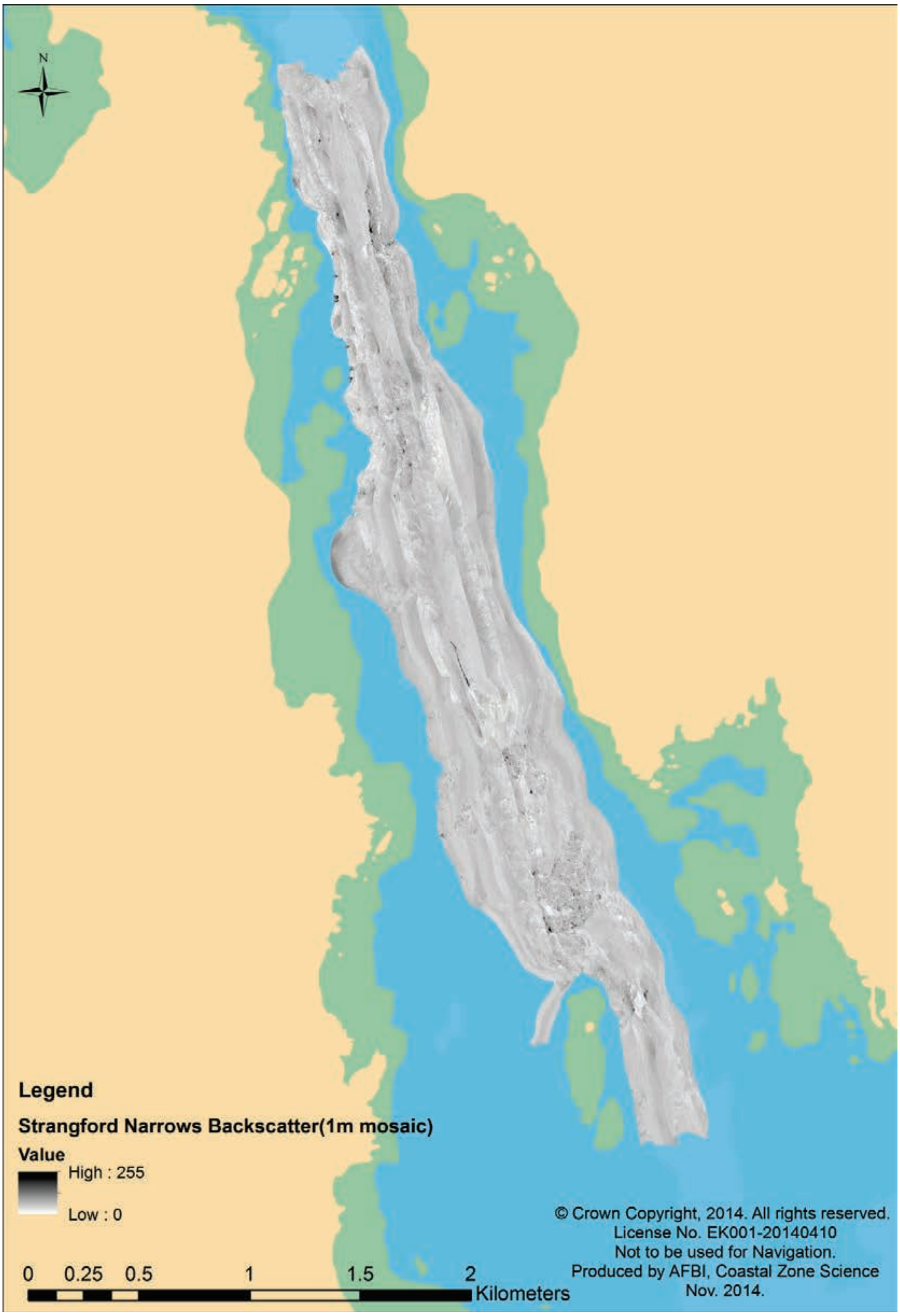

Figure 3.4 Multibeam backscatter mosaic for the Narrows. Low image values = high reflectivity (coarser or harder ground), high image values = lower reflectivity (softer ground).

Slope angles were produced from the bathymetric data, as shown in Figures 3.5 and 3.6 below. Submerged pladdies/a drumlin field are evident in the main lough, with the edges of these highlighted by the increased slope angle. In the northern part of the lough the bathymetry shows a fairly flat topography, while in the south of the lough there are increasing steep slopes approaching the Narrows. Bedrock reefs in the Narrows shallows and mid channel are clear in the slope angle data and corroborates the pattern seen in the backscatter data.

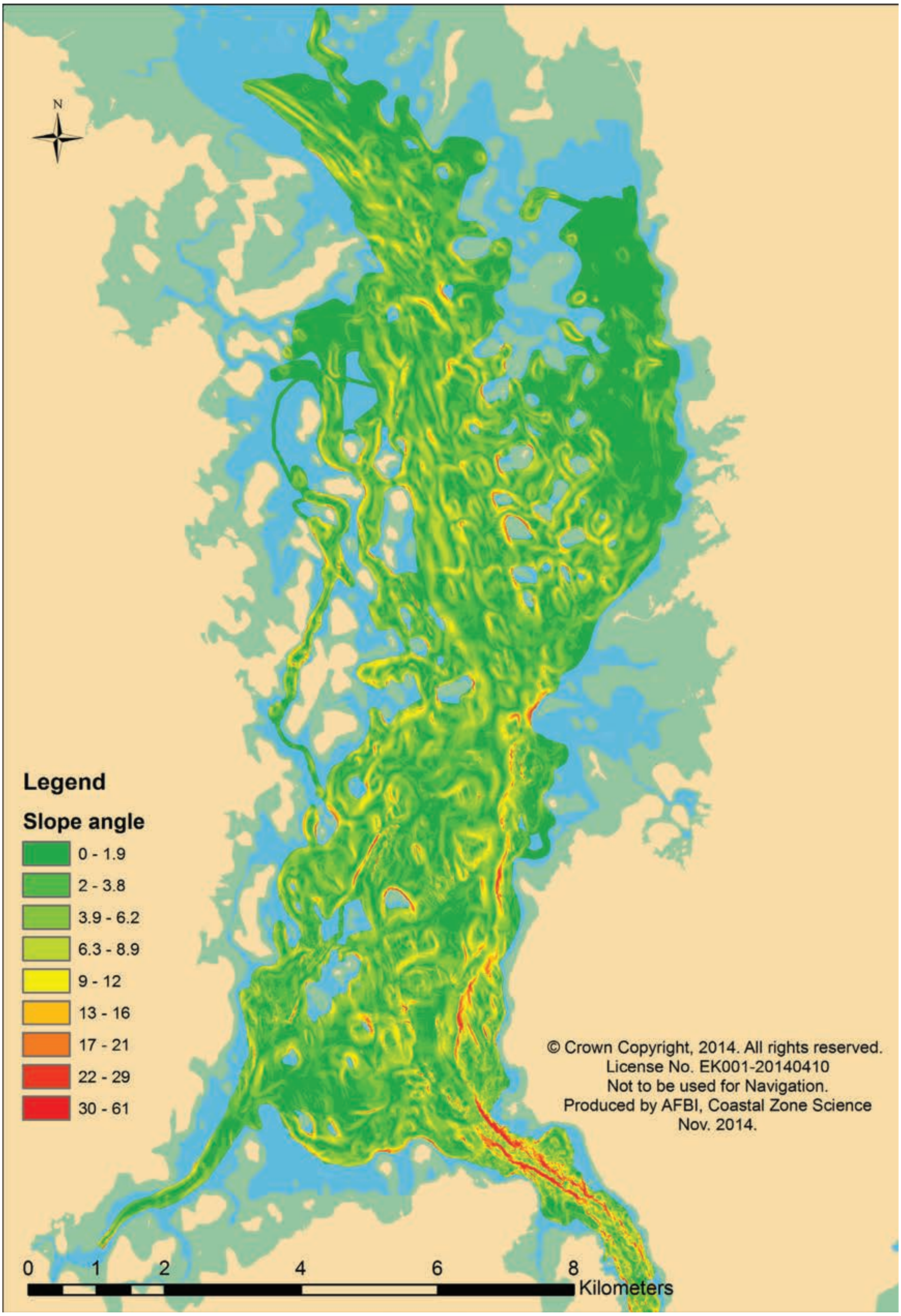

Figure 3.5. Slope angles (in degrees) for the main Lough.

