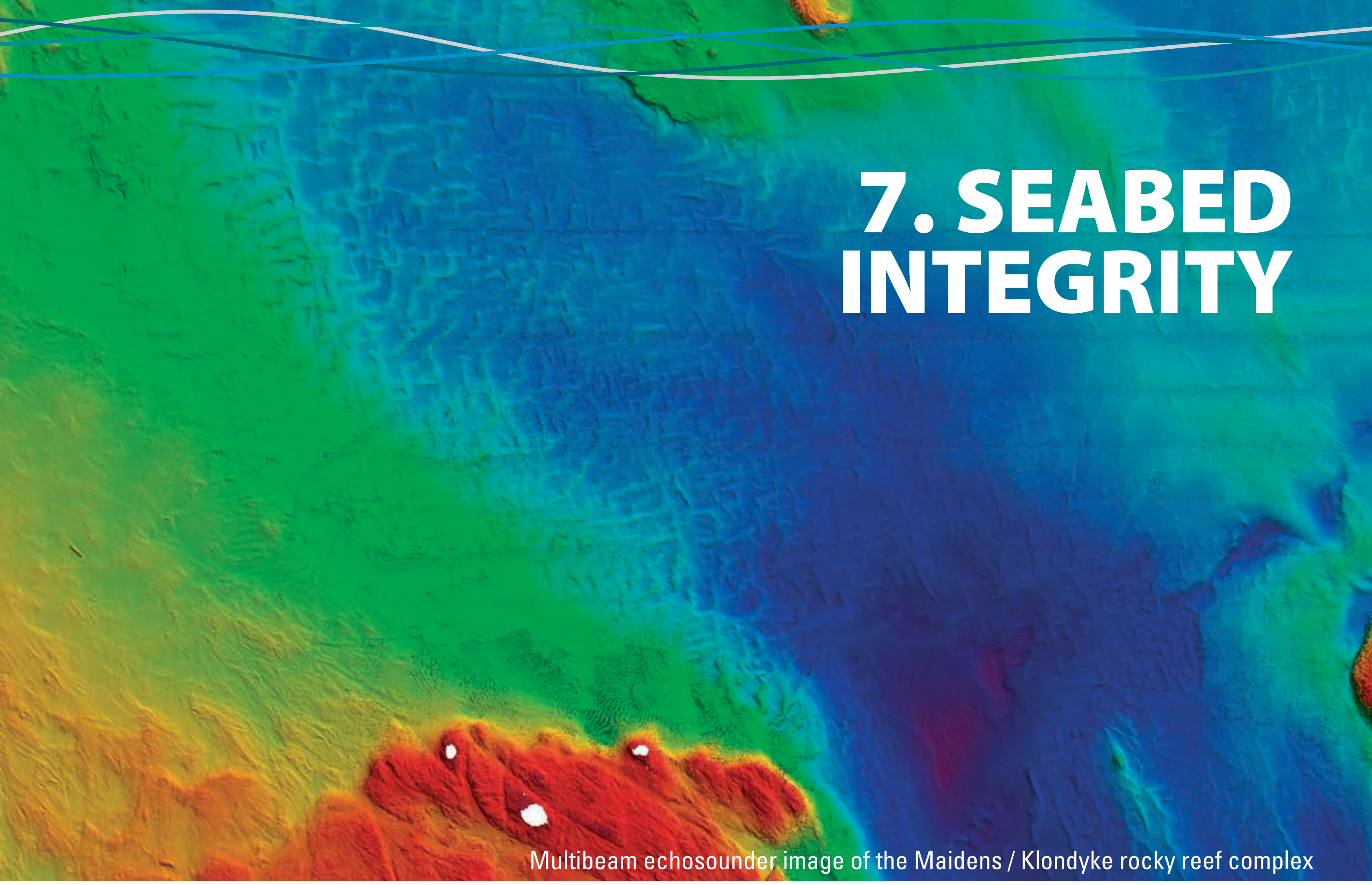
7. SEABED INTEGRITY



Multibeam echosounder image of the Maidens / Klondyke rocky reef complex

Key messages

- The seabed surrounding Northern Ireland can be divided into 3 roughly equal areas of mixed coarse sediment, sand and mud.
- Mixed, coarse ground is not subject to the same pressures as other areas and has a relatively high integrity.
- Sandy areas are under more pressure and may be in poorer condition but tend to show high rates of recovery.
- Fishing activity is the most important pressure on seabed integrity and is concentrated on muddy seabeds for Dublin Bay prawn. As a result, integrity is likely to be lower than in coarser substrata.
- Within the sea loughs, some aspects of seabed integrity are low.
- Approximately 21% of the seabed area around Northern Ireland has been physically mapped in detail.
- A much smaller portion of this area has been ground-truthed to allow the accurate assessment of habitat types.
- Further information is needed to make an accurate assessment of seabed integrity at the local scale.
- More baseline information such as spatial surveys, non-modelled coverage and time series are required.
- Accurate information on the seabed will be vital to marine planning and good licensing decisions in the future.

Why is the seabed important?

The seabed is important for many reasons. Firstly, animals and plants that live on the seabed are valuable sources of food both for the marine food web and humans, via commercial fisheries.

Secondly, the shape and nature of the seabed can affect the waves and currents. These processes shape the coastline through coastal erosion and deposition.

Thirdly, biological material sinking to the seabed is either recycled and the nutrients returned to support surface water productivity or buried thereby trapping contaminants and carbon in the seabed.

Fourthly, the seabed is used for the disposal of harbour dredgings, extraction of sand and aggregates for construction and locating renewable energy facilities.

Finally, the seabed has a rich biodiversity and is a refuge for species that may be of future ecological or commercial importance. Biodiversity also increases the resilience within biological communities, enabling them to adapt to and recover from environmental variation, such as climate change [1].

