

[Home](#) / [Action areas](#) / [Monitoring and assessment](#) / [Monitoring Manual](#) / [Phytoplankton](#) / [Pigments](#)

Monitoring programme: Eutrophication, Biodiversity - Water column habitats

Programme topic: Phytoplankton

SUB-PROGRAMME: PIGMENTS

TABLE OF CONTENTS

[Regional coordination](#)

[Purpose of monitoring](#)

[Monitoring concepts](#)

[Assessment requirements](#)

[Data providers and access](#)

[References](#)

REGIONAL COORDINATION

The monitoring of this sub-programme is: **fully coordinated**.

- [Common monitoring guidelines](#).
- Common quality assurance programme: [HELCOM COMBINE manual](#).
- Common database: ICES.

PURPOSE OF MONITORING (Q4K)

Follow up of progress towards:

Baltic Sea Action Plan (BSAP)	Segments	Eutrophication
	Ecological objectives	Natural level of algal blooms
Marine strategy framework directive (MSFD)	Descriptors	D5 Eutrophication
	Criteria (Q5a)	5.2 Direct effects of nutrient enrichment
	Features (Q5c)	Biological features: A description of the biological communities associated with the predominant seabed and water column habitats.
Other relevant legislation (Q8a)	Water Framework Directive	

Assessment of: ([Q4k](#))

State/Impacts	X	temporal trends, spatial distribution status classification
Pressures		
Human activities causing the pressures		
Effectiveness of measures		

Scale of data aggregation for assessments: ([Q10a](#))

HELCOM assessment unit Level 1: Baltic Sea	
HELCOM assessment unit Level 2: Subbasin	
HELCOM assessment unit Level 3: Subbasins with coastal and offshore division	
HELCOM assessment unit Level 4: Subbasins with coastal WFD division	X

MONITORING CONCEPTS TABLE

Coordination	Elements <u>Q9a (Q5c)</u>	Parameter <u>Q9a (Q5c)</u>	Method <u>Q9c, Q9d</u>	QA/QC <u>Q9e, 9f</u>	Frequency <u>Q9h, 9i</u>	Spatial resolution <u>Q9g, 9i</u>	Link to HELCOM core indicators	Link to MSFD GES characteristics <u>Q5b</u>	Spatial scope <u>Q4i</u>	Monitoring started <u>Q4h</u>	CPS monitoring
Regional (COMBINE)	Phytoplankton	Concentration of chlorophyll- a	Fixed stations, in situ (HELCOM COMBINE manual, <u>Part C, Annex C4</u>)	National, ICESData TypeGuide and <u>HELCOM COMBINE manual</u>	<u>See map for details</u>	<u>See map for details</u>	Chlorophyll- a (summer)	5.2.1 Chlorophyll concentration in the water column	EEZ	1979	All HELCOM Contracting Parties
National	Phytoplankton	Concentration of chlorophyll- a	Ship-of- opportunity, flow-through	National	Continually	20% (transect)	Chlorophyll- a (summer)	5.2.1 Chlorophyll concentration in the water column	EEZ	1999	EE, FI, SE
National	Phytoplankton	Concentration of chlorophyll- a	Earth Observation, (MODIS,VIIRS)	Other	Continually	100% (1km or 300m resolution grid)	Chlorophyll- a (summer)	5.2.1 Chlorophyll concentration in the water column	EEZ	2003	FI
National	Phytoplankton	Concentration of chlorophyll- a	Ship-of- opportunity, laboratory analysis, (HELCOM COMBINE manual, <u>Part C, Annex C4</u>)	National	Weekly	20%	Chlorophyll- a (summer)	5.2.1 (Chlorophyll concentration in the water column)	EEZ	1999	EE, FI, SE
National	Phytoplankton	Concentration of phycocyanin	~30 fixed stations	National	Yearly	Offshore. <u>See map for details</u>	-	-	EEZ	2005	FI
National	Phytoplankton	Concentration of phycocyanin (SoO)	Ship of opportunity: flow through	National	Biweekly	20% (transects)	-	-	EEZ	2005	FI
National	Phytoplankton	Concentration of phycocyanin	Earth Observation, (MODIS,VIIRS)	National	Daily	100%	-	-	EEZ	2014	FI

National	Phytoplankton	Surface concentrations	Earth Observation (MODIS)	Other	Continually	100% (1 km or 300 m resolution grid)	Summer	5.2.1 (Chlorophyll concentration in the water column)	EEZ	2002	SE
----------	---------------	------------------------	---------------------------	-------	-------------	--------------------------------------	--------	---	-----	------	----

Brief description of monitoring

Full description in [HELCOM COMBINE manual](#). Detailed information on monitoring frequency and spatial resolution has not yet been collected from all countries but will be added.