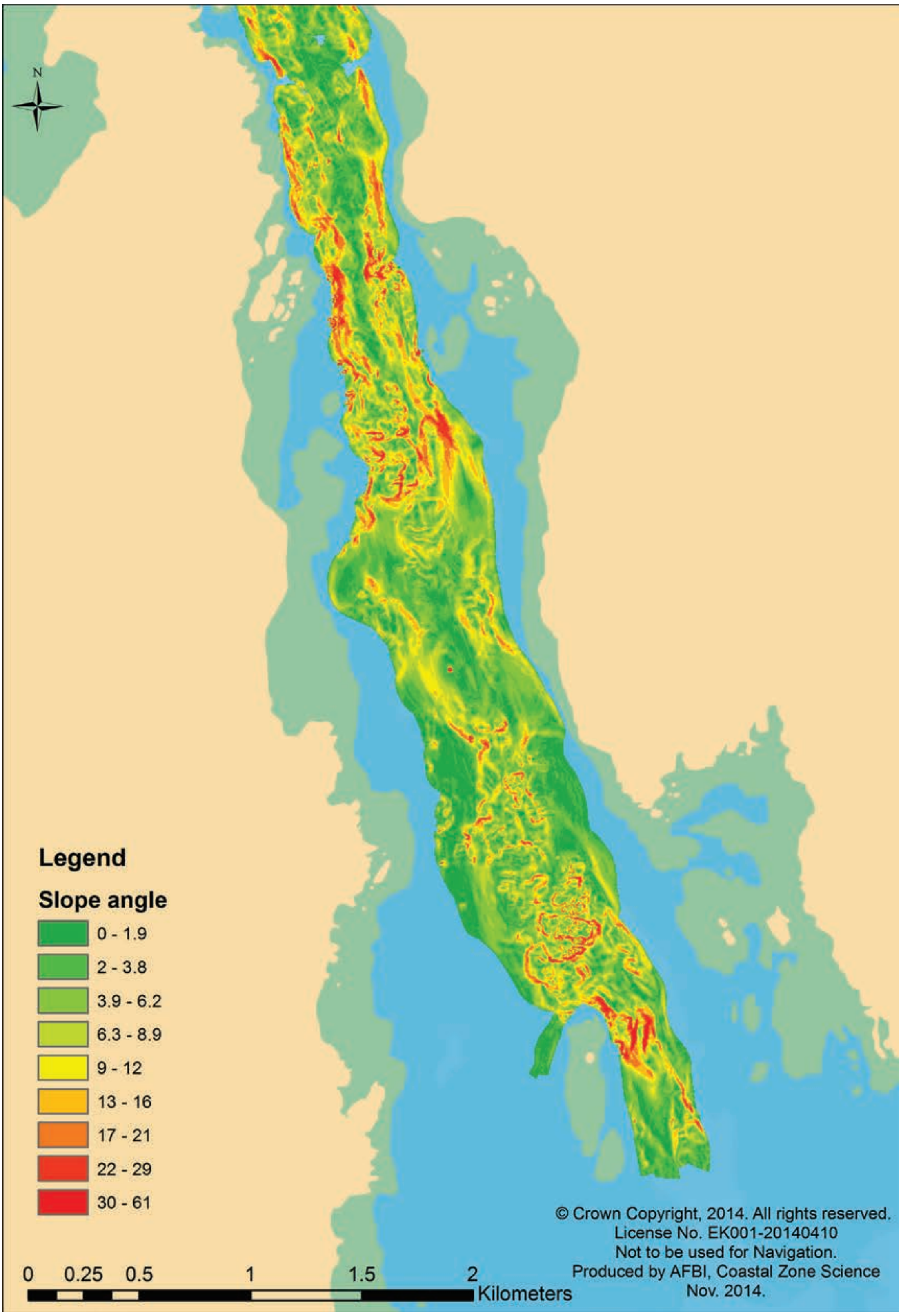

Figure 3.6. Slope angle (in degrees) for the Narrows.

Terrain ruggedness (Figure 3.7 and 3.8) allowed a depiction of the heterogeneity of the seabed, largely following the patterns identified from the slope angle and backscatter data.

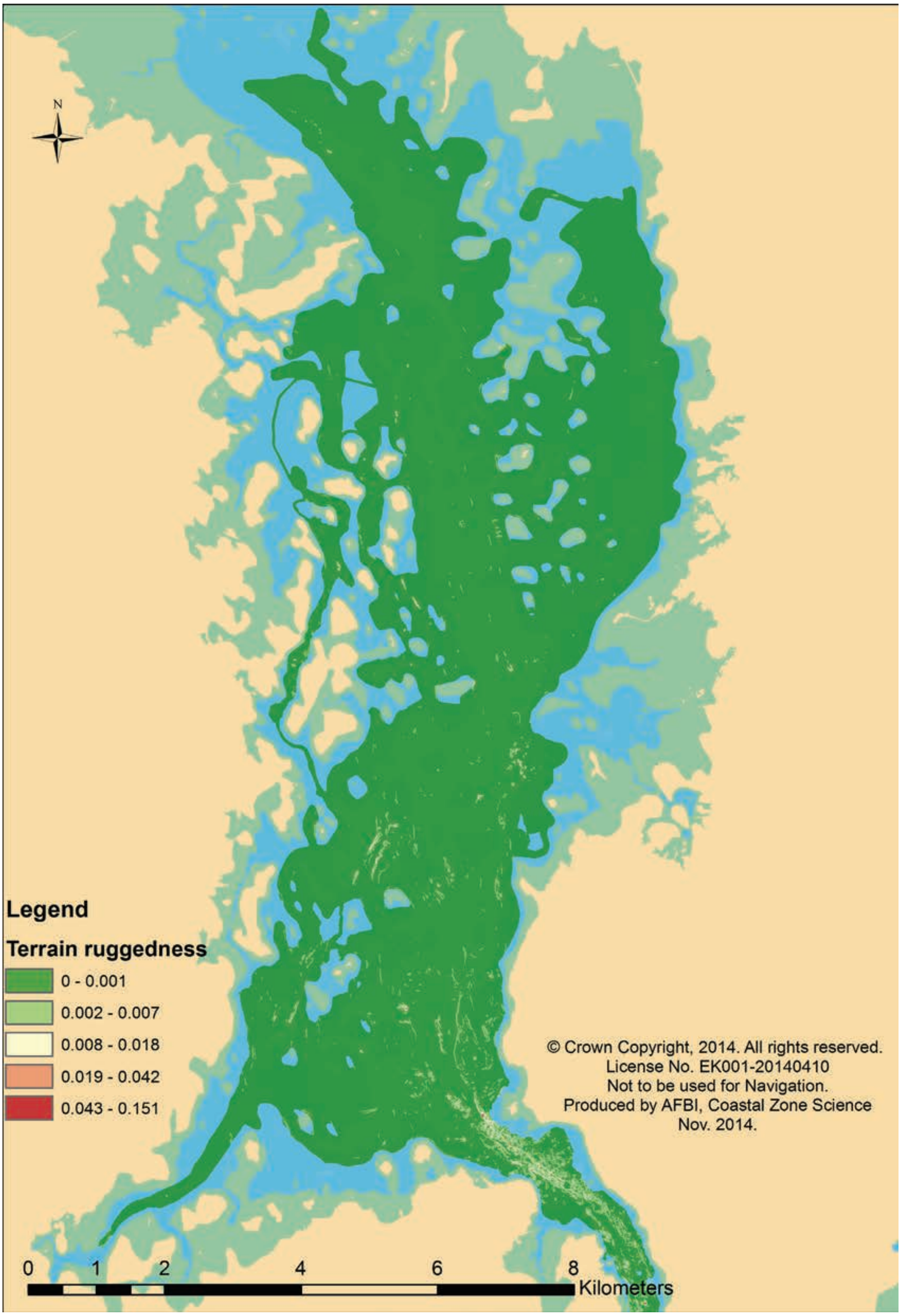

Figure 3.7. Terrain ruggedness from bathymetric data in the main Lough.

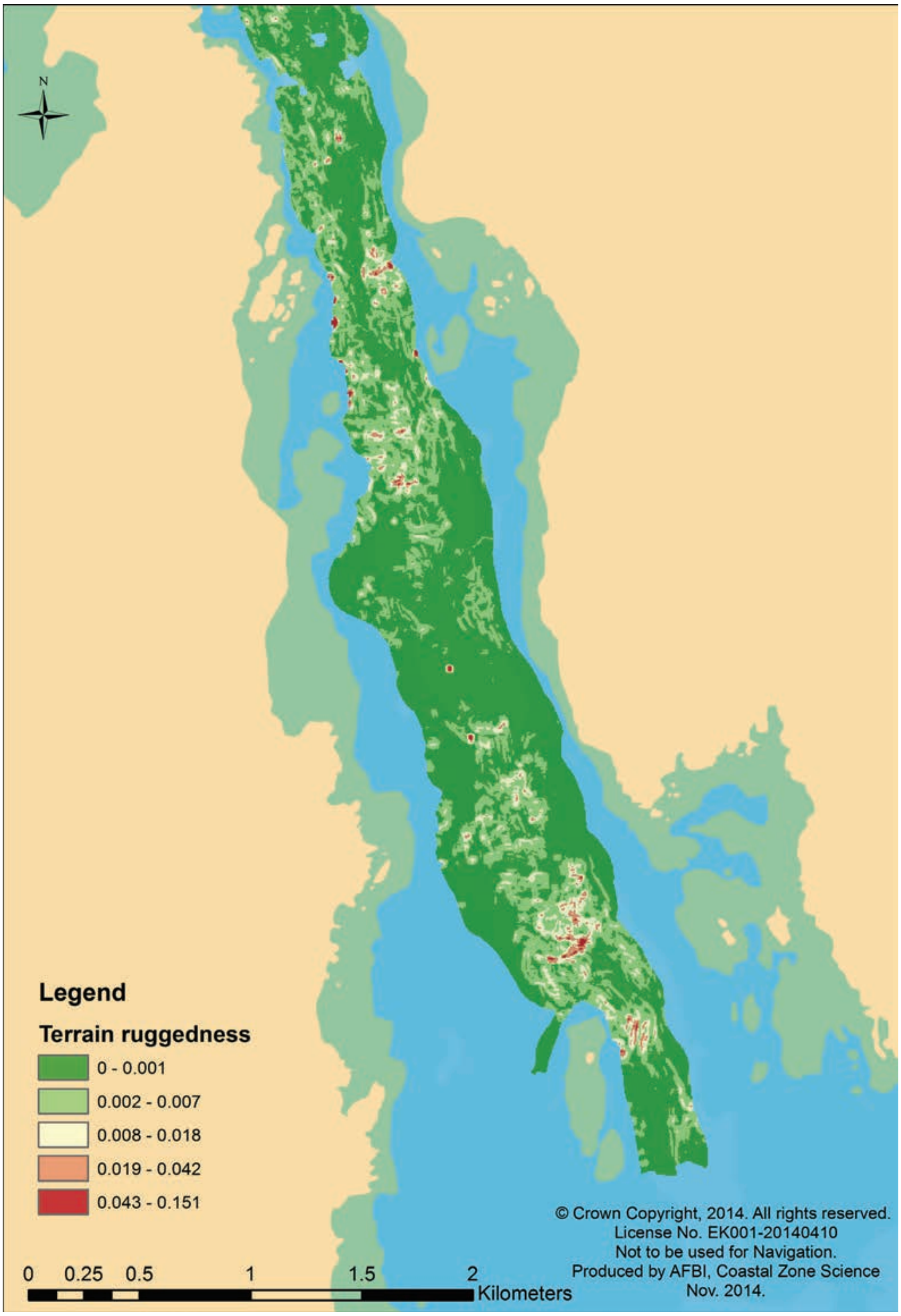

Figure 3.8. Terrain ruggedness from bathymetric data for the Narrows.