For these reasons, it is critical that the condition, known technically as 'integrity', of the seabed is assessed. Integrity describes the extent, unity and functioning of seabed ecosystems. High integrity means the ecosystems are unfragmented, functioning normally, uncontaminated and containing characteristic species at appropriate abundances. A preliminary assessment of integrity will be made later in this chapter.

What is already known about the seabed surrounding Northern Ireland?

The local seabed is predominantly under shallow water, with approximately two thirds of the area having water less than 100 metres deep. There are broadly 3 sediment classes, which are approximately equal in area (Figure 7.1). They are mixed coarse ground (mixture of bedrock, cobble, pebble and gravel), sands and soft mud. The type of seabed often reflects the strength of the tides at these sites; coarse sediments occur in strong tidal conditions and mud in sheltered areas.

Off the north coast the tides are moderate and the seabed is mobile sand that is highly sculptured with few epifaunal species (species that live on the seabed surface rather than infaunal species that live within the seabed). Bedrock and strong currents around Rathlin Island however, provide excellent rocky reef habitat, rich in a variety of epifaunal species, especially sponges. The North Channel has stronger tides and extensive areas of sand with large ripples and coarse sediment. The rocky outcrops at the Maidens provide additional habitat for a diverse epifaunal community.

Off the coast of Down, large areas of muddy sand near the coast are replaced in deeper water with a distinct area of soft mud. This is of great importance locally for the Dublin Bay prawn fishery. Dublin Bay prawns form extensive burrows that are important for maintaining the structure of the seabed, oxygenating mud and recycling nutrients (Figure 7.2).

The sea loughs contain a wide array of productive seabed habitats, some of which are of international importance for their biodiversity as well as being of commercial value to the aquaculture sector. Each of the sea loughs has distinct physical characteristics that promote particular biological communities. Table 7.1 details the extent and value of the surrounding seabed, not just in monetary terms but also as functioning ecosystems (sometimes called 'ecosystem goods and services').

