Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB)

Sampling of Lake Müggelsee (Berlin, Germany) within the long-term ecological research programme of the IGB: Metadata description of sampling and phytoplankton analyses

Phytoplankton Metadata Description

Data storage: IGB Database FRED: https://fred.igb-berlin.de/data/package/29

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Study site description: Müggelsee (area 7.3 km^2, mean depth 4.9m, maximum depth 8.0 m) is a shallow, polymictic, and eutrophic lake lying to the southeast of Berlin, Germany. It is situated between maritime and continental climatic zones, characterized by high intra- and interannual weather variability. The lake has an average retention time of 6 – 8 weeks. Further physiographical and limnological characteristics are described by Driescher et al. (1993).

Lake Müggelsee is one of our prime case study sites within the long-term ecological research programme of the IGB. The lake is affected by global climate change along with a change in trophic state in the early 1990ties. The lake experienced a reduction in external nutrient loading by more than 50% in both total phosphorus (TP) and total nitrogen (TN) loading from the hypereutrophic period (1979-1990) to the eutrophic period (Köhler et al. 2005). An ice cover is usually developed during winter. However, ice cover duration has declined following a trend towards milder winters. Summer surface water temperatures increased by 0.52 °C per decade between 1976 and 2013. The lake is usually mixed during summer- but builds up thermal stratification during times of high air temperatures and calm wind conditions. The number of days, when the lake stratifies during summer has increased along with the warming trend the lake has experienced (Wagner & Adrian 2009).

Sampling protocol: The lake is sampled at weekly intervals during the growing season and at biweekly intervals during periods with ice cover. Between 1979 and 1986, phytoplankton samples were drawn weekly (in winter biweekly) at the deepest section of the lake (M7 in Table 1; integrated from 0.5, 4, and 7m). A detailed description of the sampling strategy is given in Driescher et al. (1993). Since 1987, integrated samples were collected weekly at five different lake stations (see description below). We assume that change in the sampling strategy did not cause a significant bias in the plankton series, as analysis of synchronous zooplankton counts in 1987 (n-15) revealed no significant differences (Wilcoxon-Mann-Whitney: $p>0.1$). Moreover, Schellenberger and Stellmacher (1986) found that seston concentrations were quasi homogeneously distributed across the lake.

