Section 2

Phytoplankton biomass metrics - ANNEXES

Content

Annex A – Alpine GIG

Annex A – Part 1: Description of Alpine GIG data basis

The phytoplankton data are collected in a MS Access data base, which was developed by Ute Mischke (Germany) and then slightly adapted for the Alpine GIG. The Rebecca codes are used for all phytoplankton taxa in order to enable future comparisons of data from different GIGs.

Number of lakes and lake years

Table A-1 and Figures A-1 to A-1a to A-1c give an overview on the data basis of the Alpine GIG (status: Feb 2007).

Table A-1. Overview on lakes and sampling sites in the database ALPDAT.

MS	lakes	sampling sites
AT	31	35
FR	1	1
GE	39	44
IT	13	18
SI	2	2
Sum	86	100

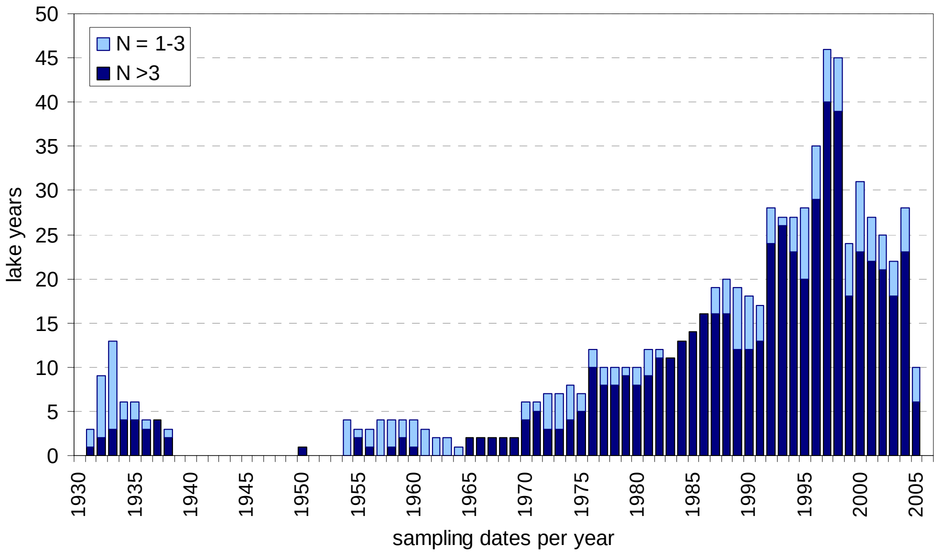


Figure A-1a. Number of data ('lake years', sampling sites within one lake treated separately) per year between 1931 and 2005. Light blue bars = lake years with less than 4 sampling dates per year, dark blue bars = lake years with 4–42 sampling dates per year.

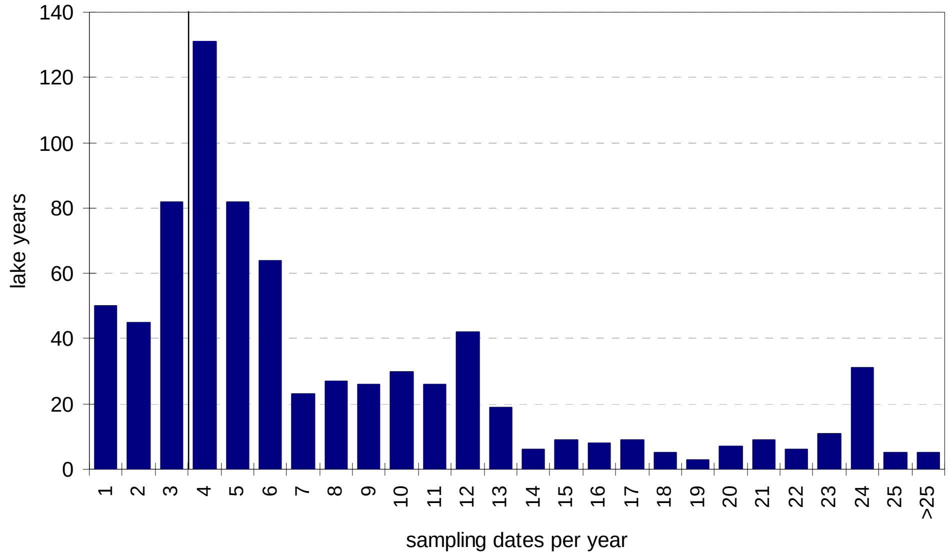


Figure A-1b. Number of lake years with different sampling dates per year.

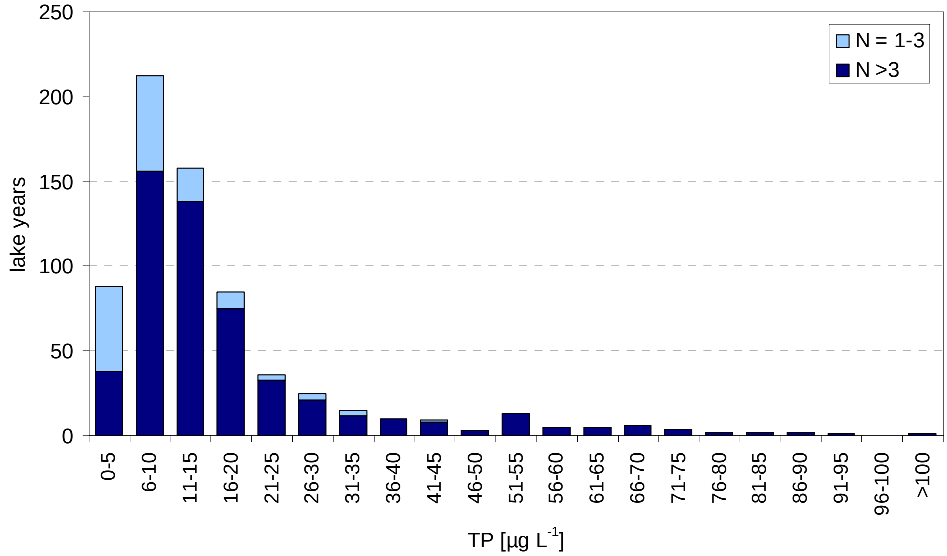


Figure A-1c Distribution of Alpine lakes years along a gradient of TP concentration. Light blue bars indicate lake years with less than 4 sampling dates per year.

Sampling and analysis methods

Sampling frequency: at least 4 sampling dates in most cases; in case of lakes with several lake years occasionally less than 4 sampling dates. The national monitoring programmes starting in 2007 require at least 4 (AT, FR) or 6 (GE, IT) sampling dates.

For the GIG boundaries, the various sampling dates were used to calculate an annual mean (arithmetic mean, no matter how the dates were distributed within the year). The circulation period in late winter/spring was included. For the GE boundaries (national method), the mean of the vegetation period was used, i.e. winter dates and the spring circulation was excluded. It was not calculated as mean of the sampling dates, but weighed by the months.

Sampling sites: usually one sampling site at the deepest point, in some lakes more than 1 sampling site (e.g. Lago di Como, Wolfgangsee), but treated as separate sites

Sampling depth: integrated sample over the euphotic zone or epilimnion or fixed depth (at least 0–6 m, up to 0–21 m), never single depth samples

Analytical method total biovolume: Utermöhl (1958)

Analytical method chlorophyll-a: extraction using ethanol or acetone, turbidity correction after Lorenzen (1967), spectral photometry or HPLC

Annex A – Part 2: Description of national classification systems

Austrian classification method on phytoplankton

a) Status

Agreed method. No official scientific publications, but various technical reports for the Ministry of Agriculture and Forestry, Environment and Water Management. The final version (in German and English) of the method is available on the homepage of the Ministry („)

b) Metrics and approach

The method includes 2 metrics: biovolume (biomass) and the "Brettum index". Planktonic blooms are not regarded as they occur too rarely and irregularly (if at all) to include them in a routine monitoring.

The total biovolume is the arithmetic annual mean of several sampling dates. It is derived by countings (abundance) after Utermöhl (1958) and calculating the biovolume (biomass) using taxon-specific cell volumes (*cf.* Rott 1981, EN 15204, draft "N96 CEN TC 230/WG 2/TG 3").

The Brettum index is a trophic index developed by Dokulil (2001, 2003) and Dokulil *et al.* (2005) after Brettum (1989). It is based on the probability of occurrence of phytoplankton taxa within five trophic classes (defined by total phosphorus concentration). Each taxon is given a trophic score. The index thus mirrors the taxonomic composition as required by the WFD.

The chlorophyll-a concentration is not part of the AT phytoplankton classification method, but can be used additionally for trophic assessment.

Class boundaries for the total biovolume are the same as the agreed GIG values. Class boundaries for the Brettum index are derived from a regression with the total biovolume (see Technical Report, equation 1 in chapter 2.1.4) and validated using the spatial approach of the common BSP (GIG data set, median of reference sites) as well as on the basis of changes of relative proportions of sensitive and tolerant taxa. The EQR values of both metrics are linearised by using logarithmic (biovolume) or linear (Brettum index) regression equations. The normalised EQRs of the two metrics are finally equally weighed and so give a final EQR for the site (Wolfram *et al.* 2006, BMLFUW 2007).

German classification method on phytoplankton

a) Status

The principal approach is described in Nixdorf *et al.* (2005a). The final report (Nixdorf *et al.* 2005b) is currently reviewed and the method is the final test phase. (Download current report version March 2006:

http://www.tu-cottbus.de/BTU/Fak4/Gewschu/downloads/projekte/meckpom/bericht_bewertung_seen_2006.pdf

The version has been improved in spring 2007 and finalised in June 2007 (Download of the current version: http://unio.igb-berlin.de/abt2/mitarbeiter/mischke/#Downloads).

b) Metrics and approach

The assessment procedure leads to a multimetric index (weighted average) and works with at least 3 metrics (for latest version see download):

1. Metric total biomass (result: normalized EQR):
Average composed of assessment values of the three biomass parameters

a) total biovolume of phytoplankton in the epilimnic or euphotic zone of the lake (arithmetic mean in the vegetation period from April to October (optional with March and November) with at least 6 samples per year, 4 samples during May to September)
b) chlorophyll-a concentration (arithmetic mean in the vegetation period from March to November)
c) maximum chlorophyll-a (only applicable if it deviates from mean chl-a by more than 25% and if the sampling period covers more than 2 months)

2. Metric algae classes: mean biovolume (in case of cyanobacteria, chlorophytes) or its percentage of total biovolume (in case of chrysophytes, dinophytes during specific time periods (July to October or whole season)). Result: Mean value combining all algal classes, expressed as normalized EQR.

3. Metric PTSI (abbreviation for 'Phytoplankton-Taxa-Seen-Index'): evaluates species composition based on lake-type specific lists of indicator species and their special trophic scores and weighting factors. The method works in two steps: 1. trophic assignment (result: PTSI per sample or lake year). 2. assessment by comparing current trophic state with the lake type specific trophic reference status (result: normalized EQR)

Especially for the German lowland lakes there is an additional metric in test, *viz.* the composition of planktonic diatoms (abundance = no. of cells) collected from the upper zone of the profundal sediment. It is not applied to Alpine lakes.

The class boundaries for the total biovolume and the metric algae classes are derived by using a pre-assignment of ecological quality of the lakes. The assignment was based on the German LAWA-Index, the estimation of local experts and in consideration of the lake-type specific trophic reference state (modelling approach).

The trophic reference status of lake types are defined with a view to paleo-limnological investigations, true reference sites without anthropogenic impact (spatial approach) and ideas about background concentrations ot total phosphorus and morphometric conditions in lakes (modeling approach). It is given as a trophic class according to the German LAWA-approach for assessing lakes (LAWA 1999).

The trophic scores of indicator species for the PTSI were developed along the trophic gradient German LAWA-index, total phosphorus concentration and biovolume mean value per lake year. See Technical Report, section 2.1.4\5 and 2.1.5\2.

Combination rules: The metrics are not combind using the one-out-all-out principle, but using a weighted average.

Weightds for L-AL3 lakes: algal classes = 1, biomass = 2, PTSI = 4

Weightds for L-AL4 lakes: algal classes = 1, biomass = 2, PTSI = 2

c) Method standardisation

The German assessment procedure includes and requires a fixing of standardised methods for: 1. sampling, 2. preservation and storing, 3. microscopic analysis (counting, determination level, taxonomical encoding based on the "harmonized German taxa list". Download of the current version: http://unio.igb-berlin.de/abt2/mitarbeiter/mischke/#Downloads).

Italian classification method on phytoplankton

a) Status

A phytoplankton classification method using a trophic index was developed for large deep Subalpine lakes and is already published in a scientific journal (Salmaso *et al.* 2006). An extended version of this method suitable for the other lakes types is currently under development. Buzzi *et al.* (2007) developed a new index for small and medium sized lakes.

b) Metrics and approach

The method includes 4 metrics: biovolume, $PTI_{species}$, PTI_{orders} and PTI_{ot}. No WFD compliant method, which combines all metrics, is currently used in Italy. It will be implemented soon.

Sampling frequency used to define the indices was monthly. No particular season or period of the year was excluded.

The total biovolume is derived by countings with Utermöhl technique (1958) and calculating the biovolume using taxon-specific cell volumes formulae (*cf.* Rott 1981, prEN 15204, draft "N96 CEN TC 230/WG 2/TG 3").

Two trophic indices $PTI_{species}$ and PTI_{orders} were drawn up on the basis of the distribution of phytoplankton along a trophic gradient defined by multivariate methods. Algal orders and species have their own trophic score. The two indices are obtained by the biovolume weighted mean of the scores. The trophic scores were assigned to five classes comprised in the interval 1–5 in accordance with WFD. ($PTI_{species}$ is applied to the large sub-Alpine lakes such as Lago di Como and Lago Maggiore only. Within the IC exercise it is also applied to Lake Constance and Lac Léman.)

The index PTI_{ot} was derived taking into account the "niche centroid" approach suggested by ter Braak *et al.* (1995). As a principle, two values for each species are calculated with respect to the gradient of TP concentration for all the lakes considered, an optimum concentration and a tolerance: their ratio allows to derive a trophic score, which is used for the final calculation of PTI_{ot}. The index is applied to all Alpine lakes except large sub-Alpine lakes.

The metrics are not combined in an one-out-all-out-principle. Detailled combination rules will be defined in near future.

Annex A – Part 3: Specific criteria for selecting phytoplankton reference sites

1. In the Alpine region, historical data on phytoplankton are available from the 1930ies from Carinthian lakes (Findenegg 1932–1954, Reichmann & Schulz 2004) and from several lakes in the Northern Calcareous Alps (Ruttner 1937). The time before the Second World War is considered as "reference period" in most cases, as there was no significant anthropogenic pressure on most lakes from industrialisation, intensive urbanisation or agriculture (Reichmann & Schulz 2004; *cf.* EC, 2003a: section 3.4.1). A high discharge of nutrients into lakes and subsequent eutrophication has been however described from some Alpine lakes already in the 19th century, especially in several Swiss lakes with intensive urbanisation (*e.g.*, Müller & Stadelmann 2004, www.esf.edu). Amann (1918 *cit.* in Dokulil 2001) mentions an *Anabaena* bloom in the Bavarian Weßlinger See at the beginning of the 20th century. Also paleolimnological data confirm that some Alpine lakes suffered from anthropogenic eutrophication already more than 100 years ago due to major urbanisation (*e.g.* Feuillade *et al.* 1995, Guilizzoni *et al.* 1986, Guilizzoni & Lami 1992).

Measurements on transparency are available from several lakes from the beginning of the 20th century, partly dating back even to the second half of the 19th century. They can partly be used for validation of the reference trophic state.

(Historical data on macrophytes are mostly of little value. One of the few exceptions are the descriptions of Brand (1896) on the vegetation of Starnberger See, which indicate an oligotrophic state of the lake at that time.)

2. Sites are accepted as reference sites in terms of the trophic state if the actual trophic state does not deviate from the reference trophic state prior to industrialisation, intensive urbanisation or agriculture. From paleo-reconstruction (*e.g.*, Löffler 1972, Guillizzoni *et al.* 1982, 1983, Klee & Schmidt 1987, Schmidt 1989, 1991, Danielopol & Casale 1990, Henschel *et al.* 1992, Schaumburg 1992, 1996, Klee *et al.* 1993, Marchetto & Bettinetti 1995, Alefs *et al.* 1996, Voigt 1996, Loizeau *et al.* 2001, Marchetto & Musazzi 2001, IGKB 2004a, A. Marchetto pers. comm.) and theoretical considerations using the Vollenweider phosphorus loading model (Vollenweider 1976, OECD 1982) it was concluded that oligotrophy is the natural reference trophic state of deep Alpine lakes (L-AL3).

Lakes belonging to the IC type L-AL4, however, tend to have a higher trophic level. This is proved again by loading model calculations and paleo-reconstruction (*e.g.*, Frey 1955, 1956, Löffler 1972, 1978, 1997, Danielopol *et al.* 1985, Higgit *et al.* 1991 *cit.* in Gerdeaux & Perga 2006, Lotter 2001, Schmidt *et al.* 2002, Hofmann & Schaumburg 2005a, 2005b; *cf.* also Kamenik *et al.* 2000). In several L-AL4 lakes, the critical export rate (calculated from the critical load after Vollenweider) is lower than the potential natural *TP* export rate (*cf.* LAWA 1999, ON M 6231, Barbiero 1991, Pagnotta & Barbiero 2003 [both *cit.* in Buraschi *et al.* 2005], Dokulil *et al.* 2001). Hence, for L-AL4 sites, oligo-mesotrophy is suggested as general reference trophic state. It has however to be stressed that there are some lakes among lake type L-AL4 that are clearly oligotrophic (proved by paleo-reconstruction: Hofmann & Schaumburg 2005a & b, but also by monitoring data, *e.g.* Pressegger See/AT: www.kis.ktn.gv.at). Some shallow lakes might even be mesotrophic under natural conditions (*e.g.*, Lago di Segrino, Lago di Varese: A. Marchetto pers. comm., Lago di Pusiano: G. Tartari pers comm.). Generally, the range of trophic reference states is larger in L-AL4 lakes than in L-AL3 lakes. L-AL3 occurs mainly in truly Alpine catchment are, whereas L-AL4 typically occurs in the Northern and North-Western pre-Alpine region

(AT, GE, FR), in southern Alpine inner-Alpine basins (Carinthia/AT, SI) and in the Southern Subalpine region (IT).

Accepting the rough assignment of natural trophic state to the two IC lake types, monitoring data were used to select oligotrophic L-AL3 and oligo-mesotrophic L-AL4 lakes as reference sites. It is suggested to use threshold values of the *TP* concentration (volume weighted annual mean or the spring overturn) for a pre-selection of reference sites.

Examples from the literature show that a significant increase of phytoplankton biomass may occur already below a *TP* concentration of 10 $\mu g\ L^{-1}$. Besides, monitoring data indicate that the taxonomic composition of planktonic algae changes along a *TP* gradient of 5 to 10 $\mu g\ L^{-1}$ (Fricker 1980, BMGU & BMWF 1983, Malicky 1987, IGKB 2004a, b) Hence, for L-AL3 lakes, a *TP* threshold value of $\leq 8\ \mu g\ L^{-1}$ is suggested to select reference sites. For the shallow (pre-)Alpine lakes of IC type L-AL4 a threshold value of TP $\leq 12\ \mu g\ L^{-1}$ is proposed.