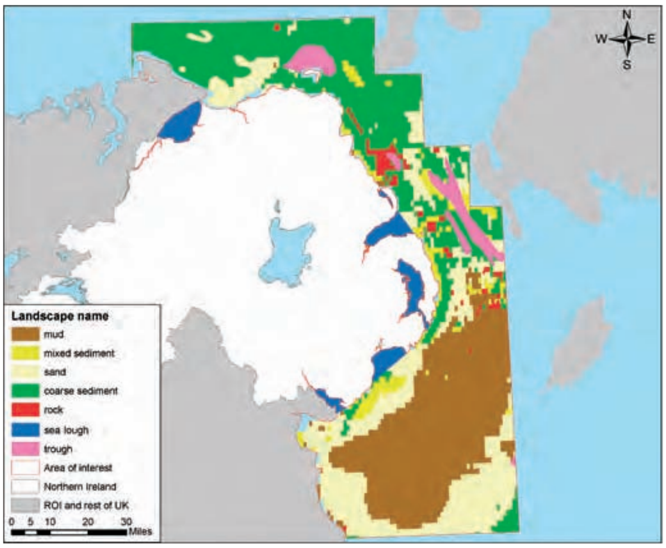


Figure 7.1 The seabed classes modelled by the MESH (Mapping European Seabed Habitats project http://www.searchmesh.net) for the Area of Interest.

Figure 7.2 Burrowed mud in the NW Irish Sea.

Seabed type	% of AOI*	Value: ecosystem goods and services, and direct values for humans	Target fishing species	% of total annual fishing effort**	Approx. fisheries value £m***
Rock Outcrop/ Shelf trough	6%	Refuges for fish, epifaunal habitat, renewable energy sites	cod, haddock, hake, crab, lobster	1.7%	0.5
Mixed Coarse sediment	36%	Spawning grounds, infaunal and epifaunal habitat, aggregate supply, renewable energy sites	cod, haddock, hake, herring, monkfish, dogfish, scallops	6.5%	3.1
Sand	24%	Infaunal and epifaunal habitat, coastal protection, geochemical processes, aggregate supply, renewable energy sites	cod, haddock, hake, whiting, scallops, plaice, dogfish, monkfish, sole	14.7%	2.7
Mud	29%	Infaunal habitat, geo-chemical recycling, contaminant and carbon capture, renewable energy sites	Dublin Bay prawn, haddock, hake, whiting, plaice, dogfish, sole	76.8%	11.3
Sea Loughs	5%	Infaunal and epifaunal habitat, geochemical recycling and primary or secondary productivity, renewable energy sites	crab, Dublin Bay prawn, scallops, lobster, cockles, oysters, mussels	0.3%	3.0

Table 7.1 Extent, ecosystem value and fishing intensity for the seabed types (identified within Figure 7.1).
* Area of interest
** Calculated from 2006 VMS (Vessel Monitoring System): data provided by the DARD.
*** Values are based on an average from 2008 landings http://www.marinemanagement.org.uk/fisheries/statistics/annual2008.htm and 2006 VMS data.

How do we assess overall seabed integrity?
Seabed integrity is assessed using the attributes in Table 7.2 but fundamentally relies on data concerning the following:

a) The physical seabed structure and distribution
b) The chemical and biological makeup of the sediments
c) Monitoring of detrimental activities that puts pressure on seabed integrity.