The bathymetric data were successfully utilised to calculate broad Benthic Position Index (Figures 3.9 and 3.10), which integrates slope angle, aspect and rugosity to highlight trough and crest areas, and are related to the distribution of sediments.

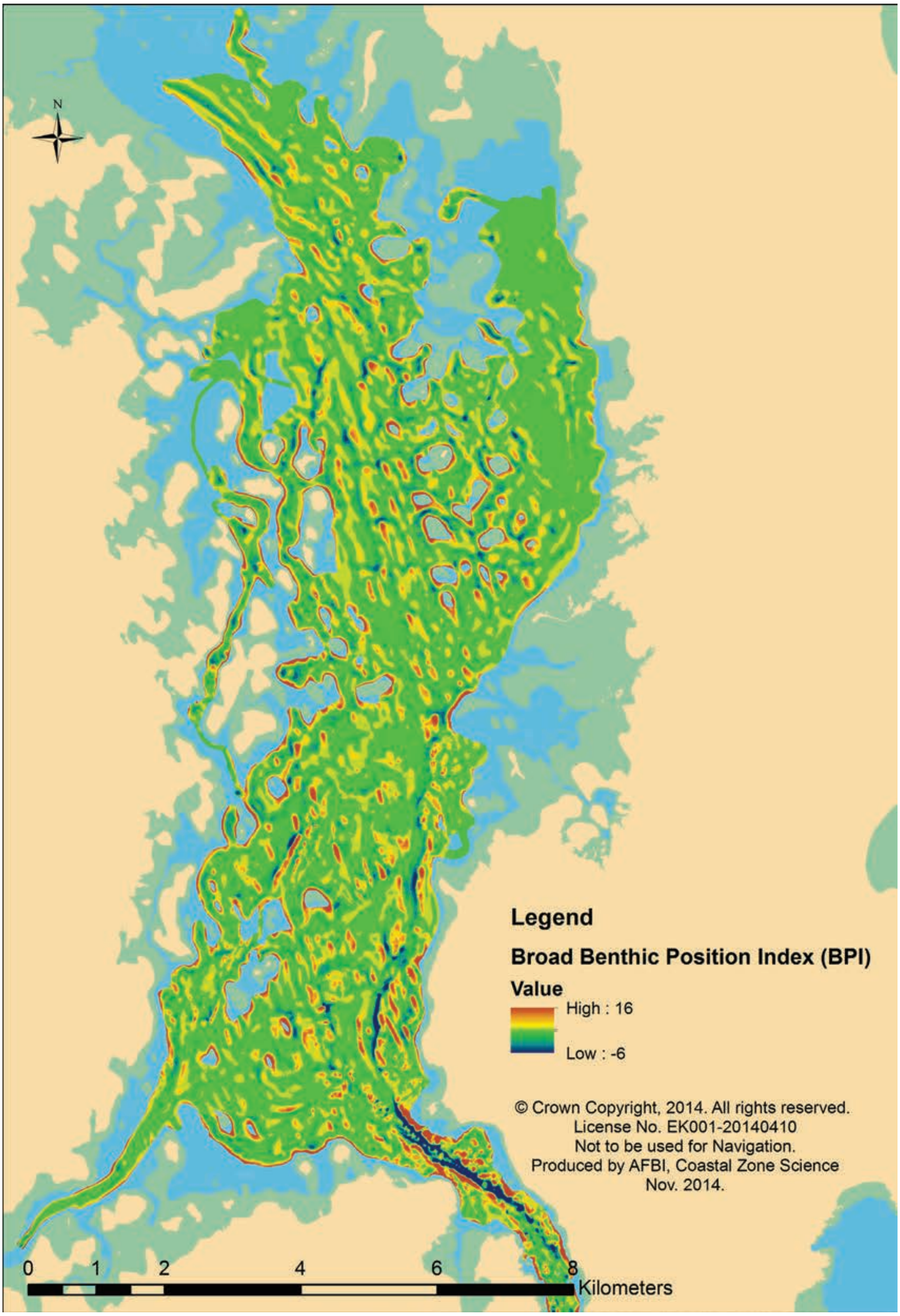

Figure 3.9. Broadscale benthic position index (BPI) for the main Lough with crest areas shown as high positive values and trough areas shown as high negative values.

Figure 3.10. Broadscale benthic position index (BPI) for the Narrows with crest areas shown as high positive values and trough areas shown as high negative values.

Backscatter data were subjected to unsupervised classification in order to extract general spatial patterns across the Lough (Figures 3.11 and 3.12 below). Unsupervised classification divides data into statistically different units ("clusters") using only the variation in the data; these are then mapped across the data’s spatial extent. Cluster numbers are arbitrary but the resulting spatial patterns may be used as an additional data layer in the final classification to produce the habitat maps. This worked well for the main Lough, however as previously mentioned, the number of backscatter artefacts in the Narrows data resulting in a very patchy classified images, with along-track artefacts magnified which limit its usefulness in the final map production. In this case, the backscatter mosaic was used for final map production rather than the classified backscatter image in Figure 3.12.

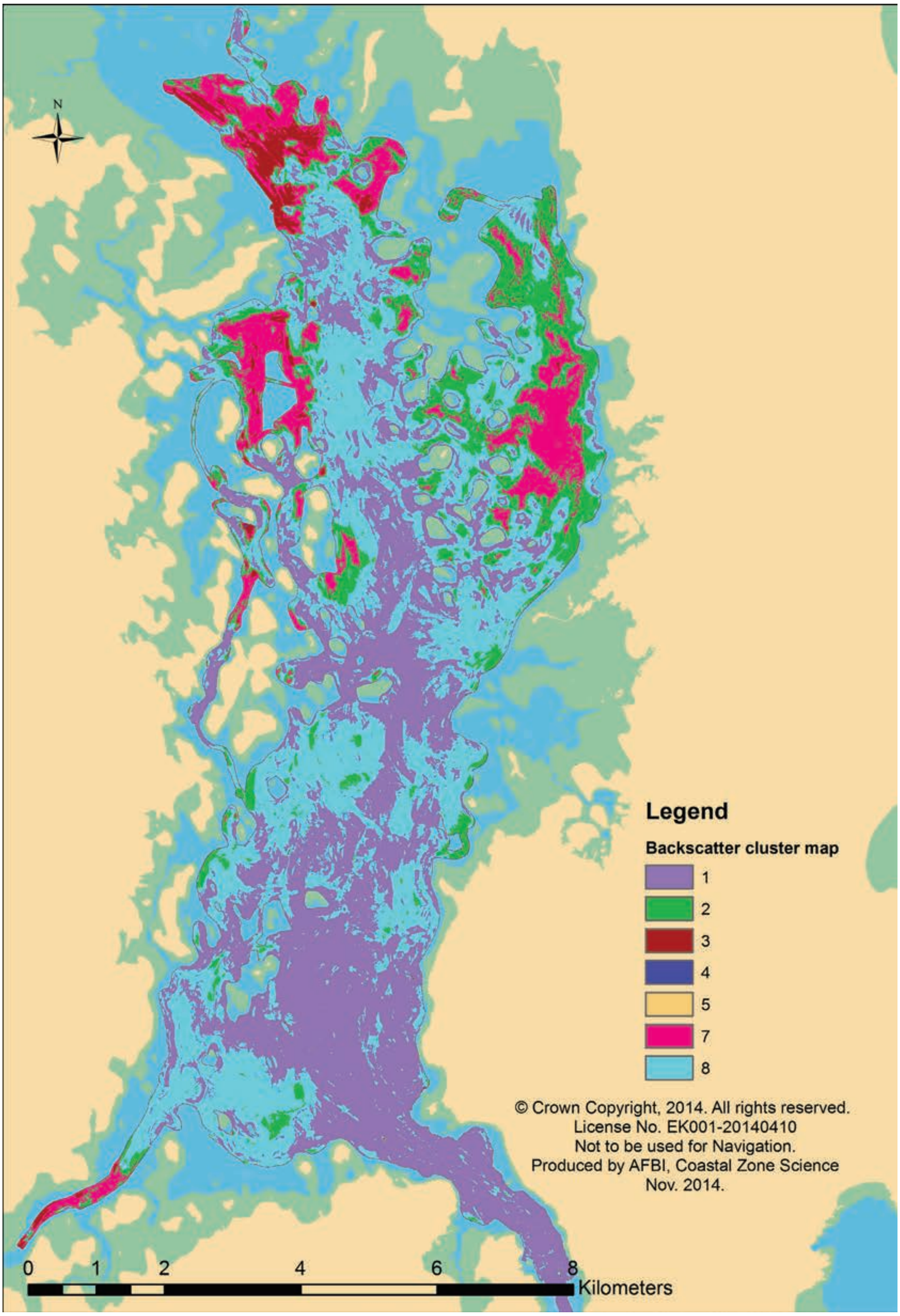

Figure 3.11. Unsupervised classification of backscatter data for the main lough (showing seven classes).

