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Determining Good Environmental Status under the Marine Strategy Framework Directive: Case study for descriptor 8 (chemical contaminants)

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ABSTRACT

The European Union Marine Strategy Framework Directive (MSFD) requires individual member states to develop a robust set of tools for defining eleven qualitative descriptors of Good Environmental Status (GES), such as demonstrating that "Concentrations of contaminants are at levels not giving rise to pollution effects" (GES descriptor 8). Adopting the recommendations of the ICES/OSPAR Study Group for the Integrated Monitoring of Contaminants and Biological Effects (SGIMC), we present a case study demonstrating how the proposed approach, using chemical contaminant (metals and polycyclic aromatic hydrocarbons and polychlorinated biphenyls) and biological effects (EROD, bile metabolites and pathology) data in different matrices (sediment and biota), could be used to contribute to the determination of GES in a region of the North Sea region off the east coast of the UK.

1. Introduction

The Marine Strategy Framework Directive (MSFD) aims to have all European marine waters achieving, or progressing towards the achievement, of Good Environmental Status (GES) by 2020 (MSFD, 2008). In order to achieve this, the EU Commission has selected eleven high-level qualitative descriptors of GES, which are defined in Annex I of the directive. As a consequence the MSFD is now one of the key policy drivers shaping marine monitoring and assessment across Europe. Providing the framework, around which, management measures will be developed by individual member states. A key objective in the first phase of the implementation of the MSFD was the development of common indicators and methodological standards, which will ensure consistency and comparability in the determination of GES across Europe (MSFD, 2008; Lyons et al., 2010; Borja et al., 2013; Giltrap et al., 2013; Gago et al., 2014; Tornero and Ribera d'Alcalà, 2014).

In order to harmonise the approach adopted across Europe, the Joint Research Centre (JRC) and the International Council for the Exploration of the Sea (ICES) were commissioned to prepare the scientific bases for such indicators and to propose methodological standards in relation to eight of the eleven GES descriptors. This included the establishment of a task group that set out to develop a common framework for assessing descriptor 8, "Concentrations of contaminants are at levels not giving rise to pollution effects" (Law et al., 2010). The approach proposed by Law and his co-authors was based upon an ecosystem-based approach, as previously outlined by ICES, which denotes that pollution effects ought to be considered at various biological levels of organisation (Thain et al., 2008). It was recommended that the specific indicators and methodological standards for descriptor 8 should, wherever possible, rely on the existing approaches developed in the Regional Seas Conventions, including the chemical and biological effects monitoring programmes currently conducted under the guidance of the OSPAR Convention (Convention for the Protection of the Marine Environment of the North- East Atlantic: http://www.ospar.org) and similar programmes run by HELCOM (Baltic marine Environment Protection Commission: http://www.helcom.fi) and MEDPOL (Convention for the Protection of the Mediterranean Sea Against Pollution: Barcelona Convention http://www.unepmap.org). ICES and OSPAR held a series of workshops and study groups over a six

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year period that proposed methods for integrating chemical contaminant and biological effects data for assessing the OSPAR Maritime Area. This culminated in the Study Group Integrated Monitoring of Contaminants and Biological Effects (SGMIC) proposing an integrated approach, which if validated could be deployed to assess GES in relation to descriptor 8 (ICES, 2011).

In recent years a large amount of effort has been focused on developing Background Assessment Criteria (BACs) and Environmental Assessment Criteria (EACs) for specific contaminants in sediment and biota (OSPAR, 2008; Roose, 2012). OSPAR has developed Background Concentrations (BCs), which is the concentration of a contaminant at a 'pristine' or 'remote' site based on contemporary or historical data, which observed concentrations are said to be 'near background' if the mean concentration is statistically significantly below the corresponding BAC (OSPAR, 2008; QSR, 2010). Priority substance specific EACs are defined as a concentration of chemical contamination in the environment below which it is unlikely that unexpected or unacceptable biological effects will occur in exposed marine species. EACs and other appropriate assessment criteria (e.g. US EPA adopted Effects Range Low (ERLs), Long et al., 1995) have been developed to act as pivot points when assessing safe limits of contaminant concentrations in sediment and biota and therefore can be considered analogous to the Environmental Quality Standards (EQS) applied to water under the Water Framework Directive (WFD). The list of suitable marine EACs for key priority pollutants is by no means complete and work is continuing to develop EACs for a range of contaminants of interest to OSPAR (Roose, 2012). However, it is widely acknowledged that an approach which relies solely on chemical concentration based EQSs and/or EACs/ERLs has inherent limitations (ICES, 2011; Roose, 2012; Hutchinson et al., 2013). This obviously includes the relatively small range of substances for which assessment criteria have been defined (including a limited number developed for new and emerging chemical contaminants), and importantly a lack of direct measurements of pollutant related biological effects in the field (Hagger et al., 2008; Giltrap et al., 2013; Wernersson et al., 2015). This is required to fully assess the health of marine environments and to answer questions relating to the bioavailability of hazardous substances, interactions between chemical mixtures or co-stressors and the subsequent impact these combined factors have on the health of marine organisms. Therefore, ICES/OSPAR proposed that the assessment of descriptor 8 should be based upon an integrated approach using concentrations of chemical contaminants and biological measurements relating to the effects of pollutants on marine organisms that have been assessed against internationally agreed criteria (Law et al., 2010; ICES, 2011; Vethaak et al., this volume). In practice this would include the assessment of concentrations of priority contaminants in environmental matrices (water, sediment, and the tissues of biota) and the data interpreted against assessment thresholds (e.g. EACs ERLs and EQSs) that are aimed at protecting against the occurrence of pollution related effects. In parallel, contaminant related biological effects would be assessed against threshold levels of response that are indicative of significant harm to the species under investigation (Lyons et al., 2010; ICES, 2011; Giltrap et al., 2013).