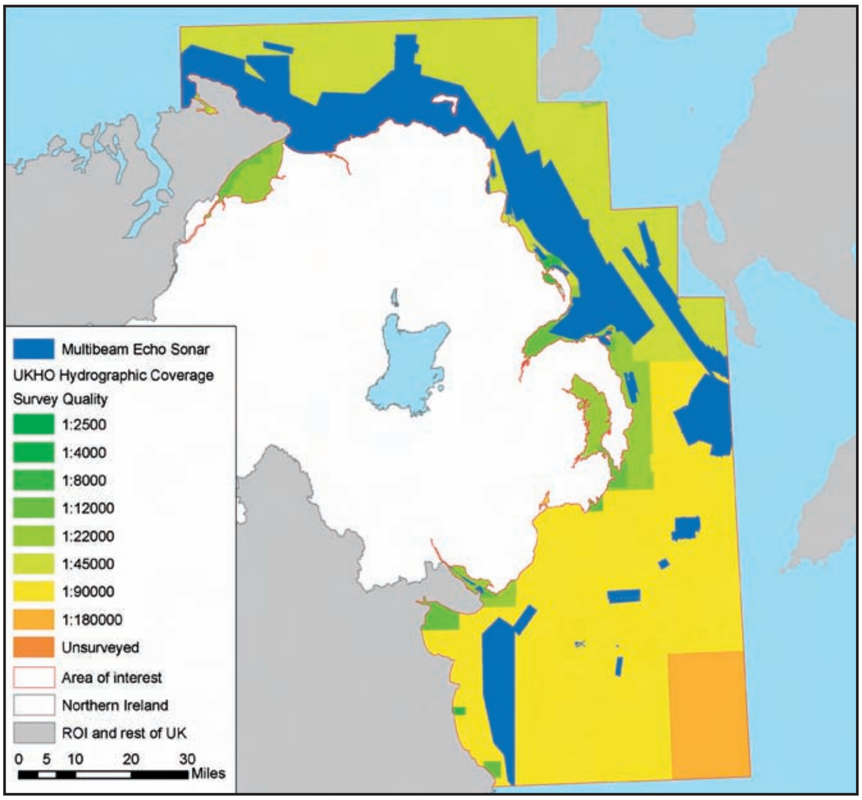
a) Physical seabed structure and distribution

The depth of the water and basic shape of the seabed are the initial information we need to understand our seabed habitats. Low-resolution information collected with single-beam echo sounders is available for large areas but is too coarse for mapping finer physical features and habitats (orange, yellow and green areas in Figure 7.3). The blue areas in Figure 7.3 are surveyed mostly by multi-beam echo sounders (example image, Figure 7.3) and some high-density single-beam echo sounders which produce high resolution data suitable for seabed mapping and assessment of integrity.

To date, about 21% of the 'Area of Interest' has been surveyed in this way. The area of interest is not the territorial waters of Northern Ireland but a larger, more relevant and cohesive seabed area. This area has been used in all the figures in this section.

b) Seabed composition - sediment, chemistry and biology

Multi-beam echo sounders have made physical mapping of the seabed easier - the process of examining seabed composition, mapping species distributions and measuring ecosystem processes is however much harder. It requires direct sampling of the seabed for analysis and extensive camera surveys. This 'ground-truthing' is time consuming and expensive but vital as it represents the bulk of the information required for the seabed integrity assessment. Although 21% of the area of interest has been physically mapped at a high resolution, only 8% has sufficient ground-truthing to generate completed habitat maps (Figure 7.4).
A greater area is clearly needed for a complete investigation of integrity. This is a problem



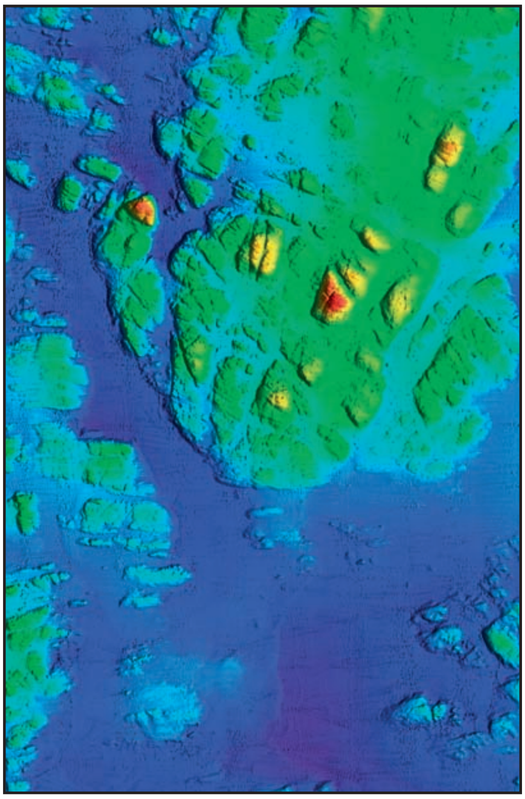


Figure 7.3 Distribution and resolution of physical 'bathymetric' data within the Area of Interest. Image to right is an example of bathymetry collected with a multibeam echo sounder from within the area of interest (red areas) – dark blue is deeper water and red areas are shallower bedrock outcrops.

throughout Europe which has been partially addressed by using models to predict seabed habitats such as in the MESH (Mapping European Seabed Habitats) project (e.g. Figure 7.1). These, however, remain too coarse and uncertain for a thorough assessment of seabed integrity.

