HELCOM

Lead

INDICATOR TYPE: Core
INDICATOR CATEGORY: State indicator
BSAP SEGMENT: Hazardous substances and litter
MSFD CRITERIA: D8C1

Pb

Lead

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1 Key message

This core indicator evaluates the status of the marine environment based on concentrations of lead (Pb) measured in seawater, biota and sediments, in the Baltic Sea. Good Environmental Status (GES) is achieved when the concentrations of lead in specified matrices are below the specific regionally agreed threshold values.

The indicator presents a status evaluation using all monitoring data for the HELCOM region during the assessment period 2016 – 2021 (Figure 1).

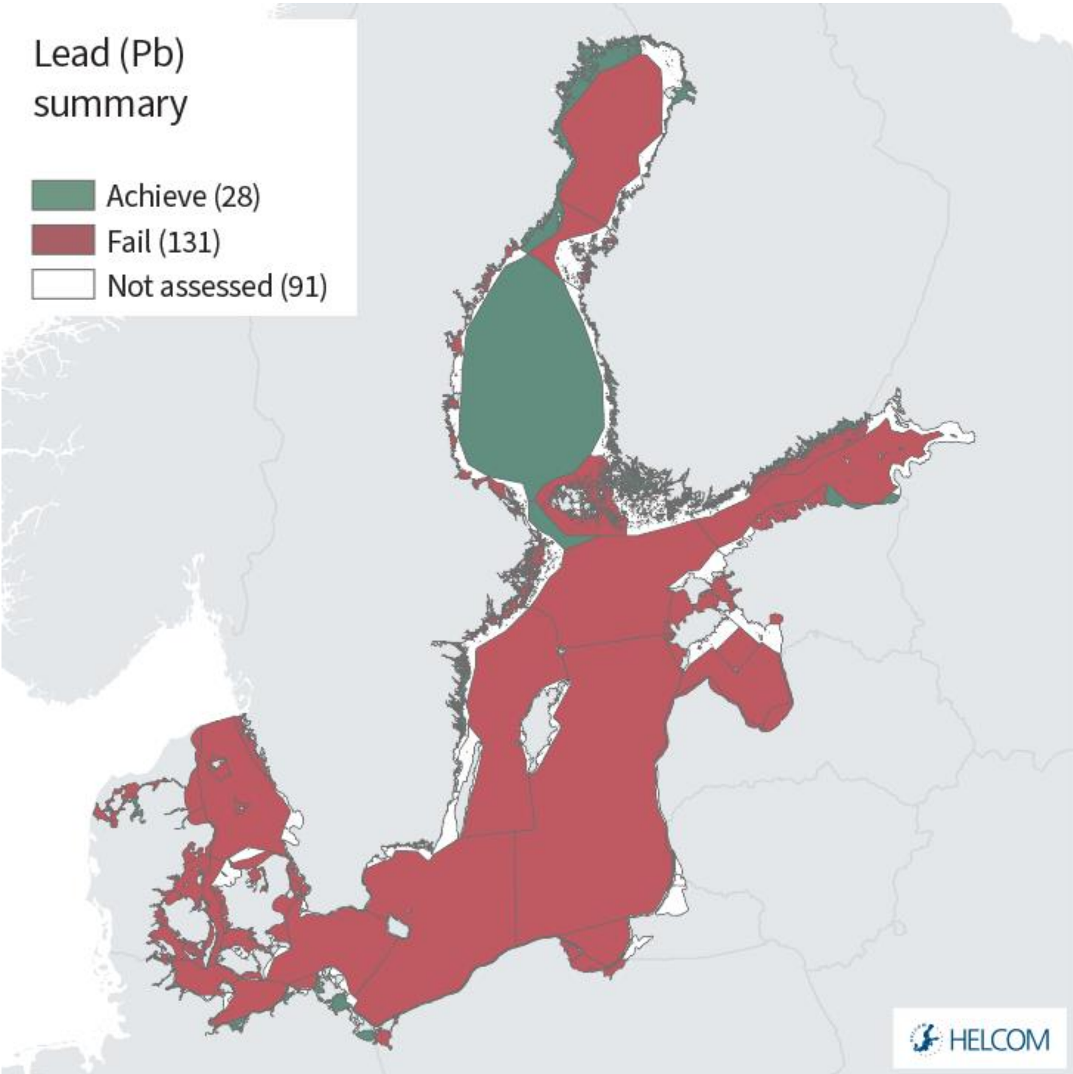

Figure 1. Status evaluation results based on the evaluation of lead concentrations. One-Out-All-Out (OOAO) method incorporating seawater, biota and sediment. The evaluation is carried out using Scale 4 HELCOM assessment units (defined in the HELCOM Monitoring and Assessment Strategy Annex 4). **See 'data chapter' for interactive maps and data at the HELCOM Map and Data Service.**

Lead (Pb) is evaluated in 159 assessment units, including all seventeen sub-basins and the threshold value is achieved (in GES) in 28 of these assessment units, including two open sea sub-basin (SEA-014 Åland Sea and SEA-015 Bothnian Sea). Failure to achieve the threshold value occurs in all three monitoring matrices (water, biota and sediment), contributing to this overall evaluation (generated via a one-out-all-out, OOAO) approach. Where distinct directional trends were possible to assign the downward trends (decreasing concentrations, 16) outnumbered those stations with identified upward trends (increasing concentrations, 3), and in general the majority of these station also achieve the threshold value and were in GES (14 out of 19 being in GES).

The confidence of the indicator evaluation is moderate, with a few assessment units achieving high or low confidence. The data on metal concentrations is generally spatially adequate and time series are available for several stations.

The indicator is applicable in the waters of all countries bordering the Baltic Sea.

1.1 Citation

The data and resulting data products (e.g. tables, figures and maps) available on the indicator web page can be used freely given that it is used appropriately and the source is cited. The indicator should be cited as follows:

HELCOM (2023) Lead. HELCOM Core Indicator Report. Online. [Date Viewed], [Web link].

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2 Relevance of the indicator

Lead has historically entered the Baltic Sea at elevated levels due to human activities and has known negative environmental impacts where concentrations exceed acceptable levels. Releases of lead, for example from combustion activities, remains a relevant source of contamination for the marine environment.

2.1 Ecological relevance

Heavy metals, including lead (Pb) are toxic to wildlife and humans, and even at low levels, they can be harmful to organisms. The severity of the effect mainly depends on the concentration in the tissues. When heavy metals bioaccumulate in tissues they can cause different biological effects on the individual organism, which transform into changes at the population, then species level, and finally affect biodiversity and ecosystem functioning. Heavy metal accumulation in fish, specifically destined for human consumption, directly affects human health. Lead can cause increased blood pressure and cardiovascular problems in humans. Long-term exposure to high levels of lead can affect the neurological system. Lead (Pb) is a metal that is not essential for life processes and proves acutely toxic to most organisms. Compared to other metals Pb is rather immobile in the environment but still, its biogeochemical cycling is greatly perturbed by human activities.

2.2 Policy relevance

The core indicator evaluating concentrations of the metal Lead (Pb) addresses a major goal and various ecological objectives of the Baltic Sea Action Plan (BSAP 2021). This includes the goal of the hazardous substances and litter segment of a 'Baltic Sea unaffected by hazardous substances (and litter)', and key ecological objectives of: 'Marine life is healthy', 'Concentrations of hazardous substances are close to natural levels', and 'All sea food is safe to eat'. There is also relevance for the BSAP biodiversity goals (Table 1).

Table 1. Overview of key policy relevance elements.

	Baltic Sea Action Plan (BSAP)	Marine Strategy Framework Directive (MSFD)
Fundamental link	Segment: Hazardous substances and litter goal Goal: "Baltic Sea unaffected by hazardous substances and litter" • Ecological objective: "Marine life is healthy", "Concentrations of hazardous substances are close to natural levels" and "All sea food is safe to eat". • Management objective: "Minimize input and impact of hazardous substances from human activities".	Descriptor 8 Concentrations of contaminants are at levels not giving rise to pollution effects. • Criteria 1 The health of species and the condition of habitats (such as their species composition and relative abundance at locations of chronic pollution) are not adversely affected due to contaminants including cumulative and synergetic effects. • Feature – Contaminants list. • Element of the feature assessed – Contaminants list.
Complementary link	Segment: Biodiversity Goal: "Baltic Sea ecosystem is healthy and resilient" • Ecological objective: "Viable populations of all native species", "Natural distribution, occurrence and quality of habitats and associated communities", and "Functional, healthy and resilient food webs". • Management objective: "Reduce or prevent human pressures that lead to imbalance in the foodweb".	Descriptor 9 Contaminants in fish and other seafood for human consumption do not exceed levels established by Union legislation or other relevant standards. • Criteria 1 The level of contaminants in edible tissues (muscle, liver, roe, flesh or other soft parts, as appropriate) of seafood (including fish, crustaceans, molluscs, echinoderms, seaweed and other marine plants) caught or harvested in the wild (excluding fin-fish from mariculture) does not exceed: (a) for contaminants listed in Regulation (EC) No 1881/2006, the maximum levels laid down in that Regulation, which are the threshold values for the purposes of this Decision; (b) for additional contaminants, not listed in Regulation (EC) No 1881/2006, threshold values, which Member States shall establish through • Feature – Contaminants in seafood. • Element of the feature assessed – Contaminants in Foodstuffs Regulation.

Other relevant legislation:	• The Water Framework Directive (Pb is listed as a priority substance). • UN Sustainable Development Goal 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development) is most clearly relevant, though SDG 12 (Ensure sustainable consumption and production patterns) and 13 (Take urgent action to combat climate change and its impacts) also have relevance.

The core indicator also addresses the following qualitative descriptors of the MSFD for determining good environmental status (European Commission 2008a), in particular being of direct relevance to Descriptor 8 and of significance for Descriptor 9 as set out under the specific Descriptors and Criteria in Commission Decision (EU) 2017/848.

Lead is listed as a priority substance (European Commission 2013) monitoring under the EU Water Framework Directive is done in the water matrix (European Commission 2000). As a highly toxic element, lead is included in the recommendations concerning the acceptable levels in products for consumption including seafood (Commission Regulation (EC) No 1881/2006, European Commission 2006a).

Article 3 of the EU directive on environmental quality standards states that also long-term temporal trends should be assessed for substances that accumulate in sediment and/or biota (European Commission 2008b).

2.3 Relevance for other assessments

The status of the Baltic Sea marine environment in terms of contamination by hazardous substances is assessed using several core indicators.

These core indicators focus on contaminants with well-established knowledge base on their environmental impacts, often accompanied by long-standing monitoring activities. These core indicator contaminants include e.g. heavy metals (Pb, Cd and Hg), PAHs, PCBs and PCDD/Fs. Each of these indicators focuses on one important aspect of the complex issue, and are further used in producing an overall hazardous substances assessment. Pb as one of the metal indicators will give an evaluation of the status in terms of heavy metals concentration. The Lead indicator will be included in the integrated hazardous substances assessment, using the HELCOM hazardous substances assessment tool CHASE.

3 Threshold values

Good Environmental Status (GES) is achieved if the concentrations of lead are below the specified threshold values for each relevant monitoring matrix, as illustrated in Figure 2.