Several other approaches were tested to select reference sites, e.g. pressure criteria (land use, population density equivalents) or the morphoedaphic index (Vighi & Chiaudani 1985). These were however not correlated with reference conditions (or trophic sate) clearly enough to allow for a selection of reference sites with high confidence.

3. Sites are also accepted as reference sites if nutrient loading calculations or measurements prove that the anthropogenic contribution to the total nutrient load is insignificant.

4. Sites that undergo a re-oligotrophication process and have not reached stable trophic conditions are not considered as reference sites even if they meet the criteria.

According to the Refcond Guidance, reference state sites can be used in unaltered parts of water bodies elsewhere slightly altered. Also sites can be used that are altered only regarding certain biological elements. This aspect is relevant for several Alpine lakes that are significantly altered in terms of hydro-morphology and can thus not be considered as true reference sites. Data on phytoplankton, which may not be affected by the hydro-morphological changes, can however be used for the calculation of boundaries.

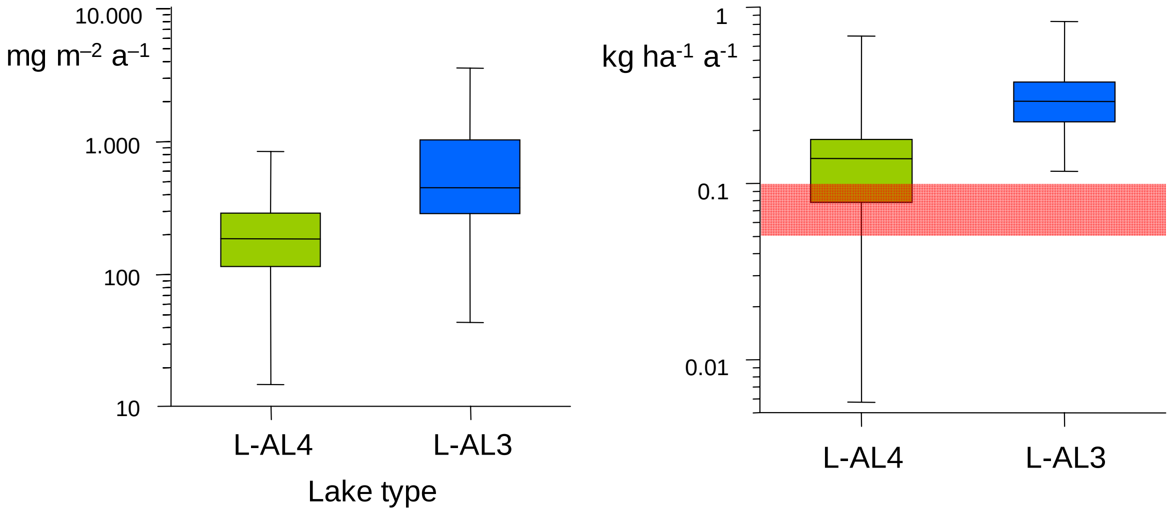


Figure A-3. Critical *TP* load per lake area after Vollenweider [mg m^{-2} a^{-1}] (left) and critical *TP* export rate from the catchment area [kg ha^{-1} a^{-1}] in the two Alpine lake types L-AL3 (mean depth >15 m) and L-AL4 (mean depth 3–15 m). The red-shaded bar in the right diagram indicates the range of potential natural *TP* export rate for forest (after LAWA 1999, Dokulil *et al.* 2001, ON M 6231). The critical export rate in deep lakes is always large than what can be expected from a natural catchment area. In some L-AL4 lakes, however, the natural export rate (estimated as *TP* export from forest) exceeds the critical *TP* export rate that may cause a shift from oligotrophy to mesotrophy. In other words, some L-AL4 lakes can be assumed to be naturally oligo-mesotrophic.

Critical *TP* load, after Vollenweider:

$$L_c = 10 q_s (1 + \sqrt{\frac{z_m}{q_s}}) \quad (1)$$

with L_c = critical *TP* load [mg m^{-2}]
$q_s = Q/A = z_m/\ _w$ = hydraulic load [m a^{-1}]
Q = annual discharge [m^3 a^{-1}]
A = lake surface area [km^2]
Z_m = mean depth [m]

Critical *TP* export rate from the catchment area:

$$ER_c = L_c \frac{A}{E} 100 \quad (2)$$

with ER_c = critical *TP* export rate [kg ha^{-1}]
L_c = critical *TP* load [mg m^{-2}] following *equation (2)*
A = lake surface area [km^2]
E = catchment area [km^2]

Annex A – Part 4: List of reference sites and data for phytoplankton

Table A-4a. Reference sites from Alpine lakes belonging to IC lake type L-AL3 and L-AL4, based on historical data.

MS	*Lake*	*IC type*	*Mean depth [m]*	*Year(s)*
AT	Millstätter See	L-AL3	89	1932–1938
AT	Ossiacher See	L-AL3	20	1932–1938
AT	Weißensee/AT	L-AL3	37	1932–1934
AT	Wörthersee	L-AL3	42	1931–1938
AT	data from Ruttner (1937): *Erlaufsee, Lunzer See, Leopoldsteiner See, Altausseer See, Grundlsee, Hallstätter See, Toplitzsee, Wolfgang-see*	L-AL3	20–65	1931–1932
AT	Faaker See	L-AL4	16	1931–2004
AT	Längsee	L-AL4	13	1934–1935

Table A-4b. Pre-selection of reference sites from Alpine lakes belonging to IC lake type L-AL3 and L-AL4, based the compliance of reference and actual trophic state. *TP* = total phosphorus concentration (volume weighted annual mean). Some sites are valid as reference sites only for phytoplankton (PP).

MS	*Lake*	*IC type*	*Mean depth [m]*	*TP [µg L^{-1}]*	*Year(s)*	*comment*
AT	Achensee	L-AL3	67	<3	1999–2001	only for PP
FR	Aiguebelette	L-AL3	31	5	1974–1976	
FR	Allos	L-AL3		5	2005	
GE	Alpsee bei Füssen	L-AL3	28	5	2001	
AT	Altausseer See	L-AL3	35	4	1983-2003	
AT	Annecy	L-AL3	42	<3	2004	
AT	Attersee	L-AL3	84	3	1989-2003	
SI	Bohinjsko jezero	L-AL3	28	<5	1997–2005	
AT	Fuschlsee	L-AL3	37	6	1997-2000	
AT	Grundlsee	L-AL3	41	3–4	1981-2003	
AT	Hallstätter See	L-AL3	65	9	2002-2003	
AT	Heiterwanger See	L-AL3	40	3	1999–2001	only for PP
GE	Königssee	L-AL3	98	5	2000	
AT	Lunzer See	L-AL3	20	4–7	1979-1981	
IT	Mergozzo	L-AL3	45	5	2003–2004	
IT	Monate	L-AL3	18	6	2003–2004	
GE	Obersee/Berchtesgaden	L-AL3	30	6	2000	
AT	Offensee	L-AL3	19	4	1994	
AT	Plansee	L-AL3	43	3	1999–2001	only for PP
AT	Schwarzensee	L-AL3	27	5	1998–2000	only for PP
GE	Tegernsee	L-AL3	36	7	1991-1992	
AT	Toplitzsee	L-AL3	62	5	1983–2004	
GE	Walchensee	L-AL3	81	4	1995–2003	only for PP
AT	Weißensee/AT	L-AL3	37	5	1987-2004	
AT	Wolfgangsee	L-AL3	52	3	1998–2000	
AT	Traunsee	L-AL3	90	2	1991–1997	only for PP

MS	*Lake*	*IC type*	*Mean depth [m]*	*TP [µg L^{-1}]*	*Year(s)*	*comment*
AT	Vorderer Gosausee	L-AL3	31	4	1994	only for PP
AT	Vorderer Langbathsee	L-AL3	(15)	3	1994	
AT	Zeller See	L-AL3	38	6	1999-2000	
GE	Bannwaldsee	L-AL4	6	10	1997-2001	
FR	Etival	L-AL4		8	2005	
AT	Faaker See	L-AL4	16	6	1987–2004	
AT	Feldsee	L-AL4	15	9	2000-2004	
AT	Irrsee	L-AL4	15	8	2002-2003	
AT	Keutschacher See	L-AL4	10	9	2000-2003	
GE	Lustsee	L-AL4	6	6	1996-2000	
AT	Magdalenensee	L-AL4	3	8	2000-2004	
AT	Mattsee	L-AL4	17	10	1997-2000	
FR	Montriond	L-AL4		(<15)	2005	
FR	Maclu	L-AL4		7	2005	
AT	Nussensee	L-AL4	8	6	1994	
AT	Pressegger See	L-AL4	3	5	2001-2004	
AT	Rauschelesee	L-AL4	6	11	2000-2004	
AT	Turnersee	L-AL4	8	10	2000-2003	
GE	Weitsee	L-AL4	4	4	2001	
GE	Wörthsee	L-AL4	15	8	1993-2002	

Table A-4c. Total biovolume data [mm^3 L^{-1}] from pre-selected reference sites in IC lake type L-AL3.

Lake (L-AL3)	*Year*	*BV*	*Lake (L-AL3)*	*Year*	*BV*
Ossiacher See	1932	0.18	Altausseer See	2002	0.16
Ossiacher See	1933	0.10	Altausseer See	2003	0.22
Ossiacher See	1934	0.22	Weißensee	1932	0.10
Ossiacher See	1935	0.40	Weißensee	1933	0.21
Ossiacher See	1936	0.34	Weißensee	1934	0.15
Ossiacher See	1937	0.42	Weißensee	1987	0.15
Ossiacher See	1938	0.39	Weißensee	1988	0.20
Wörthersee	1931	0.29	Weißensee	1989	0.14
Wörthersee	1932	0.28	Weißensee	1990	0.48
Wörthersee	1933	0.27	Weißensee	1991	0.24
Wörthersee	1934	0.25	Weißensee	1992	0.28
Wörthersee	1935	0.21	Weißensee	1993	0.38
Wörthersee	1936	0.28	Weißensee	1994	0.70
Wörthersee	1937	0.42	Weißensee	1995	0.39
Wörthersee	1938	0.30	Weißensee	1996	0.73
Hallstätter See	14.10.1932	0.07	Weißensee	1997	0.52
Hallstätter See	2002	0.05	Weißensee	1998	0.29
Hallstätter See	2003	0.07	Weißensee	1999	0.55
Wolfgangsee	1932-33	0.33	Weißensee	2000	0.22
Attersee	1997	0.21	Weißensee	2001	0.19
Attersee	1998	0.24	Weißensee	2002	0.31
Attersee	2002	0.15	Weißensee	2003	0.24
Attersee	2003	0.19	Weißensee	2004	0.09

Lunzer See	1932-33	0.38	Alpsee bei Füssen	2001	0.36
Lunzer See	1979	*0.32*	Königssee	2000	0.44
Lunzer See	1980	*0.33*	Obersee	2000	0.51
Lunzer See	1981	*0.24*	Tegernsee	1991	0.45
Erlaufsee	1932-33	0.11	Tegernsee	1992	0.50
Leopoldst.See	07.07.1933	0.10	Walchensee	1995	0.22
Millstätter See	1932	0.19	Walchensee	2003	0.39
Millstätter See	1933	0.09	Zeller See	1999	0.38
Millstätter See	1934	0.31	Zeller See	2000	0.60
Millstätter See	1935	0.40	Fuschlsee	1997	0.62
Millstätter See	1936	0.42	Fuschlsee	1998	0.41
Millstätter See	1937	0.32	Fuschlsee	1999	0.77
Millstätter See	1938	0.51	Fuschlsee	2000	0.59
Toplitzsee	1932-33	0.84	Bohinj	2005	0.15
Grundlsee	1932-33	0.22			
Grundlsee	2002	0.08			
Grundlsee	2003	0.15			
Altausseer See	1932-33	0.07			

Table A-4d. Mean total biovolume *BV* [$mm^3\ L^{-1}$] from pre-selected reference sites in IC lake type L-AL3 and summary statistics to set the reference value (median) and the H/G boundary (95%-percentile).

Lake	BV	statistic	value	
Alpsee bei Füssen	0.36	max	0.60	
Altausseer See	0.19	median	0.30	**reference**
Attersee	0.20	mean	0.31	
Fuschlsee	0.60	SD	0.14	
Grundlsee	0.11	95% perc	0.52	**H/G boundary**
Hallstätter See	0.06	90% perc	0.49	
Königssee	0.44	75% perc	0.42	
Lunzer See	0.29	min	0.06	
Millstätter See	0.32	N	18	
Obersee	0.51			
Tegernsee	0.48			
Walchensee	0.31			
Weißensee	0.31			
Wörthersee	0.29			
Zeller See	0.49			
Ossiacher See	0.29			
“Ruttner lakes” (1932–33)	0.26			
Bohinj	0.15			

Table A-4e. Total biovolume data [$mm^3\ L^{-1}$] from pre-selected reference sites in IC lake type L-AL4.

Lake (L-AL4)	Year	BV	Lake (L-AL4)	Year	BV
Mattsee	1997	0.16	Keutschacher See	2000	1.03

Mattsee	1998	0.25	Keutschacher See	2001	0.72
Mattsee	1999	0.40	Keutschacher See	2002	1.07
Mattsee	2000	0.36	Keutschacher See	2003	0.58
Irrsee	2002	0.42	Längsee	1934	0.59
Irrsee	2003	0.76	Längsee	1935	1.12
Faaker See	1931	0.39	Magdalenensee	2000	1.02
Faaker See	1934	0.57	Magdalenensee	2001	0.79
Faaker See	1935	0.16	Magdalenensee	2004	1.63
Faaker See	1936	0.18	Rauschelesee	2000	0.97
Faaker See	1937	0.31	Rauschelesee	2001	0.75
Faaker See	1987	0.20	Rauschelesee	2002	0.94
Faaker See	1988	0.26	Rauschelesee	2003	1.14
Faaker See	1989	0.55	Rauschelesee	2004	0.43
Faaker See	1990	0.59	Turnersee	2000	1.12
Faaker See	1991	0.48	Turnersee	2001	1.13
Faaker See	1992	0.82	Turnersee	2003	0.84
Faaker See	1993	0.42	Feldsee	2000	0.53
Faaker See	1994	0.27	Feldsee	2001	1.17
Faaker See	1995	0.28	Feldsee	2002	0.90
Faaker See	1996	0.24	Feldsee	2003	0.57
Faaker See	1997	0.20	Feldsee	2004	0.70
Faaker See	1998	0.42	Bannwaldsee	1997	0.44
Faaker See	1999	0.35	Bannwaldsee	1998	0.46
Faaker See	2000	0.31	Bannwaldsee	2000	0.63
Faaker See	2001	0.36	Bannwaldsee	2001	1.28
Faaker See	2002	0.39	Lustsee	1996	0.25
Faaker See	2003	0.38	Lustsee	1997	0.28
Faaker See	2004	0.08	Lustsee	1998	0.47
Pressegger See	2001	0.23	Lustsee	1999	0.33
Pressegger See	2002	0.43	Lustsee	2000	0.43
Pressegger See	2003	0.10	Wörthsee	1993	0.22
Pressegger See	2004	0.13	Wörthsee	1994	0.40
			Wörthsee	2002	0.67

Table A-4f. Mean total biovolume *BV* [$mm^3\ L^{-1}$] from pre-selected reference sites in IC lake type L-AL4 and summary statistics to set the reference value (median) and the H/G boundary (95%-percentile).

Lake	BV	statistic	value	
Mattsee	0.29	max	1.14	
Irrsee	0.59	median	0.70	**reference**
Faaker See	0.36	mean	0.65	
Pressegger See	0.22	SD	0.30	
Keutschacher See	0.85	95% perc	1.07	**H/G boundary**
Längsee	0.86	90% perc	0.99	
Magdalenensee	1.14	75% perc	0.85	
Rauschelesee	0.84	min	0.22	
Turnersee	1.03	N	13	
Feldsee	0.77			

Bannwaldsee	0.70
Lustsee	0.35
Wörthsee	0.43

Annex A – Part 5: Various approaches to set the G/M boundary for total biovolume/chlorophyll-a

Discontinuity analysis: In their general boundary setting protocol, Pollard & van de Bund (2005) suggest to use discontinuities in the gradients of impact for the definition of the G/M boundary. Various metrics have been tested for discontinuities in the correlations. There are however only few, if any significant, discontinuities. An interesting disconitnuity could be the breakdown of *Cyclotella* with increasing trophic levels. *Cyclotella* often dominates in oligotrophic lakes and may reach a relative proportion of annual mean total biovolume in reference lakes of up to 95% in single years and 66% for lake means. It would be compliant with the normative definitions to set a boundary at a significant change of species composition, especially where a sensitive taxon declines. There are however several arguments not to use *Cyclotella* as a metric for setting a boundary:

- There are general concerns to use a single taxon for setting the important G/M boundary;
- There are big difficulties in the determination of small single centric diatoms;
- *Cyclotella* is a species rich genus. Some species predominantly occur under meso- to eutrophic conditions;
- In some reference sites, the proportion of *Cyclotella* is rather low. The dominance of sensitive *Cyclotella* species in oligotrophic lakes is thus not a general rule, not even if we consider only the deep lakes (L-AL3);
- Finally, probably for all these reasons, the variability in the data is generally high.

The proportion of *Cyclotella* is thus not recommended to be used as a criterion for definitively setting the G/M boundary. We can but derive a span of total biovolume, where the relative proportion of *Cyclotella* significantly declines (*e.g.*, below 20% in L-AL3). The G/M boundary should be set somewhat within that span, which is approximately between 1 and 2 mm^3 L^{-1} total biovolume.

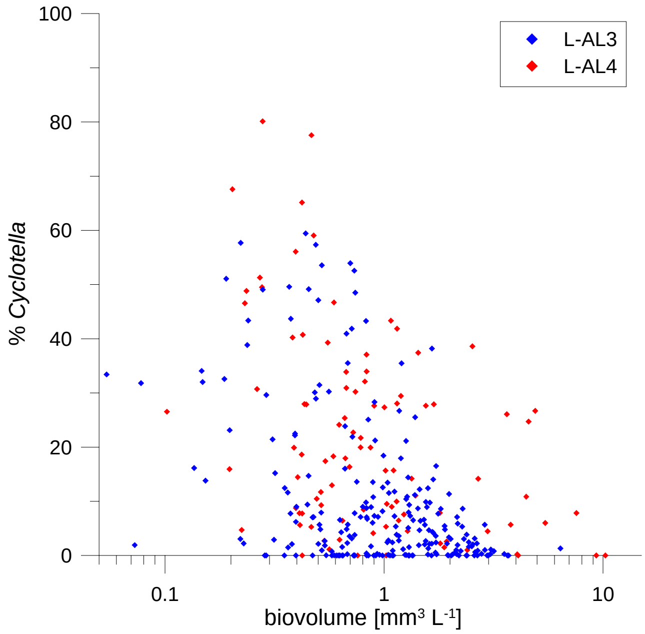


Figure A-5. Relationship between the total biovolume of phytoplankton and the relative biovolume proportion of *Cyclotella* in Alpine lakes of lake type L-AL3 and L-AL4.