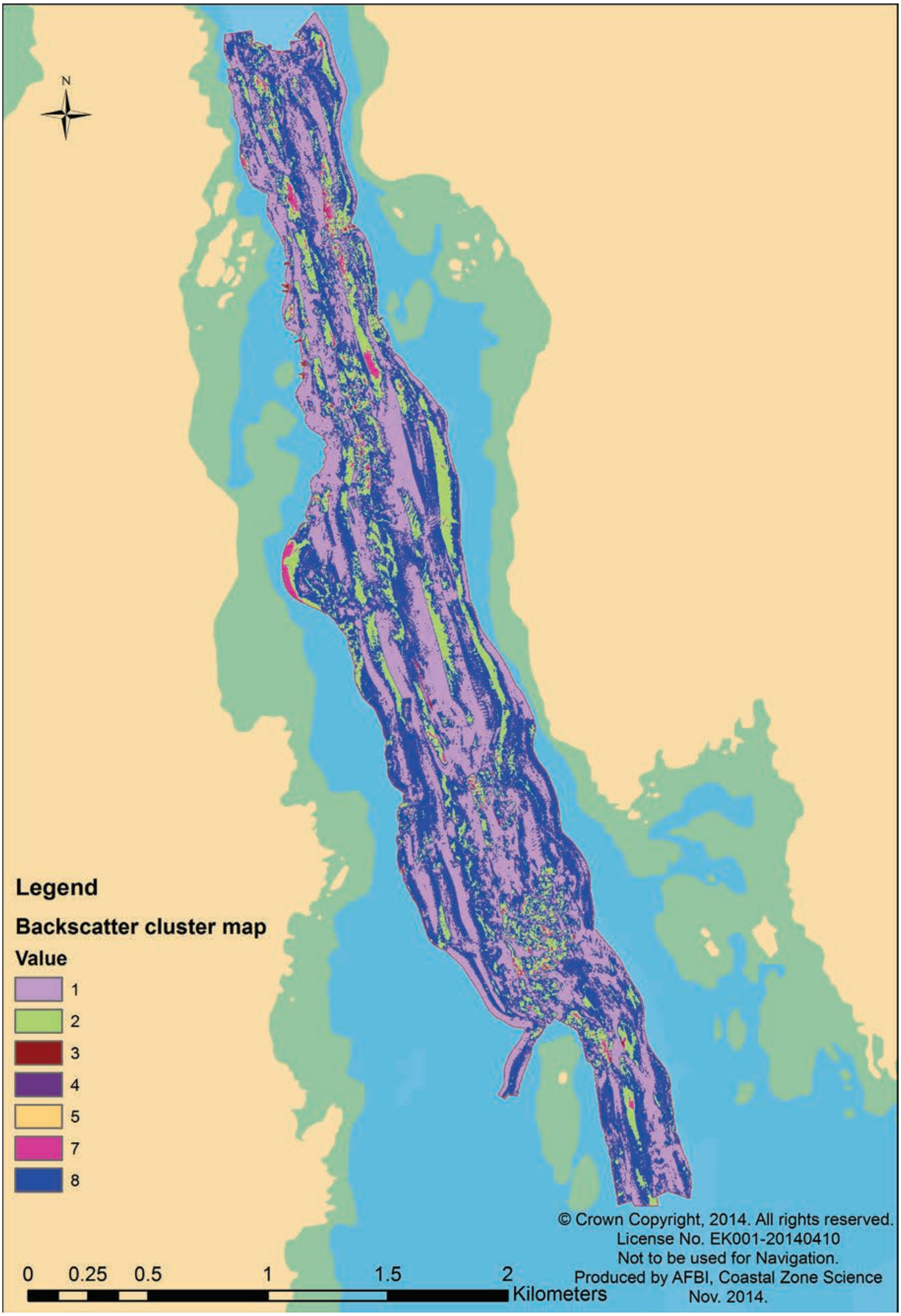

Figure 3.12. Unsupervised classification of backscatter data for the Narrows (showing eight classes).

3.2. Ground-truthing classification

All ground-truthing data were analysed through use of (a) video footage review or (b) multivariate statistical routines (see Appendices I and II) to yield biotope complexes (EUNIS/MNCR Level 4) and where data permitted biotopes (EUNIS/MNCR Level 5) and sub-biotopes (EUNIS/MNCR Level 6), with the exception of the CEDaR dive biotope records which included level 4 and 5 habitats.

A total of 26 biotope complexes were identified (as shown in Table 3.1 below), 41 biotopes (Table 3.2 below) and 17 sub-biotopes (Table 3.3 below). The tables provide the EUNIS alphanumeric codes in addition to the MNCR codes, and also indicate the total number of records assigned to each habitat and the most recent year of these. This is to draw attention to the "dominant" records for some habitats, and "sparse" records for others, and the case that for some habitats records are over 20 years old.

For many ground-truthing records, habitats were assigned as mosaics (more than one associated with a particular record/location), due to the heterogeneity of the area and scale of such heterogeneity (occurring within for example the minimum biotope recording area of 25m^2). As such multiple combinations of habitats were recorded.

Table 3.1. Biotope complexes identified from ground-truthing data

BiotopeL4	EUNIS Code	Title	Number of records	Most recent record year
IR.HIR.KSed	A3.12	Sediment-affected or disturbed kelp and seaweed communities	23	2013
IR.MIR.KR	A3.21	Kelp and red seaweeds (moderate energy infralittoral rock)	68	2013
IR.MIR.KT	A3.22	Kelp and seaweed communities in tide-swept sheltered conditions	5	2011
IR.LIR.K	A3.31	Silted kelp on low energy infralittoral rock with full salinity	14	2012
CR.HCR.FaT	A4.11	Very tide-swept faunal communities on circalittoral rock	161	2013
CR.HCR.XFa	A4.13	Mixed faunal turf communities on circalittoral rock	113	2011
CR.MCR.EcCr	A4.21	Echinoderms and crustose communities on circalittoral rock	88	2013
CR.MCR.CFaVS	A4.25	Circalittoral faunal communities in variable salinity	2	1983
CR.LCR.BrAs	A4.31	Brachiopod and ascidian communities on circalittoral rock	7	2012
SS.SCS.ICS	A5.13	Infralittoral coarse sediment	11	2013
SS.SCS.CCS	A5.14	Circalittoral coarse sediment	78	2013
SS.SSA.IFiSa	A5.23	Infralittoral fine sand	4	2011
SS.SSA.IMuSa	A5.24	Infralittoral muddy sand	3	2013
SS.SSA.CFiSa	A5.25	Circalittoral fine sand	11	2011
SS.SSA.CMuSa	A5.26	Circalittoral muddy sand	2	2012
SS.SSA.OSa	A5.27	Deep circalittoral sand	8	2012
SS.SMU.ISaMu	A5.33	Infralittoral sandy mud	88	2013
SS.SMU.IFiMu	A5.34	Infralittoral fine mud	28	2012
SS.SMU.CSaMu	A5.35	Circalittoral sandy mud	64	2012
SS.SMU.CFiMu	A5.36	Circalittoral fine mud	36	2012
SS.SMX.IMx	A5.43	Infralittoral mixed sediments	39	2013
SS.SMX.CMx	A5.44	Circalittoral mixed sediments	139	2012
SS.SMP.Mrl	A5.51	Maerl beds	1	2012
SS.SMP.KSwSS	A5.52	Kelp and seaweed communities on sublittoral sediment	18	2013
SS.SMP.SSgr	A5.53	Sublittoral seagrass beds	3	2009
SS.SBR.SMus	A5.62	Sublittoral mussel beds on sediment	10	2012

Table 3.2. Biotopes identified from ground-truthing.

