ECOREGION **General advice**
SUBJECT **OSPAR request to investigate spatial representation of existing CEMP sediment monitoring stations**

Advice summary

ICES advises that there is no single method that can be recommended to determine the geographic representativeness of existing sediment monitoring stations that would meet all monitoring purposes. Four different methods might be considered, depending on the monitoring purpose:

i) Sediment transport models are not yet sufficiently developed to be able to describe (with sufficient detail on a region scale) where sampling stations should be located;
ii) Existing monitoring stations that are in areas of fine sediment can be used for regional-scale assessment of status in relation to GES for MSFD Descriptor 8, based on whole sediment concentrations (i.e. not normalized or sieved). Monitoring of temporal change should, however, use data from sieved samples. If only sieved samples are available, then whole sediment concentrations can be back-calculated from concentrations in the sieved fraction.
iii) There is no strong relationship between variability of concentrations and size of a geographic area/strata.
iv) Visual representations of existing data can provide information on the geographic pattern of concentrations of sediment contamination.

It is apparent from several lines of enquiry that the degree of variability will differ for different substances and between geographic areas.

Request

Monitoring of hazardous substances within the framework of OSPAR has been carried out for decades and at stations scattered throughout the OSPAR area. Good time trends and statistical tools for assessing these are available. Assessment criteria like BACs and EACs have been developed for sediment, shellfish and fish to assess levels.

Except for some work on sediment (Warren 1994, 1995), little is known of what geographical area each station represents. Given the current state of ocean models combined with measured changes at each station ICES is requested to advice whether a method can be recommended to determine the geographic representativeness of existing sediment monitoring stations.

ICES advice

ICES advises that there is no single method to determine the geographic representativeness of existing sediment monitoring stations that would meet all monitoring purposes.

OSPAR has classified the purposes of sediment monitoring into four categories (OSPAR JAMP guidelines):

a) To assess spatial distributions;
b) To assess temporal changes;
c) To retrospectively assess temporal changes;
d) For more specialized purposes (e.g. effects of contaminants in organisms).

ICES assumes that the request relates primarily to the first two categories (a,b) of sediment monitoring and therefore has not commented on sampling strategies for categories c) and d). In 2013, ICES advised that for spatial sediment monitoring, sampling should be randomized within specific geographic strata, defined as areas characterized by specific sediment characteristics (principally grain size). If this advice is followed, then the sampling stations represent the geographic area occupied by the sediment stratum. If an individual site is visited, there is no single answer for the wider area that it represents.

ICES notes that background assessment concentrations (BACs) have been derived predominantly at the scale of the OSPAR Area from sampling of cores (category c). ICES also notes that the geographic representativeness of the samples used in this process has not been examined statistically. At present, BACs are not used in assessing good environmental status (GES) but have been used in OSPAR Quality Status Reports. If BACs are used in understanding variance in environmental quality at a wider geographic scale, it is important to understand the geographic representativeness of the samples used.

Four aspects of sediment sampling to a) assess spatial distribution and b) assess temporal changes are described in the advice below:

1. The suitability of sediment transport models to inform on the spatial distribution of monitoring stations.
2. The use of existing monitoring stations in determining GES.
3. The relationship of variability of sediment concentrations with size of a geographic area / stratum.
4. Visual representations of variability of sediment concentrations between sampling stations.

Request item i) The suitability of sediment transport models to inform on the spatial distribution of monitoring stations

ICES advises that sediment transport models do not currently contain sufficient detail at a region scale e to identify where sampling stations should be located. However, existing hydrodynamic models can predict the dispersion of suspended particulate matter (SPM) from riverine input, but require knowledge of the contaminant concentrations of SPM before they can be used to model the input of contaminants to a given sampling area.

