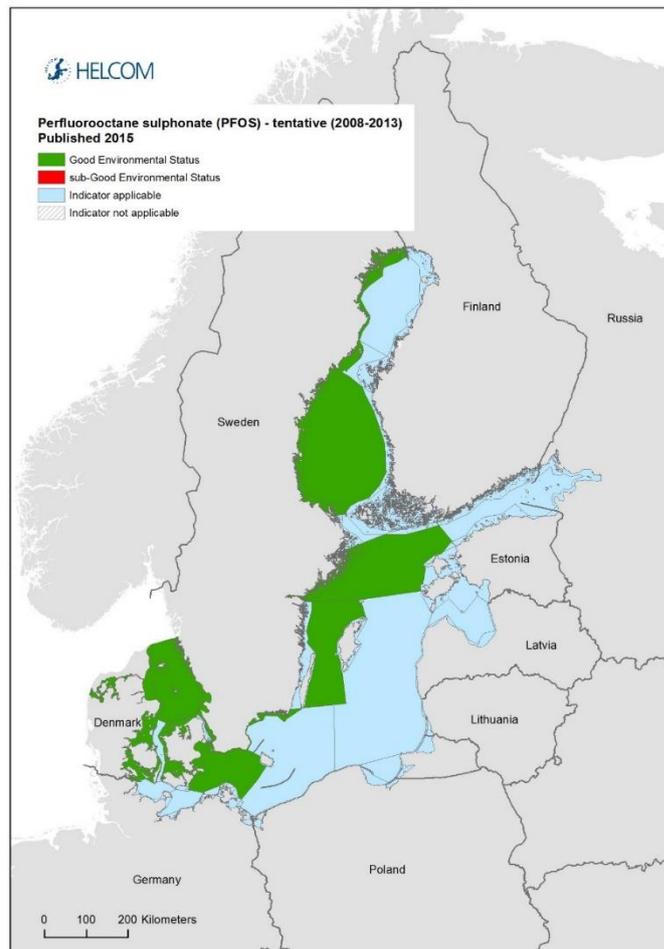


Perfluorooctane sulphonate (PFOS)

Key Message

This core indicator evaluates the status of the marine environment based on concentrations of perfluorooctane sulphonate (PFOS) in Baltic Sea fish. Good Environmental Status (GES) is achieved when the concentrations of PFOS are below the upper boundary defining GES. The current evaluation is based on data from the period 2008-2013.



Key message figure 1: Status assessment results based on evaluation of the indicator 'perfluorooctane sulphonate (PFOS)'. The assessment is carried out using Scale 3 HELCOM assessment units (defined in the [HELCOM Monitoring and Assessment Strategy Annex 4](#)).

GES is achieved for all monitored areas during the period 2008–2013. At present, data are only available from Sweden and Denmark, and there are areas where data are absent, therefore, extended monitoring is required to enable status evaluation throughout the Baltic Sea.

Time series of PFOS levels in biota show increasing concentrations since the 1970s and 1980s in Baltic Proper and Bothnian Sea. However, during the last 10 years, downward trends are seen in guillemot eggs from Baltic Proper and in herring from the West coast of Sweden.

Confidence of the indicator evaluation results is considered to be moderate for those areas for which data are available.

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

Relevance of the core indicator

PFOS is a persistent, bioaccumulative and toxic compound with possible effects on the immune, reproductive and developmental systems as well as lipid metabolism in organisms. It is considered a global environmental contaminant. PFOS has been produced since the 1950s, and has been used for production of fluoropolymers and used commercially to provide grease, oil and water resistance to materials such as textiles, carpets, paper and coatings in general. PFOS has also been used in firefighting foams.

The presence of PFOS in biological samples provides information on the contaminant load of the Baltic Sea and reflects the bioavailable part of the contaminant. (Top)predators and humans are exposed to the contaminant through consumption of the species assessed in this indicator.

Policy relevance of the core indicator

	BSAP segment and objectives	MSFD Descriptor and criteria
Primary link	Hazardous substances <ul style="list-style-type: none"> Radioactivity at pre-Chernobyl level 	D8 Concentrations of contaminants 8.1 Concentration of contaminants
Secondary link	Hazardous substances <ul style="list-style-type: none"> Fish safe to eat 	D9 Contaminants in fish and seafood 9.1 Levels, number and frequency of contaminants
Other relevant legislation: In some Contracting Parties also Water Framework Directive (identified as a priority substance)		

Cite this indicator

HELCOM (2016) Perfluorooctane sulphonate (PFOS). HELCOM Core Indicator Report. Online. [Date Viewed], [Web link].

