Status and Trends for Heavy Metals (Cadmium, Mercury and Lead) in Sediment

MSFD Descriptor: 8 - Concentration of contaminants

MSFD Criterion: 8.1 - Concentration of contaminants

OSPAR COMMISSION

Key Message Mean concentrations of mercury, cadmium and lead concentrations in marine sediments are decreasing or show no significant change in the majority of areas assessed. Nevertheless, concentrations in all areas are above natural background levels, and in four of the six areas assessed are above levels where adverse ecological effects cannot be ruled out

Background

OSPAR's strategic objective is to prevent pollution of the OSPAR Maritime Area by continuously reducing discharges, emissions and losses of hazardous substances. Metals are ubiquitous hazardous substances in the environment, found in marine sediments in all OSPAR regions. The most toxic metals to humans and animals are mercury, cadmium and lead, known as heavy metals, all of which naturally occur in the environment.

Mercury, cadmium and lead enter the marine environment from a number of natural, agricultural and industrial processes, such as emissions from coal-fired power stations, via long range transportation by air, riverine input or run-off from land (Heavy metal inputs Indicator Assessment). Some metals used as antifouling chemicals (mainly copper) and corrosion anodes (mainly zinc) are deliberately placed in the marine environment through their use on ships' hulls or marine installations, causing hot spots concentrations of these metals in and around harbours.

Mercury is highly toxic. Mercury and cadmium accumulate in the food chain, while lead is not accumulated via the food chain.

Heavy metals do not disappear over time and can be trapped in deeper levels of sediment until mining, geological or biological processes release them, at which point they may affect biota.

There are natural concentrations of heavy metals in all waters, sediments, and marine biota, referred to as the background concentrations. OSPAR uses the United States National Oceanic and Atmospheric Administration guidelines for assessing the ecological significance of contaminant concentrations in sediment (Effects Range-Low; ERL) as proxy for Environmental Assessment Criteria (EAC).

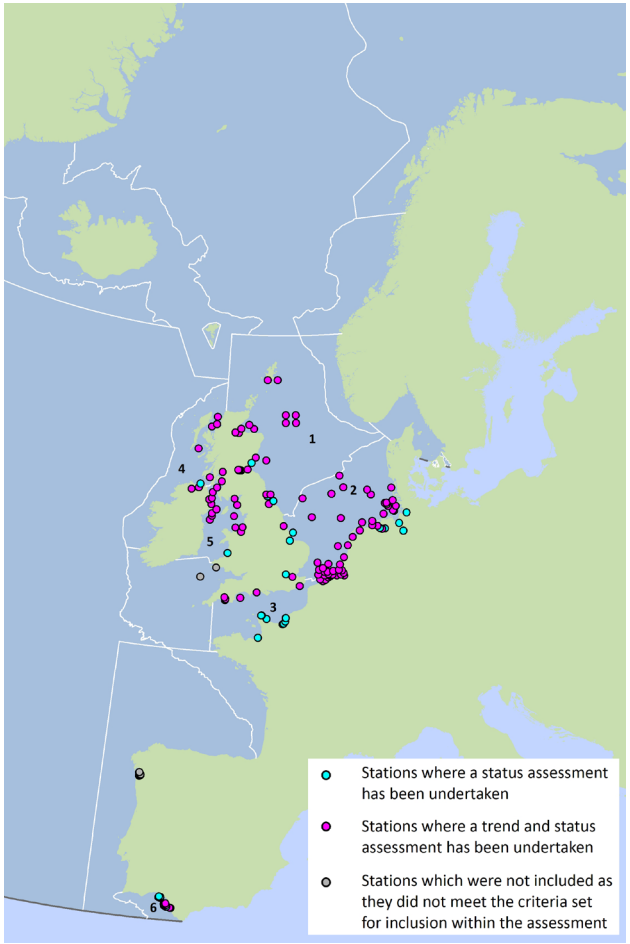

Figure 1: Monitoring sites used to assess heavy metal concentrations in sediment within OSPAR contaminants assessment areas (white lines) determined by hydrogeographic principles and expert knowledge, not OSPAR internal boundaries.