Paired metrics analysis: Various metrics have been tested in paired metrics analyses. No paired correlation could however be used to define any class boundary. The variability in the single metrics was already much too high, and any paired metrics analysis just correlated two highly variable parameters – which made it impossible to set a boundary within a scattered cloud of data points. The paired metrics analysis can thus not be used for Alpine lakes.

Undesirable disturbances – secondary effects: Section 4.4. of the guidance of the ECO-STAT group "Eutrophication assessment in the context of European water policies" (draft, version 9.1, 10 Oct 2005) includes the following definitions:

- The condition of phytoplankton, phytobenthos, and macroalgae (of macrophytes and angiosperms) would not be consistent with good status unless there was a negligible probability (i.e. risk) that *accelerated algal growth* (growth of higher forms of plant life) would result in a *significant undesirable disturbance* to the aquatic ecosystem.
- A significant undesirable disturbance is a direct or indirect anthropogenic impact on an aquatic ecosystem that appreciably degrades the health or threatens the sustainable human use of that ecosystem. For a water body to be at good status there must be a *negligible probability of such disturbances* being present as a result of human activity.
- In some cases, undesirable disturbances in the balance of the taxonomic composition of a plant quality element may occur at a level of nutrient enrichment that is insufficient to produce a plant biomass that has potential to be the cause of significant undesirable disturbances to other quality elements. (In other words: the regular occurrence of undesirable disturbances indicates at least moderate status, but moderate status may take place also where undesirable disturbances do not yet occur.)

The central point in this approach is the "significant undesirable disturbance". Examples taken from the eutrophication paper are given in Table A-5a.

Table A-5a. Significant undesirable disturbance that may result from accelerated growth of the phytoplankton, macroalgae, phytobenthos, macrophytes or angiosperms (from "eutrophication paper").

a. Causes the condition of other elements of aquatic flora in the ecosystem to be moderate or worse (*e.g.* as a result of decreased light availability due to increased turbidity & shading)
b. Causes the condition of benthic invertebrate fauna to be moderate or worse (*e.g.* as a result of increased sedimentation of organic matter; oxygen deficiency; release of hydrogen sulphide; changes in habitat availability)
c. Causes the condition of fish fauna to be moderate or worse (*e.g.* as a result of oxygen deficiency; release of hydrogen sulphide; changes in habitat availability)
d. Compromises the achievement of the objectives of a Protected Area for economically significant species (*e.g.* as a result of accumulation of toxins in shellfish)
e. Compromises the achievement of objectives for a Natura 2000 Protected Area
f. Compromises the achievement of objectives for a Drinking Water Protected Area (*e.g.* as a result of disturbances to the quality of water)
g. Compromises the achievement of objectives for other protected areas, e.g. bathing water.
h. Causes a change that is harmful to human health (*e.g.* shellfish poisoning; toxins from algal blooms in water bodies used for recreation or drinking water)

i. Causes a significant impairment of, or interference with, amenities and other legitimate uses of the environment (*e.g.* impairment of fisheries)
j. Causes significant damage to material property

For Alpine lakes, the following examples for significant undesirable disturbance or changes may be useful for defining moderate (or worse) status:

a) One example of an impact of phytoplankton growth on another BQE of aquatic flora, given in Annex 2 in the eutrophication paper, is the "sudden decline of certain lake macrophytes communities, such as charophytes, caused by reduced light penetration as a result of increased phytoplankton growth". It is suggested as "a good significant impact or undesirable disturbance to signify a change to moderate status for that water body".

Charophytes are the dominant macrophyte form in many oligotrophic Alpine lakes (Pall *et al.* 2005), *e.g.* Attersee, Weißensee, Fuschlsee, Altausseer See, Grundlsee, Hallstätter See, Chiemsee, Starnberger See, Königsee and Bohinjsko jezero. They disappeared however during eutrophication from several lakes such as Ammersee, Mondsee (K. Pall pers. comm.), Bodensee (Deufel 1978; appeared again during the 1990ies: IGKB 2004a), Pfäffikersee (Burgermeister & Lachavanne 1980), Lake Morat (= Murtensee) and Burgaschsee (Lachavanne 1979a, b). These lakes could therefore be considered as moderate or worse. Charophytes showed also clear signs of reduction in diversity and density during the first macrophyte mapping of Chiemsee in 1985, which had a *TP* concentration >15 µg L^{-1} at that time (Melzer *et al.* 2003). Following the criterion from the eutrophication paper, the deterioration of this lake during the 1970ies and 1980ies would correspond to the transition from high to good status.

Apart from charophytes, also other macrophytes or helophytes were reduced due to eutrophication in some Alpine lakes. In Lake Constance, semiterrestrial vegetation had disappeared due to the surface drift of phytoplankton algae in the eutrophic 1980ies (IGKB 2004a). Schroeder (1979) reports of a decrease of reed in this lake from 1924 to 1974 due to eutrophication. Increased nutrient concentrations and phytoplankton growth also caused a decrease of reed in Pfäffikersee (Burgermeister & Lachavanne 1980).

b–c) Data on the impact of eutrophication on benthic invertebrates or fish are scarce. Long term data exist for Lake Constance, where eutrophication clearly changed the fish community (IGKB 2004b). First impacts from eutrophication on fish in Bodensee are known from the 1950/60ies, when growth of *Coregonus* had increased. Also total fish catch by fisheries had increased from the beginning the 20th century until 1955. One of four endemic species, the so-called "kilch" *(Coregonus gutturosus)*, was not found since 1960.

The decrease or disappearance of white fish *(Coregonus)* or charr *(Salvelinus)* in consequence of eutrophication has been reported from several Alpine or North American lakes (Baldegger See and Hallwiler See: Brutschy & Güntert 1923, Stadelmann 1984 – *cit.* in Müller & Stadelmann 2004; Bodensee: Hartmann & Quoss 1993, IGKB 2004; Lac Léman: www.cipel.org; Züricher See: www.esf.edu; overview on Austrian Alpine lakes: Gassner *et al.* 2003, Wolfram & Mikschi 2006; Lake Simcoe: COSEWIC 2005). In Lac Léman, *Coregonus* increased again since 1990 as a result of re-oligotrophication (www.cipel.org). Gerdeaux (2004) assumes that viability of whitefish *(Coregonus)* eggs in Lake Geneva was lower during the highly eutrophic 1970ies (*TP* = 70–90 µg L^{-1}) and improved since the 1980ies when the *TP* concentration was reduced (today ca. 30–40 µg L^{-1}). It is unclear at which trophic level first impairments of fish recruitment and of fisheries had occurred. Data from Lake Constance indicate that in case of ultra-oligotrophic lakes, first changes in the fish community occur already at oligo-mesotrophic conditions and become clearly visible changes at mesotrophic conditions.

g) The problem of phytoplankton blooms compromising the use of lakes as bathing water is well known from several Alpine lakes. At some Carinthian lakes (*e.g.* Millstätter See 1972/1973), tourism nearly totally declined as consequence of the occurrence of heavy *Planktothrix* blooms and could be re-established after mesaures of nutrient reduction (Sampl 1975, Schulz *et al.* 2005). The presence of *Planktothrix* alone cannot be used as indicator of moderate status, as it may occur also in nutrient-poor lakes in low densities or form high biomass layers in the metalimnion of oligo-mesotrophic lakes. If *Planktothrix* blooms shall be used as indicator of moderate or worse status, it seems to be necessary to distinguish between surface blooms and deep chlorophyll maxima (DCM; *cf.* Nixdorf *et al.* 2005).

h) The occurrence of Cyanobacteria toxins harmful to human health is another "significant undesirable disturbance", the relevance of which is very little known. Fish kills occurred in Sempacher See and Baldegger See in consequence of fish toxins (Gächter & Stadelmann 1993, Stadelmann 1984 – *cit.* in Müller & Stadelmann 2004).

i) A well-known example of eutrophication significantly affecting fisheries is Lake Constance, where the increase of nutrients caused a significant change of fish community structure and clearly impaired local fisheries (IGKB 2004a). Other pressures than eutrophication however also affected the fish fauna and fisheries in Lake Constance, *e.g.* the cut-off of spawing grounds of the lake trout, *Salmo trutta*, in the River Rhine.

The undesirable conditions discussed above elucidate the diverse interactions between phytoplankton growth and other quality elements. They are interesting examples of direct and indirect effects of eutrophication on "other legitimate uses of the environment", but also of secondary effects on other BQEs. The interferences remain however descriptive and can *hardly be used to predict a certain threshold level of phytoplankton growth or trophic state*. In most cases, no real data are available to carry out statstical analyses with a minimum of confidence and precision. Besides, the interactions between phytoplankton and other BQE are different in the phase of eutrophication and re-oligotrophication phase (Dokulil *et al.* 2001, Lang 1998, Anneville & Pelletier 2000).

Annex A – Part 6: Setting of ranges for biovolume/chlorophyll

1. Ranges for L-AL3

The L-AL3 lakes form a rather uniform and homogeneous group as regards reference trophic state. Previous calculations on the correlation of TP and biovolume indicated, however, a difference between very large and deep lakes such as Lake Constance and 'normal' deep L-AL3 lakes, especially in the correlation of TP vs biovolume (or chlorophyll-a). It was suggested to distinguish these two groups, either by defining subtypes or ranges for L-AL3.

More recent calculations now showed that there was no clear distinction into two groups. Whereas Lake Constance is characterized by a rather low TP:biovolume relation, other large lakes such as Lago Maggiore group well together with smaller L-AL3 and L-AL4 lakes (Figure A-6a).

The fact remains that variability in the TP:biovolume relation (i.e. in the correlation between trophic pressure and response in phytoplankton) is high. One reason for low biovolume/chlorophyll values at higher nutrient concentrations may be the presence of other limiting factors (e.g. light as a a consequence of deep epilimnic mixing in – at least some of the – very large lakes). On the other hand, several small L-AL3 lakes are characterised by a high dominance of *Planktothrix rubescens* at comparatively low TP concentrations, which may lead to a high TP:biovolume relation.

In order to avoid missclassifications in the parameter total biovolume/chlorophyll-a, ranges are set for the boundaries of this metric in L-AL3 lakes. Figure A-6a shows a regression between trophic pressure (using TP concentration) and phytoplankton response (total bio-volume). From this regression, the 95% confidence interval can be calculated for the reference value of biovolume, which was derived using the BSP described in den Technical Report:

Reference value total biovolume L-AL3:	0.3 $mm^3 L^{-1}$
95% upper confidence limit:	0.44 $mm^3 L^{-1}$
95% lower confidence limit:	0.2 $mm^3 L^{-1}$

From this approach, a range for the reference value of total biovolume from 0.2 to 0.44 $mm^3 L^{-1}$ could be set. However, in order not to weaken the results obtained so far (IC report autumn 2006), the reference value of 0.3 $mm^3 L^{-1}$ is suggested to remain a the upper limit of the ranges. The lower confidence limit is used as lower end of the range:

Range reference value total biovolume: 0.2–0.3 $mm^3 L^{-1}$

The chlorophyll-a values are derived from the regression chl-a : biovolume (Technical Report, chapter 2.1.5):

Range reference value chlorophyll-a : 1.5–1.9 $mm^3 L^{-1}$

The other boundaries for biovolume and chlorophyll-a are derived from the EQR values.

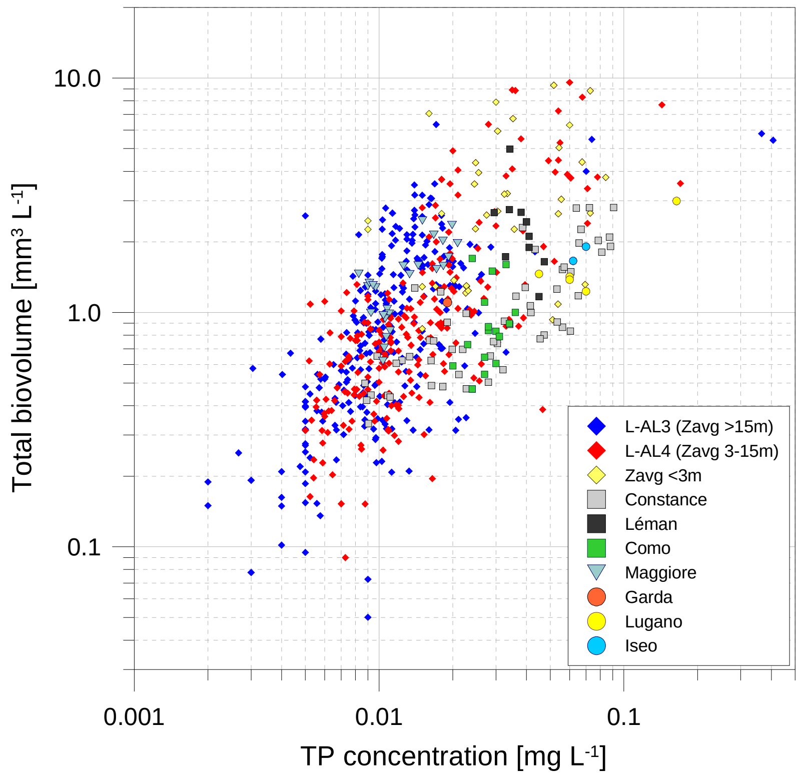
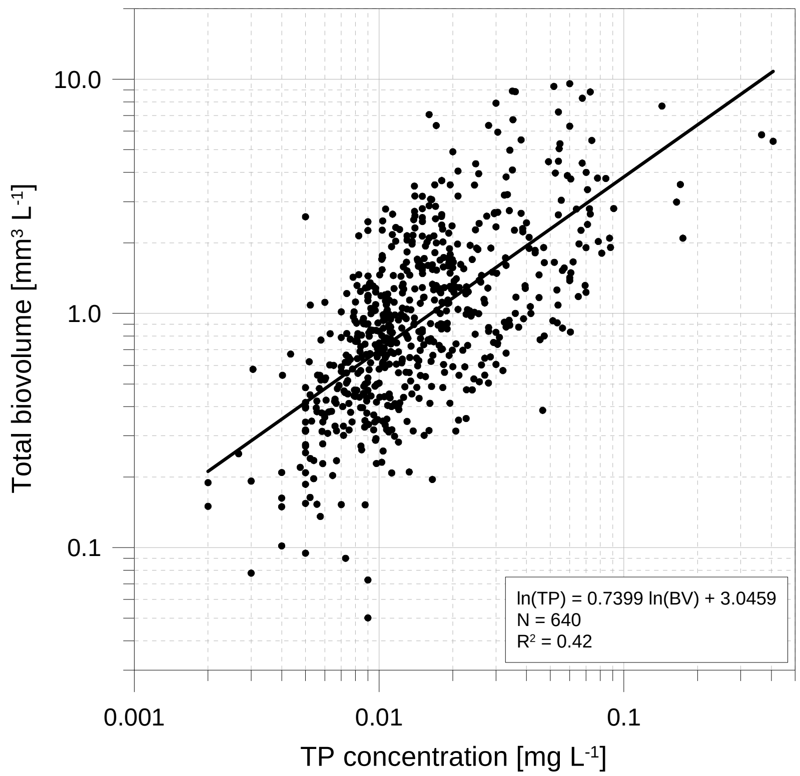


Figure A-6a. Relationship between the TP concentration (mostly volume weighted annual mean or concentration during spring circulation) and the total biovolume of phytoplankton (annual mean) in Alpine lakes of different lake types. The data base includes not only data from the GIG MS Access data base, but also literature and unpublished data from other Alpine lakes.



2. Ranges for L-AL4

A re-calculation of the reference value and the H/G boundary for L-AL4 was carried out by strictly following the agreed BSP. For this purpose, new data for L-AL4 lakes from Carinthia (last annual report 2005) were used. Although the data basis is weak due to a reduced sampling programme in 2005 (few sampling dates), the data indicate a reduction in total biovolume for the reference values. Besides, Feldsee was removed from the list of reference sites, as it had a TP concentration >12 µg L^{-1} in 2005 (*cf.* reference criteria in BSP).

For the remaining dataset, the following statistics were calculated. Column 4 gives the values calculated from the EQR (see IC report chapter 2.1.6), column 5 gives the values calculated by applying the BSP (see IC report chapter 2.1.4\3 and 2.1.4\1). Slightly different EQR values are derived from the second approach. Both reference value and boundaries are lower when derived from the updated data set. The G/M boundary gets closer to the boundary used in the GE national method, the H/G boundary slightly deviates from the national GE boundary.

Table A-6a. Re-calculation of total biovolume reference value and boundaries, with new data from 2005.

Biovolume	L-AL4		re-calculation L-AL4			National boundaries in GE
	original values		via orig. EQR	'equal class widths' approach		
	mm^3 L^{-1}	*orig. EQR*	mm^3 L^{-1}	mm^3 L^{-1}	*new EQR*	
ref. value	**0.7**	*1.00*	**0.62**		*1.00*	
H/G	**1.1**	*0.64*	**0.97**	0.93	*0.67*	*1.0*
G/M	**2.7**	*0.26*	**2.38**	2.36	*0.26*	*1.9*
M/P	**6.9**	*0.10*	**6.20**	5.97	*0.10*	*3.6*
P/B	**17.4**	*0.04*	**15.50**	15.14	*0.04*	*6.9*

Ranges can now be defined by including both the original values and the new ones, which were derived after adding new data to the set of reference lakes. (It illustrates the general uncertainty in the boundary setting, which is due to the small data set of reference sites.)

Another approach is to apply the BSP to those lakes only, which lie strictly within the definitions of the IC types, e.g. by excluding lakes with a surface area <50 ha. The data indicate a tendency towards higher values in smaller sites. In the list of reference sites (Tables A-4a & A-4b), there are two small lakes with surface area <50 ha: Maltschacher See (A = 14 ha) and Rauschelesee (A = 19 ha). They have a annual mean total biovolume of 0.76–1.02 mm^3 L^{-1}. The median value of the *remaining* sites (i.e. these tow lakes excluded; remaining N = 10) is <u>0.51 mm^3 L^{-1}</u>, the 95%perc. is 0.81 mm^3 L^{-1}.

Taking into account the re-calculation of the reference value and the boundaries (with new data) as well as the slight deviation of lakes outside the strict definitions of the IC types, the following ranges for reference value and boundaries for L-AL4 are suggested.

Table A-6b. Re-calculation of total biovolume reference value and boundaries, with new data from 2005.

