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Viewpoint

# Towards an integrated approach to marine benthic monitoring

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ABSTRACT

In the UK, most marine benthic monitoring is carried out in a piecemeal fashion, funded by different sectors of industry that utilise the marine environment under licence. Monitoring requirements are imposed by licence conditions, which can vary considerably between licences. The UK Government also conducts marine environmental surveys in support of its legislative commitments. The present investigation reviews these different monitoring approaches to highlight whether synergies between them could be developed into an integrated approach to marine benthic monitoring. An integrated approach would have ecological benefits, as greater consistency in sampling and analytical protocols would reduce uncertainty in the predictions of impact, and facilitate the assessment of Good Environmental Status under the Marine Strategy Framework Directive. The same approach would also be of financial benefit, as spatio-temporal duplication in sampling would be reduced, and the value of acquired data would be maximised, resulting in a more efficient and cost-effective approach.



## 1. Introduction

Marine benthic monitoring, in its various guises (from surveillance to feedback monitoring; see Elliot (2011)), provides the necessary evidence to assess the direct effects of human activities on the seabed and its resident biota, as well as assisting in the understanding of the ecological functioning of the marine ecosystem. This system-wide understanding is essential for the assessment and maintenance of Good Environmental Status (GES) – a requirement from all maritime member states of the European Union (EU) under the Marine Strategy Framework Directive (MSFD) – yet gaining such understanding is not always straightforward (Borja, 2014; Shephard et al., 2015), for reasons outlined below.

Many benthic monitoring programmes have been carried out over relatively short time periods (less than 10 years) and at relatively small spatial scales (less than 10 $km^2$), often focusing on isolated, temporally short-lived and spatially discrete activities (Cooper, 2013a; MMO, 2014). Whilst there is no doubt that such programmes have collectively contributed a wealth of knowledge to our understanding of impacts on marine benthos, the inherent differences of approach between programmes operating independently and in isolation have made it difficult to access and compile comparable data records that enable the quantitative investigation of broad-scale patterns and variability in the benthos over decadal time scales. It is these long-term and broad-scale trends in benthic community variability, together with an understanding of the causative factors behind such variability (natural vs anthropogenic), which are necessary for the informed assessment of environmental quality.

It is widely recognised and accepted in EU environmental law that, under the 'polluter pays principle', industries directly responsible for inflicting disturbance to the environment should support governments in their legal obligations to ensure the sustainable utilisation of resources. For several years, a variety of sectors of offshore industry in the UK have been required to monitor the effects of their activities on the environment ('self-monitoring' in the nomenclature of Elliot (2011)), most recently by adhering to activity-specific licence conditions imposed under the auspices of the Marine and Coastal Access Act 2009 (MCAA) and its predecessors. It is the fundamental premise of this communication that both industry and government should work together towards a common goal, that is, to consolidate benthic monitoring effort that complies with licence conditions and the MSFD without imposing additional burdens. To this end, an integrated approach to benthic monitoring across sectors is proposed, based on those practices that would optimise the benefits for all stakeholders (i.e., industry, government, and environmental protection agencies). This approach is also consistent with the 'collect once, use many times' philosophy, increasingly favoured by marine stakeholders.

## 2. The rationale for large-scale benthic monitoring

Monitoring is necessary to establish the magnitude, and spatial and temporal distribution of anthropogenic impacts in the receiving environment. On a large enough scale, it is also useful in providing the environmental context into which smaller-scale concerns can be judiciously managed. The proliferation of activities with a widespread, spatially-exclusive footprint and long-term prospects (e.g., renewable

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energy developments, aggregate extraction areas) requires that an equally widespread, long-term and compatible benthic monitoring programme is established, to ensure that human-induced, large-scale change can be detected, judicious and pragmatic management can be applied, and any lasting ecological damage can be avoided. To do this against a potentially changing baseline brought about by the effects of climate change just adds to the challenge, yet it is a challenge that cannot be ignored (see Elliott et al., 2015).

### 2.1. Why monitor benthos?

Collectively, benthic invertebrates have an important role in the functioning of ecosystems, as food for higher trophic levels, as bioturbators and ecosystem engineers, and in nutrient cycling (e.g., Solan et al., 2004; Gray and Elliott, 2009; Bertics et al., 2010). In addition, benthic invertebrates are relatively small (therefore, easy to sample) and mostly sedentary (therefore, must either adapt to disturbance or perish) (Bilyard, 1987). Standardised benthic sampling protocols already exist (Kramer, 1994; Ware and Kenny, 2011; Eleftheriou, 2013) and are implemented by most benthic monitoring practitioners. Given such characteristics and the potential for comparability in benthic responses across datasets, they can be a useful indicator of the effects of localised disturbance, as a footprint of effect on the seabed can be identified through changes in benthic community composition. Such changes can be obvious, with a loss of most organisms, or more subtle, where only those vulnerable to the disturbance are affected.

