Estuarine, Coastal and Shelf Science 84 (2009) 409–418

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

The impact of scour processes on a smothered reef system in the Irish Sea

Alexander Callaway[a,*], Jennifer Smyth[a], Craig J. Brown[a], Rory Quinn[a], Matthew Service[b], David Long[c]

[a] Centre for Coastal and Marine Research, Environmental Sciences Research Institute, School of Environmental Sciences, University of Ulster, Coleraine BT52 1SA, Ireland
[b] Agri-Food and Biosciences Institute, 18 Newforge Lane, Belfast BT9 5PX, Ireland
[c] British Geological Survey, Murchison House, West Mains Road, Edinburgh EH9 3LA, Scotland, UK

ARTICLE INFO

Article history:
Received 21 May 2009
Accepted 20 July 2009
Available online 23 July 2009

Keywords:
scour
sediment dynamics
Nephrops norvegicus
predation pressure
Pisces Reef system
Irish Sea

ABSTRACT

The Irish Sea, like many marine areas, is threatened by anthropogenic activities. In particular the Pisces Reef system, a series of smothered rocky reefs are subject to fishing pressures as a result of their position within a *Nephrops norvegicus* fishery. In an area of sediment deposition and retention the reefs modify the environment by increasing the energy of near-bottom currents which results in localised scouring. This is the first study to attempt to characterise and investigate the ecological functioning of the Pisces Reef system. A multidisciplinary approach was essential for accurate investigation of the area. To facilitate more effective management of the benthic habitats of the Reef system, this study integrates acoustic, seismic, grab sampling and video ground-truthing methods for benthic habitat discrimination. Orientation of the scour hollows also suggest that seabed features could be used to infer dominant flow regimes such as the Irish Sea Gyre. The data revealed significant geology–benthos relationships. A unique biotope was described for the reef habitat and it was demonstrated that scouring may influence community composition through disturbance mechanisms. This study provides preliminary information required for management of a unique habitat within a uniform region.

© 2009 Elsevier Ltd. All rights reserved.

1. Introduction

Scour occurs through interaction of fluid flow with obstacles (Whitehouse, 1998). Commonly, scour is initiated by either the migration or change in morphology of bedforms (Soulsby, 1997; Whitehouse, 1998) or by the intentional (e.g. coastal engineering) or natural (e.g. reef exposure) introduction of an object to the seafloor (Soulsby, 1997; Whitehouse, 1998; Sumer et al., 2001). Scour is a major consideration for engineering in the marine environment as the resulting scour hollows can compromise the stability of man-made structures. The process is characterised by the removal of bed material from around an object by current induced sediment transport (Whitehouse, 1998; Vijaya Kumar et al., 2003; Myrhaug and Rue, 2005; Dey and Barbhuiya, 2006). Scouring of the seabed is initiated when drag and lift forces of the erosive flow exceed the gravitational, frictional and/or cohesive forces that hold sediment particles together (Ram Babu et al., 2002). Thus, sediment particles are hydraulically scoured when the fluid shear stress exceeds a critical value. This critical shear value is a function of mean particle size and submerged density of sediment (Whitehouse, 1998). When an object is introduced to the seabed, the flow pattern surrounding it changes resulting in sediment removal around, although predominantly in lee, of the object (Whitehouse, 1998; Sumer et al., 2001).

A range of structures can be affected by scouring such as barrages, dam toes, navigation channels, groynes, breakwaters, pipelines, shipwrecks, electrical cables, vertical piles, piers and offshore platforms (Whitehouse, 1998; Ginsberg and Perillo, 1999; Rame Gowda et al., 1999; Sumer et al., 2001; Ram Babu et al., 2002; Myrhaug and Rue, 2005; Gao et al., 2006; Quinn, 2006; Cataño-Lopera and Garcia, 2007; Dey and Singh, 2007). Scour signatures adjacent to these features form parallel to peak water flow and have been used as palaeo-current indicators (Quinn et al., 1997) and to elucidate contemporary bottom-flow regimes in the absence of other data (Caston, 1979). Natural structures, such as exposed rocky reefs, also experience scouring, yet research concerning scour processes around natural structures is limited (Borg et al., 2007).

Offshore reefs host important ecological systems due to the diversity of habitats available on and around the exposed rock. The effects of temporally variable sedimentation which can reduce the epifaunal diversity and the resulting ecological functioning of a reef are well documented (Schiel et al., 2006; Balata et al., 2007; Ryan et al., 2007). However, there are no reports in the literature of temperate reef systems subject to prolonged depositional processes, with recent investigations describing exposed reef in areas of low deposition and moderate

* Corresponding author.
E-mail address: callaway-a1@ulster.ac.uk (A. Callaway).

0272-7714/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ecss.2009.07.011

erosive potential (Diesing et al., 2009). Hydrodynamic processes acting on reef systems exert primary control on associated habitat type and availability and therefore areas under the influence of strong external hydrodynamic forcing offer an opportunity to study the effects of scouring around large stable structures introduced to the seabed. Whilst the structural impact of scour on rocky reefs may be less than on man-made structures, many of the same physical principles apply. Increasingly, reef systems are threatened by anthropogenic activity (e.g. fishing for *Nephrops norvegicus*) and therefore effective environmental management is needed to ensure the ecological and economic status of these unique sites.