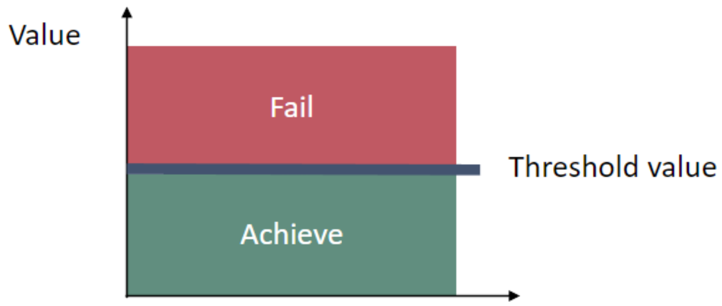


Figure 2. Good Environmental Status (GES) is achieved if the concentrations of metals are below the agreed threshold value.

The threshold value for lead is based on Environmental Quality Standards (EQS) for water as a primary matrix (Thresholds table 1) which have been defined at the EU level for substances included in the priority list under the Water Framework Directive, WFD (European Commission 2000, 2013). For historical reasons, the countries around the Baltic Sea have differing monitoring strategies and data on lead concentrations in water are not available in all regions of the Baltic Sea. In order to perform the evaluation based on other matrices, secondary thresholds were proposed: QS for sediments, BAC for fish liver and values based on scientific studies for fish muscle and mussel soft tissue (Table 2). Under the WFD, Member States may establish other values than EQS for alternative matrices if specific criteria are met (see Art 3.3. in European Commission 2008b, revised in European Commission 2013).

Table 2. Threshold values for Lead (EQS – Environmental Quality Standard, AA- Annual Average Concentration, QS – Quality Standard, BAC = Background Assessment Criteria). Underlined supporting parameters represent parameters without which the indicator evaluation cannot be applied. MU = muscle, LI = fish liver, SB = soft body, CORG = organic carbon, Al = Aluminium, Li = Lithium. European Commission (2013) Directive 2013/39/EU, Lead and its compounds - CIRCABC - Europa EU, 2011, and EG HAZ 16-2021 document 3-4.

Indicator	Threshold value	Parameters (PARAM) / Parameter groups (PARGROUP) (see also http://vocab.ices.dk/)	Matrix	Species	Matrix	Basis	Supporting parameters and information
Metals (Pb)	Primary threshold EQS water 1.3 µg/l	PARAM = PB	Water		WT (filtered, unfiltered if the concentration is below the EQS)		Surface water layer (≤ 5.5 m)
	Secondary threshold OSPAR proxy BAC 26 µg/kg ww fish liver 110 ug/kg ww – mussel and fish muscle BAC maintained for liver samples as muscle/liver conversion is currently not available.		Biota	Herring & cod (open sea) Flounder, sole, eelpout & Perch (coastal) Mussels	Muscle & LI SB	W W	Dry weight Dry weight
	*Secondary threshold QS from EQS dossier 120 mg/kg sediment (DW)		Sediment (surface, ICES 'upper sediment layer - 0-X cm')			D	Al Li CORG Grain size

*Denmark retains a study reservation on this threshold value and is currently carrying out national work to review and evaluate a suitable threshold value, but supports the application of the regional indicator for HOLAS 3.

It should be noted that for HOLAS 3 and subsequent to HOLAS II a new threshold value has been implemented. The Secondary threshold value, an EQS secondary poisoning (DK derived) 110 ug/kg ww mussels and fish muscle. This overrides the previous threshold value applied in HOLAS II for mussels of 1300 µg kg-1 d.w (OSPAR BAC). For HOLAS 3, since fish muscle/liver conversion factor are not currently available it has been decided to use the BAC for fish liver until studies have been made to provide well-justified conversion factors applicable across the relevant species and the Baltic Sea region.

3.1 Setting the threshold value(s)

The threshold value for lead is based on Environmental Quality Standards (EQS) for water as a primary matrix (Thresholds table 1) which have been defined at the EU level for substances included in the priority list under the Water Framework Directive, WFD (European Commission 2000, 2013). In order to perform the evaluation based on other matrices, secondary thresholds were proposed: QS for sediments, BAC for fish liver and values based on scientific studies for fish muscle and mussel soft tissue.

There are chronic effect values for 8 sediment species, of which 2 are marine. The species represent 3 major taxonomic groups, and at least 4 different foraging strategies. The two marine species, a crustacean and an oligochaete, are neither more nor less sensitive than their freshwater taxonomic counterparts, and so the freshwater and saltwater data are combined. A recent Danish evaluation expanded on the existing information pool, increasing the number of species to three (including two marine species). Further details are provided in EG HAZ 16-2021 document 3-4.

4 Results and discussion

The results of the indicator evaluation that underlie the key message map and information are provided below.

4.1 Status evaluation

The data underlying the core indicator evaluation are based on regular monitoring data gathered by HELCOM Contracting Parties and reported to the HELCOM COMBINE data base (hosted by ICES). The indicator presents information on the current levels of lead concentrations in selected marine matrices: seawater, fish (muscle and liver tissue), soft body of mussels as well as in the bottom sediment for the assessment period 2016-2021, assessed against regionally agreed threshold values. The values presented in the report refer to the concentrations and mean values calculated from them, while the status evaluations are based on the so-called representative concentrations assessed against threshold values, which result from data evaluation (see Methodology), and are considered as values representative of status for the given assessment units.

Seawater

The primary matrix for lead is water, as the primary threshold value for the core indicator is agreed to be the EQS value for water. This is in conflict with the HELCOM COMBINE monitoring program, where the preferred matrix for monitoring is biota and sediment. As a result, very limited data is available for lead in water.

Lead concentrations in the seawater have been measured by Germany, Estonia, Lithuania and Poland.

An evaluation was possible for 50 assessment units, of which 5 were open sea HELCOM sub-basins. All open sea assessment units achieved the threshold value (were in GES) and of the remaining assessment units an additional 19 achieved the threshold value (in GES) (Figure 3). However, lead concentrations in the seawater have been measured only by Germany, Estonia, Lithuania and Poland, and even in these instances in relatively low coverage and frequency, thus the spatial coverage of the evaluation in water is low.

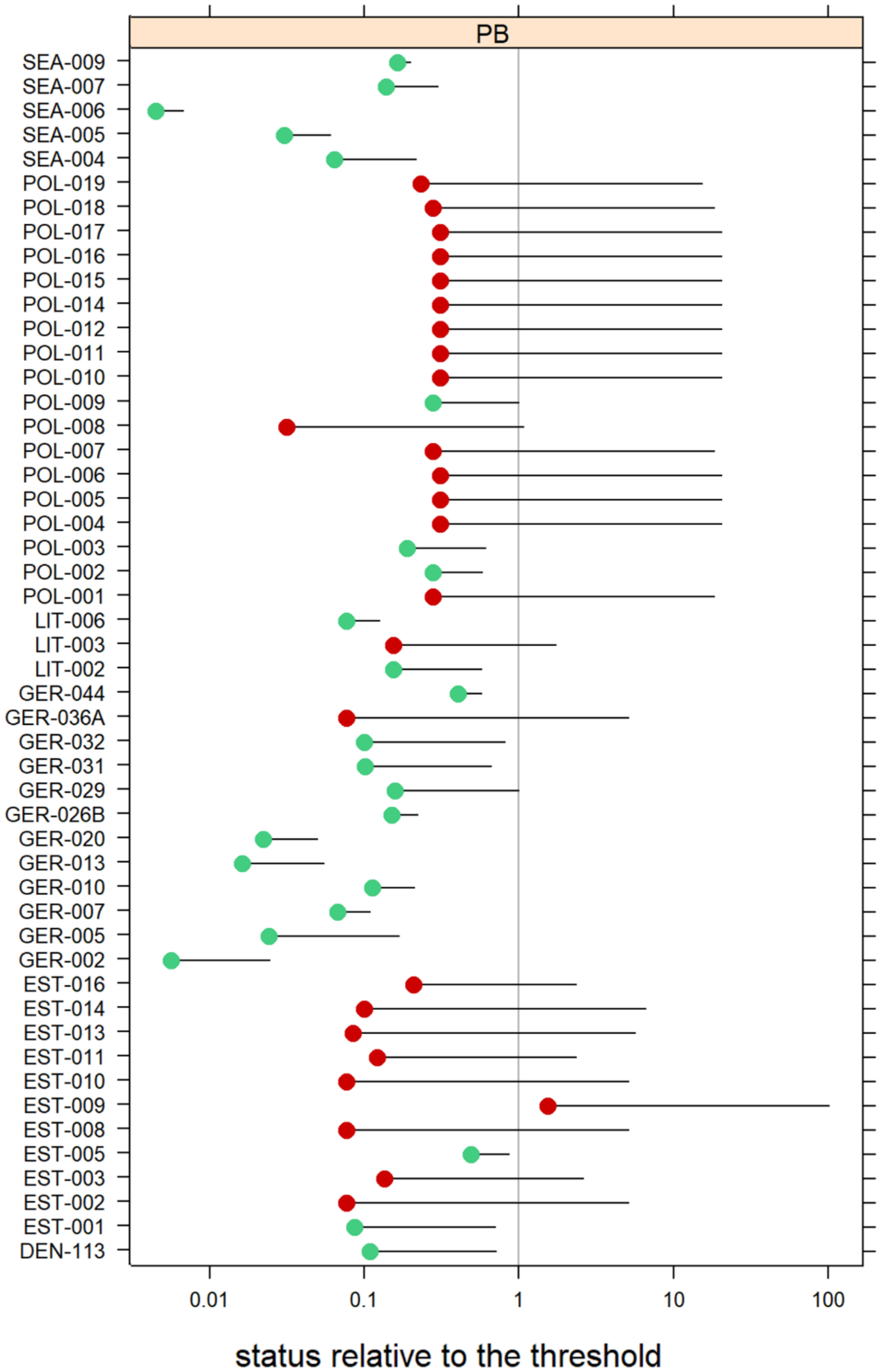


Figure 3. Overview of HELCOM Level 4 assessment units evaluated for Lead (Pb) in water. The 95% confidence limit on the mean concentration is presented. Filled circles represent a mean value for each assessment unit and the bar represents the upper 95% confidence limit. Green colour indicates that the assessed area achieves the threshold value and red colour that the assessed area fails the threshold.

The concentration in the last year of the evaluation (i.e. the most recent concentration in any given data series) is informative of latest reference point and will occur in the current assessment period. At the station level (i.e. per data series) the concentrations in the last year of evaluation (ug/l) varied, in cases somewhat widely even within a single sub-basin. This varied between and within the 17 HELCOM sub-basins when comparing all stations, inclusive of open sea and coastal, within each sub-basin (Table 3). These values show the variation across sub-basins and also the latest station level concentrations in the assessment period but do not themselves reflect status as status is derived from the entire assessment period and is also influenced by the 95% confidence limit on the mean concentration (as in Figure 3).

Table 3. Overview of number of stations within each HELCOM sub-basin (coastal and open sea), the mean value of the concentrations in the last year of evaluation across the stations and the lowest and largest of these values within each sub-basin (where evaluated).