Sampling is also undertaken to measure contamination or assess the impact of particular activities on the seabed. Many of those studies are one-off surveys and few provide repeated measures over time or provide greater spatial coverage. Exceptions include the extensive Northern Ireland Sublittoral Survey and programmes, such as the UK National Clean Seas Environmental Monitoring Programme that provide annual surveys of seabed contamination and health around Northern Ireland (Chapter 9)[2].

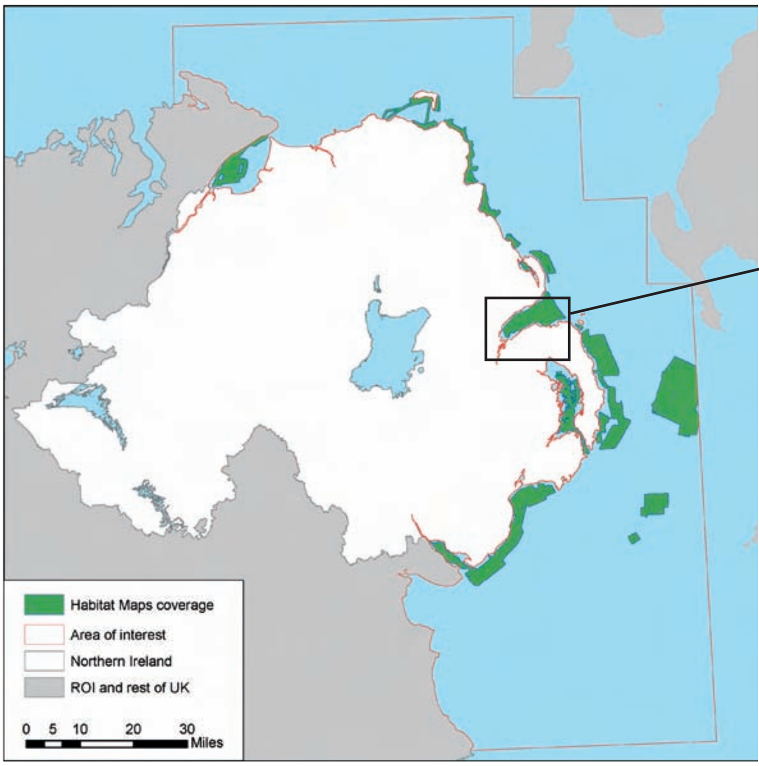
c) Monitoring of detrimental activity

A complementary approach to environmental assessment is to monitor the activities that create pressures. A useful example of this is the Vessel Monitoring System, which uses satellites to monitor the movement of fishing vessels over 12 metres in length (Figure 7.5). Similar technology is also required on all dredged material disposal vessels and the requirement is set as a licence condition. The monitoring can be translated into a pressure on seabed integrity using established studies relating cause and effect. However, a current limitation is that 58% of the Northern Ireland fishing fleet are 10 metres or smaller in length and are not monitored in this way.

How is the seabed potentially affected by human activities?

The most spatially extensive human activity that occurs on the seabed is fishing. In the seas of Northern Ireland, about 77% of the seabed fishing occurs on mud and about 15% on sandy areas (Table 7.1 and Figures 7.1 and 7.5), which reflects the importance of the Dublin Bay prawn to the Northern Ireland fishing industry.