Request item ii) The use of existing monitoring stations in determining good environmental status

ICES advised in 2013 that the existing monitoring stations situated in areas with fine sediment can be used for regional-scale assessment of status in relation to GES for Descriptor 8, based on whole sediment concentrations (i.e. not normalized or sieved). As detailed in that advice, it may be necessary to obtain samples from additional stations within a stratum in order to achieve sufficient statistical power to determine whether the assessment criterion is significantly exceeded. It should be noted that any additional sites would only be required to be sampled once within the six-year reporting cycle of the MSFD. This is to allow an assessment of status in relation to GES. For monitoring of temporal change, the existing stations should continue to be sampled at the frequency required by that monitoring programme.

In contrast to the 2013 ICES advice on monitoring for GES, monitoring of temporal change should use data from sieved samples (OSPAR JAMP guidelines). In order to avoid gaps in time-series, or the collected samples being analysed twice (sieved and unsieved), data from sieved samples can also be used for the GES assessments; however, in such cases the concentrations must be corrected for the fraction of the sample that was not analysed, i.e. concentrations should be back-calculated from the fine fraction concentration to a whole sediment basis to allow comparison with assessment criteria that are based upon whole sediments.

Request item iii) The relationship of variability of sediment concentrations with size of a geographic area/stratum

ICES advises that there is no strong relationship between variability of concentrations and size of a geographic area/stratum.

ICES examined sample data reported to OSPAR for cadmium and mercury concentrations (mg kg^{-1}, normalized to 5% Al) in sieved sediments beyond 12 km from the coast in the southern North Sea. These showed a tendency to lower variability in smaller areas. However, there was no obvious geographic scale at which variability decreased markedly and the relationship was based on a limited number of sampling areas. If this technique for understanding the representativeness of sampling in relation to areas is to be developed further, knowledge on the variability of sediment contaminant concentrations for many more areas at different spatial scales are required, or other statistical techniques employed.

Request item iv) Visual representations of variability of sediment concentrations between sampling stations

ICES advises that visual representations of existing data can provide an overview of the geographic pattern of concentrations of sediment contamination. Such visualization of OSPAR data from the southern North Sea shows differences in spatial variability between individual contaminants. These visualizations also show that concentrations in the fine fraction of samples in offshore depositional areas may be representative of sieved samples from the wider area for some substances, but not for others.

A possible approach is to plot concentration data (raw and normalized) as bubble-plots overlaid on geographic maps. This is a simple way to visualize areas with similar concentrations. This may help in understanding representativeness and possibly to enable an optimization of sampling strategy within areas of similar concentrations. It is important to note that the patterns (size and shape of these areas) may vary between contaminants, and sampling optimized for one contaminant may therefore not be suitable for others.

To illustrate this approach, the mean (1998–2009) mercury sediment concentration data (mg kg^{-1} dry weight, normalized for the co-factor (5% aluminium)) for sieved sediments from the southern North Sea were overlaid on maps indicating the areas of fine sediment (>20% silt/clay; Figure 1.6.6.2.1). This contaminant is predominantly of anthropogenic origin and the plot appears to show that fine-fraction sediment concentrations in offshore depositional areas (coloured blue) are similar to those in the fine fraction of the wider offshore area, although this may be due to a scaling effect. It is apparent that, as expected, concentrations in inshore areas of fine sediment tend to be much higher and more spatially variable than offshore. Similar patterns were seen for some other contaminants of predominantly anthropogenic origin (e.g. TBT, PCBs).

In contrast, a plot of normalized lead concentrations (Figure 1.6.6.2.2) for which there is a significant natural background, shows large differences between the offshore areas of fine and coarse sediment. This indicates that for lead (and several other metals with significant natural backgrounds), samples collected in the areas of fine sediment may not be representative of the wider offshore southern North Sea.