The aim of this current paper is to demonstrate how the proposed SGIMC integrated assessment framework for contaminants and biological effects could be applied to data collected as part of the UK's Clean Seas Environmental Monitoring Programme (CSEMP) (Cefas, 2012a). CSEMP is one of the means by which the UK's national and international commitments to monitoring chemical contaminants in estuarine and marine waters are met. The major drivers for the current programme are the European Union (EU) Water Framework Directive (WFD), the EU Marine Strategy Framework Directive (MSFD) and the Co-ordinated Environmental Monitoring Programme and Joint Assessment and Monitoring Programme of the Oslo and Paris convention (OSPAR). We have undertaken a case study comprising offshore marine samples (sediment and biota) collected from the Humber Wash region of the North Sea (as defined in Charting Progress 2, 2010; Fig. 1). This region was expected to comprise of relatively clean sites and represent a healthy marine ecosystem. In addition, not all the matrices and chemical and biological endpoints proposed by ICES were deployed at the sites studied. Where possible, a pragmatic and risk based approach was adopted, which aligned with the UKs current marine monitoring programme both in relation to affordability and known anthropogenic pressures.

2. Material and methods

2.1. Assessment approach

A multi-stage framework has been proposed by SGMIC in which the assessment of contaminants and biological effects data for sediment, fish and shellfish is used to determine whether GES is being achieved for descriptor 8 of MSFD (Lyons et al., 2010; ICES, 2011; Hylland et al., this volume; Vethaak et al., this volume). The basis for the proposed integrated monitoring framework builds on the traffic light assessment system (blue, green, red) which was deployed to indicate the status of different aspects of the marine environment within the OSPAR Quality Status Reports 2010 (QSR, 2010; for review of its application to chemical contaminants see Webster et al., 2009). The interpretation of the blue/green/red traffic light scheme in relation to chemical contaminants and biological effects is outlined in Fig. 2 and is covered in detail by Vethaak et al. (this volume). It should be noted that this framework remains a work in progress, but the overall philosophy provides the basis for the assessments undertaken in this paper. For example, there is an ongoing development of chemical related EACs, so for the purposes of this case study where uncertainty arose, we applied chemical assessment criteria used during the last major assessment of the health status of the UK's marine environment (Charting Progress 2, 2010).

The assessment framework outlined in Table 1 describes the SGIMC proposed approach for the assessment of environmental monitoring data to determine whether GES is being achieved for descriptor 8 of MSFD. Chemical and biological measurements with EAC or equivalent assessment criteria (e.g. ERLs) provide appropriate indicators with quantitative targets. This allows the assessment of chemical contaminant and biological effects data against these predefined criteria and provides information both on concentrations of contaminants likely to give rise to effects and the presence/absence of significant adverse biological effects in marine biota (ICES, 2011). Due to the relatively large number of chemical and biological endpoints measured when applying an integrated approach, it is unrealistic to adopt a stance whereby failure of a single determinant results in failure of GES for a given site or region. It has been suggested that a pragmatic approach should be adopted whereby a threshold (%) is set for the proportion of measurements that should be less than EAC/ERL to achieve GES for a given location or region. Exactly where this cut off should occur (e.g. >95% or >90%) is currently being debated and the setting of an appropriate threshold for overall regional assessment for MSFD will require consideration and revision after the results of several case studies, using real monitoring data, such as presented here, are critically reviewed. Further details on the application of SGIMC assessment criteria is presented by Hylland et al. (this volume) and Vethaak et al. (this volume).

This case study uses chemical and biological effect data from the Humber-Wash region of the North Sea to carry out a preliminary

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