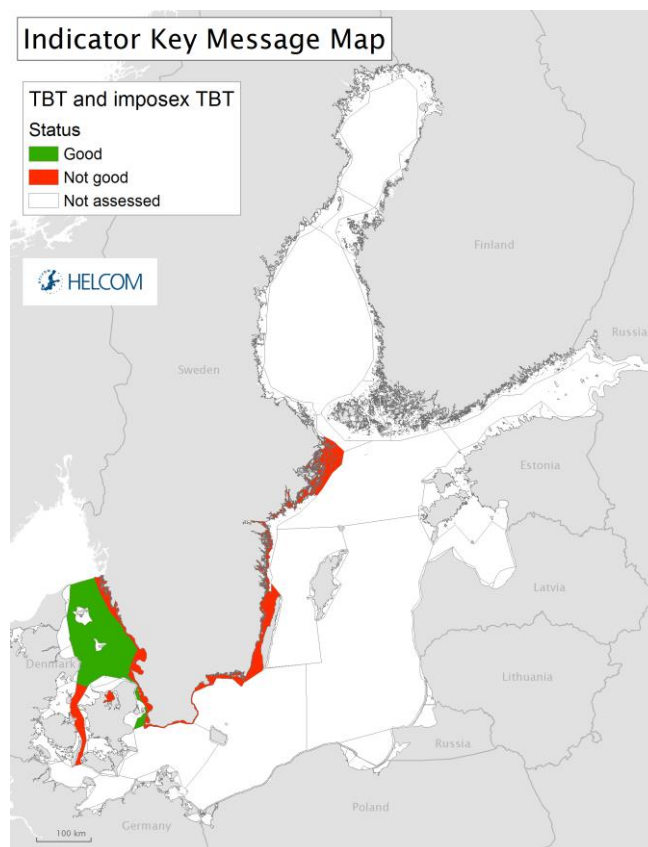


TBT and imposex

The threshold values for sediment and imposex used in this core indicator are not yet commonly agreed in HELCOM. The threshold values are included as test threshold values for the purposes of the mid-2017 'State of the Baltic Sea' report, and the results are to be considered as intermediate.

Key Message

This core indicator evaluates the status of the marine environment based on concentrations of the tributyltin (TBT) and its breakdown products dibutyltin (DBT) and monobutyltin (MBT) in the Baltic Sea; in water, biota (mussels, marine gastropods) and sediments. Imposex effects of TBT on marine gastropods are used as another source of data on TBT. Good status is achieved when the concentrations of TBT are below the threshold value. The indicator presents a status evaluation using all data available until 2015 to evaluate the assessment period 2011 - 2015.



Key message figure 1: Status assessment results based on evaluation of the TBT concentrations in sediment and biological effects in marine gastropods (VDS). The assessment is carried out using Scale 4 HELCOM assessment units (defined in the [HELCOM Monitoring and Assessment Strategy Annex 4](#)).

Data on TBT induced effects of imposex (as Vas deference Sequence index – VDSI) biological effects in marine gastropods are available from Denmark and Sweden (webtool: dome.ices.dk/HELCOMHZ2016/main.html). Data was extracted from the HELCOM COMBINE database for TBT in water and biota.

The confidence of the indicator evaluation is high in the Kattegat and Belt Sea/The sound area since the data on TBT concentrations and imposex bivalves, sediments and marine gastropods is spatially adequate and time series are available for several stations. In the rest of the Baltic Sea, confidence is low due to very limited data availability.

All significant trends is downwards, as would be expected as the main source of TBT is in antifouling paints which has been banned, but sediments are still a source for TBT in harbours and shipping lanes, which can be re-suspended during storms.

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

Relevance of the core indicator

Organotin, and in particular TBT, has been shown to be very toxic to marine life, resulting in changes in oyster shells and interfering with the marine gastropods female reproductive organ, causing sterility in some sensitive species. TBT is bioaccumulated by marine organisms causing harmful effects that mainly depend on the level of its final concentration in the tissues. Mussels are not able to degrade TBT by de-butylation, as fish and some marine gastropods are. Levels can be high in top-predators (Strand *et al*, 2005; Law *et al*, 2012). That is why the concentrations of TBT, especially those of importance to ecosystem or human health, have to be monitored. EQS values have been set for water AA-EQS at 0.2 ng/l and MAC-EQS at 1,5 ng/l, but the detection limit of analytical methods is up to 1 ng/l.

TBT and triphenyltin (TPT) were introduced in antifouling paints in the 1960s, but soon after, effects on growth and shell forming was found on French oyster grounds, and shortly after, also the effect on marine gastropods reproductive system was discovered. This led to a ban on use of these paints on pleasure boats, and eventually followed up by a total ban on TBT in antifouling paints (782/2003/EC (EC, 2003)) effective from 2008 (OSPAR, 2014).

Some concern over TBT in fish for human consumption exists, EFSA set a group TDI of 0.25 µg/kg for TBT, DBT, TPT and dioktyltn (DOT) (EFSA, 2004), noting that also pesticides, plastic additives and food contact substances can contain organotin, so an integrated risk assessment is needed to take into account all of these sources. Based on the fish intake and concentration levels in fish, it was not expected TDI in general to be exceeded, except perhaps for consumption of fish caught in harbour areas or other very polluted sites.