BiotopeL5	EUNIS Code	Title	Number of records	Most recent record year
IR.HIR.KSed.XKScrR	A3.125	Mixed kelps with scour-tolerant and opportunistic foliose red seaweeds on scoured or sand-covered infralittoral rock	21	2011
IR.HIR.KSed.XKHal	A3.126	[Halidrys siliquosa] and mixed kelps on tide-swept infralittoral rock with coarse sediment	18	2011
IR.MIR.KR.Ldig	A3.211	[Laminaria digitata] on moderately exposed sublittoral fringe rock	55	2011
IR.MIR.KR.LhypTX	A3.213	[Laminaria hyperborea] on tide-swept infralittoral mixed substrata	8	1985
IR.MIR.KR.Lhyp	A3.214	[Laminaria hyperborea] and foliose red seaweeds on moderately exposed infralittoral rock	3	2012
IR.MIR.KT.LsacT	A3.224	[Laminaria saccharina] with foliose red seaweeds and ascidians on sheltered tide-swept infralittoral rock	2	2011
IR.LIR.K.LhypLsac	A3.312	Mixed [Laminaria hyperborea] and [Laminaria saccharina] on sheltered infralittoral rock	4	2012
IR.LIR.K.Lsac	A3.313	[Laminaria saccharina] on very sheltered infralittoral rock	4	1983
CR.HCR.FaT.BalTub	A4.111	[Balanus crenatus] and [Tubularia indivisa] on extremely tide-swept circalittoral rock	3	2013
CR.HCR.FaT.CTub	A4.112	[Tubularia indivisa] on tide-swept circalittoral rock	126	2013
CR.HCR.XFa.ByErSp	A4.131	Bryozoan turf and erect sponges on tide-swept circalittoral rock	2	1975
CR.HCR.XFa.FluCoAs	A4.134	[Flustra foliacea] and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock	30	2011
CR.HCR.XFa.SpNemAdia	A4.135	Sparse sponges, [Nemertesia] spp., and [Alcyonidium diaphanum] on circalittoral mixed substrata	1	2007
CR.MCR.EcCr.FaAlCr	A4.214	Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock	78	2011
CR.LCR.BrAs.AmenCio	A4.311	Solitary ascidians, including [Ascidia mentula] and [Ciona intestinalis], on wave-sheltered circalittoral rock	4	1983
CR.LCR.BrAs.AntAsH	A4.313	[Antedon] spp., solitary ascidians and fine hydroids on sheltered circalittoral rock	3	2012
SS.SCS.ICS.HchrEdw	A5.132	[Halcampa chrysanthellum] and [Edwardsia timida] on sublittoral clean stone gravel	1	1977
SS.SCS.CCS.PomB	A5.141	[Pomatoceros triqueter] with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles	44	2011
SS.SCS.CCS.MedLumVen	A5.142	[Mediomastus fragilis], [Lumbrineris] spp. and venerid bivalves in circalittoral coarse sand or gravel	3	2012
SS.SCS.CCS.Nmix	A5.144	[Neopentadactyla mixta] in circalittoral shell gravel or coarse sand	2	1982
SS.SSA.IMuSa.EcorEns	A5.241	[Echinocardium cordatum] and [Ensis] spp. in lower shore and shallow sublittoral slightly muddy fine sand	1	1980
SS.SSA.OSa.Ofus.Afil	A5.272	[Owenia fusiformis] and [Amphiura filiformis] in deep circalittoral sand or muddy sand	8	2012
SS.SMU.ISaMu.SundAsp	A5.332	[Sagartiogeton undatus] and [Ascidiella aspersa] on infralittoral sandy mud	10	2012
SS.SMU.ISaMu.MysAbr	A5.333	[Mysella bidentata] and [Abra] spp. in infralittoral sandy mud	6	2000
SS.SMU.ISaMu.MelMagThy	A5.334	[Melinna palmata] with [Magelona] spp. and [Thyasira] spp. in infralittoral sandy mud	2	2012
SS.SMU.CSaMu.AfilMysAnit	A5.351	[Amphiura filiformis], [Mysella bidentata] and [Abra nitida] in circalittoral sandy mud	10	2012
SS.SMU.CSaMu.ThyNten	A5.352	[Thyasira] spp. and [Nuculoma tenuis] in circalittoral sandy mud	4	2012
SS.SMU.CSaMu.VirOphPmax	A5.354	[Virgularia mirabilis] and [Ophiura] spp. with [Pecten maximus] on circalittoral sandy or shelly mud	22	2012
SS.SMU.CFiMu.SpnMeg	A5.361	Seapens and burrowing megafauna in circalittoral fine mud	5	2008
SS.SMU.CFiMu.MegMax	A5.362	Burrowing megafauna and [Maxmuelleria lankesteri] in circalittoral mud	10	2012
SS.SMX.CMx.ClloMx	A5.441	[Cerianthus lloydii] and other burrowing anemones in circalittoral muddy mixed sediment	18	2012
SS.SMX.CMx.ClloModHo	A5.442	Sparse [Modiolus modiolus], dense [Cerianthus lloydii] and burrowing holothurians on sheltered circalittoral stones and mixed sediment	7	2012
SS.SMX.CMx.MysThyMx	A5.443	[Mysella bidentata] and [Thyasira] spp. in circalittoral muddy mixed sediment	5	2012
SS.SMX.CMx.FluHyd	A5.444	[Flustra foliacea] and [Hydrallmania falcata] on tide-swept circalittoral mixed sediment	19	2008
SS.SMX.CMx.OphMx	A5.445	[Ophiothrix fragilis] and/or [Ophiocomina nigra] brittlestar beds on sublittoral mixed sediment	23	2008
SS.SMP.Mrl.Lcor	A5.513	[Lithothamnion corallioides] maerl beds on infralittoral muddy gravel	1	2012
SS.SMP.KSwSS.LsacR	A5.521	[Laminaria saccharina] and red seaweeds on infralittoral sediments	5	2012
SS.SMP.KSwSS.LsacCho	A5.522	[Laminaria saccharina] and [Chorda filum] on sheltered upper infralittoral muddy sediment	3	2012
SS.SMP.KSwSS.FilG	A5.528	Filamentous green seaweeds on low salinity infralittoral mixed sediment or rock	1	1982
SS.SBR.SMus.ModHAs	A5.623	[Modiolus modiolus] beds with fine hydroids and large solitary ascidians on very sheltered circalittoral mixed substrata	4	2008
SS.SBR.SMus.ModCVar	A5.624	[Modiolus modiolus] beds with [Chlamys varia], sponges, hydroids and bryozoans on slightly tide-swept very sheltered circalittoral mixed substrata	3	2012

Table 3.3. Sub-biotopes identified from ground-truthing.

BiotopeL6	EUNIS Code	Title	Number of records	Most recent record year
IR.MIR.KR.Ldig.Bo	A3.2112	[Laminaria digitata] and under-boulder fauna on sublittoral fringe boulders	1	1985
IR.MIR.KR.LhypTX.Ft	A3.2131	[Laminaria hyperborea] forest and foliose red seaweeds on tide-swept upper infralittoral mixed substrata	6	1983
IR.MIR.KR.LhypTX.Pk	A3.2132	[Laminaria hyperborea] park and foliose red seaweeds on tide-swept lower infralittoral mixed substrata	2	1985
IR.MIR.KR.Lhyp.GzPk	A3.2142	[Laminaria hyperborea] park and foliose red seaweeds on moderately exposed lower infralittoral rock	1	1983
IR.MIR.KR.Lhyp.Pk	A3.2144	Grazed [Laminaria hyperborea] park with coralline crusts on lower infralittoral rock	1	2012
IR.LIR.K.LhypLsac.Ft	A3.3121	Mixed [Laminaria hyperborea] and [Laminaria saccharina] forest on sheltered upper infralittoral rock	1	1983
IR.LIR.K.LhypLsac.Gz	A3.3122	Mixed [Laminaria hyperborea] and [Laminaria saccharina] park on sheltered lower infralittoral rock	1	1975
IR.LIR.K.Lsac.Ft	A3.3132	[Laminaria saccharina] forest on very sheltered upper infralittoral rock	4	1983
CR.HCR.FaT.CTub.Adig	A4.1122	[Alcyonium digitatum] with dense [Tubularia indivisa] and anemones on strongly tide-swept circalittoral rock	1	2011
CR.HCR.XFa.FluCoAs.X	A4.1343	[Flustra foliacea] and colonial ascidians on tide-swept exposed circalittoral mixed substrata	30	2011
CR.MCR.EcCr.FaAlCr.Bri	A4.2144	Brittlestars on faunal and algal encrusted exposed to moderately wave-exposed circalittoral rock	1	2008
CR.MCR.EcCr.FaAlCr.Pom	A4.2145	Faunal and algal crusts with [Pomatoceros triqueter] and sparse [Alcyonium digitatum] on exposed to moderately wave-exposed circalittoral rock	30	2011
CR.LCR.BrAs.AmenCio.Bri	A4.3112	Dense brittlestars with sparse [Ascidia mentula] and [Ciona intestinalis] on sheltered circalittoral mixed substrata	4	1983
SS.SMU.CSaMu.VirOphPmax.HAs	A5.3541	[Virgularia mirabilis] and [Ophiura] spp. with [Pecten maximus], hydroids and ascidians on circalittoral sandy or shelly mud with shells or stones	9	2012
SS.SMX.CMx.ClloMx.Nem	A5.4411	[Cerianthus lloydii] with [Nemertesia] spp. and other hydroids in circalittoral muddy mixed sediment	5	2008
SS.SMP.KSwSS.LsacR.Mu	A5.5214	[Laminaria saccharina] with red and brown seaweeds on lower infralittoral muddy mixed sediment	3	2013
SS.SMP.SSgr.Zmar	A5.5331	[Zostera marina]/[angustifolia] beds on lower shore or infralittoral clean or muddy sand	2	2009

The distribution of the classified ground-truthing data, by dominant biotope complex (including mosaics), is shown in Figure 3.13 below. The year of each of these records is shown in Figure 3.14 for reference.

