The Methodology for MAR001 Hazardous substances in marine organisms

Conversion to a preferred basis for data in assessment

The classification by which the data are assessed requires conversion to the preferred basis (OSPAR, 2008). In order to create comparability between data within and between stations, and to allow comparison with assessment criteria, it is necessary to choose the bases on which all concentrations must be expressed. The preferred bases currently applied by OSPAR vary depending on organism, contaminant and type of threshold. For instance, for metals in mussels, the lower limit (in this case, background assessment concentrations or BAX) is expressed on a dry-weight basis, while the higher limits are based on EUs concentration limits for human food, which are expressed on a wet-weight basis. In some cases, we used the EQS limits, which also are expressed on a wet-weight basis. We did not attempt to adjust concentrations (or EQS limits) based on trophic level.

- wet weights for metals, and for organic compounds in mussels and fish except herring
- lipid weights for organic compounds in herring

The choice of bases aimed at meeting several considerations: scientific validity, uniformity for groups of contaminants for particular tissues and a minimum loss of data. As to the latter, the choice of bases will affect the number of data that can be included in the assessment, depending on available information on dry weights, wet weights, lipid weights and the ratio between dry and wet weight. Data available on dry weight were converted to wet weight basis, but only when sample-specific dry weight-wet weight ratio was available. An exception was made for data from Mediterranean mussels (*Mytilus galloprovincialis*) in France and Italy where it assumed the dry weight-wet weight ratio to be 0.17 in order to increase the geographic coverage. For the Mediterranean Sea, mussel data from Greece could not be converted to the preferred dry-weight basis on a sample-specific basis, and was therefore excluded from the assessment.

Aggregation of data by station

In a primary step, each time series (combination of location, species, tissue and determinant) is aggregated to median concentration for each year. We used OSPAR's rules for treatment of less-than values (http://dome.ices.dk/OSPARMIME/help_methods_less_thans.html). Basically, whether and how a trend is fitted to the data is based on N+, the number of years of data with at least one non-censored measurement. A non-linear model is fitted if N+ is 7 or more, a linear model is fitted if N+ is 5-6, and a mean model is fitted (i.e. no change over time is assumed) if N+ is 2-4. In contrast to the OSPAR method, we also estimated a mean model when N = 2, in order to increase spatial coverage. In addition, there are additional rules, e.g. that the time series is truncated from the left (omitting the first years) until $N+ \geq N/2$.

Trend assessment for each time series

For non-linear trend fitting (in the cases where N+ is at least 7, i.e. there is at least 7 years with the number of years of data with at least one non-censored measurement each) we used GAM (Generalized Additive Models). The time trend of the GAM was fitted with maximum d.f. = 2 for N+ of 7-9 and maximum d.f. = 3 for N+ = 10. It should be noted that the GAM procedure itself may set the degrees of freedom lower than this depending on the pattern of data, including using a linear model (i.e. d.f. = 1). For N+ being 5 or 6, we used a linear model. If a non-linear model was used, a time trend (up or down) is said to occur if the last year of the fitted time series is significantly different ($P < 0.05$)

from the first year. If a linear model was used, a time trend is said to occur if the time trend coefficient is significantly different from zero.

Classification of concentrations (i.e. levels) – low, moderate, high

For time series where a time trend was fitted (i.e., when N+ is at least 5), levels are estimated from the fitted value of the last year. Specifically, we used the upper limit of the 95% confidence interval of the last year of the fitted data. For time series where we only fitted a mean model (i.e., N+ is 2-4), we used simply the upper limit of the 95% confidence interval of the mean.

The level is classified as Green if the test value is below the low limit, Yellow if in the low-high classification interval, and Red if it is above the high classification level.

It should be noted that classification reflects both observed levels and the uncertainty in trends or levels indicated by data. Thus a Red classification does not necessarily mean that estimated levels are above the limit; it may merely indicate that the uncertainty is so large (because of little data and/or high variability) that it cannot be assessed with reasonable confidence that the true level is below the highest limit.

DDT assessment

For DDT, only the p,p'DDE, component is used for the assessment. The other two frequently measured components are p,p'DDD and p,p'DDT but they have in generally smaller concentrations than p,p'DDE. The p,p'DDE has also been measured in the largest number of samples. In particular p,p'DDT, is missing in a substantial number of samples. Hereafter the p,p'DDE is referred to as just DDE.

Classification table (Table 1)

There are several systems that can be used to classify the concentrations of contaminants in environemnt. These can be basically divided into two groups: systems based on presumed background concentrations[1], such as OSPAR's Background Assessment Criteria (BAC), and systems based presumed risk to the environment, such as the EQS or OSPAR's Environmental Assessment Criteria (EACs), or risk to humans, such as the EU foodstuff limits (EC, Regulation No. 186/2006).

For this indicator, a risk-based system was used wherever possible and with priority given to EQS. Table 1 provides an overview of the thresholds applied where those that are background-based beginning with a "B" and those that are risk-based begin with an "E". The former is a statistic based on measured values in field studies. The latter is based on experiments whereby concentrations above the threshold have been found to damage test organisms, and it is then inferred that marine organisms could be harmed as well. Here it is not specified as to what the damage may be beyond that of the test organism. Hence, one can not state specifically how this will impact species tissues, individuals or populations let alone how exceedances might impact a community of organisms, only that the risk for harm should be considered seriously. Note that the upper and lower thresholds for medium may be risked based (eg. Hg in mussels). All "High" concentrations have a risk-based lower limit.