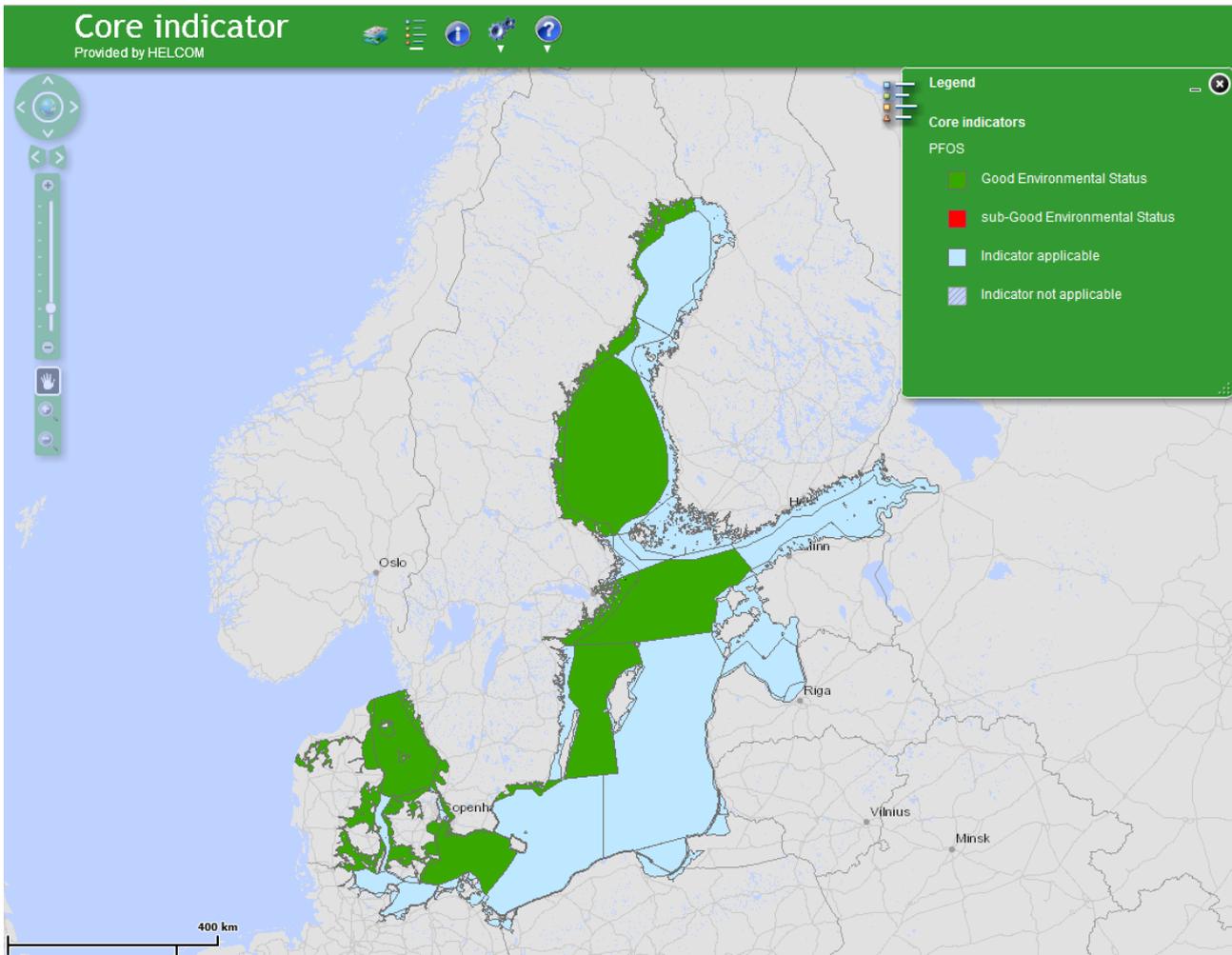
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Extended core indicator report – outcome of CORESET II project (pdf)

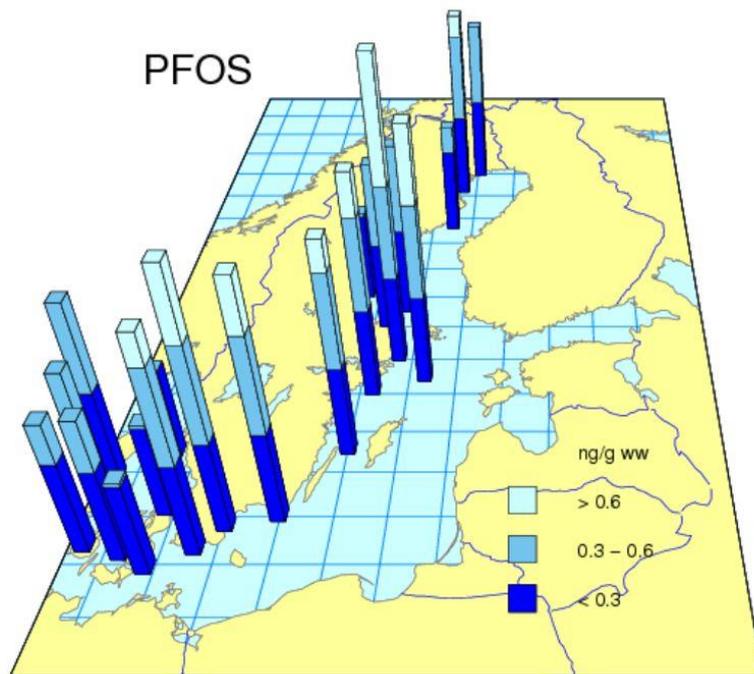
Results and Confidence

All evaluated assessment units achieved Good Environmental Status (GES) during the period 2008-2013 since the average concentration of PFOS in sampled fish was below the GES boundary (Results figure 1). The GES boundary is set to 9.1 µg/kg wet weight (or 9.1 ng/g ww) with the protection goal of human health.