	Total biovolume [mm^3 L^{-1}]

	fixed values	ranges	EQR
Reference value	0.7	0.5 – 0.7	1.00
H/G	1.1	0.8 – 1.1	0.63
G/M	2.7	1.9 – 2.7	0.26
M/P	7.0	5.0 – 7.0	0.10
P/B	17.5	12.5 – 17.5	0.04

3. The way of calculating the *mean* biovolume and its relevance for setting a reference value within the range

There are difference among the MS of the Alpine GIG how to calculate the *mean* biovolume (or chlorophyll-a), which influences the outcoming value. In GE, the mean of the vegetation period (usually IV – X) is calculated. In AT and IT the annual mean is calculated, including the early spring peak of diatoms, which is a characteristic feature of Alpine lakes.

The following figures illustrate the difference between the annual mean and the mean of the vegetation period. Figure A-6b was derived from German data. It shows that higher biovolumes are reached at higher tropher levels, when the mean of the vegetation period is used instead of the annual mean (with low winter values).

New calculations on the whole GIG data set point in the same direction. Total biovolume in the sommer months tends to reach higher values than in winter (Figure A-6c). A mean over the months April to October (vegetation period Germany) leads thus to higher avg than a calculation, which includes sampling dates in late winter (e.g. AT method) (Figure A-6d). The regression line in Figure B-A6d suggests a difference of 5–10% between calculations of the annual mean and the mean of the vegetation period. (The regression is strongly determined by the outlier Wesslinger See 1989, which has about 17 mm^3 L^{-1}. Without this lake year, the difference between the annual mean and the vegetation period mean is 6.5% (± 1.5%), if the vegetation period is defined as III–XI, and 11.5% (± 2.4%) for IV–X.)

These calculations support the use of ranges instead of fixed values.

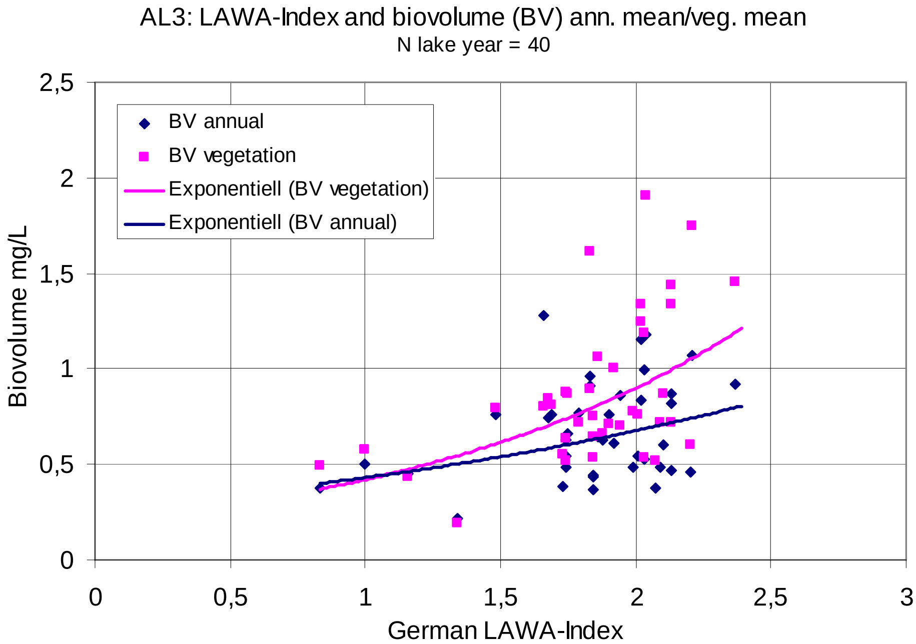


Figure A-6b. Comparison of correlation between the German LAWA index and the total biovolume, calculated as annual mean and as mean of the vegetation period. Only 'high quality' data from Germany are used in the diagram.

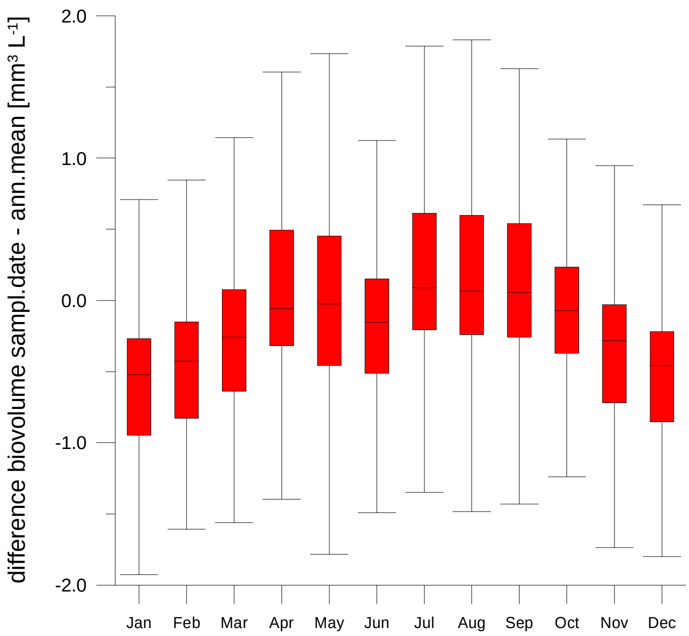


Figure A-6c. Box-plots showing the differences between the biovolume at a given sampling month and the annual means. Only lake years with at least 10 sampling dates were used. The y-axis was limited to –2 and +2 $mm^3\ L^{-1}$, outliers (up to 60 $mm^3\ L^{-1}$) are excluded.

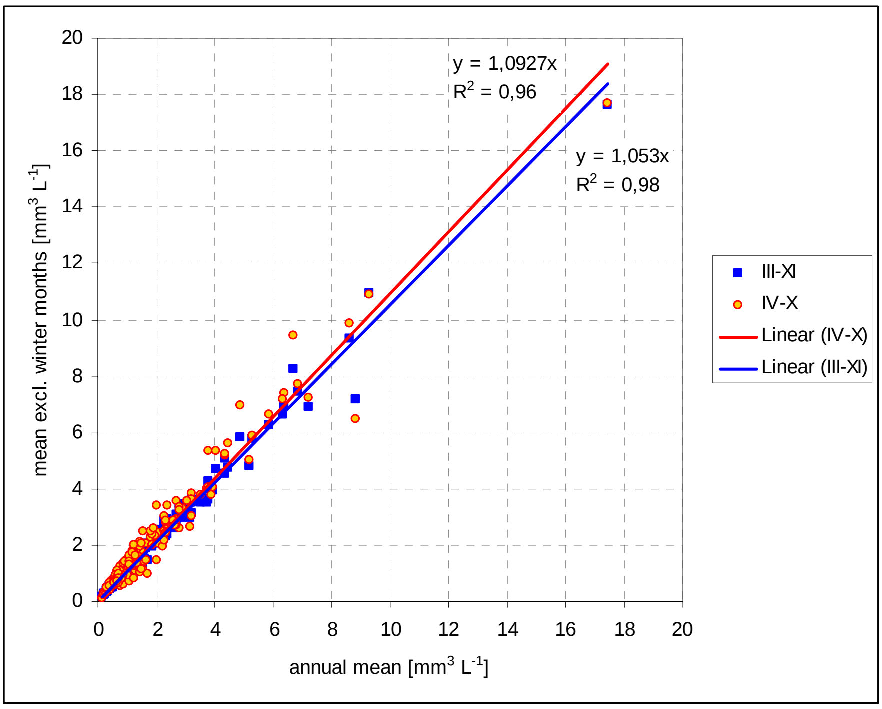


Figure A-6d. Relation between the annual mean of total biovolume and the mean of the vegetation period. Only lake years with at least 10 sampling dates were used. The regression was forced to get through zero. The mean of the months III-XI is 5.3% (± 1.3%, 95%C.L.) higher than the annual mean, which may include also dates from Dec to Feb. The mean of the months IV-X is 9.3% (± 2.2%) higher than the annual mean.

Annex A – Part 7: Correlation of biovolume/chlorophyll-a

In this part of Annex A some 'key diagrams' on the correlation between biovolume and chlorophyll-a as well as on the correlation of trophic pressure (TP concentration) and phytoplankton response (trophic indices) are presented.

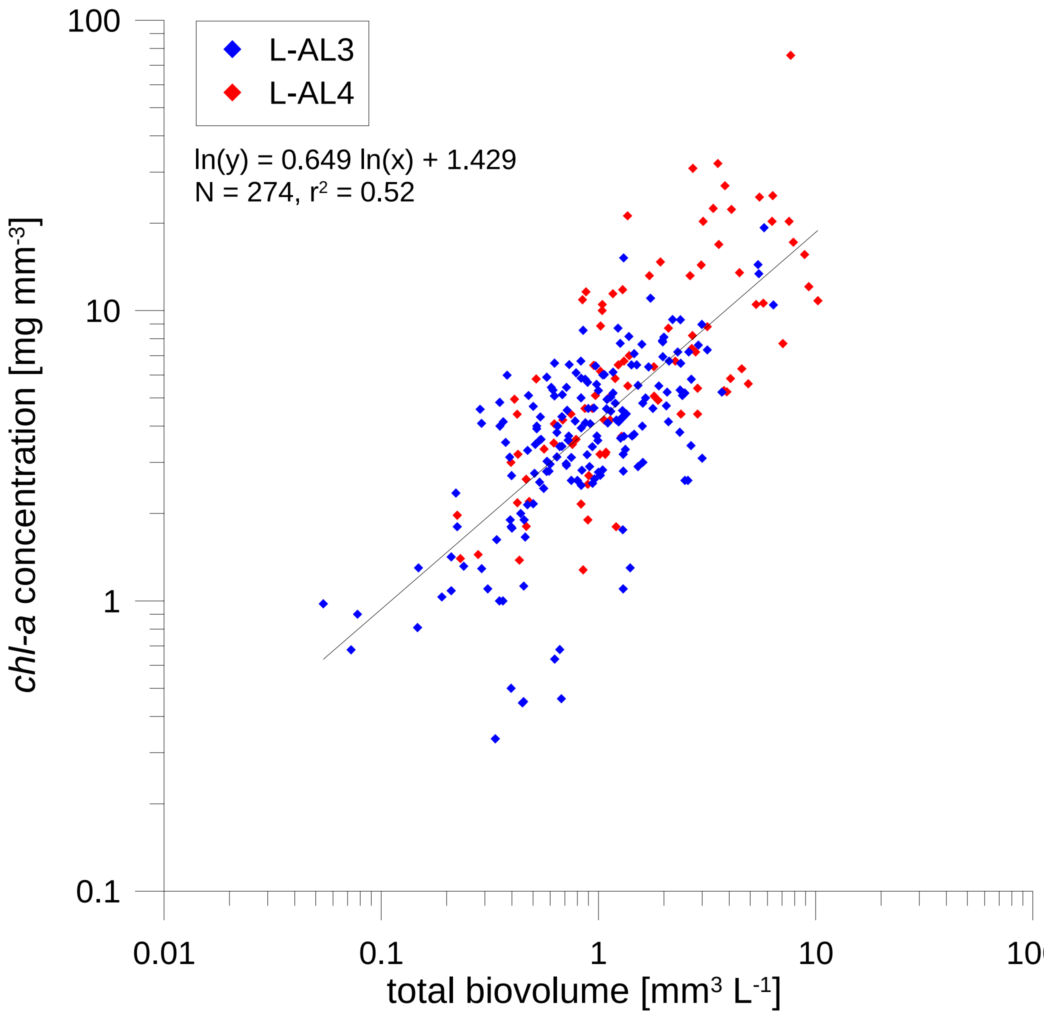


Figure A-7. Correlation between annual mean total biovolume and chlorophyll-a concentration in Alpine lakes. The regression line is calculated from the whole data set (both L-AL3 and L-AL4).

Annex B – Atlantic Lake GIG

ANNEX B - PART 1 - Amalgamation of lakes types using macrophyte data

Cluster analyses of macrophyte data (see Figure B1a and Figure B1b) - square root transformation of relative frequency of occurrence for 32 lakes and 89 taxa - supported by multidimensional scaling (Figure B1c) showed that:

- Atlantic GIG lakes did not separate by type or country;
- Lake area did not influence macrophyte taxonomic composition.

Therefore- L–A1 and L-A2 datasets were amalgamated resulting in a larger and more useful database. Data analyses courtesy of Mary Gallagher, EHS, NI.

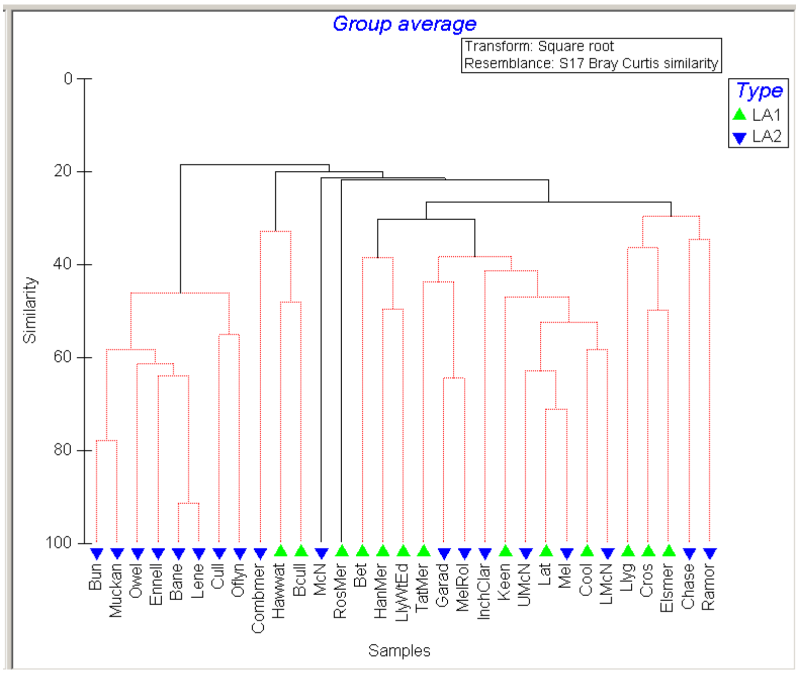


Figure B1a**.** Cluster analysis of AGIG lake sites using macrophyte data with type distinguished by symbols.

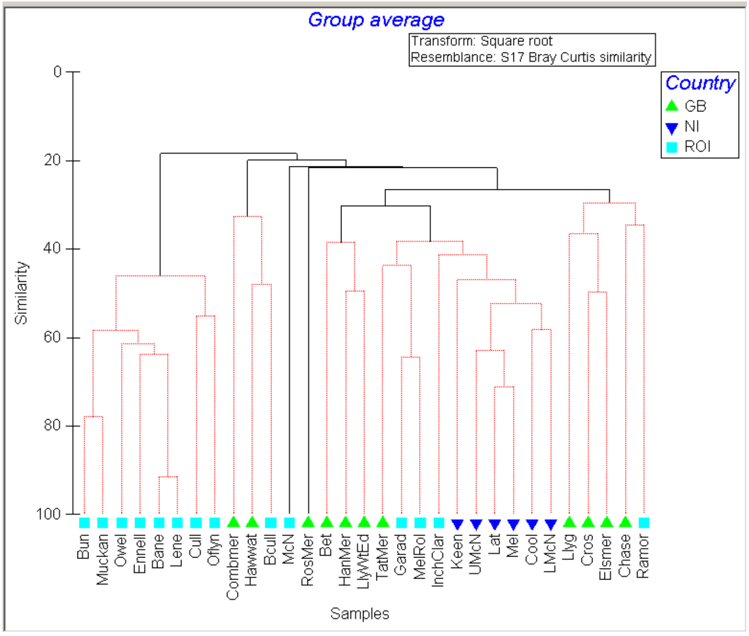


Figure B1b.Cluster analyses of AGIG lake sites using macrophyte data with countries distinguished by symbols.

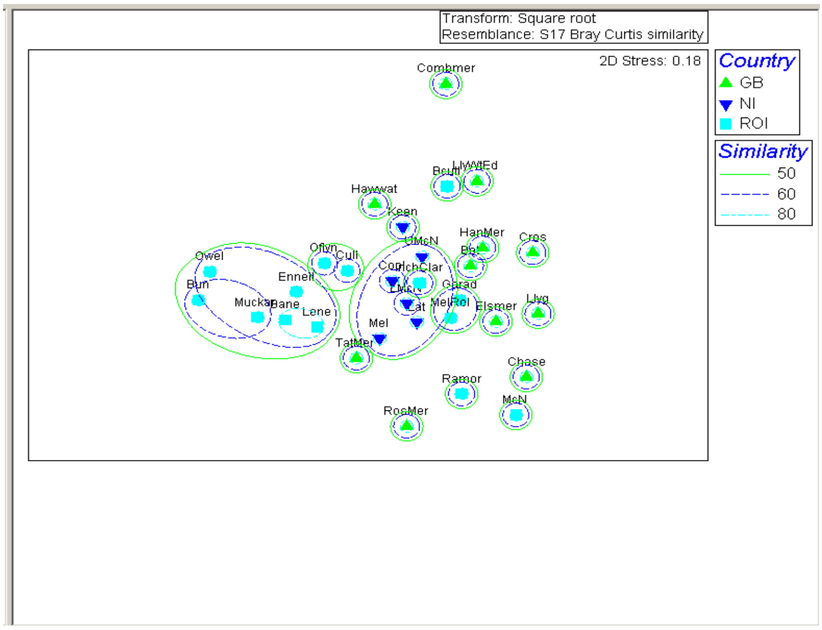


Figure B1c. Multidimensional Scaling (MDS) of AGIG lake sites using macrophyte data with symbols = country. MDS has been overlaid with similarities derived from the cluster analysis.

ANNEX B - PART 2 - Selection of reference lakes and setting of reference conditions and H/G boundary

Introduction

The WFD requires a description of type specific biological reference condition and values for hydromorphological and physico-chemical supporting elements. These conditions may be based on spatially distributed lakes and must be of a sufficient number to provide confidence. In the absence of spatially based waterbodies; type specific biological reference condition may be derived using models; either predictive or hindcasting models may be used. In the atlantic GIG, spatial approach was used in conjunction with confirmation with palaeo-limnological data.

Method:

- Taylor *et al.* (2005) conducted a palaeo-limnology study using diatom assemblages from 34 candidate reference lakes in Ireland
- eighteen lakes were confirmed to be in reference condition, including 9 Atlantic GIG intercalibration lakes;
- However, comparison of 2003 diatom assemblages with type specific reference data showed six lakes including three AGIG intercalibration lakes to be outside reference condition.
- Nevertheless these lakes were included in the description of reference condition unless there were other reasons for exclusion.

Results

Box and whisker plots were generated (all data) to screen data based **on abiotic factors** used in the typology, including colour (Figure B2a):

- McNean had high colour and a lower alkalinity by comparison to other lakes and consequently was not included in any further analysis.
- This lake also had the lowest Free Index score well below the current HG boundary value for the Free (IC) Index of 0.74.

Landuse data were not used to screen data because palaeolimnological evidence was considered to be an overriding factor (Figure B2b):

- The percentage of pasture in the catchment is evidently quite high for some lakes;
- All the lakes, except McNean, Kindrum and Talt are ground water fed marl percipitating lakes containing charaphytes. Charaphyte beds act as nutrient sinks, immobilizing P by binding it in their crystal structure or in the sediments (Kufel and Kufel, 2002);
- REFCOND guidance states that palaecology and expert judgement can be used to select reference conditions (EC, 2003).