Where EU did not have a threshold value (EQS), priority was given to thresholds provided by OSPAR or the Foodstuffs limits. Note that the EQS applies to whole organisms, and that they are not species or tissue specific. OSPAR is slightly more specific by referring to groups of organisms (i.e. mussels, oyster,

[1] This can be sub-divided into "natural" background concentrations not impacted by anthropogenic sources (e.g., metals), and "man-made" background concentrations found in areas remote from point sources but impacted by diffuse long-distance transport for purely anthropogenic substances (e.g. PCB). However, for many substances such as Hg, the "background" is a mix of both types.

fish). OSPAR also specifies an appropriate basis (e.g. dry weight or fat weight) to be used for the assessment, whereas EU only uses wet weight.

In Table 1 the thresholds delimit three classes: Low, Moderate and High concentrations. The current EQSD (2013/39/EU) has provisions for eleven substances in biota, including mercury, HCB and benzo(a)pyrene. It can also be noted that EQS applies to a given trophic level, and we have not attempted to adjust concentrations (or thresholds) to take this into account. Also note that EQS typically applies to the whole organism, whereas many of the concentrations used in this indicator are derived from measurements in fish liver.

As mentioned above the EAC is a risk-based threshold, designed to provide protection of the ecosystem. OSPAR has derived two different types of EACs. The first type is based on the derived EACs for water or sediment, and then transferred to biota using appropriate Bioconcentration Factor (BCF). The second type takes into account that fish or mussels are food for predators. Concentrations in mussel or fish can be derived that protect against this so-called secondary poisoning using appropriate Biomagnification Factors (BMF). BCF is the ratio of the factor by which result of the uptake, distribution and elimination of a substance in an organism due to waterborne exposure (EU/ Technical guidance document) Biomagnification is the accumulation and transfer of chemicals via the food chain, resulting in an increase of the internal concentration in organisms at higher levels in the trophic chain. (EU/ Technical guidance document) (E.C. 2003).

Table 1 Limit concentration used for classification in figures and maps: Concentration limits for spatial assessment which delimits the classes Low, Moderate and High. Basis indicates the basis of the threshold (W = wet weight basis, D = dry weight basis, F = fat weight basis). Type indicates the type of threshold: BAC = OSPAR Background Assessment Concentration), EAC = OSPAR Environmental Assessment Criteria, EC = EU foodstuff limits (Regulation No. 1861/2006), and EQS = EUs Environmental Assessment Criteria for biota. EQSn = Norwegian EQS. Except for EU legislation the limits have no legal application. All values are expressed units of µg/kg. The thresholds in italics differ from OSPARs assessment criteria. Note that for lindane in fish, only one threshold is given, so levels are classified as either Low or High. Also note that EQS has been used for both Low/Moderate and Moderate/High limits, so the Moderate class includes concentrations above EQS in some cases (Hg and PCB) but not in others (hexachlorobenzene, lindane and DDE).

		Upper threshold for low			**Lower threshold for high**		
dContaminant	**Group**	**Basis**	**Value**	**Type**	**Basis**	**Value**	**Type**
Mercury (Hg)	Mussel	*W*	*20*	*EQS*	W	500	EC
	Oyster	*W*	*20*	*EQS*	W	500	EC
	Fish	*W*	*20*	*EQS*	W	500	EC
Cadmium (Cd)	Mussel	D	960	BAC	W	1000	EC
	Oyster	D	3000	BAC	W	1000	EC
	Fish	W	26	BAC	W	1000	EC

Lead (Pb)	Mussel	D	1300	BAC	W	1500	EC
	Oyster	D	1300	BAC	W	1500	EC
	Fish	W	26	BAC	W	1500	EC
Hexachlorobenzene	Mussel	D	0,63	BAC	*W*	*10*	*EQS*
	Oyster	D	0,63	BAC	*W*	*10*	*EQS*
	Fish	W	0,09	BAC	*W*	*10*	*EQS*
Lindane (γ-HCH)	Mussel	D	0,97	BAC	*D*	*1,45*	*EAC*
	Oyster	D	0,97	BAC	*D*	*1,45*	*EAC*
	Fish				*D*	*11,00*	*EAC*
pp'-DDE	Mussel	D	0,63	BAC	*W*	*610*	*EQSn*
	Oyster	D	0,63	BAC	*W*	*610*	*EQSn*
	Fish	W	0,1	BAC	*W*	*610*	*EQSn*
PCB7 (sum)	Mussel	*W*	*0,6*	*EQSn*	F	2692	EAC
	Oyster	*W*	*0,6*	*EQSn*	F	2692	EAC
	Fish	*W*	*0,6*	*EQSn*	F	2692	EAC
Benzo(a)pyrene	Mussel	D	1,4	BAC	*W*	*5*	*EQS*
	Oyster	D	1,4	BAC	*W*	*5*	*EQS*