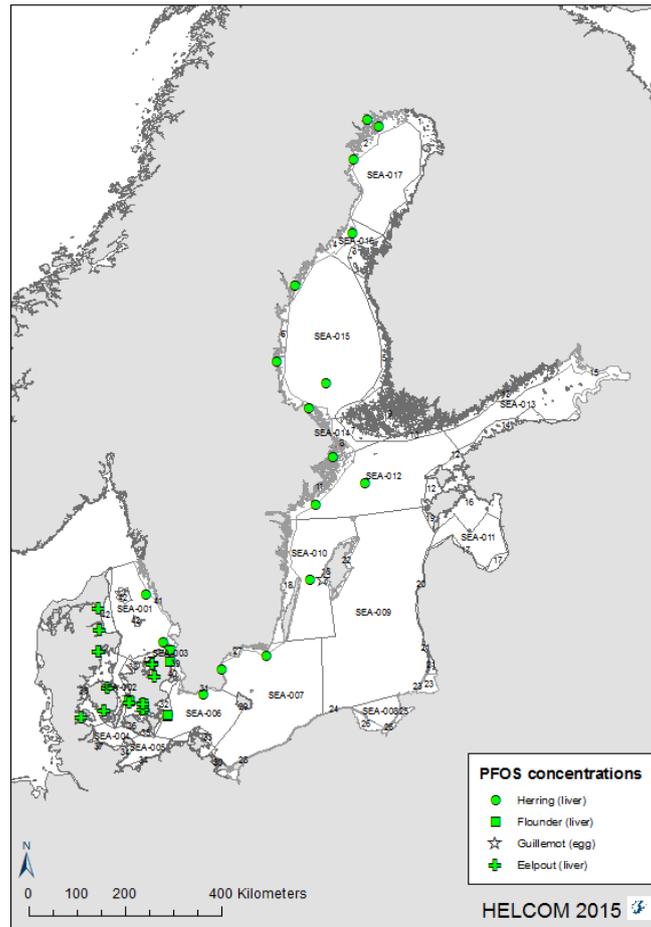
Results figure 1. The state evaluation indicates that GES is achieved for PFOS concentrations in all evaluated HELCOM assessment units.

Mean values for the monitoring stations ranges from 0.16 to 0.98 ng/g ww in fish muscle with the highest value observed in herring from Lagnö in Åland Sea (Results figure 2). The PFOS levels in fish seem to be quite homogeneous throughout the Baltic Sea with possibly somewhat lower concentrations in the westernmost parts of the HELCOM area.



Results figure 2. Spatial variation in mean concentration (2008–2013 in ng/g wet weight) of PFOS in fish muscle (values calculated from liver concentration according to Faxneld et al. 2014).

There are currently areas in the Baltic Sea that are not covered by any PFOS monitoring (Results figure 3). The eastern part of the Baltic Sea and the eastern coastline lack reported PFOS concentrations. Thus increased monitoring is needed to enable a status evaluation for the entire Baltic Sea.



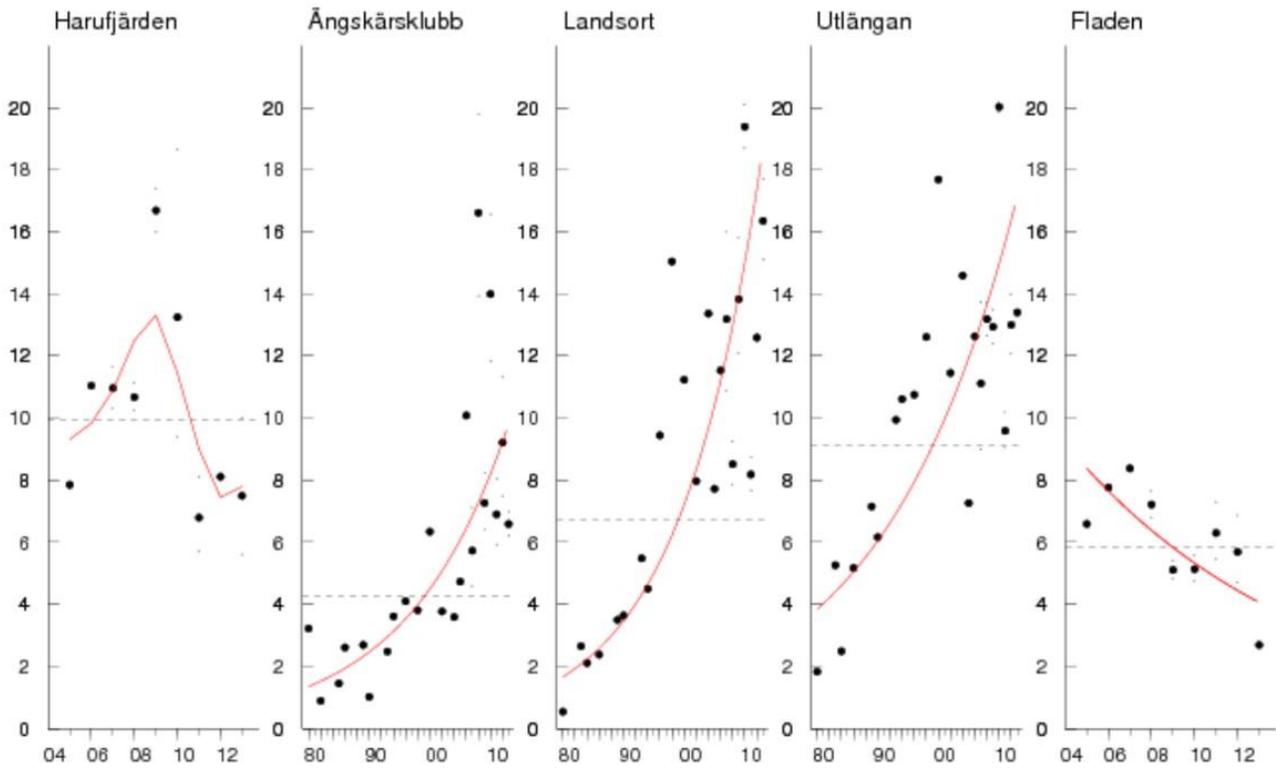
Results figure 3. Spatial distribution of PFOS monitoring stations detailing the matrix sampled. Green colour indicates that the measured concentrations are below the GES boundary.

It is important to be aware that the results used for this core indicator are mainly based on fish from stations considered as reference stations with no local pollution. There are most likely local areas within the Baltic Sea where the pollution load of PFOS is higher than presented in the evaluation outcome of this indicator.