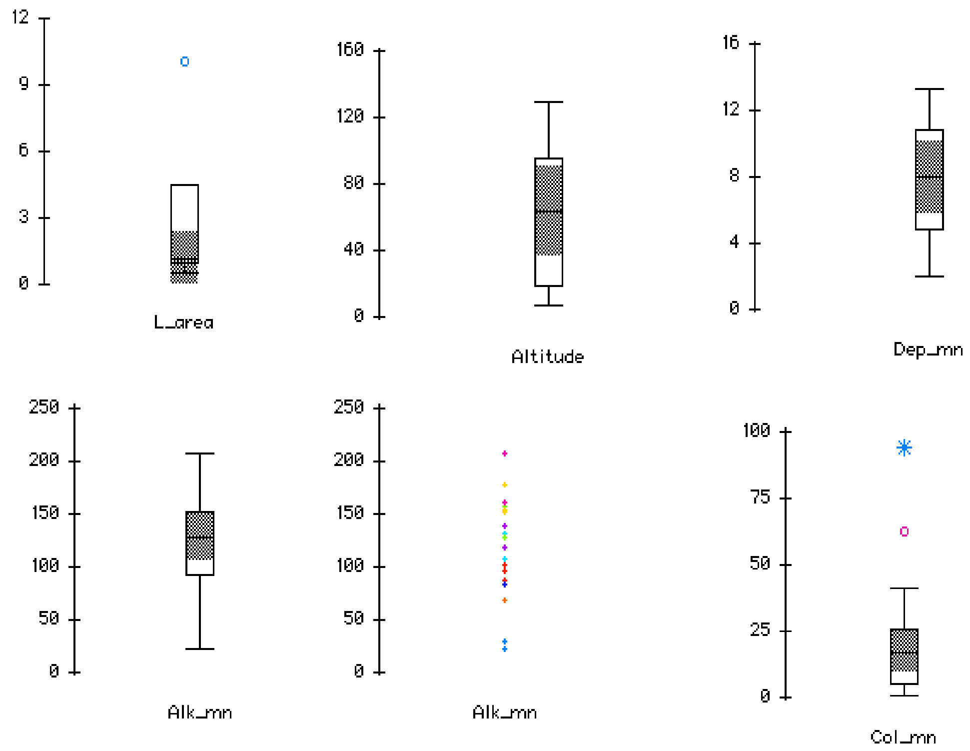


Figure B2a: The distribution of typology parameter values for reference lakes. Mn=mean value

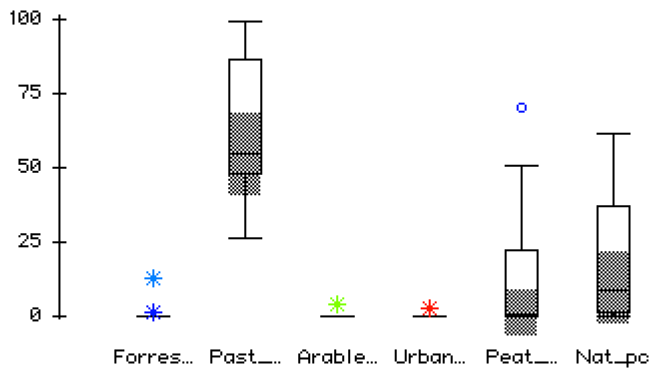


Figure B2b Patttern in land use for the initial potential 9 reference lakes including McNean Upper.

Growing season data

Growing season data was available for 8 lakes varying from 1 year's data to 4 years data or a total of 13 data points (Table B2a):

- There was not sufficient data to draw firm conclusions on reference and high good boundary values but it may be used as a guide;
- Using multiple lake year data is problematic (data from many lakes for one year is preferable because it overcomes the problem of annual variation within lakes);
- Also two lakes may be slightly deviated from reference according to Taylor *et al.*, 2005. One of these was Lough Lene which appears to have elevated TP compared to the data from the other lakes (Figure B2c, red squares). However, its chlorophyll is comparable. But it may also be the result of having multiple year data (2005 data tended to have higher values) with varying sampling frequency and different sampling techniques;
- **Consequently the 75th percentile was used to determine the HG boundary for chlorophyll.**

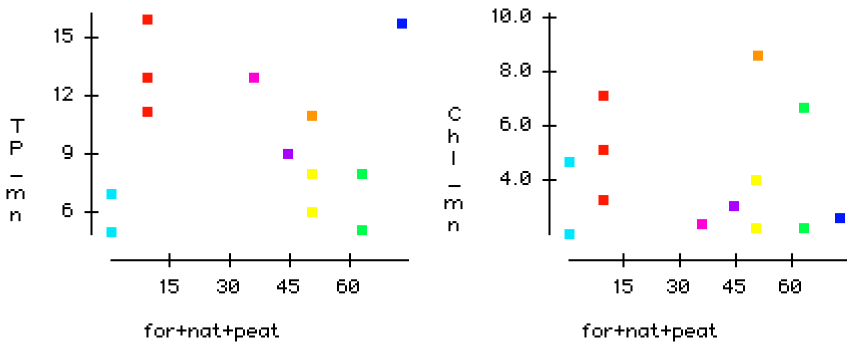


Figure B2c The growing season mean TP and chlorophyll plotted against 'natural' land use (% forestry, natural and peat). Lene =red squares.

An extremely conservative approach to the data analyses was also adopted:

- Lakes that were slightly deviated from reference according to Taylor *et. al.* (2005) were excluded;
- All lakes with a TP mean exceeding 10ug l^{-1} –the value at which slight ecological changes were noted for macrophytes– were also excluded;
- Only three lakes were left in the reference lake dataset;
- **For these data, the 90th percentile was used to set the HG boundary**. There was little difference in the resulting chlorophyll reference and HG boundary values compared to using all the data (

Setting the reference value and the HG boundary

The statistical results are presented in Table B2b and B2c:

- The reference value was taken to be 3.2 µg/l (rounded) based on the median of the growing season data (both datasets);
- The HG boundary was based on the average of 75th percentile of the growing season data and the 90th percentile from the conservative data;

- The **resulting HG Boundary value was 6 µg/l with EQR 0.53.**
- Table B2b).

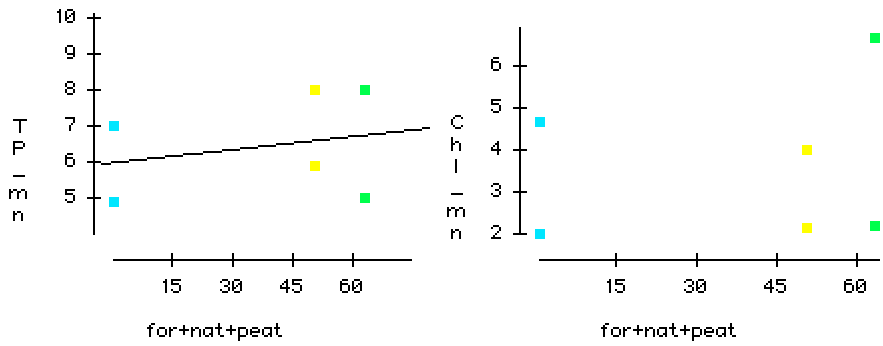


Figure B2d The growing season mean TP and chlorophyll plotted against 'natural' land use (%forestry, natural and peat). Bane, Cullaun and Bunny only.

Annual means data

Annual mean data was available from 4 lakes:

- Lene had both elevated TP and Chlorophyll values compared to the other lakes (Fig B2e);
- **However, no firm conclusions can be drawn because lake numbers are insufficient**.

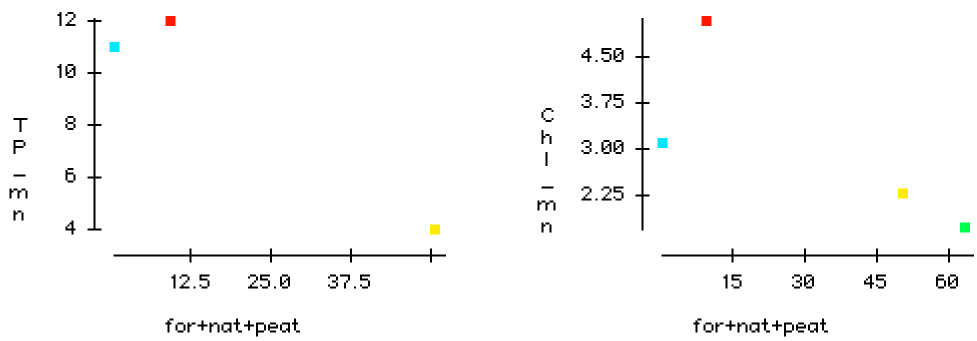


Figure B2e The annual mean TP and chlorophyll plotted against 'natural' land use (%forestry, natural and peat). Lene =red squares.

Table B2a: Data used in analyses (see CIRCA website for full reference dataset). Data used in "conservative" analyses is highlighted in yellow. Lakes requiring further investigation are bolded. Alk =alkalinity, Col =colour and mn=mean

L_Name	Year	TP_mn	Alk_mn	Col_mn	Chl_mn
Bane	1993 (12)	11.16	133.00	5.00	3.05
Bane	2005	6.90	107.50	4.00	4.70
Bane	2001(2) & 2002 (2)	4.89	128.33	1.25	1.95
Bunny	2001 & 2002	4.85	158.06	9.25	2.20
Bunny	2005	7.60	127.91	26.33	6.70
Cullaun	96 (4); 97 (6)	3.90	152.00	21.60	2.30
Cullaun	2001 & 2002	5.90	178.88	15.00	2.15
Cullaun	2005	8.43	154.55	40.67	4.00
Kindrum	2002 (2), 2001 (2)	11.00	69.47	23.00	8.63
Lene	96 (8); 97 (10)	11.70	97.00	5.25	5.07
Lene	2004	13.00		5.50	5.13
Lene	2001 & 2002	11.27	103.40	4.50	3.25
Lene	2005	15.98	88.50	8.00	7.14
Muckanagh	01 (6); 02 (2)	7.90	208.00	21.00	2.70
Muckanagh	2005	12.93	161.80	62.67	2.30
O'Flynn	96 (8); 97 (10); 98 (8)		139.00		1.40
O'Flynn	2005	8.90	120.18	41.33	3.00
Talt	2001 (2) 2002 (2)	15.75	85.09	19.75	2.55
Upper Lough McNean		20.00	24.00		7.70
Upper Lough McNean	2005	25.67	30.24	94.67	13.00

Setting the reference value and the HG boundary

The statistical results are presented in Table B2b and B2c:

- The reference value was taken to be 3.2 µg/l (rounded) based on the median of the growing season data (both datasets);
- The HG boundary was based on the average of 75th percentile of the growing season data and the 90th percentile from the conservative data;
- **The resulting HG Boundary value was 6 µg/l with EQR 0.53.**

Table B2b The results of the statistical analyses of the growing season and annual mean data. The median values and 90th and 75th percentiles are highlighted in yellow.

Data		Count	Mean	Median	StdDev	Min	Max	Range	90th %tile	75th %tile
growing season data	TP_mn	13	9.83	9.00	3.82	4.89	15.98	11.09	15.80	13.00
	Chl_mn	13	4.13	3.25	2.19	2.00	8.63	6.63	7.438	5.52
	SD_min	11	4.53	4.60	0.82	3.00	6.00	3.00	5.46	5.62
growing season data	TP_mn	6	6.46	6.45	1.41	4.89	8.00	3.11	8.00	
conservative	Chl_mn	6	3.63	3.10	1.88	2.00	6.70	4.70	6.50	
	SD_min	6	5.97	5.68	1.10	4.90	7.77	2.87	7.66	
annual mean data	TP_mn	3	9.00	11.00	4.36	4.00	12.00	8.00	12.00	
	SD_mn	4	6.11	5.89	1.19	4.96	7.70	2.74	7.70	
	Chl_mn	4	3.05	2.70	1.48	1.70	5.10	3.40	5.10	4.10

Table B2c The median values and 90th and 75th percentiles of the growing season data are presented. The HG boundary was based on the average of 75th percentile of the growing season data and the 90th percentile from the conservative data. The resulting value was 6 μg/l

		Median	90th	75th	Reference	HG
growing season data	Chl_mn	3.25	7.44	5.52	3.2	6.0
conservative data	Chl_mn	3.1	6.50			
EQR						0.53

ANNEX B - PART 3 – Defining of ecologically relevant TP boundaries

Introduction

The intercalibration process has several difficulties that may impede the setting of meaningful boundaries of high/good and good/moderate status. The first and most important is that there is a lack of established metrics that are effective in expressing the degradation of biological quality along a pressure gradient. Metrics are at an early stage of development and are likely to show variability in their response to pressure. This may be reduced in time through method refinement. A second problem is that, to a small extent at least, most metrics are method dependent. Combining data in the intercalibration process is likely to increase the variability in metric response.

Most GIGs, including the AGIG and NGIG have focused on setting boundaries in terms of TP and chlorophyll *a*. This is allowed because the guidance (EC, 2005a) states that the boundaries "..may include a relation to the physico-chemical and hydromorphological conditions." It appears that it is satisfactory for the intercalibration process to agree TP and chlorophyll *a* boundaries if the boundary setting protocol makes it clear that the boundaries have been set at points of ecological relevance that meet normative definitions. This is the purpose of this document; to set boundaries of high/good and good/moderate status that are of ecological relevance. This will attempted by:

- Examining published relationships to find criteria that match normative definitions and to define these in terms of TP;
- To see if the selected TP boundaries are supported by an examination of data from the ROI in the Atlantic GIG typology > 50 mg l^{-1} $CaCO_3$ alkalinity and 3-15 m mean depth. Marl lakes were excluded from the analysis in order to improve compatibility of the lake type across the region being intercalibrated.

Methods

A series of regression models (Table B-3-1), initially based on Spring TP, were used to successively predict summer chlorophyll *a* (Dillon & Rigler, 1974), Secchi depth (Free, 2002), depth of colonisation of Charophytes (Blindow, 1992) and depth of colonisation of Angiosperms (Chambers and Kalff, 1985). The prediction of Secchi depth used multiple regression based on predicted chlorophyll *a* and a colour of 30 mg l^{-1} PtCo.

Metrics were examined for potential relationships with TP. This was based on a survey carried out in the Republic of Ireland between 2001 and 2003. Nineteen lakes were selected that were in the Atlantic GIG typology > 50 mg l^{-1} $CaCO_3$ alkalinity and of 3-15 m mean depth.

Table B-3-1 Models used to predict summer chlorophyll *a*, Secchi depth, depth of colonisation of Charophytes and the depth of colonisation of Angiosperms. Sources: 1: Equation 2 Dillon and Rigler (1974), 2: Free 2002, 3 Equation 4 Chambers and Kalff (1985), 4: Blindow 1992. A colour value of 30 mg l^{-1} PtCo was used.

Source	Dependent variable	r^2	Model
1	Log chlorophyll *a* µg l^{-1}	0.92	1.449 log TP µg l^{-1} - 1.136
2	Log 1+Secchi depth (m)	0.82	1.34495 -0.414109 log (x + 1) colour -0.205299 log (x + 1) chlorophyll *a* µg l^{-1}
3	Zc Angiosperms$^{0.5}$		1.33 log Secchi depth + 1.4
4	Log Zc Charophyta	0.83	1.03 log Secchi depth + 0.18

For the composition metrics the ratio of Littorella to other littoral rosette species (Lobelia and Eriocaulon) was developed with the aim of detecting pollution in low alkalinity lakes as Litorella has a competitive advantage on more nutrient rich sediment (Farmer & Spence, 1986).

Results and Discussion

Figure B-3-1 shows the predicted relationships between TP (as a pressure gradient) and chlorophyll *a*, Secchi depth, depth of colonisation of Charophytes and the depth of colonisation of Angiosperms. The predictions provide a literature-based example of the interactions between a pressure gradient and ecological quality. As chlorophyll *a* increases with TP it leads to a rapid decrease in Secchi depth (transparency) which reduces the depth of colonisation of Charophytes and Angiosperms. As the extinction of light is exponential with depth, the initial change from an oligotrophic state to a mesotrophic state is where the most change takes place.

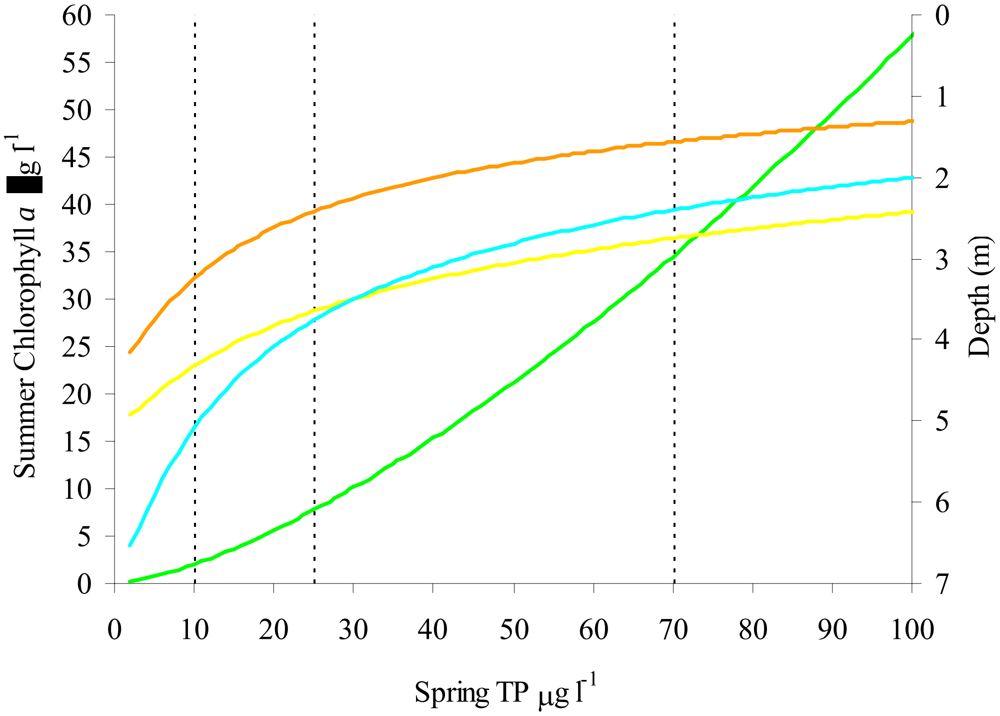


Figure B-3-1 Relationship between Spring TP and Summer chlorophyll *a* (—), and predicted Secchi depth (—), predicted depth of colonisation of Charophytes (—) and Angiosperms (—). Sources and models are listed in Table 1. Dashed lines represent proposed boundaries of 10, 25 and 70 µg l^{-1} TP.