Element / parameter	In situ phytoplankton / Concentration of chlorophyll-a
Method	<p>Water samples from the water column, chlorophyll a extracted and analysed in laboratory (applies also to monitoring of concentration of phycocyanin in offshore waters).</p> <p>Platform: boat</p> <p>Mode of sampling: fixed station (COMBINE Stations, see map for details).</p> <p>The standard sampling depths are in the upper water column the same as for nutrients: 1 m, 5 m, 10 m, 15 m and 20 m. In COMBINE, the sample from 1 m or an integrated sample (1-10 m) could be analysed. Additional sample(s) should be obtained from chlorophyll maxima present at other depths. At least two samples should be collected.</p> <p>Samples are collected using a rosette sampler which is combined with a CTD system or a cast of reversing water samplers (e.g., Niskin or Nansen bottles) equipped with reversing thermometers.</p> <p>For further details, see: (Part C Annex C4 Chapter 13 in the HELCOM COMBINE manual).</p>

QA/QC

The quality system is formalized in the quality guidance ([Part B Annex B2](#) in the [HELCOM COMBINE manual](#)). Guidance on the interpretation of ISO/IEC/EN 17025 'General'.

Requirements for the Competence of Testing and Calibration of Laboratories' (formerly EN 45001 and ISO Guide 25) was given by a joint international EURACHEM/WELAC Working Group (EURACHEM/WELAC, 1992). Specific guidance to Analytical Quality Control for Water Analysis was elaborated by European - CEN/TC 230 (EN 14996) - as well as by international - ISO/TC 147 SC 7 (ISO/TR 13530) - standardization authorities.

The analytical requirements are specified, including definition of the type and nature of the sample and its environment, concentration range of interest and permissible tolerances in analytical error ([Part B Annex B3](#) in the [HELCOM COMBINE manual](#)).

It has been established, by laboratory studies, that the performance characteristics (selectivity, sensitivity, range, limit of detection and accuracy) of the method meet the specifications related to the intended use of the analytical results ([Part B Annex B4](#) in the [HELCOM COMBINE manual](#)).

According to international standard, e.g. ISO 17025, a defined analytical quality has been achieved, maintained, and proven by documentation. The establishment of a system of control charts is a basic principle applied in this context. For further information for control charts refer to ISO/TR 13530 (1997). ([Part B Annex B5](#) in the [HELCOM COMBINE manual](#)) The comparability of the data has been ensured through an external quality assessment, such as participation in external quality schemes, ring text and/ or use of external experts ([Part B Annex B6](#) in the [HELCOM COMBINE manual](#)).

Frequency

High frequency cruise station sampling should be done >12 times per year during the growing season (basically monthly sampling but weekly in the growing season).

In Poland 1 monitoring station is monitored 12 times per year.

Spatial Scope

Chlorophyll-a is monitored in the whole Baltic including coastal, transitional water and EEZ.

Phycocyanin measured only in offshore areas.

Spatial resolution

Samples are taken on COMBINE stations (listed in [Part C Annex C1](#) of the [HELCOM COMBINE manual](#)).