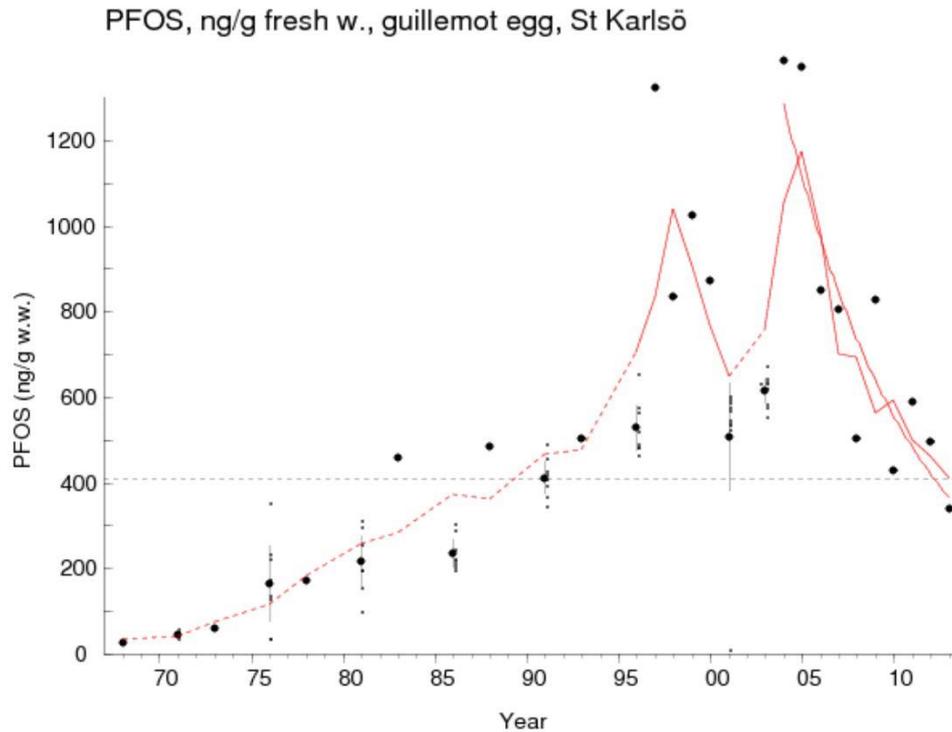
Evaluation of temporal trends

The biota trend monitoring stations show increasing PFOS concentrations from the 1970s and 1980s (Results figure 4 and Results figure 5). Guillemot eggs show an increase of more than 20 times from the start of the monitoring period until the 2000s when concentrations peaked. Also the long herring time series show an increase of PFOS concentrations of approximately ten times since the 1980s. During the most recent ten years, decreasing concentrations have been observed in guillemot eggs from the Western Gotland Basin and also in herring from the west coast of Sweden.

PFOS, ng/g wet w., herring liver



Results figure 4. Temporal trend of PFOS concentration (ng/g wet weight) in herring liver from Harufjärden (Bothnian Bay), Ångskärsklubb (Southern Bothnian Sea) and Landsort (Northern Baltic Proper), Utlängan (Bornholm Basin) and Fladen (Kattegat). A red linear line represents a significant log-linear trend while the red smoother-line represent a significant non-linear trend component. The dashed horizontal line represents the mean value for the whole monitoring period.



Results figure 5. Temporal trend of PFOS concentration (ng/g wet weight) in guillemot egg (1968-2013) from Stora Karlsö (Western Gotland Basin). The red linear line represents a significant log-linear trend of the ten last years. The red smoother-line represent a significant non-linear trend component. The dashed horizontal line represents the mean value for the whole monitoring period.

Confidence of the indicator status evaluation

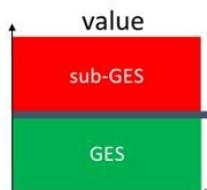
The geographical resolution for the coverage of the whole Baltic Sea is low. No detailed geographical studies to investigate the variability have yet been carried out. The conversion of PFOS concentrations in liver to muscle values introduce uncertainties into the status evaluation. In addition, the trophic level of the fish used for monitoring (predominantly herring, which has a trophic level of approximately 3 in the Baltic Sea) are lower than recommended for the GES boundary, thus leading to possible underestimations in relation to the GES boundary.

With the uncertainties and low geographical coverage taken into account, but with values considerably lower than the GES boundary, the confidence in the evaluation result of those areas reflecting GES is considered to be moderate.

Good Environmental Status

Good Environmental Status (GES) is achieved when the concentration of perflourooctane sulphonate (PFOS) in fish muscle is below 9.1 µg/ kg fish wet weight (Good environmental status figure 1).

The GES boundary is an environmental quality standard (EQS), derived at EU level as a substance included on the list of priority substances under the Water Framework Directive (European Commission 2000, 2013). GES, in accordance with the MSFD is defined as 'concentrations of contaminants at levels not giving rise to pollution effects'.



Good environmental status figure 1. GES is achieved if the concentration of PFOS is below the GES boundary of 9.1 µg/ kg fish wet weight. The boundary is an environmental quality standard (EQS) derived at EU level as a substance included on the list of priority substances under the Water Framework Directive.

EQS are derived from ecotoxicological studies to protect freshwater and marine ecosystems from potential adverse effects of chemicals, as well as adverse effects on human health via drinking water and food from aquatic environments. Quality Standards (QS) are derived for different protection goals, i.e.: pelagic and benthic communities, top-predators in these ecosystems, and human health. The most stringent of these QS is the basis for the EQS. The EQS boundary for PFOS is based on the QS set for biota to protect human health (9.1 µg/ kg fish ww), defined for edible parts in fish.

