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Action Instructions for the ecological Evaluation of Lakes for Implementation of the EU Water Framework Directive: Makrophytes and Phytobenthos

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1 Preliminary remarks

For additional information about these action instructions regarding the development and continuation of the evaluation procedure, please refer to the following literature:

- SCHAUMBURG, J., SCHMEDTJE, U., SCHRANZ, C., KÖPF, B., SCHNEIDER, S., MEILINGER, P., STELZER, D., HOFMANN, G., GUTOWSKI, A. & FOERSTER, J. (2004): Erarbeitung eines ökologischen Bewertungsverfahrens für Fließgewässer und Seen im Teilbereich Makrophyten und Phytobenthos zur Umsetzung der EU-Wasserrahmenrichtlinie. – Bayerisches Landesamt für Wasserwirtschaft, Abschlußbericht an das Bundesministerium für Bildung und Forschung (FKZ 0330033) und die Länderarbeitsgemeinschaft Wasser (Projekt Nr. O 11.03), 635 S., München.
- SCHAUMBURG, J., SCHMEDTJE, U., SCHRANZ, C., KÖPF, B., SCHNEIDER, S., MEILINGER, P., STELZER, D., HOFMANN, G., GUTOWSKI, A., FOERSTER, J. (2005): Bewertungsverfahren Makrophyten & Phytobenthos, Fließgewässer- und Seenbewertung in Deutschland nach EG-WRRL. – Informationsberichte des Bayerischen Landesamtes für Wasserwirtschaft, Heft 1/05: 245 S., München.
- SCHAUMBURG, J., SCHRANZ, C., STELZER, D., HOFMANN, G., GUTOWSKI, A., FOERSTER, J. (2005): Bundesweiter Test: Bewertungsverfahren „Makrophyten & Phytobenthos“ in Fließgewässern zur Umsetzung der WRRL. Endbericht. Bayerisches Landesamt für Umwelt, München: 225 S.
- SCHAUMBURG, J., SCHRANZ, C., HOFMANN, G., STELZER, D. (2006 in Vorb.): Bundesweiter Test: Bewertungsverfahren „Makrophyten & Phytobenthos“ in Seen zur Umsetzung der WRRL. Endbericht. Bayerisches Landesamt für Umwelt, München

Please check the following site for a download of the publications listed as well as for additional publications:
<http://www.bayern.de/lfw/technik/gkd/lmn/fliessgewaesser_seen/pilot/pub_g.htm> .

The evaluation procedure introduced here was developed on the basis of a limited number of sampling sites and was part of an examination routine of the years 2000 through 2003. It was further improved during a nationwide practical test. For that purpose organisms were attributed to different indication groups. The generated species lists were supplemented by referring to literature research. These species lists might be faulty or incomplete, but this can only be verified in the course of application. **It is of great importance that potentially required adjustment of the classification is centralised and is carried out by a team of specialists**. **Ideally the project team in cooperation with the Bavarian Environment Agency will be consulted**

2 Determination of the required number of representative shoreline transects and choice of their position for evaluation of a lake water body

In principle, a complete mapping is recommended for primary investigation of a lake water body. If a complete mapping of macrophytes has not yet been carried out for a lake, a general mapping of the entire litoral is advisable. Especially in case of large, complex lakes this is he only way to ensure a representative result of mapping and to really localize all sources of stress to this system. The general mapping procedure can, for example, be carried out by divers according to MELZER & SCHNEIDER (2001) in combination with echo localization and diving along selected transects according to JÄGER et al. (2004) or by combination of aerial pictures and transect mapping according to SCHMIEDER (1997).

Regardless of the chosen method one must make sure that the data fulfils the prerequisites of an evaluation according to SCHAUMBURG et al. (2004a) and thus those of the WFD. It must be emphasized that the depth scale and well as the scale for estimating plant abundance according to KOHLER (1978) must be adhered to.

For consecutive investigations the determination of the number of transects und the determination of their position is based on the overall mapping procedure in combination with the information about the lake surface, shore development, shore morphology and land use along the shore. If an overall or general mapping procedure cannot be carried out, as an exception the selection can exclusively be based on the criteria lake surface, shore development, shore morphology and land use along the shore.

The suggestion for determination of the required number of representative shoreline transects and their distribution along the water body was developed based on the macrophyte component (SCHAUMBURG et al. 2006, in prep.). If number and position of the investigated areas within a lake meets the requirements of this instruction, one can act on the assumption that the transects of macrophyte mapping are also representative fort he investigation of the component Phytobenthos and Diatoms. In order to evaluate an entire lake water body with the biocomponent Macrophytes & Phytobenthos according to the WFD, for each transect selected macrophytes must be mapped and diatoms must be sampled.

2.1 Determination of the number of sampling sites

The larger and the more complex a water body, the more transects must be investigated. In Table 1 there are examples of different lakes and the required transect length in correlation to the lake surface. If a lake can be subdivided in different basins, these should be treated as different water bodies, i.e. for each basin the required number of transects should be determined according to the table. Under consideration of the variety of shore morphology and land use along the shore, the exact number of transects is determined.

Table 1: Recommended number of transects in correlation with the lake surface (BB = Brandenburg, BW = Baden-Württemberg, BY = Bavaria, MV = Mecklenburg-Western Pomerania, Ni = Lower Saxony, SH = Schleswig-Holstein)

Surface of water body	Number of transects	Examples
< 0,5 km²	1 - 5	+- delimited basins
0,5 - 2,0 km²	4 - 8	Gr. Gollinsee (BB), Dieksee (SH), Mindelsee (BW)
2,0 - 5,0 km²	5 - 10	Gr. Stechlinsee (BB), Schliersee (BY), Breiter Luzin (MV)
5,0 - 10 km ²	6 - 12	Königssee (BY), Westensee (SH), Tegernsee (BY), Parsteiner See (BB)
10 - 20 km²	8 - 15	Wittensee (SH), Dümmer (NI), Walchensee (BY)
20 - 50 km²	10 - 20	Selenter See (SH), Steinhuder Meer (NI), Gr. Plöner See (SH), Ammersee (BY)
50 - 100 km²	20 - 30	Starnberger See (BY), Chiemsee (BY)
> 100 km²	30 - 50	Müritz (MV), Bodensee (BW)

The lowest value for each size class pertains to more or less uniform water bodies without typical bays or islands. Shore development can be used as a criteria for decision (values $\leq 2,0$). Furthermore, there should not be strong variations in shore morphology. The use of the shoreline must not indicate a locally increased input of nutrients.

The largest value, however, pertains to lakes with a heterogeneous shore morphology and for which the land along the shore is used in different ways. Lakes of that sort have a very differentiated shore morphology with typical bays and islands as well as shoreline sections with varying degree of steepness. Along the shore a number of different vegetation types but also embankments or other manipulations can be found. Due to the various forms of land use of the shore and adjacent land, locally an increased input of nutrients or other substances is to be expected.

2.2 Determination of transect position

The determination of the exact position of transects is carried out on site. Sampling should not be carried out in the proximity of inflows. When selecting sampling sites, one has to focus on sections that are characteristic for a lake, i.e. all typical macrophyte habitats should be considered in the mapping procedure. Upon selection the morphology of the water body must be kept in mind. Sections with different steepness, islands as well as bays must be characterised by a representative number of sampling sites. If lakes have different sections with more or less separate basins, these must be considered according to their degree of influence on the entire lake. The

transects should further be distributed in such a fashion that surf zones and more sheltered shores with siltation as well as areas with different degrees of shading are represented. In order to document possible sources of stress or nutrient input, transects should also cover areas of different land use (bathing, camping, agricultural land and pastures in close proximity).

The relative portion of different locations should be taken into account. For example, if 30% of the shore is shallow with fine sediment and 70% is steep with coarse sediment, the ratio of the sites investigated should also be 1:2. Ideally all different types of shores are investigated in a representative number of sampling sites.

3 Sampling and Determination of the Macrophyte & Phytobenthos Biocoenosis

Sampling is carried out once a year during summer, i.e. during the main growth season of macrophytes (usually early July until mid August). In addition to mapping macrophytes diatoms are sampled on the same day and are stored for evaluation. If the two components are sampled on separate occasions, macrophyte mapping without diatom sampling can be carried out from mid June on, depending on the local conditions. Diatom sampling without macrophyte sampling can be carried out until September. However, the sampling dates should not be too far apart.

The exact location of the sampling site should be marked in topographic maps of the scale 1:25 000 or 1:50 000, respectively, so that later **easting and northing** of the sampling sites can be determined. Ideally the coordinates can be determined on site directly with a GPS. In this case the precise starting point and endpoint of a survey should be noted as well as the depth limit of distribution.

The first step of sampling is the exact determination of the sampling sites. For this purpose the water system is investigated from the shoreline. A decision which site to pick for a macrophyte survey is made based on the criteria described in chapter 2.2.

Diatom sampling is carried out prior to macrophyte sampling in order to keep disturbances of the sediment and sampling material at a minimum. Generally, all surveys and sampling procedures have to be carried out as carefully as possible. It has to be seen that other groups of organisms are not destroyed.

3.1 Macrophytes

3.1.1 Preliminary remarks

The action instructions at hand were developed from the method used to survey lake macrophytes. It is the minimum requirement for the evaluation of lakes based on their macrophyte water vegetation.

Even if it is sufficient for assessment of a site to determine slope and type of substratum in addition to vegetation, the investigation of additional **structural factors** characteristic for the site is advisable. The additional effort is negligible and in some cases valuable conclusions can be drawn, e.g. regarding natural causes for the lack of vegetation in a certain location.

Moreover, this detail makes it possible to create a comprehensive data base for macrophytes in lakes as it is already available for macrozoobenthos of running water systems due to the consistent application of the Saprobic Index.

3.1.1.1 Mapping equipment

- Boat with adequate safety equipment
- Bathymetric maps and topographical maps of a scale 1:25 000 or 1:50 000 (e.g. CD-Atlas 25 GISCAD (1998a, 1998b) or TOP 200 of the BUNDESAMT FÜR KARTOGRAPHIE UND GEODÄSIE (1998).
- Wading pants and snorkelling equipment for shallow water
- Aquascope (Under water viewer)
- Weighted (e.g. diving belt), double-headed rake on a rope (59 cm head, 2 cm space between tines; modified according to DEPPE & LATHROP 1993). A string with meter markings attached to the handle of a rake allows sampling of a defined depth. The rope must not expand in water.
- Grab sampler (Ekman-Birge) and matching bucket (also for investigation of the substratum)
- Diving equipment (as an alternative to rake and grab sampler mapping by divers)
- Results of former macrophyte surveys, if available
- Field protocols and pencils
- Copy of the instruction protocol
- Camera and films
- Cooler and cooling elements
- Bags, labels, clamps, paper for moss herbarium
- Herbarium press and accessories
- Determination literature (compare below)
- Magnifier (at least 10 fold magnification)
- (Portable) stereo micoroscope and accessories
- GPS-device

3.1.1.2 Selection of determination literature

- CASPER & KRAUSCH (1980, 1981)
- KLAPP & OPITZ VON BOBERFELD (1990)
- KRAUSCH (1996)
- KRAUSE (1997)
- ROTHMALER (1994a, 1994b)
- SCHMEIL (1993)

3.1.2 Mapping instructions

There are two alternative mapping methods for application of the assessment procedure – mapping by divers and mapping with a rake. The suitable method for the transect or the body of water to be sampled must be chosen according to the different prerequisites in each case.

Generally, the sampling should cause as little damage as possible to the sampling site. The following criteria are helpful upon choosing the adequate method.

Mapping with a rake is suitable for soft sediments, tall species, and patchy vegetation, even if the water is turbid and distinguished from above (in such a case the sampled area should be extended). However, if the substratum is rocky, in nature reserves, in dense vegetation stands or during strong winds (KIELER INSTITUT FÜR LANDSCHAFTSÖKOLOGIE 2002) it can make more sense to have the survey carried out by SCUBA divers.

The method described is an inexpensive procedure, which can easily be carried out and applied to the majority of water bodies.

The macrophyte survey is carried out once during the main vegetation period (end of June until mid August). All submerged rooting vegetation and vegetation rooting below the mean water level (Characeae, water mosses and vascular plants) are recorded.

In each sampling site a belt transect of 20–30 m width orthogonal to the shoreline and positioned within an ecologically homogenous section of the littoral is surveyed. Of special importance are morphology of the shoreline, use of the riparian zone and composition of the sediment. Moreover, the sampling sites need to have a homogenous composition of macrophytes.

Transects can either be surveyed by SCUBA divers or by using a boat and adequate equipment. According to the mapping procedure of sampling sections (compare MELZER & SCHNEIDER 2001), 4 different depth zones are sampled (0–1 m, 1–2 m, 2–4 m und 4 m down to the vegetation limit). **This division into depth zones must absolutely be adhered to for correct index calculation.** If the results are also used for other evaluations, e.g. for a monitoring according to the FFH guideline, it might be necessary to subdivide the > 4m depth zone into 2m steps. In this case, for an evaluation according to the WFD the plant quantities for the > 4m zone must be noted in addition.

For all depth zones the abundance of each species observed is determined according to KOHLER'S five class scale (1978, Table 2) and entered into the field protocol (Figure 1and Figure 2). Species that are obviously washed ashore will not be considered.

The depth of the lower vegetation limit must also be noted in the field protocol. Single individuals occurring in a greater depth are not important, but the depth in which more or less dense stands can be found. It has to be ensured that one is truly dealing with the lower vegetation limit and not only at a gap in a stand of macrophytes extending to a greater depth. If the lower limit of macrophyte growth is influenced by non anthropogenic factors, e.g. by an abrupt increase in depth this must be noted in the field protocol.

Table 2 Estimating plant abundance according to KOHLER (1978)

Pflanzenmenge	Beschreibung
1	very rare
2	rare
3	common
4	frequent
5	Very frequent,

In addition details regarding the growth form (submerged or emerged) of the plants is noted. Species occurring in a submerged and emerged fashion in the same body of water are recorded

twice. The depth of the vegetation limit is noted as well as the species occurring in the greatest depth.

If species are difficult to determine, samples are taken for further determination under the stereo- or light microscope. If necessary, samples are prepared for a herbarium. Mosses can be stored and dried in the so called “moss capsules” or envelopes.

Even if it is not necessary for assessment of a site, it is recommended to record a number of different (structural) **factors characteristic for the site**. This only takes little additional effort and in some cases important conclusions can be drawn from this information, e.g. regarding the natural causes for a lack of vegetation in a certain location.

Data are collected with the two-piece field protocol. In the **description of the shoreline and riparian zone** (Figure 1) plant cover, use of adjacent land, shoreline morphology as well as other characteristics are noted. The description of the littoral (Figure 2) comprises essential water related parameters in relation to different investigated depth zones. The factors considered are composition of the substratum and the sediment cover, structural elements, periphyton (Aufwuchs), slope, unusual characteristics as well as shading in areas of shallow water (Table 3).

Table 3 Degree of shading according to WÖRLEIN (1992)

Scale	Description	Explanation
1	completely sunny	sunny from sunrise to sunset
2	sunny	most of the time between sunrise and sunset, but always in full sun during the warmest hours of the day
3	partly overcast	mostly in the sun, but in the shade during the warmest hours of the day
4	half shaded	in the shade for more than half of the day and always at noon
5	completely shaded	completely shaded by trees

Field Protocol Macrophytes and benthic Diatoms in Lakes
Shore and shallow water Areas

(Assessment of macrophytes & phytobenthos according to EG-WFD 2003; grey fields are optional)

Name of water body

Transect-/Section-No. | Editor

Sampling site No. | Report Nr.

Easting (Shore) | Northing (Shore)

Easting | (Vegetation limit) | Northing

Top. Map No. | Date

Position, description of transect

Exposition (direction) | Transect width m

Film-/Photo No. | Clarity m

Water level ☐ low ☐ medium ☐ high

Diatoms sampled? ☐ yes ☐ no

If yes: type of substrate sampled

Mapping method (please check)

Mapping by divers (entire littoral of lake) ☐
Mapping by divers (transects) ☐

Transect mapping with rake/grab sampler ☐
(cross out what is not applicable)

Vegetation of the shore (please check)	Edge (0-5 m)	Surr. Area (5-20 m)
Forest		
Shrubs (edge vegetation)		
Shrubs/individual shrubs or trees		
Reed/sedge communities		
Tall herb community		
Meadows/pastures (extensive)		
Meadows/pastures (intensive)		
Farmland/gardens		
Lawns/parking areas		
Pioneer veg./trampling veg/fallow		
Vegetation free		

Land use along shore (please check)	Edge (0-5 m)	Surr. Area (5-20 m)
Industrial areas/shipyard		
Haven, pontoons		
Meadow used for boat storage		
Street/parking/bike-/ped. Trail		
High density housing		
Low densitiy housing		
Park/camping/open air bath		
Resting/bathing area, fire place		
Agriculture		

Type of Shoreline (please check)

Bluff, bank, wall (landward) ☐
Flat shore (landward) ☐
Transect within a bay ☐ ja ☐ nein

Shore modifications (please check)

Stones/Boulders ☐
Concrete/stone walls ☐
Wood ☐
Steel ☐

Characterist. (x: indiv. Occ. xx: accumul. xxx: frequent)

Driftwood/accumul.of dead wood on land	
Garbage, debris, contamination	
Inflow (ditch, brook, river)	
Alluvial fan	
Discharger (drainage, pipes)	
Pontoons/bathing area	
Bow nets, nets	

Shading according to WÖRLEIN (1992)

☐ 1	completely sunny	Sunny from sunrise to sunset
☐ 2	sunny	in full sun most of the time between sunrise and sunset, but always during the warmest hours of the day
☐ 3	partly overcast	mostly in the sun, but in the shade during the warmest hours of the day
☐ 4	half shaded	in the shade for more than half of the day and always at noon
☐ 5	shaded	completely shaded by trees

Other

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Figure 1 Field protocol for mapping lake macrophytes (page 1)

Field Protocol Lake Macrophytes
Littoral & Macrophytes

(Assessment of Macrophytes- & Phytobenthos according to EU-WFD 2003)

Name of water body	Transect-No.	Date

Lacustrine Sediment/Substratum

(please check; x: rare; xx: abundant; xxx: massive)

	Tiefenstufe 0-1m	1-2m	2-4m	> 4m
Rock				
Boulder (>200 mm)				
Stones (63-200 mm)				
Coarse gravel (20-63 mm)				
Fine-/Medium gravel (2,0-20 mm)				
Sand				
Marl (am), Seekreide				
Sand mud (Mudde)				
Lime mud (Mudde)				
Detritus mud (Mudde)				
Organic/peat mud (Mudde)				
Sapropel				
Reed stubble				

Slope (f: flat; m: medium; s:steep)

Depth zones 0-1m	1-2m	2-4m	> 4m

Characteristics

(please check; x: rare; xx: frequent; xxx: massive)

Sudden change in depth (> 0,5m)	Tiefenstufe 0-1m	1-2m	2-4m	> 4m
Quaking bog				
Fields of reed stubble				
Overhanging Vegetat.				
Dead wood				
Influence of groundwater				
Damage due to trampling				
Damage due to achors/buoys				
Garbage, debris				
Dead leaves/detritus				
Mussels				
Painters Mussel				
Zebra Mussel				
Green algae				
Blue-green algae				
Other algae				

Macrophytes

Vegetation limit	Deepest site sampled	Deepest species (sg/pl)
m	m	

Name of species	sub-/ emerged	Abundance (1-5) in depth zones 0-1 m	1-2 m	2-4 m	>4 m

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Figure 2 Field protocol for mapping lake macrophytes (page 2)

3.2 Diatoms

3.2.1 Sampling

Sampling in the littoral of lakes largely corresponds to the sampling procedure in slowly running waters. Preferably stones are sampled in their original position and the periphyton (Aufwuchs) or sediment cover is scratched off with a toothbrush, teaspoon, spatula or a similar device and is transferred into a labelled wide neck sampling container. For reasons of contamination toothbrushes should only be used once. Generally, it has to be seen that sampling is carried out in the open water and not amidst dense stands of macrophytes. The sampling depth should exceed 30 cm. Fluctuations of the water level must be kept in mind when scheduling sampling dates. If mainly sand or soft sediments are present, the upper millimetres are lifted off with a spoon. The density of growth can vary considerably for the different lakes sampled. In some cases Aufwuchs cannot be seen with the naked eye, but can be felt on the surface of the substratum. In any case, a large amount of substratum needs to be sampled. The sedimented sample in the sampling container should add up to at least 5 ml of diatom sediment. Adding formaldehyde of a final concentration of 1–4 % preserves the samples. The sampling procedure is documented on the field protocol (compare. Figure 1 and Figure 2).

3.2.1.1 Lake sampling equipment

- Camera equipment
- Topographical maps of a scale 1:25 000 or 1:50 000
- Field protocols
- Copy of instruction protocol
- Writing utensils
- Wading pants
- Wide neck bottles or vials
- Printed labels or water proof marker to label sampling containers
- Teaspoon, spatula or something similar
- Formaldehyde solution
- Camera equipment
- Safety equipment if necessary

3.2.2 Preparation

3.2.2.1 Materials required for preparation

Chemicals

- Acetic acid 25% p. a.

- Sulphuric acid 95-97% p. a.
- Potassium nitrate p. a.
- Formaldehyde

Additional equipment

- Hood
- Hot plate
- Safety clothing (lab coat, goggles, safety gloves)
- Beakers (tall; 100 ml or larger)
- Weighing glass with diameter corresponding to beaker
- Beaker tongs
- Magnetic stirrer
- Mortar and pistil to pulverise potassium nitrate, if necessary
- Spatula
- Small plastic sieve with diameter corresponding to beaker
- Universal indicator paper for pH determination
- Aqua dest.
- Wash bottle

3.2.2.2 Acid treatment

Carry out all boiling procedures described under an effective hood. Exercise caution and adhere to all work safety rules. Protective clothing and eye protection are mandatory.

In order to determine diatoms to the species level, shape and structure of the siliceous valves must be focused on. Exact determination requires permanently mounted specimens. Especially species with small frustules can only safely be determined in a purified sample after removal of organic substance and other unwanted organic components. There are different procedures for preparation of the sampling material depending on the nature of the sample. A description of the most common preparation techniques is presented by KRAMMER & LANGE-BERTALOT (1986). For preparation of periphytic (Aufwuchs) substratum samples (stone, gravel, mud) which might contain a high percentage of organic material not containing diatoms, oxidation by strong acids, especially sulphuric acid is recommended.

3.2.2.3 Treatment with acetic acid

If the material was taken from calcareous waters, the sample is initially boiled in acetic acid in order to prevent the formation of gypsum in the subsequent treatment with sulphuric acid. If the water content of a sample is high, the sample is allowed to sediment for 24 hours and then it is carefully decanted. Alternatively the sample can be heated until most of the water is evaporated. Prior to acid treatment a portion of the sampling material must be taken as a retain sample. Shaking then mixes the remaining sample and approximately 20 ml of the sampling material are transferred into a 100 ml beaker to which 20–40 ml diluted acetic acid (25 %) are added. If the sample is strongly calcareous, prior to heating the acetic acid has to be added little by little to keep foam formation at a minimum. The sample is covered with a weighing glass and by boiling it for

30 minutes with a magnetic stirrer, the carbonates are dissolved and the protoplasm and protoplasmic threads are dissolved and frustules are separated from the substratum. If the sand content of the sample is high, it is likely that the beaker starts moving on the hotplate and that its position needs to be corrected. This can best be accomplished by using beaker tongs. When rinsing the beaker tongs in or with tap water, one must make sure not to accidentally transfer any sampling material from one sample to the next. Magnetic stirrers must also be cleaned between the different boiling routines.

After boiling the sample is allowed to cool off. Subsequently large remainders, if present, are sieved off with a small kitchen sieve and the beaker is filled with tap water. In order to largely remove sand, gravel or smaller stones, which might be present, the solution is vigorously stirred and allowed to sediment for a minute so that the diatom containing supernatant can be decanted. In the following, the sample is carefully decanted several times until approximately one third of the volume is left and is rinsed with tap water. A four-fold washing and decanting routine has proven to be adequate. However, the sedimentation time between washings should not be less than 24 hours. Alternatively the sample can be centrifuged between washings in a table centrifuge for approximately 10 minutes at maximally 2000 rpm and the supernatant (approximately two thirds) can be decanted or removed with a jet pump. This procedure allows a quick preparation, but is more labour intensive and might cause long diatom frustules to break.

3.2.2.4 Treatment with sulphuric acid

The water content of the sample is strongly reduced by decanting. Afterwards approximately 20 to 30 ml concentrated sulphuric acid are added and the sample is boiled. In 20 minute intervals a dash of potassium nitrate is added with a spatula until the sample loses its colour or gets a yellow tint. If the content of organic material is low, a few dashes of potassium nitrate are sufficient, but if the content is high, the boiling procedure can take up to eight hours. After changing colour, the sample needs to remain on the hot plate for another 20 minutes. After the sample has cooled off and the diatoms have settled, they form a white to greyish sediment. Subsequently samples are washed until neutrality (indicator paper!) is reached. When adding water for the first time after boiling, one has to exercise extreme caution as this can cause a strong reaction. Experience has shown that the washing routine should be carried out approximately eight times and that sedimentation time between washings should not be less than 24 hours. The last washing of the sample should be carried out with distilled water. The purified sample is mixed by shaking the beaker and is transferred into a labelled vial (for labelling compare labelling of the microscope slide). The vials are to be stored in a storage room for documentation.

3.2.3 Mounting permanent specimen

3.2.3.1 Material

- Microscope slides
- Cover slips (recommended are round cover slips with18 mm diameter)
- Round tip tweezers or special tweezers to handle cover slips

- Vials (10 ml recommended)
- Naphrax[2]
- Storage system for mounted specimen
- Labels

Cover slips must be cleaned prior to adding the diatom suspension. A quick immersion into a highly concentrated solution with dishwashing detergent has proven suitable to remove fat and to reduce surface tension. Afterwards the suspension in the vial is mixed by shaking and immediately after a small amount is transferred with a clean pipette on to a cover slip. In order to reduce convection, the drop of sampling solution should be kept flat. If a suspension is highly concentrated, it often is necessary to dilute it in a weighing glass with distilled water. The degree of dilution depends on the density of valves desired for the preparation and on the presence of remaining organic components. Problems are often caused by a high content of mineral components (loam and clay particles), which are difficult to remove and in a vial optically cannot be differentiated from diatoms. For this reason it is useful to prepare different dilutions of the sample.

The ideal density of valves is reached, if after checking one or more complete transects under a 1000 fold magnification the required amount of 500 valves (compare below) is determined. The explanation is a partial demixing of diatom frustules caused by convection in the drop of sample solution on the cover slip. In case of strong convection flows, small frustules can be concentrated in the middle of the cover slip, whereas a high percentage of big and heavier frustules can be concentrated along the edges. This phenomenon is compensated by counting complete transects.

In order to avoid contamination, one has to absolutely make sure to rinse used pipettes under running water prior to handling a new sample.

After air drying the diatom sample overnight, a drop of Naphrax[2] is added to a labelled, fat free microscope slide and using tweezers the cover slip is carefully placed on top of the sample coated side facing down. In order to evaporate the solvent, the sample is heated over the small flame of a Bunsen burner until bubbles can be observed for about 5 seconds. Afterwards it is immediately placed on a vibration free, smooth surface until it has cooled off. Naphrax[2] contains toluene that evaporates during heating and therefore must be handled with great care. Alternatively the evaporation of toluene can be carried out on a hot plate. Then, using tweezers it should be checked, if the cover slip strongly sticks to the microscope slide. If not, the procedure has to be repeated.

Immediately after completion of this procedure the sample can be evaluated under the light microscope and, if kept under appropriate conditions, it can be stored for decades. It is of essential importance to have a storage or archiving system and to precisely label microscope slides. The information on the slides should contain the name of the sampling site or running water, position of the site (if available easting and northing). Furthermore, the sampled substratum, the date and, if available, any coded information which can be linked to other sources of data should be added.

After mounting the permanent samples, the diatom suspension remaining in the vial is preserved by adding two to three drops of a 30 percent formaldehyde solution. Alternatively ethanol can be used for preservation. In order to keep the sample from drying out, five to ten drops of glycerine are added prior to placing the sample into storage.

3.2.4 Microscopic evaluation

In order to obtain a representative distribution, 500 diatom objects are determined to the species level with a 1000 fold up to 1200 fold magnification in microscopic slides prepared as described above. Partially the differentiation of varieties might be necessary (compare chapter 5.2). For the counting routine the valve views as well as the girdle views need to be considered. When dealing with representatives of the *Naviculaceae* it is often impossible to tell from a valve view whether one is looking at single valves or entire frustules. Therefore during evaluation no difference is made between single or double valves, but one focuses on counting diatom objects. If frustule valves were not separated during preparation, they are counted as a unit. Girdles which are impossible to determine must be characterized on the genus level and, if possible, must be grouped and categorized according to their size. After completion of microscopic analysis these diatom objects are attributed to the species they most likely represent according to the percentages with which these species occur. Fragments are only considered, if their size exceeds that of half a valve. Afterwards the sample is screened for taxa that have not yet been found. This is a valuable back-up for the Quotient of Reference Species (compare 5.2.2). Frequencies of species are presented as percentages. Taxa which were found during the additional screening process are listed with the frequency "0". The results of diatom counting are to be documented along with data processing numbers according to MAUCH et al. (2003) in Excel or Access files or in specific databases.

When counting diatoms only benthic as well as benthic/planktonic taxa are considered. Taxa, which are exclusively planktonic, are not considered. For reliable literature regarding the life of centric taxa is not in all cases available and sometimes is even contradictory, with the exception of *Melosira varians,* Centrales are not considered during counting. The same is true for pennate taxa, which are exclusively planktonic, e.g. *Asterionella formosa*, *Fragilaria crotonensis*, *Nitzschia acicularis*. Details regarding the different life forms can be found in KRAMMER & LANGE-BERTALOT (1986-1991).

The four volumes of KRAMMER & LANGE-BERTALOT (1986–1991) are the standard determination literature. In case of some genera or taxa it should be completed by the supplementary volumes and revisions of individual genera published since 1993 by the following authors: KRAMMER (2000), LANGE-BERTALOT (1993, 2001), LANGE-BERTALOT & MOSER (1994), LANGE-BERTALOT & METZELTIN (1996). In the water systems of the North German Lowland influenced by saline conditions additionally the work of WITKOWSKI & LANGE-BERTALOT (2000) must be taken into account. However, the revision of the genus *Cymbella* by KRAMMER (2000, 2002, 2003) can be neglected.

3.2.5 Criteria for a reliable assessment and evaluation

Samples are not suitable for assessment, if the percentage of diatom objects that cannot be determined (sp., spp.) and/or cannot unambiguously be determined (cf., aff.) exceeds 5 %.

If, even after the best possible isolation of the sampling material there is still only a small amount of diatoms, this suggests that sampling was not carried out correctly or that the time of sampling

was not suitable (SCHAUMBURG et al. 2006). At 1000 fold magnification a minimum of 50 objects per transect on a cover slip of 18 mm diameter are suggested as a criterion for reliable assessment. If one surmises that the sample cannot be evaluated, the density of diatoms must be tested by counting a transect. Experience has shown that despite careful operating, the portion of samples that cannot be evaluated can amount up to 3 %.

Another exclusion criterion is a large number of aerophilic diatoms in a sample. This typically occurs, if a recently flooded section is sampled in which the water level still rises. If the portion of aerophilic taxa (Table 4) exceeds 5%, most likely there is a strong aeric influence dominating or at least strongly influencing the assessment. Additional information regarding the aerophilic character of the taxa can be found in KRAMMER & LANGE-BERTALOT (1986–1991).

Table 4: Aerophilic taxa according to LANGE-BERTALOT (1996) and HILDEBRAND (1991)

DV-Nr.	Taxon	Author
6247	Achnanthes coarctata	(BREBISSON) GRUNOW
6286	Amphora montana	KRASSKE
6287	Amphora normannii	RABENHORST
16692	Denticula creticola	(OESTRUP) LANGE-BERTALOT & KRAMMER
6344	Diploneis minuta	PETERSEN
16264	Hantzschia abundans	LANGE-BERTALOT
6084	Hantzschia amphioxys	(EHRENBERG) GRUNOW
6802	Hantzschia elongata	(HANTZSCH) GRUNOW
16267	Hantzschia graciosa	LANGE-BERTALOT
16271	Hantzschia subrupestris	LANGE-BERTALOT
16276	Hantzschia vivacior	LANGE-BERTALOT
6805	Melosira dickiei	(THWAITES) KUETZING
6449	Navicula aerophila	KRASSKE
6458	Navicula brekkaensis	PETERSEN
6467	Navicula cohnii	(HILSE) LANGE-BERTALOT
6858	Navicula contenta	GRUNOW
16003	Navicula egregia	HUSTEDT
6489	Navicula gallica var. perpusilla	(GRUNOW) LANGE-BERTALOT
6492	Navicula gibbula	CLEVE
6504	Navicula insociabilis	KRASSKE
6028	Navicula mutica	KUETZING
16020	Navicula nivalis	EHRENBERG
16021	Navicula nivaloides	BOCK
16022	Navicula nolensoides	BOCK
16025	Navicula paramutica	BOCK
16026	Navicula parsura	HUSTEDT
6013	Navicula pelliculosa	(BREBISSON) HILSE
6528	Navicula pseudonivalis	BOCK
16360	Navicula pusilla var. incognita	(KRASSKE) LANGE-BERTALOT
16366	Navicula saxophila	BOCK
16036	Navicula subadnata	HUSTEDT
16375	Navicula suecorum var. dismutica	(HUSTEDT) LANGE-BERTALOT
6569	Neidium minutissimum	KRASSKE
6574	Nitzschia aerophila	HUSTEDT
16393	Nitzschia bacillariaeformis	HUSTEDT
6921	Nitzschia debilis	ARNOTT
16407	Nitzschia epithemoides var. disputata	(CARTER) LANGE-BERTALOT
16050	Nitzschia harderi	HUSTEDT
16053	Nitzschia modesta	HUSTEDT
6614	Nitzschia terrestris	(PETERSEN) HUSTEDT
16453	Nitzschia valdestriata	ALEEM & HUSTEDT
16460	Orthoseira dendroteres	(EHRENBERG) CRAWFORD
16060	Orthoseira roeseana	(RABENHORST) O'MEARA
6148	Pinnularia borealis	EHRENBERG

DV-Nr.	Taxon	Author
6635	Pinnularia frauenbergiana	REICHARDT
6645	Pinnularia krookii	(GRUNOW) CLEVE
16473	Pinnularia lagerstedtii	(CLEVE) CLEVE-EULER
6654	Pinnularia obscura	KRASSKE
6225	Simonsenia delognei	(GRUNOW) LANGE-BERTALOT
6679	Stauroneis agrestis	PETERSEN
16081	Stauroneis borrichii	(PETERSEN) LUND
16558	Stauroneis gracillima	HUSTEDT
16083	Stauroneis lundii	HUSTEDT
16084	Stauroneis muriella	LUND
6685	Stauroneis obtusa	LAGERSTEDT
16095	Surirella terricola	LANGE-BERTALOT & ALLES

4 Determination of the type of running water

The attribution of the lake sampling sites to the biocoenotic typology, which is required for the assessment procedure, can be carried out with the lake typology according to MATHES et al. 2002. A comparison of the typologies is presented in Table 5.

Table 5 Comparison of the biocoenotic lake typology based on the results of the project Macrophytes and Phytobenthos and the lake typology according to MATHES et al. (2002**)**

Types (MATHES et al. (2002))	Macrophyte Typology		Diatom-Typology	
2, 3, 4	AK(s)	Sites of carbonaceous, stratified water bodies of the Alps and Alpine Foreland (AK) incl. The subtype of extremely steep sites of the carbonaceous lakes of the Alps (Aks)	D 1.1	Lakes of the Alps and the Alpine Foreland with a volume development > 0,4
1	AKp	Sites of carbonaceous, polimictic water bodies of the Alps and the Alpine Foreland	D 1.2	Lakes of the Alps and Alpine Foreland with a volume development < 0,4
9	MTS	Sites of siliceous water bodies of the Central German Upland and the North German Lowlands	D 9	Siliceous lakes of the Central German Upland
10	TKg10	Sites of carbonaceous water bodies with a stable stratification and a relatively large catchment area in the North German Lowland	D 10.1	Stratified lakes with a retention time between ten years and one year (P-limited)
			D 10.2	Stratified lakes with a retention time of less than a year (N-limited)
13	TKg13	Sites of carbonaceous water bodies with a stable stratification and a small catchment area in the North German Lowland	D 13.1	Stratified lakes with a retention time of more than ten years
			D 13.2	Stratified lakes with a retention time between ten years and one year ((P-limited)
11	TKp	Sites of carbonaceous, polimictic water bodies of the North German Lowland	D 11	Unstratified lakes with a retention time of more than 30 days
12			D 12	River lakes with a retention time of less than 30 days
14			D 14	Unstratified lakes with a retention time of more than 10 years

For the typology has great influence on the assessment of a body of water, it must critically be verified. If in doubt, assessment has to be carried out for different types of lakes and should be discussed with all available information in mind. In rare and special cases and if a good justification is at hand one must not stick with the schematic typology.

5 Assessment

5.1 Macrophytes

5.1.1 Calculation of the Reference Index

For calculation of the Reference Index exclusively submerged species are considered, i.e. all submerged growing species as well as those with floating leaves. Amphiphytic taxa are taken into account if they are submerged. Helophytic species are not considered.

5.1.1.1 Transformation of plant abundance into quantity

Prior to performing any calculations, the nominally scaled values of plant abundance are converted into metric quantities using the following function:

$$macrophyte\ abundance^3 = Quantity$$

5.1.1.2 Incorporation of taxa into different species group

The taxa occurring at the sampling site will be assigned to ***type specific*** species groups (compare Table 6).

If in the course of new surveys additional s**pecies** are found, which are **not mentioned in the following species list,** these taxa should not be considered for index calculation. If the number of unlisted (=non indicative) species is high, this most likely will falsify the calculated index. Consequently, if the percentage of non indicative species is ≥ 25 %, the index value cannot be considered reliable.

5.1.1.3 Calculation of total quantities

The quantities of the different species calculated from the plant abundances will be summed up separately for each group and for all submerged species of a sampling site.

5.1.1.4 Calculation of the Reference Index

The Reference Index is calculated according to the following formula (Equation 1):

Equation 1 Calculation of the Reference Index

$$RI = \frac{\sum_{i=1}^{n_A} Q_{Ai} - \sum_{i=1}^{n_C} Q_{Ci}}{\sum_{i=1}^{n_g} Q_{gi}} * 100$$

RI = Reference Index
Q_{Ai} *= Quantity of the i-th taxon of species group A*
Q_{Ci} *= Quantity of the i-th taxon of species group C*
Q_{gi} *= Quantity of the i-th taxon of all groups*
n_A *= Total number of taxa in group A*
n_C *= Total number of taxa in group C*
n_g *= Total number of taxa in all groups*

The calculation of the Reference Index takes into account additional type specific characteristics (compare chapter 5.1.1.5 up to 5.1.1.10). Only this final value can be used for the total assessment of lakes and combination of the module Macrophytes with the diatom assessment.

Table 6: List of indicator species. Newly added species are marked in yellow, species that now are in a higher category are marked in green and species that now are in a lower category are marked in red. The specification in meters refers to the depth zone in which the taxon was found.

	AK(S)	Akp	MTS	TKg10	TKg13	TKp
Butomus umbellatus (flutend)				B	B	B
Callitriche hermaphroditica	B	B	B	B	B	B
Ceratophyllum demersum 0-1m	C	C	C	C	C	C
Ceratophyllum demersum >1m	C	C	C	B	B	B
Ceratophyllum submersum						B
Chara aspera	A	A	B	A	A	A
Chara contraria 0-1m	B	B	B	B	B	B
Chara contraria 1-2m	B	B	B	B	B	A
Chara contraria 2-4m	B	A	B	A	A	A
Chara contraria >4m	A	A	B	A	A	A
Chara delicatula 0-1m	B	A	B	B	B	B
Chara delicatula 1-2m	B	A	B	B	B	A
Chara delicatula >2m	A	A	A	A	A	A
Chara denudata	B	B				
Chara filiformis				A	A	A
Chara globularis 0-1m	B	B	B	B	B	B
Chara globularis 1-2m	B	B	B	B	B	A
Chara globularis 2-4m	B	A	B	A	B	A
Chara globularis >4m	A	A	B	A	A	A
Chara hispida	A	A		A	A	A
Chara intermedia	A	A		A	A	A
Chara polyacantha	A	A		A	A	A
Chara rudis	A	A		A	A	A
Chara strigosa	A					
Chara tomentosa	A	A		A	A	A
Chara vulgaris	B	B		B	B	A
Drepanocladus fluitans			B			
Elatine hexandra			A	A	A	A
Elatine hydropiper			A	A	A	A
Elatine triandra			A	A	A	A
Eleocharis acicularis	B	B	B	B	B	B
Elodea canadensis 0-1m	C	C	C	C	C	C
Elodea canadensis 1-4m	C	C	C	C	C	B
Elodea canadensis >4m	B	C	C	B	B	B
Elodea nuttallii 0-1m	C	C	C	C	C	C
Elodea nuttallii 1-4m	C	C	C	C	C	B
Elodea nuttallii >4 m	B	C	C	C	C	B
Fontinalis antipyretica 0-1m	B	B	B	B	B	B
Fontinalis antipyretica 1-4m	B	B	B	B	B	A
Fontinalis antipyretica >4m	B	B	B	A	A	A
Groenlandia densa	C	C				
Glyceria flutans (flutend)			B			
Hippuris vulgaris	C	B		B	B	B
Isoetes echinospora			A			
Isoetes lacustris			A			
Juncus bulbosus f. fluitans			B			
Lagarosiphon major	C					
Lemna minor	C	C	C	C	C	B
Lemna trisulca 0-2 m	C	C	C	C	C	B
Lemna trisulca 2-4 m	C	C	C	B	C	B
Lemna trisulca > 4 m	B	B	C	B	B	B
Littorella uniflora	A	A	A	A	A	A
Lobelia dortmanna			A			

	AK(S)	Akp	MTS	TKg10	TKg13	TKp
Myriophyllum alterniflorum 0-1m			B	A	A	A
Myriophyllum alterniflorum >1m			A	A	A	A
Myriophyllum spicatum 0-2m	B	B	C	B	B	B
Myriophyllum spicatum >2 m	B	B	B	B	B	B
Myriophyllum verticillatum 0-1m	B	B	C	B	B	A
Myriophyllum verticillatum 1-2m	B	B	C	A	B	A
Myriophyllum verticillatum >2m	B	B	B	A	B	A
Najas flexilis	B	B				
Najas marina ssp. intermedia 0-2m	B	B	C	B	B	B
Najas marina ssp. intermedia 2-4m	B	B	C	B	B	A
Najas marina ssp. intermedia >4m	B	B	C	A	B	A
Najas marina 0-2m	C	C	C	C	C	C
Najas marina 2-4m	C	C	C	C	C	C
Najas marina >4m	C	C	C	C	C	C
Nitella capillaris			A	A	A	A
Nitella flexilis 0-2m	B	B	B	B	B	A
Nitella flexilis 2-4m	B	B	B	A	B	A
Nitella flexilis >4m	A	A	A	A	A	A
Nitella gracilis			A	A	A	A
Nitella mucronata 0-2m	B	B	B	B	B	A
Nitella mucronata 2-4m	B	B	B	A	B	A
Nitella mucronata >4m	A	A	A	A	A	A
Nitella opaca 0-1 m	B	A	B	A	B	A
Nitella opaca > 1 m	A	A	A	A	A	A
Nitella syncarpa	A	A	A	A	A	A
Nitella translucens			A			
Nitellopsis obtusa 0-2m	B	B		B	B	B
Nitellopsis obtusa 2-4m	B	A		A	B	A
Nitellopsis obtusa >4m	A	A		A	A	A
Nuphar lutea	B	B	B	B	B	B
Nymphaea alba	B	B	B	B	B	B
Nymphoides peltatus	B	B	B	B	B	B
Potamogeton acutifolius 0-2 m				B	B	A
Potamogeton acutifolius >2 m				A	A	A
Potamogeton alpinus	A	A		A	A	A
Potamogeton berchtoldii 0-2m	B	B	B	B	B	B
Potamogeton berchtoldii 2-4m	B	B	B	A	B	A
Potamogeton berchtoldii >4m	B	B	A	A	A	A
Potamogeton compressus	C	C		A	B	A
Potamogeton crispus x perfoliatus	B	B	C	B	B	B
Potamogeton crispus 0-1m	C	C	C	C	C	C
Potamogeton crispus 1-4m	C	C	C	C	C	B
Potamogeton crispus >4m	C	C	C	B	B	B
Potamogeton filiformis	A	A	B	A	A	A
Potamogeton friesii 0-2m	C	C	C	B	C	B
Potamogeton friesii 2-4m	B	B	C	B	B	A
Potamogeton friesii >4m	B	B	B	A	B	A
Potamogeton gramineus	A	A	A	A	A	A
Potamogeton lucens 0-1m	C	C	B	B	B	B
Potamogeton lucens 1-2m	C	B	B	B	B	A
Potamogeton lucens 2-4m	B	B	B	A	B	A
Potamogeton lucens >4m	B	B	A	A	A	A
Potamogeton nodosus	C	C	C	B	C	B
Potamogeton obtusifolius	C			B	B	B
Potamogeton natans	B	A	B	A	A	A
Potamogeton pectinatus 0-4 m	C	C	C	B	B	B
Potamogeton pectinatus >4 m	B	B	B	B	B	B
Potamogeton perfoliatus	B	B	B	B	B	B
Potamogeton polygonifolius			A			
Potamogeton praelongus	B	A	B	A	A	A
Potamogeton pusillus 0-1m	C	B	C	B	C	B
Potamogeton pusillus 1-2m	C	B	C	B	B	B
Potamogeton pusillus 2-4m	B	B	C	B	B	B

	AK(S)	Akp	MTS	TKg10	TKg13	TKp
Potamogeton pusillus >4m	B	B	B	A	B	B
Potamogeton rutilus				A	A	A
Potamogeton trichoides 0-1m				B	B	B
Potamogeton trichoides 1-2m				A	B	A
Potamogeton trichoides >2m				A	A	A
Potamogeton x nitens	B	B	B	A	B	A
Potamogeton x zizii	A		B	A	A	A
Ranunculus circinatus 0-1m	C	C	C	C	C	C
Ranunculus circinatus 1-2m	C	C	C	B	C	B
Ranunculus circinatus 2-4 m	C	C	C	B	C	B
Ranunculus circinatus >4 m	C	C	C	B	B	B
Ranunculus eradicatus	A					
Ranunculus peltatus	C	C	B	B	B	A
Ranunculus reptans	B	B				
Ranunculus trichophyllus	C	C	C	B	B	A
Sagittaria sagittifolia (flutend)	C	C	C	C	C	B
Schoenoplectus lacustris (flutend)	B	B	B	B	B	B
Sparganium emersum (flutend)	B	B	B	B	B	B
Spirodela polyrhiza	C	C	C	C	C	B
Sphagnum spp			C			
Stratiotes aloides	B	A		A	A	A
Tolypella glomerata 0-2 m	B	B		A	B	A
Tolypella glomerata 2-4 m	B	A		A	A	A
Tolypella glomerata > 4 m	A	A		A	A	A
Utricularia australis 0-2 m	B	A	B	B	B	A
Utricularia australis 2-4 m	A	A	B	A	B	A
Utricularia australis > 4 m	A	A	B	A	A	A
Utricularia intermedia	A	A	A	A	A	A
Utricularia minor	A	A	A	A		
Utricularia ochroleuca	A	A	A			
Utricularia stygia	A	A	A			
Utricularia vulgaris 0-1m			B	B	B	A
Utricularia vulgaris 1-4m			B	A	B	A
Utricularia vulgaris >4m			B	A	A	A
Zannichellia palustris 0-1m	C	C	C	C	C	C
Zannichellia palustris 1-2m	C	C	C	C	C	B
Zannichellia palustris >2 m	B	B	C	B	B	B

5.1.1.5 Type AK(s)

Criteria for assessment

The **total quantity** of submerged macrophytes at a sampling site must amount to **a minimum of 55**. Below a total quantity of 55 the index must be considered not reliable. Along with other groups of organisms it can only be used as an additional assessment criterion. If natural causes can be excluded, it must be verified if macrophyte depopulation is the possible reason. If exclusively macrophytes are assessed and depopulation is confirmed, the **ecological status class 5** is assigned.

The percentage of *Nuphar lutea* and *Nymphaea alba* must be below 80 % of the total quantity. Otherwise the index must be considered not reliable.

In sampling sites of the subtype **AK** the **absence of macrophytes** cannot be used as an indicator of degradation.

Additional criteria

- if RI > 0 and the vegetation limit is between 5 m und 8 m, the RI is reduced by 20
- if RI > 0 and the lower vegetation limit is less than 5 m, the RI is reduced by 50
- in dominant occurrences (at least 80%) of the following species, the RI is reduced by 50
    - *Elodea canadensis/ nuttallii or*
    - *Myriophyllum spicatum or*
    - *Najas marina subsp. intermedia*
- If due to application of thesecriteria RI < -100, it is set to be -100

5.1.1.6 Type AKp

Criteria for assessment

For a reliable assessment, the total quantity of submerged macrophytes at the site must add up to at least 35. The portion of *Nuphar lutea* and *Nymphaea alba* must be below 80%. If one of these requirements is not met, the index cannot be considered reliable. If natural causes can be excluded, it must be verified if macrophyte depopulation is the possible reason. If exclusively macrophytes are assessed and depopulation is confirmed, the ecological status class 5 is assigned

Also, if the portion of non classified species is at least 25%, the assessment cannot be considered reliable.

Additional criteria

- If RI > 0 and if the vegetation limit is below 4,5 m, the RI is reduced by 50, if the lake has a maximum depth of at least 4,5 m
- If the following species are dominant (at least 80% quantity) the RI is reduced by 50:
    - *Elodea canadensis/ nuttallii or*
    - *Myriophyllum spicatum or*
    - *Najas marina subsp. intermedia*
- If due to application of these criteria RI < -100, it is set to be -100

5.1.1.7 Type MTS

Criteria for assessment

The total quantity of submerged macrophytes at the site must add up to at least 55. Below a total quantity of 55 the index cannot be considered reliable. Along with other groups of organisms it can only be used as an additional assessment criterion. If natural causes can be excluded, it must be verified if macrophyte depopulation is the possible reason. If exclusively macrophytes are assessed and depopulation is confirmed, the ecological status class 5 is assigned

The portion of *Nuphar lutea* und *Nymphaea alba* of the total quantity must be below 80%, otherwise, the index must be considered not reliable.

Additional criteria

- If RI > 0 and the lower vegetation limit is between 5 m und 8 m, RI is reduced by 20
- If RI >0 and the lower vegetation limit is less than 5 m, RI is reduced by 50
- If the following species are dominant (at least 80% quantity) RI is reduced by 50:
    - *Elodea canadensis/ nuttallii or*
    - *Myriophyllum spicatum or*
    - *Najas marina subsp. intermedia*
- If due to application of these criteria RI < -100, it is set to be -100

5.1.1.8 Type TKg10

Criteria for assessment

For a reliable assessment the total quantity of submerged macrophytes at the site must add up to at least 55. The portion of *Nuphar lutea* and *Nymphaea alba* must be below 80%. If one of these requirements is not met, the index cannot be considered reliable. Along with other groups of organisms it can only be used as an additional assessment criterion. If natural causes can be excluded, it must be verified if macrophyte depopulation is the possible reason. If exclusively macrophytes are assessed and depopulation is confirmed, the ecological status class 5 is assigned.

Also, if the portion of non classified species is at least 25%, the assessment cannot be considered reliable.

Additional criteria

- If RI > 0 and the lower vegetation limit is less than 5 m, RI is reduced by 50
- If one of the following species is dominant (at least 80% quantity) RI is reduced by 50:
    - *Elodea canadensis/ nuttallii or*
    - *Myriophyllum spicatum or*
    - *Najas marina subsp. intermedia or*
    - *Potamogeton pectinatus or*
    - *Ceratophyllum demersum or*
    - *Ceratophyllum submersum*
- If due to application of these criteria RI < -100, it is set to be -100

5.1.1.9 Type TKg13

Criteria for assessment

For a reliable assessment the total quantity of submerged macrophytes at the sampling site must add up to at least 55. The portion of *Nuphar lutea* and *Nymphaea alba* must be below 80%. If one of these requirements is not met, the index cannot be considered reliable. Along with other groups of organisms it can only be used as an additional assessment criterion. If natural causes can be

excluded, it must be verified if macrophyte depopulation is the possible reason. If exclusively macrophytes are assessed and depopulation is confirmed, the ecological status class **5** is assigned.

Also, if the portion of non classified species is at least 25%, the assessment cannot be considered reliable.

Additional criteria

- If RI > 0 and if the lower vegetation limit is between 5 m and 8 m, RI is reduced by 20
- If RI > 0 and if the lower vegetation limit is less than 5 m, RI is reduced by 50
- If one of the following species is dominant (at least 80% quantity), RI is reduced by 50
    - *Elodea canadensis/ nuttallii or*
    - *Myriophyllum spicatum or*
    - *Najas marina subsp. intermedia or*
    - *Potamogeton pectinatus or*
    - *Ceratophyllum demersum or*
    - *Ceratophyllum submersum*
- If due to application of these criteria RI < -100, it is set to be -100

5.1.1.10 Type TKp

Criteria for assessment

For a reliable assessment the total quantity of submerged macrophytes at the sampling site must add up to at least 35. The portion of *Nuphar lutea* and *Nymphaea alba* must be below 80%. If one of these requirements is not met, the index cannot be considered reliable. If natural causes can be excluded, it must be verified if macrophyte depopulation is the possible reason. If exclusively macrophytes are assessed and depopulation is confirmed, the ecological status class 5 is assigned

Also, if the portion of non classified species is at least 25%, the assessment cannot be considered reliable.

Additional criteria

- If RI > 0 and if the lower vegetation limit is less than 3 m, the RI is reduced by 50, if the body of water has a maximum depth of at least 3 m
- If the following species are dominant (at least 80% quantity) the RI is reduced by 50:
    - *Elodea canadensis/ nuttallii or*
    - *Myriophyllum spicatum or*
    - *Najas marina subsp. intermedia or*
    - *Potamogeton pectinatus or*
    - *Ceratophyllum demersum or*
    - *Ceratophyllum submersum*
- If due to application of these criteria RI < -100, it is set to be -100

5.2 Diatoms

For assessment of the diatom biocoenosis the modules „Trophic-Index“ and the module „Quotient of Reference Species“ (RAQ) are combined.

5.2.1 Module „Trophic-Index“

For the lakes of southern Germany and the Central German Upland (types 1 to 9 according to MATHES et al. 2002) the trophic index according to HOFMANN (1994, 1999), here called $TI_{Süd(South),}$ is determined. For the lakes of the North German Low Land the trophic index (DIPA) was developed, which describes the state of the lakes of type 10 to 14 according to MATHES et al. (2002) (Schönfelder et al. unpublished). This index, here called $TI_{Nord\ (North),}$ is used with slight deviations for the assessment of the lakes types mentioned.

5.2.1.1 Trophic-Index according to HOFMANN (1999) $TI_{Süd(South)}$

The Indicative species of the trophic index (table 7) found at the littoral site to be assessed and their percentages are the basis for calculating the Trophic Index according to HOFMANN (1999) (compare Equation 2). A sufficient number of indicative species is the prerequisite. If there are less than ten indicative species in the sample, the Trophic Index cannot be considered reliable. In this case, the module Diatoms cannot be evaluated.

Equation 2 Trophic-Index according to HOFMANN (1999) $TI_{Süd}$

$$TI_{Süd} = \frac{\sum_{i=1}^{n} H_i * G_i * T_i}{\sum_{i=1}^{n} H_i * G_i}$$

$TI_{Süd}$ = *Trophic-Index Süd (South)*
H_i = *Percentage of the i-th species*
G_i = *Weighting of the i-th species*
T_i = *Trophic value of the i-th species*

Table 7 **I**ndicative species of the Trophic Index according to HOFMANN (1999) $TI_{Süd\ (South)}$

Taxon	Trophic	Weighting
Achnanthes		
- bahusiensis (GRUNOW) LANGE-BERTALOT	4,5	3
- catenata BILY & MARVAN	4,0	2
- clevei GRUNOW	3,5	2
- daonensis LANGE-BERTALOT	2,5	1
- delicatula (KÜTZING) GRUNOW	5,0	3
- delicatula ssp. engelbrechtii (CHOLNOKY) LANGE-BERTALOT	5,0	3
- didyma HUSTEDT	1,5	3
- exigua GRUNOW	4,0	2
- flexella (KÜTZING) BRUN	1,7	3
- helvetica (HUSTEDT) LANGE-BERTALOT	1,5	3
- holsatica HUSTEDT	3,2	2
- hungarica (GRUNOW) GRUNOW	5,0	3
- kranzii LANGE-BERTALOT	1,5	3
- kuelbsii LANGE-BERTALOT	1,5	3
- lacus-vulcani LANGE-BERTALOT & KRAMMER	1,5	3
- lapidosa KRASSKE	2,0	2
- laterostrata HUSTEDT	1,5	3
- lauenburgiana HUSTEDT	4,5	3

Taxon	Trophic	Weighting
- levanderi HUSTEDT	1,5	3
- marginulata GRUNOW	1,5	3
- minuscula HUSTEDT	4,0	2
- minutissima var. affinis (GRUNOW) LANGE-BERTALOT	4,1	2
- minutissima var. gracillima (MEISTER) LANGE-BERTALOT	1,0	3
- minutissima var. scotica (CARTER) LANGE-BERTALOT	1,8	3
- oblongella OESTRUP	1,5	3
- petersenii HUSTEDT	2,0	2
- ploenensis HUSTEDT	4,5	3
- pseudoswazi CARTER	1,5	3
- pusilla (GRUNOW) DE TONI	1,5	3
- rechtensis LECLERCQ	1,0	3
- rosenstockii LANGE-BERTALOT	2,4	2
- rossii HUSTEDT	1,5	3
- silvahercynia LANGE-BERTALOT	1,5	3
- subatomoides (HUSTEDT) LANGE-BERTALOT	2,0	2
- trinodis (W. SMITH) GRUNOW	1,3	3
- ventralis (KRASSKE) LANGE-BERTALOT	1,5	3
- ziegleri LANGE-BERTALOT	3,8	2
Amphora		
- inariensis KRAMMER	2,5	1
- ovalis (KÜTZING) KÜTZING	4,0	2
- thumensis (MAYER) CLEVE-EULER	2,3	1
- veneta var. capitata HAWORTH	2,2	2
Anomoeoneis		
- sphaerophora (EHRENBERG) PFITZER	5,0	3
Brachysira		
- brebissonii ROSS	1,5	3
- calcicola LANGE-BERTALOT	1,0	3
- hofmanniaea LANGE-BERTALOT	1,0	3
- liliana LANGE-BERTALOT	1,0	3
- neoexilis LANGE-BERTALOT	1,9	2
- serians (BRÉBISSON) ROUND & MANN	1,0	3
- styriaca (GRUNOW) HUSTEDT	1,1	3
- vitrea (GRUNOW) ROSS	1,5	3
- zellensis (GRUNOW) ROUND & MANN	1,0	3
Caloneis		
- aerophila BOCK	1,5	3
- alpestris (GRUNOW) CLEVE	1,9	2
- amphisbaena (BORY) CLEVE	4,5	3
- bacillum (GRUNOW) CLEVE	4,0	2
- latiuscula (KÜTZING) CLEVE	1,0	3
- obtusa (W. SMITH) CLEVE	1,0	3
- tenuis (GREGORY) KRAMMER	1,0	3
Cocconeis		
- neothumensis KRAMMER	3,7	2
- pediculus EHRENBERG	4,4	3
Cymatopleura		
- solea (BRÉBISSON) W. SMITH	4,5	3
Cymbella		
- affinis 1 KÜTZING (siehe in HOFMANN, 1994)	2,4	1
- affinis 2 KÜTZING (siehe in HOFMANN, 1994)	4,1	2
- alpina GRUNOW	1,0	3
- amphicephala NAEGELI	2,2	1
- ancyli CLEVE	2,7	1
- austriaca GRUNOW	1,7	3
- cesatii (RABENHORST) GRUNOW	1,5	3
- cymbiformis AGARDH	1,3	2
- delicatula KÜTZING	1,5	3
- descripta (HUSTEDT) KRAMMER & LANGE-BERTALOT	1,0	3
- falaisensis (GRUNOW) KRAMMER & LANGE-BERTALOT	2,0	2
- gaeumannii MEISTER	1,5	3
- gracilis (EHRENBERG) KÜTZING	1,5	3

Taxon	Trophic	Weighting
- hebridica (GRUNOW) CLEVE	1,5	3
- helvetica KÜTZING var. helvetica	1,7	2
- helvetica var. compacta (OESTRUP) HUSTEDT	4,0	2
- hybrida GRUNOW	1,1	3
- incerta (GRUNOW) CLEVE	1,1	3
- laevis NAEGELI	1,9	2
- lapponica GRUNOW	2,0	3
- mesiana CHOLNOKY	1,5	3
- minuta HILSE	2,0	2
- norvegica GRUNOW	1,5	3
- perpusilla CLEVE-EULER	1,5	3
- prostrata (BERKELEY) CLEVE	4,3	3
- reichardtii KRAMMER	4,4	3
- schimanskii KRAMMER	1,0	3
- simonsenii KRAMMER	1,5	3
- stauroneiformis LAGERSTEDT	1,5	3
- subaequalis GRUNOW	1,6	2
- tumida (BRÉBISSON) VAN HEURCK	4,5	3
- tumidula GRUNOW var. tumidula	1,5	3
- tumidula var. lancettula KRAMMER	1,5	3
Denticula		
- kuetzingii GRUNOW	1,9	2
- tenuis KÜTZING	3,0	1
Diatoma		
- anceps (EHRENBERG) KIRCHNER	2,0	2
- hyemalis (ROTH) HEIBERG	1,5	3
- mesodon (EHRENBERG) KÜTZING	2,0	2
- moniliformis KÜTZING (elliptische bis ovale Sippen)	5,0	3
- problematica LANGE-BERTALOT	5,0	3
- vulgaris BORY	4,4	3
Diploneis		
- elliptica (KÜTZING) CLEVE	2,2	1
- oblongella (NAEGELI) CLEVE-EULER	2,4	2
- ovalis (HILSE) CLEVE	1,0	3
- petersenii HUSTEDT	2,0	2
Eunotia		
- arcubus NÖRPEL & LANGE-BERTALOT	1,5	2
- botuliformis WILD et al.	1,5	3
- diodon EHRENBERG	1,5	3
- fallax A. CLEVE	1,0	3
- flexuosa (BREBISSON) KÜTZING	1,5	3
- glacialis MEISTER	1,5	3
- implicata NÖRPEL et al.	1,5	3
- incisa GREGORY	1,5	3
- meisteri HUSTEDT	1,5	3
- muscicola var. tridentula NÖRPEL & LANGE-BERTALOT	1,5	3
- nymanniana GRUNOW	1,0	3
- pectinalis (DILLWYN) RABENHORST	1,5	3
- praerupta EHRENBERG	1,5	3
- rhomboidea HUSTEDT	1,5	3
- septentrionalis OESTRUP	1,0	3
- silvahercynia NÖRPEL et al.	1,0	3
- sudetica O. MÜLLER	1,0	3
- tenella (GRUNOW) HUSTEDT	1,5	3
Fragilaria		
- acidoclinata LANGE-BERTALOT & HOFMANN	1,5	3
- capucina DESMAZIÈRES var. capucina	4,5	3
- capucina var. amphicephala (GRUNOW) LANGE-BERTALOT	1,6	2
- capucina var. austriaca (GRUNOW) LANGE-BERTALOT	2,5	1
- capucina var. mesolepta (RABENHORST) RABENHORST	4,0	2
- capucina perminuta-Sippe KRAMMER & LANGE-BERTALOT	4,2	2
- capucina var. vaucheriae (KÜTZING) LANGE-BERTALOT	5,0	3
- delicatissima (W. SMITH) LANGE-BERTALOT	2,0	2

Taxon	Trophic	Weighting
- exigua GRUNOW	1,5	3
- famelica (KÜTZING) LANGE-BERTALOT	4,5	3
- fasciculata (AGARDH) LANGE-BERTALOT	5,0	3
- incognita REICHARDT	2,9	1
- nanana LANGE-BERTALOT	2,1	2
- parasitica (W. SMITH) GRUNOW	4,0	2
- pulchella (RALFS) LANGE-BERTALOT	5,0	3
- robusta (FUSEY) MANGUIN	2,5	1
- tenera (W. SMITH) LANGE-BERTALOT	2,5	1
- ulna angustissima-Sippen in KRAMMER & LANGE-B.	5,0	3
- virescens RALFS	2,0	2
Frustulia		
- rhomboides (EHRENBERG) DE TONI	1,5	3
- vulgaris (THWAITES) DE TONI	5,0	3
Gomphonema		
- acutiusculum (O. MÜLLER) CLEVE-EULER	1,5	3
- angustum AGARDH	2,0	2
- augur EHRENBERG	5,0	3
- auritum A. BRAUN	2,5	1
- bavaricum REICHARDT & LANGE-BERTALOT	1,5	3
- bohemicum REICHELT & FRICKE	1,5	3
- dichotomum KÜTZING	2,0	2
- hebridense GREGORY	2,5	1
- helveticum BRUN	1,1	3
- lagerheimii A. CLEVE	1,5	3
- lateripunctatum REICHARDT & LANGE-BERTALOT	1,8	2
- minutum (AGARDH) AGARDH	4,5	3
- occultum REICHARDT & LANGE-BERTALOT	1,8	2
- olivaceum (HORNEMANN) BRÉBISSON var. olivaceum	4,1	2
- olivaceum var. olivaceoides (HUSTEDT) LANGE-BERTALOT	2,5	1
- olivaceum var. olivaceolacuum LANGE-B. & REICHARDT	4,5	3
- parvulum var. parvulius LANGE-BERTALOT & REICHARDT	1,5	3
- procerum REICHARDT & LANGE-BERTALOT	2,0	2
- productum (GRUNOW) LANGE-BERTALOT & REICHARDT	2,5	1
- pseudoaugur LANGE-BERTALOT	5,0	3
- pseudotenellum LANGE-BERTALOT	2,0	2
- pumilum (GRUNOW) REICHARDT & LANGE-BERTALOT	4,3	2
- subtile EHRENBERG	2,5	1
- tenue FRICKE	1,3	3
- tergestinum FRICKE	4,0	2
- vibrio EHRENBERG	1,7	2
Gyrosigma		
- acuminatum (KÜTZING) RABENHORST	4,5	3
- nodiferum (GRUNOW) REIMER	5,0	3
Mastogloia		
- smithii var. lacustris GRUNOW	1,3	3
Meridion		
- circulare (GREVILLE) AGARDH var. circulare	4,0	1
Navicula		
- abiskoensis HUSTEDT	1,5	3
- absoluta HUSTEDT	2,5	1
- angusta GRUNOW	1,5	3
- bacillum EHRENBERG	3,7	2
- canoris HOHN & HELLERMANN	4,5	3
- capitata EHRENBERG var. capitata	5,0	3
- capitatoradiata GERMAIN	4,8	3
- cari EHRENBERG	4,3	3
- cataractarheni LANGE-BERTALOT	2,5	1
- cincta (EHRENBERG) RALFS	5,0	3
- citrus KRASSKE	5,0	3
- clementis GRUNOW	4,0	2
- cocconeiformis GREGORY	2,0	2
- concentrica CARTER	1,8	3

Taxon	Trophic	Weighting
- constans HUSTEDT	4.0	2
- cryptocephala KÜTZING	4.9	3
- cryptofallax LANGE-BERTALOT & HOFMANN	4.5	3
- cuspidata (KÜTZING) KÜTZING	5.0	3
- dealpina LANGE-BERTALOT	1.5	3
- decussis OESTRUP	3.9	2
- densilineolata (LANGE-BERTALOT) LANGE-BERTALOT	1.9	3
- detenta HUSTEDT	1.5	3
- diluviana KRASSKE	2.3	1
- elginensis (GREGORY) RALFS	4.0	2
- erifuga LANGE-BERTALOT	5.0	3
- exilis KÜTZING	2.0	2
- festiva KRASSKE	1.5	3
- gastrum (EHRENBERG) KÜTZING	4.5	3
- gottlandica GRUNOW	1.9	2
- gregaria DONKIN	5.0	3
- halophila (GRUNOW) CLEVE	5.0	3
- heimansioides LANGE-BERTALOT	1.5	3
- hustedtii KRASSKE	4.5	3
- integra (W. SMITH) RALFS	4.5	3
- jaagii MEISTER	1.0	3
- jaernefeltii HUSTEDT	2.5	1
- joubaudii GERMAIN	4.0	2
- laevissima KÜTZING	2.5	1
- lanceolata (AGARDH) EHRENBERG	5.0	3
- leistikowii LANGE-BERTALOT	2.0	2
- lenzii HUSTEDT	2.3	1
- leptostriata JÖRGENSEN	1.5	3
- libonensis SCHOEMAN	5.0	3
- mediocris KRASSKE	1.5	3
- menisculus var. grunowii LANGE-BERTALOT	4.0	2
- minuscula var. muralis (GRUNOW) LANGE-BERTALOT	5.0	3
- monoculata HUSTEDT	5.0	3
- naumannii HUSTEDT	1.0	3
- notha WALLACE	2.0	2
- oligotraphenta LANGE-BERTALOT & HOFMANN	2.0	2
- oppugnata HUSTEDT	4.0	2
- placentula (EHRENBERG) GRUNOW	4.0	2
- porifera var. opportuna (HUSTEDT) LANGE-BERTALOT	1.5	3
- praeterita HUSTEDT	2.2	2
- protracta (GRUNOW) CLEVE	4.5	3
- pseudanglica LANGE-BERTALOT	4.1	2
- pseudobryophila HUSTEDT	1.5	3
- pseudolanceolata LANGE-BERTALOT	4.0	2
- pseudoscutiformis HUSTEDT	1.5	3
- pseudotuscula HUSTEDT	2.5	1
- pygmaea KÜTZING	4.5	3
- recens (LANGE-BERTALOT) LANGE-BERTALOT	5.0	3
- reichardtiana LANGE-BERTALOT var. reichardtiana	4.3	2
- reichardtiana var. crassa LANGE-BERTALOT & HOFMANN	4.3	2
- reinhardtii GRUNOW	4.0	2
- rhynchotella LANGE-BERTALOT	5.0	3
- schadei KRASSKE	2.0	2
- schmassmannii HUSTEDT	1.5	3
- schoenfeldii HUSTEDT	4.1	3
- schroeterii MEISTER sensu lato	5.0	3
- scutelloides W. SMITH	4.5	3
- silesicensis GRUNOW	4.3	3
- soehrensis KRASSKE	1.5	3
- splendicula VAN LANDINGHAM	4.5	3
- stroemii HUSTEDT	1.8	2
- subalpina REICHARDT	2.1	1
- sublucidula HUSTEDT	4.5	3

Taxon	Trophic	Weighting
- submolesta HUSTEDT	1,5	3
- subrotundata HUSTEDT syn. utermoehlii HUSTEDT	4,0	1
- subtilissima CLEVE	1,5	3
- suchlandtii HUSTEDT	1,5	3
- tripunctata (O.F. MÜLLER) BORY	5,0	3
- trivialis LANGE-BERTALOT	5,0	3
- tuscula (EHRENBERG) GRUNOW	1,9	1
- tuscula f. minor in KRAMMER & LANGE-BERTALOT	3,5	2
- variostriata KRASSKE	1,5	3
- viridula var. rostellata (KÜTZING) CLEVE	5,0	3
- vulpina KÜTZING	2,0	2
- wildii LANGE-BERTALOT	1,3	3
Neidium		
- affine (EHRENBERG) PFITZER	1,5	3
- alpinum HUSTEDT	1,5	3
- ampliatum (EHRENBERG) KRAMMER	2,0	2
- binodis (EHRENBERG) HUSTEDT	3,9	2
- bisulcatum (LAGERSTEDT) CLEVE	1,5	3
- iridis (EHRENBERG) CLEVE	1,5	3
Nitzschia		
- acicularis (KÜTZING) W. SMITH	5,0	3
- acula HANTZSCH	5,0	3
- alpina HUSTEDT	1,5	3
- amphibia GRUNOW	5,0	3
- angustatula LANGE-BERTALOT	3,9	2
- bacilliformis HUSTEDT	1,7	3
- bacillum HUSTEDT	2,9	1
- calida GRUNOW	5,0	3
- clausii HANTZSCH	5,0	3
- constricta (KÜTZING) RALFS	5,0	3
- dealpina LANGE-BERTALOT & HOFMANN	2,5	1
- debilis ARNOTT	5,0	3
- dissipata (KÜTZING) GRUNOW var. dissipata	4,7	3
- diversa HUSTEDT	2,1	2
- draveillensis COSTE & RICARD	5,0	3
- fibulafissa LANGE-BERTALOT	2,0	2
- filiformis (W. SMITH) VAN HEURCK	5,0	3
- fonticola GRUNOW	4,5	3
- fossilis GRUNOW	4,5	3
- frustulum (KÜTZING) GRUNOW	5,0	3
- gessneri HUSTEDT	2,1	2
- gisela LANGE-BERTALOT	1,4	3
- heufleriana GRUNOW	4,5	3
- hungarica GRUNOW	5,0	3
- inconspicua GRUNOW	5,0	3
- intermedia HANTZSCH	5,0	3
- levidensis (W. SMITH) GRUNOW	5,0	3
- liebetruthii RABENHORST	5,0	3
- linearis-Sippen (AGARDH) W. SMITH	5,0	3
- microcephala GRUNOW	5,0	3
- paleacea GRUNOW	5,0	3
- pusilla GRUNOW	5,0	3
- radicula HUSTEDT	2,5	1
- regula HUSTEDT	1,3	3
- sigmoidea (NITZSCH) W. SMITH	5,0	3
- sinuata var. delognei (GRUNOW) LANGE-BERTALOT	4,1	2
- sociabilis HUSTEDT	4,5	3
- solita HUSTEDT	5,0	3
- subacicularis HUSTEDT	4,2	3
- supralitorea LANGE-BERTALOT	5,0	3
- tryblionella HANTZSCH	5,0	3
- valdestriata ALEEM & HUSTEDT	4,0	2
- wuellerstorffii LANGE-BERTALOT	4,5	3

Taxon	Trophic	Weighting
Peronia		
- fibula (BREBISSON) ROSS	1.5	3
Pinnularia		
- gibba EHRENBERG var. gibba	4.5	3
- irrorata (GRUNOW) HUSTEDT	1.5	3
- neomaior KRAMMER	1.5	3
- microstauron (EHRENBERG) CLEVE var. microstauron	2.0	2
- nodosa EHRENBERG	1.5	3
- subcapitata GREGORY	1.5	3
Rhoicosphenia		
- abbreviata (AGARDH) LANGE-BERTALOT	4.5	3
Rhopalodia		
- gibba (EHRENBERG) O. MÜLLER var. gibba	4.5	3
- gibba var. parallela (GRUNOW) H. & M. PERAGALLO	1.7	3
Simonsenia		
- delognei (GRUNOW) LANGE-BERTALOT	4.5	3
Stauroneis		
- borrichii (PETERSEN) LUND	1.5	3
- kriegerii PATRICK	4.0	2
- smithii GRUNOW	4.0	2
- undata HUSTEDT	1.5	3
Stenopterobia		
- delicatissima (LEWIS) BRÉBISSON	1.5	3
Surirella		
- brebissonii KRAMMER & LANGE-BERTALOT	5.0	3
- linearis W. SMITH	2.0	2
- minuta BRÉBISSON	5.0	3
- roba LECLERCQ	2.0	2
Tabellaria		
- ventricosa KÜTZING	1.0	3

5.2.1.2 Trophic-Index according to Schönfelder et al. (unpublished) $TI_{Nord(North)}$

The indicative species of the trophic index (Table 8) which were found at the littoral site to be assessed and their percentages are the basis for calculating the Trophic Index according to Schönfelder et al. (unpublished) (Equation 3).

Equation 3 Trophic-Index according to Schönfelder et al. (unpublished) $TI_{Nord(North)}$

$$TI_{Nord} = \frac{\sum_{i=1}^{n} \sqrt{H_i} * T_i}{\sum_{i=1}^{n} \sqrt{H_i}}$$

$TI_{Nord(North)}$ = *Trophic-Index Nord(North)*
H_i = *Percentage of the i-th species*
T_i = *Trophic value of the i-th species*

Table 8 Indicative species of the Trophic Index according to Schönfelder et al. (unpublished), modified TI_{Nord}

Taxon	Trophic
Achnanthes	
- altaica (PORETZKY) CLEVE-EULER	0,38
- clevei GRUNOW	2,25
- clevei var. rostrata	0,00
- conspicua A.MAYER	2,62
- daonensis LANGE-BERTALOT	0,98
- daui FOGED	0,98
- delicatula (KUETZING) GRUNOW	5,43
- didyma HUSTEDT	0,48
- exigua GRUNOW	2,41
- exilis KUETZING	0,00
- flexella (KUETZING) BRUN	0,02
- flexella var. alpestris BRUN	0,54
- helvetica (HUSTEDT) LANGE-BERTALOT	0,48
- holsatica HUSTEDT	1,70
- hungarica (GRUNOW) GRUNOW	6,67
- joursacense HERIBAUD	1,96
- kolbei HUSTEDT	4,12
- kranzii LANGE-BERTALOT	0,48
- kuelbsii LANGE-BERTALOT	0,48
- lacus-vulcani LANGE-BERTALOT & KRAMMER	0,48
- laevis OESTRUP	0,52
- lanceolata ssp. frequentissima LANGE-BERTALOT	2,28
- lanceolata ssp. lanceolata (BREBISSON) GRUNOW	1,15
- lapidosa KRASSKE	0,66
- laterostrata HUSTEDT	0,48
- lauenburgiana HUSTEDT	4,23
- levanderi HUSTEDT	0,38
- marginulata GRUNOW	0,48
- minuscula HUSTEDT	3,04
- minutissima var. affinis (GRUNOW) LANGE-BERTALOT	3,38
- minutissima var. gracillima (MEISTER) LANGE-BERTALOT	0,38
- minutissima var. scotica (CARTER) LANGE-BERTALOT	0,14
- oblongella OESTRUP	0,48
- oestrupii (CLEVE-EULER) HUSTEDT	1,55
- petersenii HUSTEDT	0,66
- ploenensis HUSTEDT	4,23
- pseudoswazi CARTER	0,48
- pusilla (GRUNOW) DE TONI	0,75
- rechtensis LECLERCQ	0,38
- rosenstockii LANGE-BERTALOT	0,09
- rossii HUSTEDT	0,48
- silvahercynia LANGE-BERTALOT	0,48
- straubiana LANGE-BERTALOT	0,00
- subatomoides (HUSTEDT) LANGE-BERTALOT &	0,66
- trinodis (W.SMITH) GRUNOW	0,43
- ventralis (KRASSKE) LANGE-BERTALOT	0,48
- ziegleri LANGE-BERTALOT	1,72
Amphipleura	
- pellucida (KUETZING) KUETZING	1,21
Amphora	
- fogediana KRAMMER	0,90
- inariensis KRAMMER	0,98
- libyca EHRENBERG	3,96
- ovalis (KUETZING) KUETZING	3,26
- pediculus (KUETZING) GRUNOW	2,89
- thumensis (A.MAYER) CLEVE-EULER	0,38
- veneta KUETZING	5,70
- veneta var. capitata HAWORTH	0,77
Anomoeoneis	

Taxon	Trophic
- sphaerophora (EHRENBERG) PFITZER	5,30
Brachysira	
- brebissonii ROSS	0,48
- calcicola LANGE-BERTALOT	0,38
- hofmanniae LANGE-BERTALOT	0,38
- liliana LANGE-BERTALOT	0,38
- neoexilis LANGE-BERTALOT	0,74
- procera LANGE-BERTALOT & MOSER	0,38
- serians (BREBISSON) ROUND & MANN	0,38
- styriaca (GRUNOW) ROSS	0,40
- vitrea (GRUNOW) ROSS	0,48
- zellensis (GRUNOW) ROUND & MANN	0,38
Caloneis	
- aerophila BOCK	0,48
- alpestris (GRUNOW) CLEVE	0,40
- amphisbaena (BORY DE SAINT VINCENT) CLEVE	4,05
- bacillum (GRUNOW) CLEVE	3,21
- latiuscula (KUETZING) CLEVE	0,38
- obtusa (W.SMITH) CLEVE	0,38
- schumanniana (GRUNOW) CLEVE	1,86
- silicula (EHRENBERG) CLEVE	3,25
- tenuis (GREGORY) KRAMMER	0,78
Cocconeis	
- disculus (SCHUMANN) CLEVE	2,02
- neothumensis KRAMMER	2,15
- pediculus EHRENBERG	4,33
- placentula EHRENBERG	3,45
- placentula var. lineata (EHRENBERG) VAN HEURCK	2,93
- placentula var. pseudolineata GEITLER	3,45
Cymatopleura	
- elliptica (BREBISSON) W.SMITH	3,33
- solea (BREBISSON) W.SMITH	4,08
Cymbella	
- affinis KUETZING	1,09
- alpina GRUNOW	0,38
- amphicephala NAEGELI	1,41
- amphicephala var. hercynica (SCHMIDT) CLEVE	0,00
- ancyli CLEVE	1,14
- angustata (W.SMITH) CLEVE	0,00
- aspera (EHRENBERG) CLEVE	2,58
- austriaca GRUNOW	0,54
- caespitosa (KUETZING) BRUN	1,55
- cesatii (RABENHORST) GRUNOW	0,45
- cistula (EHRENBERG) KIRCHNER	2,56
- cuspidata KUETZING	0,77
- cymbiformis J.G.AGARDH	0,71
- delicatula KUETZING	0,48
- descripta (HUSTEDT) KRAMMER & LANGE-BERTALOT	0,38
- ehrenbergii KUETZING	2,36
- elginensis KRAMMER	0,38
- falaisensis (GRUNOW) KRAMMER & LANGE-BERTALOT	0,68
- gaeumannii MEISTER	0,48
- gracilis (EHRENBERG) KUETZING	0,97
- hebridica (GRUNOW) CLEVE	0,48
- helvetica KUETZING	0,50
- helvetica var. compacta (OESTRUP) HUSTEDT	3,04
- hustedtii KRASSKE	1,47
- hybrida GRUNOW	0,40
- incerta (GRUNOW) CLEVE	0,40
- lacustris (J.G.AGARDH) CLEVE	0,04
- laevis NAEGELI	0,62
- lanceolata (EHRENBERG) KIRCHNER	3,60
- lapponica GRUNOW	0,66

Taxon	Trophic
- lata GRUNOW	1,51
- leptoceros (EHRENBERG) KUETZING	0,95
- mesiana CHOLNOKY	0,48
- microcephala GRUNOW	1,02
- minuta HILSE	0,70
- norvegica GRUNOW	0,48
- perpusilla CLEVE-EULER	0,48
- prostrata (BERKELEY) CLEVE	3,39
- reichardtii KRAMMER	3,97
- schimanskii KRAMMER	0,38
- simonsenii KRAMMER	0,48
- sinuata GREGORY	2,79
- stauroneiformis LAGERSTEDT	0,48
- subaequalis GRUNOW	0,83
- subcuspidata KRAMMER	2,14
- tumida (BREBISSON) VAN HEURCK	4,49
- tumidula GRUNOW	0,48
- tumidula var. lancettula KRAMMER	0,48
Denticula	
- kuetzingii GRUNOW	0,97
- tenuis KUETZING	0,80
Diatoma	
- anceps (EHRENBERG) KIRCHNER	0,66
- ehrenbergii KUETZING	0,00
- hyemalis (ROTH) HEIBERG	0,48
- mesodon (EHRENBERG) KUETZING	0,66
- problematica LANGE-BERTALOT	5,74
- tenuis J.G.AGARDH	4,97
- vulgaris BORY DE SAINT VINCENT	5,61
Diploneis	
- elliptica (KUETZING) CLEVE	1,44
- modica HUSTEDT	0,02
- oblongella (NAEGELI) CLEVE-EULER	0,30
- ovalis (HILSE) CLEVE	0,44
- petersenii HUSTEDT	0,66
- subconstricta	0,00
Ellerbeckia	
- arenaria (MOORE) CRAWFORD	3,17
Epithemia	
- adnata (KUETZING) BREBISSON	2,42
- smithii CARRUTHERS	0,00
- sorex KUETZING	2,46
- turgida (EHRENBERG) KUETZING	2,95
Eunotia	
- arcubus NOERPEL & LANGE-BERTALOT	0,62
- bilunaris (EHRENBERG) MILLS	3,66
- botuliformis WILD et al.	1,61
- diodon EHRENBERG	0,48
- exigua (BREBISSON) RABENHORST	0,64
- faba EHRENBERG	0,42
- fallax A.CLEVE	0,38
- flexuosa (BREBISSON) KUETZING	0,48
- formica EHRENBERG	5,86
- glacialis MEISTER	1,81
- hexaglyphis EHRENBERG	0,38
- implicata NOERPEL et al.	1,11
- incisa GREGORY	1,02
- meisteri HUSTEDT	0,38
- muscicola var. tridentula NOERPEL & LANGE-BERTALOT	0,48
- naegelii MIGULA	1,07
- nymanniana GRUNOW	0,38
- pectinalis (DILLWYN) RABENHORST	0,48
- praerupta EHRENBERG	0,48

Taxon	Trophic
- praerupta var. bigibba (KUETZING) GRUNOW	0,48
- rhomboidea HUSTEDT	0,48
- septentrionalis OESTRUP	0,38
- serra EHRENBERG	0,38
- serra var. diadema (EHRENBERG) PATRICK	0,38
- serra var. tetraodon (EHRENBERG) NOERPEL	0,38
- silvahercynia NOERPEL et al.	0,38
- sudetica O.MUELLER	0,38
- tenella (GRUNOW) HUSTEDT	0,48
Fragilaria	
- acidoclinata LANGE-BERTALOT & HOFMANN	0,48
- berolinensis (LEMMERMANN) LANGE-BERTALOT	2,28
- bidens HEIBERG	6,87
- brevistriata GRUNOW	2,81
- capucina DESMAZIERES	3,79
- capucina distans - Sippen KRAMMER & LANGE-BERTALOT	0,38
- capucina var. amphicephala (GRUNOW) LANGE-BERTALOT	0,51
- capucina var. austriaca (GRUNOW) LANGE-BERTALOT	0,98
- capucina var. mesolepta (RABENHORST) RABENHORST	3,82
- capucina var. rumpens (KUETZING) LANGE-BERTALOT	4,12
- capucina var. vaucheriae (KUETZING) LANGE-BERTALOT	5,33
- cyclopum (BRUTSCHY) LANGE-BERTALOT	2,04
- delicatissima (W.SMITH) LANGE-BERTALOT	0,90
- exigua GRUNOW	0,48
- famelica (KUETZING) LANGE-BERTALOT	4,23
- fasciculata (J.G.AGARDH) LANGE-BERTALOT	5,66
- incognita REICHARDT	1,34
- lapponica GRUNOW	2,50
- leptostauron var. dubia (GRUNOW) HUSTEDT	4,18
- leptostauron var. martyi (HERIBAUD) LANGE-BERTALOT	3,98
- nanana LANGE-BERTALOT	1,57
- nitzschioides GRUNOW	5,66
- parasitica (W.SMITH) GRUNOW	3,28
- parasitica var. subconstricta GRUNOW	4,83
- pinnata EHRENBERG	2,57
- pulchella (RALFS) LANGE-BERTALOT	5,92
- robusta (FUSEY) MANGUIN	1,51
- tenera (W.SMITH) LANGE-BERTALOT	1,89
- ulna (NITZSCH) LANGE-BERTALOT	5,27
- ulna angustissima - Sippen KRAMMER & LANGE-BERTALOT	5,74
- ulna var. acus (KUETZING) LANGE-BERTALOT	3,78
- virescens RALFS	0,66
Frustulia	
- rhomboides (EHRENBERG) DE TONI	1,00
- rhomboides var. crassinervia (BREBISSON) ROSS	0,48
- rhomboides var. saxonica (RABENHORST) DE TONI	0,48
- vulgaris (THWAITES) DE TONI	5,71
Gomphonema	
- acuminatum EHRENBERG	3,31
- acutiusculum (O.MUELLER) CLEVE-EULER	0,48
- angustum J.G.AGARDH	0,76
- augur EHRENBERG	4,99
- auritum A.BRAUN	0,27
- bavaricum REICHARDT & LANGE-BERTALOT	0,48
- bohemicum REICHELT & FRICKE	0,48
- clavatum EHRENBERG	4,00
- dichotomum KUETZING	0,61
- gracile EHRENBERG	1,35
- hebridense GREGORY	0,23
- helveticum BRUN	0,40
- insigne GREGORY	5,37
- lagerheimii A.CLEVE	0,48
- lateripunctatum REICHARDT & LANGE-BERTALOT	0,25

Taxon	Trophic
- micropus KUETZING	6,49
- minutum (J.G.AGARDH) J.G.AGARDH	4,23
- occultum REICHARDT & LANGE-BERTALOT	0,57
- olivaceum (HORNEMANN) BREBISSON	4,30
- olivaceum var. minutissimum HUSTEDT	0,98
- olivaceum var. olivaceoides (HUSTEDT) LANGE-BERTALOT	0,98
- olivaceum var. olivaceolacuum LANGE-BERTALOT &	4,23
- parvulum (KUETZING) KUETZING	2,95
- parvulum var. exilissimum GRUNOW	0,98
- parvulum var. parvulius LANGE-BERTALOT & REICHARDT	0,48
- procerum REICHARDT & LANGE-BERTALOT	0,66
- productum (GRUNOW) LANGE-BERTALOT & REICHARDT	0,98
- pseudotenellum LANGE-BERTALOT	0,66
- pumilum (GRUNOW) LANGE-BERTALOT & REICHARDT	2,75
- sarcophagus GREGORY	7,76
- subtile EHRENBERG	0,13
- tenue FRICKE	0,43
- tergestinum FRICKE	3,04
- truncatum EHRENBERG	3,25
- vibrio EHRENBERG	0,77
Gyrosigma	
- attenuatum (KUETZING) RABENHORST	3,62
- nodiferum (GRUNOW) REIMER	4,40
Mastogloia	
- baltica GRUNOW	0,00
- elliptica J.G.AGARDH	0,00
- grevillei W.SMITH	0,00
- smithii THWAITES	0,37
- smithii var. lacustris GRUNOW	0,43
Melosira	
- varians J.G.AGARDH	4,89
Meridion	
- circulare (GREVILLE) J.G.AGARDH	4,92
Navicula	
- abiskoensis HUSTEDT	0,48
- absoluta HUSTEDT	0,60
- atomus (KUETZING) GRUNOW	4,74
- atomus var. permitis (HUSTEDT) LANGE-BERTALOT	5,74
- bacillum EHRENBERG	2,48
- brockmannii HUSTEDT	0,38
- bryophila PETERSEN	0,52
- capitata EHRENBERG	5,37
- capitata var. hungarica (GRUNOW) ROSS	5,37
- capitata var. lueneburgensis (GRUNOW) PATRICK	4,59
- capitatoradiata GERMAIN	4,20
- cari EHRENBERG	3,06
- cariocincta	2,20
- cincta (EHRENBERG) RALFS	2,20
- citrus KRASSKE	5,74
- clementioides HUSTEDT	2,00
- clementis GRUNOW	2,72
- cocconeiformis GREGORY	0,66
- concentrica CARTER	0,40
- constans HUSTEDT	3,04
- costulata GRUNOW	5,86
- cryptocephala KUETZING	3,00
- cryptofallax LANGE-BERTALOT & HOFMANN	4,23
- cryptotenelloides LANGE-BERTALOT	1,37
- cuspidata (KUETZING) KUETZING	4,85
- dealpina LANGE-BERTALOT	0,48
- decussis OESTRUP	3,02
- densilineolata (LANGE-BERTALOT) LANGE-BERTALOT	0,62
- detenta HUSTEDT	0,48

Taxon	Trophic
- diluviana KRASSKE	0,23
- elginensis (GREGORY) RALFS	2,50
- erifuga LANGE-BERTALOT	5,74
- exilis KUETZING	0,66
- explanata HUSTEDT	0,60
- festiva KRASSKE	0,48
- gallica var. perpusilla (GRUNOW) LANGE-BERTALOT	0,48
- gastrum (EHRENBERG) KUETZING	3,57
- goeppertiana (BLEISCH) H.L.SMITH	5,74
- gotlandica GRUNOW	0,22
- gregaria DONKIN	6,76
- halophila (GRUNOW) CLEVE	5,75
- heimansioides LANGE-BERTALOT	0,48
- helensis SCHULZ	0,70
- hustedtii KRASSKE	4,23
- integra (W.SMITH) RALFS	4,23
- jaagii MEISTER	0,38
- jaernefeltii HUSTEDT	0,98
- jentzschii GRUNOW	1,60
- joubaudii GERMAIN	3,04
- krasskei HUSTEDT	0,38
- laevissima KUETZING	2,32
- lanceolata (J.G.AGARDH) EHRENBERG	7,05
- laterostrata HUSTEDT	1,09
- leistikowii LANGE-BERTALOT	0,66
- lenzii HUSTEDT	0,83
- leptostriata JOERGENSEN	0,48
- libonensis SCHOEMAN	5,74
- mediocris KRASSKE	0,48
- menisculus SCHUMANN	4,67
- menisculus var. grunowii LANGE-BERTALOT	3,04
- menisculus var. upsaliensis GRUNOW	4,00
- minuscula var. muralis (GRUNOW) LANGE-BERTALOT	5,74
- minusculoides HUSTEDT	5,74
- molestiformis HUSTEDT	5,74
- monoculata HUSTEDT	5,74
- naumannii HUSTEDT	0,38
- notha WALLACE	0,66
- oblonga KUETZING	2,02
- oligotraphenta LANGE-BERTALOT & HOFMANN	0,11
- oppugnata HUSTEDT	4,62
- placentula (EHRENBERG) GRUNOW	2,64
- porifera HUSTEDT	2,70
- porifera var. opportuna (HUSTEDT) LANGE-BERTALOT	0,48
- praeterita HUSTEDT	0,41
- protracta (GRUNOW) CLEVE	3,23
- pseudanglica LANGE-BERTALOT	3,13
- pseudobryophila (HUSTEDT) HUSTEDT	0,48
- pseudolanceolata LANGE-BERTALOT	3,24
- pseudoscutiformis HUSTEDT	0,42
- pseudotuscula HUSTEDT	1,12
- pseudoventralis HUSTEDT	2,63
- pupula KUETZING	3,01
- pygmaea KUETZING	4,23
- radiosa KUETZING	1,90
- recens (LANGE-BERTALOT) LANGE-BERTALOT	5,74
- reichardtiana LANGE-BERTALOT	3,51
- reinhardtii GRUNOW	3,31
- rhynchotella LANGE-BERTALOT	5,74
- rotunda HUSTEDT	2,90
- saprophila LANGE-BERTALOT	5,74
- schadei KRASSKE	0,66
- schmassmannii HUSTEDT	0,48

Taxon	Trophic
- schoenfeldii HUSTEDT	2,71
- schroeterii MEISTER	5,74
- scutelloides W.SMITH	3,91
- seibigiana LANGE-BERTALOT	2,83
- seminulum GRUNOW	5,70
- slesvicensis GRUNOW	4,65
- soehrensis KRASSKE	0,48
- soehrensis var. hassiaca (KRASSKE) LANGE-BERTALOT	0,48
- soehrensis var. muscicola (PETERSEN) KRASSKE	0,48
- splendicula VAN LANDINGHAM	4,23
- striolata (GRUNOW) LANGE-BERTALOT	2,36
- stroemii HUSTEDT	0,72
- subalpina REICHARDT	0,54
- subhamulata GRUNOW	1,17
- sublucidula HUSTEDT	4,23
- subminuscula MANGUIN	5,74
- submolesta HUSTEDT	0,48
- subplacentula HUSTEDT	2,10
- subrotundata HUSTEDT	2,43
- subtilissima CLEVE	0,48
- suchlandtii HUSTEDT	0,48
- tridentula KRASSKE	0,48
- tripunctata (O.F.MUELLER) BORY DE SAINT VINCENT	5,31
- trivialis LANGE-BERTALOT	4,92
- trophicatrix LANGE-BERTALOT	2,62
- tuscula (EHRENBERG) GRUNOW	1,17
- tuscula f. minor KRAMMER & LANGE-BERTALOT	1,36
- variostriata KRASSKE	0,48
- viridula var. rostellata (KUETZING) CLEVE	5,74
- viridulacalcis	0,50
- vitabunda HUSTEDT	1,09
- vulpina KUETZING	0,71
- wildii LANGE-BERTALOT	0,43
Neidium	
- affine (EHRENBERG) PFITZER	0,48
- alpinum HUSTEDT	0,48
- ampliatum (EHRENBERG) KRAMMER	0,92
- bisulcatum (LAGERSTEDT) CLEVE	0,48
- dubium (EHRENBERG) CLEVE	2,20
- iridis (EHRENBERG) CLEVE	0,48
Nitzschia	
- acicularis (KUETZING) W.SMITH	5,83
- acidoclinata LANGE-BERTALOT	2,85
- acula HANTZSCH	5,74
- agnita HUSTEDT	5,56
- alpina HUSTEDT	0,48
- amphibia GRUNOW	4,99
- amphibia var. frauenfeldii	1,27
- angustata (W.SMITH) GRUNOW	1,76
- angustatula LANGE-BERTALOT	2,84
- bacilliformis HUSTEDT	0,54
- bacillum HUSTEDT	1,34
- calida GRUNOW	5,74
- capitellata HUSTEDT	7,29
- communis RABENHORST	5,74
- commutata GRUNOW	9,72
- constricta (KUETZING) RALFS	6,72
- dealpina LANGE-BERTALOT & HOFMANN	0,98
- debilis ARNOTT	5,74
- dissipata (KUETZING) GRUNOW	3,92
- dissipata ssp. oligotraphenta LANGE-BERTALOT	1,07
- dissipata var. media (HANTZSCH) GRUNOW	2,91
- diversa HUSTEDT	0,71

Taxon	Trophic
- fibulafissa LANGE-BERTALOT	0,66
- filiformis (W.SMITH) VAN HEURCK	5,74
- fonticola GRUNOW	3,72
- fossilis (GRUNOW) GRUNOW	3,65
- gessneri HUSTEDT	0,62
- gisela LANGE-BERTALOT	0,45
- heufleriana GRUNOW	2,78
- homburgiensis LANGE-BERTALOT	0,98
- hungarica GRUNOW	5,74
- inconspicua GRUNOW	5,74
- intermedia HANTZSCH	5,74
- lacuum LANGE-BERTALOT	1,27
- levidensis var. salinarum GRUNOW	8,08
- linearis (J.G.AGARDH) W.SMITH	4,77
- linearis var. subtilis (GRUNOW) HUSTEDT	5,74
- linearis var. tenuis (W.SMITH) GRUNOW	5,74
- microcephala GRUNOW	5,74
- palea (KUETZING) W.SMITH	3,05
- paleacea GRUNOW	3,50
- pusilla GRUNOW	5,74
- radicula HUSTEDT	0,98
- regula HUSTEDT	0,43
- sigmoidea (NITZSCH) W.SMITH	3,40
- sociabilis HUSTEDT	4,23
- solita HUSTEDT	5,74
- subacicularis HUSTEDT	3,49
- supralitorea LANGE-BERTALOT	5,74
- tryblionella HANTZSCH	5,74
- umbonata (EHRENBERG) LANGE-BERTALOT	5,74
- valdecostata LANGE-BERTALOT & SIMONSEN	6,34
- valdestriata ALEEM & HUSTEDT	3,04
- wuellerstorffii LANGE-BERTALOT	5,74
Peronia	
- fibula (BREBISSON) ROSS	0,48
Pinnularia	
- anglica KRAMMER	0,87
- appendiculata (J.G.AGARDH) CLEVE	5,88
- borealis EHRENBERG	2,95
- legumen EHRENBERG	1,76
- mesolepta (EHRENBERG) W.SMITH	2,02
- microstauron (EHRENBERG) CLEVE	2,41
- neomajor KRAMMER	0,48
- nobilis (EHRENBERG) EHRENBERG	4,06
- nodosa (EHRENBERG) W.SMITH	1,72
- polyonca (BREBISSON) W.SMITH	1,23
- rupestris HANTZSCH	2,91
- silvatica PETERSEN	0,48
- subcapitata GREGORY	0,94
- subcapitata var. hilseana (JANISCH) O.MUELLER	0,48
- subgibba KRAMMER	2,16
- subrupestris KRAMMER	4,18
- viridiformis KRAMMER	2,91
Rhoicosphenia	
- abbreviata (J.G.AGARDH) LANGE-BERTALOT	4,35
Rhopalodia	
- gibba (EHRENBERG) O.MUELLER	2,81
- gibba var. parallela (GRUNOW) H.ET M.PERAGALLO	0,54
Simonsenia	
- delognei (GRUNOW) LANGE-BERTALOT	4,23
Stauroneis	
- anceps EHRENBERG	1,72
- borrichii (PETERSEN) LUND	0,48
- kriegerii PATRICK	3,84

Taxon	Trophic
- phoenicenteron (NITZSCH) EHRENBERG	1,27
- siberica	0,00
- smithii GRUNOW	3,04
- undata HUSTEDT	0,48
Stenopterobia	
- curvula (W.SMITH) KRAMMER	0,48
- delicatissima (LEWIS) BREBISSON	0,48
- densestriata (HUSTEDT) KRAMMER	0,48
Surirella	
- angusta KUETZING	7,05
- bifrons EHRENBERG	2,42
- brebissonii KRAMMER & LANGE-BERTALOT	6,83
- linearis W.SMITH	1,69
- linearis f. constricta	0,48
- minuta BREBISSON	5,74
- roba LECLERCQ	0,66
Tabellaria	
- flocculosa (ROTH) KUETZING	1,13
- ventricosa KUETZING	0,38

5.2.2 Module „Quotient of Reference Species“ (RAQ)

The type specific occurrence in different ecological conditions is used to distinguish two species groups (compare 1).

A type specific reference species

C types specific degradation indicator

Table 9: Species groups A and C in the biocoenotic lake types of the Alps, the Alpine Foreland, the Central German Upland and the North German Lowland

DV-Nr	Taxon	1.1	1.2	9	13.1	13.2	10.1	11	10.2	12
6699	Achnanthes altaica			A						
16105	Achnanthes bahusiensis			C						
6835	Achnanthes bioretii				C	C	C		A	A
6246	Achnanthes calcar			A						
16108	Achnanthes carissima			A						
6056	Achnanthes catenata	C	C	C						
6700	Achnanthes chlidanos			A						
6180	Achnanthes clevei	C	C	C						
16111	Achnanthes daonensis			A						
6701	Achnanthes daui			A						
6248	Achnanthes delicatula	C	C	C	C	C	C	C		
16112	Achnanthes delicatula ssp. engelbrechtii	C	C	C	C	C	C	C	C	
16114	Achnanthes didyma			A						
16116	Achnanthes distincta			A						
6986	Achnanthes exigua	C	C	C						
6249	Achnanthes exilis	A	A		A	A	A	A	A	A
6250	Achnanthes flexella	A	A	A	A	A	A	A	A	A
6250	Achnanthes flexella	A	A		A	A	A	A	A	A
6251	Achnanthes flexella var. alpestris	A	A	A	A	A	A	A	A	A
6251	Achnanthes flexella var. alpestris	A	A		A	A	A	A	A	A
16585	Achnanthes grana				C	C	C	C	C	
6253	Achnanthes helvetica			A						
6152	Achnanthes holsatica	C	C	C						
6047	Achnanthes hungarica	C	C	C	C	C	C	C	C	
16118	Achnanthes impexiformis			A						
6255	Achnanthes joursacense			A						

DV-Nr	Taxon	1.1	1.2	9	13.1	13.2	10.1	11	10.2	12
6703	Achnanthes kolbei	C	C		C	C	C			
6256	Achnanthes kranzii			A						
6257	Achnanthes kryophila			A						
16119	Achnanthes kuelbsii			A						
16121	Achnanthes lacus-vulcani			A						
6258	Achnanthes laevis			A	A	A	A	A	A	A
16122	Achnanthes laevis var. austriaca				A	A	A	A	A	A
16123	Achnanthes laevis var. diluviana				A	A	A	A	A	A
6259	Achnanthes laevis var. quadratarea				A	A	A	A	A	A
6260	Achnanthes lanceolata ssp. frequentissima				C					
6261	Achnanthes lanceolata ssp. rostrata				C					
6262	Achnanthes lapidosa			A						
6705	Achnanthes laterostrata			A						
6705	Achnanthes laterostrata			A						
6263	Achnanthes lauenburgiana	C	C	C	C	C	C	C		
6264	Achnanthes levanderi			A						
6706	Achnanthes lutheri			A						
6265	Achnanthes marginulata			A						
16529	Achnanthes microscopica			A						
6266	Achnanthes minuscula	C	C	C	C	C				A
6014	Achnanthes minutissima				A	A	A	A	A	A
6173	Achnanthes minutissima var. affinis	C	C	C						
6240	Achnanthes minutissima var. gracillima	A	A		A	A	A	A	A	A
6267	Achnanthes minutissima var. scotica	A	A	A	A	A	A	A	A	A
6267	Achnanthes minutissima var. scotica	A	A		A	A	A	A	A	A
6267	Achnanthes minutissima var. scotica	A	A		A	A	A	A	A	A
6709	Achnanthes nodosa			A						
6268	Achnanthes oblongella			A						
6270	Achnanthes peragalli			A						
6271	Achnanthes petersenii	A	A		A	A	A	A	A	A
6271	Achnanthes petersenii	A	A	A	A	A	A	A	A	A
6271	Achnanthes petersenii	A	A		A	A	A	A	A	A
6984	Achnanthes ploenensis	C	C	C	C	C	C	C	C	C
16140	Achnanthes pseudoswazi			A						
6272	Achnanthes pusilla	A	A	A	A	A	A	A	A	A
6711	Achnanthes rechtensis			A						
6273	Achnanthes rosenstockii	A	A		A	A	A	A	A	A
16143	Achnanthes rossii			A						
6275	Achnanthes silvahercynia			A						
16662	Achnanthes straubiana				A	A	A	A	A	A
6276	Achnanthes subatomoides			A						
16146	Achnanthes subexigua			A						
6277	Achnanthes suchlandtii			A						
6279	Achnanthes trinodis	A	A		A	A	A	A	A	A
6713	Achnanthes ventralis			A						
6280	Achnanthes ziegleri	C	C	C		A	A	A	A	A
6048	Amphipleura pellucida				A	A	A	A	A	A
6283	Amphora fogediana			A						
16582	Amphora hemicycla				C	C	C	C		
6171	Amphora inariensis			A						
6860	Amphora libyca				C	C				
6044	Amphora ovalis	C	C	C	C	C	C	C	C	C
6288	Amphora thumensis	A	A		A	A	A	A	A	A
6181	Amphora veneta	C	C		C	C	C	C	C	C
6289	Amphora veneta var. capitata	A	A		A	A	A	A	A	A
6049	Anomoeoneis sphaerophora	C	C	C	C	C	C	C	C	C
6291	Brachysira brebissonii			A						
6292	Brachysira calcicola	A	A		A	A	A	A	A	A
16165	Brachysira follis			A						
16166	Brachysira garrensis			A						
6293	Brachysira hofmanniae	A	A		A	A	A	A	A	A
6294	Brachysira liliana	A	A		A	A	A	A	A	A
6295	Brachysira neoexilis	A	A	A	A	A	A	A	A	A

DV-Nr	Taxon	1.1	1.2	9	13.1	13.2	10.1	11	10.2	12
6295	Brachysira neoexilis	A	A		A	A	A	A	A	A
16167	Brachysira procera	A	A	A	A	A	A	A	A	A
6296	Brachysira serians			A						
6297	Brachysira styriaca	A	A	A	A	A	A	A	A	A
6297	Brachysira styriaca	A	A		A	A	A	A	A	A
6298	Brachysira vitrea	A	A		A	A	A	A	A	A
16168	Brachysira wygaschii			A						
6299	Brachysira zellensis	A	A	A	A	A	A	A	A	A
6299	Brachysira zellensis	A	A		A	A	A	A	A	A
6300	Caloneis aerophila			A						
6166	Caloneis alpestris	A	A		A	A	A	A	A	A
6043	Caloneis amphisbaena	C	C	C	C	C	C	C		
6051	Caloneis bacillum	C	C	C	C					
6301	Caloneis latiuscula	A	A		A	A	A	A	A	A
6301	Caloneis latiuscula	A	A		A	A	A	A	A	A
6301	Caloneis latiuscula	A	A	A	A	A	A	A	A	A
6721	Caloneis lauta			A						
6302	Caloneis obtusa	A	A		A	A	A	A	A	A
6302	Caloneis obtusa	A	A	A	A	A	A	A	A	A
6302	Caloneis obtusa	A	A		A	A	A	A	A	A
6304	Caloneis schumanniana	A	A		A	A	A	A	A	A
6810	Caloneis tenuis	A	A		A	A	A	A	A	A
6175	Caloneis undulata			A						
6306	Cocconeis neothumensis	C	C	C						
6020	Cocconeis pediculus	C	C	C						
6058	Cymbella affinis				A	A	A	A	A	A
6310	Cymbella alpina	A	A		A	A	A	A	A	A
6311	Cymbella amphicephala	A	A		A	A	A	A	A	A
6311	Cymbella amphicephala	A	A		A	A	A	A	A	A
6311	Cymbella amphicephala	A	A	A	A	A	A	A	A	A
6739	Cymbella amphicephala var. hercynica	A	A		A	A	A	A	A	A
6740	Cymbella amphioxys			A						
6741	Cymbella angustata			A						
6313	Cymbella austriaca	A	A		A	A	A	A	A	A
16195	Cymbella austriaca var. erdobenyiana	A	A		A	A	A	A	A	A
6314	Cymbella brehmii	A	A	A	A	A	A	A	A	A
6314	Cymbella brehmii	A	A		A	A	A	A	A	A
6183	Cymbella cesatii	A	A		A	A	A	A	A	A
6183	Cymbella cesatii	A	A	A	A	A	A	A	A	A
6059	Cymbella cistula								A	A
6979	Cymbella cymbiformis	A	A		A	A	A	A	A	A
6315	Cymbella delicatula	A	A		A	A	A	A	A	A
6316	Cymbella descripta	A	A	A	A	A	A	A	A	A
6316	Cymbella descripta	A	A		A	A	A	A	A	A
6317	Cymbella elginensis			A						
6318	Cymbella falaisensis	A	A		A	A	A	A	A	A
6318	Cymbella falaisensis	A	A	A	A	A	A	A	A	A
6319	Cymbella gaeumannii	A	A	A	A	A	A	A	A	A
6320	Cymbella gracilis			A						
6321	Cymbella hebridica			A						
6184	Cymbella helvetica	A	A		A	A	A	A	A	A
6323	Cymbella helvetica var. compacta	C	C	C						
6978	Cymbella hustedtii	A	A		A	A	A	A	A	A
6324	Cymbella hybrida	A	A		A	A	A	A	A	A
16581	Cymbella hybrida var. lanceolata	A	A		A	A	A	A	A	A
6325	Cymbella incerta	A	A	A	A	A	A	A	A	A
6325	Cymbella incerta	A	A		A	A	A	A	A	A
6326	Cymbella lacustris						A			
6327	Cymbella laevis	A	A		A	A	A	A	A	A
6328	Cymbella lapponica	A	A	A	A	A	A	A	A	A
6328	Cymbella lapponica	A	A		A	A	A	A	A	A
6331	Cymbella mesiana			A						
6895	Cymbella microcephala				A	A	A	A	A	A

DV-Nr	Taxon	1.1	1.2	9	13.1	13.2	10.1	11	10.2	12
6895	Cymbella microcephala			A	A	A	A	A	A	A
6909	Cymbella minuta	A	A							
6909	Cymbella minuta	A	A	A						
16196	Cymbella naviculacea			A						
6747	Cymbella norvegica			A						
6332	Cymbella obscura			A						
16197	Cymbella paucistriata			A						
6977	Cymbella perpusilla			A	A	A	A	A	A	A
6040	Cymbella prostrata	C	C	C	C					
6333	Cymbella proxima	A	A		A	A	A	A	A	A
6334	Cymbella reichardtii	C	C	C	C					
6749	Cymbella reinhardtii			A						
6335	Cymbella rupicola			A						
16199	Cymbella schimanskii	A	A		A	A	A	A	A	A
6336	Cymbella simonsenii	A	A		A	A	A	A	A	A
6338	Cymbella stauroneiformis			A						
6150	Cymbella subaequalis	A	A	A	A	A	A	A	A	A
6150	Cymbella subaequalis	A	A		A	A	A	A	A	A
6066	Cymbella tumida	C	C	C	C	C	C	C	C	C
6067	Cymbella tumidula	A	A		A	A	A	A	A	A
6339	Cymbella tumidula var. lancettula	A	A		A	A	A	A	A	A
6340	Denticula kuetzingii	A	A		A	A	A	A	A	A
6068	Denticula tenuis	A	A		A	A	A	A	A	A
6167	Diatoma hyemalis			A						
6949	Diatoma mesodon	A	A	A						
6949	Diatoma mesodon	A	A							
16208	Diatomella balfouriana			A						
6341	Diploneis alpina			A						
6807	Diploneis elliptica	A	A		A	A	A	A	A	A
6346	Diploneis oblongella	A	A							
6070	Diploneis ovalis	A	A							
6349	Diploneis petersenii			A						
6754	Entomoneis ornata			A						
6351	Epithemia goeppertiana	A	A		A	A	A	A	A	A
6352	Epithemia smithii	A	A		A	A	A	A	A	A
6998	Eunotia			A						
16666	Eunotia angusta			A						
6354	Eunotia arcubus	A	A		A	A	A	A	A	A
16221	Eunotia arculus			A						
6886	Eunotia arcus			A						
6760	Eunotia arcus var. bidens			A						
16222	Eunotia bilunaris var. linearis			A						
6355	Eunotia bilunaris var. mucophila			A						
6761	Eunotia botuliformis			A						
16223	Eunotia circumborealis			A						
6356	Eunotia denticulata			A						
16667	Eunotia diadema			A						
6357	Eunotia diodon			A						
16224	Eunotia elegans			A						
6975	Eunotia exigua			A						
16225	Eunotia exigua var. undulata			A						
6358	Eunotia faba			A						
6359	Eunotia fallax			A						
6762	Eunotia fallax var. groenlandica			A						
6360	Eunotia flexuosa			A						
6361	Eunotia formica			A						
6362	Eunotia glacialis	A	A	A	A	A	A	A	A	A
6363	Eunotia hexaglyphis			A						
6364	Eunotia implicata			A						
6214	Eunotia incisa			A						
6365	Eunotia intermedia			A						
16226	Eunotia islandica			A						
16104	Eunotia jemtlandica			A						

DV-Nr	Taxon	1.1	1.2	9	13.1	13.2	10.1	11	10.2	12
6366	Eunotia lapponica			A						
6072	Eunotia lunaris			A						
16228	Eunotia major			A						
6367	Eunotia meisteri			A						
6368	Eunotia microcephala			A						
6885	Eunotia monodon			A						
6763	Eunotia monodon var. bidens			A						
6764	Eunotia muscicola var. perminuta			A						
6370	Eunotia muscicola var. tridentula			A						
6371	Eunotia naegelii			A						
16695	Eunotia neofallax			A						
6372	Eunotia nymanniana			A						
6373	Eunotia paludosa			A						
6884	Eunotia paludosa var. trinacria			A						
6765	Eunotia parallela			A						
16533	Eunotia parallela var. angusta			A						
6168	Eunotia pectinalis			A						
6766	Eunotia pectinalis var. undulata			A						
6851	Eunotia praerupta	A	A	A	A	A	A	A	A	A
6767	Eunotia praerupta var. bidens			A						
6374	Eunotia praerupta var. bigibba			A						
6768	Eunotia praerupta var. curta			A						
6769	Eunotia praerupta var. inflata			A						
16229	Eunotia pseudopectinalis			A						
6375	Eunotia rhomboidea			A						
16230	Eunotia rhynchocephala			A						
16231	Eunotia rhynchocephala var. satelles			A						
16232	Eunotia ruzickae			A						
6376	Eunotia septentrionalis			A						
6850	Eunotia serra			A						
6770	Eunotia serra var. diadema			A						
6377	Eunotia serra var. tetraodon			A						
6378	Eunotia silvahercynia			A						
6379	Eunotia soleirolii			A						
6380	Eunotia steineckei			A						
6381	Eunotia subarcuatoides			A						
6382	Eunotia sudetica			A						
6383	Eunotia tenella			A						
16668	Eunotia tetraodon			A						
6771	Eunotia triodon			A						
6827	Eunotia veneris			A						
6908	Fragilaria capucina var. amphicephala	A	A		A	A	A	A	A	A
6389	Fragilaria capucina var. austriaca	A	A		A	A	A	A	A	A
6393	Fragilaria capucina var. mesolepta	C	C	C	C					
6394	Fragilaria capucina var. perminuta	C	C	C	C	C				
6186	Fragilaria capucina var. vaucheriae	C	C	C	C	C				
16234	Fragilaria constricta			A						
6401	Fragilaria exigua			A						
6234	Fragilaria fasciculata	C	C	C	C	C	C	C		
6238	Fragilaria pulchella			C						
6408	Fragilaria robusta	A	A		A	A	A	A	A	A
6169	Fragilaria virescens			A						
6187	Frustulia rhomboides			A						
6412	Frustulia rhomboides var. crassinervia			A						
6413	Frustulia rhomboides var. saxonica			A						
6414	Frustulia rhomboides var. viridula			A						
6079	Frustulia vulgaris	C	C	C						
6417	Gomphonema acutiusculum			A						
16246	Gomphonema amoenum			A						
6819	Gomphonema angustum	A	A		A	A	A	A	A	A
6081	Gomphonema augur			C						
6419	Gomphonema auritum	A	A		A	A	A	A	A	A
6419	Gomphonema auritum	A	A	A	A	A	A	A	A	A

DV-Nr	Taxon	1.1	1.2	9	13.1	13.2	10.1	11	10.2	12
6420	Gomphonema bavaricum	A	A		A	A	A	A	A	A
6421	Gomphonema bohemicum			A						
6423	Gomphonema dichotomum	A	A		A	A	A	A	A	A
6423	Gomphonema dichotomum	A	A		A	A	A	A	A	A
6423	Gomphonema dichotomum	A	A	A	A	A	A	A	A	A
6424	Gomphonema hebridense	A	A	A	A	A	A	A	A	A
6425	Gomphonema helveticum	A	A		A	A	A	A	A	A
6426	Gomphonema lagerheimii			A						
6427	Gomphonema lateripunctatum	A	A		A	A	A	A	A	A
6912	Gomphonema minutum	C	C	C	C	C	C	C		
6429	Gomphonema occultum	A	A		A	A	A	A	A	A
6867	Gomphonema olivaceum	C	C	C	C	C		C		
6430	Gomphonema olivaceum var. minutissimum	A	A	A	A	A	A	A	A	A
6431	Gomphonema olivaceum var. olivaceoides	A	A		A	A	A	A	A	A
6431	Gomphonema olivaceum var. olivaceoides	A	A	A	A	A	A	A	A	A
6432	Gomphonema olivaceum var. olivaceolacuum	C	C	C						
6158	Gomphonema parvulum	C	C		C	C	C			
6434	Gomphonema procerum	A	A		A	A	A	A	A	A
6435	Gomphonema productum			A						
6436	Gomphonema pseudoaugur			C						
6911	Gomphonema pseudotenellum			A						
6437	Gomphonema pumilum	C	C	C	C	C	C		C	
6440	Gomphonema subtile			A						
6441	Gomphonema tenue	A	A		A	A	A	A	A	A
6897	Gomphonema tergestinum	C	C	C						
6999	Gomphonema ventricosum			A						
6442	Gomphonema vibrio	A	A		A	A	A	A	A	A
6036	Gyrosigma acuminatum			C						
6443	Gyrosigma nodiferum			C						
16279	Mastogloia baltica	A	A		A	A	A	A	A	A
16281	Mastogloia elliptica	A	A		A	A	A	A	A	A
6804	Mastogloia grevillei	A	A		A	A	A	A	A	A
6445	Mastogloia smithii var. lacustris	A	A		A	A	A	A	A	A
6026	Meridion circulare			C						
6448	Navicula absoluta	A	A		A	A	A	A	A	A
6448	Navicula absoluta	A	A	A	A	A	A	A	A	A
6018	Navicula accomoda	C	C	C	C	C	C	C	C	C
16717	Navicula adversa			A						
6809	Navicula angusta			A						
16292	Navicula arvensis var. major			C						
6117	Navicula atomus	C	C	C	C	C	C	C	C	C
6241	Navicula atomus var. permitis	C	C	C	C	C	C	C	C	C
6087	Navicula bacillum	C	C	C	C	C	C			A
6460	Navicula brockmannii			A						
6461	Navicula bryophila				A	A	A	A	A	A
6462	Navicula canoris			C						
6868	Navicula capitata	C	C	C	C	C	C			
6966	Navicula capitata var. hungarica	C	C		C	C	C	C	C	
6463	Navicula capitata var. lueneburgensis	C	C		C	C	C			
6910	Navicula capitatoradiata	C	C	C	C	C				
6088	Navicula cari	C	C	C	C	C				
6464	Navicula catalanogermanica							A	A	A
6089	Navicula cincta	C	C	C						
6968	Navicula citrus			C						
6465	Navicula clementioides	C	C		C	C	C	C	C	
6466	Navicula clementis	C	C	C	C	C	C	C	C	C
6969	Navicula cocconeiformis	A	A	A	A	A	A	A	A	A
6969	Navicula cocconeiformis	A	A		A	A	A	A	A	A
6468	Navicula concentrica	A	A		A	A	A	A	A	A
6468	Navicula concentrica	A	A	A	A	A	A	A	A	A
6469	Navicula constans	C	C	C						
6470	Navicula costulata	C	C		C	C	C	C		
6010	Navicula cryptocephala	C	C	C	C	C	C	C	C	C

DV-Nr	Taxon	1.1	1.2	9	13.1	13.2	10.1	11	10.2	12
6471	Navicula cryptofallax			C						
6038	Navicula cuspidata	C	C	C	C	C	C	C		
6472	Navicula dealpina	A	A		A	A	A	A	A	A
16308	Navicula declivis			A						
6473	Navicula decussis	C	C	C	C	C	C			A
6474	Navicula densilineolata	A	A		A	A	A	A	A	A
6475	Navicula detenta			A						
16000	Navicula digitulus			A						
6478	Navicula diluviana	A	A		A	A	A	A	A	A
16001	Navicula disjuncta			A						
6826	Navicula elginensis	C	C	C	C	C	C	C	C	A
6481	Navicula erifuga			C						
6917	Navicula exilis			A						
6485	Navicula festiva			A						
6489	Navicula gallica var. perpusilla			A						
6967	Navicula gastrum	C	C	C						A
6490	Navicula gastrum var. signata	C	C							A
6916	Navicula goeppertiana	C	C	C	C	C	C	C	C	C
6493	Navicula gotlandica	A	A		A	A	A	A	A	A
6015	Navicula gregaria	C	C	C	C	C	C	C	C	C
6833	Navicula halophila	C	C	C	C	C	C	C	C	C
6496	Navicula heimansioides			A						
16324	Navicula hoefleri			A						
6500	Navicula hustedtii			C						
6502	Navicula ignota var. palustris			A						
6812	Navicula integra	C	C	C						
6505	Navicula jaagii	A	A		A	A	A	A	A	A
6505	Navicula jaagii	A	A	A	A	A	A	A	A	A
6506	Navicula jaernefeltii	A	A		A	A	A	A	A	A
6507	Navicula joubaudii			C						
6509	Navicula krasskei			A						
6882	Navicula laevissima	A	A		A	A	A	A	A	A
6882	Navicula laevissima	A	A	A	A	A	A	A	A	A
6864	Navicula lanceolata	C	C	C	C	C	C	C	C	C
16010	Navicula lapidosa			A						
6923	Navicula lenzii	A	A							
16011	Navicula leptostriata			A						
16337	Navicula levanderii			A						
6510	Navicula libonensis			C						
16012	Navicula maceria			A						
6513	Navicula mediocris			A						
6094	Navicula menisculus	C	C		C	C	C	C	C	C
6514	Navicula menisculus var. grunowii	C	C	C	C	C	C			
6515	Navicula minuscula			A						
6872	Navicula minuscula var. muralis			C						
6516	Navicula minusculoides	C	C	C	C	C	C	C	C	C
6219	Navicula molestiformis	C	C	C	C	C	C	C	C	C
6861	Navicula monoculata	C	C	C	C	C	C	C	C	C
16349	Navicula notha			A						
6521	Navicula oligotraphenta	A	A		A	A	A	A	A	A
6522	Navicula oppugnata	C	C	C	C	C	C	C		
6099	Navicula placentula	C	C	C	C	C	C	C		A
16356	Navicula porifera var. opportuna			A						
6524	Navicula praeterita	A	A		A	A	A	A	A	A
6100	Navicula protracta	C	C	C	C	C	C			
6525	Navicula pseudanglica	C	C	C	C	C	C			A
6527	Navicula pseudobryophila			A						
6529	Navicula pseudoscutiformis	A	A	A	A	A	A	A	A	A
6529	Navicula pseudoscutiformis	A	A		A	A	A	A	A	A
16028	Navicula pseudosilicula			A						
6530	Navicula pseudotuscula				C					A
6531	Navicula pseudoventralis				A	A	A	A	A	A
6533	Navicula pusio			A						

DV-Nr	Taxon	1.1	1.2	9	13.1	13.2	10.1	11	10.2	12
6102	Navicula pygmaea			C						
6534	Navicula recens	C	C	C	C	C	C	C	C	C
6221	Navicula reichardtiana	C	C	C	C					
6535	Navicula reichardtiana var. crassa			C						
6104	Navicula reinhardtii	C	C	C	C	C	C	C	C	C
16362	Navicula rhynchotella	C	C	C	C	C	C	C	C	C
6536	Navicula rotunda			A						
6537	Navicula saprophila	C	C	C	C	C	C	C	C	C
6538	Navicula schadei	A	A							
6539	Navicula schmassmannii			A						
6926	Navicula schoenfeldii	C	C	C	C	C				
6540	Navicula schroeterii			C						
6541	Navicula scutelloides	C	C	C	C				A	A
6192	Navicula seminulum	C	C	C	C	C	C	C	C	C
6873	Navicula slesvicensis	C	C	C	C	C	C	C	C	C
6543	Navicula soehrensis			A						
16034	Navicula soehrensis var. hassiaca			A						
6544	Navicula soehrensis var. muscicola			A						
6813	Navicula splendicula			C						
6546	Navicula stroemii	A	A		A	A	A	A	A	A
6547	Navicula subalpina	A	A		A	A	A	A	A	A
6548	Navicula sublucidula			C						
6896	Navicula subminuscula	C	C	C	C	C	C	C	C	C
6549	Navicula submolesta			A						
6550	Navicula subrotundata			C						
6878	Navicula subtilissima			A						
6551	Navicula suchlandtii			A						
6554	Navicula tridentula			A						
6831	Navicula tripunctata	C	C	C	C	C				
6870	Navicula trivialis	C	C	C	C	C	C	C	C	C
16578	Navicula trophicatrix			C						
6989	Navicula tuscula	A	A		A	A	A	A	A	A
6555	Navicula tuscula f. minor	C	C	C	A	A	A	A	A	A
6556	Navicula utermoehlii	C	C	C	C					
16037	Navicula variostriata			A						
6890	Navicula veneta	C	C	C	C	C	C	C	C	C
16736	Navicula ventraloconfusa			A						
6037	Navicula viridula	C	C							
16577	Navicula viridula - Sippen	C	C	C						
6832	Navicula viridula var. linearis				A	A	A	A	A	A
6559	Navicula vitabunda				A	A	A	A	A	A
6560	Navicula vulpina	A	A		A	A	A	A	A	A
6561	Navicula wildii	A	A		A	A	A	A	A	A
16589	Naviculadicta schaumburgii				C	C	C	A	A	A
6820	Neidium affine	A	A	A	A	A	A	A	A	A
6820	Neidium affine	A	A		A	A	A	A	A	A
6563	Neidium alpinum			A						
6564	Neidium ampliatum	A	A		A	A	A	A	A	A
6564	Neidium ampliatum	A	A	A	A	A	A	A	A	A
6856	Neidium binodis			C						
6566	Neidium bisulcatum			A						
6567	Neidium carterii			A						
16383	Neidium densestriatum			A						
6109	Neidium iridis			A						
16386	Neidium ladogensis			A						
6110	Neidium productum			A						
6571	Neidium septentrionale			A						
6965	Nitzschia acula			C						
6575	Nitzschia alpina	A	A	A	A	A	A	A	A	A
16100	Nitzschia alpinobacillum	A	A							
16100	Nitzschia alpinobacillum	A	A	A						
6039	Nitzschia amphibia	C	C	C	C	C				
6991	Nitzschia angustata							A	A	A

DV-Nr	Taxon	1.1	1.2	9	13.1	13.2	10.1	11	10.2	12
6576	Nitzschia angustatula			C						
6577	Nitzschia bacilliformis	A	A		A	A	A	A	A	A
16396	Nitzschia bryophila			A						
16048	Nitzschia calida	C	C	C	C	C	C	C	C	C
6964	Nitzschia capitellata	C	C	C	C	C	C	C	C	C
6193	Nitzschia clausii			C						
6194	Nitzschia communis	C	C	C	C	C	C	C	C	C
6242	Nitzschia constricta	C	C	C	C	C	C	C	C	C
6584	Nitzschia dealpina	A	A		A	A	A	A	A	A
6921	Nitzschia debilis			C						
6008	Nitzschia dissipata	C	C	C	C		C			
6587	Nitzschia diversa	A	A		A	A	A	A	A	A
6589	Nitzschia fibulafissa	A	A		A	A	A	A	A	A
6195	Nitzschia filiformis	C	C	C	C	C	C	C	C	C
6025	Nitzschia fonticola	C	C	C	C	C				
6222	Nitzschia fossilis	C	C	C	C	C	C	C	C	C
6196	Nitzschia frustulum	C	C	C	C	C	C	C	C	C
16749	Nitzschia garrensis			A						
6592	Nitzschia gessneri	A	A		A	A	A	A	A	A
6593	Nitzschia gisela	A	A		A	A	A	A	A	A
6963	Nitzschia heufleriana	C	C	C						
16051	Nitzschia homburgiensis			A						
6114	Nitzschia hungarica	C	C	C	C	C	C	C	C	C
6595	Nitzschia inconspicua	C	C	C	C	C	C	C	C	C
6597	Nitzschia lacuum								A	A
6888	Nitzschia levidensis	C	C	C	C	C	C	C	C	C
16102	Nitzschia levidensis var. salinarum	C	C	C	C	C	C	C	C	C
16423	Nitzschia liebetruthii	C	C	C	C	C	C	C	C	C
6024	Nitzschia linearis	C	C		C	C	C	C		
16560	Nitzschia linearis - Sippen			C						
6599	Nitzschia linearis var. subtilis	C	C		C	C	C	C	C	C
6600	Nitzschia linearis var. tenuis	C	C		C	C	C	C	C	C
6198	Nitzschia microcephala	C	C	C	C	C	C	C	C	
16433	Nitzschia paleaeformis			A						
6925	Nitzschia pusilla			C						
6607	Nitzschia radicula	A	A		A	A	A	A	A	A
6608	Nitzschia regula	A	A		A	A	A	A	A	A
6610	Nitzschia sinuata var. delognei			C						
6961	Nitzschia sociabilis	C	C	C	C	C	C	C	C	
6612	Nitzschia solita			C						
6960	Nitzschia sublinearis				A	A	A	A	A	A
6924	Nitzschia supralitorea	C	C	C	C	C	C	C	C	C
6119	Nitzschia tryblionella			C						
6118	Nitzschia umbonata	C	C	C	C	C	C	C	C	C
16453	Nitzschia valdestriata			C						
6616	Nitzschia wuellerstorffii			C						
6619	Peronia fibula			A						
6151	Pinnularia			A						
6125	Pinnularia microstauron	A	A	A	A	A	A	A	A	A
6842	Pinnularia polyonca			A						
16074	Pinnularia silvatica			A						
16075	Pinnularia spec.[1]			A						
6126	Pinnularia subcapitata			A						
6665	Pinnularia subcapitata var. hilseana			A						
6667	Pinnularia subgibba	A	A		A	A	A	A	A	A
6224	Rhoicosphenia abbreviata	C	C	C	C	C				
6677	Rhopalodia gibba			C	A	A	A	A	A	A
6678	Rhopalodia gibba var. parallela	A	A		A	A	A	A	A	A
16495	Rhopalodia rupestris			A						
6225	Simonsenia delognei			C						
6129	Stauroneis anceps			A						

[1]the attribution as a reference species must specifically be verified for each species referring to autecological literature

DV-Nr	Taxon	1.1	1.2	9	13.1	13.2	10.1	11	10.2	12
16498	Stauroneis anceps var. siberica	A	A		A	A	A	A	A	A
6681	Stauroneis kriegerii	C	C	C						
6840	Stauroneis nobilis			A						
6131	Stauroneis smithii	C	C	C						
6689	Stauroneis undata			A						
16087	Stenopterobia curvula			A						
6690	Stenopterobia delicatissima			A						
16503	Stenopterobia densestriata			A						
6133	Surirella angusta	C	C							
16507	Surirella barrowcliffia			A						
6693	Surirella brebissonii	C	C	C	C	C	C	C	C	C
6135	Surirella linearis			A						
6229	Surirella minuta	C	C	C						
6694	Surirella roba			A						
6137	Surirella robusta			A						
6097	Surirella spiralis			A						
16519	Tabellaria binalis			A						

For assessment the Quotient of Reference Species is determined under consideration of the type specific reference species and their ecological groups. Only the number of species is considered whereas the abundance of the individual species is neglected (compare Equation 4).

Equation 4: Calculation of the Quotient of Reference Species for the siliceous lakes of the Central German Upland

$$RAQ = \frac{Number\ of\ taxa\ A - Number\ of\ taxa\ C}{Number\ of\ taxa\ A + Number\ of\ taxa\ C}$$

So far investigations regarding the required number of taxa for a reliable assessment with the module „RAQ“ are not at hand. The suggestion is to stipulate 12 to be the number of indicative taxa required for a reliable assessment for lakes of the Alps, the Alpine Foreland and the Central German Upland. For lakes of the North German Lowland of the types 13.1, 13.2 and 10.1 12 indicative taxa are suggested as well. For lakes of the North German Lowland of the types 10.2, 11 and 12, 8 indicative taxa are postulated. If the respective values cannot be reached, not even by further screening samples after completion of the described species count, the result of evaluation of the benthic diatoms must be considered not reliable.

5.2.3 Determination of the Diatom-Index ($DI_{Seen/Lakes}$)

The overall assessment of the component Phytobenthos-Diatoms is carried out by a combination of the modules „Trophic-Index (TI)“ and „Quotient of Reference Species (RAQ)“ to obtain the Diatom-Index for lakes (DI_{Seen}). For this purpose the calculated values of both components are transformed according to the following equations (Equation 5 through Equation 8) and the arithmetic mean of the results is determined to obtain the Diatom- $Index_{Seen}$ ($DI_{Seen/Lakes}$).

Equation 5 Transformation of the calculated trophic value $TI_{Süd(South)}$ $TI_{Süd}$

$$M_{TI_{Süd}} = 1 - ((TI_{Süd} - 1) * 0{,}25)$$

$M_{TISüd}$ = *Module Trophic-Index Süd(South)*
$TI_{Süd}$ = *calculated Trophic-Index*$_{Süd(South)}$

Equation 6 Transformation of the calculated trophic value $TI_{Nord(North)}$ (modified according to Schönfelder 2006, unpublished)

$$M_{TINord} = 0{,}8 - 0{,}8 * ((TI_{Nord} - TI_{Nord_{H/G}}) / 2{,}00)$$

M_{TINord} = Module Trophi-Index $_{Nord(North)}$)
0,8 = Module value for transition „very good“/„good“
TI_{Nord} = calculated Trophic-Index$_{Nord(North)}$
$TI_{Nord\ H/G}$ = Value $TI_{Nord(North)}$ of the transition „very good“/„good“(Table 10)
2,00 = Scale width between classes „very good“ and „good“ with the limit of the ecological and the type specific worst Trophic-Index$_{Nord}$ module value 0,00 (at the lower class status class “poor”)

Table 10: Value of the $TI_{Nord(North)}$ at the transition „very good“ – „good“

Type Diatoms	Transition very good/good TI_{Nord}
13.1	1,74
13.2/10.1	2,24
10.2	2,74
14	1,99
11	2,49
12	2,99

If module values calculated with Equation 6 are greater than 1, the result is set to be 1. For values smaller than 0, the value is set to be 0.

Equation 7 Transformation of the type specifically calculated Quotient of Reference Species

$$M_{RAQ} = (RAQ + 1) * 0{,}5$$

M_{RAQ} = Module Quotient of Reference Species
RAQ = calculated Quotient of Reference Species

Equation 8 Calculation of the $DI_{Seen(Lakes)}$

$$DI_{Seen} = \frac{M_{RAQ} + M_{TI}}{2}$$

DI_{Seen} = Diatom-Index$_{Seen(Lakes)}$
M_{RAQ} = Module Quotient of Reference Species
M_{TI} = Module Trophic-Index

6 Overall assessment of lake littoral sites with Macrophytes & Phytobenthos

According to the WFD the **entire group of organisms** Macrophytes & Phytobenthos is considered to be **one of the four biological components** for assessing a body of water. For this reason, the assessment procedures developed for the two subcomponents must be considered as modules or metrics for evaluation of the Water Frame Work Directive.

6.1 Assessment of littoral sites

6.1.1 Combination of the metrics Macrophytes and Diatoms

For the overall assessment of lakes with the biocomponent Macrophytes & Phytobenthos it is indispensable that assessment of the two modules Macrophytes and Diatoms is carried out exactly according to the methods described in this section. Prerequisite for this procedure is the exact determination of the biocoenotic type.

In order to create a basis for comparison for the metrics Macrophytes and Diatoms, the index values must be transformed. A unified scale from "0" to "1" is suitable. The value "1" represents the best ecological status according to the WFD, i.e. status class 1. The value "0" stands for the highest degree of degradation of a water body, i.e. status class 5. The transformation for the module „Macrophytes" (Reference Index, RI) is carried out according to Equation 9. The result of the module "Diatoms" (Diatom $Index_{Seen(Lakes)}$, $DI_{Seen(Lakes)}$) is already on this scale and therefore does not need to transformed.

Equation 9 Transformation of the module $RI_{Seen/Lakes}$ (Reference $Index_{Seen/Lakes}$ Macrophytes) on a scale from 0 to 1.

$$M_{MP} = \frac{(RI_{Seen} + 100) * 0{,}5}{100}$$

M_{MP} = Module Macrophyte Assessment
$RI_{Seen/Lakes}$ = type specifically calculated Reference $Index_{Seen/Lakes}$

Calculation of the index is carried out according to Equation 10. If an individual module cannot be considered reliable, the Macrophyte-Phytobenthos Index for lakes ($M\&P_{Seen/Lakes}$) corresponds to the reliably calculated module. However, the result must critically be verified.

Equation 10 Calculation of the Index $M\&P_{Seen/Lakes}$ for determination of the ecological status in case of two reliable modules.

$$M\&P_{Seen/Lakes} = \frac{M_{MP} + M_D}{2}$$

$M\&P_{seen}$ = Macrophyte & Phytobenthos-Index for lakes
M_{MP} = Module Macrophytes
M_D = Module Diatoms

6.1.2 Determination of the ecological status class

Separated according to ecoregions, the tables 11 to 24 represent the limits of the calculated Index $M\&P_{Seen/Lakes}$ for attribution of the ecological status class according to the WFD. If during assessment a module turns out to be unreliable, the results are kept in mind when interpreting the final result, but will be omitted from determination of the ecological status class according to the WFD. The index limits in case of unreliable individual assessments are also listed in the tables mentioned.

In all ecoregions the reason for an absence of macrophytes and therefore an unreliable module Macrophytes must be determined. If, for example due to physicochemical parameters, structural modifications (embankments), mowing, introduction of fish or other anthropogenic influences a macrophyte depopulation is noticed, an overall assessment of "very good" or "good" (Macrophytes & Phytobenthos) must be downgraded to the status class 3.

Based on the present knowledge acidified and saline lakes cannot be evaluated (regardless of the reasons: natural or anthropogenic).

6.1.2.1 Alps and Alpine Foreland

Assessment with the modules Macrophytes and Diatoms

Table 11 Index limits for classification of the ecological status: lakes of the Alps and Alpine Foreland

MATHES et al. (2002)	Type 1	Types 2, 3, 4	
Macrophytes	AKp	AK(s)	
Diatoms	D 1.2	D 1.1	D 1.2
Ecological status class			
1	1,00 - 0,74	1,00 - 0,81	1,00 - 0,74
2	< 0,74 - 0,47	< 0,81 - 0,54	< 0,74 - 0,47
3	< 0,47 - 0,25	< 0,54 - 0,28	< 0,47 - 0,25
4	< 0,25 - 0,00	< 0,28 - 0,00	< 0,25 - 0,00
5	-	-	-

Assessment with the module Diatoms, to be applied if the module Macrophytes is not reliable

Table 12 Index limits for classification of the ecological status, if the module Macrophytes is unreliable: Lakes of the Alps and Alpine Foreland

MATHES et al. (2002)	Type 1	Types 2, 3, 4	
Diatoms	D 1.2	D 1.1	D 1.2
Ecological status class			
1	1,00 - 0,69	1,00 - 0,83	1,00 - 0,69
2	< 0,69 - 0,44	< 0,83 - 0,58	< 0,69 - 0,44
3	< 0,44 - 0,25	< 0,58 - 0,30	< 0,44 - 0,25
4	< 0,25 - 0,00	<0,30 - 0,00	< 0,25 - 0,00
5	-	-	-

Assessment with the module Macrophytes, to be applied if the module Diatoms is not reliable

Only in rare exceptional cases a correctly taken and processed samples of diatoms cannot be evaluated. If possible, such a site should be sampled again as it must be assumed that a mistake slipped in during sampling or that sampling was carried out immediately after a disturbance of the area adjacent to the sampling site (compare 3.2.5). If the latter is the case, the results of all other modules must be critically checked.

Table 13 Index limits for classification of the ecological status, if the module Diatoms is unreliable: lakes of the Alps and Alpine Foreland

MATHES et al. (2002)	Type 1	Types 2, 3, 4
Macrophytes	AKp	AK(s)
Ecological status class		
1	1,00 - 0,78	1,00 - 0,78
2	< 0,78 - 0,51	< 0,78 - 0,51
3	< 0,51 - 0,26	< 0,51 - 0,26
4	< 0,26 - 0,00	< 0,26 - 0,00
5	- -	- -

6.1.2.2 Central German Upland

Assessment with the module Macrophytes and Diatoms

Table 14 Index limits for classification of the ecological status class: siliceous lakes of the Central German Upland

MATHES et al. (2002)	Type 9
Macrophytes	MTS
Diatoms	D 9
Ecological status class	
1	1,00 - 0,87
2	< 0,87 - 0,53
3	< 0,53 - 0,28
4	< 0,28 - 0,00
5	

Assessment with the module Diatoms, to be applied if the module Macrophytes is unreliable

Table 15 Index limits for the classification of the ecological status, if the module Macrophytes is unreliable: siliceous lakes of the Central German Upland

MATHES et al. (2002)	Type 9
Diatoms	D 9
Ecological status class	
1	1,00 - 0,83
2	< 0,83 - 0,55
3	< 0,55 - 0,30
4	< 0,30 - 0,00
5	-

Assessment with the module Macrophytes, to be applied if the module Diatoms is unreliable

Only in rare exceptional cases a correctly taken and processed samples of diatoms cannot be evaluated. If possible, such a site should be sampled again as it must be assumed that a mistake slipped in during sampling or that sampling was carried out immediately after a disturbance of the area adjacent to the sampling site (compare 3.2.5). If the latter is the case, the results of all other modules must be critically checked.

Table 16 Index limits for classification of the ecological status, if the module Diatoms is unreliable: siliceous lakes of the Central German Upland

MATHES et al. (2002)	Type 9
Macrophytes	MTS
Ecological status class	
1	1,00 - 0,91
2	< 0,91 - 0,51
3	< 0,51 - 0,26
4	< 0,26 - 0,00
5	- -

6.1.2.3 North German Lowland

The type 14 according to MATHES et al. (2002) can only be assessed with the module Macrophytes. The index limits can be found in Table 24 in the category assessment with the module Macrophytes, to be applied if the module Diatoms is unreliable

Assessment with the modules Macrophytes and Diatoms

Table 17 Index limits for classification of the ecological status: stratified lakes of the North German Lowland, type 10 according to MATHES et al. (2002)

MATHES et al. (2002)	Type 10	
Macrophytes	TKg10	
Diatoms	D 10.1	D 10.2
Ecological status class		
1	1,00 - 0,77	1,00 - 0,77
2	< 0,77 - 0,53	< 0,77 - 0,53
3	< 0,53 - 0,29	< 0,53 - 0,29
4	< 0,29 - 0,00	< 0,29 - 0,00
5		

Table 18 Index limits for classification of the ecological status: stratified lakes of the North German Lowland, type 13 according to MATHES et al. (2002)

MATHES et al. (2002)	Type 13	
Macrophytes	TKg13	
Diatoms	D 13.1	D 13.2
Ecological status class		
1	1,00 - 0,80	1,00 - 0,77
2	< 0,80 - 0,53	< 0,77 - 0,53
3	< 0,53 - 0,29	< 0,53 - 0,29
4	< 0,29 - 0,00	< 0,29 - 0,00
5		

Table 19 Index limits for classification of the ecological status: unstratified lakes of the North German Lowland, types 11 and 12 according to MATHES et al.

MATHES et al. (2002)	Type 11	Type 12
Macrophytes	TKp	
Diatoms	D 11	D 12
Ecological status class		
1	1,00 - 0,77	1,00 - 0,77
2	< 0,77 - 0,53	< 0,77 - 0,53
3	< 0,53 - 0,29	< 0,53 - 0,29
4	< 0,29 - 0,00	< 0,29 - 0,00
5		

Assessment with the module Diatoms, to be applied if the module Macrophytes is unreliable

Table 20 Index limits for classification of the ecological status, if the module Macrophytes is unreliable: stratified lakes of the North German Lowland, type 10 according to MATHES et al. (2002).

MATHES et al. (2002)	Type 10	
Diatoms	D 10.1	D 10.2
Ecological status class		
1	1,00 - 0,78	1,00 - 0,78
2	< 0,78 - 0,55	< 0,78 - 0,55
3	< 0,55 - 0,33	< 0,55 - 0,33
4	< 0,33 - 0,10	< 0,33 - 0,10
5	< 0,10 - 0,00	< 0,10 - 0,00

Table 21 Index limits for classification of the ecological status if the module Macrophytes is unreliable: stratified lakes of the North German Lowland, type 13 MATHES et al. (2002)

MATHES et al. (2002)	Type 13	
Diatoms	D 13.1	D 13.2
Ecological status class		
1	1,00 - 0,84	1,00 - 0,78
2	< 0,84 - 0,55	< 0,78 - 0,55
3	< 0,55 - 0,33	< 0,55 - 0,33
4	< 0,33 - 0,10	< 0,33 - 0,10
5	< 0,10 - 0,00	< 0,10 - 0,00

Table 22 Index limit for classification of the ecological status if the module Macrophytes is unreliable: unstratified lakes of the North German Lowland, types 11 and 12 according to MATHES et al. (2002)

MATHES et al. (2002)	Type 11	Type 12
Diatoms	D 11	D 12
Ecological status class		
1	1,00 - 0,78	1,00 - 0,78
2	< 0,78 - 0,55	< 0,78 - 0,55
3	< 0,55 - 0,33	< 0,55 - 0,33
4	< 0,33 - 0,10	< 0,33 - 0,10
5	< 0,10 - 0,00	< 0,10 - 0,00

Assessment with the module Macrophytes, to be applied if the module Diatoms is unreliable

Only in rare exceptional cases a correctly taken and processed samples of diatoms cannot be evaluated. If possible, such a site should be sampled again as it must be assumed that a mistake slipped in during sampling or that sampling was carried out immediately after a disturbance of the area adjacent to the sampling site (compare 3.2.5). If the latter is the case, the results of all other modules must be critically checked.

Table 23 Index limits for classification of the ecological status, if the module Diatoms is unreliable: stratified lakes of the North German Lowland

MATHES et al. (2002)	Type 10	Type 13
Macrophytes	TKg10	TKg13
Ecological status class		
1	1,00 - 0,76	1,00 - 0,76
2	< 0,76 - 0,51	< 0,76 - 0,51
3	< 0,51 - 0,26	< 0,51 - 0,26
4	< 0,26 - 0,00	< 0,26 - 0,00
5	- -	- -

Table 24 Index limits for classification of the ecological status, if the module Diatoms is unreliable: unstratified lakes of the North German Lowland

MATHES et al. (2002)	Types 11, 12,
Macrophytes	TKp
Ecological status class	
1	1,00 - 0,76
2	< 0,76 - 0,51
3	< 0,51 - 0,26
4	< 0,26 - 0,00
5	- -

6.2 Assessment of lake water bodies

For the assessment of lake waterbodies the investigation of a representative number of transect or a survey of the entire lake is **an indispensible prerequisite**. In chapter 2 there is a description of how to determine the number of reqired transects as well as how to chose their position.

The ecological status class according to the WFD is calculated with the data gathered following the instructions in chapter 3 for each transect surveyed in accordance with the rules explained in chapter 4 and chapter5.

Then the mean of status classes determined in that fashion will be taken. The result will be the ecological status class according to the WFD based on the components Macrophytes & Phytobenthos.

6.3 Estimating the expenditure of time

Only experienced specialists familiar with the mapping procedure can only realize the indicated time spans. Untrained workers will need more time.

Macrophytes

The investigations in the field (compare instruction protocol) take 30 to 90 minutes per site depending on the on-site conditions like visual conditions, shoreline morphology and the resulting length of the transect to be investigated as well as the species richness of the plant cover. In addition travelling to the site and preparations on-site (e.g. lowering the boat) need to be considered. For this reason it must be noted that in case of surveying several sites within the same water body the average time required per site is reduced.

It is recommended to have the sampling carried out by at least two people. The additional recording of structural aspects at the most takes ten minutes in addition to mapping the vegetation.

The mapping method with the different sampling devices is easy to carry out, and is an inexpensive sampling procedure, which can easily be applied to most bodies of water. Under certain conditions like strong winds (e.g. wind force 3 or 4) it might make more sense to have mapping carried out by SCUBA divers (KIELER INSTITUT FÜR LANDSCHAFTSÖKOLOGIE 2002). In lakes with occurrences of rare species the more gentle mapping procedure with SCUBA divers should be taken into consideration.

Approximately 60 minutes are necessary for the final determination of species which could not unambiguously be identified in the field (e.g. Characeae).

Diatoms

Determination of the ecological status of a lake section requires the following steps: sampling, preparation of the sampled diatom material, determination of species composition and abundances by counting 500 valves under the light microscope, processing of the data regarding diatom assemblages as well as calculating the required metrics and the resulting ecological status. For sampling (planning and travelling time excluded) approximately 20 minutes are estimated. The mean processing time of the diatom sample depends on the preparation method and the respective number of samples and the size of the available hot plate. For a preparation by oxidation in salt and sulphuric acid with subsequent preservation and mounting of permanent samples the estimated time frame is two to three days – up to 50 samples the additional effort required with increasing number of samples is negligible. Depending on the density of valves in the sample and the diversity of the diatom assemblages, the microscopic evaluation by an expert amounts to approximately one to three hours. For entering the data into a database on average 20 to 30 minutes are estimated.

Overall procedure

An overview of the required time is given in Table 25. The time required for travelling to and finding the respective sampling sites is not considered. As up to 50 diatom samples the time required for processing remains the same (two to three days), the preparation is not listed in the table.

Table 25 Overview of the time required per sampling site and sampling procedure to assess the components Macrophytes & Phytobenthos according to the WFD

	Minimum time frame	**Maximum time frame**	**Mean**
Macrophytes	2 h	3 h	2,5 h
Diatoms	2 h	4 h	3 h
Overall	**4 h**	**7 h**	**5,5 h**

7 Literature

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Figures, Tables and Equations

Figures

Tables

Equations