Policy relevance of the core indicator

	BSAP segment and objectives	MSFD Descriptor and criteria
Primary link	Hazardous substances <ul style="list-style-type: none"> • Concentration of hazardous substances close to natural levels • Healthy wildlife 	D8 Concentrations of contaminants D8C1 Within coastal and territorial and beyond territorial waters, the concentration of contaminants do not exceed the threshold values.
Secondary link	Hazardous substances <ul style="list-style-type: none"> • Fish safe to eat 	D9 Contaminants in fish and seafood D9C1 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 the threshold values
Other relevant legislation: For some Contracting Parties also Water Framework Directive Tributyltin is listed as no. 30 on the priority substances list in directive 2013/39/EU		

Cite this indicator

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ISSN: 2343-2543

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Results and Confidence

The data presented in the core indicator report were collected in the HELCOM COMBINE data base from the monitoring activities reported by all Baltic countries. Several countries experienced data reporting issues, and substantial improvements are expected when the report is updated to include 2016 data. The report presents information on the current levels of TBT concentrations in selected marine matrices: seawater, biota (mussels, marine gastropods) and sediments. Fish data have not been used, as currently no thresholds have been defined for TBT in this matrix.

Seawater

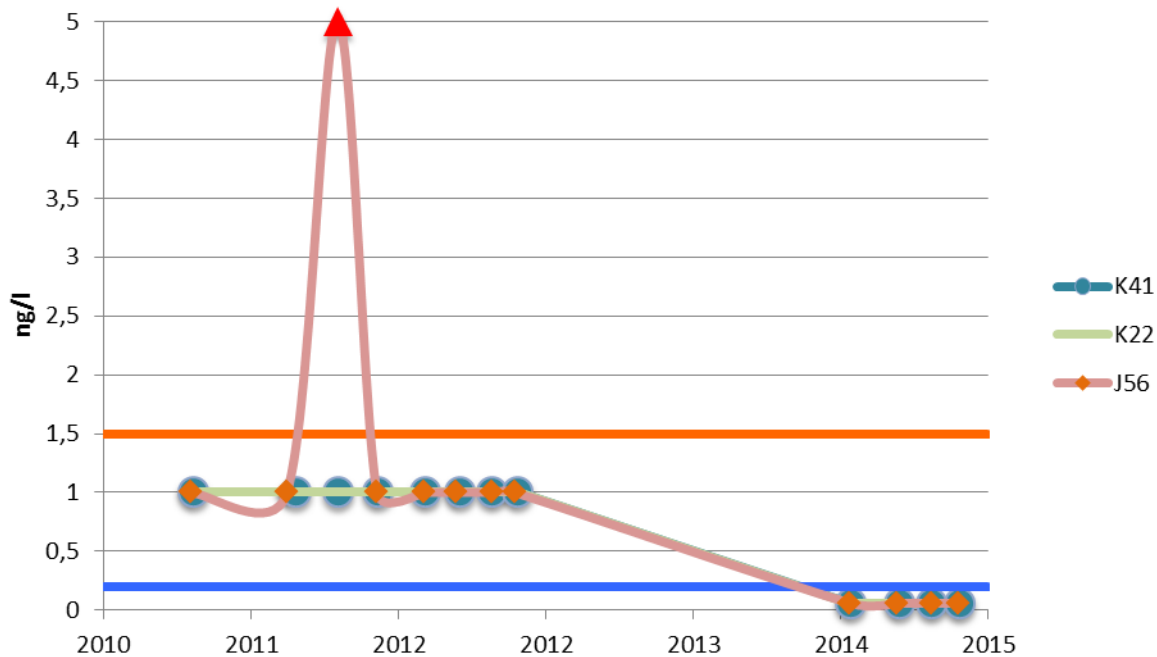
The agreed secondary threshold value for TBT in water is the EQS value (AA-EQS) of 0.2 ng/l. This is in conflict with the HELCOM COMBINE monitoring program, where the preferred matrix is biota and sediment. As a result, very little data is available for TBT in water.

TBT concentrations in the water phase have been measured by Poland (2011–2012) and Lithuania (2010–2015) (Results figure 1). Only 6% of these values were above the maximum annual Environmental Quality Standards (MAC-EQS) of 1.5 ng/l. Most samples was above the averaged annual concentration EQS (AA-EQS) of 0.2 ng/l, which was below the quantification limits in Lithuania until 2015, and the lowest value measured in Poland. The AA-EQS is considered to be high. For example compared to the OSPAR (Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic) Environmental Assessment Criteria (EACs) in seawater (0.01-0.1 ng/l). The 2004 revision of OSPAR EACs suggested using the AA-EQS as the lower and MAC-EQS as the upper EAC value. Hence, the AA-EQS is considered to be the relevant threshold value, not MAC-EQS that would normally be used for spot samples (Results figure1). With a quantification limit (QL) around 0.06-1 ng/l, even the newest, best method with QL at 0.06 ng/l is at 30% of the AA-EQS, which is the minimum performance criteria for methods of analysis used in the Water Framework directive set by the European Commission (2009). Unfortunately, the minimum requirement was only achieved in 2015 for Lithuanian samples where the newest analytical method was used.

The Lithuanian results show a slight tendency for decreasing concentrations from 2011 to 2012, but interpretation is difficult due to results being close to (and below) the quantification limits. In 2015, no samples were above the quantification limit.