Otter trawls are mostly used to catch Dublin Bay prawns locally and are less damaging to seabed integrity than other mobile gear such as beam trawls and dredges [3]. However this



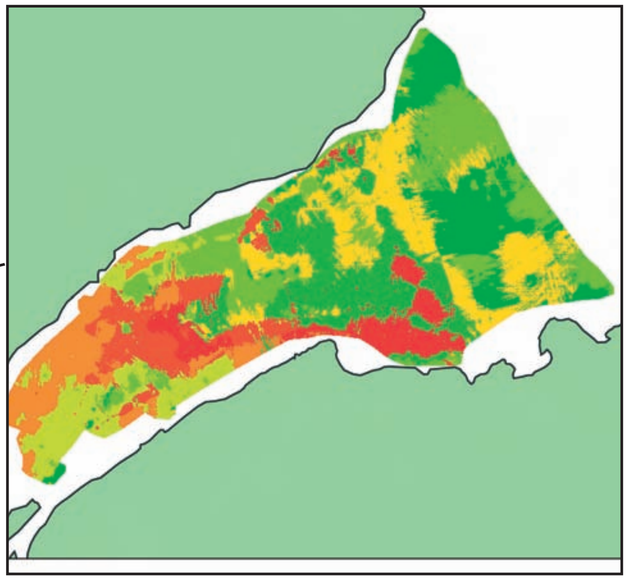


Figure 7.4 Left: Existing habitat maps within the Area of Interest.
Above: Example of a habitat map for Belfast Lough.

form of trawling removes both target and non-target species and the otter boards (the structures that keep the mouth of the trawl net open) plough furrows in the seabed that can last weeks or even years [4,5,6]. The passage of nets and ground ropes is known to impact fragile species even within the seabed and also species, such as seapens, which are partially exposed above the seabed [7].

Scientific studies consistently find that otter trawling modifies seabed habitats, although the impact on integrity is variable. This variability is a combination of seabed composition, fishing intensity and how much natural seabed disturbance there is from the tides and storms. Areas with weak tides, such as the northwest Irish Sea mud patch, are more at risk as they are not adapted to high levels of natural disturbance compared to areas that experience frequent large-scale natural disturbances [8,9]. Reefs made by animals that are prominent above the seabed are also more affected than communities below the seabed surface[7].

Fishing is particularly intense in the northwest mud patch and, on average, the bed may be trawled between 5 and 10 times per year[10]. As a result, it is highly likely that the local mud seabed is constantly in a modified condition. This in turn will result in reduced diversity, modified abundance and shifts from surface filter feeding species to animals below the sediment surface or mobile scavengers. It is worth noting that, although the habitat may be affected, the abundance of large species like the Dublin Bay prawn can remain relatively unchanged helping to maintain some of the seabed processes that promote higher integrity[11].

Sandy seabeds are less intensively fished in our seas. Due to the higher natural disturbance regime, rapid recovery and reduced fishing effort, it is estimated that sandy seabeds are less damaged than other substrata and therefore have a higher integrity. There are important exceptions because this type of seabed provides habitats for some important species such as horse mussels *Modiolus modiolus*, fan mussels *Atrina fragilis* and maerl *Lithothamnion* and *Phymatolithon* species. It is well documented that the physical disturbance associated with bottom fishing is highly damaging for these species and that they may be very slow to recover, if indeed they ever do[12].

Built structures on the seabed and capital dredging also have an effect. The loss of seabed from maintenance dredging (i.e. seabed extraction to maintain the workable