From a management perspective, data generated by the monitoring of benthic invertebrates can be quantitative and measured within estimable bounds of variability, provided that an appropriate sample size and degree of replication is maintained (Gray and Elliott, 2009). Using the quantitative, site-specific data that benthic invertebrate sampling provides, it is possible to establish criteria for sediment quality based on values of benthic variables, such as the number of taxa or abundance values. The sedentary habits of benthic invertebrates also facilitate the development of models that describe cause–effect relationships (e.g., Pearson and Rosenberg (1978)).

Monitoring benthos can have disadvantages, mostly focused on the costs of sample collection and subsequent processing (Kingston and Riddle, 1989; Borja and Elliott, 2013), although with careful planning and understanding of the objectives of the monitoring exercise, most disadvantages can be minimised and mitigated.

### 2.2. Legislative imperative

The UK has responsibilities under a number of different legislative obligations to survey and monitor marine biodiversity across its territorial waters, and to assess and report on the conservation status of this biodiversity. For example, the main pieces of legislation relating to nature conservation in England and Wales are the 1981 Wildlife and Countryside Act (as amended), the 2000 EU Water Framework Directive, the 2009 Marine and Coastal Access Act, and the 2010 Conservation of Habitats and Species Regulations. The aim of these, among other things, is to implement the various nature conservation directives adopted by the European Union/Commission, in particular the EC Birds Directive and the EC Habitats Directive. Together, these provide for the protection of animal and plant species of European importance and the habitats which support them, by the establishment of the Natura 2000 network of protected sites (www.natura.org).

Specifically tailored to protect the marine environment, the MSFD outlines a transparent, legislative framework for an ecosystem-based approach to the management of human activities, to support the sustainable use of marine goods and services. The overarching goal of the Directive is to achieve good environmental status (GES) by 2020 (Borja et al., 2013). To achieve GES in a coherent and strategic manner, the MSFD has defined a set of sub-regions nested within regions based on geographical and environmental criteria. Each of the EU member states whose territorial waters overlap with these sub-regions must develop a marine strategy to: (i) assess the current environmental status of those waters, (ii) determine what GES means for those waters, (iii) define targets and indicators that will show whether GES is achieved, (iv) devise a monitoring programme to measure progress towards GES, and (v) devise, agree and implement measures designed to achieve or maintain GES. Coordination of these strategies across EU member states that are responsible for territorial waters within the same marine region is achieved through the Regional Seas Conventions, which for the UK is the OSPAR Convention (www.ospar.org).

### 2.3. Seabed usage around the UK

Over several decades there has been a steady increase of many offshore activities and related environmental pressures, mainly from shipping, construction of coastal defence and other coastal structures, construction and operation of windfarms, placement of telecommunication and power cables and artificial reefs, as well as an increase of oil and gas exploration and exploitation and tourism. Mariculture activities and fisheries have decreased. A further increase is expected until 2020 for many activities, especially offshore windfarm developments (OSPAR, 2009).

As marine activities continue to expand in spatial and temporal footprint, competition for space will undoubtedly increase. Areas in which the footprint of several activities can overlap are likely to be exposed to multiple pressures, with the potential for these to cause cumulative, combined and unpredictable effects on the seabed and the marine environment beyond (i.e., plankton, pelagic fish, marine mammals and birds). According to Goodsir et al. (2015), 63% of the seabed (42,839 $km^2$) within a 67,500 $km^2$ hypothetical management area in the Southern North Sea was exposed to one or more activity (namely: aggregate extraction, fishing, oil and gas, offshore windfarms, and telecommunications). The spatial distribution of each activity varied between sectors, from 20 $km^2$ (0.03%) for telecommunications to 30,000 $km^2$ (44%) for fishing, with a spatial overlap of activities ranging from 45% to 90%. Clearly, any attempt at monitoring the effects of these activities on the benthic ecosystem will require an approach that can take into consideration such overlap of activities, and not assume that pressures from each activity can be determined in isolation.

## 3. The monitoring burden

The UK Government is responsible for conducting surveillance seabed monitoring (sensu Elliot, 2011) at a national scale to comply with the full range of its national and international commitments under the OSPAR Convention, EU/EC Directives, and devolved national Acts. For example, the Clean Seas Environment Monitoring Programme (CSEMP), formerly the National Marine Monitoring Programme (NMMP), has been undertaken by the government's statutory agencies since the late 1980s as part of their regulatory functions (see Table 1). The programme aims to provide data to assess the quality of the marine environment, and benthic monitoring of subtidal sedimentary habitats has been conducted at an established network of stations around the UK, including estuarine, coastal and offshore sites (Davies et al., 2001). The UK Government is also embarking on a monitoring programme which will include an assessment of the condition of benthic habitats in marine protected areas designated under the auspices of its nationally devolved marine acts (i.e., MCAA (England and Wales), Marine (Scotland) Act, Marine Act (Northern Ireland)), the EU MSFD, and the EC Birds and Habitats Directives.

In England and Wales, prior to the introduction of the MCAA in 2009, the monitoring of human activities (e.g., port construction, aggregate extraction, renewable energy developments, oil and gas extraction, nuclear power generation, and dredge material disposal) was undertaken in accordance with sector specific regulatory regimes. After 2009, the