Some Lithuanian stations have been monitored in the period 2010 to 2015 (Results figure 2), but most results were at the quantification limit, so no further interpretation of the results is possible.

Selected time trend stations



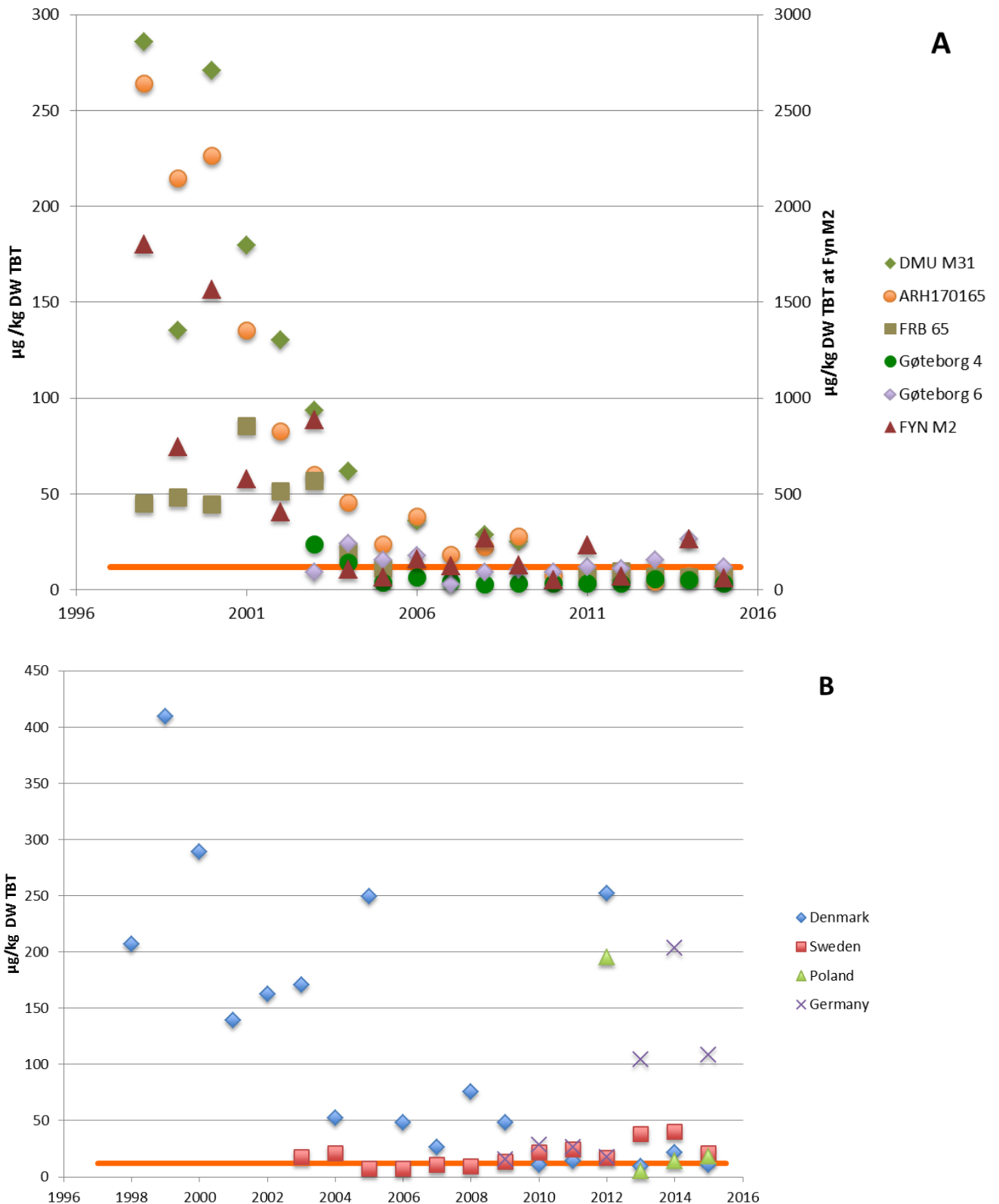
Results figure 2. Selected time trend stations from Lithuania. Notice that except for one data point (at 600 ng/l, above range), all results are at the quantification limit (1 ng/l), which was reduced for from 1 ng/l to 0.06 ng/l in 2015.