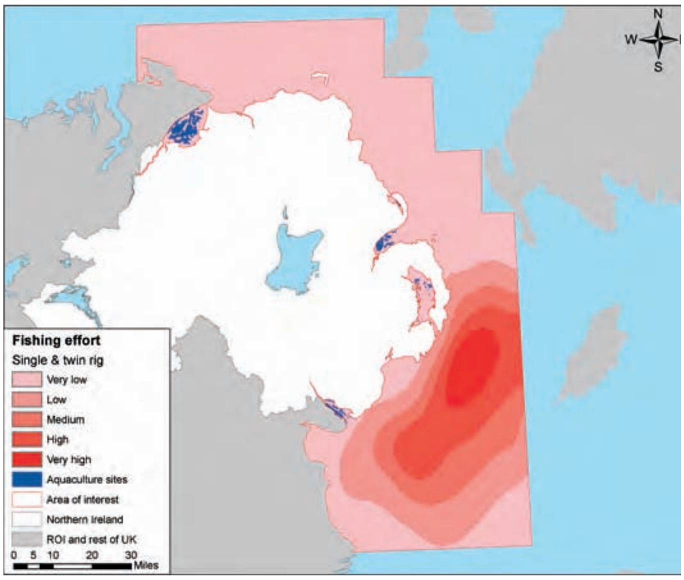


Figure 7.5 The distribution of aquaculture beds in blue and fishing activity in red, shaded by intensity (2006 VMS data)

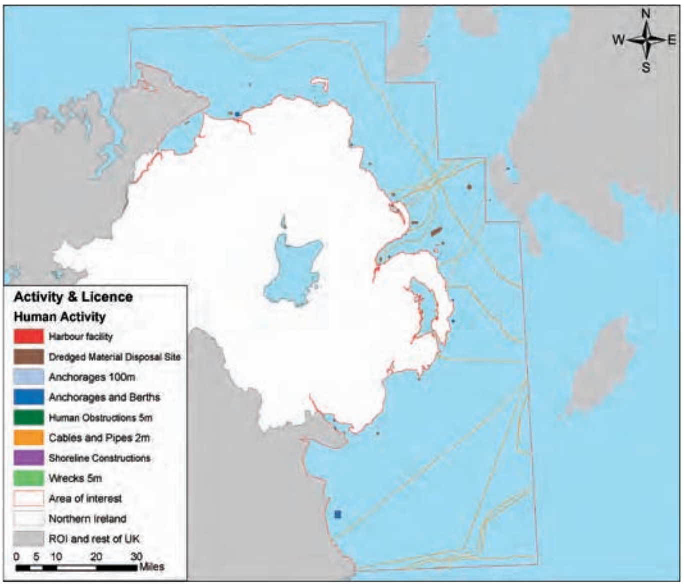


Figure 7.6 The location of human structures placed onto the seabed within the Area of Interest.

depths of our ports) and the disposal of the spoil is licensed by NIEA under the Food and Environment Protection Act and is carefully monitored. Although this can be highly destructive, especially if near or on sensitive habitats, the area affected is very small (around 0.1% of the area of interest: Figure 7.6). The loss of seabed through port extensions, the placement of cables and other man-made structures represents the complete and permanent loss of natural seabed. Again, although the impact is particularly severe, the area lost to these constructions is very small (around 0.3% of the area of interest: Figure 7.6). When planning these structures, comprehensive studies are undertaken to predict the likely impact on the seabed of the 'footprint' of the construction and its operation. Monitoring may also be required during the operational phase of some structures. Currently there is no commercial aggregate extraction in our seas, although there is a licensing system in place, should a developer be interested in this activity.

It is well known that the contamination of sediments with various metals and organic compounds can have serious effects on species, seabed processes and the marine food web [13]. Due to the low level of industrialisation within Northern Ireland and legislation controlling discharge, contamination by metals and organic compounds is low. It is not considered to be a significant threat to seabed integrity and further analysis of marine contamination is described in Chapter 9. Traces of the radionuclides released from Sellafield are detectable throughout the seabed surrounding Ireland and are more concentrated in the north east [14]. However, the concentrations of these elements are too low to significantly affect seabed integrity.

Other issues such as low oxygen concentrations associated with eutrophication (see Chapter 6) are rarely problematic except in small, enclosed water bodies with limited water exchange or areas of intense stratification. Overall, these are not a significant threat to seabed integrity.