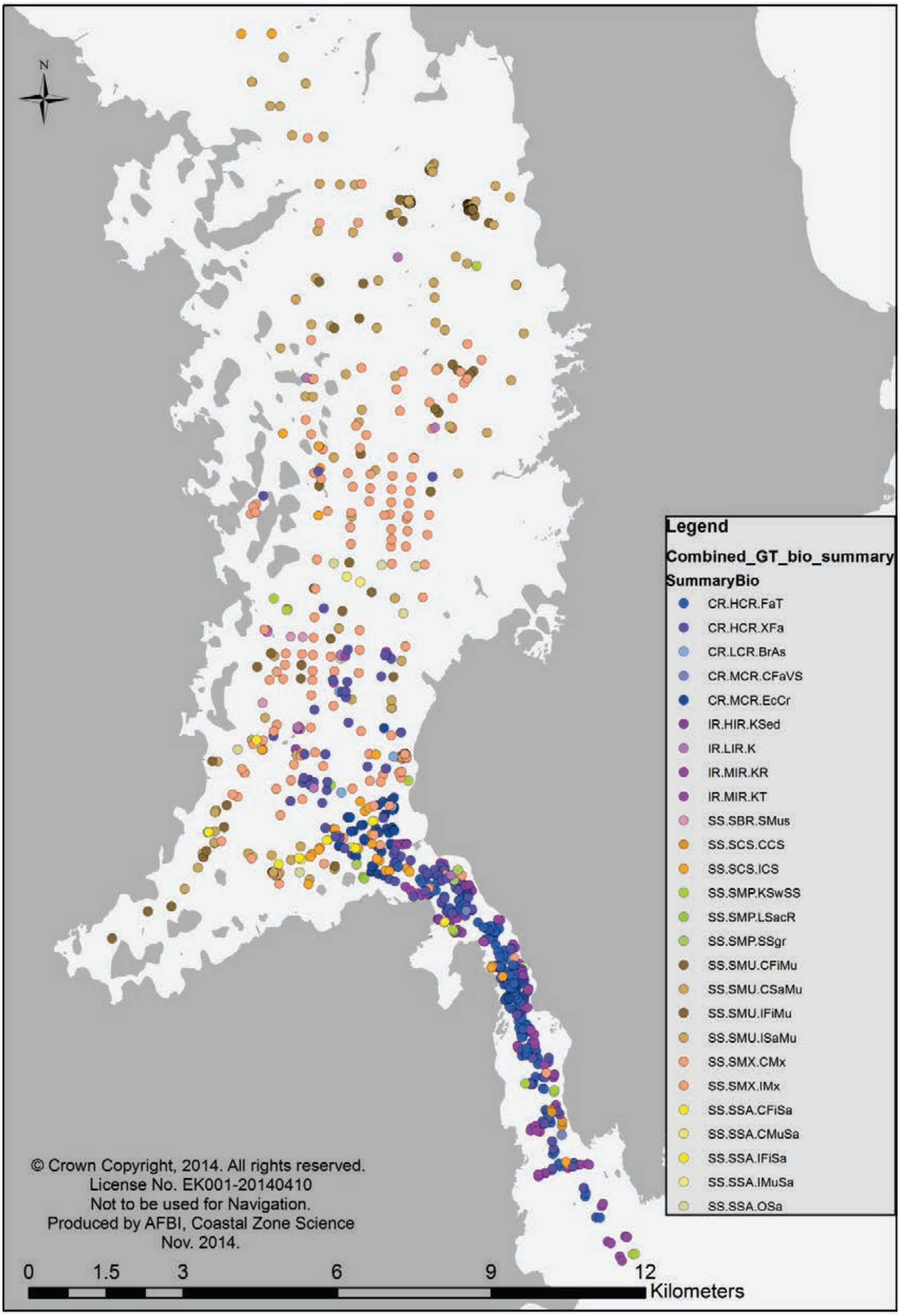

Figure 3.13. Ground-truthing records classified by dominant biotope complex.

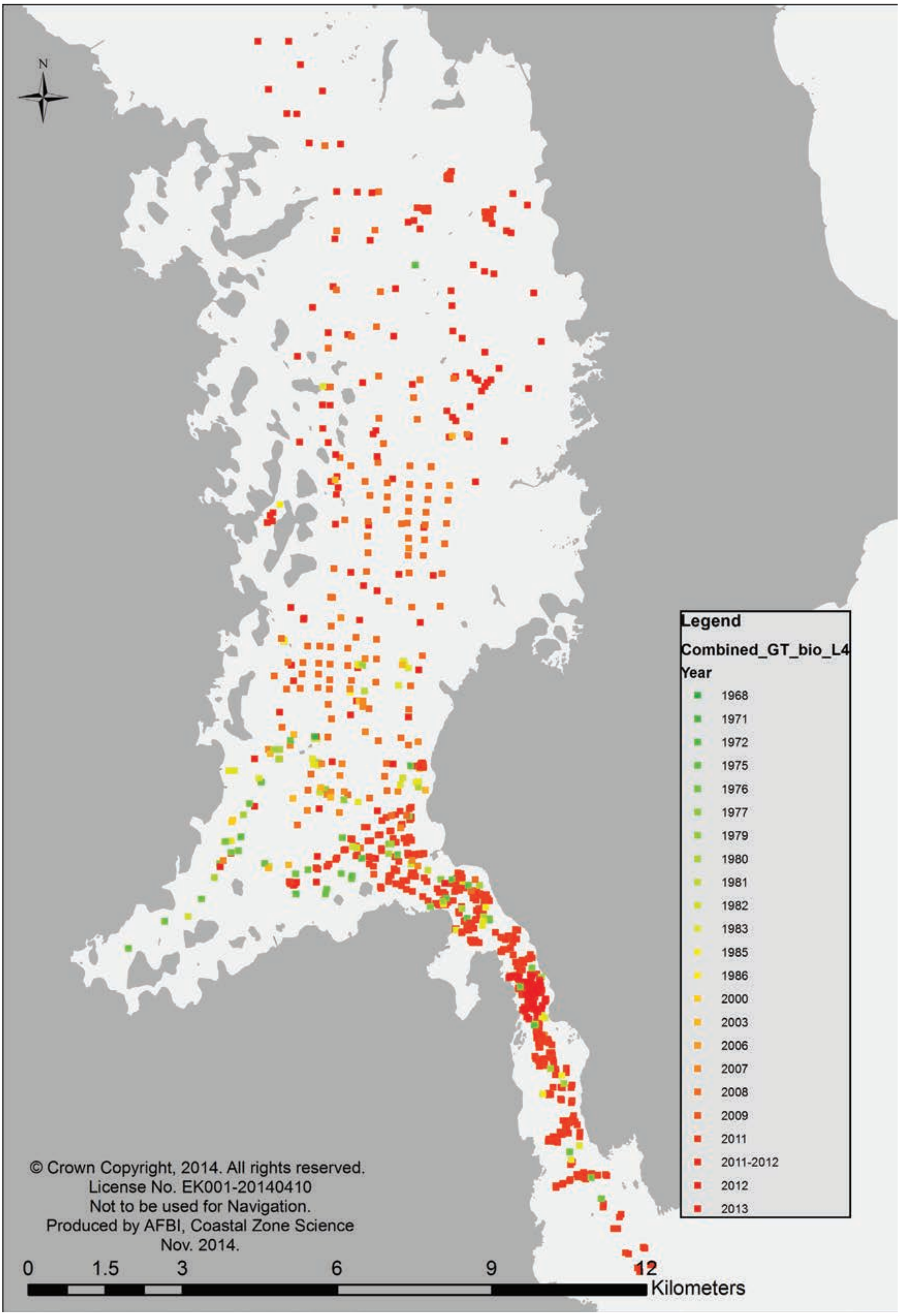

Figure 3.14. Ground-truthing records symbolised by year of record.

3.3. Final habitat map production

Due to the high number of habitats identified in the ground-truthing data, the use of habitat mosaics and the variation in ancillary data (e.g. detailed substratum descriptions), the ground-truthing records were summarised into a smaller number of categories to allow possible correspondence with the multibeam data derived “acoustic facies”. Level 4 “dominant biotope complexes” were assigned with a total of 45 categories. These were further narrowed to 24 single (non-mosaic) biotope complexes which records were slotted into.

The clusters identified from the cluster analysis of the multibeam data were cross-tabulated with the summary biotope complexes and the “majority” biotope complex noted for each cluster. Due to the number of summary biotope complexes, it was inevitable that multiple biotope complexes mapped to each cluster. Therefore, a detailed inspection was made of each area in the lough to examine (a) the trends in the multibeam data (bathymetric derivatives and backscatter), and (b) the details of the ground-truthing data in the area (including the original, rather than summary, biotope information, including mosaics). Polygon attributes were revised accordingly to best represent, consistently, the information shown in these datasets. The final maps are shown in Figures 3.15, 3.16 and 3.17 below. Figure 3.15 includes the full range of mapped mosaics whereas Figure 3.16 shows a summary of these (fewer categories) which are simpler to view but are less true to the data.

The total area of each summary biotope complex as shown in Figures 3.16 and the Narrows level 4 biotopes (Figure 3.17) combined is presented in Table 3.4. The habitat areas of potential Annex I habitats and habitats of conservation interest are also noted in this table (the colour coding shows their relation to the level 4 biotope complexes).