Mussel – intermediate results based on test threshold value

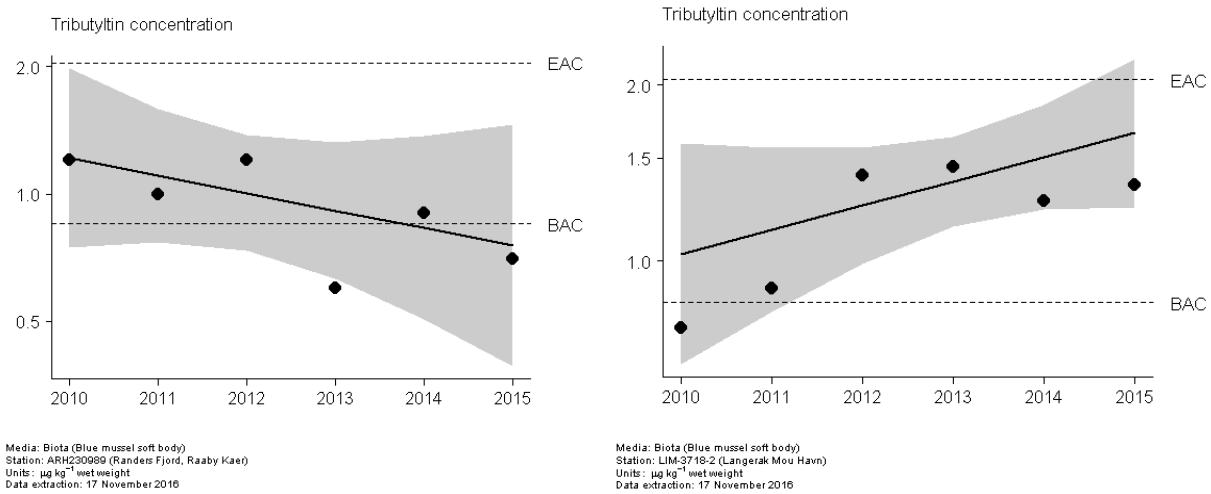
Soft body of mussel was indicated as a secondary matrix for TBT status assessment. Data was extracted from the HELCOM COMBINE database, however no assessment of results has been developed due to issues with data processing. There is no data in northern part of the Baltic Sea, while in the western part the net of sampling stations is very dense (Results figure 4).

For the stations in the HELCOM COMBINE database, the average of each of the four countries reporting (Denmark, Germany, Poland and Sweden) are shown in Results figure 3 (upper). The levels in Germany are influenced by some stations with very high concentrations in 2013-15, probably harbour areas. The Danish stations in the sound (DMU M31), Odense Fjord (FYN M2, 10x higher levels on 2. Axis scale), and Bay of Århus (close to harbour, ARH 170165) have a clear tendency of decreasing concentrations from 1998 to 2005, and then concentrations seems to level out at these stations.

Time trend analysis has been performed by OSPAR at some stations in the Kattegat area (according to the same principles as in the HELCOM assessment but with different threshold values) but no significant trends were detected (Result figure 4).



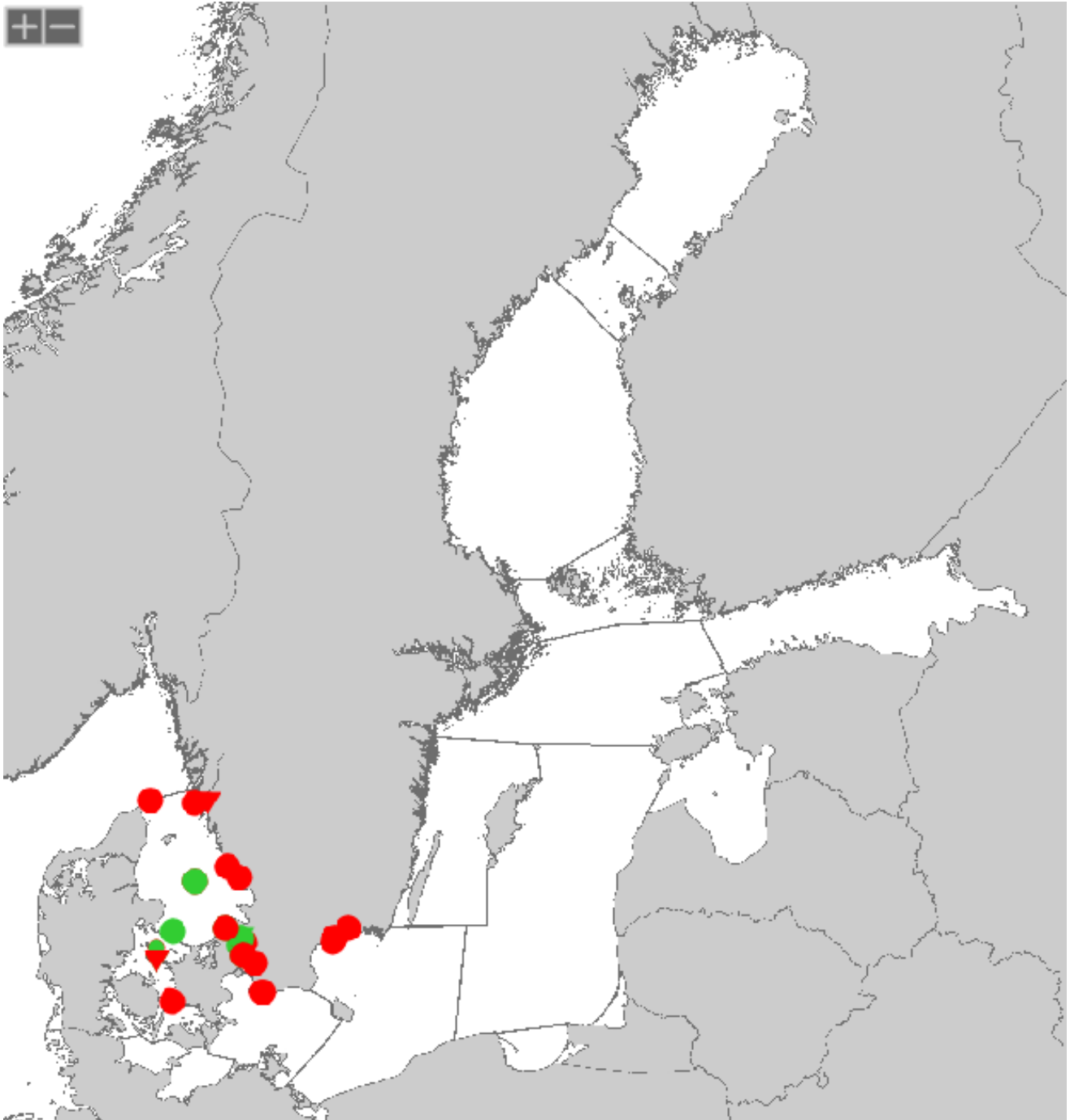
Results figure 3. Time trends for mussels in HELCOM stations. A – Selected stations from Denmark and Sweden with long time trends (Notice FYN M2 on right axis a factor of 10 higher than other stations). B – Average for all results of each country, indicating data availability and levels. Note that stations vary from year to year. Orange line marks the threshold value of 12 µg/kg DW.