HELCOM sub-basin	Mean (ug/l)	Number of stations	Lowest concentration (ug/l)	Largest concentration (ug/l)
Kattegat (SEA-001)	NA	NA	NA	NA
Great Belt (SEA-002)	0.1	1	0.1	0.1
The Sound (SEA-003)	NA	NA	NA	NA
Kiel Bay (SEA-004)	0.1	9	0.0	0.2
Bay of Mecklenburg (SEA-005)	0.1	9	0.0	0.5
Arkona Basin (SEA-006)	0.1	8	0.0	0.2
Bornholm Basin (SEA-007)	0.3	16	0.1	0.4
Gdansk Basin (SEA-008)	0.3	11	0.0	0.4
Eastern Gotland Basin (SEA-009)	0.2	12	0.1	0.4
Western Gotland Basin (SEA-010)	NA	NA	NA	NA
Gulf of Riga (SEA-011)	0.5	6	0.1	2.0
Northern Baltic Proper (SEA-012)	0.1	2	0.1	0.1
Gulf of Finland (SEA-013)	0.3	9	0.1	0.9
Åland Sea (SEA-014)	NA	NA	NA	NA
Bothnian Sea (SEA-015)	NA	NA	NA	NA
The Quark (SEA-016)	NA	NA	NA	NA
Bothnian Bay (SEA-017)	NA	NA	NA	NA

The status evaluation is derived based on the station level evaluation of 83 individual stations across the Baltic Sea region. Eight of these stations represented ‘full data’ and of these two distinct downward trends (e.g. decreasing concentrations) were recorded (these were also in GES). These stations were located in the Bornholm Basin and Bay of Mecklenburg sub-basin. Other stations were evaluated as ‘initial’ data series due to the lower number of years with data available (Figure 4).

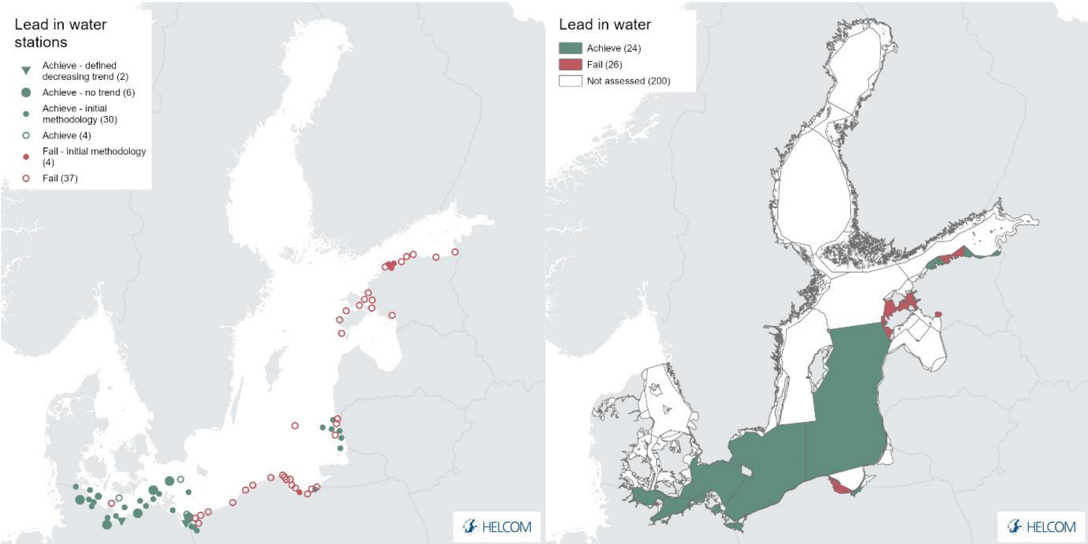


Figure 4. Map presenting station based status of lead concentrations in water (left) and assessment unit based status evaluation for lead in water (right). Green colour represents good environmental status and red colour represents not good status. Large filled triangles indicate data series of three or more years for which statistical trends could be assigned (upwards-increasing concentrations or downwards-decreasing concentrations), large filled circles triangles indicate data series of three or more years for which statistical trends could be assigned but where no detectible trend was observed, and full evaluation with MIME Script (see Methodology) was carried out. Small filled circles represent data series of three or more years for which statistical trends could not be assigned due to specific data factors and open circles represent data series of less than three years for which statistical trends could not be assigned due to data series length, and these data types are treated with initial status evaluation (see Methodology). **See 'data chapter' for interactive maps and data at the HELCOM Map and Data Service.**

Stations with 'full' (>3 years of data in the assessment period) and 'initial' data (<2 years of data in the assessment period), the latter which limits the application of the full statistical analyses, were available to support the evaluation, though in general spatial and temporal aspects of the data set are limited at the Baltic Sea scale. Examples of different trend patterns at the station level (station time series) are presented in Figure 5.

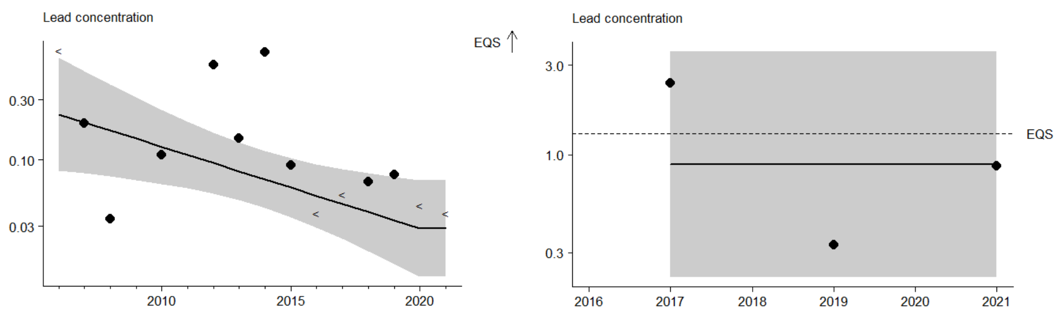


Figure 5. Examples of Lead concentration in water at stations in the Bornholm Basin (left – distinct decreasing trend, 'full data', in GES), and the Gulf of Finland (right – no distinct directional trend, 'initial' data, sub-GES).

Biota

The evaluation of the core indicator status is based on data on Pb concentrations in the muscles of fish of the following species: herring, cod, perch, flatfish, eelpout and soft tissues of mussels of the species: *Mytilus edulis, Macoma balthica* and *Limecola balthica* (figure 6). Biota is a secondary matrix for the Pb status evaluation.

An evaluation was possible for 134 assessment units, of which 16 were open sea HELCOM sub-basins (of a possible 17 sub-basins). All but one open sea assessment unit (Bothnian Sea, SEA-015) failed to achieve the threshold value (were sub-GES) and of the remaining 118 coastal station only 17 achieved the threshold value (were in GES) (Figure 6).

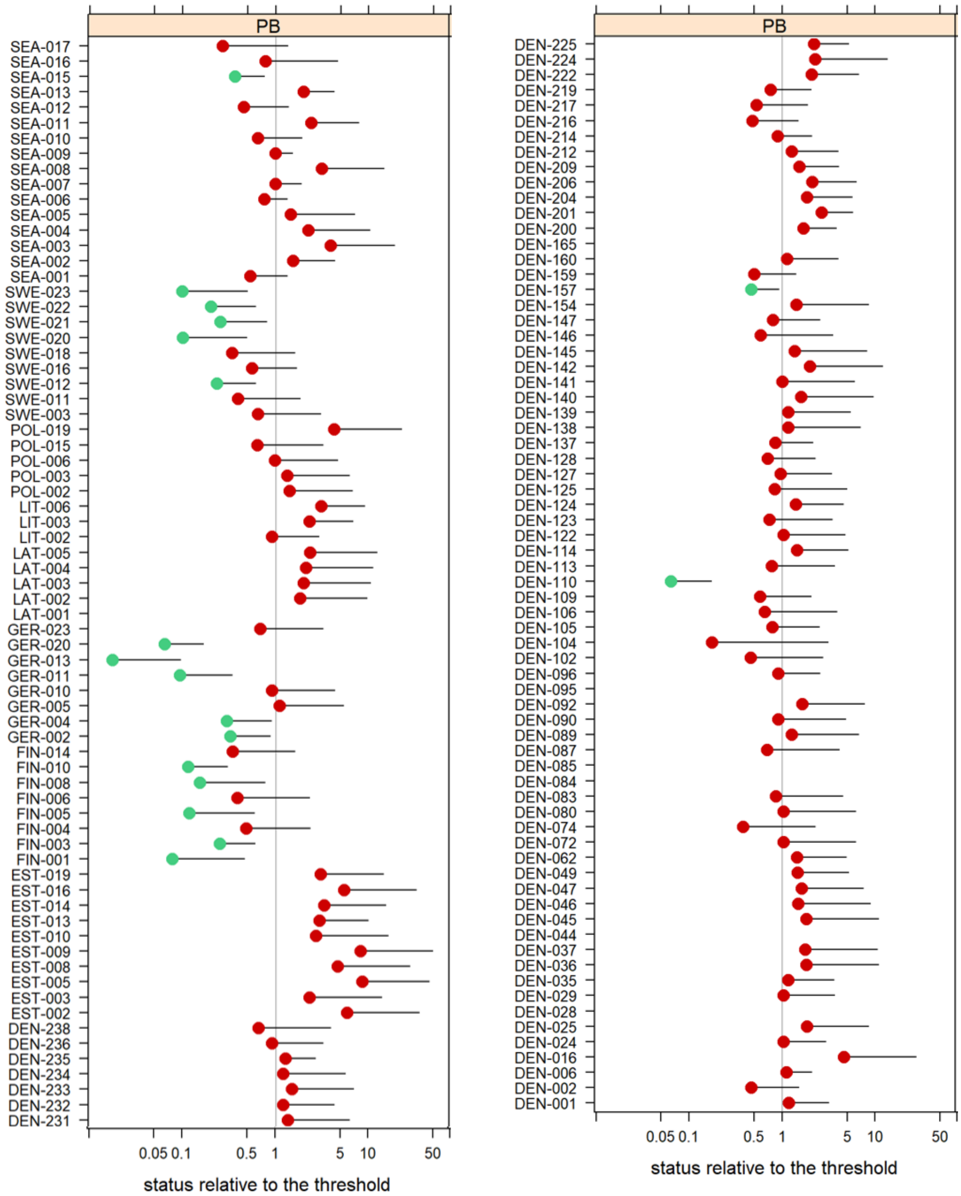


Figure 6. Overview of HELCOM Level 4 assessment units evaluated for Lead (Pb) in biota. The 95% confidence limit on the mean concentration is presented.