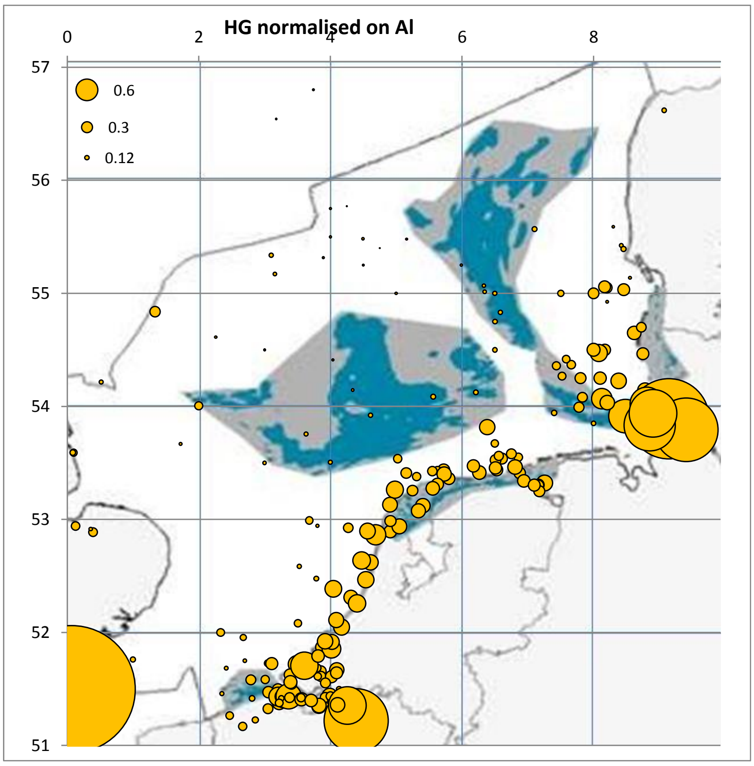

Figure 1.6.6.2.1 Bubble plot of sediment mercury concentrations in the southern North Sea (mg kg^{-1} dw, normalized to 5% aluminium). The blue areas have >20% silt-clay fraction (< 63 µm). Grey and white areas are coarser grained.

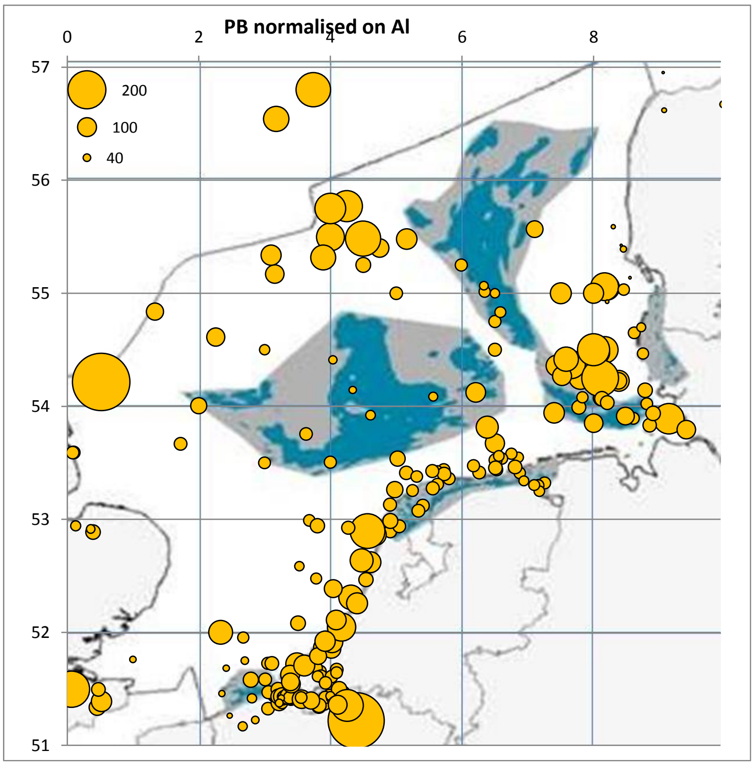

Figure 1.6.6.2.2 Bubble plot of sediment lead concentrations in the southern North Sea (mg kg^{-1} dw, normalized to 5% aluminium). The blue areas have >20% silt-clay fraction (< 63 µm). Grey and white areas are coarser grained.

