Guidelines for monitoring of water transparency (Secchi depth)

1. Background

1.1 Introduction

Water transparency serves as an index for the trophic state of a water body. It reflects eutrophication through changes in the phytoplankton abundance; increase in the ambient nutrient status in the water leads to higher phytoplankton biomass that diminishes the propagation of light in the water.

Water transparency is approached by Secchi depth (Cialdi and Secchi 1865, Whipple 1899). Secchi depth is influenced by dissolved and/or colloidal inorganic and organic substances as well as total suspended solids and resident seston. It is thus affected by substances unrelated to eutrophication as well. This source of error has to be taken into consideration whenever eutrophication state is assessed using Secchi depth in the Baltic Sea that is optically classified as a Case II water body (Morel and Prieur 1977), i.e., the body where concentrations of colour producing substances (e.g. phytoplankton, inorganic particles and CDOM) vary independently from each other. Those Secchi depth estimations should be treated with special caution that are collected in the sub-basins possessing high absorption by chromophoric dissolved organic matter (the Gulf of Riga, the Gulf of Bothnia).

Secchi depth relates to primary production by being a proxy for the thickness of the euphotic zone wherein the large bulk of the gross production takes place. In principle, the euphotic depth is twice Secchi depth, but this relation varies largely in practice (French et al. 1982).

1.2 Purpose and aims

Monitoring of Secchi depth provides information of water transparency that is used for assessing direct effects of eutrophication (with certain limitations shown above). The aim is to provide spatiotemporal information for detection of short-term status and long-term trends and to ensure that the data is compatible for the HELCOM core indicator 'Water transparency'. The indicator description, including its monitoring requirements, is given in the HELCOM core indicator web site: [http://helcom.fi/baltic-sea-trends/indicators/water-clarity].

2. Monitoring methods

2.1 Monitoring features

Transparency is measured *in situ* at fixed HELCOM stations by using a Secchi disk. The depth where the Secchi disk settles beyond visual recognition, Secchi depth, is an index of water transparency.

2.2 Time and area

Secchi depth monitoring is carried out by all HELCOM Contracting Parties, and the monitored area covers the entire Baltic Sea area, both the open sea and coastal areas.

Secchi depth should be measured all year round whenever meaningful. It is to note that Secchi measurements during the summer and winter months are not necessarily commensurate to each other due to seasonal variation in the amount of colour producing substances in the water.

2.3 Monitoring procedure

2.3.1 Monitoring strategy

Being straightforward to determine and not relying on contemporary technical solutions, Secchi depth has been measured longer than any other index of eutrophication, and thus serves as the primary parameter for long-term water quality investigation.

In very tide-influenced coastal waters or in reservoirs with turbid waters from e.g. tributaries the results in relation to phytoplankton are not very informative because the results are influenced by very high concentrations of suspended mineral matter. Humic substances may also considerably reduce transparency.

To reach sufficiently high confidence criteria of the core indicator, the joint monitoring should produce annually at least 15 measurements in June–September for each assessment unit, i.e., for open sea sub-basins. The measurements should be as evenly spatially distributed as possible.

Light attenuation in the water column can be determined more accurately by underwater radiometry – and is required in the context of primary production studies – but the approach misses the simplicity of Secchi depth measurement. Underwater radiometry is optimally used to supplement Secchi disk based monitoring of water clarity by being attached to a CTD system.

2.3.2 Sampling method(s) and equipment

The methodology is based on the forthcoming ISO/WD 7027-2 standard.

Measuring equipment

- *Testing disk (Secchi disk).* A white disk with a diameter of 30 cm. The disk should weigh at least 1.7 kg so as to descend quickly and not be affected by horizontal water movements. Should the disk be lighter, an additional weight can be fastened to the down-facing side of the disk. As the observed Secchi depth tends to increase with the diameter of the disk (Aas et al. 2014), the disks of other sizes are not advised to be used.
- *Measuring tape/rope* of non-elastic material. Depth recognition:
    - colour-coded marks at 10 cm intervals. The upper side of the disk equals 0 cm. Half and full meters should be marked so as to be easily distinguishable.
    - depth indicator of a winch
- *Weight* for waters with currents, fixed in the middle of the down-facing side of the disk.
- *Optional devices* for suppression of reflections, e.g., polarized glasses for the observer. Note: Secchi depth measurement is dependent on the observer's eyesight, and any aids for vision tend to increase Secchi depth, which should be considered, e.g., in the context of long-term data series.