Bondary settingh:

- The high/good boundary was placed at 10 µg l^{-1} TP as this is where there appears to be a significant change in slope/response of the depth of macrophyte colonisation to TP concentration (Figure 1);
- The good/moderate boundary was placed at 25 µg l^{-1} TP as this is where the depth of colonisation of the Charophytes is reduced by 24% from reference condition. This appears to fit normative definitions (WFD, Annex V) where phytoplankton biomass is such as to produce a significant undesirable disturbance in the condition of another biological quality element. The depth of colonisation of angiosperms is less useful in this regard as a reduction in transparency may be accompanied by a shift to taller growing species such as *Potamogeton lucens*.

Ecological data from 19 lakes in the ROI that fit the Atlantic GIG typology (> 50 mg l^{-1} $CaCO_3$ alkalinity and 3-15 m mean depth) were examined to see if the boundaries were relevant. Figure B-3-2 shows the relationship between four macrophyte metrics and TP (measured in Spring or early Summer):

- The lakes of presumed high status (< 10 µg l^{-1} TP) appeared distinct in that they had a deeper depth of colonisation of Charophytes and a low to high species richness (species richness typically having a unimodal relationship with TP).
- In good status (10-25 µg l^{-1} TP) species richness reaches a maximum, which may conform to normative definitions in that it is a 'slight' change but one that is not 'undesirable'.

- At TP concentrations > 25 μg l^{-1} species richness declines, lakes may have fewer littoral rosette species, the depth of colonisation of Charophytes decreases and the relative frequency of canopy forming species increases. These changes, especially the decline in species richness appear to match normative definitions for moderate status (WFD, Annex V) where phytoplankton biomass is such as to produce a significant undesirable disturbance in the condition of another biological quality element.

A draft macrophyte multimetric has been developed in the ROI and is applied by averaging the scaled deciles for six metrics (Table B-3-2). The macrophyte multimetric shows a linear response to TP (Figure B-3-3), and although linear relationships may not present clear 'break-points' that might suggest an appropriate point to position a boundary, they do demonstrate that ecological change is clearly taking place across the chosen pressure gradient – total phosphorus.

Ideally, selected boundaries of TP would also be supported by information from the other biological elements required to be monitored by the WFD. Figure B-3-4 shows that the proportion of the generally regarded pollution 'tolerant' genus *Chironomus* increases at TP concentrations > 25 μg l^{-1}. This appears to meet the normative definition in annex 5 of moderate status for benthic invertebrate fauna: "Major taxonomic groups of the type specific community are absent. The ratio of disturbance sensitive to insensitive taxa, and the level of diversity, are substantially lower than the type-specific level and significantly lower than for good status."

Table B-3-3 summarises the selected TP boundaries of high, good and moderate status and associated ecological changes. This is largely a fixed boundary system similar to the older proposals of the OECD (OECD, 1982). The WFD marks a departure from this in that a state-change system is favoured. A state-change system recognises that there is natural variability in lakes. For example, there may be a natural range in TP concentrations of 5-10 μg l^{-1} for a lake type. While it is accepted that there is such natural variation in reference condition, the methods for determining what the natural variation is, especially in the absence of present day examples of reference lakes are not well defined. It may be possible that the variation, at least in background nutrients may be sufficiently low that a fixed boundary system may be the most useful. The usefulness of the morphoedaphic index (MEI) (Vighi & Chiaudani, 1985) in predicting reference TP concentration may be limited, at least in Ireland. Table B-3-4 shows that predicted reference annual TP concentrations were about 10 μg l^{-1} <u>higher</u> than concentrations measured in Spring and Summer in <u>reference</u> lakes.

Ideally, the mean TP within a large population of existing reference lakes would be used to estimate reference TP concentration. Only three lakes were regarded as being in potential reference condition: Lough Glencar, Talt and Kindrum (Table B-3-4). Although three lakes may be insufficient to determine a type specific reference TP concentration the clear relationship between the macrophyte multimetric and TP (Figure B-3-3) may partly validate the reference lake selection and provide some confidence in determining that the reference TP is more than likely to be below 10 μg l^{-1} for this type.

In conclusions:

- The proposed boundaries of TP (Table B-3-3) appeared to have broad ecological support;

- Published models indicated that ecological change was likely to be most dramatic between 10 and 25 µg l^{-1} TP (Figure B-3-1);
- This was found to be supported by recent biological surveys within the AGIG type lakes in the Republic of Ireland;
- Biological metrics appeared to support our reference lake selection. Reference TP concentrations for this type are likely to be below 10 µg l^{-1}.

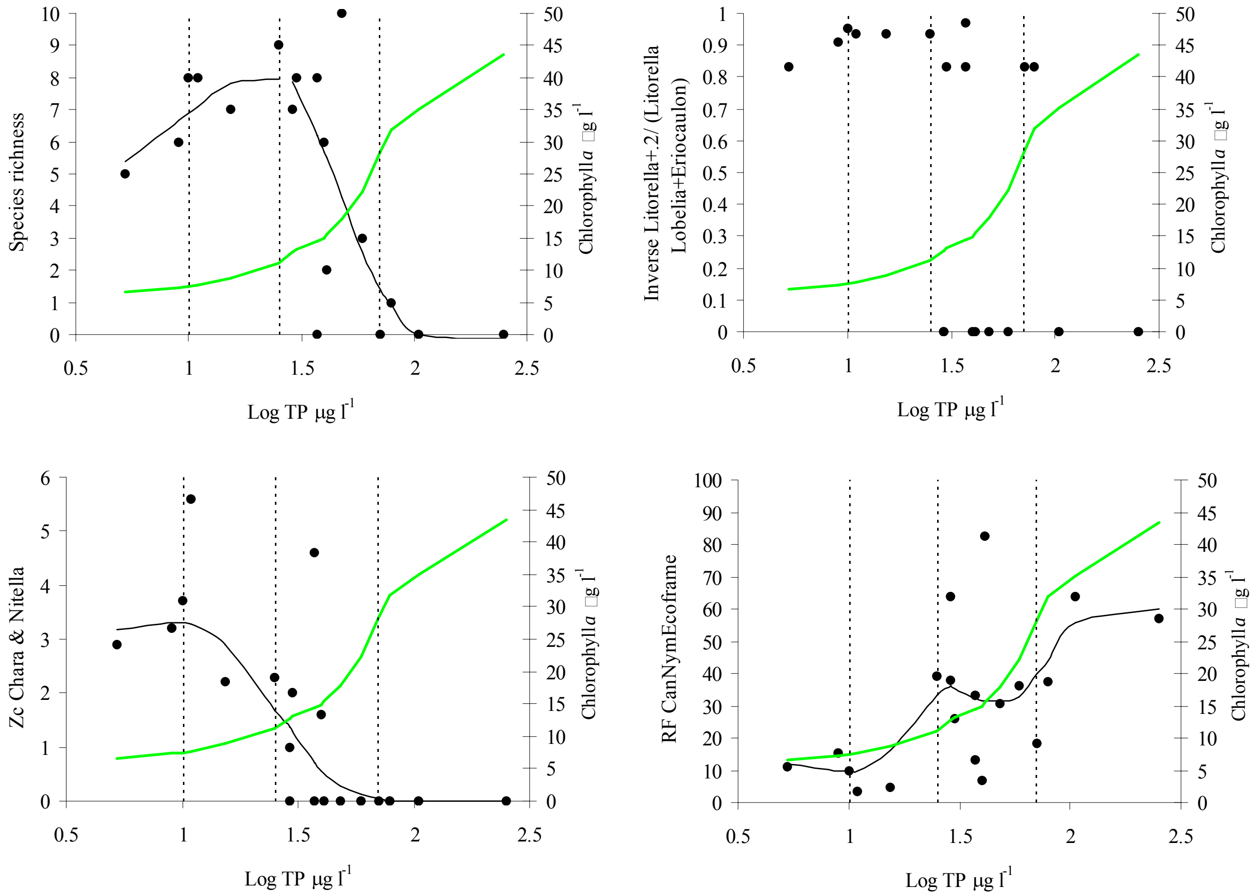


Figure B-3-2 Relationship between TP (Spring or early Summer) and species richness, inverse *Littorella* +0.2/ (*Littorella* + *Lobelia* + *Eriocaulon*), depth of colonisation (Zc) of *Chara* & *Nitella*, RF of CanNymEcoframe (canopy forming species – Moss *et al*. (2003)). The lowess smoothed relationship between TP and chlorophyll *a* is overlain (▬). n = 19, lakes between 50 and 100 mg l^{-1} $CaCO_3$, 3-15 m mean depth and non-marl precipitating. Dashed lines represent proposed boundaries of 10, 25 and 70 µg l^{-1} TP.

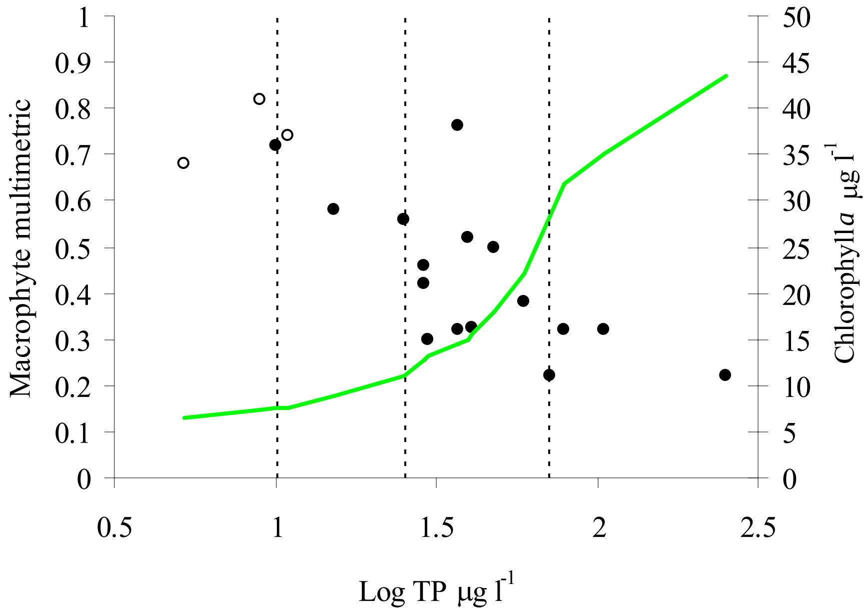


Figure B-3-3 The relationship between TP (Spring or early Summer) and the macrophyte multimetric. The lowess smoothed relationship between TP and chlorophyll *a* is overlain (—). n = 19, lakes between 50 and 100 mg l^{-1} $CaCO_3$, 3-15 m mean depth and non-marl precipitating. Dashed lines represent proposed boundaries of 10, 25 and 70 µg l^{-1} TP. ○ = lakes of potential reference condition: Lough Glencar, Talt and Kindrum.

Table B-3-2 Table of scaled deciles for six metrics that were averaged to give the macrophyte multimetric index.

Scaled deciles	Plant trophic score	Zc	Mean depth of presence	RF% Elodeids (functional group)	RF% Chara	RF% Tolerant
1.0	<28.2	>5.1	>2.00	<19	>67	<26
0.9	28.2 - 30.4	5.1 - 4.1	2.00 - 1.66	19 - 31	67 - 61	26.0 - 37.9
0.8	30.4 - 31.8	4.1 - 3.5	1.66 - 1.49	31 - 37	61 - 45	37.9 - 51.7
0.7	31.8 - 33.1	3.5 - 2.9	1.49 - 1.35	37 - 48	45 - 29	51.7 - 60.4
0.6	33.1 - 34.0	2.9 - 2.5	1.35 - 1.25	48 - 53	29 - 23	60.4 - 70.1
0.5	34.0 - 35.2	2.5 - 2.1	1.25 - 1.13	53 - 59	23 - 10	70.1 - 77.9
0.4	35.2 - 38.2	2.1 - 1.8	1.13 - 0.94	59 - 65	10 - 7	77.9 - 84.8
0.3	38.2 - 40.2	1.8 - 1.6	0.94 - 0.81	65 - 75	7 - 5	84.8 - 90.0
0.2	40.2 - 43.7	1.6 - 1.0	0.81 - 0.30	75 - 80	5 - 2	90.0 - 98.9
0.1	>43.7	<1.0	<0.30	>80	<2	>98.9

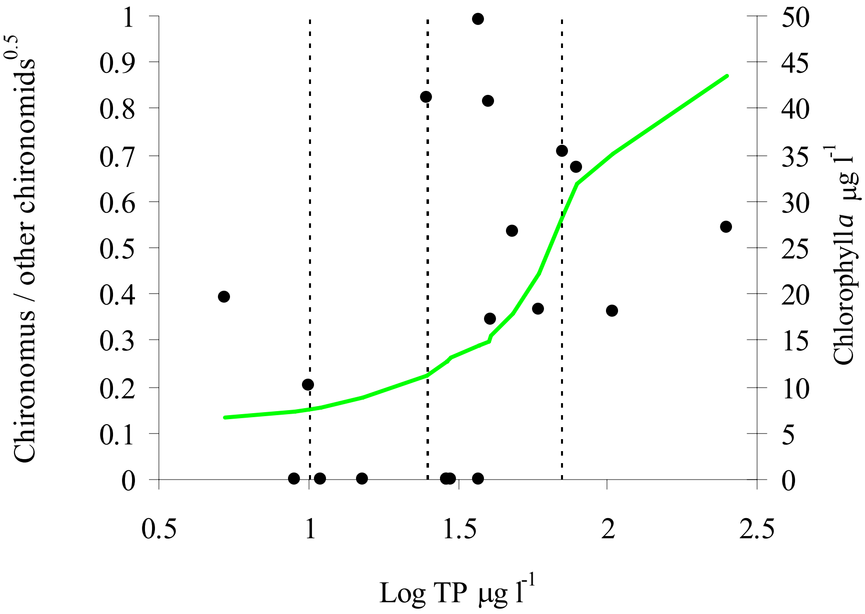


Figure B-3-4 The relationship between TP (Spring or early Summer) and the transformed (square root) ratio of *Chironomus spp.* to other chironomids . The lowess smoothed relationship between TP and chlorophyll *a* is overlain (—). n = 19, lakes between 50 and 100 mg l^{-1} $CaCO_3$, 3-15 m mean depth and non-marl precipitating. Dashed lines represent proposed boundaries of 10, 25 and 70 µg l^{-1} TP.

Table B-3-3 Summary of TP bands defining high, good and moderate status and associated ecological changes.

	High status	Good status	Moderate status
TP	< 10 µg l^{-1}	10-25 µg l^{-1}	25-70 µg l^{-1}
Summer Chlorophyll *a**	< 2 µg l^{-1}	< 2-8 µg l^{-1}	8 - 35 µg l^{-1}
Zc Charophytes From Figure1	> 5 m	5 m – 3.8 m	< 3.8 m A 24% reduction in the depth of colonisation found in reference condition.
Zc Angiosperms From Figure1	> 4.3 m	4.3 m – 3.7 m	< 3.7 A smaller reduction in the depth of colonisation can be caused by a succession of taller taxa.
Species richness	Tends to be naturally low but variable	Tends to be at a maximum	Declines markedly in moderate status.
Littoral rosette species	Present	Present	May only be present in the shallowest areas of the littoral
Canopy forming taxa	Infrequent	Infrequent	More frequent
Ratio *Chironomus spp.* to other chironomids	Low	Low	High

* Predicted from equation 2: Dillon and Rigler (1972), figures may be higher for a methanol extraction.
Zc predictions are for 30 mg l^{-1} PtCo colour.

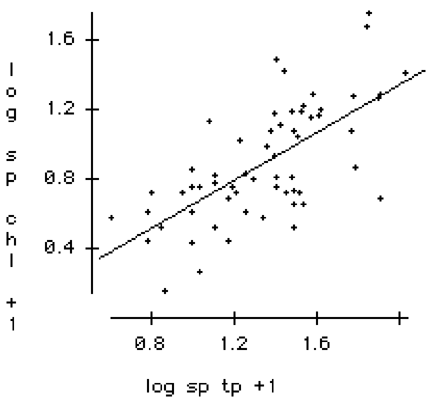
Table B-3-4 Summary characteristics and chemistry of the lakes. MEI predicted reference TP calculated using equation 1 from Vighi & Chiaudani (1985) Click on table to access data.

Lake	Altitude m	Lake area (km2)	predicted mean depth	Alkalinity mg l^{-1} $CaCO_3$	MEI	MEI predicted ref TP	TP ug l^{-1} (Spring)	TP ug l^{-1} (Summer)	Chlorophyll *a* ug l^{-1} (Summer)	Ref lakes
Glencar	28	1.15	8.5	94	0.22	18	5	<10	8	Yes
Talt	130	0.97	8.8	85	0.19	18	9	5	5	Yes
Rowan	73	0.48	5.0	56	0.22	18	10	23	7	
Kindrum	8	0.61	4.7	69	0.29	20	11	11	10	Yes
Melvin	25	22.06	4.7	54	0.23	19	15	10	4	
Drumlaheer	65	0.74	5.9	71	0.24	19	25	56	17	
Corry	41	1.54	3.8	51	0.27	20	29	37	17	
Alewnaghta	31	0.55	3.1	70	0.45	23	29	10	6	
Garadice	49	3.89	3.9	75	0.38	22	30	18	5	
Glasshouse	48	0.54	6.5	52	0.16	16	37	49	27	
Aughrusbeg	8	0.50	4.3	54	0.25	19	37	17	17	
Derryhick	25	0.54	4.9	84	0.34	21	40	21	18	
Derrycassan	45	0.71	3.3	80	0.49	24	41	61	11	
Doon	22	0.49	4.9	82	0.33	21	48	27	13	
Scur	62	1.14	3.4	60	0.35	21	59	71	15	
Muckno L	86	3.57	5.1	62	0.24	19	71	65	21	
Drumlona	77	0.53	5.0	99	0.40	22	79	114	40	
White	75	0.54	4.8	85	0.35	21	105	156	44	
Dromore	79	0.61	5.1	90	0.35	21	250	91	39	

ANNEX B - PART 4 – Setting the GM boundary using Irish chlorophyll and TP data.

A previous discussion documented setting of the boundary values of total phosphorus (TP) concentrations (the point of ecological change for macrophytes has been noted to occur at a TP value of 25 µg l^{-1}).TP value at the GM boundary was subsequently used to determine the corresponding chlorophyll a value:

- by a regression equation from the North American literature (Dillon & Rigler, 1972) which suggested a GM boundary of 8 µg l^{-1} Chlorophyll using spring TP and summer chlorophyll values;
- by a chlorophyll a vs TP relationship from the MS dataset which suggested a GM boundary of 8.5 ug l^{-1} using the equation below (Figure B-4).



Dependent variable is: **log sp chl +1**
No Selector
65413 total cases of which 65352 are missing
R squared = 45.2% R squared (adjusted) = 44.3%
s = 0.249 with 61 - 2 = 59 degrees of freedom

Source	Sum of Squares	df	Mean Square	F-ratio
Regression	3.0159	1	3.0159	48.6
Residual	3.65807	59	0.0620011	

Variable	Coefficient	s.e. of Coeff	t-ratio	prob
Constant	-0.0370353	0.1384	-0.268	0.7899
log sp tp +1	0.692363	0.09927	6.97	≤ 0.0001

Figure B-4 The relationship between spring chlorophyll and spring TP values for lakes > 50 mg l^{-1} $CaCO_3$ and output form datadesk.