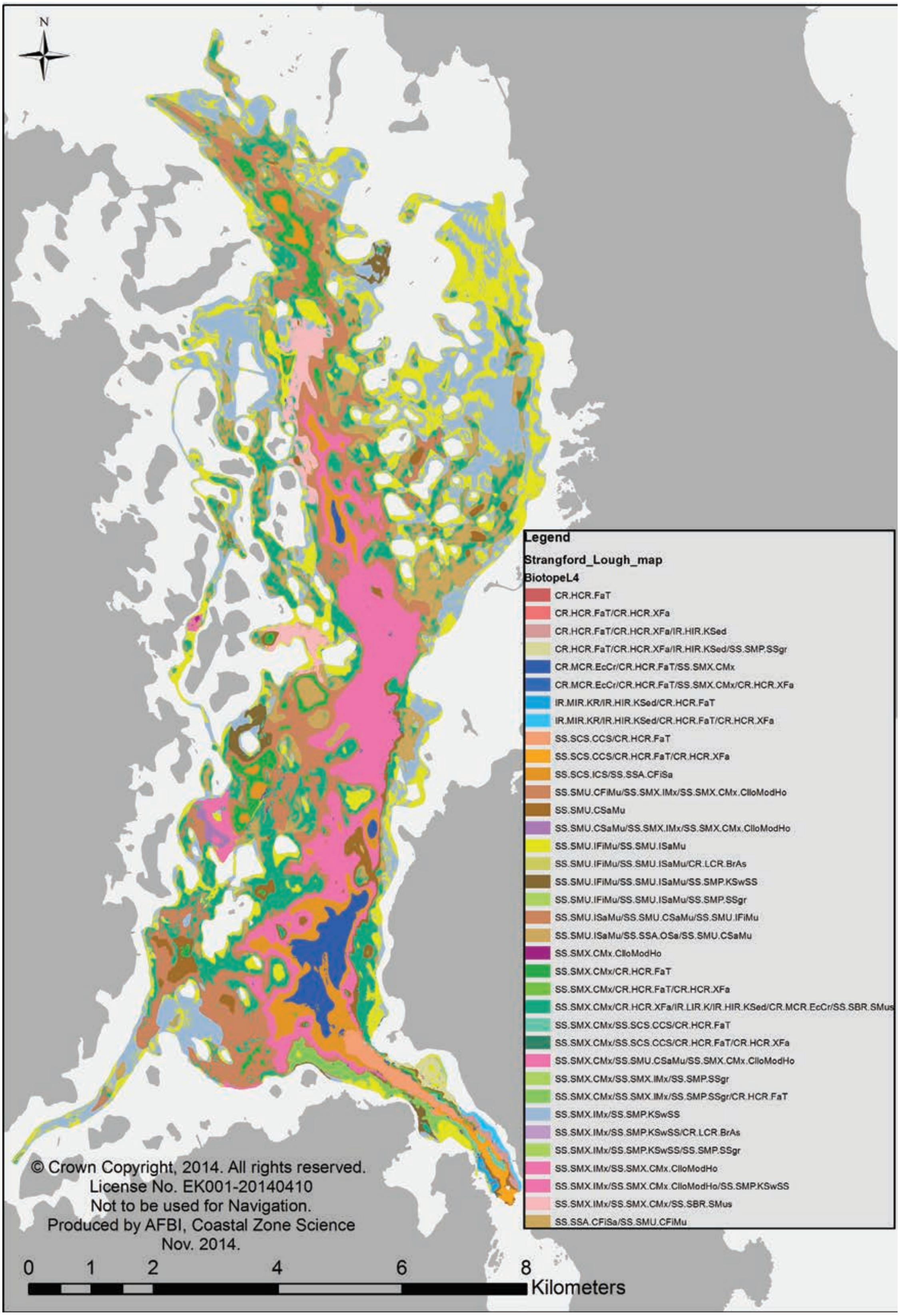

Figure 3.15. Habitat map (level 4 biotope complexes) for the main Lough.

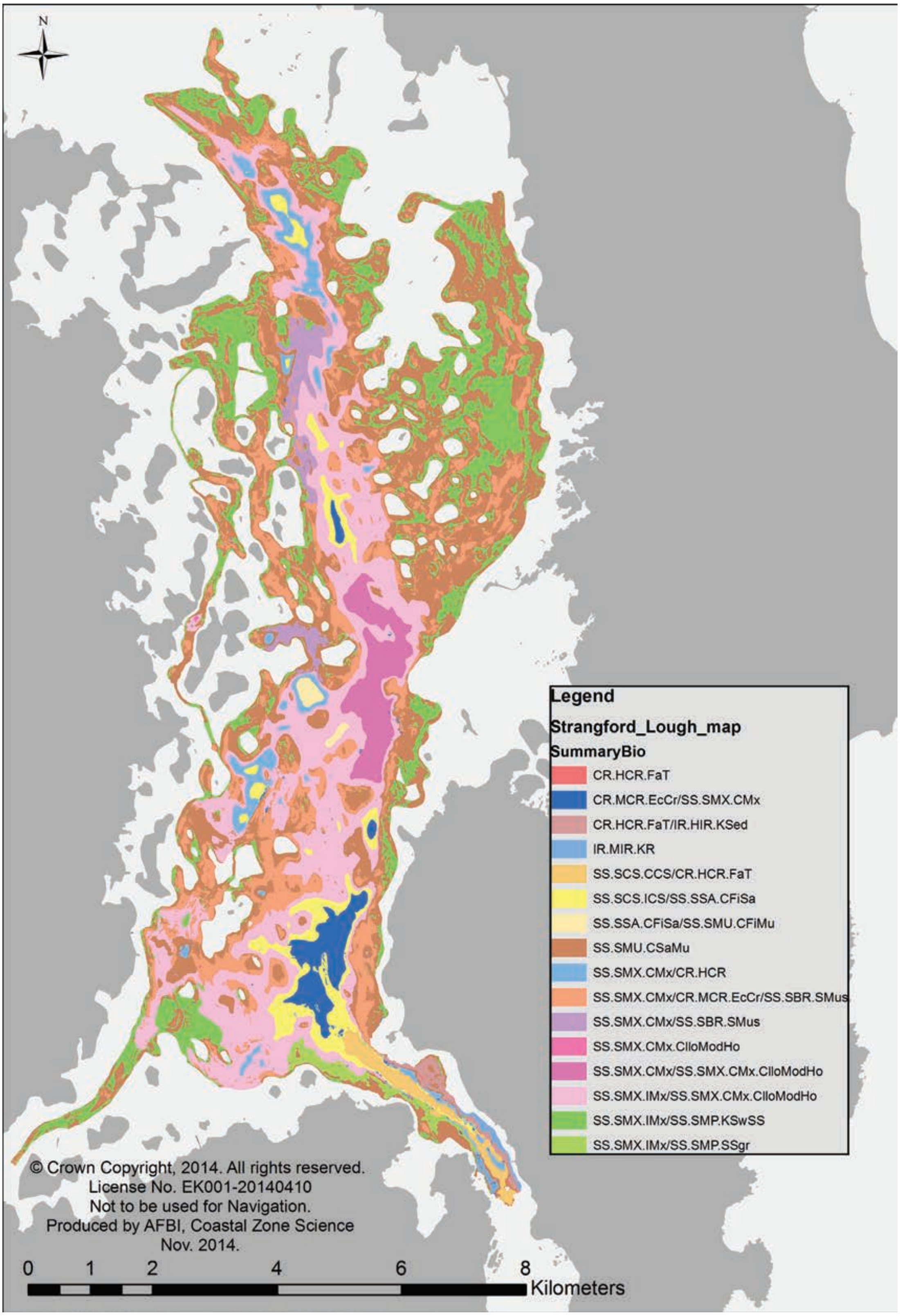

Figure 3.16. Habitat map (level 4 summarised biotope complexes) for the main lough.