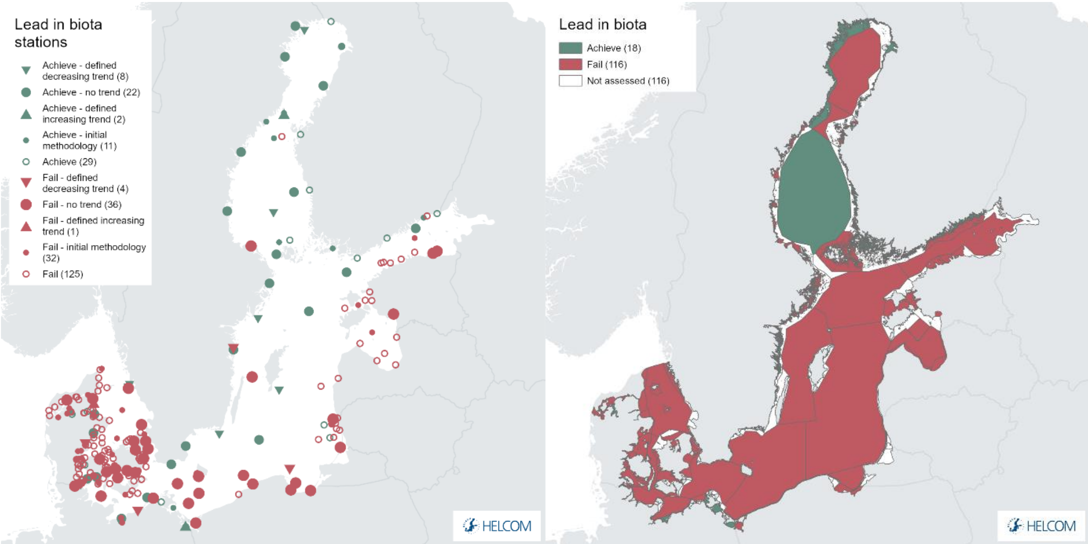
The concentration in the last year of the evaluation (i.e. the most recent concentration in any given data series) is informative of latest reference point and will occur in the current assessment period. At the station level (i.e. per data series) the concentrations in the last year of evaluation (ug/kg) varied, in cases somewhat widely even within a single sub-basin. This varied between and within the 17 HELCOM sub-basins when comparing all stations, inclusive of open sea and coastal, within each sub-basin (Table 4). These values show the variation across sub-basins and also the latest station level concentrations in the assessment period but do not themselves reflect status as status is derived from the entire assessment period and is also influenced by the 95% confidence limit on the mean concentration (as in Figure 6).

Table 4. Overview of number of stations within each HELCOM sub-basin (coastal and open sea), the mean value of the concentrations in the last year of evaluation across the stions and the lowest and largest of these values within each sub-basin (where evaluated). The table summarises all biota thus includes fish muscle and liver and also mussel soft body. This contributes to the broad range in values.

HELCOM sub-basin	Mean (ug/kg)	Number of stations	Lowest concentration (ug/kg)	Largest concentration (ug/kg)
Kattegat (SEA-001)	120	52	9	361
Great Belt (SEA-002)	122	75	0	510
The Sound (SEA-003)	251	8	14	447
Kiel Bay (SEA-004)	66	2	58	75
Bay of Mecklenburg (SEA-005)	112	9	5	204
Arkona Basin (SEA-006)	143	22	2	501
Bornholm Basin (SEA-007)	43	12	3	148
Gdansk Basin (SEA-008)	74	3	34	108
Eastern Gotland Basin (SEA-009)	1031*	29	1	28000*
Western Gotland Basin (SEA-010)	34	5	1	125
Gulf of Riga (SEA-011)	90	12	50	210
Northern Baltic Proper (SEA-012)	26	4	10	70
Gulf of Finland (SEA-013)	59	14	2	220
Åland Sea (SEA-014)	6	2	3	99
Bothnian Sea (SEA-015)	11	9	4	29
The Quark (SEA-016)	10	5	3	20
Bothnian Bay (SEA-017)	8	7	2	29

*a single station appears to have a unit or reporting error that generates this high value and will also influence the average value in this table. The highest value excluding this is 210.10 and the mean would be 67.48. The potential error here is not expected to have a strong influence on the overall status evaluation.

The status evaluation is derived based on the station level evaluation of 270 individual stations across the Baltic Sea region. Seventy-three of these stations represented 'full data' and of these 12 distinct downward trends (e.g. decreasing concentrations) were recorded (8 of which were in GES). These stations were located in the Bay of Mecklenburg, Bornholm Basin, Bothnian Bay, Bothnian Sea, Eastern Gotland Basin (2), Great Belt, Kattegat (2), Kiel Bay, and Western Gotland Basin (2) sub-basins. There were a lower number of stations that exhibited upwards trends (i.e. increasing concentrations), two of which were in GES, located in the Bornholm Basin, Kattegat and The Quark. Other stations were evaluated as 'initial' data series due to the data available (Figure 7).



Results figure 7. Map presenting station based status of lead concentrations in biota (left) and assessment unit based status for lead in biota (right). Green colour represents good status and red colour represents not good status. Large filled triangles indicate data series of three or more years for which statistical trends could be assigned (upwards-increasing concentrations or downwards-decreasing concentrations), large filled circles triangles indicate data series of three or more years for which statistical trends could be assigned but where no detectible trend was observed, and full evaluation with MIME Script (see Methodology) was carried out. Small filled circles represent data series of three or more years for which statistical trends could not be assigned due to specific data factors and open circles represent data series of less than three for which statistical trends could not be assigned due to data series length, and these data types are treated with initial status evaluation (see Methodology). **See 'data chapter' for interactive maps and data at the HELCOM Map and Data Service.**

In certain instances, especially where a small number of stations occur in an assessment unit or the stations are dominantly 'initial' data series, a difference in status outcome between the outcome at the separate station level evaluations and the assessment unit evaluation level can occur. This is due to the precautionary approach applied and the application of psi values derived from the full regional data set (see methodology) being applied. Where large ranges in the data occur and increased uncertainties are part of the overall evaluation these factors can influence status. This aspect is also likely compounded by the lack of fish muscle/liver conversion factors and may explain apparent differences between the left and right panels in figure 7 (e.g. in Swedish coastal waters of the Northern Baltic Proper).

Stations with 'full' (>3 years of data in the assessment period) and 'initial' data (<2 years of data in the assessment period), the latter which limits the application of the full statistical analyses, were available to support the evaluation. There is a high spatial coverage of stations with long time series ('full' data) for this evaluation at the Baltic Sea scale. Examples of different trend patterns at the station level (station time series) are presented in Figure 8.

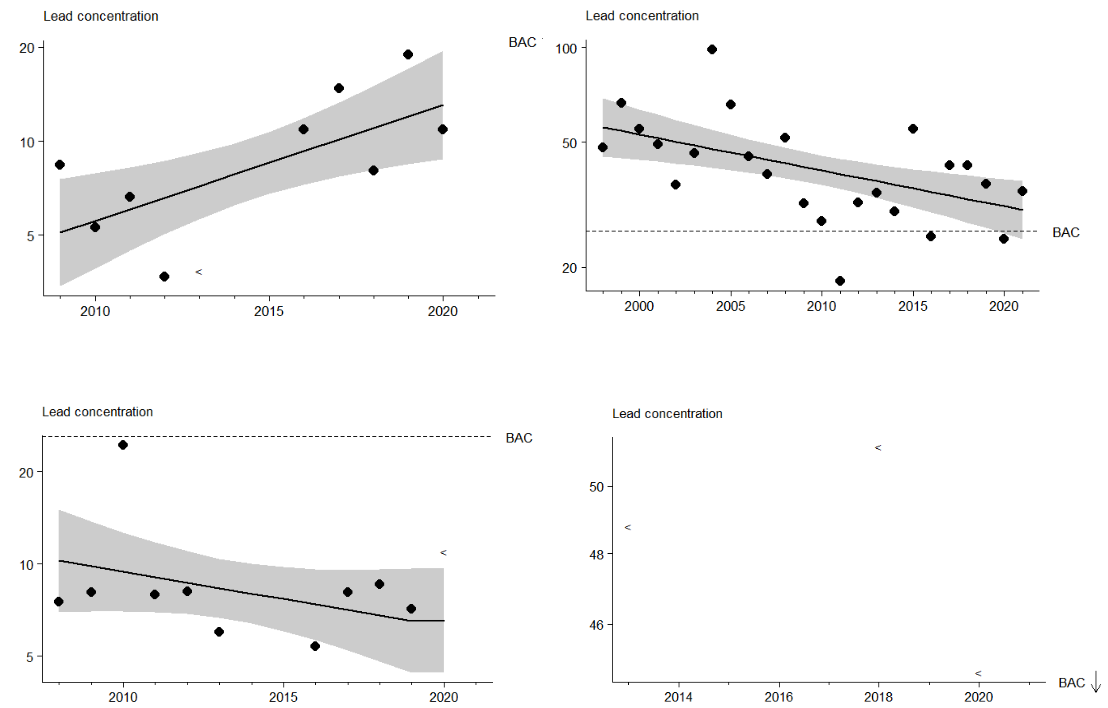


Figure 8. Examples of Lead concentration in biota at stations (grey colour- confidence level 95% range (see Methodology)) in The Quark (top left – Holmöarna, distinct increasing trend, 'full data', in GES), the Eastern Gotland Basin (top right – LWLA, distinct downward trend, 'full data', sub-GES), the Bothnian Bay (bottom left – Kinnbäcksfjärden, no distinct directional trend, 'full data', in GES), and the Eastern Gotland Basin (bottom right – Z06, no distinct directional trend, 'initial' data, sub-GES).

Sediment

The evaluation of sediment in the core indicator evaluating Lead (Pb) is possible for 31 assessment units, of which 13 were open sea HELCOM sub-basins (of a possible 17 sub-basins). Three of the open sea assessment unit failed to achieve the threshold value (were sub-GES) and of the remaining 18 coastal station only five failed to achieve the threshold value (only 5 were sub-GES) (Figure 9).

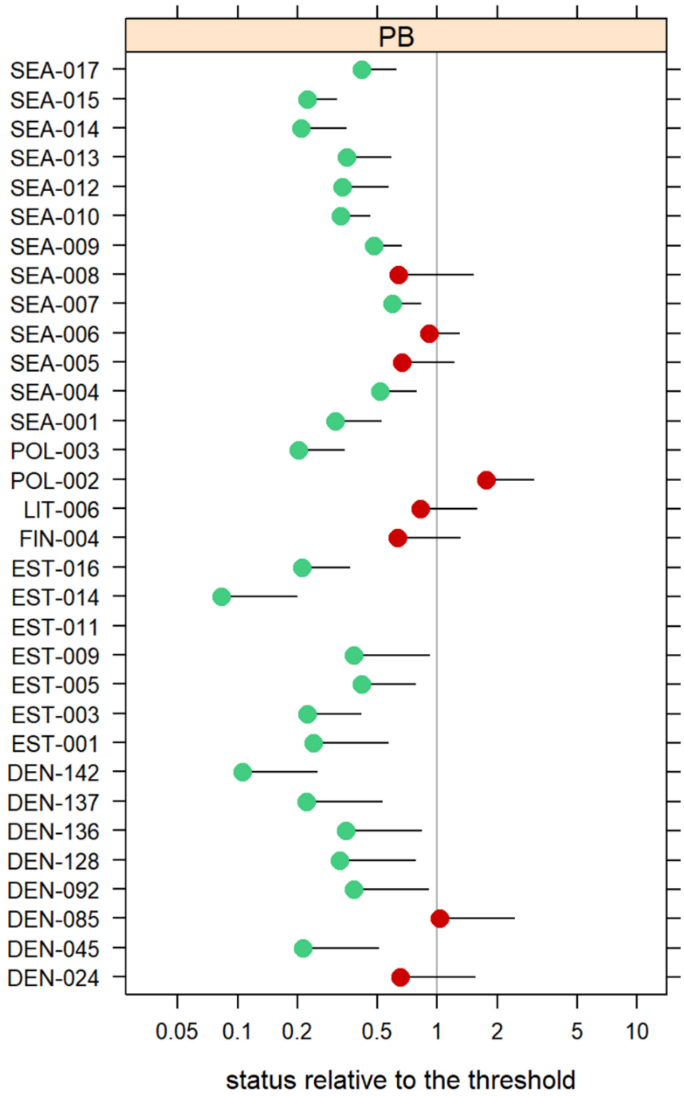


Figure 9. Overview of HELCOM Level 4 assessment units evaluated for Lead (Pb) in sediment. The 95% confidence limit on the mean concentration is presented.