The Irish Sea separates the islands of Great Britain and Ireland, and like many marine areas, is threatened by anthropogenic activities, subsequently its natural resources are under pressure from over-exploitation. This is well documented for many regions of the world of natural importance, (e.g. Kenny et al., 2003; Pickrill and Todd, 2003; Diaz et al., 2004; Stevens and Connelly, 2004; Weiers et al., 2004) but studies of these effects in the Irish Sea are relatively few (Allen et al., 1998; Rogers et al., 1999; Veale et al., 2000; Evans et al., 2003). Within Europe, marine resources are important for the economies of many nations, and without effective, sustainable management these resources are in danger of being over-exploited, which could potentially cripple the industries reliant upon them. The potential impacts from these activities have led to the creation of environmental management strategies, such as the European biodiversity strategy which aims to "anticipate, prevent and attack the causes of significant reduction or loss of biological diversity at the source" (European Commission, 1998). Unfortunately, implementation of such strategies is constrained by a deficit of reliable information on the location, extent and condition of natural habitats (Weiers et al., 2004), which is essential information for the effective sustainable management of natural resources.

The purpose of this study is to address the issues above by utilising the biotic and abiotic information collected to characterise the ecology of the Pisces Reef system. In doing this, essential preliminary information will be available to inform management strategies for the area. The aims of this study will be achieved by testing the following hypothesis: The distribution of *N. norvegicus* and benthic infauna is influenced by the geology, geomorphology and hydrodynamics of the Pisces Reef system.

2. Study area

Located in the Western Mud Belt (WMB) of the Irish Sea, the Pisces Reef system comprises three known Tertiary igneous bedrock extrusions (Area 1, Area 2 and Area 3) in Permo-Triassic sediments (Fig. 1) (Holmes and Tappin, 2005; Judd, 2005; Judd et al., 2007). The reefs range in size from 0.6 to 1.8 km in length and rise 15–35 m above the surrounding seabed. The magnitude and relief of these features present significant obstacles to the low velocity bottom currents of the WMB which have been demonstrated to have a velocity around 30% lower than the overlying water column in hydrodynamic models (Xing and Davies, 2001). Therefore, reduction of mid-water current speeds (0.11–0.50 m s^{-1} mean peak spring tidal current) recorded in the area (Holmes and Tappin, 2005), is potentially counteracted by significant acceleration of local currents by the reefs, creating a relatively dynamic area compared to the surrounding WMB. As a result of the obstruction caused by the reefs, each has an associated scour hollow where the surrounding sediment has been eroded to depths between 15 and 35 m below the average seabed depth (Holmes and Tappin, 2005).

The WMB is an area of both economic and ecological importance supporting part of the Irish Sea demersal fish and Norway lobster (*Nephrops norvegicus*) fisheries and is at risk of over-exploitation from European fleets (Eggert and Ulmestrand, 1999). The Pisces Reef system may help mitigate these affects by offering a sanctuary area for *N. norvegicus* and associated by-catch species due to the nature of reefs making them inaccessible by traditional fishing methods (García-Charton and Pérez-Ruzafa, 1999; Rogers et al., 1999; Ball et al., 2000; Bergmann et al., 2002; Catchpole et al., 2007). Also, the reefs are veneered with fine sediment which is in places thick enough to support *N. norvegicus* and other infauna upon which *N. norvegicus* prey. The reefs may also offer an alternative mosaic of habitats in an otherwise uniform area increasing the local diversity (Holmes and Tappin, 2005). Furthermore, benthic scour may potentially create a unique niche within the mud habitat of the WMB by allowing some species associated with the sediment deposits on the reef top to colonise the scoured mud flat.

3. Methodology

3.1. Data acquisition

Multibeam bathymetry and backscatter data were acquired as part of the Mapping European Seabed Habitats (MESH) partnership during survey work conducted by the Agri-Food and Biosciences Institute of Northern Ireland (AFBINI) and the Irish Marine Institute (MI) on *RV Celtic Voyager*. The vessel was equipped with a Kongsberg Simrad EM1002-S multibeam echo-sounder (MBES) operating at frequencies between 93 and 95 kHz with angular coverage set to 130°. Ship position was recorded by onboard Leica MX412 Professional and Litton Marine LMX4000 Differential Global Positioning Systems (DGPS); these data were integrated with inertial measurements by a Seatex Seapath 200 to give real time heading, attitude, position and velocity.

Ground-truthing stations were selected based on interpretation of backscatter and bathymetric data derived from the MBES data. A Simrad Kongsberg OE14-124 3 CCD colour video camera mounted on a metal drop frame for tows 1–3 and a tow sled for tow 4, was deployed from *RV Corystes* during drifts (0.2–0.8 knots) and an active tow (0.5 knots) over the ground-truthing sites. Tows 1–3 ranged from 0.2 km to 0.6 km in length and tow 4 was 1.6km in length. Due to the undulating topography of the reef and poor visibility a bed hop method was employed when using the drop frame. The camera was oriented perpendicular to the seabed on the drop frame giving a field of view of 1 m^2 when resting on the bed. When attached to the tow sled the camera was oriented at −40° from horizontal giving a field of view of 0.86 m^2. An ultra short base line (USBL) system was used to give drop frame and tow sled position. The camera was controlled via an umbilical cable to the ship where real time images were viewed and recorded. The images were time-, date- and GPS-stamped to authenticate the data and allow for geo-referencing in ArcGIS (Mitchell and Coggan, 2007).

Eight grab samples were collected using a 0.1 m^2 Day grab over three target regions described below. Positional information was recorded as above. The samples were washed over a 0.5 mm sieve and fixed in formalin for subsequent faunal identification. In the laboratory, the grab samples were washed with freshwater over a 0.5 mm sieve to remove excess formalin and transferred to Petri dishes for sorting and identification.

3.2. Geophysical data processing

Morphological analysis of the MBES-derived bathymetric data was conducted in *ArcGIS* v9.1 and *Surfer* v8.1. Bathymetric data were supplied as ungridded, tidally corrected XYZ data by the

Download English Version:

https://daneshyari.com/en/article/4541019

Download Persian Version:

https://daneshyari.com/article/4541019

Daneshyari.com