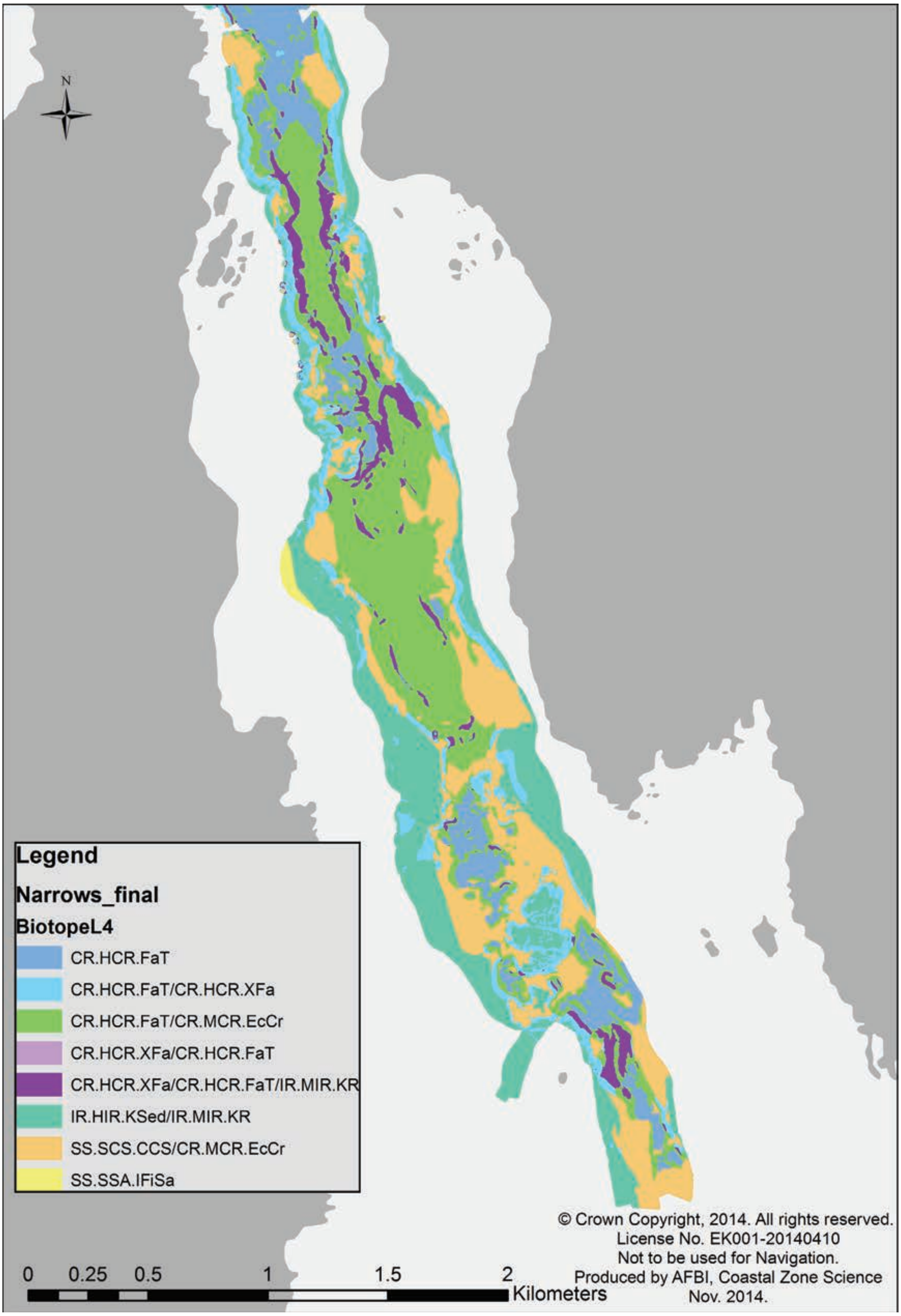

Figure 3.17. Habitat map (level 4 biotope complexes) for the Narrows.

Table 3.4. Summary area tables for dominant biotope complexes, with habitats of conservation interest extracted.

Strangford Lough - main

Summary Biotope Complex	m2	km2
CR.HCR.FaT	5875	0.006
CR.HCR.FaT/IR.HIR.KSed	311525	0.312
CR.MCR.EcCr/SS.SMX.CMx	1259525	1.260
IR.MIR.KR	175125	0.175
SS.SCS.CCS/CR.HCR.FaT	720357	0.720
SS.SCS.ICS/SS.SSA.CFiSa	2844432	2.844
SS.SMU.CSaMu	17424248	17.424
SS.SMX.CMx.ClloModHo	4700	0.005
SS.SMX.CMx/CR.HCR	1449475	1.449
SS.SMX.CMx/CR.MCR.EcCr/SS.SBR.SMus	7326000	7.326
SS.SMX.CMx/SS.SBR.SMus	1056150	1.056
SS.SMX.CMx/SS.SMX.CMx.ClloModHo	1713800	1.714
SS.SMX.IMx/SS.SMP.KSwSS	10138987	10.139
SS.SMX.IMx/SS.SMP.SSgr	475900	0.476
SS.SMX.IMx/SS.SMX.CMx.ClloModHo	10981700	10.982
SS.SSA.CFiSa/SS.SMU.CFiMu	196250	0.196
TOTAL	**56084049**	**56.084**

TOTALS	km2
Sands and gravels	3.496
Muds	17.620
Potential Modiolus habitat	10.101
Bedrock reef	1.372
Stony reef	5.001

Strangford Narrows

Summary Biotope Complex	m2	km2
CR.HCR.FaT	391720	0.392
CR.HCR.FaT/CR.HCR.XFa	337310	0.337
CR.HCR.FaT/CR.MCR.EcCr	898508	0.899
CR.HCR.XFa/CR.HCR.FaT/IR.MIR.KR	150730	0.151
IR.HIR.KSed/IR.MIR.KR	673252	0.673
SS.SCS.CCS/CR.MCR.EcCr	638317	0.638
SS.SSA.IFiSa	13611	0.014
TOTAL	**3103448**	**3.103**

3.4. Confidence assessment

The correspondence between the mapped dominant biotope complexes and the ground-truthing biotope complex records, known as ‘accuracy assessment’, was completed through extraction of co-located records in ArcGIS, and percentage agreement between biotope complexes calculated in Excel. This analysis gave the following results:

- Agreement of 48.7% in the main Lough (all ground-truthing data included)
- Agreement of 71.7% in the Narrows

Both results are greater than the potential agreement between ground-truthing records and mapped habitats that could be generated by chance.

Due to the high heterogeneity of ground-truthing records in the main Lough, data were re-examined excluding records that were dated pre-2009. This resulted in increased agreement, of 66.7%.

The assessment of confidence in the final habitat maps was undertaken following the MESH confidence assessment methodology, and the following scores in Table 3.5 were derived for both the main Lough and Narrows maps combined. This included an assessment of the remote sensing (multibeam) data, the ground-truthing data, the ground-truthing interpretation and the map accuracy. Together, these were combined in the confidence tool macro to give an overall score of **77.**

Table 3.5. Habitat map confidence assessment

RemoteTechnique	RemoteCoverage	RemotePositioning	RemoteStdsApplied	RemoteVintage	BGTTechnique	PGTTechnique	GTPositioning	GTDensity	GTStdsApplied	GTVintage	GTInterpretation	RemoteInterpretation	DetailLevel	MapAccuracy	**Remote score**	**GT score**	**Interpretation score**	**Overall score**
3	3	3	2	3	2	2	2	3	0	2	2	3	2	2	**93.33**	**61.67**	**75.00**	**77**

4. Discussion

High resolution acoustic remote sensing provides consistent and full coverage data which yield information regarding the shape of the seabed and the seabed texture. These data allow a classification to be made of “acoustic facies”, or “ground-types”, which can be related to seabed (benthic) habitats. The correspondence between acoustic facies and habitats is a complex one, with acoustic facies typically influenced by the substratum composition, which may or may not be biologically modified (for instance through turf-forming species, bioturbation, or large semi-infaunal bivalves). Habitat mapping recommended protocols (e.g. MESH) indicate that for the most robust results it is necessary to first analyse the acoustic data to reveal the distribution of acoustic facies, and then target a ground-truthing campaign to gather information that will support their “translation” into habitats. Such ground-truthing should ideally include detailed substratum information collected at an appropriate scale (the minimum mapping unit, as dictated by the acoustic data and positional accuracy), and the number of samples should be proportional to (a) the area of each acoustic facies, and (b) the heterogeneity exhibited by the acoustic data.

In this project, due to the lack of adequate recent ground truthing, the recommended workflow for habitat mapping was not possible, and the use of “historic” ground-truthing data were necessary. These data were from a range of surveys for a wide variety of objectives, but were not designed for habitat mapping per se. Although ground-truthing data are abundant and have been sourced from a wide variety of projects, the necessary substratum data were not always available in adequate detail or at an appropriate scale. A decision was made to proceed using the biotope complex information from the ground-truthing records, and attempt to associate these in a statistically meaningful and objective manner to the acoustic data. Unfortunately, the biotope classification scheme is not designed to represent substratum information in adequate detail for habitat mapping, but summarises these into broad sedimentary classes and “rock”. Although the biotope classification includes some of the biological “modifiers” of relevance to acoustic data interpretation, such as burrowing megafauna, or faunal turf, these are not consistently represented at the biotope complex level (EUNIS/MNCR level 4) – for example, “CR.HCR.XFa” (level 4) includes faunal turf, while “SS.SCS.CCS” is purely a description of sediment (circalittoral coarse sediments). It has therefore been a challenge to consistently relate level 4 biotope complexes to the acoustic facies. In addition, the highly heterogeneous nature of Strangford Lough at relatively short scales resulted in extensive use of “biotope mosaics” upon analysis of the ground-truthing data – in fact mixed sediments (SS.SMX.IMx and SS.SMX.CMx) are one of the most frequently recorded biotope complexes. This presents a particular challenge to mapping, and has resulted in polygons attributed with a mosaic of up to four habitats.

The use of historic records in an area of documented habitat change is also problematic, and it is clear that older records include some biotopes which have not since been recorded. This may be due to not re-visiting these sites, but may also be due to change.

Notably, the number of ground-truthing records for each biotope complex has a direct impact upon the mapped biotope complexes – the more records, the higher likelihood that these biotope complexes will be represented in the final maps. Where few records exist, it is impossible to attribute an ‘acoustic signature’ to such habitats, and they are therefore missed out or under-represented in the final map.

There was considerable confusion in the correspondence between ground-truthing records and mapped polygons for mixed sediment (SS.SMX.IMx and SS.SMX.CMx), sandy mud (SS.SMU.ISaMu and SS.SMU.CSaMu), fine sand (SS.SSA.IFiSa and SS.SSA.CFiSa) and fine mud (SS.SMU.IFiMu and SS.SMU.CFiMu). This is due to the overlapping acoustic signature for these categories, and the issue of mixed sediments incorporating components of sands, muds and coarser sediments (including cobbles), along with often notable shell hash cover. It is therefore advised that the results for these biotope complexes is treated with appropriate caution.

In spite of the limitations of this project, this is the first attempt to fully utilise full coverage acoustic data with existing ground-truthing records, many of which were within a two year period of the multibeam survey. As such, the results provide evidence of the present distribution of habitats throughout the lough, including detailed information for the Narrows.
Verification of the mapped habitats should be ongoing, and preferably informed by the acoustic facies distributions and acoustic heterogeneity. DOE intend to conduct an extensive seabed video survey within Strangford Lough as part of the ongoing Modiolus Biogenic reef research. These maps will be utilised in the selection of survey sites and the data gathered may be used to further refine the benthic habitat maps.

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