For harmonization purposes the EC Guidance Document No. 32 on biota monitoring (the implementation of EQS_{biota}) under the WFD was developed (European Commission 2014). This guidance document recommends that the results from the monitoring should be standardized to represent fish at a trophic level of 4, which is an estimate of the general trophic level in commercial fish in Europe. The recommendation to obtain PFOS data in fish at a trophic level of 4 is to adjust the values from monitoring in accordance with trophic magnification factors and trophic level.

An alternative, secondary GES boundary at 0.00047 µg/l is set for water. It is derived within the EQS process by using a bioconcentration factor and biomagnification factor for PFOS and represents the corresponding water concentration to the selected QS biota, secondary poisoning (PFOS EQS dossier, 2011). The secondary GES boundary should only be used when it is not possible to evaluate an area using the primary biota-based GES boundary.

Article 3 of the EU Directive on environmental quality standards (EQSD) states that also long-term temporal trends should be assessed for substances that accumulate in sediment and/or biota, such as PFOS (European Commission 2008a). A trend indicates if the status of the environment is improving and approaching GES or if the status is deteriorating.

Assessment Protocol

Data processing

The PFOS data requires some treatment before an evaluation against the GES boundary can be made.

If the data contains values below the quantification limit, then the value is to be replaced by half of the value of the limit for quantification.

Since the GES boundary is defined with the protection goal to prevent adverse effects on human health via consumption of fishery products, and human fish consumption is mainly focused on muscle fillet of fish, the status evaluation is calculated based on PFOS concentrations in fish muscle. The data may require transformation into the relevant unit and base for the GES boundary which is $\mu\text{g}/\text{kg}$ wet weight.

Ideally, the data should be expressed in the same matrix, which for the purposes of the indicator evaluation ought to be muscle fillet concentrations in fish, representing a trophic level of 4 (European Commission 2014). However, all of the PFOS data reported are analyzed in liver tissue in different fish species at varying trophic levels. The PFOS concentration values are originally measured in fish liver and then recalculated to concentrations in muscle.

In the present indicator report, conversion from PFOS concentrations in liver to PFOS concentrations in muscle was done by the use of conversion factors generated in a study, based on Swedish national monitoring, comparing muscle and liver concentrations (Faxneld et al. 2014). The conversion was performed with the use of the general conversion factors for 'all species' (liver:muscle ratio: 17.9).

Assessment protocol table 1. Mean liver:muscle ratios for PFOS with 95% confidence intervals within parentheses. The column indicated "all species" includes herring, perch (marine and limnic), eelpout, pike, arctic char and cod. Data taken from (Faxneld et al. 2014).

	All species	Herring	Perch	Eelpout
PFOS	17.9 (16, 20)	19.0 (17, 21)	18.2 (16, 20)	11.1 (6.0, 16)

The use of liver values would lead to an overestimation of PFOS concentrations in relation to the GES boundary since PFOS is reported by several studies to accumulate in protein rich tissue, with liver being one of the tissues where the highest concentrations are found (Goeritz et al. 2013; Shi et al. 2012). However, it is of great importance to be aware of the uncertainties introduced to the results in the conversion procedure.

Additionally, no correction for trophic level has been made. The monitored species are at a lower trophic level than the general trophic level estimated for commercial fish and suggested by the EC Guidance Document No. 32 (European Commission 2013), implying a risk of underestimation of the concentrations, since PFOS biomagnifies in the food web. The information on trophic level, are lacking for the reported results and a proper trophic magnification factor (TMF) has not been agreed upon yet. It is therefore presently not possible to translate the results to the recommended trophic level 4 for the status evaluation. The results should therefore be considered tentative at this time.

More studies on relations between liver, muscle and whole body concentrations of PFOS in relevant Baltic Sea fish species is needed in order to improve the comparisons to the GES boundary.

Statistical evaluation

Annual geometric mean concentrations for samples in an assessment unit are compared to the GES boundary. Compliance is checked by means of one-tailed one-sample t-tests. For an assessment unit, all annual mean values during the last six years are used in the t-test for compliance check. The minimum number of independent measurements to be able to conduct the one-sample t-test is three. The power of the test depends on the variance in the sample, the distance to the target value and the sample size. This test can also be applied on single stations for compliance check in relation to the GES boundary.

Trend detection

PFOS data is also evaluated with the purpose to detect possible long-term trends in contaminant concentration. The EU directive (2013/39/EU) states that 'member states shall arrange for the long-term trend analysis of concentrations of those priority substances listed in Part A of Annex I'.

If the data contains values below the quantification limit, then the value is to be replaced by half of the value of the limit for quantification. The trend detection is carried out in three steps;

1. Log-linear regression analyses,
2. Non-parametric trend test, and
3. Non-linear trend components.

1. Log-linear regression analyses

Log-linear regression analyses are performed for the entire investigated time period and also for the most recent 10 years for the longer time series. The slope of the line describes the yearly percentage change. A slope of 5% implies that the concentration is halved in 14 years, whereas a slope of 10% corresponds to a similar reduction in 7 years, and 2% in 35 years (Assessment protocol table 2).

Assessment protocol table 2. The approximate number of years required to double or half the initial concentration, assuming a continuous annual change of 1, 2, 3, 4, 5, 7, 10, 15 or 20% a year.