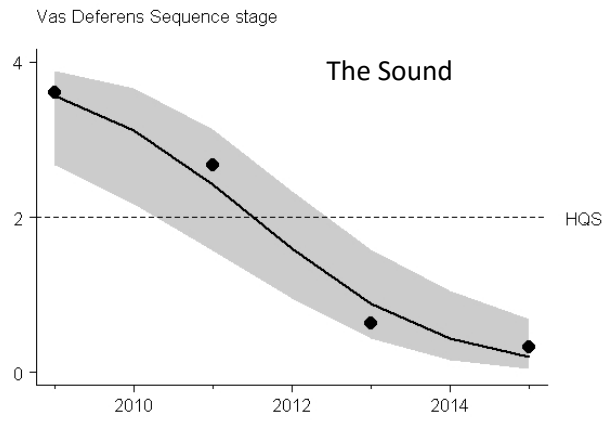
Results figure 4. Examples from OSPAR assessment in the Kattegat area, notice the limits are not the same as used in the HELCOM assessment, and the measurements are per wet weight. Neither of trends are significant. [source: <http://dome.ices.dk/OSPARMIME2016/main.html>]

Marine Gastropods – intermediate results based on test threshold value

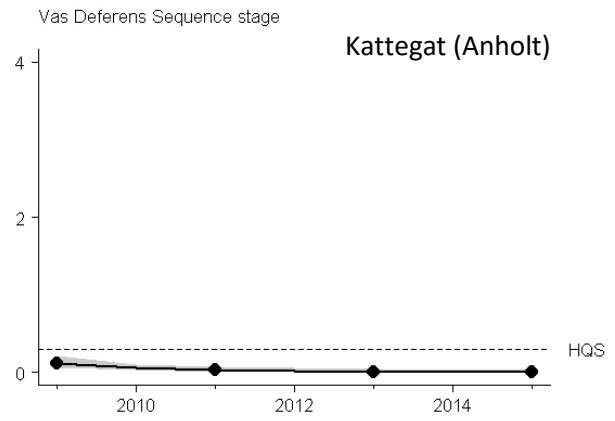
The biological effect on marine gastropods reproductive organs has been classified after the Vas deference Sequence index (VDSI), and due to the different sensitivity, good status is achieved at the threshold value of VDSI 2 for the sensitive species dog whelk (*Nucella lapillus*) and red whelk (*Neptunea antiqua*). Most other less sensitive species are set at good status for a threshold value of VDSI 0.3, with exception of the laver spire shell (*Peringa ulvea*) for which good status threshold value is set at only VDSI 0.1. The stations assessed are shown in Results figure 5. Examples of time trends are shown in Results figure 6.



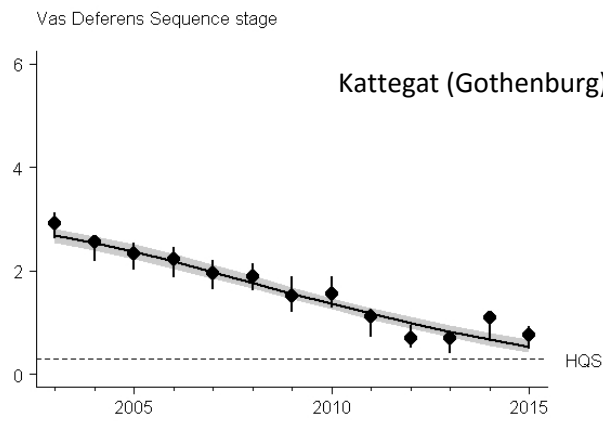
Results figure 5. Map presenting status based on imposex effect in marine gastropods (VDSI) at each sampling station. Green colour represents achieving the threshold value (good status) and red colour represents failing the threshold value (not good status). Filled large circles represent results based on five or more years, full evaluation (see Assessment protocol), small filled circles represent results based on three-four years and empty circles represent results based on <3 years, initial status assessment. Triangles indicating trends (downward) at Gothenburg and Great Belt. Results based on preliminary status assessment based on the Assessment protocol. [Source: <http://dome.ices.dk/HELCOMHZ2016/main.html>].