Element / parameter

SoO flow-through chlorophyll-a / Concentration of chlorophyll-a

Method	<p>Measured in the water column with flow-through fluorometer, 5 m depth to represent mixed layer (applies also to phycocyanin).</p> <p>Platform: In Finland Finnmaid (commercial ship on regular route Helsinki-Travemünde).</p> <p>Mode of sampling: Sampling is done en route, at constant intervals.</p> <p>Measured at approximately 5 m depth, and represents the mixed surface layer. Flow-through fluoromete.</p> <p>Validation from chlorophyll-a fluorescence, phycocyanine-fluorescence and turbidity with weekly in situ measurements, of water samples with chlorophyll-a extracted and analysed in laboratory, measurements, using multiple linear regression.</p>
QA/QC	<p>Fluorometers are calibrated annually in laboratory against standards.</p> <p>In Finland the analysis procedure is audited annually by FINAS laboratory accreditation. Accreditation measures performance characteristics (selectivity, sensitivity, range, limit of detection and accuracy) of the method to the intended use of the analytical results and comparability of data has been ensured through an external quality assessment.</p>
Frequency	<p>Sampling is done between March – December, during the ice-free season. Observations are made according to the ship's schedule, with appr. 1-3 day intervals between ship passing a point along it's route.</p>
Spatial Scope	<p>Chlorophyll-a is monitored in the whole Baltic including coastal, transitional water and EEZ.</p>
Spatial resolution	<p>The spatial resolution of the observations is 200 m along a transect.</p>
Element / parameter	Earth Observation (EO) chlorophyll-a / Concentration of chlorophyll-a
Method	<p>Remote sensing observations derived from satellite imagery (applies also to phycocyanin).</p> <p>Platform: satellite (current instruments/satellites: MODIS/Aqua and VIIRS/Suomi-NPP, during 2003-2011: MERIS/Envisat)</p> <p>Mode of sampling: images are observed daily, timing depends on the overpasses of the satellites.</p> <p>Measurements cover non-cloudy areas with 2000-3000 km wide swath.</p> <p>Current instruments observe images with pixel size (ground resolution) of ~1 km size (historical years 2003-2011: ~300 m pixel size).</p>

The sampling represents the mixed surface layer. The observed depth depends on the transparency of the water.

Satellite instrument sensors detect reflected signal at several visible and near infrared wavelengths forming an image that covers a 2000-3000 km wide region at one overpass. The ground resolution of the observations depends on the instrument, varying between 300m and 1 km.

These observations are transformed to radiances from which Chlorophyll-a is determined using an instrument dependent model. The observations are received from roll-on archives (dependent on the instrument mission) and processed automatically following the procedure: calibration to radiance units, atmospheric correction, cloud detection, rectification. Either a bio-optical or band ratio model is used to derive Chlorophyll-a concentrations [$\mu\text{g/l}$] from the pre-processed data. For MODIS and VIIRS, an instrument default chl-a determination (OC3, O'Reilly et al., 2000) is utilized with adjusted parameterization for the Baltic Sea. For the Baltic Sea, MUMM atmospheric correction method (Ruddick et al., 2000) is used instead of standard Gordon and Wang, 1994. References: Gordon, H.R., and Wang, M. (1994). Retrieval of water-leaving radiance and aerosol optical thickness over the oceans with SeaWiFS: a preliminary algorithm. *Appl. Opt.*, 33, 443-452. O'Reilly, J.E., et al. (2000). In S.B. Hooker, and E.R. Firestone (Eds.), *Ocean Chlorophyll-a*.

Algorithms for SeaWiFS, OC2 and OC4: version 4. SeaWiFS Postlaunch Calibration and Validation Analyses, Part 3. NASA Tech. Memo.2000206892, Vol. 11, 9-23. NASA Goddard Space Flight Center, Greenbelt, Maryland. Ruddick, K.G., Ovidio, F., and Rijkeboer, M. (2000). Atmospheric correction of SeaWiFS imagery for turbid coastal and inland waters. *Appl. Opt.*, 39, 897-912.

Method of validation carried out by SYKE/Finland, based on the work in EUTRO-OPER (all CP's have been invited to join if they wish): Satellite instrument determinations of chl-a are annually compared against match-ups of in situ measurements and Alg@line (water samples and flow-through measurements). Currently, ICES and Finnish national monitoring programme in situ chlorophyll-a are used as reference in situ.

Chl-a algorithm applied on the comparisons is a neural network based bio-optical model that takes into account the humic substances in calculations. The bio-optical module of FUB processor is mainly based on data typical to the European coastal waters. The original training ranges of water constituents in FUB are: 0.05 - 50.0 $\mu\text{g/l}$ (Chl-a), 0.05 - 50.0 mg/l-1 (TSM) and 0.005 - 1.0 m-1 (aCDOM (443 nm)), but it has been found to perform well on circumstances with higher concentrations than the original training ranges. This applies specially for a CDOM that accounts for humic substances in the water. The accuracy of chl-a interpretation has been examined on different parts of the Baltic Sea (comparisons against available monitoring station, Alg@line and ICES data).