	1%	2%	3%	4%	5%	7%	10%	12%	15%	20%
Increase	70	35	24	18	14	10	7	6	5	4
Decrease	69	35	23	17	14	10	7	6	4	3

2. Non-parametric trend test

The regression analysis assumes, among other things, that the regression line gives a good description of the trend. The leverage effect of points at the end of the line is also a well-known fact. An exaggerated slope, caused 'by chance' by a single or a few points at the end of the line, increases the risk of a false significant result when no real trend exists. A non-parametric alternative to the regression analysis is the Mann-Kendall trend test (Gilbert 1987, Helsel and Hirsch 1992a, ICES 1995). This test generally has lower

power than the regression analysis, and does not take into account differences in magnitude of concentrations; it only counts the number of consecutive years where the concentration increases or decreases compared with the year before. If the regression analysis yields a significant result but the Mann-Kendall test does not, the explanation could be either that the latter test had lower power, or that the influence on the slope of end points in the time series has become unjustifiably high. If the tests give different results, the reason for this should be investigated. The Kendall's ' τ ' range from 0 to 1 like the traditional correlation coefficient ' r ', but will generally be lower. 'Strong' linear correlations of 0.9 or above correspond to τ -values of about 0.7 or above (Helsel and Hirsch, 1992b). This test was recommended by the US Environmental Protection Agency (EPA) for use in water quality monitoring programmes with annual samples, in an evaluation comparing several other trend tests (Loftis et al. 1989).

3. Non-linear trend components

In order to describe development over time, an alternative to the regression line is a type of smoothed line. The smoother applied here is a simple 3-point running mean smoother fitted to the annual geometric mean values. In cases where the regression line is a poor fit, the smoothed line may be more appropriate. The significance of this line is tested by means of an analysis of variance, where the variance is explained by the smoother line, and the regression line is compared with the total variance. This procedure has been used in assessments at ICES (The International Council for the Exploration of the Sea) and is described by Nicholson and co-workers (Nicholson et al. 1998).

Graphical presentation

Three dimensional maps

The height of the bars in the three dimensional maps presented in the [Results](#) section represents the arithmetic mean for the last six years, or less if results are not available. The bars are split into three sections to ease concentration comparisons.

Description of time-trend figures

The plot displays the geometric mean concentration of each year (circles) together with the individual analyses (small dots) and the 95% confidence intervals of the geometric means. The overall geometric mean value for the time series is depicted as a thin horizontal line.

The trend for the whole time period is presented by a regression line (plotted if $p < 0.10$, two-sided regression analysis); $p < 0.05$ is presented by a red line and $0.05 < p < 0.10$ is presented by a dashed blue line. The trend for the last ten years is plotted if $p < 0.2$ and $p < 0.05$ is presented by a red line and $0.05 < p < 0.2$ is presented by a dashed light blue line. Ten years is often a too short period to statistically detect a trend unless it is of considerable magnitude. Nevertheless, the ten year regression line will indicate a possible change in the direction of a trend. Furthermore, the residual variance around the line compared to the residual variance for the entire period will indicate if the sensitivity has increased as a result of e.g. an improved sampling technique or the disappearance of problems in the chemical analysis.

A smoother is applied to test for non-linear trend components. The smoothed line is plotted if $p < 0.05$. A broken line segment indicates a gap in the time series with a missing year.

The log-linear regression lines fitted through the geometric mean concentrations follow smooth exponential functions.

Assessment units

PFOS is considered as a global environmental chemical, widely spread in biological samples and even present in samples from as remote places such as the Arctic region. The PFOS core indicator is therefore relevant for the whole Baltic Sea and can theoretically be applied in all regions.

The core indicator evaluates the status with regard to concentration of PFOS using HELCOM assessment unit scale 3 (division of the Baltic Sea into 17 sub-basins and further division into coastal and offshore areas). This division is applied in order to take into account the different routes by which PFOS enters the Baltic Sea - via air and via run-off from land, including also potential point sources.

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 perfluorooctane sulphonate (PFOS) in the marine environment, this indicator will also contribute to the next overall hazardous substances assessment to be completed in 2018 along with the other hazardous substances core indicators.

Policy relevance

The core indicator on PFOS 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'.

The core indicator is relevant to the following specific BSAP commitment:

- 'Agree to start by 2008 to work for strict restrictions on the use in the whole Baltic Sea catchment area of the Contracting States.'

PFOS is included in the HELCOM list of substances or substance groups of specific concern to the Baltic Sea which was adopted as part of the BSAP.

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):

- Criterion 8.1 (concentration of contaminants)
- Criterion 9.1 (levels, number and frequency of contaminants)

PFOS is included on the revised list of the EU Priority Substances (European Commission 2013) and in the Stockholm Convention list of persistent organic pollutants (POPs), Annex B, which requires the parties to the convention to restrict the production and use of the substance.

The production and use of perfluorooctane sulfonate (PFOS) has been regulated in some countries (e.g., US, Canada, and the EU), but large-scale PFOS production continues in other parts of the world, e.g. China. PFOS has been produced and used since the 1950s, but due to findings of detectable concentrations in human blood in the general population and negative health effects on living organisms, PFOS was phased out in 2002 by its main producer 3M.

Role of PFOS in the ecosystem

Perfluorooctane sulphonate (PFOS), perfluoro octanoic acid (PFOA) and other perfluorinated compounds are considered global environmental contaminants. PFOS and PFOA are chemically and biologically inert and very stable (Poulsen et al. 2005). PFOS meets the P (Persistent) and vP (very Persistent) criteria due to slow degradation. PFOS is also bioaccumulative (B) and toxic (T) (OSPAR 2005). PFOA is considered as very persistent (vP) and toxic (T), but not bioaccumulative (Van der Putte et al. 2010). It has a capacity to undergo long-range transportation.

PFOS related substances and PFOA are members of the larger family of perfluoroalkylated substances (PFAS). Perfluorooctanyl sulfonate compounds are all derivatives of PFOS and can degrade to PFOS, also called as PFOS-related compounds. Some 100–200 PFOS-related compounds have been identified (KEMI 2006). PFOS binds to blood proteins and bioaccumulates in the liver, egg yolks, serum, and gall bladder unlike most persistent organic pollutant compounds that typically accumulate into fat (Renner 2001; Nordén et al. 2013; Goeritz et al. 2013; Shi et al. 2012).