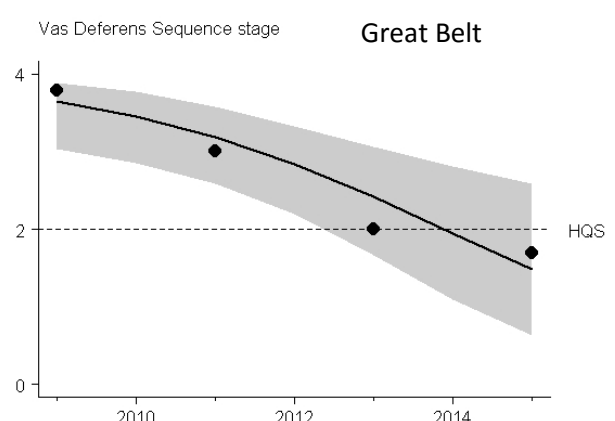
Media: Biota (Red whelk soft body)
 Station: DMU D13
 Units: stage
 Data extraction: 3 February 2017



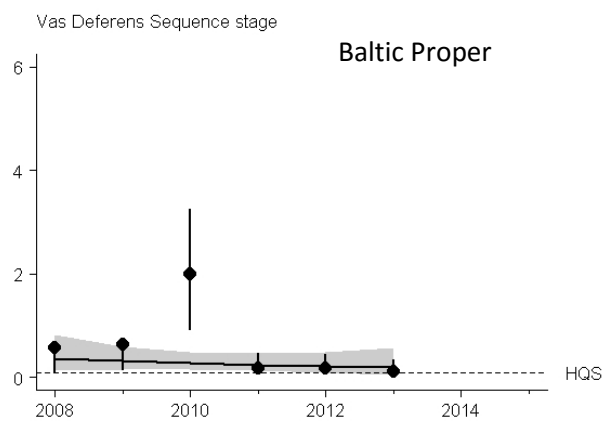
Media: Biota (Common whelk soft body)
 Station: DMU D9
 Units: stage
 Data extraction: 3 February 2017



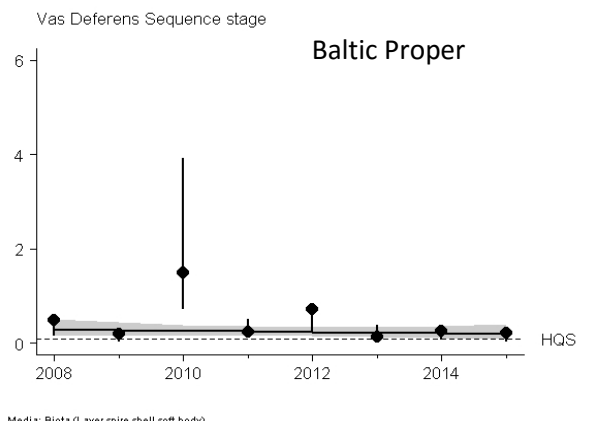
Media: Biota (Netted dog whelk soft body)
 Station: Göteborg 6
 Units: stage
 Data extraction: 3 February 2017



Media: Biota (Red whelk soft body)
 Station: DMU D4
 Units: stage
 Data extraction: 3 February 2017



Media: Biota (Laver spire shell soft body)
 Station: Ost om Öre
 Units: stage
 Data extraction: 3 February 2017