Measuring method

The observer should try to ensure that the measuring rope stays in an as upright position as possible. Deviations from the upright position stem from water currents and waves as well as ship's movement and thruster operation.

Measure the Secchi depth on the shaded side of the ship to avoid direct sunlight reflections from the water surface. However, the observer has to consider the source of error in the shaded side that occurs whenever the Secchi depth stretches beyond the shade of the ship. In this case, the disk is suddenly lighted by the sun and a higher reading will be attained.

Allow sufficient time (preferably 2 min) when looking at the disc near its extinction point for the eyes to completely adapt to the prevailing luminance level. Lower the disc further until it is no longer visible. The achieved depth is to be read and written down. After that, the disc is lowered by another 0.5 m. Then, during a slow elevation, the disc becomes visible as a greenish-bluish spot. The achieved depth is to be read and written down. It is recommended to repeat the test two times as a minimum. The Secchi depth is the arithmetic average of all readings.

The precision of a Secchi measurement depends on the turbidity of the water. In the waters of high turbidity, the precision can approach 0.1 m under calm seas. In clearer waters, the precision ranges 0.2 to 0.5 m, depending on actual conditions (e.g., waving or sun glitter; see later).

2.3.3 Sample handling

Not relevant: *in situ* measurement.

2.4 Data analysis

Secchi depth and the metadata of the station are documented in a field protocol.

3. Data reporting and storage

The data is included in the station data along with depth-dependent variables, stored by the Contracting Parties, and reported annually to the COMBINE database hosted by ICES. The Secchi depth is expressed in meters (m).

The Secchi depth shall be rounded to 0.1–0.5 m depending on the optical properties of the water, and actual conditions. The diameter and shape of the disc should be noted.

4. Quality control

4.1 Quality control of methods

Laboratories carrying out Secchi measurements should have established a quality management system according to EN ISO/IEC 17025 standard.

Secchi depth is an apparent optical property. Its determination is thus sensitive to weather conditions.

- Waving. Optimally, Secchi depth should be measured when the sea is relatively calm, only this is not often the case. Waving introduces a source of error in the Secchi measurement by worsening the overall visibility, and waves > 0.5 m in height obscure the identification of the actual surface. The length reading of the rope at the surface should be judged to be an average of the extreme values due to waving. The determination of Secchi depth is not meaningful in high seas.
- Sunlight: Secchi depth should be determined so as to avoid direct sunlight reflections from the water surface. Sun glitter decreases the Secchi depth estimation irrespective of optical properties of water; on the average by 12 % (Aas et al. 2014). Already this decrease exceeds the uncertainty of Secchi measurement in the typical optical conditions of the Baltic Sea water.

The length markings of the rope should be checked and made clearer annually. The rope should be changed whenever it stretches > 5 %.

Contracting Parties should follow the HELCOM monitoring guideline but minor deviations from this are acceptable if the method achieves comparable results. Validation of the adopted method needs to be performed on the relevant matrix and concentration range e.g. by taking part regularly at inter-comparison studies or proficiency testing schemes.

4.2 Quality control of data and reporting

For overall QC guidelines, see HELCOM (2015).

The measuring accuracy of the Secchi depth information should be 2 % of the mean reading value in low Secchi depths and under optimal conditions. Waving and sun glitter considerably increase this percentage.

5. Contacts and references

5.1 Contact persons

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5.2 References

Arvola L (1981). Spectrophotometric determination of chlorophyll a and phaeopigments in ethanol Aas E, Høkedal J, Sørensen K (2014). Secchi depth in the Oslofjord–Skagerrak area: theory, experiments and relationships to other quantities. Ocean Science 10: 177–199.

Cialdi, M. and Secchi, P. A. (1865). Sur la transparence de la mer. Comptes Rendu de l'Acadamie des Sciences 61: 100–104.

EN ISO/IEC 17025*: General requirements for the competence of testing and calibration laboratories.

French RH, Cooper JJ, Vigg S (1982). Secchi disc relationships. Water Resources Bulletin 18: 121-123.

HELCOM (2015) Eutrophication assessment manual, Annex 3A. http://www.helcom.fi/helcom-at-work/projects/eutro-oper/. Last revision 31.12.2015.

ISO/WD 7027-2*: Water quality – Determination of turbidity – part 2: Semi-quantitative methods. Draft version.

Morel A and Prieur L (1977). Analysis of variations in ocean color. Limnology and Oceanography 22: 709-722.

Whipple, George C. (1899). The microscopy of drinking-water. New York: John Wiley & Sons. pp. 73-75.

* For undated references, the latest edition of the referenced document (including any amendments) applies