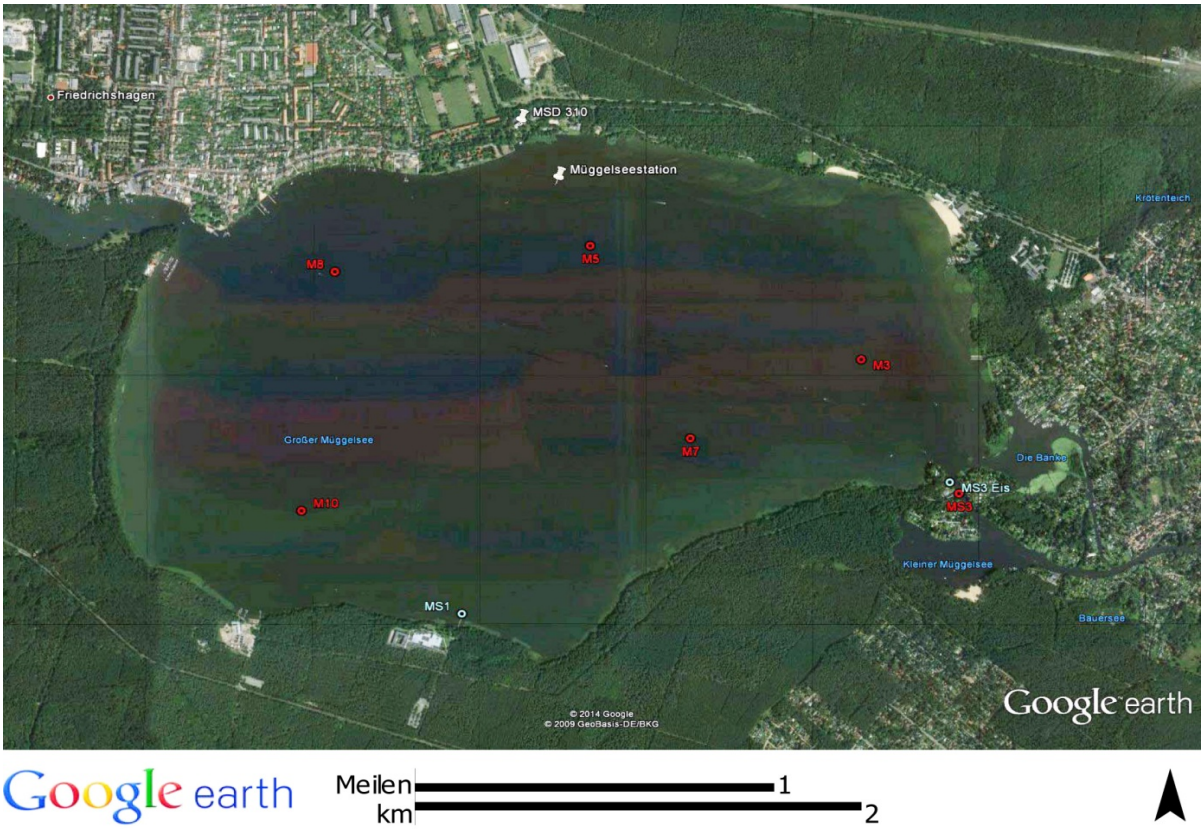

Figure 1: Google Earth Map of Lake Müggelsee: The sampling stations are depicted in red letters. Sample stations during periods of ice cover are depicted in white letters.

Coordinates of sampling stations

(A)

Sampling stations	Coordinates North	Coordinates East
M5	52°26.610`	013°39.142`
M3	52°26.308`	013°40.217`
MS3	52°25.953`	013°40.603`
M7	52°26.099`	013°39.539`
M10	52°25.907`	013°37.967`
M8	52°26.541`	013°38.129`

(B)

Sampling stations	Coordinates North	Coordinates East
MS3 bei Eis	52°25.983`	013°40.566`
MS1 bei Eis	52°25.634`	013°38.633`

Table 1: Locations of the Müggelsee sampling stations during ice free (A) and ice covered (B) periods.

Sampling stations		M5	M3	MS3	MS3 During ice	M7	MS1 During ice	M10	M8
Epilimnion	0.5m	X		X	10l	X	30l	X	X
	1.5m	X	X	X		X		X	X
	2.5m	X				X			X
	3.5m	X				X			X
Hypo-limnion	4.5m	X				X		X	
	5.5m	X				X			
	7.0m					X/**X**			

*Table 2: Depth specific sampling profiles at the different lake stations in Lake Müggelsee depicted by X: During thermal stratification an additional sample is taken at 7m (**X**) for chemical analysis.*

Sampling depths at each sampling station are depicted by (X) in Table 2. At each sampling location 5 liter of lake water are sampled via a transparent Hydro Bios Universal Water Sampler (see picture Figure 2). For accuracy the sampler is lowered via a winch equipped with a depth measurement device.

Integration of samples: The integrated samples derive from samples taken at the differed sampling stations and water depths (Table 2). In Table 3 the sample integration scheme is summarized for ice free and ice covered periods, and for thermally stratified and non stratified periods. MPO stands for the upper 0-4m; MPU stand for the lower 5-7 m. Sample number in table x is for internal use only. Co-ordinates of the different measuring stations are depicted in table 1. During thermally un-stratified conditions all samples are integrated into one sample (MPS in Table 3). During periods of thermal stratification samples from the upper 0-4 m depths and the lower 5-7 m depth are separated. The 4m water depths basically relates to the location of the thermocline. We consider the lake thermally stratified if oxygen concentrations decline by more than 20% between 2m and 5m water depth. During periods of thermal stratification an additional sample is taken at M7 above the sediment for chemical analysis. Samples at 'MS'3 and 'MS3 Ice' are routinely taken.