Annex C – Central / Baltic GIG

Annex C – Part 1 - Reference conditions

Introduction

The GIG has made a common interpretation of the reference condition as described in Annex V of the WFD. The GIG has used spatial references within its territory as methodology. The lakes are selected using criteria for human activity in the catchment of the lakes, but in some cases additional information is used such as historical data, paleolimnological data and expert judgment.
Under strict conditions it is allowed to exceed some of the criteria. All Central Baltic lakes complying with the criteria and possibly exceptions on these criteria, constitute the type specific reference lake population. In this section the criteria used, the distributions of reference values, and characteristics of the reference lakes are presented. In addition, some comparisons are made with reference values of similar types from the Nordic GIG, EU FP6 project REBECCA and provided in literature.

Reference criteria

Selection criteria for the catchment use are agreed on a GIG level and applied to the GIG data base. The criteria are believed to ensure that the human pressure in the lakes is absent or very minor. To designate a lake as reference lake three criteria should be met:

1. **No point sources in the catchment**: Point sources are sources where waste water (treated or not) is discharged to the lake or to the connected catchment of the lake. Examples of point sources are waste water treatment plants, untreated waste water of cities, waste water from industrial activities, waste water from more than 10 inhabitants per km^2
2. **Land use in catchment is <= 10 % unnatural**: Land use is determined based on of the catchment of the lake using corine land cover categories. In some cases, more accurate national maps and categories are used. As natural land use is considered: forest, wetland, water and nature. As unnatural land use is considered agricultural land and urban areas. Forest might be in some cases plantings. In case where the intensity of use of the plantings is high (e.g. use of manure or fertilizers), forest is considered as agricultural land
3. **Population density <= 10 inhabitants km^{-2}** Population density is a rough estimation of the number of people living in the catchment based on national data bases or based on detailed maps showing the number of houses. In the latter case the number of houses can be multiplied with the national average size of one household. When no data on population density are available, it is assumed that when the urban area in the catchment is smaller than <1 % this criterion is fulfilled.

Overruling of reference criteria

Several reasons are possible to overrule one or more criteria. In some cases this overruling relies on expert judgement. For us as GIG, however, it is very important to be as straight forward as possible. A lake exceeding the criteria can be considered as 'suspect'. The GIG has to have convincing facts why the criteria in a particular case can be overruled. The expert judgement should therefore rely on facts, and/or publicly available information.

Criteria can be overruled by:

- clear and sound evidence from paleolimnological data, which is published or otherwise publicly available.
- The catchment and population density can be overruled if it is very likely that the use in the catchment is not reaching or affecting the lake. This may be in cases where:
    - the direct related catchment of the lake is surrounded is for more than 90 % of the area by natural land use and there are no signs of any disturbance, or
    - the use of agricultural land is very extensive meaning that no artificial fertilizers are used and densities of cattle are sustainable (e.g. pastures in Scotland), or
    - the whole population in the catchment is connected to waste water treatment plants while the discharge is not connected to the candidate reference lake, or
    - other reasons, to be specified in the data base

Other pressures

Reference sites are waters with no or very minor human pressure. Although the criteria applied by the GIG will ensure that most pressures will be absent or very minor, the GIG has to stress that this not might hold true for all pressures. For pressures related with hydromorphology (like artificial abstraction) or alien species (like introduction of Carp, *Cyprinus carpio*), based on expert judgement all sites will comply with the definition, but due to poor data availability we cannot guarantee for fully 100 % that all sites will comply with the definitions from the WFD. Some Dutch sites are artificial and may have hydromorphological pressure. However, the GIG is very sure that its criteria, and all other information available, guarantees that human pressure do not have a significant effect on the reference state for the indicators considered in this exercise. It should not be assumed necessarily that the sites selected would be reference sites for other quality elements.

Variance in time vs. spatial variance

The data analysis and assessment of chlorophyll-a in lakes is based on average values of the vegetation period. Weather conditions may be a source of variation, and may explain differences in chlorophyll-a reference values from one year to another. Because the assessment is based on values within one year, the variation in values between years should be considered as valid for setting reference values. Therefore, different years of one site are not averaged for determining the reference value. Importantly, it should be kept in mind that the number of sites is very low, and this is not solved by considering lake-years.

Different types, same reference criteria

Selection criteria fundamentally should be the same for lake types. That is because lakes should be selected on basis of pressure. In some cases, however, not all pressures have an impact that can be measured because its impact is too low and is dependent on type. In cases when impact is absent or very low, the pressure can be considered as part of the natural variation of the undisturbed condition. An example may be diffusive pollution by air. For L-CB1 and L-CB2 air pollution most likely does not contribute to measurable impacts in biology when considered relatively to the natural variation. However, L-CB3 may be sensitive for pollution by air. Different substances (NH_3, SO_2, or derivates dissolved in precipitation) are transported by air and are not necessarily related to the catchments. For the Nordic GIG air pollution is less intensive as it is in Central Baltic region. Therefore, the GIG will compare its L-CB3 reference values with the similar type of the Nordic GIG. In case of significant deviation between the GIGs, our GIG may use the Nordic GIG values (for the similar type), or a more stringent percentile of the CB-GIG population will be proposed.

Discussion and results

Site selection

At the GIG meeting in Enkhuizen it was agreed to use all sites identified on the "Ref Clean List" as provided in the general Central Baltic data base (Table C-1-1). This list includes also lakes which do not meet the strict GIG criteria as described above, but where countries have provided an explanation of the reasons for this according the overruling mechanism. Data from the clean list were screened using TP v Chla scatter plots and the following outliers were identified (Fig. C-1-1):

- *Naardermeer pre 1990* - Excluded from analysis, because of uncertainty of delayed response on restoration measures
- *Loch Scarmclate* - Excluded from analysis as lake catchment has evidence of improved pasture
- *Beuven* - Retained in analysis, but is later excluded because definition of depth limit L-CB3 has changed

A full list of sites is provided in Table C-1-1.

The summary data in the GIG database from Denmark contained both seasonal and annual averages. This causes duplication and the annual data from DK has thus been excluded in this analysis. In addition allocation of types were checked. It was noted that the allocation of lakes with a mean depth of 3.0m was not consistent and some other lakes were out of the agreed depth range. All lakes with a mean depth of 3.0 m were allocated to L-CB 1 type in accordance with the JRC guidance document which defines the type as 3.0 – 15.0 m. The resulting distribution of values in relation to total phosphorus is shown in Fig. C-1-1.

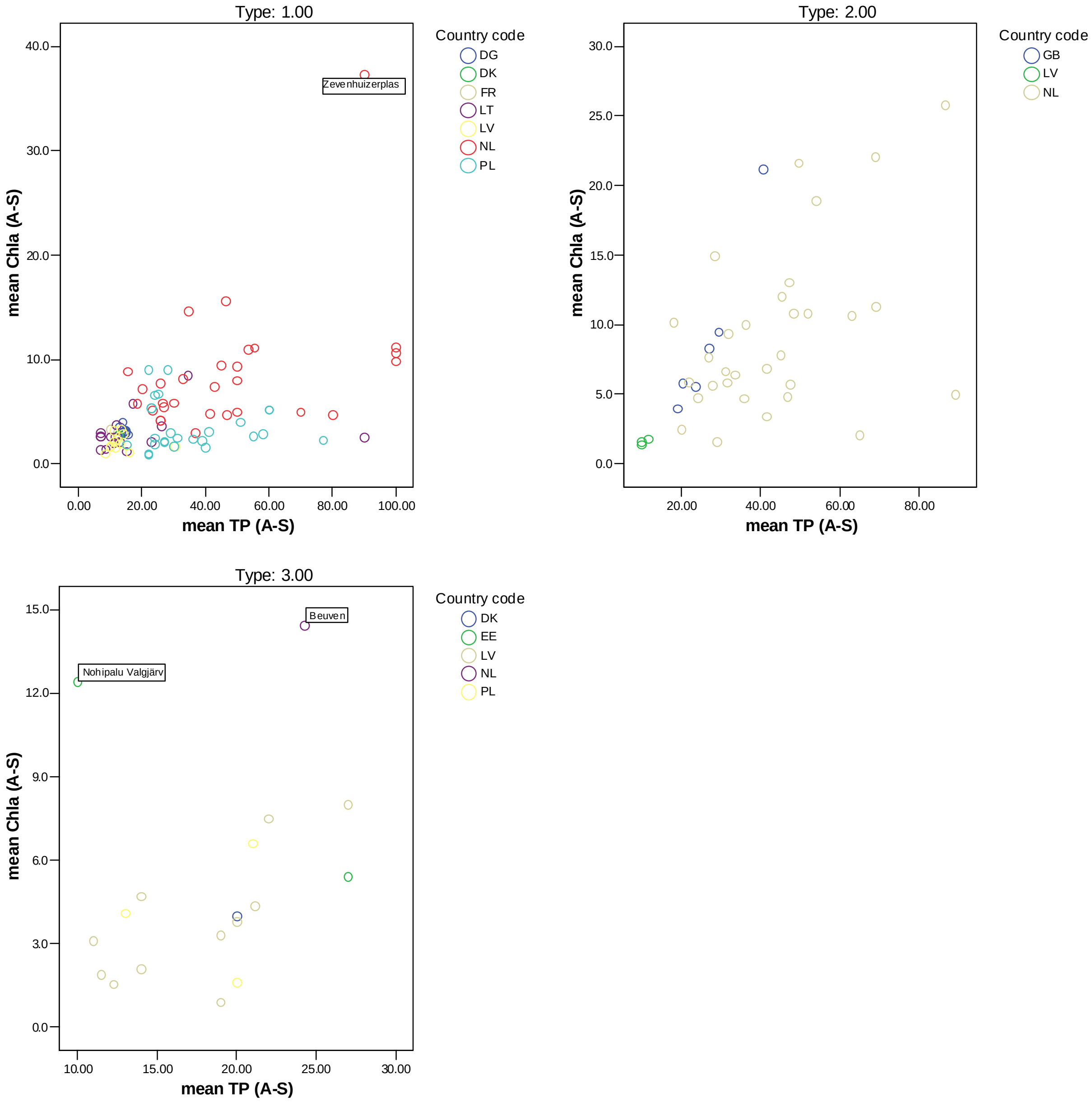


Figure C-1-1. Scatter plot of mean chlorophyll a (µg/L) v total phosphorus (µg/L) for reference lakes in GIG types L-CB1, L-CB2 and L-CB3. Note that L-CB3 is presented here as depth range 0-15m. DG=Germany

Depth, alkalinity and catchment size characteristics

The mean depth, catchment and alkalinity of the reference lakes are presented in Figure C-1-2. L-CB3 has a significant range of mean depth, overlapping those of L-CB2 and L-CB1. This will make the type less comparable with the Northern GIG shallow moderate alkalinity type L-N1. It is proposed to set the depth limit of L-CB3 to 3-15 meter. The French lake Cazaux-Sanquinet appeared to have an incorrect alkalinity value, which is corrected afterwards (L-CB3 type).

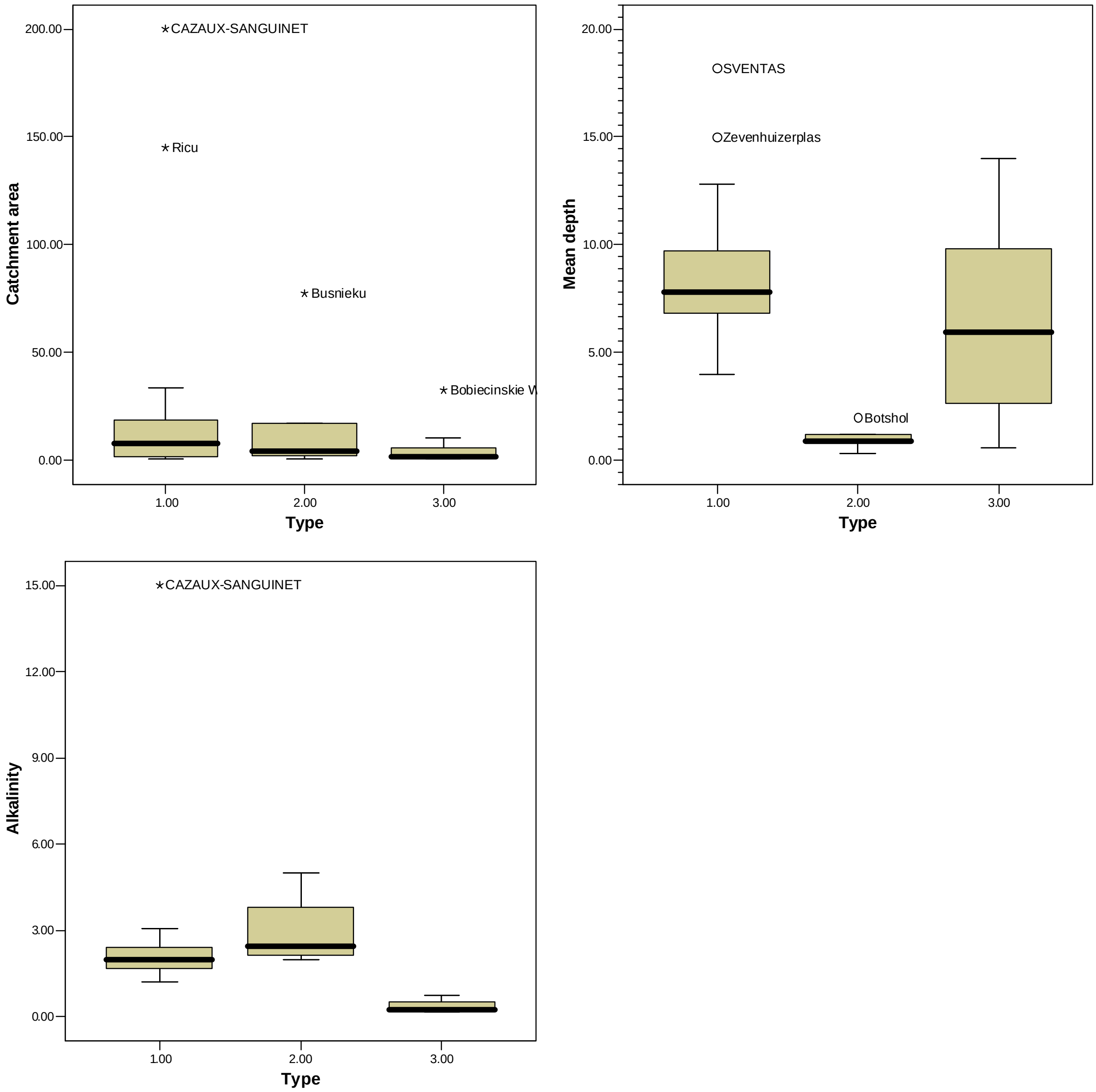


Figure C-1-2 Distribution of type characteristics for CB-GIG reference lakes (catchment area, mean depth, alkalinity)

Number of sites

The analysis of distributions is based on lake-years. The data available for each type are shown in Fig C-1-3. Most countries contribute to the reference population. All types have more than 10 lake years of data available. In this figure L-CB3 is presented by all depths. All Dutch lake-years are deleted when considering the depth of L-CB3 as 3-15m.

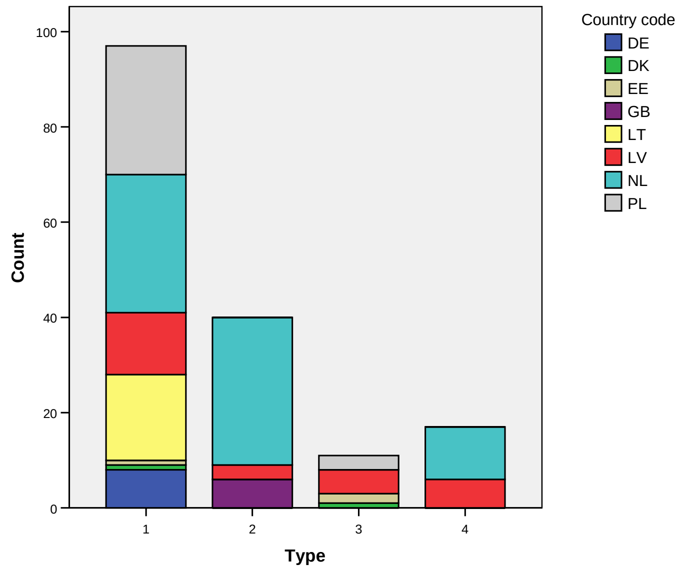


Fig C-1-3 Number of reference lake years for each GIG type and contribution of Member States finally used in the analysis. Type 4 contains the L-CB3 lakes with depth < 3m, and is not considered in this intercalibration exercise.

Comparison of reference TP with literature

Although agreement on reference tP values is not within the mandate of the GIGs, a comparison of values with other methods provides some information on the validity of the selected sites. The morpho edaphic index model (Vighi & Ghiaudani, 1985) is used as bench market. This model has recently been calibrated with data from UK and developed to a new model. In addition, a similar model has been developed based on the Rebecca data base. The distribution of CB GIG sites in comparison to these relationships is shown in Fig C-1-4. From this it can be seen that much of the reference TP data from CGIG has higher values than would be predicted from these models. This may be due to the cut level for phosphorus based on expert judgement used for the Rebecca sites which results in a less valid and transparent model. In addition, for most sites selected, the criteria for including them in the models are not clear and not necessarily WFD compliant. Given the rigorous nature of the GIG selection criteria it is concluded that these models underestimate reference TP for the GIG lowland types in our region. More data should be collected on reference sites to further validate this conclusion in the next round of intercalibration.