Results

Heavy metals in sediment are monitored on a regular basis as part of the OSPAR Co-ordinated Environmental Monitoring Programme (CEMP), at between 65 and 125 monitoring sites (**Figure 1**) depending on the heavy metal monitored. The assessment is based on monitoring sites that have been monitored at least since 2009; with some monitored since 1989. Temporal trends are assessed from the 10 years of monitoring data (i.e. 2005–2015), and the trend is determined from the last 5 years of data.

The concentrations of mercury, cadmium and lead were compared to Background Assessment Concentrations (BACs) and Effects Range-Low (ERL) values. Mercury and lead concentrations in sediment are at or above the BAC in all sub-regions. Mean concentrations of cadmium are below the BAC (**Figure 2**) in three of the six sub-regions assessed: Northern North Sea, Irish and Scottish West Coast and the Irish Sea.

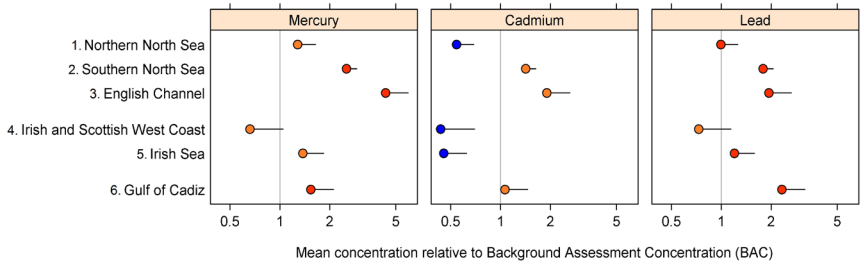

Figure 2: Mean concentrations of three heavy metals in sediment in OSPAR sub-regions relative to the Background Assessment Concentration (BAC) (with 95% upper confidence limits) where value of 1 means that the mean concentration equals the BAC. Blue: mean concentration statistically significantly ($p < 0.05$) below the BAC and the ERL, orange: mean concentrations at or above BAC but statistically significantly below the Effects Range-Low (ERL), red: mean concentration is above the BAC and at or above the ERL

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Results cont...

Mercury concentrations in sediment are at or above ERL in three of the six sub-regions (**Figure 3**). Concentrations of cadmium in sediment are below the ERL in all OSPAR sub-regions. Lead concentrations are at or above the ERL in five of the six sub-regions, and below the ERL only in the Irish and Scottish West Coast sub-region.

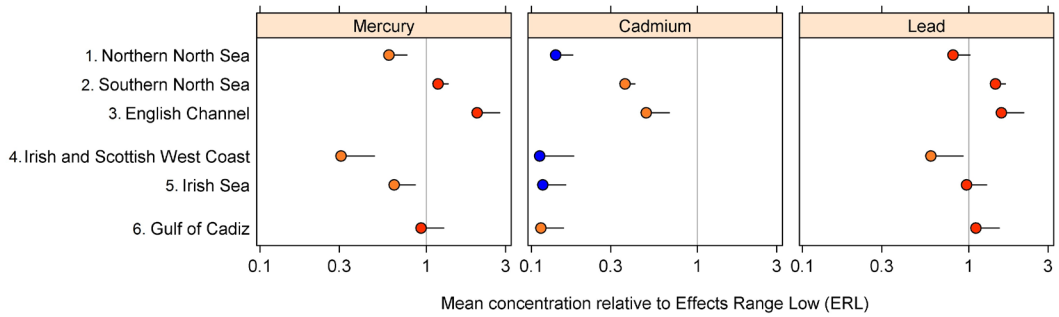

Figure 3: Mean concentrations of heavy metals in sediments relative to Effects Range-Low (ERL) concentration (with 95% upper confidence limits), where value of 1 means that the mean concentration equals the ERL. Blue: mean concentration is statistically significantly ($p < 0.05$) below the Background Assessment Concentration (BAC) and the ERL. Orange: mean concentration significantly below the ERL but at or above BAC. Red: mean concentration is above the BAC and at or above the ERL

Results cont...