PFOS has been shown to disturb the immune system, development and reproduction (endocrine disruption) of organisms and influence lipid metabolism. It is also suspected to induce liver necrosis. Falandysz et al. (2006) have suggested that the consumption of contaminated fish from the Baltic Sea contributes significantly to human blood levels of perfluoroalkyl compounds.

Marine mammals have considerably higher contamination levels of PFOS compared to marine and freshwater fish, and were found to be the most contaminated by PFOS of all Nordic biota studied (HELCOM 2010). Several hundreds to one thousand $\mu\text{g kg}^{-1}$ ww of PFOS have been found in the livers of grey seals (in the southern Baltic Proper and Bothnian Sea; Nordic Council of Ministers 2004), harbour seals (Great Belt and the Sound; Nordic Council of Ministers 2004) as well as ringed seals (Bothnian Bay; Kannan et al. 2002). In the eggs of common guillemots (Western Gotland Basin), PFOS concentrations were greater than 1,000 $\mu\text{g kg}^{-1}$ ww (Holmström et al. 2005). An OSPAR risk assessment (OSPAR 2005) on the marine environment concluded that the major area of concern for PFOS is the secondary poisoning of top predators, such as seals and predatory birds.

The evaluations in this core indicator are made based on concentrations mainly sampled in fish, usually from reference areas with no specific local pollution load. The case studies and measurements from marine mammals in the Baltic Sea, highlight that PFOS may pose more severe contamination risks to the Baltic Sea than the current indicator evaluation would suggest.

Only a few measurements of PFAS in Baltic Sea surface water exist (Nordic Council of Ministers 2004; Theobald et al. 2007; Lilja et al. 2009) and they were mostly performed in potentially affected coastal areas. PFOA and PFOS dominated the water samples. Concentrations of PFOA were determined in the range 0.57–0.68 ng l^{-1} (Little Belt, Kiel Bight, Mecklenburg Bight, Arkona Basin) up to 4–7 ng l^{-1} (Little Belt, the Sound, coast of Poland, Gulf of Finland). PFOS was found at levels of 0.34–0.90 ng l^{-1} for all locations mentioned, with the exception of single measurements of 2.9 ng l^{-1} (coast of Poland) and 22 ng l^{-1} close to Helsinki (Gulf of Finland). Farther away from the coast, in the Arkona Basin, PFOA and PFOS levels were 0.35–0.40 ng l^{-1} .

Limited data exist for PFAS concentrations in Baltic Sea sediments (Nordic Council of Ministers 2004; SEPA 2006; NERI 2007; Theobald et al. 2007). PFOS and/or PFOA were occasionally detected, but consistently at levels below 1 µg kg⁻¹ dw or ww. The highest levels reported so far have been from the Gulf of Finland close to Helsinki (PFOS 0.9 µg kg⁻¹ ww), close to Stockholm (PFOS 0.6 µg kg⁻¹ ww) and along the coast of Poland (PFOS and PFOA both around 0.6 µg kg⁻¹ dw). Along the German Baltic Sea coast, concentrations of PFOS in sediments were in the order of 0.02-0.67 µg kg⁻¹ dw and those of PFOA 0.09-0.68 µg kg⁻¹ dw (Theobald et al. 2007).

The most important route of PFOS for humans is uptake from food (especially fish), drinking water and exposure to indoor dust (FOI 2013).

Human pressures linked to the indicator

General		MSFD Annex III, Table 2
Strong link	Use of synthetic compounds to increase grease, oil and water resistance of materials Use of firefighting foams	Contamination by hazardous substances <ul style="list-style-type: none"> introduction of synthetic compounds
Weak link		

PFOS is both intentionally produced as well as an unintended transformation product of related anthropogenic chemicals. PFOS is still produced in several countries, such as China. Some PFAS have been manufactured for more than five decades. They are applied in industrial processes (e.g., production of fluoropolymers) and in commercial products such as water- and stain-proofing agents and fire-fighting foams, electric and electronic parts, photo imaging, hydraulic fluids and textiles (Paul et al. 2009).

The American company 3M, was the main producer of PFOS and its related substances until 2002. They started the production of perfluorochemicals already in 1949. The production of PFOS increased between 1966 and 1990 and peaked between 1990 and 2000. In 2003, China started a large scale production of PFOS. Between 2003 and 2008 China was both the main global producer and user of PFOS substances. However, also Japan and Germany produced PFOS during the same time period, but after 2007 no PFOS production occurs in Germany (Carloni 2009).

The major transport ways of PFOS to the Baltic Sea has been shown to be rivers (77%) but also atmospheric deposition (20%). Waste water treatment plants on the other hand were shown to have a negligible contribution (less than 2%) (Filipovic et al. 2013). The sources of PFOS to the atmosphere are still not clear, but a major contributor is believed to be transformation of precursor compounds (FOSA (Perfluorooctane sulfonamide) and FOSE (Perfluorooctane sulfonamidoethanol)) that have been emitted from production facilities and fluorochemical products (Armitage et al. 2009). Seventy-eight percent of the total PFOS in the Baltic Sea was estimated to be stored in the water column (Filipovic et al. 2013).

PFAS can be introduced into the environment both from point sources (e.g. landfills, manufacturing plants, application of firefighting foam containing PFOS) and non-point sources such as atmospheric deposition and degradation of precursors (Ahrens & Bundschuh 2014). High amounts of PFOS has been found in both sludge and groundwater close to military air base sites and airports where firefighting foam has been used to prevent fires (FOI 2013; Arias et al. 2015). Furthermore high levels of PFAS, including PFOS, has been found close to industries producing fluortelomers (Wang et al. 2014; Shan et al. 2014).