QA/QC	<p>Quality system: The processing steps and the quality of service chain have been described in Marcoast GMES service network Service Provider Validation report (Deliverable N° C6).</p> <p>Comparability: The data is compared annually against in situ and Alg@line-measurements. The quality assessments are reported in ongoing validation deliverables of EU/ESA projects related to operational satellite service chains (at European level). Recent quality assessments have been made in Marcoast II and CoBiOS validation deliverables. Marcoast II project validation and service quality assessment is done under MarCoast Validation Bureau that controls the validation activities within the service chain. MarCoast II ended during 2013.</p>
--------------	---

Frequency	<p>Period of monitoring: from beginning of April to end of October.</p> <p>Data is collected daily. Cloud coverage causes gaps in data collection.</p>
------------------	--

Spatial Scope	Chlorophyll-a is monitored in the whole Baltic including coastal and transitional waters and EEZ.
----------------------	---

Spatial resolution	<p>Spatial resolution depends on the instrument. Currently used MODIS and VIIRS detect with 1km and 750m ground resolution (pixel size), respectively. The image area covers Baltic Sea completely during one day, excluding the cloudy areas. All HELCOM assessment units are covered.</p>
---------------------------	---

Element / parameter	SoO in situ chlorophyll-a / Concentration of chlorophyll-a
Method	<p>Measured in the water column, bottle samples taken from ship of opportunity lines.</p> <p>Platform: boat (ship-of-opportunity)</p> <p>Mode of sampling: Sampling is done en route, at fixed longitudes.</p> <p>Sampling is done at appr. 5 m depth, and represents the mixed surface layer. At least two samples should be taken.</p> <p>Water is continuously pumped through a system, taking water samples according to programming (Ferrybox sampling programme). The samples are stored in a dark refrigerator for max. 2 days.</p> <p>For further details of sample analysis, see: (Part C Annex C4 Chapter 13 in the HELCOM COMBINE manual).</p>

QA/QC

The quality system is formalized in the quality guidance ([Part B Annex B2](#) in the COMBINE manual). Guidance on the interpretation of ISO/IEC/EN 17025 'General Requirements for the Competence of Testing and Calibration of Laboratories' (formerly EN 45001 and ISO Guide 25) was given by a joint international EURACHEM/WELAC Working Group (EURACHEM/WELAC, 1992). Specific guidance to Analytical Quality Control for Water Analysis was elaborated by European - CEN/TC 230 (EN 14996) - as well as by international - ISO/TC 147 SC 7 (ISO/TR 13530) - standardisation authorities.

The analytical requirements are specified, including definition of the type and nature of the sample and its environment, concentration range of interest and permissible tolerances in analytical error ([Part B Annex B3](#) in the [HELCOM COMBINE manual](#)).

It has been established, by laboratory studies, that the performance characteristics (selectivity, sensitivity, range, limit of detection and accuracy) of the method meet the specifications related to the intended use of the analytical results ([Part B Annex B4](#) in the [HELCOM COMBINE manual](#)).

According to an international standard, e.g. ISO 17025, a defined analytical quality has been achieved, maintained, and proven by documentation. The establishment of a system of control charts is a basic principle applied in this context. For further information for control charts refer to ISO/TR 13530 (1997). ([Part B Annex B5](#) in the [HELCOM COMBINE manual](#)).

The comparability of the data has been ensured through an external quality assessment, such as participation in external quality schemes, ring text and/ or use of external experts ([Part B Annex B6](#) in the [HELCOM COMBINE manual](#)).

Frequency

Sampling is done between March–December, during the ice-free season. Samples are taken weekly / biweekly / monthly.

Spatial Scope

Chlorophyll a is monitored in the whole Baltic including coastal, transitional water and EEZ.

Spatial resolution

-

ASSESSMENT REQUIREMENTS**Monitoring requirements and gaps**

Monitoring is to be carried out to fulfill assessment requirements of HELCOM ecological objectives that are specified through HELCOM core indicators. The requirements on monitoring can include number of stations, the sampling frequency and replication.

Monitoring requirements

At least 15 observations during the period June-September should be made yearly in each assessment unit is required. The compilation of observations is expected to be distributed spatially within the assessment unit in a non-biased way.

Gaps

Existing coordinated monitoring does not provide sufficient temporal coverage to achieve high confidence in the core indicator status estimate ([BSEP 143](#)). Including Earth Observation and/or Ferrybox monitoring offers means to fill this gap.

Adequacy for assessment of GES ([Q5d](#))

Monitoring should provide adequate data and information to enable the periodic assessment of environmental status, and distance from and progress towards GES as required by MSFD under Article 9 and 11.

Adequate data?

Yes

Established methods for assessment?

Yes

Adequate understanding of GES?

Yes

Adequate capacity to perform assessments?

Yes

Assessment of natural variability ([Q5e](#))

Quantitative.

DATA PROVIDERS AND ACCESS

Data access point	HELCOM, ICES database, Algalbase, SYKE (Earth Observation-data)
Data type (Q10c)	Processed datasets Data products
Data availability (Q10c)	Data in national data centre: to be specified for Ferrybox-data Data in international data centre: <u>ICES database</u> . To be specified for Ferrybox-data.
Data access (Q10c)	Open access to data (covered by ICES data policy)
INSPIRE standard (Q10c)	
When will data become available? (Q10c)	In situ fixed stations: The data currently available is from 2011/2012 and before, the 2013 data will be reported in May 2014 and become available by November 2014.
Data update frequency (Q10c)	Yearly
Describe how the data and information from the programme will be made accessible to the EC/EEA	Through HELCOM web portal/via ICES
Contact points in the Contracting parties	Contact point to national monitoring programmes will be added
Data is used in the following Baltic Sea Environment Fact Sheets (BSEF)	Chlorophyll-a concentrations, temporal variations and regional differences from satellite remote sensing
Has the data been used in HELCOM assessments?	Yes, e.g. <u>BSEP143</u> Eutrophication status of the Baltic Sea 2007-2011 - A concise thematic assessment

REFERENCES

Edler, L., 1979. Recommendations for marine biological studies in the Baltic Sea: Phytoplankton and chlorophyll. Working Group 9, The Baltic Marine Biologists, publication No. 5, 38 pp.

- Grasshoff, K. 1975. The hydrochemistry of landlocked basins and fjords. In *Chemical Oceanography*, 2nd edition, part 2. Ed. by J.P. Riley and G. Skirrow. Academic Press, London.
- Grasshoff, K. 1976. *Methods of seawater analysis*. Verlag Chemie, Weinheim, New York.
- Grasshoff, K., Ehrhardt, M., and Kremling, K. (Eds.) 1983. *Methods of sea water analysis*. Verlag Chemie, Weinheim.
- HELCOM, 1988. *Guidelines for the Baltic Monitoring Programme for the Third Stage. Part D. Biological Determinands*.
- Jeffrey, S.W., Mantoura, R.F.C., Wright, S.W., 1997. *Phytoplankton pigments in oceanography: guidelines to modern methods*. UNESCO Publishing, Paris, 661 pp.
- Kirkwood, D. 1994. Nutrients: Practical notes on their determination in seawater. In *ICES/HELCOM Workshop on Quality Assurance of Chemical Analytical Procedures for the Baltic Monitoring Programme*. Ed. by G. Topping and U. Harms. *Baltic Sea Environment Proceedings No. 58*: 23-47.
- Koroleff, F. 1983. Determination of phosphorus. In *Methods of sea water analysis*. pp. 125-139. Ed. by K. Grasshoff, M. Ehrhardt, and K. Kremling. Verlag Chemie, Weinheim.
- Lindahl, O., 1986. A dividable hose for phytoplankton sampling. In *Report of the ICES Working Group on Exceptional Algal Blooms, Hirtshals, Denmark, 17-19 March, 1986*. ICES, C.M. 1986/L:26.
- Strickland, J.D.H. and Parsons, T.R., 1968. *A practical handbook of seawater analysis*. Fish. Res. Board of Canada, Bulletin 169, Ottawa.
- UNESCO, 1994. *Protocols for the Joint Global Ocean Flux Study (JGOFS). Core Measurements*. IOC Manuals and Guides 29: 179 pp.

IMAGE RIGHTS