The concentration in the last year of the evaluation (i.e. the most recent concentration in any given data series) is informative of latest reference point and will occur in the current assessment period. At the station level (i.e. per data series) the concentrations in the last year of evaluation (mg/kg) varied, in cases somewhat widely even within a single sub-basin. This varied between and within the 17 HELCOM sub-basins when comparing all stations, inclusive of open sea and coastal, within each sub-basin (Table 5). These values show the variation across sub-basins and also the latest station level concentrations in the assessment period but do not themselves reflect status as status is derived from the entire assessment period and is also influenced the 95% confidence limit on the mean concentration (as in Figure 9).

Table 5. Overview of number of stations within each HELCOM sub-basin (coastal and open sea), the mean value of the concentrations in the last year of the station time series and the lowest and largest of these values within each sub-basin (where evaluated) for sediment.

HELCOM sub-basin	Mean (mg/kg)	Number of stations	Lowest concentration (mg/kg)	Largest concentration (mg/kg)
Kattegat (SEA-001)	44.21	4	31.88	55.58
Great Belt (SEA-002)	54.86	5	33.53	78.88
The Sound (SEA-003)				
Kiel Bay (SEA-004)	14.79	2	9.95	19.63
Bay of Mecklenburg (SEA-005)	79.66	1	79.66	79.66
Arkona Basin (SEA-006)	101.77	3	65.45	134.77
Bornholm Basin (SEA-007)	98.75	5	24.91	210.26
Gdansk Basin (SEA-008)	40.52	2	40.14	40.89
Eastern Gotland Basin (SEA-009)	49.24	5	24.21	73.12
Western Gotland Basin (SEA-010)	48.82	3	26.60	77.87
Gulf of Riga (SEA-011)	36.18	4	17.92	58.06
Northern Baltic Proper (SEA-012)	29.21	1	29.21	29.21
Gulf of Finland (SEA-013)	56.59	8	12.67	123.00
Åland Sea (SEA-014)	59.38	1	59.38	59.38
Bothnian Sea (SEA-015)	48.47	3	20.43	98.81
The Quark (SEA-016)				
Bothnian Bay (SEA-017)	53.42	2	32.53	74.30

The status evaluation is derived based on the station level evaluation of 49 individual stations across the Baltic Sea region. Two of these stations represented 'full data' both showing distinct downward trends and both were in GES. The low number of long-term time series is in part due to the relatively infrequent sampling that is standard practice for sediment monitoring. There are however spatial gaps in the monitoring of sediment at the Baltic Sea scale (Figure 10).

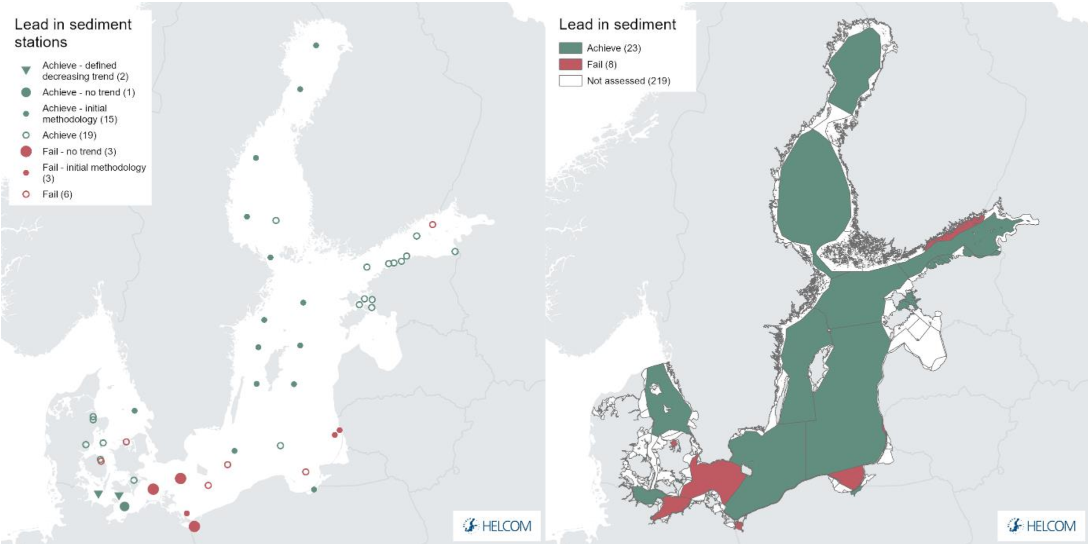


Figure 10. Map presenting station based status of lead concentrations in sediment (left) and assessment unit based evaluation for lead in sediment (right). Large filled triangles indicate data series of three or more years for which statistical trends could be assigned (upwards-increasing concentrations or downwards-decreasing concentrations), large filled circles triangles indicate data series of three or more years for which statistical trends could be assigned but where no detectible trend was observed, and full evaluation with MIME Script (see Methodology) was carried out. Small filled circles represent data series of three or more years for which statistical trends could not be assigned due to specific data factors and open circles represent data series of less than three for which statistical trends could not be assigned due to data series length, and these data types are treated with initial status evaluation (see Methodology). **See 'data chapter' for interactive maps and data at the HELCOM Map and Data Service.**

4.2 Trends

Examples of key station level trends at selected stations are provided above (Figures 5 and 8). The evaluation of lead includes a large number of high-quality datasets with long trends and the possibility to assign statistical trends. However, the depth, frequency and spatial coverage of data does differ between the monitoring matrices evaluated. Trends are described for each matrix separately.

In water only 2 downward trends (distinct decreasing concentrations) were recorded.

In biota 13 downward trends and 3 upward trends (distinct increasing concentrations) were recorded.

In sediment 2 downward trends (distinct decreasing concentrations) were recorded.

4.3 Discussion text

Lead can be directly toxic or cause significant harmful effects in the marine environment if suitable levels are exceeded. While trends for decreasing concentrations (downward trends) in biota outweigh those where deterioration appears to occur (upward trends) by circa four-fold there remains generally sub-GES conditions across the Baltic Sea region, especially where all evaluated sampling matrices are utilized. Local variation can also be seen, particularly in areas dominated by shorter ('initial') data series.

In addition, some variation in the results may be generated due to the different monitoring matrices applied (Figure 11), an issue that may be relevant for further study beyond HOLAS 3. An initial overview may suggest there is a slight bias towards monitored samples in fish muscle (these generally contribute a small portion of the data) being more likely to achieve the threshold value that other matrix types, however further studies beyond HOLAS 3 would be needed to carry out a proper evaluation of this issue.

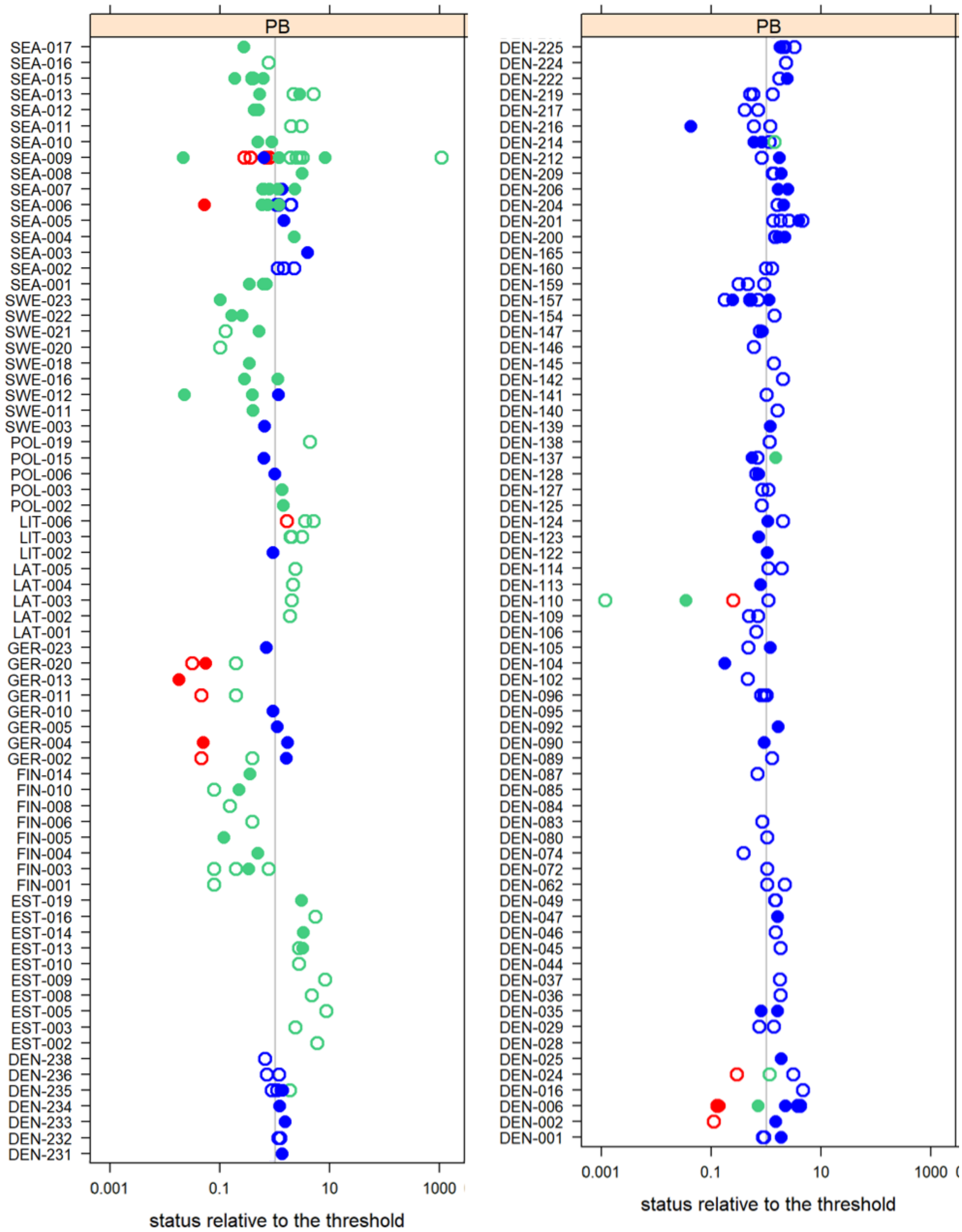


Figure 11. The same assessment units as shown in Figure 3 are presented but each assessment unit visualises the individual stations included in making the assessment unit level status evaluation. Potential difference in evaluation outcome due to different sampling matrices are highlighted: Red = fish muscle, blue = mussel soft body, and green = fish liver.