Some of the OSPAR dataset used to create the bubble plots (Figures 1.6.6.2.1 and 1.6.6.2.2) was used to create visualizations of kriging output (Figure 1.6.6.2.3) – a geostatistical approach that interpolates values between sampled stations. The figure illustrates broad patterns of contamination, but the modelling technique may be misleading in data-poor areas. For example, two red points off Scotland are responsible for the much of the red area off the eastern Scottish coast; it seems unlikely that this whole area is more heavily contaminated. In the southern North Sea offshore of the Netherlands, where sampling points are closer together (approximately 20–30 nautical miles apart), the interpolated area of relatively low contamination appears more convincing.

In relation to the question as to how much area is represented by a sampling point, Figure 1.6.6.2.3 demonstrates that there is no one rule. For example, in the Fladen Ground (offshore of Northeast Scotland) four points show widely differing relative concentrations of cadmium within a 20–30 nautical mile range, while in the southern North Sea offshore of the Netherlands, points at a similar range apart show similar relative concentrations of cadmium.

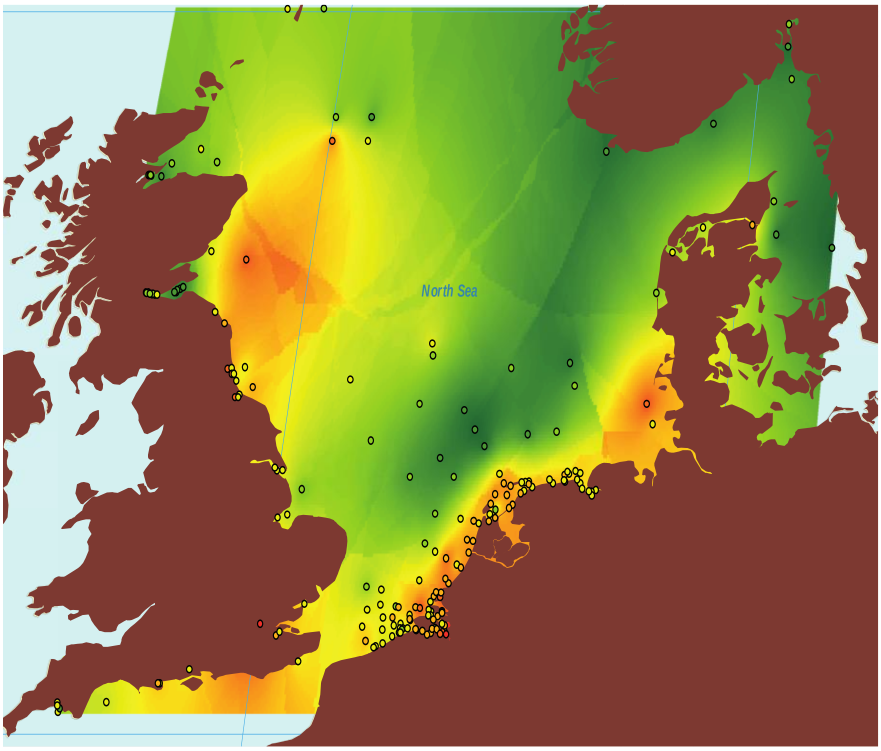

Figure 1.6.6.2.3 Relative concentrations of cadmium as interpolated by kriging between sampling points. Sample point concentrations are the log-transformed modelled variance relative to the overall North Sea mean for the most recent year, after conversion to µg kg^{-1} to avoid negative logarithms. Red sampling points are > 2.5 standard deviations above this mean (relatively more contaminated), yellow for the range around one standard deviation, green between −1.5 and −0.5 standard deviations, and blue for < −1.5 standard deviations (relatively less contaminated).

Sources

ICES. 2013. OSPAR request on spatial design of a regional monitoring programme for contaminants in sediments. *In* Report of the ICES Advisory Committee, 2013. ICES Advice 2013, Book 1, Section 1.5.6.8.

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Warren, W. G. 1995. Spatial analysis of trace metal concentrations in North Sea sediment: a follow up (Annex 8). *In* Report of the Working Group on Statistical Aspects of Environmental Monitoring (WGSAEM). ICES CM 1995/D:2.