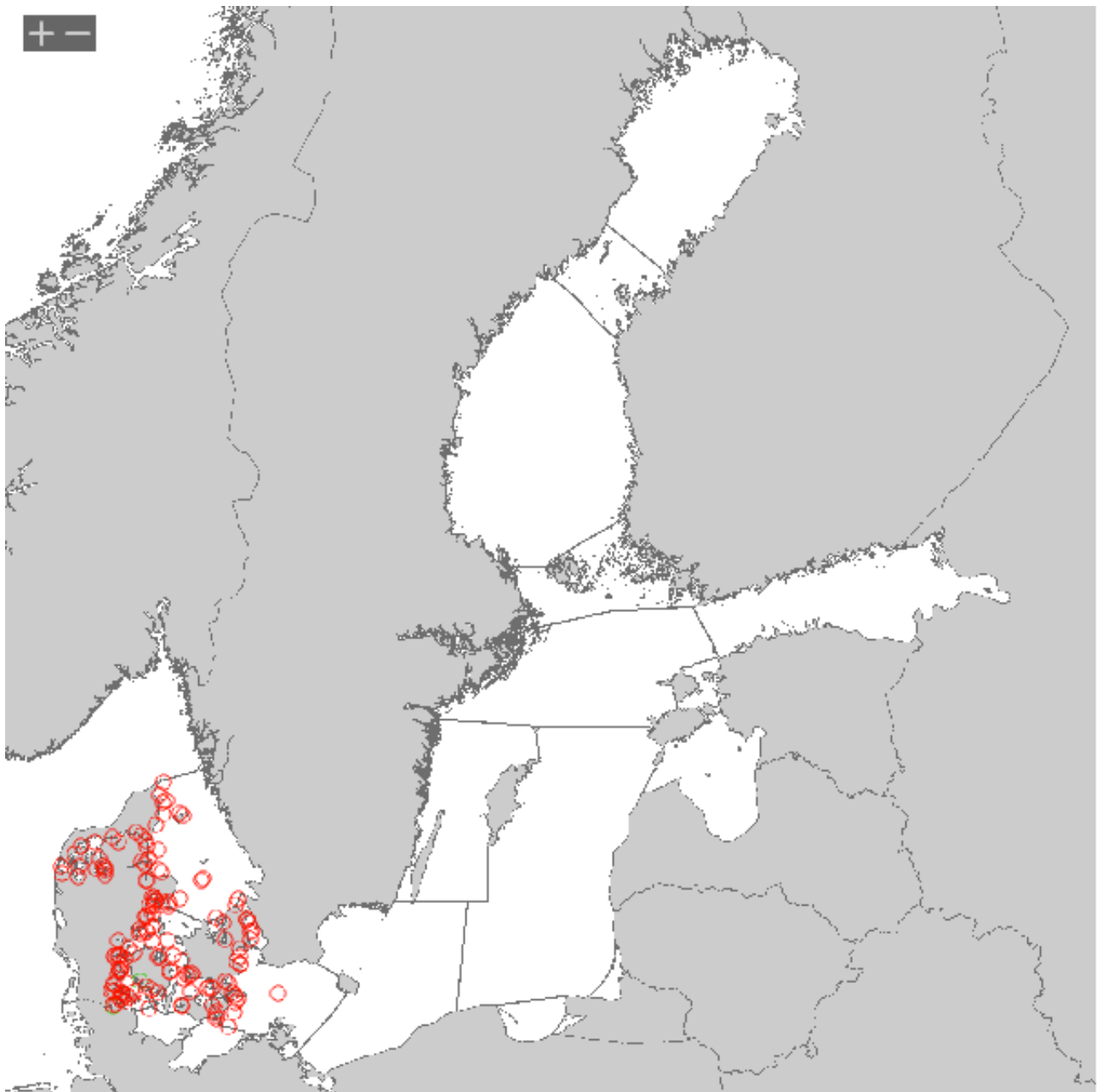


Media: Biota (Laver spire shell soft body)
 Station: Låkaö naturhamn
 Units: stage
 Data extraction: 3 February 2017

Results figure 6. Long-term trends of VDSI stage in gastropods at chosen stations (HQS – target level, grey colour-confidence level 95% range (see Assessment protocol)). Notice that for most stations in the Baltic Proper, the 2010

data are an outlier due to an error in the database and updated figures will be made when corrected. [Source: <http://dome.ices.dk/HELCOMHZ2016/main.html>]

The VDSI is measured at 41 stations, and at 7 of these, downward trends were observed. No upward trends were found. 10 stations achieve good status. The biological effects therefore support the observations of TBT in mussels and water, generally indicating a reduction in contamination levels. But even so, most stations are still not at good status. As most stations are time trend stations, the biological effects measurements generally have a high confidence rating.



Results figure 7. Map presenting status based on TBT in sediment at each sampling station. Green colour represents achieved threshold value (good status) and red colour represents failed threshold value (not good status). Filled large circles represent results based on five or more years, full evaluation (see Assessment protocol), small filled circles represent results based on three-four years and empty circles represent results based on <3 years, initial status assessment (see Assessment protocol). [Source: <http://dome.ices.dk/HELCOMHZ2016/main.html>].

Sediment – intermediate results based on test threshold value

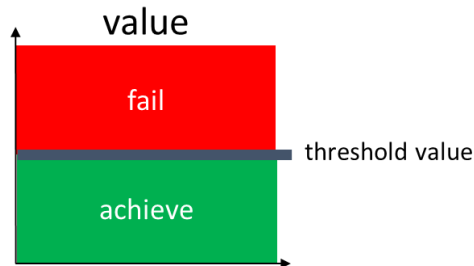
Only Danish results were available for the sediment assessment for the period 2011-2015 (Results figure 7), but no time trends are available, as sediments are not analyzed for time trends only up to 3 results per station were available. Hence, only an initial status assessment is available for sediments. Of the 138 stations investigated, only 2 from the Great Belt were found to be below the QS for sediment (1.6 µg/kg).

The average organic carbon content is around 2%, and less than 10% of the stations are above 5% organic carbon, which increases the concentrations.

TBT is only slowly debutylated to DBT, MBT and finally tin, especially in anoxic sediments, so the sediment concentration are expected to be above the QS many years ahead, but to eventually follow the decreasing pattern seen in imposex and biota. As the stations are only based on 1-3 data points, only a low confidence rating can be given to the data.

Good Environmental Status

Good Environmental Status is achieved if the concentrations of TBT are below the specified threshold values (Good Status figure 1).



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

The good status threshold for TBT 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 value is applicable 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 (sediment). However, if suitable monitoring data is not available in a region the secondary threshold value can be used for the evaluation of alternative matrixes (biota, water) (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 TBT and imposex (EQS – Environmental Quality Standard, AA- Annual Average Concentration, QS – Quality Standard, BAC = Background assessment criteria). Note that the threshold values for sediment (*), biota (*) and imposex (*) are not yet commonly agreed and included as test threshold value.

	Threshold values					
	Primary			Secondary		
	Matrix	Concentration	References	Matrix	Concentration	References
TBT	Sediment*	1.6 µg /kg dw sediment (5% TOC)	QSsediment ^[1]	Water	0.2 ng/l water	EQS water
				Mussel*	12 µg/kg dw mussel	EAC ^[2]
Imposex VDSI* (ISI for <i>Littorina littorea</i>)	Gastropods	<i>Peringia ulvae</i> : 0.1 <i>Nucella lapillus</i> : 2.0 <i>Neptunea antiqua</i> : 2.0 <i>Hinia reticulata</i> : 0.3 <i>Buccinum undatum</i> : 0.3 <i>Littorina littorea</i> : <0.3	Gercken & Sordyl 2009; Magnusson et al 2016; OSPAR (2010a) EcoQO			

[1] HELCOM 2016. Draft core indicator report on TBT and imposex. [2] OSPAR 2010b

Assessment Protocol

To evaluate contamination status of Baltic Sea, the ratio of concentration of TBT in the biotic and abiotic elements of marine environment to the specified concentration (threshold) levels are used. Data are extracted from the HELCOM COMBINE database as specified in the extraction table to ensure that the values are from the appropriate measurement matrices (Assessment protocol table 1).