An overview of the outcomes for the open sea sub-basins is provided below (Table 6).

Table 6. Overview of evaluation outcomes and comparison with previous evaluation (using the OOAO evaluation outcomes per assessment unit). Currently this approach is only applied for open sea assessment units.

HELCOM Assessment unit name (and ID)	Threshold value achieved/failed – HOLAS II	Threshold value achieved/failed – HOLAS 3	Distinct trend between current and previous evaluation.	Description of outcomes, if pertinent.
Kattegat (SEA-001)	Achieved	Failed	Deterioration in status outcome. Likely driven by greater data availability and the implementation of a new threshold value.	The threshold value is not achieved (sub-GES). The majority of 'full' data stations fail to achieve the threshold value (mainly biota).
Great Belt (SEA-002)	Achieved	Failed	Deterioration in status outcome. Likely driven by greater data availability and the implementation of a new threshold value.	The threshold value is not achieved (sub-GES). The 'initial' data stations fail to achieve the threshold value (biota).
The Sound (SEA-003)	Not evaluated	Failed	New data availability has facilitated an evaluation for this assessment period.	
Kiel Bay (SEA-004)	Failed	Failed	No change in status between the two assessment periods.	The threshold value is not achieved (sub-GES). Water and sediment achieve their threshold values but biota does not.
Bay of Mecklenburg (SEA-005)	Failed	Failed	No change in status between the two assessment periods.	
Arkona Basin (SEA-006)	Failed	Failed	No change in status between the two assessment periods.	The threshold value is not achieved (sub-GES). Water achieves the threshold value, some sediment stations also,

				but biota does not.
Bornholm Basin (SEA-007)	Failed	Failed	No change in status between the two assessment periods.	The threshold value is not achieved (sub-GES). Stations both fail and achieve their threshold values for all monitoring matrices.
Gdansk Basin (SEA-008)	Failed	Failed	No change in status between the two assessment periods.	The threshold value is not achieved (sub-GES). Neither sediment or biota achieve their threshold values.
Eastern Gotland Basin (SEA-009)	Failed	Failed	No change in status between the two assessment periods.	The threshold value is not achieved (sub-GES). Stations both fail and achieve their threshold values for all monitoring matrices.
Western Gotland Basin (SEA-010)	Failed	Failed	No change in status between the two assessment periods.	The threshold value is not achieved (sub-GES). Sediment and some biota stations achieve their threshold values, but not all biota evaluations.
Gulf of Riga (SEA-011)	Not evaluated	Failed	New data availability has facilitated an evaluation for this assessment period.	The threshold value is not achieved (sub-GES) Monitoring only occurs in biota.
Northern Baltic Proper (SEA-012)	Failed	Failed	No change in status between the two assessment periods.	The threshold value is not achieved (sub-GES). Sediment achieves but biota stations fail to achieve their threshold value.
Gulf of Finland (SEA-013)	Failed	Failed	No change in status between the two assessment periods.	

Åland Sea (SEA-014)	Achieved	Achieved	No change in status between the two assessment periods.	The threshold value is achieved (GES). Only a single sediment station is evaluated.
Bothnian Sea (SEA-015)	Achieved	Achieved	No change in status between the two assessment periods.	The threshold value is achieved (GES). Sediment and biota achieved their threshold values.
The Quark (SEA-016)	Failed	Failed	No change in status between the two assessment periods.	The threshold value is not achieved (sub-GES) Monitoring only occurs in biota.
Bothnian Bay (SEA-017)	Failed	Failed	No change in status between the two assessment periods.	The threshold value is not achieved (sub-GES). Sediment achieved the threshold value but biota did not.

5 Confidence

The overall confidence of the indicator evaluation is generally moderate, with some assessment units being classified as high or low confidence (Figure 12 and further details in Annex 1).

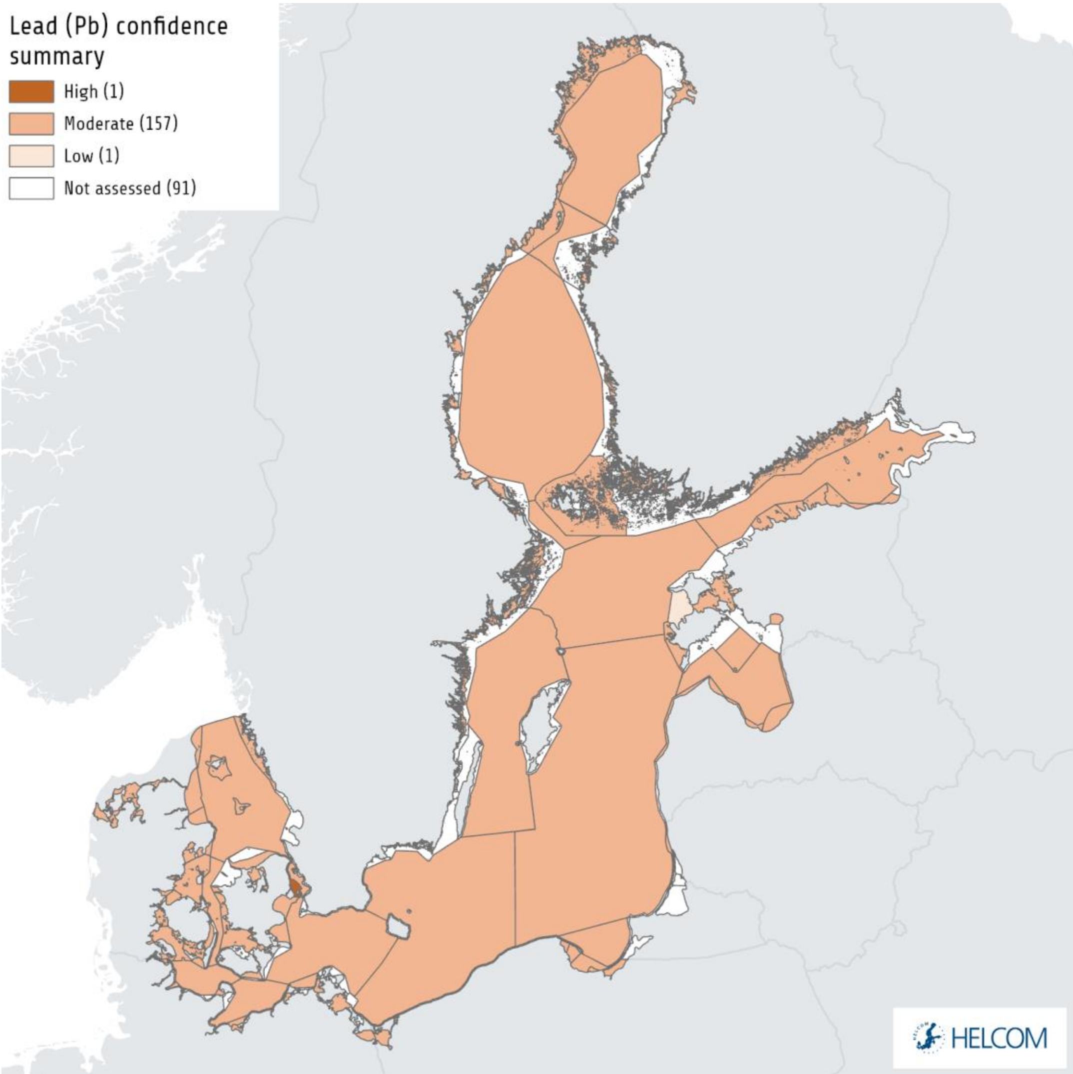


Figure 12. Map presenting the confidence in the overall evaluation based on a OOAO summary of confidence across all monitored matrices (see Annex 1). The evaluation is carried out using Level 4 HELCOM assessment units (defined in the HELCOM Monitoring and Assessment Strategy Annex 4).

The accuracy of the estimation method is considered to be high, and the risk of false status classifications is considered to be very low. The underlying monitoring data is of high quality and regionally comparable.

The data on lead concentrations in seawater was reported by Estonia, Germany, Lithuania and Poland and covers 10 sub-basins. The confidence of the evaluation based on seawater results is medium.

The data on metal concentrations in fish and bivalves, as well as in sediment, is spatially adequate and time series are available for several stations, therefore the confidence in the results is high.

6 Drivers, Activities, and Pressures

Drivers are often large and complex issues that are difficult to quantify, though in certain instances proxies can be utilised to express them or changes in them. A driver for example may relate to globalisation or political will and, while difficult to quantify in terms of specific relevance to an indicator, changes in drivers can catalyse changes in activities that will consequently influence pressures for example resulting in altered levels of shipping and the subsequent pressures for that activity. A brief overview of key pressures and activities is provided in Table 7.

One of the biggest sources of environmental pollution, including the marine environment, with heavy metals, is the combustion of solid fuels - such as coal, lignite, peat and wood - both in industrial and domestic conditions. In the case of lead, the main source was also leaded fuels until their ban in Europe in the 1990s. Current legal use of lead includes lead car batteries. In the last decades, EU or worldwide legislation has been put in place banning most uses of heavy metals.

The main routes of lead transport to the Baltic Sea are atmospheric deposition and river inflow (https://helcom.fi/wp-content/uploads/2019/08/BSEP162.pdf). The atmospheric deposition to the Baltic Sea can also originate from the transport of metals from outside the Baltic Sea catchment area.

Table 7. Brief summary of relevant pressures and activities with relevance to the indicator.

	General	**MSFD Annex III, Table 2a**
Strong link		Substances, litter and energy - Input of other substances (e.g. synthetic substances, non-synthetic substances, radionuclides) – diffuse sources, point sources, atmospheric deposition, acute events
Weak link		

7 Climate change and other factors

The observed climate change may impact the distribution and levels of lead in the marine environment. Among the direct parameters of climate change, the fate of lead in the Baltic Sea environment may be affected by the following:

1. Seawater temperature - an increase in water temperature may affect the metabolism of marine organisms and increase the efficiency of bioaccumulation of lead
2. Large-scale atmospheric circulation - it can affect the transport of pollutants, including lead and thus influence the amount of deposition to the waters of the Baltic Sea
3. Precipitation - changes in the precipitation regime may affect the amount of atmospheric lead deposition to the Baltic Sea
4. River run-off - may be an important source of lead entering the Baltic Sea; increasing the inflow in flood situations increases the inflow of lead
5. Carbonate chemistry - changes in the pH of the aquatic environment may affect the transformations and thus the chemical forms of lead in the marine environment; they may affect also the metabolism of organisms and thus the efficiency of bioaccumulation of lead
6. Sediment transportation - due to significant amounts of lead deposited in bottom sediments, dynamics at the bottom and transport of sediments may lead to secondary isotope release

Among the indirect parameters of climate change affecting lead fate in the marine environment are changes in oxygen levels. Projected warming may enhance oxygen depletion in the Baltic Sea, which may influence the biogeochemical processes involving lead.