Thermal regime / Ice cover			Sample acronym	Sample number	Sample stations
No ice		Thermally stratified	**M7**	**202**	**M7**
			MPO	206	M3, M5, M7, M8, M10
			MPU	207	M3, M5, M10
	mixed		MS3	203	MS3
			MPS	208	M3, M5, M7, M8, M10
Ice cover			MS3 Ice	204	MS3
			MS1 Ice	201	MS1

Table 3: Overview of sample description for sample taken during thermally mixed and stratified conditions and during ice free and ice covered periods. MPO: Mixed epilimnetic sample, 0-4m; MPU: mixed hypolimnetic sampl, 5-7m; MPS: sample during non-stratified conditions (mixed; 0-7m). Sample number for internal use only.

In situ measurements: Depths profiles at 0.5 -1m intervals are taken (MS3 and M7) for water temperature (°C); conductivity (µS/sec); pH; oxygen (mg/Liter and % saturation), chlorophyll *a* fluorescence (µg/Liter); depth of the measuring location using an YSI 6600 V2 4 probe.

***Sechii depth**:* Sechii depth readings are performed at station MS3 and M7 using a 25cm diameter white Sechii disk.

Figure 2: Hydro Bios Universal Water Sampler

References:

DriescherE, H. Behrend, G. Schellenberger, R. Stellmacher. 1993. Lake Müggelsee and ist environment, natural conditions and anthropogenic impacts. Int. Rev. Gesammten Hydrobiologie 78:327-343.

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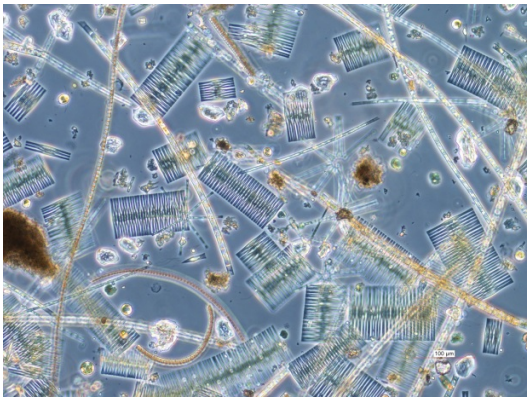
Köhler J. Hilt S., R Adrian, Nicklisch A, HP Kozerski, N. Walz. 2005. Long-term response of a shallow, moderately flushed lake to reduced external phosphorus and nitrogen loading. Freshwater Biology 50:1639-1650.

Wagner, C., **Adrian** R. 2009. Cyanobacteria blooms: Quantifying the effects of climate change. Limnology and Oceanography 54(6): 2460-2468.

Phytoplankton sample processing:



On each sampling date a non fixed concentrated water sample (concentrated through a 5 µm mesh size) is screened for actual species composition in order to guarantee an accurate species determination in the fixed sample. An aliquot of this concentrated sample is preserved in formaldehyde and stored. Since mid 2016 a photo is taken from this concentrated sample on each sampling date. A species list of all phytoplankton taxa, which contribute to the total biovolume estimates (Appendix 1) and a list of stray findings (Appendix 2; single encountered species recorded in the concentrated live sample and in the fixed sample), are given in the Appendix.

For the identification and quantification of the phytoplankton we basically follow descriptions given in:

DIN EN 15204: 2006 -12 (D): Wasserbeschaffenheit – Anleitung für die Zählung von Phytoplankton mittels Umkehrmikroskopie (Utermöhl-Technik). Deutsche Fassung. http://www.beuth.de/de/norm/din-en-15204/88755296

and

TÜMPLING VON, W. & G. FRIEDRICH (Hrsg.) (1999): Methoden der biologischen Wasseruntersuchung, Bd. 2. Jena, Stuttgart, Lübeck, Ulm (G. Fischer Verlag).

Sample preservation: Samples are fixed with Lugol's solution (PADISÀK, KRIENITZ & SCHEFFLER; pages: 35-53*;* SCHWOERBEL 1994).