All available data on TBT concentrations in seawater, molluscs and sediments from 2011 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. Also imposex in marine gastropods, as VDSI, was used.

Assessment protocol Table 1. 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 = TBTIN, TBSN+	SED			5% COR G	Surface water layer (1-5.5 m)	Biota	Molluscs (<i>Mytilus edulis</i> , <i>Macoma baltica</i>)	SB	D	Dry weight
						Water	filtered and Unfiltered	WT	W	
PARAM = VDSI, ISI	Biota	<i>Peringia ulvae</i> ; <i>Nucella lapillus</i> ; <i>Neptunea antiqua</i> ; <i>Hinia reticulata</i> ; <i>Buccinum undatum</i> ; <i>Littorina littorea</i>	Reproductive organs	W						

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

A two-way approach was used to determine the representative concentrations of the individual TBT and imposex 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 detail description of MIME Script method could be found:

for biota http://dome.ices.dk/osparmime/help_ac_biota_imposex.html

for sediment http://dome.ices.dk/osparmime/help_methods_sediment_organo-metals.html

Assessment units

The assessment of the present environmental status in respect of TBT content has been carried out in all assessment units at level 4.

The core indicator evaluates the status with regard to concentrations of TBT using HELCOM assessment unit scale 4 (division of the Baltic Sea into 17 sub-basins and further division into coastal and offshore areas). 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 TBT in the marine environment, this indicator along with the other hazardous substances core indicators contributes to the overall assessment of hazardous substances.

Policy relevance

The core indicator on TBT concentrations and imposex 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'. The natural level of TBT is zero. TBT is 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 2010):

- D8C1 (concentration of contaminants)
- D9C1 (levels, number and frequency of contaminants).

TBT and its compounds are included in the EU WFD (in water). 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), TBT and imposex are to be measured on a mandatory basis in sediment and marine gastropod (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 TBT in the ecosystem

Since 1960, the tri-substituted OTC (TBT and TPT) has been used extensively as biocide in antifouling paints for boats. It was very efficient and considered to have a low toxicity to mammals. The use has been restricted in many countries, starting in France 1982, because of the recognised adverse effects of these compounds on the aquatic ecosystem. The European Union, Regulation 782/2003/EC (EC, 2003c) requires TBT free anti-fouling systems to be used from 1 July 2003, and removal of TBT containing paints from 2008.

The uses of TBT and TPT, their persistence, their tendency to bioaccumulate through the food chain (in particular fish and seafood), their high toxicity to aquatic organisms even at levels below 1 ng/l in water, and their complex toxicity profile in experimental animals cause concerns about risks to humans and nonhuman organisms. Apart from the discovery that organotins were causing deformation and

reproductive failure for oysters in France in the 1970s, and at the same time discovery of the imposex effect of masculinisation of female gastropods was later followed by observation of masculinisation of fish (Shimasaki et al., 2003), suggesting that these compounds are strong endocrine disruptors (WHO-IPCS, 1999a,b).

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	

After the ban on TBT in antifouling paints, few uses of organotins as pesticides (mainly phenyltins) are still legal. The major source is now its release from impacted sediments in harbour areas and shipping routes (dredging) and illegal use of TBT-containing antifouling paints.

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](#)) and Biological effects of contaminants (imposex)** [still under development]

Quality assurance in the form of international workshops and proficiency testing has been organized annually by QUASIMEME starting from development exercises in 1998, 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 \[DK only listed in COMBINE program from 2015 in mussels\]](#)

Sub-programme: Contaminants in water

[Monitoring Concept Table](#)

Sub-programme: Contaminants in sediment

[Monitoring Concept Table](#)

Concentrations of TBT and imposex are monitored regularly in few countries, mainly in the more saline parts of the Baltic Sea. Monitoring is performed in sediment (Denmark only), mussels and fish liver (several contracting partners but no threshold for fish livers) and Water (Germany, Lithuania and Poland). Imposex is reported by Denmark and Sweden.

The number of sediment and biota monitoring stations per sub-basin is indicated in Monitoring Figure 1.

Description of optimal monitoring

TBT 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 mussels and marine gastropods. Current levels are close to detection limits in pristine areas away from ship routes and harbours with historic contaminations.

Sediment monitoring can complement the assessment. Sediment represents longer timespans than biota (typically years vs. months), and is 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.

Water monitoring is generally at levels close to or below the current quantification levels, and can only be recommended with quantification levels around 0.05 ng/l or preferably better.

Monitoring of TBT 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) TBT and imposex. HELCOM core indicator report. Online. [Date Viewed], [Web link].

ISSN: 2343-2543

Metadata

[Result: TBT and imposex](#)

[Data: TBT and imposex sediment data](#)

[Data: TBT and imposex 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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HELCOM Expert Network on Hazardous Substances

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 \(pdf\)](#)

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