8 Conclusions

In general, the indicator is fully operational and a wide-ranging evaluation can be made across the region. Lead persists in the environment and is toxic to marine life at elevated concentrations. A number of decreasing trends are detected, offering a good indication of improving conditions, however the evaluation of Good Environmental Status (GES) generally results in sub-GES conditions. Although in certain assessment units the threshold values in water and/or sediments are not achieved the failure to achieve the threshold value is somewhat common in biota (i.e. this commonly drives the overall evaluation). Biota is the most widely evaluated monitoring matrix across the region and when summarised (i.e. in the OOAO approach) sub-GES conditions are generally identified.

8.1 Future work or improvements needed

The current annual sampling of biota and sediment is considered to be of adequate frequency for the core indicator. The biota monitoring in each sub-basin depends on the availability of certain species during the time of monitoring cruises and cannot be secured at all times.

Further development of the confidence evaluation is likely valuable. It may also be relevant to explore trends in and between species used in the evaluation to explore if certain trends exist and may be possible to link with food web structure or function.

Exploring the possibility to include sediment core data in the future and to evaluate the added value of trends from dated sediment cores, in particular to evaluate trends over more extended time periods would be valuable.

Countries should consider extending monitoring to include lead measurements in seawater.

9 Methodology

The overall methodology is set out below.

9.1 Scale of assessment

The core indicator evaluates the status with regard to concentrations of metals using HELCOM assessment unit scale 4 (division of the Baltic Sea into 17 sub-basins division into coastal and offshore areas, and the coastal areas further divided into WFD water types or bodies).

The assessment units are defined in the [HELCOM Monitoring and Assessment Strategy Annex 4.]

9.2 Methodology applied

The evaluation is carried out using an agreed R-script (MIME) that applies the statistical analysis.

To evaluate the contamination status of the Baltic Sea, the ratio of the concentration of a metal to the specified concentration (threshold) levels is used for each biotic and abiotic elements (matrix) of the marine environment. A ratio above 1 therefore indicates non-compliance (failure to meet threshold). Taking into account the scope of monitoring programmes implemented by the EU MS regarding heavy metals, and the target concentrations of individual elements, the appropriate measurement matrices were recommended to allow the use of results in Descriptor 8.

All available data on lead (in seawater, fish liver, fish muscle, mussel soft tissue and bottom sediments) concentrations up to 2021, reported by HELCOM Contracting Parties to the HELCOM COMBINE database, was used to assess the state of the Baltic Sea environment.

The evaluation of the present environmental status in respect of heavy metal content has been carried out in all assessment units at scale 4, where data availability was sufficient.

The basis for the evaluation carried out in the sub-basins was the determination of the concentrations of individual metals in the respective matrices for each station, which were then compared with threshold values to determine the contamination ratio (CR). Good status in respect of single element is scored if CR ≤ 1.

A two-way approach was used to determine the representative concentrations of the individual metals in the individual matrices. In the case of stations where long-term data series exist, the agreed script (MIME Script) was used. This method allows determination of the upper value of the 95% confidence level which is regarded as a representative concentration. In the case of stations where data are from 1-2 years only or 'less-than' values make the correct assignment of the above statistical procedures impossible then data are treated as 'initial' data. All initial data is handled in a highly precautionary manner to further ensure that the risk of false positives is minimalised. For all initial data the 95% confidence limit on the mean concentration, based on the uncertainty seen in longer time series throughout the HELCOM area, is used. Applying a precautionary approach, the 90% quantile (psi value, Ψ) of the uncertainty estimates in the longer time series from the entire HELCOM region are used. The same approach is used for time series with three or more years of data, but which are dominated by less-than values (i.e. no parametric model can be fitted). The mean concentration in the last monitoring year (meanLY) is obtained by: restricting the time series to the period 2016-2021 (the last six monitoring years), calculating the median log concentration in each year (treating 'less-than' values as if they were above the limit of detection), calculating the mean of the median log concentrations, and then back-transforming (by exponentiating) to the concentration scale. The upper one-sided 95% confidence limit (clLY) is then given by: exp(meanLY + qnorm(0.95) * Ψ / sqrt(n)), where n is the number of years with data in the period 2016-2021 (HELCOM 2018).

In order to ensure comparability of the measurements to the core indicator threshold value, the data to be extracted from the HELCOM COMBINE database has been defined in a so called 'extraction table'. Relevant sections of the extraction table are presented in Table 2.

The evaluation of the present environmental status in respect of heavy metal content should be carried out, if possible – regarding data availability, in all assessment units (assessment units at scale 4).

9.3 Monitoring and reporting requirements

Monitoring methodology

HELCOM common monitoring of relevance to the indicator is described on a general level in the HELCOM Monitoring Manual in the programme topic: Concentrations of contaminants.

Quality assurance in the form of international workshops and proficiency testing has been organized annually by QUASIMEME since 1993, with two rounds each year for water, sediment and biota.

Current monitoring

The monitoring activities relevant to the indicator that is currently carried out by HELCOM Contracting Parties are described in the HELCOM Monitoring Manual in the relevant Monitoring Concept Tables.

Sub-programme: Contaminants in biota
Monitoring Concept Table

Sub-programme: Contaminants in water
Monitoring Concept Table

Sub-programme: Contaminants in sediment
Monitoring Concept Table

Concentrations of lead are being monitored by all the Baltic Sea countries. In addition to long-term monitoring stations of herring, cod, perch, flounder and eelpout, there is a fairly dense grid of monitoring stations for mussels and perch at the shoreline, but very few stations in the open areas of the Baltic Sea. The monitoring is, however, considered to be representative.

Description of optimal monitoring

Lead concentrations are spatially highly varying in the Baltic Sea. Therefore, a dense network of monitoring stations is needed to have reliable overviews of the state of the environment. The monitoring should contain both long-lived and mobile species (herring, cod, flounder) and more local species (perch and shellfish).

Sediment monitoring can complement the evaluation. Sediment represents longer timespans than biota (typically years vs. months), and are available in all places, whereas especially local species are not always available for spatial surveys. Time-trends from dated sediment cores in undisturbed (anoxic) areas can be a valuable source of information on the development in concentrations from before monitoring was started and even back to pre-industrialized times.

Monitoring of lead is relevant in the entire sea area.

10 Data

The data and resulting data products (e.g. tables, figures and maps) available on the indicator web page can be used freely given that it is used appropriately and the source is cited.

Results: Lead in biota

Results: Lead in sediment

Results: Lead in water

Data: Hazardous substances in biota

Data: Hazardous substances in sediment

Data: Hazardous substances in water

The indicator is based on data held in the HELCOM COMBINE database, hosted at the International Council for the Exploration of the Seas (ICES).

11 Contributors

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12 Archive

This version of the HELCOM core indicator report was published in April 2023:

The current version of this indicator (including as a PDF) can be found on the HELCOM indicator web page.

Older versions of the core indicator report are available:

Metals HELCOM core indicator 2018 (pdf)

HOLAS II component - core indicator report – web-based version July 2017 (pdf)

HELCOM-CoreIndicator-Metals(Lead, Cadmium, Mercury) 2013 (pdf)

13 References

European Commission (2000) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Off. J. Eur. Union L 327.

European Commission (2006a) Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. Off. J. Eur. Union L 364.

European Commission (2008a) Directive 2008/56/EC of the European Parliament and the Council establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Off. J. Eur. Union L 164: 19-40.

European Commission (2008b) Directive 2008/105/EC of the European Parliament and the Council on environmental quality standards in the field of water policy (Directive on Environmental Quality Standards). Off. J. Eur. Union L 348.

European Commission (2013) Directive 2013/39/EU of the European Parliament and of the Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy. Off. J. Eur. Union L 226: 1-17.

14 Other relevant resources

HELCOM (2010) Hazardous substances in the Baltic Sea – An integrated thematic assessment of hazardous substances in the Baltic Sea. Balt. Sea Environ. Proc. No. 120B.

HELCOM (2018): HELCOM Thematic assessment of hazardous substances 2011-2016. Baltic Sea Environment Proceedings n°157.

Law, R., Hanke, G., Angelidis, M., Batty, J., Bignert, A., Dachs, J., Davies, I., Denga, Y., *et al.* (2010) MARINE STRATEGY FRAMEWORK DIRECTIVE Task Group 8 Report Contaminants and pollution effects. JRC Scientific and Technical Reports.

Annex 1 Assessment unit level confidence summary

Confidence is evaluated per assessment unit based on a relative evaluation of following parameters for the copper indicator: 1) spatial component, 2) temporal component, 3) methodological component, and 4) the evaluation component. Despite the common approach applied with other indicators the information set out here is not directly comparable as it only focusses on an evaluation within each indicator (i.e. is relative only between the evaluated assessment units for lead) and it furthermore only addresses the evaluated units. More general information related to overarching confidence and required improvements are detailed in the main report.

The confidence for each component was applies based on a categorical approach using high, moderate and low. To achieve the overall summary confidence a score of 0.25 was applied to low, 0.5 to moderate and 1.0 to high with an average value calculated across the components and the same scores used to then select he final overall category.

Spatial component: Open Sea and coastal areas were treated separately due to the scale of sea area being vastly different. The area (km^2) for each evaluated assessment unit was divided by the total number of stations in the assessment unit and the resulting area per station was used to divide into three categories, roughly interpreted as stations addressing small, medium or large areas. If a large number (relatively) of stations were still available despite the area being large an increase of 1 category was applied.

Temporal component: The presence of 'full' and/or 'initial' data series was utilised to evaluate this. Where only a single initial data series/station was present a category of low was applied, where two initial data series were available a category of moderate was applied, where a single full data series was present a category of moderate was applied, and where two or more full data series were present a category of high was applied.

Methodological component: A score of high is applied to all evaluated assessment units since the indicator is evaluated using the MIME tool and applies a regionally agreed methodology and threshold values on national monitoring data.

Evaluation component: The standard error generated within the MIME assessment tool is utilised as a proxy for this component. In simple terms the basis of this evaluation is that standard error can be roughly equated to a coefficient of variance. This therefore provides a general confidence evaluation of the underlying data and variation within it. A categorical approach was applied where standard error values >0.70 were scored as low, 0.4-0.7 were scored as moderate and <0.4 were scored as high.

The confidence is provided for for water, sediment and biota below (Annex 1 - Tables 1-3)..

The overall confidence for the OOAO status evaluation is also generated using a OOAO approach from these tables below, suing the overall category.

Annex 1 – Table 1. Summary table showing categorical confidence per component and overall for lead in water.

Region	Spatial	Temporal	Methodological	Evaluation	Overall
DEN-113	High	Low	High	Low	Moderate
EST-001	High	Moderate	High	Low	Moderate
EST-002	Moderate	Low	High	Low	Moderate
EST-003	High	Moderate	High	Low	Moderate
EST-005	High	High	High	High	High
EST-008	High	Low	High	Low	Moderate
EST-009	High	Low	High	Low	Moderate
EST-010	Moderate	Low	High	Low	Moderate
EST-011	High	Moderate	High	Low	Moderate
EST-013	High	Low	High	Low	Moderate
EST-014	Moderate	Low	High	Low	Moderate
EST-016	High	Moderate	High	Low	Moderate
GER-002	High	Moderate	High	Low	Moderate
GER-005	High	Moderate	High	Low	Moderate
GER-007	High	Moderate	High	High	Moderate
GER-010	High	Moderate	High	High	Moderate
GER-013	High	Moderate	High	Low	Moderate
GER-020	High	Moderate	High	Moderate	Moderate
GER-026B	High	Moderate	High	High	Moderate
GER-029	High	Low	High	Low	Moderate
GER-031	High	Low	High	Low	Moderate
GER-032	High	Low	High	Low	Moderate
GER-036A	High	Low	High	Low	Moderate
GER-044	High	Moderate	High	High	Moderate
LIT-002	High	Moderate	High	Low	Moderate
LIT-003	High	Low	High	Low	Moderate
LIT-006	High	Moderate	High	High	Moderate
POL-001	High	Low	High	Low	Moderate
POL-002	High	Moderate	High	Moderate	Moderate
POL-003	High	Moderate	High	Low	Moderate
POL-004	High	Low	High	Low	Moderate
POL-005	High	Low	High	Low	Moderate
POL-006	Moderate	Low	High	Low	Moderate
POL-007	High	Low	High	Low	Moderate
POL-008	High	Moderate	High	Low	Moderate
POL-009	High	Low	High	Low	Moderate
POL-010	High	Low	High	Low	Moderate
POL-011	High	Low	High	Low	Moderate
POL-012	High	Low	High	Low	Moderate
POL-014	High	Low	High	Low	Moderate
POL-015	High	Low	High	Low	Moderate

POL-016	High	Low	High	Low	Moderate
POL-017	High	Low	High	Low	Moderate
POL-018	High	Low	High	Low	Moderate
POL-019	High	Low	High	Low	Moderate
SEA-004	High	Moderate	High	Low	Moderate
SEA-005	High	High	High	Moderate	Moderate
SEA-006	Moderate	High	High	High	Moderate
SEA-007	Moderate	High	High	Moderate	Moderate
SEA-009	Low	High	High	High	Moderate

Annex 1 – Table 2. Summary table showing categorical confidence per component and overall for lead in sediment.

Region	Spatial	Temporal	Methodological	Evaluation	Overall
DEN-024	High	Low	High	Moderate	Moderate
DEN-045	High	Low	High	Moderate	Moderate
DEN-085	High	Low	High	Moderate	Moderate
DEN-092	High	Low	High	Moderate	Moderate
DEN-128	High	Low	High	Moderate	Moderate
DEN-136	High	Low	High	Moderate	Moderate
DEN-137	High	Low	High	Moderate	Moderate
DEN-142	High	Low	High	Moderate	Moderate
EST-001	Moderate	Low	High	Moderate	Moderate
EST-003	High	Moderate	High	High	Moderate
EST-005	High	Moderate	High	High	Moderate
EST-009	High	Low	High	Moderate	Moderate
EST-014	Moderate	Low	High	Moderate	Moderate
EST-016	High	Moderate	High	High	Moderate
FIN-004	Low	Low	High	Moderate	Moderate
LIT-006	High	Moderate	High	High	Moderate
POL-002	High	Moderate	High	High	Moderate
POL-003	High	Moderate	High	High	Moderate
SEA-001	Moderate	High	High	High	Moderate
SEA-004	High	High	High	High	High
SEA-005	High	High	High	High	High
SEA-006	High	High	High	High	High
SEA-007	High	High	High	High	High
SEA-008	High	Low	High	Moderate	Moderate
SEA-009	Moderate	High	High	High	Moderate
SEA-010	High	High	High	High	High
SEA-012	Low	High	High	High	Moderate
SEA-013	High	Moderate	High	High	Moderate
SEA-014	High	Moderate	High	High	Moderate
SEA-015	Moderate	High	High	High	Moderate
SEA-017	Moderate	High	High	High	Moderate

Annex 1 – Table 3. Summary table showing categorical confidence per component and overall for lead in biota.

Region	Spatial	Temporal	Methodological	Evaluation	Overall
DEN-001	High	High	High	Moderate	Moderate
DEN-002	High	High	High	Low	Moderate
DEN-006	High	High	High	High	High
DEN-016	High	Low	High	Low	Moderate
DEN-024	High	Moderate	High	Moderate	Moderate
DEN-025	High	Moderate	High	Low	Moderate
DEN-029	High	Moderate	High	Low	Moderate
DEN-035	High	High	High	Moderate	Moderate
DEN-036	High	Low	High	Low	Moderate
DEN-037	High	Low	High	Low	Moderate
DEN-045	High	Low	High	Low	Moderate
DEN-046	High	Low	High	Low	Moderate
DEN-047	High	Moderate	High	Low	Moderate
DEN-049	High	Moderate	High	Moderate	Moderate
DEN-062	High	Moderate	High	Low	Moderate
DEN-072	High	Low	High	Low	Moderate
DEN-074	High	Low	High	Low	Moderate
DEN-080	High	Low	High	Low	Moderate
DEN-083	High	Low	High	Low	Moderate
DEN-087	High	Low	High	Low	Moderate
DEN-089	High	Low	High	Low	Moderate
DEN-090	High	Moderate	High	Low	Moderate
DEN-092	High	Moderate	High	Low	Moderate
DEN-096	High	Moderate	High	Moderate	Moderate
DEN-102	High	Low	High	Low	Moderate
DEN-104	High	High	High	Low	Moderate
DEN-105	High	High	High	Low	Moderate
DEN-106	High	Low	High	Low	Moderate
DEN-109	High	Moderate	High	Low	Moderate
DEN-110	High	High	High	Moderate	Moderate
DEN-113	High	Moderate	High	Low	Moderate
DEN-114	High	Moderate	High	Low	Moderate
DEN-122	High	Moderate	High	Low	Moderate
DEN-123	High	Moderate	High	Low	Moderate
DEN-124	High	High	High	Low	Moderate
DEN-125	High	Low	High	Low	Moderate
DEN-127	High	Moderate	High	Low	Moderate
DEN-128	High	High	High	Low	Moderate
DEN-137	High	High	High	Moderate	Moderate
DEN-138	High	Low	High	Low	Moderate
DEN-139	High	Moderate	High	Low	Moderate

DEN-140	High	Low	High	Low	Moderate
DEN-141	High	Low	High	Low	Moderate
DEN-142	High	Low	High	Low	Moderate
DEN-145	High	Low	High	Low	Moderate
DEN-146	High	Low	High	Low	Moderate
DEN-147	High	High	High	Low	Moderate
DEN-154	High	Low	High	Low	Moderate
DEN-157	High	High	High	Moderate	Moderate
DEN-159	High	Moderate	High	Moderate	Moderate
DEN-160	High	Moderate	High	Low	Moderate
DEN-200	High	High	High	Moderate	Moderate
DEN-201	High	High	High	Moderate	Moderate
DEN-204	High	High	High	Moderate	Moderate
DEN-206	High	High	High	Moderate	Moderate
DEN-209	High	High	High	Moderate	Moderate
DEN-212	High	High	High	Low	Moderate
DEN-214	High	High	High	Moderate	Moderate
DEN-216	High	High	High	Moderate	Moderate
DEN-217	High	Moderate	High	Low	Moderate
DEN-219	High	Moderate	High	Moderate	Moderate
DEN-222	High	High	High	Low	Moderate
DEN-224	High	Low	High	Low	Moderate
DEN-225	High	High	High	Moderate	Moderate
DEN-231	High	Moderate	High	Low	Moderate
DEN-232	High	Moderate	High	Low	Moderate
DEN-233	High	Moderate	High	Low	Moderate
DEN-234	High	Moderate	High	Low	Moderate
DEN-235	High	High	High	Moderate	Moderate
DEN-236	High	Moderate	High	Low	Moderate
DEN-238	High	Low	High	Low	Moderate
EST-002	High	Low	High	Low	Moderate
EST-003	High	Low	High	Low	Moderate
EST-005	High	Low	High	Low	Moderate
EST-008	High	Low	High	Low	Moderate
EST-009	High	Low	High	Low	Moderate
EST-010	Low	Low	High	Low	Low
EST-013	High	High	High	Low	Moderate
EST-014	High	Moderate	High	Low	Moderate
EST-016	High	Low	High	Low	Moderate
EST-019	Moderate	Moderate	High	Low	Moderate
FIN-001	Moderate	Low	High	Low	Moderate
FIN-003	High	High	High	Moderate	Moderate
FIN-004	Low	Moderate	High	Low	Moderate
FIN-005	Moderate	Moderate	High	Low	Moderate
FIN-006	High	Low	High	Low	Moderate
FIN-008	High	Low	High	Low	Moderate

FIN-010	High	High	High	Moderate	Moderate
FIN-014	Low	Moderate	High	Low	Moderate
GER-002	High	High	High	Moderate	Moderate
GER-004	High	High	High	Moderate	Moderate
GER-005	High	Moderate	High	Low	Moderate
GER-010	High	Moderate	High	Low	Moderate
GER-011	High	Moderate	High	Low	Moderate
GER-013	High	Moderate	High	Low	Moderate
GER-020	High	High	High	Moderate	Moderate
GER-023	High	Moderate	High	Low	Moderate
LAT-002	High	Low	High	Low	Moderate
LAT-003	High	Low	High	Low	Moderate
LAT-004	High	Low	High	Low	Moderate
LAT-005	High	Low	High	Low	Moderate
LIT-002	High	High	High	Low	Moderate
LIT-003	High	Moderate	High	Moderate	Moderate
LIT-006	High	Moderate	High	Moderate	Moderate
POL-002	High	Moderate	High	Low	Moderate
POL-003	High	Moderate	High	Low	Moderate
POL-006	High	Moderate	High	Low	Moderate
POL-015	High	Moderate	High	Low	Moderate
POL-019	High	Low	High	Low	Moderate
SWE-003	High	Moderate	High	Low	Moderate
SWE-011	Low	Moderate	High	Low	Moderate
SWE-012	High	High	High	Moderate	Moderate
SWE-016	High	High	High	Moderate	Moderate
SWE-018	Moderate	Moderate	High	Low	Moderate
SWE-020	High	Low	High	Low	Moderate
SWE-021	High	High	High	Moderate	Moderate
SWE-022	High	High	High	Moderate	Moderate
SWE-023	Low	Moderate	High	Low	Moderate
SEA-001	Moderate	High	High	Moderate	Moderate
SEA-002	High	Moderate	High	Moderate	Moderate
SEA-003	High	Moderate	High	Low	Moderate
SEA-004	High	Moderate	High	Low	Moderate
SEA-005	High	Moderate	High	Low	Moderate
SEA-006	High	High	High	High	High
SEA-007	Moderate	High	High	High	Moderate
SEA-008	High	Moderate	High	Low	Moderate
SEA-009	High	High	High	High	High
SEA-010	Low	High	High	Moderate	Moderate
SEA-011	High	Moderate	High	Moderate	Moderate
SEA-012	Low	High	High	Moderate	Moderate
SEA-013	High	High	High	Moderate	Moderate
SEA-015	Moderate	High	High	Moderate	Moderate
SEA-016	High	Low	High	Low	Moderate

SEA-017	Low	Moderate	High	Low	Moderate