Lugol's solution:

50 g Potassium Iodide p.a. + 100 ml Aqua dest.
25 g double sublimated Iodine p.a.
250 ml Aqua dest.
25 ml 10% pure acetic acid
Stored in dark bottle; mixed for ca. 4 hours; keep cold

A few drops of the basic Lugol's solution are added to the phytoplankton sample (2 x 100mL bottles) until the sample reaches a 'Cognac like' color. Change in sample volume through adding the preservative are neglected.

Quantitative biovolume determination: Cell number and biovolume are determined using an inverted microscope (Utermöhl 1958). We use sedimentation tube volumes between 2–100 ml with a diameter of 2.5 cm. We use original Hydro-Bios (Kiel) tubes or tubes following the Hydro-Bios prototype that were built in the IGB workshop.

Sedimentation time table according to ROTT (1981)

Tube height (cm):	Sedimentation time (h):
10	40
5	20
2	8
0.4	2

Counting procedure: Transects are counted across the middle of the chamber. If two transects are counted the chamber is turned by 180° for the analysis of a second transect. At least 400 individuals per sample are counted. For large (e.g. C*eratium)* and rare species the entire chamber area is screened and counted. Data are documented in a counting protocol according to the programme developed by HAMILTON (1996); Version 3.1 B.

Determination of cell dimensions: Cell dimensions are determined via an ocular micrometer or a microscope camera. At least 20 individuals per species are measured if individual numbers are n>20. Used magnifications are: 200 x; 400 x; 1000 x. If measuring of the third dimension (including cells in colonies) is not possible we use 'length - width - depth relationships' from the literature. For centric diatoms and cryptophytes we assume that cell length equals half of the cell diameter.

Biovolume determination: Cell biovolume estimates are based on simple geometric forms such as cuboid, sphere, cylinder, cone, spheroid (PADISÀK & ADRIAN 1999, pages 334-351). Cell biovolume estimates for e.g. *Ceratium, Staurastrum, Peridinium, Gymnodinium* are based on a mix of several different geometric forms, which make the best fit to the cell shape. A list of the specific geometric forms used for each species is given in Appendix 3.

Calculation of phytoplankton biomass: The biomass of a single species equals the product of the cell number in the sample and the determined biovolume assuming that:

10^9 µm³ = 1 mm³ = 1 mg (specific weight = 1 g/cm³) =10^6 µm³ = 1 µg

The biomass of all single species is added up to gain the total biomass of the sample. Biomass is given in µg/liter respectively mg/m³. For more detail of the biovolume - biomass relationships see MISCHKE & BEHREND (2007).

Recognition of counting problems or limitations: Cell numbers in colonies can only be an estimate. Counting of filamentous algae go sometimes across the two predetermined chamber transects. Some species such as centric diatoms, *Cryptomonas, Aulacoseira, Peridinium, and Gymnodinium* are assigned to size classes. Please notice: Finding rare species (biomass relevant) is limited if short sedimentation chambers are used. This is the case when total algal mass is high. We refer to rare species here, which are included in the database and contribute to the biovolume calculations. Additionally stray findings of single species in the live sample (see above) or the Utermöhl counts are recorded. A list of stray findings in given in Appendix 2.

Used microscopes: Nicon Diaphot 300; Axiovert 135

Names of processors and their taxonomic skills: The following people processed and counted the Müggelsee phytoplankton samples:

1979 - 1998:	Sigrid Hoeg
1998 - July 2015:	Helgard Täuscher
August 2015-ongoing:	Katrin Preuss

All three processors are skilled phytoplankton taxonomists. Prior to the change of each processor, the new person was trained for one year by the preceding person. Training of the 'new' processor was considered successful if discrepancies between parallel processing of the same sample by the respective

overlapping two processors were in the same range of parallel counting of the same sample by the 'old' processor.

Changes in taxonomic resolution:
Since 1993, 1994, 1995 the taxomonic resolution has been increased due to the expertise of Judith Padisak, who spent several months at the IGB training Sigrid Hoeg. Since then, Aulacosira, centric diatoms, Peridinium, and Gymnodinium were additionally assigned to different size classes. Prior to 1995 unidentified taxa were aggregated on genus or family/class level, and are thus incorporated in the total algal biovolume. That means that the total algal biovolume of the entire time series reflects the total algal mass adequately.

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