Monitoring Requirements

Monitoring methodology

Environmental monitoring of perfluorooctane sulphonate (PFOS) in biota is currently not coordinated in the HELCOM community, but general information about monitoring in the region is documented in the HELCOM Monitoring Manual under the [sub-programme: Contaminants in biota](#).

So far, there are no technical guidelines related to PFOS monitoring in biota in the HELCOM Monitoring Manual and there is a need to develop such common monitoring guidelines.

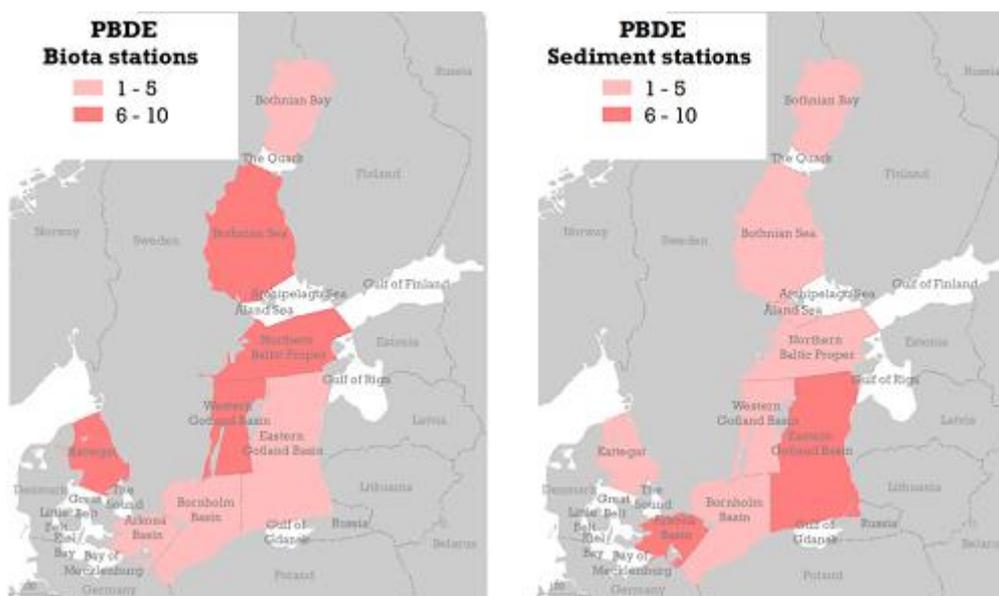
Current monitoring

The monitoring activities relevant to the indicator that are currently carried out by HELCOM Contracting Parties are described in the HELCOM Monitoring Manual in the relevant [Monitoring Concept Table](#).

Sub-programme: Contaminants in biota

[Monitoring Concept Table](#)

The number of PFOS monitoring stations per sub-basin are indicated in Monitoring figure 1. Sweden and Denmark monitor PFOS concentrations in their national monitoring programmes. During the period 2014-2019, Poland will include PFOS analysis in fish muscle to their national monitoring. Germany monitors PFOS in biota on a project basis. Finland (fish) and Lithuania (sediment) are planning to include PFOS in their national monitoring programmes. The substance is not included in the monitoring programmes in Latvia. No information is available from Estonia or Russia. A few measurements in water and fish (flounder and herring) were taken from Estonia, Latvia, Lithuania and Poland during the HELCOM SCREEN project (2009). Finland has screening data from several fish species along the coast line.



Monitoring figure 1. Number of biota monitoring stations per-sub-basin.

Description of optimal monitoring

The core indicator for PFOS requires better geographical coverage in national monitoring programmes and time series data to enable evaluation of temporal trends. In addition, common HELCOM sampling guidelines would enhance the comparability of results.

The performance of existing monitoring should be evaluated in relation to the monitoring objectives, but first there is a need to quantify these objectives. These quantitative objectives need to be specified for each kind of monitoring, e.g. temporal trend-, incident-, geographical (spatial)- and compliance monitoring. For example, for temporal trend monitoring: what statistical power is required, during what time period should a certain trend be possible to detect and with what specified power (with certain one- or two-tailed statistical tests at a specified significant level)? With these definitions at hand it is possible to estimate e.g. required sample sizes and sampling frequencies. It can be shown that for a monitoring period of 12 years or shorter, generally the power to detect trends will decrease substantially if the sampling is carried out every second or every third year compared to annual sampling. For geographical studies the required spatial resolution should be determined. For compliance monitoring, it is imperative to know the distance to target levels (and variance) before sample sizes are estimated.

Time series of PFOS concentrations in fish are missing or too short to enable evaluation for several sub-basins in the Baltic Sea region. The geographical resolution is generally too poor to make reliable generalized maps from interpolation of the existing stations using Kriging. No serious attempts to study patterns of variation in fish (coastal- offshore) through variograms have been made that could give guidance to the uncertainty and to the distance between sites required to achieve required confidence in generalized maps.

Studies on relations between liver and whole body concentrations of PFOS in fish are needed in order to make more relevant comparisons to the GES boundary.

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 (2016) Perfluorooctane sulphonate (PFOS). HELCOM core indicator report. Online. [Date Viewed], [Web link].

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Metadata

The data used in the assessment is based upon a data request from the International Council for the Exploration of the Seas (ICES). The data request concerns all reported PFOS posts in biota, sediment and water from the HELCOM region that are included in the ICES database (database for contaminants and biological effects dataset for HELCOM, OSPAR and AMAP) as well as data included in the database held by European Environmental Information and Observation Network (EIONET). Only results measured in biota from Sweden and Denmark were delivered and no data were reported from EIONET database.

Contributors and references

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Archive

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Core indicator report – web-based version February 2016 (pdf)

Extended core indicator report – outcome of CORESET II project (pdf)

Older versions of the core indicator are available:

2013 Indicator report (pdf)

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