The temporal trends in (overall mean) heavy metal concentrations in sediment (**Figure 4**) show decreasing levels of mercury in five of the six sub-regions and no statistically significant change in concentrations in the English Channel. Concentrations of cadmium show no statistically significant change in five sub-regions, but are decreasing in the Southern North Sea. Lead concentrations show no statistically significant change in four sub-regions and a downward trend in the Southern North Sea. In the Gulf of Cadiz there is an upward trend for lead.

This is a different pattern from that for biota, where most mercury concentrations show no statistically significant change and lead concentrations at most monitoring sites are decreasing (Common Indicator Heavy Metals in Biota). The response of sediments to measures taken to reduce heavy metal is expected to be slower than for biota, because the upper sediment layer (top few centimetres) sampled for analysis can represent several years of sedimentation and thus integrate heavy metal inputs over the corresponding period.

There is high confidence in the assessment and sampling methodology and high confidence in the data used.

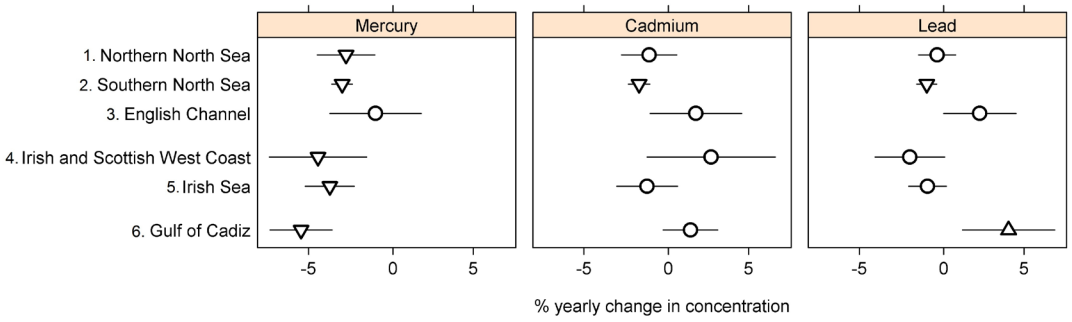

Figure 4: Percentage annual change in heavy metal concentrations in sediment in six OSPAR sub-regions. No statistically significant change in mean concentration (circle), mean concentration is significantly decreasing (downward triangle), mean concentration is significantly increasing (upward triangle), 95% confidence limits (lines)

Conclusion

The ultimate aim of the OSPAR Hazardous Substances Strategy is for concentrations of heavy metals in sediment to be at natural background levels. However, in most sub-regions heavy metal concentrations in sediment are above natural background concentrations. The highest concentrations in sediment of mercury and cadmium are found in the English Channel. Lead concentrations in sediment are highest in the Gulf of Cadiz. The lowest concentrations for all heavy metals are in the Irish and Scottish West Coast.

In half of the sub-regions mercury concentrations in sediment are above the ERL and in five of six monitoring sites lead concentrations are at or above the ERL. This means that in these sub-regions adverse ecological effects cannot be ruled out. In contrast cadmium concentrations are below the ERL in all six sub-regions.

The generally decreasing trends for mercury are not reflected in the concentrations of cadmium and lead; most cadmium and lead concentrations in sediment show no statistically significant change.

Knowledge Gaps

There is a lack of ecotoxicological data for developing new assessment criteria based on the European Union Water Framework Directive or OSPAR Environmental Assessment Criteria (EAC) principles, to replace the current Effects Range-Low (ERL) criteria. There are too few monitoring sites in Arctic Waters for a sub-regional assessment to be carried out.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments