HELCOM core indicator report
July 2017

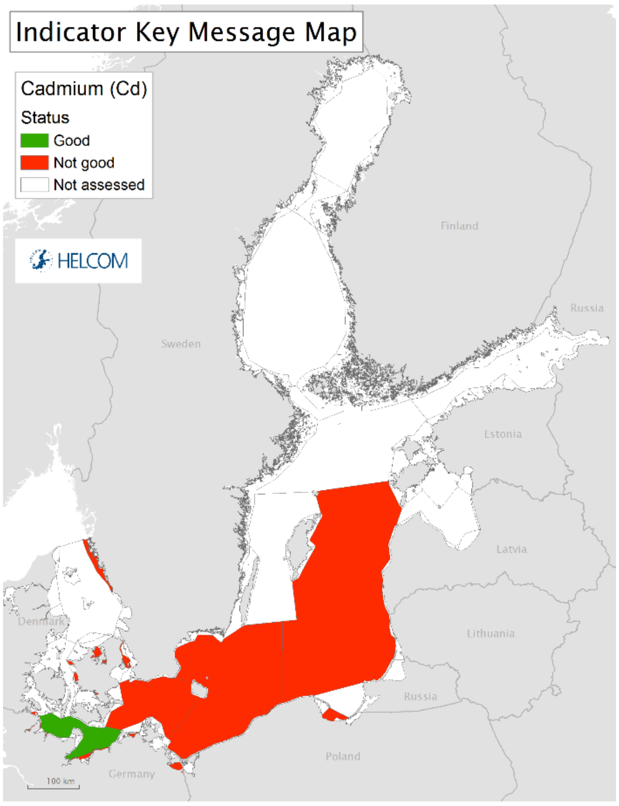
Metals (lead, cadmium and mercury)

Key Message

This core indicator evaluates the status of the marine environment based on concentrations of the heavy metals in the Baltic Sea, namely lead (Pb), cadmium (Cd) and mercury (Hg) measured in water, biota (fish and mussels) and sediments. Good status is achieved when the concentrations of heavy metals are below the threshold values.

The indicator presents a status evaluation using all available data until 2015 to evaluate the assessment period 2011 - 2015.

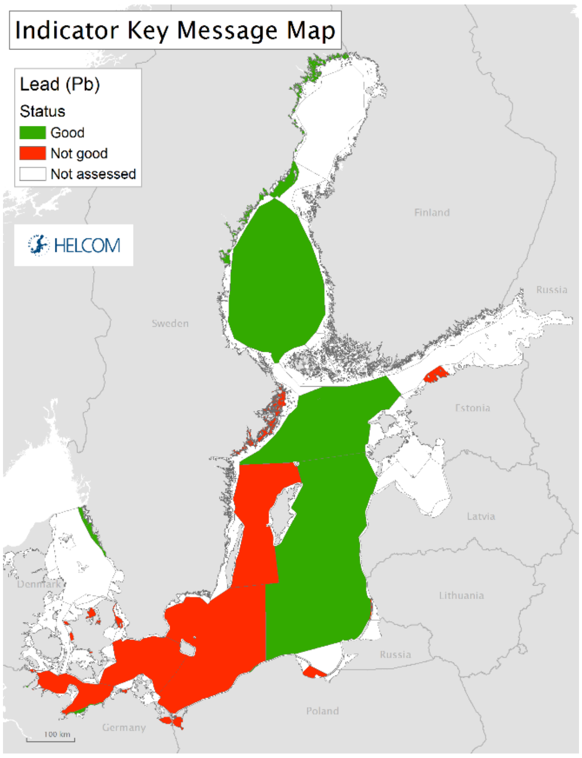
Concentrations of cadmium (Cd) in seawater, mussel and sediment did not achieve good status in most of the monitoring areas, that is in the Eastern Gotland Basin, the Bornholm Basin, the Arkona Basin and in coastal waters of the Gdańsk Basin, the Kattegat, Great Belt and The Sound. Good status was found in the Kiel Bay and Bay of Mecklenburg (Key message figure 1).



Key message figure 1: Status assessment results based on evaluation of the cadmium concentrations in seawater, mussel and sediment. The assessment is carried out using Scale 4 HELCOM assessment units (defined in the HELCOM Monitoring and Assessment Strategy Annex 4).

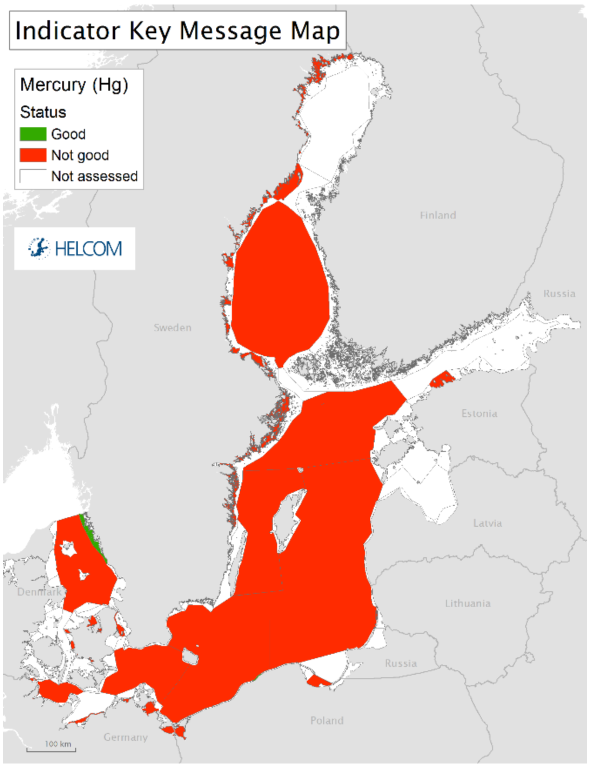
Concentrations of lead (Pb) in seawater, fish, mussel and sediment indicated good status in the Bothnian Sea, Northern Baltic Proper, Eastern Gotland Basin and in coastal areas of the Gulf of Finland, The Quark and the

Kattegat. Areas where the status exceeded the threshold value were Western Gotland Basin, Bornholm Basin, Arkona Basin, Kiel Bay and the Bay of Mecklenburg, as well as in some of the coastal areas in Gulf of Finland and Gdańsk Basin (Key message figure 2).



Key message figure 2: Status assessment results based on evaluation of the lead concentrations in seawater, mussel and sediment. The assessment is carried out using Scale 4 HELCOM assessment units (defined in the [HELCOM Monitoring and Assessment Strategy Annex 4]).

Mercury (Hg) concentration threshold value in fish muscle exceeded the threshold level in almost all monitored sub-basins indicating not good status, that is the Bothnian Sea, Northern Baltic Proper, Western- and Eastern Gotland Basins, Bornholm Basin, Arkona Basin, the Kiel Bay and the Kattegat. Only some coastal areas of the Kattegat achieved good status (Key message figure 3).



Key message figure 3: Status assessment results based on evaluation of the mercury concentrations in fish muscle. The assessment is carried out using Scale 4 HELCOM assessment units (defined in the HELCOM Monitoring and Assessment Strategy Annex 4).

The confidence of the indicator evaluation is high. The data on metal concentrations in fish and bivalves is spatially adequate and time series are available for several stations.

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

Relevance of the core indicator

The heavy metals cadmium (Cd), lead (Pb) and mercury (Hg) are toxic to marine organisms at high concentrations.

Metals are bioaccumulated by marine organisms causing harmful effects. The severity of effect mainly depends on the concentration in the tissues. Additionally, both Cd and Hg are also known to biomagnify, i.e. the concentration levels increase upwards through the food chain. When heavy metals bioaccumulate in tissues they cause different biological effects on the individual organism, which transform into changes at population, then species level, and finally affect the biodiversity and ecosystem functioning. Heavy metal contents in fish, specifically destined for human consumption, directly affect human health.

Policy relevance of the core indicator

	BSAP segment and objectives	MSFD Descriptor and criteria
Primary link	Hazardous substances • Concentration of hazardous substances close to natural levels • Healthy wildlife	D8 Concentrations of contaminants D8C1 Within coastal, territorial and areas beyond territorial waters the concentration of contaminants do not exceed the threshold values
Secondary link	Hazardous substances • Fish safe to eat	D9 Contaminants in fish and seafood D9C1 The level of contaminants in edible tissues of seafood caught or harvested in the wild does not exceed maximum levels which are the threshold values
Other relevant legislation: The Water Framework Directive (Cd, Pb and Hg are listed as priority substances).		

Cite this indicator

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

Results and Confidence

The data underlying the core indicator evaluation are based on regular monitoring data from Contracting Parties of HELCOM reported to the HELCOM COMBINE data base. The indicator presents information on the current levels of cadmium, lead and mercury concentrations in selected marine matrices: seawater, fish (muscle and liver tissue) as well as in the soft body of mussels for the assessment period 2011-2015. Several countries experienced data reporting issues, and substantial improvements are expected when the report is updated to include 2016 data.

General remark:

The presented version of the report is based on currently available data. There are data that are not included due to lack of supplemental parameters or have too short a series. In the text, the mean values of the concentrations from all data are used, while the table is based on the data that has undergone the whole evaluation. Hence there may be some discrepancies. All gaps and discrepancies will be fixed in the final report (June 2018), which will also be supplemented with 2016 data, which may affect the final status assessment.

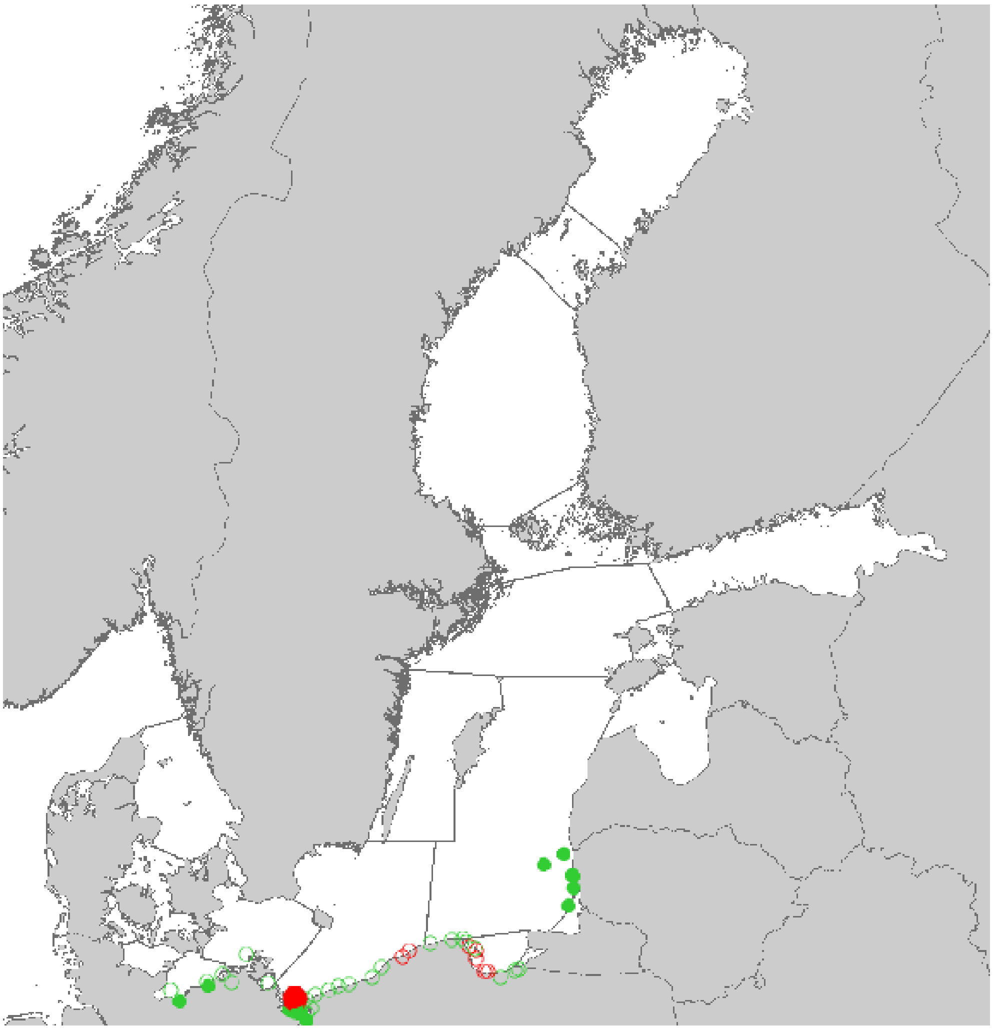
Cadmium

Seawater

The primary matrix for cadmium 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 little data is available for cadmium in water.

Cadmium concentrations in the water phase have been measured by Russia (1995–1998), Germany (1998–2015), Lithuania (2007–2015) and Poland (2011-2015). Only few percent of these values were above the annual average (AA EQS).

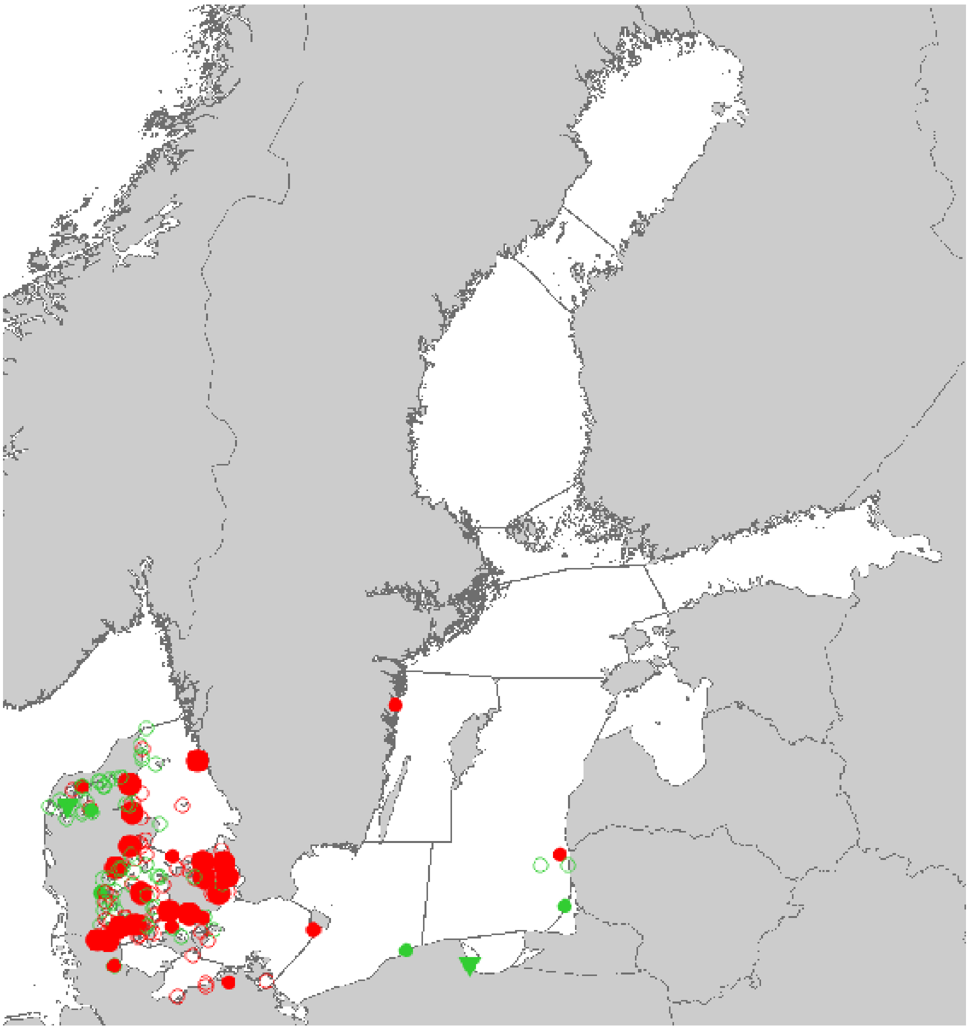
The map in Results figure 1 presents monitoring stations with full status assessment (filled circle) and initial status assessment small empty circles of Cd in seawater (for method description see Assessment protocol). In most cases the representative concentrations of Cd were below the threshold value. Only in few stations in the Gdańsk Basin and the Bornholm Basin the concentrations exceeded 0.2 µg l^{-1}. The average concentrations in the sub-basins were below the threshold value. The concentrations aggregated per assessment unit were 0.09 µg l^{-1} in the Eastern Gotland Basin, 0.11 µg l^{-1} in the Bornholm Basin, 0.07 µg l^{-1} in the Bay of Mecklenburg and 0.09 µg l^{-1} in the Arkona Basin.



Results figure 1. Map presenting status based on Cd concentrations in seawater at each sampling station. Green colour represents good status, red colour represents not good status. Filled large circles represent results based on five or more years, full evaluation with MIME Script (see Assessment protocol), small filled circles represent results based on three-four years and empty circles represent results on <3 years, initial status assessment (see Assessment protocol) [source: http://dome.ices.dk/HELCOMHZ2016/main.html]

Biota - Mussels

Soft body tissue of mussel is a secondary matrix for Cd status assessment. There is no data available in northern part of the Baltic Sea, while in the western part the network of sampling stations is very dense (Results figure 2). The Result figure 2 map presents monitoring stations with full status assessment (large filled circle) and initial status assessment (small filled and empty circles) of Cd concentration in mussel (for method description see Assessment protocol).

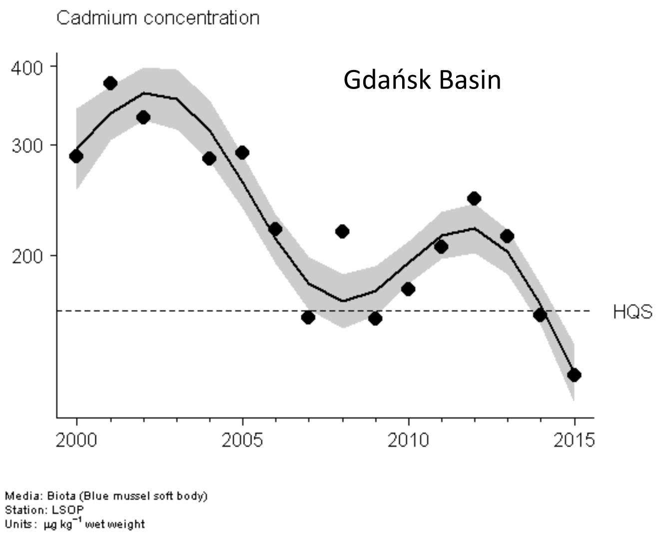


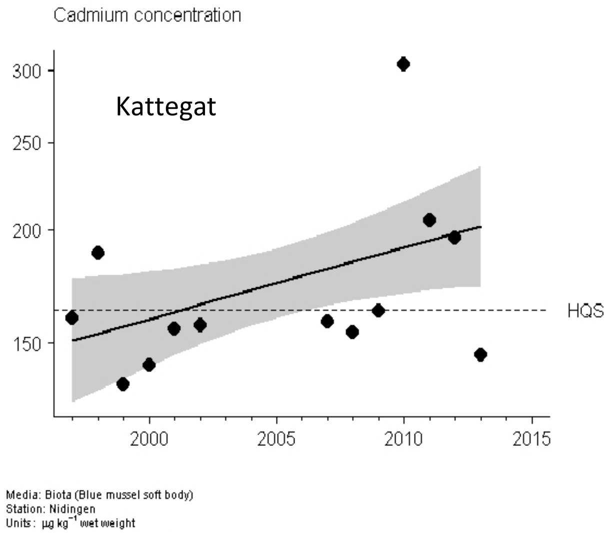
Results figure 2. Map presenting status based on Cd concentrations in mussel at each sampling station. Green colour represents good status, red colour represents not good status. Filled large circles represent results based on five or more years, full evaluation with MIME Script (see Assessment protocol), small filled circles represent results based on three-four years and empty circles represent results on <3 years, initial status assessment (see Assessment protocol) triangles represent increasing or decreasing trends [source: http://dome.ices.dk/HELCOMHZ2016/main.html]

At most sampling stations the representative concentrations of Cd in mussel exceeded the threshold value (960 µg kg^{-1} dry weight), which was recalculated to wet weight (163.2 µg kg^{-1} wet weight) as the majority of data is reported as concentration expressed in wet weight.

The aggregated mean concentrations calculated for sub-basins exceeded the threshold level in six assessed areas, that is in the Kattegat (168.9 µg kg^{-1} wet weight), the Arkona Basin (244.5 µg kg^{-1} wet weight), The Sound (263.9 µg kg^{-1} wet weight), the Bay of Mecklenburg (364.6 µg kg^{-1} wet weight) and the Western Gotland Basin (399.2 µg kg^{-1} wet weight) where the contamination was the most severe. The status in four sub-basins in relation to the Cd in mussel is good: the Eastern Gotland Basin (155.8 µg kg^{-1} wet weight – the value slightly below the threshold value), The Gdańsk Basin (129.0 µg kg^{-1} wet weight), the Bornholm Basin (99.7 µg kg^{-1} wet weight) and the Kattegat (152.6 µg kg^{-1} wet weight).

In some areas statistically significant decreasing and increasing trends could be detected, some examples of which are presented in the Results figure 3.





Results figure 3. Long-term trends of Cd concentrations in mussel at chosen stations form the Gdańsk Basin and Kattegat (HQS – threshold level, grey colour- confidence level 95% range (see Assessment protocol)) [source: http://dome.ices.dk/HELCOMHZ2016/main.html]

Results table 1. Aggregated Cd status assessment in off-shore and coastal sub-basins based on assessment carried out for indicated matrix.

Area (Code)	Secondary matrix: mussel					Secondary matrix: sediment					Aggregated
	Threshold value [µg/kg dw] (recalculated threshold value) [µg/kg ww]	Representative concentration [µg/kg ww mussels]	Representative concentration ratio to threshold value	Confidence	Secondary threshold status mussel (above/ below)	Threshold value [mg/kg sediment]	Concentration [mg/kg sediment]	Upper concentration ratio to threshold value	Confidence	Secondary threshold status sediment (above/ below)	Status (above/ below)
Kiel Bay (SEA-004)						2.3	0.8	0.34	HIGH	good	good
Bay of Mecklenburg (SEA-005)						2.3	1.1	0.46	HIGH	good	good
Arkona Basin (SEA-006)	960 (163.2)	590.2	3.62	HIGH	not good	2.3	0.9	0.38	HIGH	good	not good
Bornholm Basin (SEA-007)						2.3	10.1	4.41	HIGH	not good	not good
Gdansk Basin (SEA-009)	960 (163.2)	144.0	0.88	HIGH	good						not good
Coastal areas											
DEN-002	960 (163.2)	299.8	1.84	HIGH	not good	2.3	2.3	0.98	HIGH	good	not good
DEN-003	960 (163.2)	347.4	2.13	HIGH	not good						not good
DEN-008	960 (163.2)	340.3	2.09	HIGH	not good						not good
DEN-009	960 (163.2)	559.5	3.43	HIGH	not good						not good
DEN-010	960 (163.2)	704.8	4.32	HIGH	not good						not good
DEN-012	960 (163.2)	690.5	4.23	HIGH	not good						not good
DEN-014	960 (163.2)	224.8	1.38	HIGH	not good	2.3	3.3	1.45	HIGH	not good	not good

DEN-015	960 (163.2)	229.2	1.41	HIGH	not good						not good
GER-004						2.3	3.0	1.28	HIGH	not good	not good
GER-009	960 (163.2)	1084.2	6.64	HIGH	not good	2.3	1.5	0.67	HIGH	good	not good
GER-020						2.3	9.5	4.13	HIGH	not good	not good
GER-023	960 (163.2)	439.0	2.69	HIGH	not good						not good
GER-026						2.3	3.2	1.39	HIGH	not good	not good
GER-028	960 (163.2)	529.8	3.25	HIGH	not good						not good
GER-031						2.3	2.5	1.07	HIGH	not good	not good
LIT-002	960 (163.2)	177.8	1.09	HIGH	not good						not good
POL-006	960 (163.2)	144.0	0.88	HIGH	good						good
POL-015	960 (163.2)	158	0.97	HIGH	good						good
SWE-003	960 (163.2)	548.5	3.36	HIGH	not good						not good

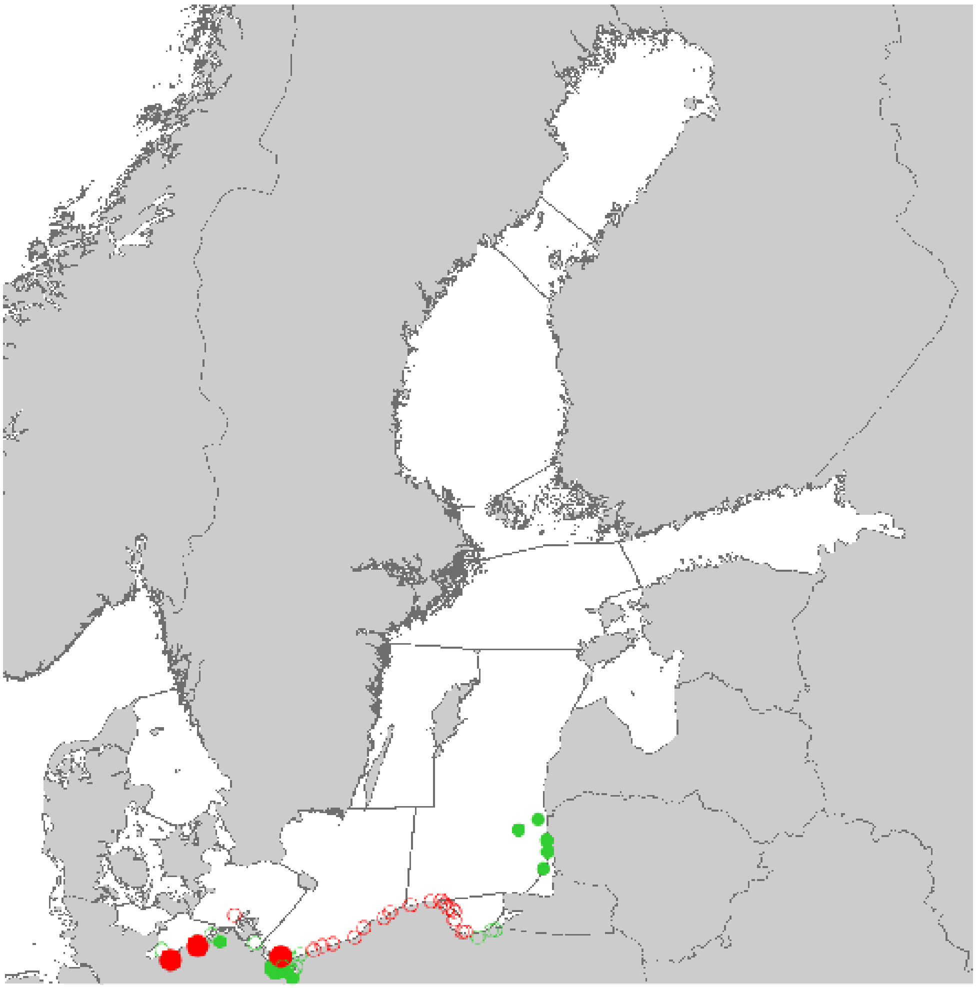
Representative concentration - an upper value of the 95% confidence level (see Assessment protocol)

Lead

Seawater

The primary matrix for lead (Pb) is water, thus an EQS value has only been suggested for water. This is in conflict with the HELCOM Combine monitoring program, where the preferred matrix is biota and sediment (see discussion on Good Environment Status). As a result, very little data is available for lead in water.

Some long-term results for lead concentrations in seawater exist, as measurements by Russia (1995–1998), Germany (1998–2015), Lithuania (2007–2015) and Poland (2011-2015). Eleven percent of German and Lithuanian measurements were above the average annual AA-EQS of 1.3 µg/l.

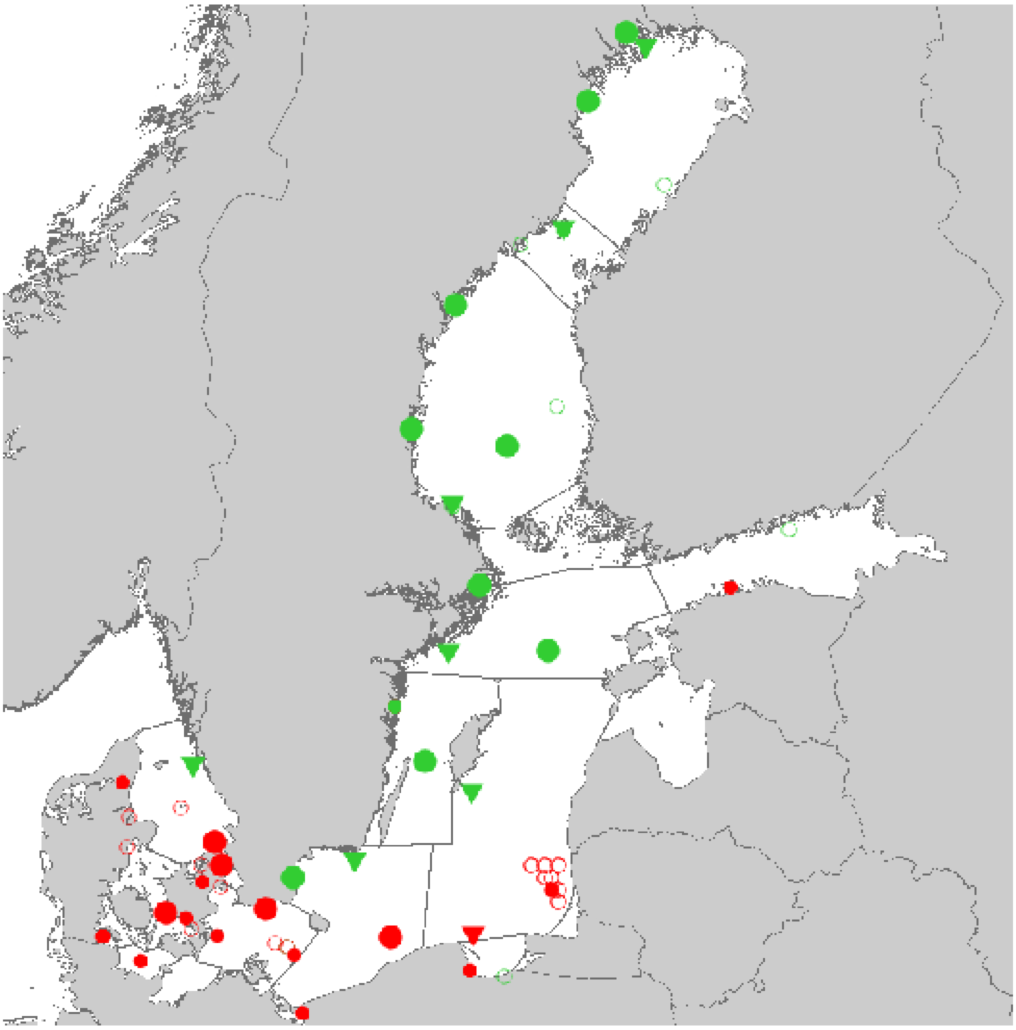


Results figure 4. Map presenting status based on Pb concentrations in seawater at each sampling station. Green colour represents good status, red colour represents not good status. Filled large circles represent results based on five or more years, full evaluation with MIME Script (see Assessment protocol), small filled circles represent results based on three-four years and empty circles represent results on <3 years, initial status assessment (see Assessment protocol) [source: http://dome.ices.dk/HELCOMHZ2016/main.html].

The map (Results figure 4) presents monitoring stations with full status assessment (filled circles) and initial status assessment (small empty circles) of Pb in seawater (for method description see Assessment protocol). In the Lithuanian coastal area the representative concentrations of Pb were below the threshold value, while in Polish coastal water concentrations exceeded the threshold value of 1.3 µg l^{-1}, but it should be pointed out that final status assessment in this area is based on limited number of data. The average concentrations of Pb in seawater were below the threshold value in the Bornholm Basin – 1.19 µg l^{-1}, the Bay of Mecklenburg - 0.18 µg l^{-1} and the Arkona Basin - 0.09 µg $l^{-1,}$ while the threshold value was exceeded in the Gdańsk Basin- 3.40 µg l^{-1} and the Eastern Gotland Basin, 1.75 µg l^{-1}.

Biota - Fish

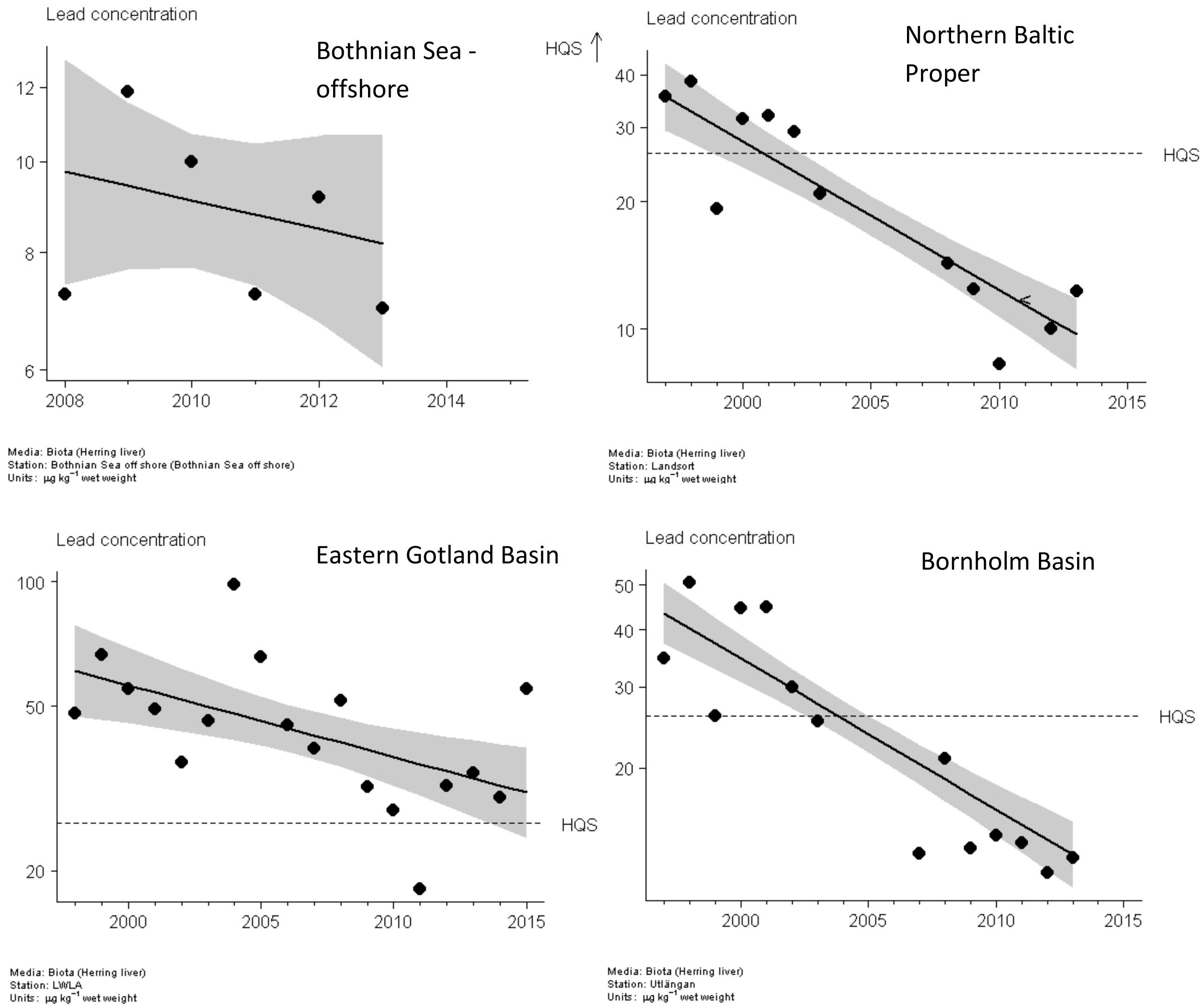
Fish liver is used as a secondary matrix. The number of data on Pb in fish liver reported by Contracting Parties to HELCOM is quite large and guaranties good coverage of the Baltic Sea (Results figure 5).

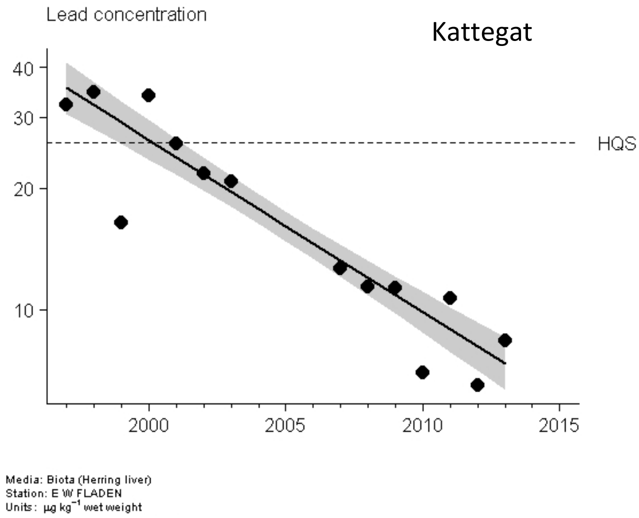


Results figure 5. Map presenting status based on Pb concentrations in fish liver at each sampling station. Green colour represents good status, red colour represents not good status. Filled large circles represent results based on five or more years, full evaluation with MIME Script (see Assessment protocol), small filled circles represent results based on three-four years and empty circles represent results on <3 years, initial status assessment (see Assessment protocol) triangles represent increasing or decreasing trends [source: http://dome.ices.dk/HELCOMHZ2016/main.html].

The lowest concentrations of Pb in fish liver were found in northern and central parts of the Baltic Sea. The aggregated concentrations calculated for sub-basin were clearly below the threshold value (26 µg kg-1 wet weight) indicating good status in the Bothnian Bay (7.3 µg kg^{-1} wet weight), The Quark (3.3 µg kg^{-1} wet weight), the Bothnian Sea (7.1 µg kg^{-1} wet weight), the Åland Sea (12.7 µg kg^{-1} wet weight), the Northern Baltic Proper (10.9 µg kg^{-1} wet weight), the Western Gotland Basin (11.1 µg kg^{-1} wet weight) and the Bornholm Basin (20.9 µg kg^{-1} wet weight). The aggregated concentration of Pb in fish liver in the Gdańsk Basin (26.5 µg kg^{-1} wet weight) was only slightly above the threshold value. Concentrations (referring to the aggregated indicator result values per assessment unit) in the range from 30.8 to 49.8 µg kg^{-1} wet weight were detected in the Kattegat, the Great Belt, The Sound, the Gulf of Finland and the Kiel Bay. The highest mean concentrations were found in the Eastern Gotland Basin (65.0 µg kg^{-1} wet weight) and the Arkona Basin (69.3 µg kg^{-1} wet weight).

Considering temporal changes in Pb concentrations in liver of the common Baltic fish species – herring and flounder, statistically significant decreasing trends were observed for fish from the majority of the Baltic Sea area (Result figure 6). This decrease is most probably the result of the ban on leaded fuels imposed in the 1980s.



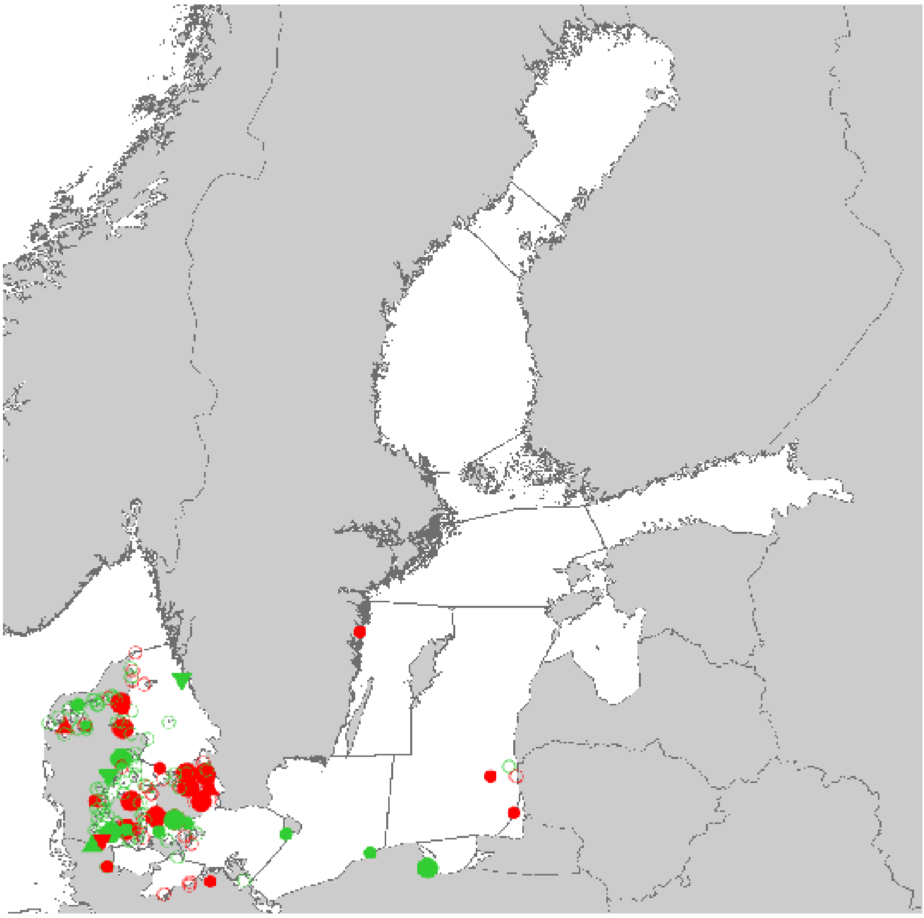


Results figure 6. Long-term trends of Pb concentrations in fish liver at stations from the Bothnian Sea, the Baltic Proper and Kattegat (HQS –threshold value, grey colour- confidence level 95% range (see Assessment protocol)) [source: http://dome.ices.dk/HELCOMHZ2016/main.html].

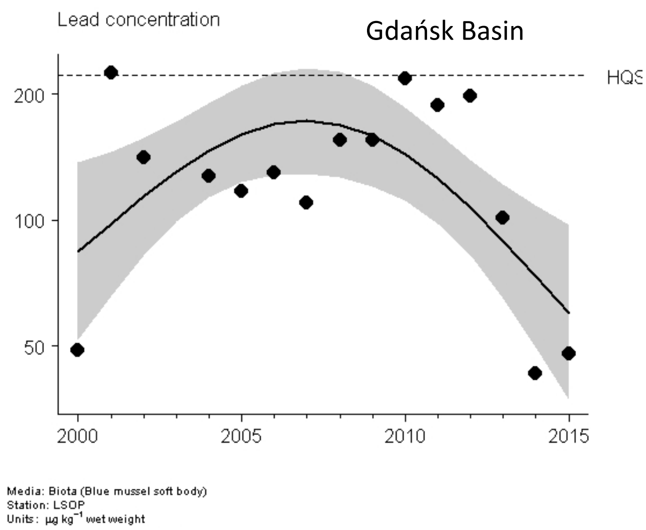
Biota - Mussel

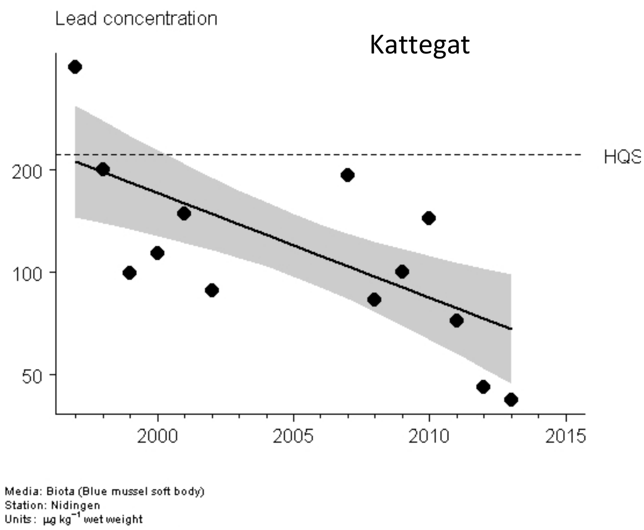
Mussel soft body is another secondary matrix for monitoring of Pb levels in the Baltic Sea. Most of the stations, where this monitoring is carried out are located in the western part of the Baltic Sea (Results figure 7). There are only four stations in the Eastern Gotland Basin (three of them show not good status). In the Western Gotland Basin there is only one station indicating not good status, while in the Bornholm Basin and the Gdańsk Basin concentrations found at single stations indicate good status, as they were below the threshold value (1300 µg kg^{-1} dry weight and 221 µg kg^{-1} wet weight after recalculation to the wet weight).

The lowest mean concentration (calculated as an aggregated value for assessment unit) of Pb in mussel was found in the Bornholm Basin (35.1 µg kg^{-1} wet weight) and slightly higher in the Gdańsk Basin (60.1 µg kg^{-1} wet weight). Mean concentrations below threshold value were also detected in the Western Gotland Basin (197.5 µg kg^{-1} wet weight), the Eastern Gotland Basin (171.9 µg kg^{-1} wet weight), the Kiel Bay (156.9 µg kg^{-1} wet weight), the Great Belt (145.4 µg kg^{-1} wet weight) and the Kattegat (152.6 µg kg^{-1} wet weight). Values exceeding the threshold value were found in the Arkona Basin (224.2 µg kg^{-1} wet weight) and the Bay of Mecklenburg (284.3 µg kg^{-1} wet weight). The highest mean concentration of Pb in mussel was observed in The Sound (338.4 µg kg^{-1} wet weight).



Results figure 7. Map presenting status based on Pb concentrations in mussel soft body at each sampling station. Green colour represents good status, red colour represents not good status. Filled large circles represent results based on five or more years, full evaluation with MIME Script (see Assessment protocol), small filled circles represent results based on three-four years and empty circles represent results on <3 years, initial status assessment (see Assessment protocol) [source: http://dome.ices.dk/HELCOMHZ2016/main.html].





Results figure 8. Long-term trends of Pb concentrations in mussel at stations in the Gdansk Basin and Kattegat (HQS – threshold value, grey colour- confidence level 95% range (see Assessment protocol)) [source: http://dome.ices.dk/HELCOMHZ2016/main.html].

Results table 2 Aggregated Pb status assessment in off-shore and coastal sub-basins based on assessment carried out for indicated matrix.

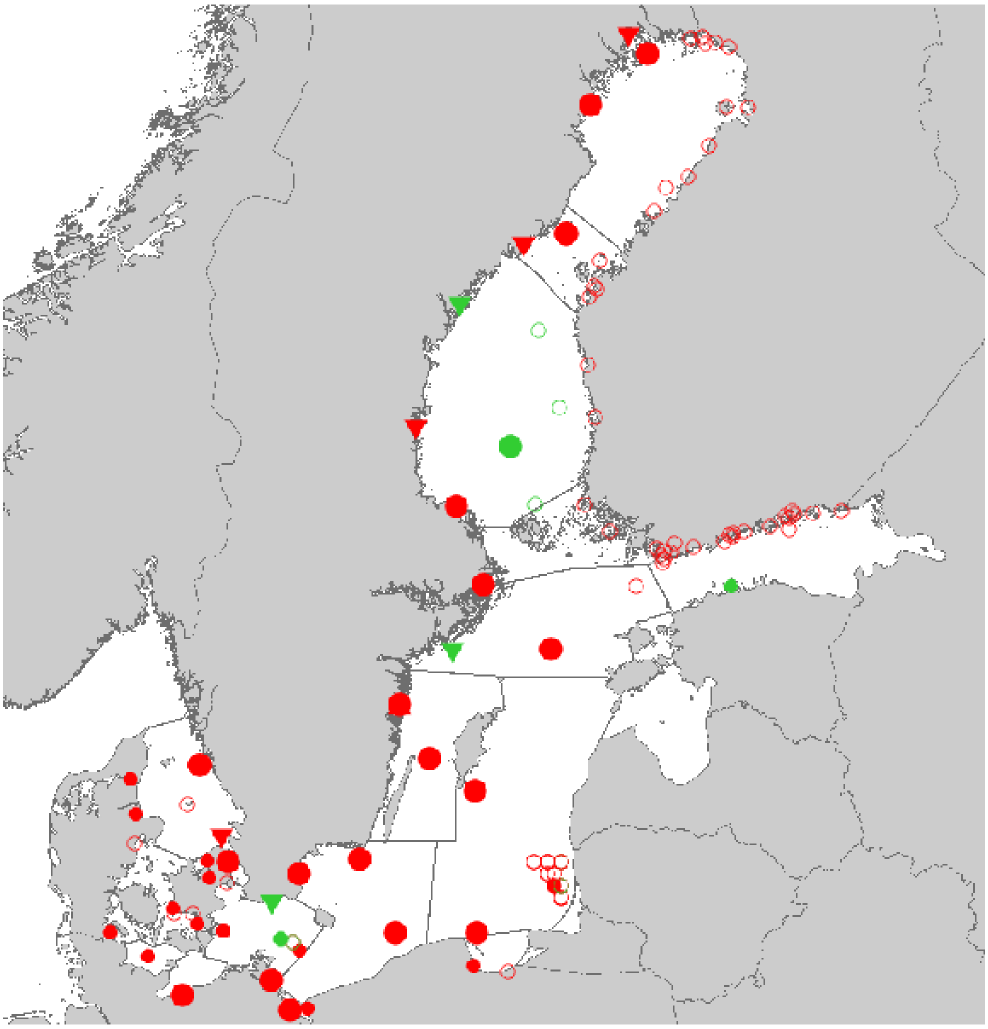
	Secondary matrix: fish liver and mussel				Secondary matrix: sediment					Aggregated
Area (Code)	**Threshold values: fish liver mussel**	**Representative concentration ratio to threshold value**	**Confidence**	**Secondary threshold status mussel (above/ below)**	**Threshold value** [mg/kg d.w.]	**Concentration** [mg/kg sediment]	**Upper concentration ratio to threshold value**	**Confidence**	**Secondary threshold status sediment (above/ below)**	**Status (above/ below)**
Kiel Bay (SEA-004)	26 µg/kg ww 1300 µg/kg dw	5.15	HIGH	not good	120	86.3	0.72	HIGH	good	not good
Bay of Mecklenburg (SEA-005)					120	130.8	1.09	HIGH	not good	not good
Arkona Basin (SEA-006)	26 µg/kg ww 1300 µg/kg dw	1.44	HIGH	not good	120	167.2	1.39	HIGH	not good	not good
Bornholm Basin (SEA-007)	26 µg/kg ww 1300 µg/kg dw	1.25	HIGH	not good	120	557.7	4.65	HIGH	not good	not good
Gdansk Basin (SEA-009)	26 µg/kg ww 1300 µg/kg dw	0.79	HIGH	good						good
Western Gotland Basin (SEA-010)	26 µg/kg ww 1300 µg/kg dw	1.64	HIGH	not good						not good
Gulf of Riga (SEA-012)	26 µg/kg ww 1300 µg/kg dw	0.85	HIGH	good						good
Bothnian Sea (SEA-015)	26 µg/kg ww 1300 µg/kg dw	0.87	HIGH	good						good
Coastal areas										
DEN-002	26 µg/kg ww 1300 µg/kg dw	1.53	HIGH	not good	120	52.1	0.43	HIGH	good	not good
DEN-003	26 µg/kg ww 1300 µg/kg dw	1.17	HIGH	not good						not good
DEN-008	26 µg/kg ww 1300 µg/kg dw	1.92	HIGH	not good						not good
DEN-009	26 µg/kg ww 1300 µg/kg dw	1.45	HIGH	not good						not good
DEN-010	26 µg/kg ww 1300 µg/kg dw	4.21	HIGH	not good						not good
DEN-012	26 µg/kg ww 1300 µg/kg dw	1.63	HIGH	not good						not good

DEN-014	26 µg/kg ww 1300 µg/kg dw	0.63	HIGH	good	120	95.3	0.79	HIGH	good	good
DEN-015	26 µg/kg ww 1300 µg/kg dw	1.46	HIGH	not good						not good
EST-005	26 µg/kg ww 1300 µg/kg dw	7.98	HIGH	not good						not good
GER-004					120	81.9	0.68	HIGH	good	good
GER-009	26 µg/kg ww 1300 µg/kg dw	2.76	HIGH	not good	120	177.6	1.48	HIGH	not good	not good
GER-020					120	229.4	1.91	HIGH	not good	not good
GER-023	26 µg/kg ww 1300 µg/kg dw	2.06	HIGH	not good						not good
GER-026					120	92.6	0.77	HIGH	good	good
GER-028	26 µg/kg ww 1300 µg/kg dw	2.74	HIGH	not good						not good
GER-031					120	178.1	1.48	HIGH	not good	not good
LIT-002	26 µg/kg ww 1300 µg/kg dw	2.62	HIGH	not good						not good
POL-002	26 µg/kg ww 1300 µg/kg dw	2.83	HIGH	not good						not good
POL-006	26 µg/kg ww 1300 µg/kg dw	1.38	HIGH	not good						not good
POL-015	26 µg/kg ww 1300 µg/kg dw	0.47	HIGH	good						good
SWE-003	26 µg/kg ww 1300 µg/kg dw	0.88	HIGH	good						good
SWE-011	26 µg/kg ww 1300 µg/kg dw	1.39	HIGH	not good						not good
SWE-018	26 µg/kg ww 1300 µg/kg dw	0.98	HIGH	good						good
SWE-021	26 µg/kg ww 1300 µg/kg dw	0.24	HIGH	good						good
SWE-022	26 µg/kg ww 1300 µg/kg dw	0.72	HIGH	good						good

Representative concentration - an upper value of the 95% confidence level (see Assessment protocol)

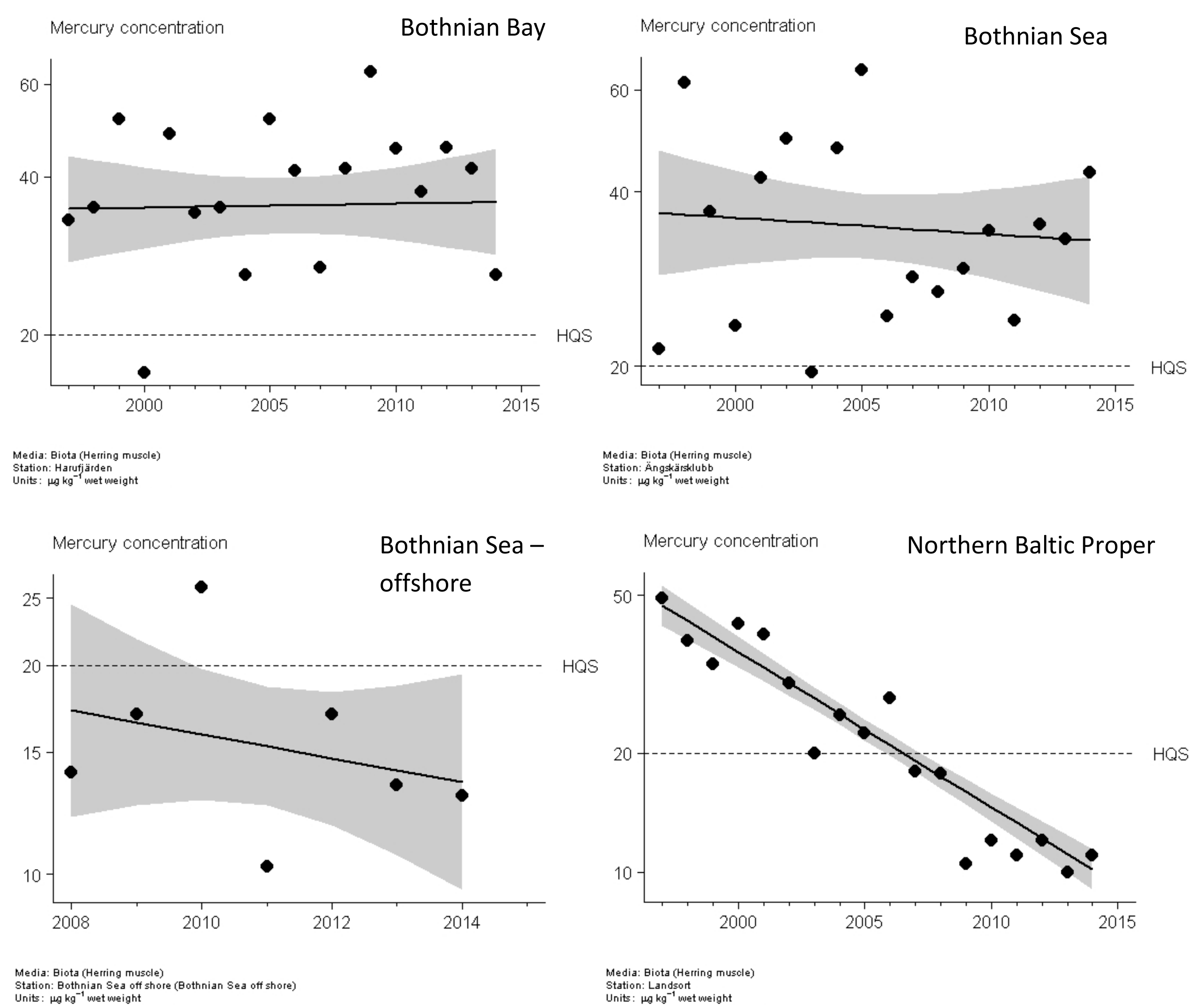
Biota - Fish

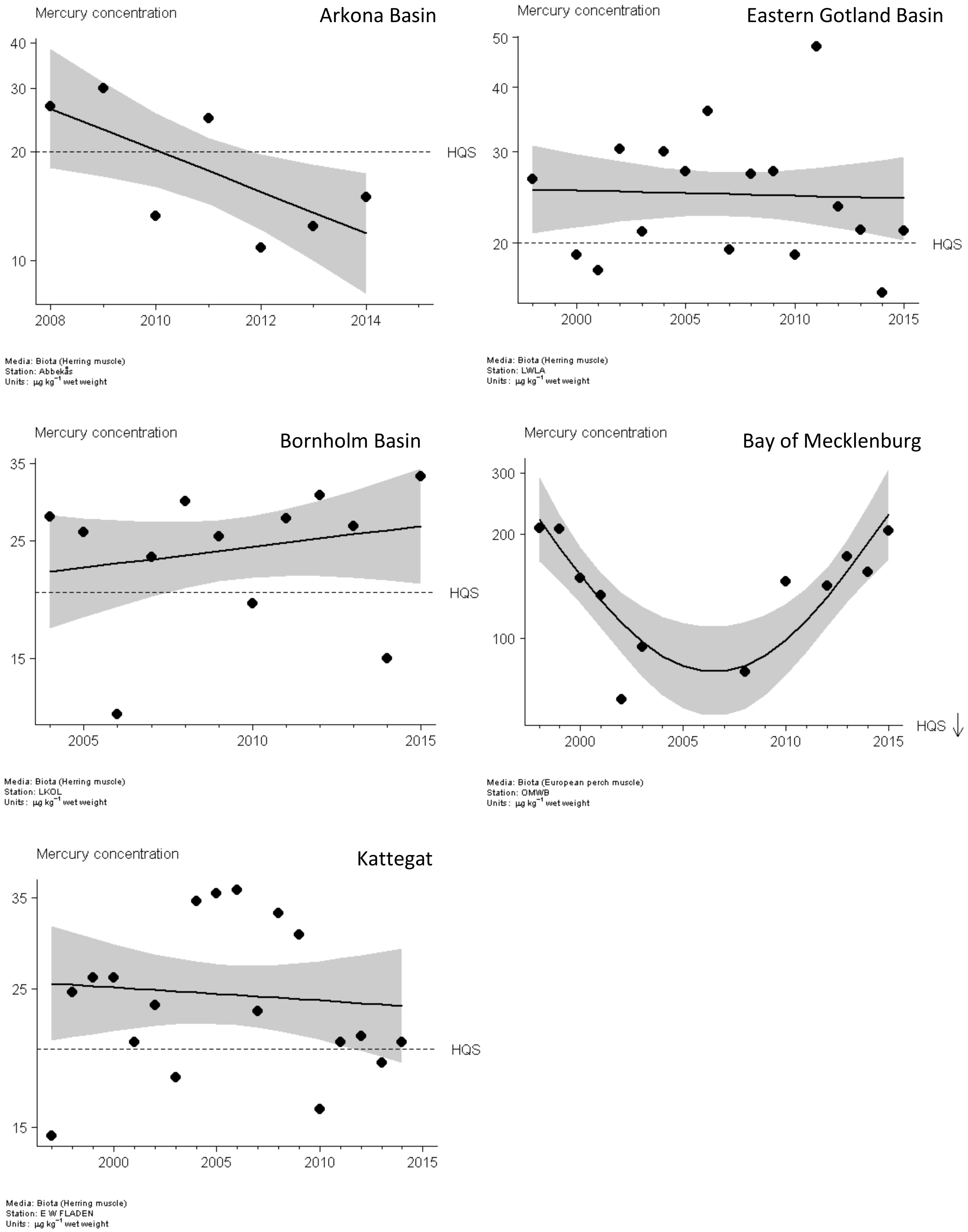
Mercury is analysed in fish muscle as a primary matrix, and the network of sampling station is dense (Results figure 9). The most common species in which Hg is measured are herring and cod in the open sea area and flounder and perch in coastal areas. Concentrations of Hg exceeded the threshold value of 20 µg kg^{-1} wet weight at a majority of the stations. Concentrations were only lower at a few stations. The mean concentrations on a sub-basin level were above the threshold value in all assessed areas. The lowest mean concentrations were found in the Northern Baltic Proper (27.5 µg kg^{-1} wet weight) and the Kiel Bay (28.0 µg kg^{-1} wet weight). Slightly higher concentrations were calculated for the Eastern Gotland Basin (34.4 µg kg^{-1} wet weight), the Bornholm Basin (36.8 µg kg^{-1} wet weight), the Kattegat (38.9 µg kg^{-1} wet weight) and the Western Gotland Basin (45.9 µg kg^{-1} wet weight). In the Bothnian Sea, The Quark, the Great Belt and the Gdańsk Basin the mean values were at level of 60 µg kg^{-1} wet weight. In the areas of the Åland Sea, the Bothnian Bay, the Gulf of Finland and The Sound the mean concentrations ranged from 115.7 µg kg^{-1} wet weight to 160.6 µg kg^{-1} wet weight. The highest value of 227.8 µg kg^{-1} wet weight was found in the Bay of Mecklenburg.



Results figure 9. Map presenting status based on Hg concentrations in fish muscle at each sampling station. Green colour represents good status, red colour represents not good status. Filled large circles represent results based on five or more years, full evaluation with MIME Script (see Assessment protocol), small filled circles represent results based on three-four years and empty circles represent results on <3 years, initial status assessment (see Assessment protocol). Downward or upward arrow shows a significant trend during the monitoring period [source: http://dome.ices.dk/HELCOMHZ2016/main.html].

There is no common general trend for mercury in fish muscle for the investigated time series (Results figure 10).





Results figure 10. Long-term trends of Hg concentrations in fish muscle at stations from the Botnian Bay, the Bothnian Sea and the northern and southern Baltic Proper (HQS –threshold value, grey colour- confidence level 95% range (see Assessment protocol)) [source: http://dome.ices.dk/HELCOMHZ2016/main.html].

Results table 3 Aggregated Hg status assessment in off-shore and coastal sub-basins based on assessment carried out for indicated matrix.

Area (Code)	**matrix**	**Threshold value** [µg/kg ww]	**Representative concentration** [µg/kg ww]	**Representative concentration ratio to threshold value**	**Confidence**	**Status (above/below)**
Kattegat (SEA-001)	fish muscle	20	59.3	2.96	HIGH	not good
Kiel Bay (SEA-004)	fish muscle	20	78.1	3.90	HIGH	not good
Arkona Basin (SEA-006)	fish muscle	20	22.6	1.13	HIGH	not good
Bornholm Basin (SEA-007)	fish muscle	20	36.1	1.81	HIGH	not good
Gdansk basin (SEA-009)	fish muscle	20	54.3	2.72	HIGH	not good
Western Gotland Basin (SEA-010)	fish muscle	20	60.0	3.00	HIGH	not good
Gulf of Riga (SEA-012)	fish muscle	20	30.4	1.52	HIGH	not good
Bothnian Sea (SEA-015)	fish muscle	20	38.1	1.91	HIGH	not good
Coastal areas						
DEN-002	fish muscle	20	37.9	1.89	HIGH	not good
DEN-003	fish muscle	20	36.9	1.84	HIGH	not good
DEN-008	fish muscle	20	58.3	2.92	HIGH	not good
DEN-009	fish muscle	20	34.1	1.71	HIGH	not good
DEN-010	fish muscle	20	102.1	5.10	HIGH	not good
DEN-012	fish muscle	20	40.1	2.01	HIGH	not good
DEN-014	fish muscle	20	20.6	1.03	HIGH	not good
DEN-015	fish muscle	20	39.4	1.97	HIGH	not good
EST-005	fish muscle	20	24.7	1.23	HIGH	not good
GER-004	fish muscle	20	636.4	31.82	HIGH	not good
GER-009	fish muscle	20	46.9	2.34	HIGH	not good
GER-013	fish muscle	20	209.8	10.49	HIGH	not good
GER-020	fish muscle	20	182.8	9.14	HIGH	not good
GER-023	fish muscle	20	38.9	1.95	HIGH	not good
GER-028	fish muscle	20	48.8	2.44	HIGH	not good

LIT-002	fish muscle	20	46.2	2.31	HIGH	not good
POL-002	fish muscle	20	168.3	8.42	HIGH	not good
POL-006	fish muscle	20	44.0	2.20	HIGH	not good
POL-015	fish muscle	20	18.5	0.93	HIGH	not good
SWE-003	fish muscle	20	19.0	0.95	HIGH	not good
SWE-011	fish muscle	20	119.8	5.99	HIGH	not good
SWE-012	fish muscle	20	53.4	2.67	HIGH	not good
SWE-016	fish muscle	20	49.9	2.49	HIGH	not good
SWE-018	fish muscle	20	39.1	1.96	HIGH	not good
SWE-020	fish muscle	20	169.9	8.50	HIGH	not good
SWE-021	fish muscle	20	68.8	3.44	HIGH	not good
SWE-022	fish muscle	20	66.3	3.32	HIGH	not good

Representative concentration - an upper value of the 95% confidence level (see Assessment protocol).

Confidence of indicator status evaluation

The overall confidence of the indicator evaluation is **high**.

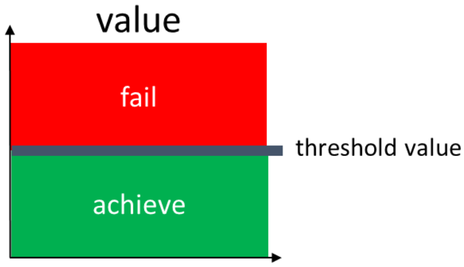
The accuracy of the estimation method is considered to be high, and the risk of false status classifications is considered to be very low. The underlying monitoring data is of high quality and regionally comparable.

The data on metal concentrations in seawater is not spatially adequate. Time series are available only for the German area: Bay of Mecklenburg, Bornholm Basin, Great Belt and Kiel Bay. For Eastern Gotland Basin (Lithuanian data) there are available data only for the period 2012-2014. The confidence of the results is low.

The data on metal concentrations in fish and bivalves is spatially adequate and time series are available for several stations therefore the confidence of the results is expected to be high.

Good Environmental Status

Good Status is achieved if the concentrations of metals are below the specified threshold values boundary of (Good environmental status figure 1).



Good environmental status figure 1. Good status is achieved if the concentrations of metals are below the threshold values listed in Good status table 1.

The threshold values for metals are based on Environmental Quality Standards (EQS) for water and biota (Good environmental status table 1) which have been defined at EU level for substances included in the priority list under the Water Framework Directive, WFD (European Commission 2000, 2013).The threshold can only be evaluated if concentrations are measured in the appropriate matrix. For historical reasons, the countries around the Baltic Sea have differing monitoring strategies. As a pragmatic approach, a threshold value is defined for primary matrix for each metal. However, if suitable monitoring data is not available in a region to evaluate the primary threshold, then the secondary threshold value can be used for the evaluation of alternative matrixes (Good environmental status table 1). Under the WFD, Member States may establish other values than EQS for alternative matrixes if specific criteria are met (see Art 3.3. in European Commission 2008a, revised in European Commission 2013).

Good environmental status table 1. Threshold value for the included metals (EQS – Environmental Quality Standard, AA- Annual Average Concentration, QS – Quality Standard, BAC = Background Assessment Criteria).

	Threshold values					
Metal	**Primary**			**Secondary**		
	Matrix	**Concentration**	**References**	**Matrix**	**Concentration**	**References**
Cadmium	Water	AA 0.2 µg l^{-1}	EQS $_{water}$	Sediment	2.3 mg kg^{-1} d.w.	QS $_{sediment}$[1]
				Mussel	960 µg kg^{-1} d.w	OSPAR BAC
Mercury	Fish, mussel	20 µg kg^{-1} ww	EQS $_{biota\ secondary\ poisoning}$	-	-	-
Lead	Water	AA 1.3 µg l^{-1}	EQS $_{water}$	Sediment	120 mg kg^{-1} d.w.	QS $_{sediment}$[1]
				Mussel	1300 µg kg^{-1} d.w	OSPAR BAC
				Fish	26 µg kg^{-1} w.w.	OSPAR BAC

[1] Applies to freshwater sediment (standard for marine sediment is currently not available). Sweden however considers this standard to be applicable also for assessment of the marine environment.

Assessment Protocol

The evaluation is carried out using an agreed R-script that runs a statistical analysis.

To evaluate the contamination status of the Baltic Sea, the ratio of concentration of metals in the biotic and abiotic elements of the marine environment to the specified concentration (threshold) levels are used. A ratio above 1 therefore indicates non-compliance. 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 (Assessment protocol table 1).

All available data on cadmium concentrations in seawater, mussel and sediments, mercury in fish muscle and lead in water, fish liver and bottom sediments up to 2015 or longer, reported by HELCOM Contracting Parties to the HELCOM COMBINE database, were used to assess the state of the Baltic Sea environment.

The assessment 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 assessment 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, the average values were calculated and these values were defined as initial status assessment station data. The lower confidence of these data was taken into account during assessment process.

The detailed description of MIME Script method can be found:
for biota http://dome.ices.dk/osparmime/help_methods_biota_metals.html

for sediment http://dome.ices.dk/osparmime/help_methods_sediment_metals.html

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 Assessment protocol Table 1.

Assessment protocol Table 1. HELCOM COMBINE 'extraction table' relevant to the Metals core indicator. Overview table of the parameters, matrices, basis and supporting parameters selected for extraction from the COMBINE database to evaluate the core indicators

Parameters (PARAM) / Parameter groups (PARGROUP) (see also http://vocab.ices.dk/)	**Primary matrix**	**Species**	**Matrix**	**Basis**	**Supporting parameters and information**	**Secondary matrix**	**Species**	**Matrix**	**Basis**	**Supporting parameters and information**
PARAM = CD	Water		WT (filtered, unfiltered if the concentration is below the EQS)		Surface water layer (1-5.5 m)	Biota	Molluscs (Mytilus edulis, Macoma baltica)	SB	W	Dry weight
						Sediment			D	Al (aluminium)
PARAM = PB	Water		WT (filtered, unfiltered if the concentration is below the EQS)		Surface water layer (1-5.5 m)	Biota	herring, cod (open sea) flounder, sole, eelpout , perch (coastal)	LI	W	Dry weight
							Molluscs (Mytilus edulis, Macoma baltica)	SB	W	Dry weight
						Sediment			D	Al (aluminium
PARAM = HG	Biota	herring, cod (open sea) flounder, sole, eelpout , perch (coastal)	MU ('fillet')	W	Dry weight					
		Molluscs (Mytilus edulis, Macoma baltica)	SB	W	Dry weight					

WT – water; MU – muscle; SB – soft body; LI – liver; W – wet weight; D- dry weight

The assessment 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).

Assessment units

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.

Relevance of the Indicator

Hazardous substances assessment

The status of the Baltic Sea marine environment in terms of contamination by hazardous substances is assessed using several core indicators. Each indicator focuses on one important aspect of the complex issue. In addition to providing an indicator-based evaluation of the status of the Baltic Sea in terms of concentrations of metals in the marine environment, this indicator also contributes to the overall hazardous substances assessment along with the other hazardous substances core indicators.

Policy relevance

The core indicator on metal concentrations addresses the Baltic Sea Action Plan's (BSAP) hazardous substances segment's ecological objectives 'Concentrations of hazardous substances close to natural levels' and 'All fish safe to eat'. Mercury and cadmium are included in the HELCOM list of substances or substance groups of specific concern to the Baltic Sea.

The core indicator also addresses the following qualitative descriptors of the MSFD for determining good environmental status (European Commission 2008b):

- Descriptor 8: 'Concentrations of contaminants are at levels not giving rise to pollution effects' and
- Descriptor 9: 'Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards'

and the following criteria of the Commission Decision (European Commission 2017):

- D8C1 Within coastal, territorial and areas beyond territorial waters the concentration of contaminants do not exceed the threshold values
- D9C1 The level of contaminants in edible tissues of seafood caught or harvested in the wild does not exceed maximum levels which are the threshold values.

All the three metals are included in the EU WFD (Pb and Cd in water, Hg in biota) and EU Shellfish directive (in shellfish) (European Commission 2000, 2006b). Part of the EU food directives set limits in a range of fish species, shellfish and other seafood. In the OSPAR Coordinated Environmental Monitoring Programme (CEMP), metals are to be measured on a mandatory basis in fish, shellfish and sediment (OSPAR 2010).

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 2008a).

Role of metals in the ecosystem

Metals are naturally occurring substances that have been used by humans since the Iron Age. The metals cadmium (Cd), lead (Pb) and mercury (Hg) are the most toxic and they have no known essential biological function. Mercury and cadmium are furthermore biomagnifying, implying that the toxic effect may be enhanced through the food web. For mercury, the organic form methyl-mercury (MeHg) is more toxic than elemental mercury and further MeHg is bioaccumulated, i.e. activity transferred to lipid containing organs. Due to its high evaporation pressure, the net transport is from soils in the tropics up to Scandinavia to the Baltic Sea, and further north until concentrating in the Arctic due to the low temperatures and the resulting low evaporation - a process known as global distillation or the grasshopper effect.

Lead and mercury have been connected to impaired learning curves for children, even at small dosage. Lead can cause increased blood pressure and cardio-vascular problems in adults. Acute metal poisoning generally results in vomiting. Long term exposures of high levels of lead and mercury can affect the neurological system. Mercury can lead to birth defects as seen in Minamata bay among fishermen in a mercury polluted area, and also after ingestion of methylmercury treated corn in Iran. Cadmium is concentrated in the kidney, and can result in impaired kidney function, and cadmium can exchange for calcium in bones and produce bone fractures (Itai-Itai disease).

Human pressures linked 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		

The main source of all three metals is burning of fossil fuels. The atmospheric deposition to the Baltic Sea mainly originates from long range transport of the metals from outside the Baltic Sea catchment area (details available through the Baltic Sea Environment Fact Sheet [Atmospheric deposition of heavy metals on the Baltic Sea]). All three metals have been used for centuries, but in the last decades EU or world-wide legislation has been put in place banning most uses.

Current legal use of cadmium and lead includes rechargeable Ni-Cd batteries and for lead car batteries. For mercury current legal use includes low energy light sources. Sources of mercury include use in amalgams for dentistry (the loss from this use have been reduced by installing mercury traps in sinks and generally reducing the use of amalgams in dental works), as electrodes in paper bleaching, in thermometers and mercury switches and a range of other products that have been phased out. For lead, the main source was leaded fuels until their ban in Europe in the 1990s. Both cadmium and lead have pollution hotspots in connection with metal processing facilities, and cadmium coexists with all zinc ores, and is typically present at levels of 0.5–2% in the final products. Weathering of outdoor zinc-products thus leads to cadmium pollution.

Monitoring 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 cadmium, mercury and 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

Cadmium, mercury and 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 assessment. 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 cadmium, mercury and lead is relevant in the entire sea area.

Data and updating

Access and use

The data and resulting data products (tables, figures and maps) available on the indicator web pages can be used freely given that the source is cited. The indicator should be cited as following:

HELCOM (2017) Metals (lead, cadmium and mercury). HELCOM core indicator report. Online. [Date Viewed], [Web link].

ISSN 2343-2543

Metadata

Result: Heavy metals - Cadmium (Cd)

Data: Heavy metals - Cadmium (Cd) sediment data

Data: Heavy metals - Cadmium (Cd) water data

Data: Heavy metals - Cadmium (Cd) biota data

Result: Heavy metals – Lead (Pb)

Data: Heavy metals – Lead (Pb) sediment data

Data: Heavy metals – Lead (Pb) water data

Data: Heavy metals – Lead (Pb) biota data

Result: Heavy metals – Mercury

Data: Heavy metals – Mercury biota data

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

Contributors and references

Contributors

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Archive

This version of the HELCOM core indicator report was published in July 2017

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

Older versions of the core indicator report are available:

2013 Indicator report (pdf)

References

Bignert, A., Berger, U., Borg, H., Danielsson S., Eriksson, U., Faxneld, S., Haglund, P., Holm, K., Nyberg, E., Nylund, K. (2012) Comments Concerning the National Swedish Contaminant Monitoring Programme in Marine Biota. Report to the Swedish Environmental Protection Agency 2012. 228 pp.

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 (2006b) Directive 2006/113/EC of the European Parliament and of the Council of 12 December 2006 on the quality required of shellfish waters. Off. J. Eur. Union L 376.

European Commission (2008a) 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 (2008b) 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 (2010) Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (2010/477/EU). Off. J. Eur. Union L232: 12-24.

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.

Grasshoff, K., Kremling, K., Ehrhardt, M. (eds) (1999) Methods of Seawater Analysis, Weinheim. Wiley-VCH. 600 pp.

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.

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.

OSPAR (2008) Monitoring and Assessment Series Publication Number No. 379

OSPAR (2010) OSPAR Quality Status Report 2010. OSPAR Commission, London. 176 pp. Available at: http://qsr2010.ospar.org/en/downloads.html

Additional relevant publications

Bignert, A., Danielsson, S., Faxneld, S., Nyberg, E., Vasileiou, M., Fång, J., Dahlgren, H., Kylberg, E., Staveley Öhlund, J., Jones, D., Stenström, M., Berger, U., Alsberg, T., Kärsrud, A.-S., Sundbom, M., Holm,K., Eriksson, U., Egebäck, A.-L., Haglund, P., Kaj, L. (2015) Comments Concerning the National Swedish Contaminant Monitoring Programme in Marine Biota 2015, 2:2015. Swedish Museum of Natural History, Stockholm, Sweden.

Jensen, J.N. (2012) Temporal trends in contaminants in Herring in the Baltic Sea in the period 1980-2010. HELCOM Baltic Sea Environment Fact Sheet 2012.

OSPAR CEMP Assessment Manual. Co-ordinated Environmental Monitoring Programme Assessment Manual for contaminants in sediment and biota. OSPAR Commission, London. 39 pp.

OSPAR (2009) Draft Agreement on CEMP Assessment Criteria for the QSR 2010. Meeting of the Environmental Assessment and Monitoring Committee (ASMO), Bonn, Germany, 20 - 24 April 2009.

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