Summary

The proposed attributes used to measure seabed integrity are shown in Table 7.2. However, the guidance for how integrity relates to thresholds of good environmental status within the Marine Strategy Framework Directive has yet to be established. From the information available, some assessment can be made on the state of seabed integrity. The 2006 Vessel Monitoring System data indicates that the mixed category of coarse ground and bedrock is not subject to the same pressures as other areas and probably has a relatively high integrity. Sandy seabeds are under more pressure but tend to show high rates of recovery. As much of the fishing activity is concentrated on the mud, integrity is likely to be lower in these areas compared with coarser substrata. Within the sea loughs, where aquaculture predominates or key species have been removed, like the horse mussels in Strangford Lough, it is anticipated that some aspects of seabed integrity will be low.

What more needs to be done?

Future work is required to address the substantial knowledge gaps that still exist, especially in offshore areas.
Of particular importance are:

Mapping - the potential for a full integrity assessment is greatly reduced by the limited extent of existing habitat maps and consequentially, reliance on predictions from seabed models. Although projects like the Joint Irish Bathymetric Survey and AFBI high resolution marine mapping ventures have made significant contributions to map coverage, more effort must be placed into extending this area and ground-truthing new and existing survey sites.

Monitoring – the vessel monitoring system is a valuable tool but the data currently has restrictions on its availability and use. This means it's not currently possible to use the tool in the analysis of fishing pressure between years. Access to this data along with more research and evidence-gathering is necessary, in order to relate the range of observed fishing effort to a quantifiable change in seabed integrity across different substrata.

Processes - the modification of nutrient supply, mobilisation, regeneration in the benthos and sediments at differing levels of impaction is poorly understood. We also need a better understanding of seabed resilience and how damaged areas recover. The implications of climate change on integrity have not been addressed in this report. Clearly, these represent a substantial shift in environmental conditions and the implications of climate change on seabed integrity are not yet understood and will need further investigation.

Attribute	Criteria
Substrata condition	Reduction in natural three-dimensional structure Substantial alteration of composition Large area exposed to pressures known to alter substrate
Bio-engineer presence	Reduction in number and/or spatial extent of bio-engineers* Large area exposed to pressures known to alter substrate
Oxygen concentration	Decreasing oxygen concentration of bottom water and/or upper sediment layer
Contaminant concentration	Accumulation of contaminants in sediment and biota
Species composition	Increasing proportion of community comprised of few species in high abundance and/or permanent loss of species
Biotic size composition	Increasing/decreasing proportion of the community comprised of small/large individuals
Trophodynamics	Nutrient supply, mobilisation, regeneration in the benthos and sediments Decreasing carrying capacity
Life history traits	Loss of functional diversity Increase/decrease in relative abundance of traits associated with opportunistic/ sensitive species

Table 7.2 Proposed attributes of seabed integrity [15]

*Bio-engineer presence = bioengineers are species that significantly and disproportionally change their habitat. For many species this occurs when they generate structural elements that dominant the habitat and thereby provide shelter and food for other species that might not otherwise be present without the bioengineer.

Legislation	
Marine Framework Strategy Directive Descriptor 6 **Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected**	
Other relevant EC Directives **(full references and corresponding regulations – Appendix II)**	
Water Framework Directive	Driving overall improvements in water quality incorporating seabed integrity in estuarine and coastal waters
Habitats Directive	To protect, maintain and restore natural habitats and species of European importance, in favourable conservation status
International Agreements	
OSPAR Convention for the protection of the marine environment of the North-East Atlantic	Biodiversity and ecosystems strategy
Local legislation	
The Fisheries Act (NI) 1966	Conservation and protection of fisheries
Foyle and Carlingford (2007) Act	Licensing and management of shell fisheries in Foyle and Carlingford
Food and Environment Protection Act, (1985) Part II	This allows NIEA to regulate deposits in the sea, and can set licence conditions to ensure that environmental noise is limited in marine construction projects. New marine licensing legislation is due to be introduced in April 2011
Environmental Impact Assessment and Natural Habitats (Extraction of Minerals by Marine Dredging) (England and Northern Ireland) Regulations 2007	This introduced a formal licensing system for marine aggregate extraction in Northern Ireland waters
Wildlife (Northern Ireland) Order 1985	Affording national protection measures to certain species
Environment (Northern Ireland) Order 2002	The principal measure for site protection in Northern Ireland

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