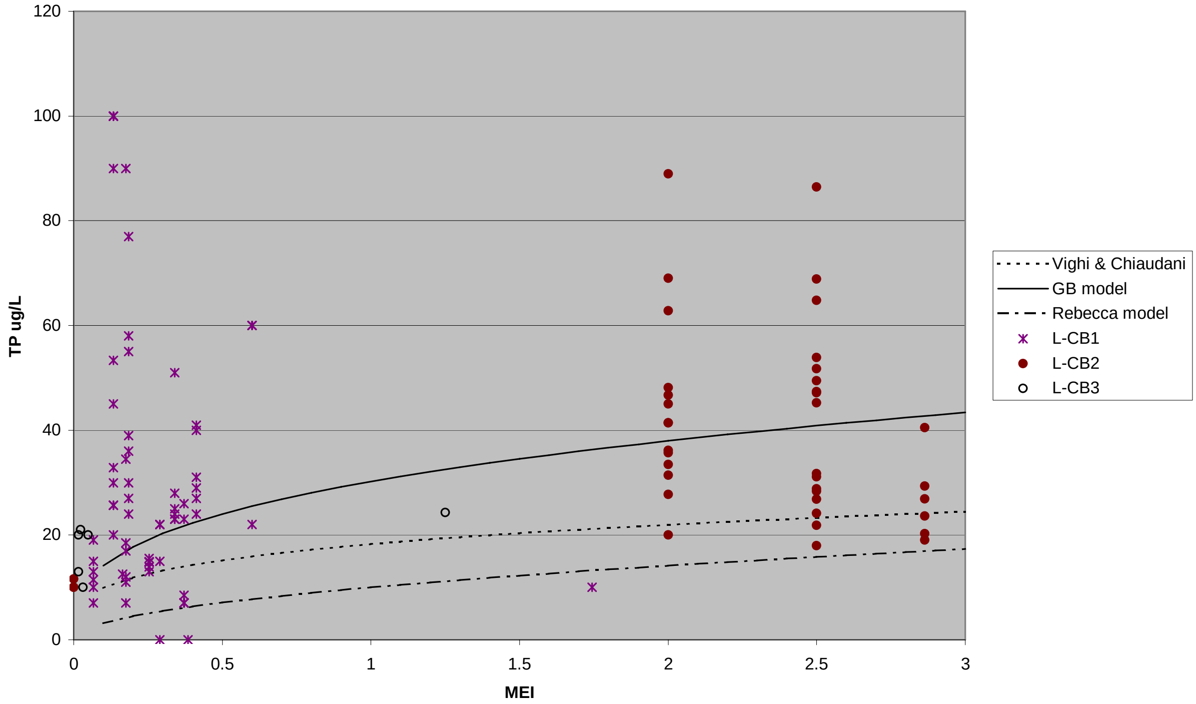
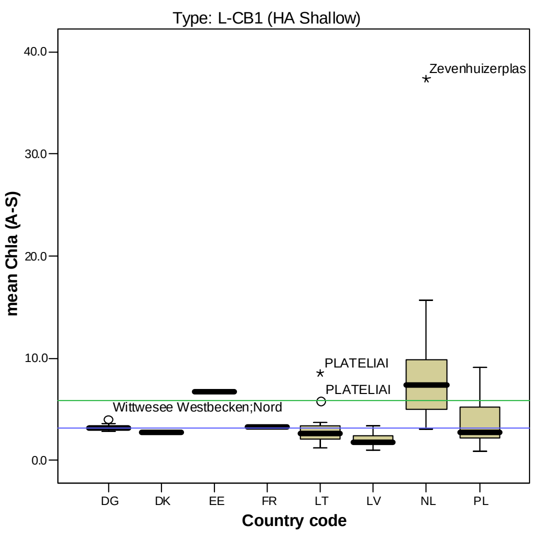


Fig C-1-4. Distribution of reference TP values in comparison to morpho edaphic index models

Distributions of reference sites and setting H/G boundary

The distribution of chlorophyll-a values of the reference population of lakes is presented per type (Table C-1-2). The cumulative distributions of the reference lake population as compared to the non-reference lake population are used to justify the choice of the 75th percentile of as H/G boundary. In all types the use of the 90th percentile for setting H/G boundary results in a relative high proportion of all lakes in the data base that would be assessed as high status, but were originally not assigned as reference lakes. Therefore, the 75th percentile is considered as a appropriate value for setting the H/G boundary. For each type the distribution of reference chlorophyll-a values is presented per Member State and for all Member states together (Figs C-1-5, 6, 7).



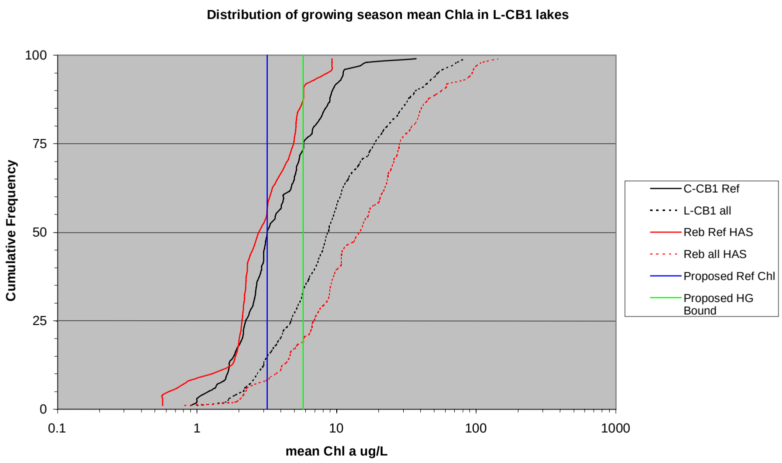
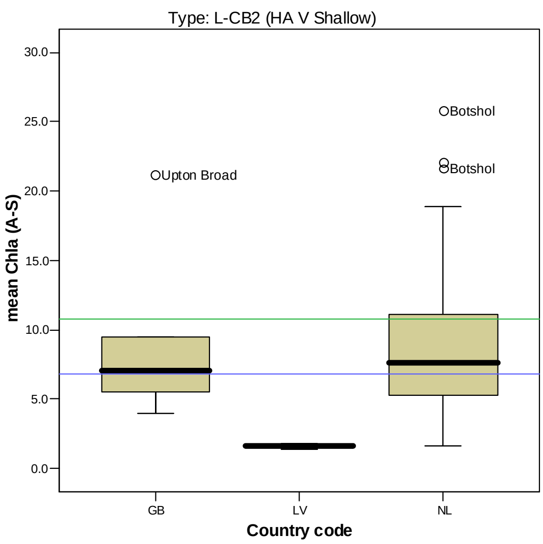


Fig **C-1-5**. Distributions of chlorophyll-a concentrations for different Member States and lake types for LCB1 type (shallow alkaline lakes).



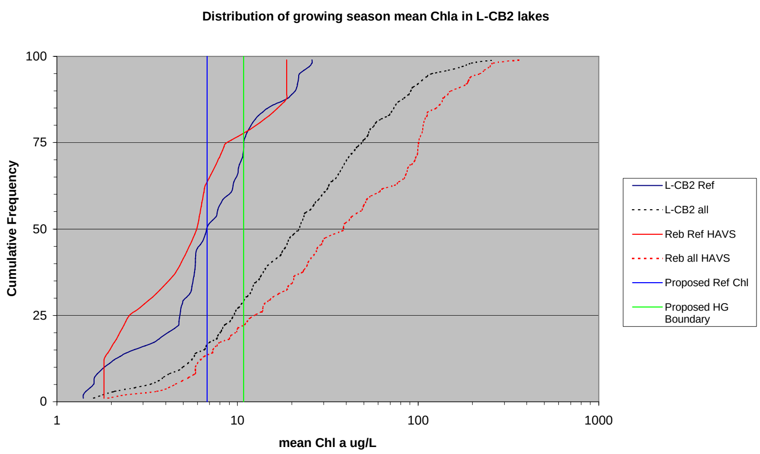


Fig C-1-5. Distributions of chlorophyll-a concentrations for different Member States and lake types for LCB2 type (very shallow alkaline lakes)

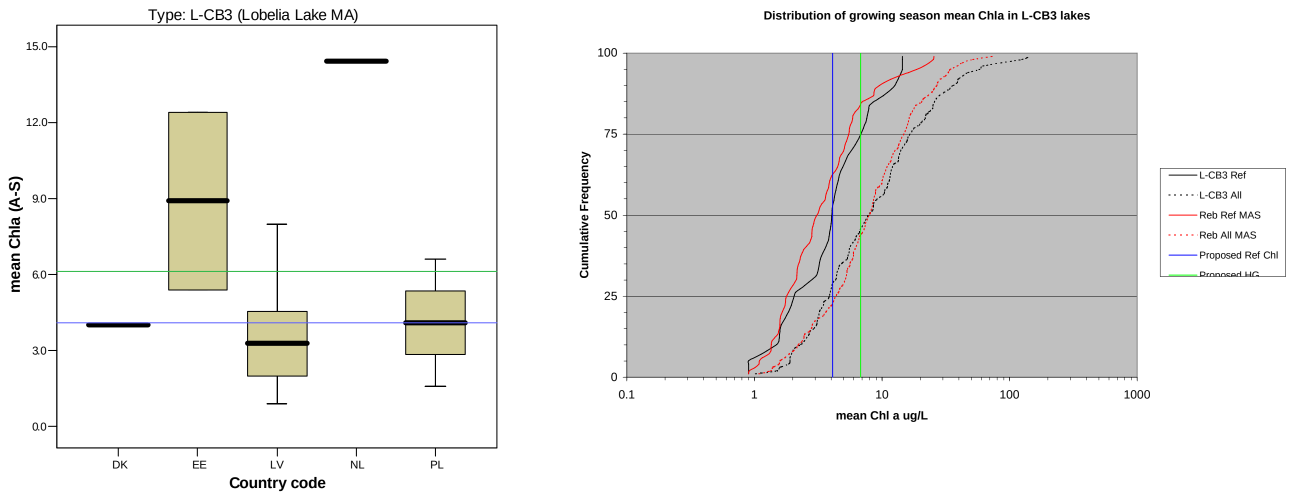


Fig C-1-6. Distributions of chlorophyll-a concentrations for different Member States and lake types for LCB3 type (shallow soft-water lakes)

For L-CB3 a very small data set is used. However, the median and 75th percentiles for the type are almost identical to the L-CB1 type and t-tests of log chlorophyll show there not to be a significant difference. This type has a wide depth range, including several lakes <3m mean depth, which is likely to increase the upper tail of the distribution of chlorophyll-a. The 75th percentile of L-CB3 excluding lakes < 3m mean depth has a slightly lower value. Excluding the very shallow lakes results in distributions that are very similar to the moderate alkalinity Rebecca reference lakes and the Northern GIG L-N1 type (Moderate alkalinity, Shallow, clear water lakes). It is suggested that the current type has too broad depth types to provide for useful boundaries and that the type should narrowed to only include lakes of 3m mean depth or greater. There are too few lakes to draw conclusion for the remaining very shallow lakes in the current L-CB3 type.

Table C-1-1. List of Central Baltic GIG Reference Lakes (Ref_clean list =1), used to establish statistical distributions to determine reference criteria and high/good boundary for chlorophyll a. For the final analysis type 3 lakes less than 3m are not considered.

Site_Code	Country code	Site name	Latitude	Longitude	Type	Alkalinity	Mean depth	Catchment area	REF1	REF_Clean list	Ref Criteria
DE12	DE	Schöhsee 1			1		10.9	2.3		1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
DE13	DE	Suhrer See 1			1		8.3	4.4		1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
DE15	DE	Wittwesee Westbecken ;Nord	5888,355	4562,704	1	1.40	5.5	8.6	-1	1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
DK17	DK	SLÅENSØ	5607,41	0937,26	1	1.20	7.3	0.7		1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
EE4	EE	Kooraste Kõverjärv	5758,35	2641,15	1	1.92	5.0	0.5	-1	1	
FR2	FR	CAZAUX-SANGUINE T	49,45 gr	3,90 gr	1	15.00	8.6	200.0	-1	0	is excluded based on not meeting criteria for point sources in September report
LT1	LT	ALNIS			1	2.20	5.9	5.6	-1	1	
LT11	LT	SVENTAS			1	1.20	18.2	15.0	-1	1	
LT8	LT	PLATELIAI	5602,6	2151,07	1	2.00	11.4	33.2	0	1	
LV119	LV	Ricu	264258,3	554148,4	1		9.7	145.0	0	1	Use of agricultural land is very extensive; no artificial fertilizers used; densities of cattle are sustainable
LV145	LV	Sudrabezers	242044	570142,1	1		4.1	1.2	0	1	
LV147	LV	Sventes	262117,6	555115,9	1		7.8	18.5	0	1	Use of agricultural land is very extensive; no artificial fertilizers used; densities of cattle are sustainable
LV15	LV	Balts	272944,2	555102,7	1		7.1	1.5	0	1	Use of agricultural land is very extensive; no artificial fertilizers used; densities of cattle are sustainable
LV36	LV	Dridzis	271731,6	555838,5	1		12.8	33.5	0	1	Use of agricultural land is very extensive; no artificial fertilizers used; densities of cattle are sustainable
LV59	LV	Juveris	254025,2	571316,8	1		8.5	8.7	0	1	
NL13	NL	Zevenhuizer plas	5158,41	0433,54	1	2.00	15.0	1.2	0	1	Lake isolated
NL2	NL	Broekvelden Vettebroek	5203,20	0444,56	1	2.00		1.7	-1	1	Lake isolated
PL13	PL	Dlugie Wigierskie	5401,4	2301,4	1	3.05	7.4	7.5	-1	1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
PL22	PL	Jegocin	5340,2	2141,8	1	1.66	9.0	12.1	-1	1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance

Site_Code	Country code	Site name	Latitude	Longitude	Type	Alkalinity	Mean depth	Catchment area	REF1	REF_Clean list	Ref Criteria
PL30	PL	Kolowin	5343,8	2124,3	1	2.40	4.0	20.2	-1	1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
PL32	PL	Krepsko Dlugie	5322,5	1636,5	1	2.58	7.6	13.6	-1	1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
PL7	PL	Busznica	5356,7	2305,2	1	1.97	6.8	3.0		1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
GB15	GB	Upton Broad	52,665799556	1,5326364537	2	2.29	0.8	0.7	0	1	Lake isolated
GB17	GB	Loch Scarmclate	58,52	-3,39	2	2.60	0.8	16.9	0	0	Catchment contains pasture, but recent information suggests this is improved pasture and site should be excluded from strict definition of Reference
LV25	LV	Busnieku	213838	572643,9	2		1.2	77.5	0	1	
LV39	LV	Dunieris	232957,7	565918,9	2		0.3	2.0	0	1	
NL1	NL	Botshol	5214,59	0455,35	2	5.00	2.0	2.2	0	1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
NL7	NL	Naardermeer	5218,15	0506,33	2	2.00	1.0	6.1	-1	1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance Data before 1990 excluded from analysis
DK1	DK	Almind Sø	5608,99	0932,70	3	0.50	10.4	4.2		1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
EE11	EE	Väike Palkna	5837,15	2657,3	3		14.0	1.0	-1	1	
EE6	EE	Nohipalu Valgjärv	5756,28	2720,49	3	0.19	6.2	0.8	-1	1	
LV100	LV	Ojatu	272233,7	560324,7	3		9.2	2.3	0	1	Use of agricultural land is very extensive; no artificial fertilizers used; densities of cattle are sustainable
LV13	LV	Baltezers (Timsmales)	223804,6	564049,8	3		5.7	1.5	-1	1	
LV155	LV	Tolkaja	262552,5	563840,2	3		5.2	0.6	-1	1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
LV159	LV	Ummis	241952,4	571004,4	outside 3		2.9	1.0	0	1	
LV32	LV	Daugulu Mazezers			outside 3		2.4	5.8		1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
LV50	LV	Garezers (Ance)	219580	575662	outside 3		1.1	5.9	-1	1	
NL16	NL	Beuven	5124,11	0538,47	outside 3	0.75	0.6	10.3	-1	1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
PL53	PL	Piasek	5400,7	1707,8	3	0.25	11.2	1.3	0	1	Catchment lake surrounded >90% by natural land use and no signs of any disturbance
PL6	PL	Bobiecinskie Wielkie	5400,5	1648,3	3	0.15	9.1	32.4	0	1	Use of agricultural land is very extensive; no artificial fertilizers used; densities of cattle are sustainable

Table C-1-2. Overview of statistics (percentiles) of reference values for chlorophyll-a and total phosphorus (mean vegetation season values) per type. Values are also compared with all lakes in the general CB GIG data base and all lakes in Rebecca data base, and the reference lakes of the Rebecca. HA=high alkalinity, MA=moderate alkalinity, S=shallow, VS=very shallow.

L-CB1

L-CB1	Chlorophyll			
	Ref lake/years GIG Clean	All lake/years	GIG Ref Lakes Rebecca HAS	All Lakes Rebecca HAS
N	96	650	23	171
10th PC		2.7		3.6
25th PC		4.7		6.9
50th PC	3.1		2.8	
75th PC	5.8		4.9	
90th PC	9.4		5.8	
EQR 75	0.53		0.57	
EQR 90	0.33		0.48	
	Total P			
	Ref lake/years GIG Clean	All lake/years	GIG Ref Lakes Rebecca HAS	All Lakes Rebecca HAS
N	96	655	23	171
10th PC		16		14
25th PC		23		22
50th PC	24		13	
75th PC	41		24	
90th PC	60		41	
EQR 75	0.59		0.55	
EQR 90	0.40		0.32	

Table C-1-2 (continue) L-CB2

L-CB2	Chlorophyll			
	Ref lake/years GIG Clean	All GIG lake/years	Ref Lakes Rebecca HAVS	All Lakes Rebecca
N	40	396	7	135
10th PC		5.0		5.9
25th PC		9.5		12.2
50th PC	6.8		6.0	
75th PC	10.8		8.6	
90th PC	20.9		18.7	
EQR 75	0.62		0.69	
EQR 90	0.32		0.32	
	Total P			
	Ref lake/years GIG Clean	All GIG lake/years	Ref Lakes Rebecca HAVS	All Lakes Rebecca
N	40	394	7	132
10th PC		26		28
25th PC		42		69
50th PC	35		16	
75th PC	48		40	
90th PC	68		60	
EQR 75	0.72		0.41	
EQR 90	0.51		0.27	

Table C-1-2 (continue) L-CB3, all depths

L-CB3	Chlorophyll					
	Ref lake/years GIG Clean	All lake/years GIG	Ref Lakes Rebecca MAS	All Lakes Rebecca MAS	Ref Lake L-N1	All Lake L-N1
N	18	119	52	211	22	73
10th PC		2.3		2.2		2.1
25th PC		3.9		4.4		2.9
50th PC	4.1		3.1		2.9	
75th PC	6.8		5.5		4.8	
90th PC	12.6		9.6		5.8	
EQR 75	0.59		0.56		0.59	
EQR 90	0.32		0.32		0.49	

	Total P					
	Ref lake/years GIG Clean	All lake/years GIG	Ref Lakes Rebecca MAS	All Lakes Rebecca MAS	Ref Lake L-N1	All Lake L-N1
N	28	141	52	208	22	73
10th PC		14		7		5
25th PC		20		11		8
50th PC	22		9		8	
75th PC	40		14		12	
90th PC	105		20		13	
EQR 75	0.55		0.68		0.64	
EQR 90	0.21		0.47		0.59	

Table C-1-2 (continue) L-CB3, mean depth >= 3.0m

L-CB3 >=3m mean depth	Chlorophyll					
	Ref lake/years GIG Clean	All GIG lake/years	Ref Lakes Rebecca MAS	All Lakes Rebecca MAS	Ref Lake L-N1	All Lake L-N1
N	11	119	52	211	22	73
10th PC		2.3		2.2		2.1
25th PC		3.9		4.4		2.9
50th PC	3.1		3.1		2.9	
75th PC	5.4		5.5		4.8	
90th PC	11.2		9.6		5.8	
EQR 75	0.57		0.56		0.59	
EQR 90	0.28		0.32		0.49	
	Total P					
	Ref lake/years GIG Clean	All GIG lake/years	Ref Lakes Rebecca MAS	All Lakes Rebecca MAS	Ref Lake L-N1	All Lake L-N1
N	11	141	52	208	22	73
10th PC		14		7		5
25th PC		20		11		8
50th PC	14		9		8	
75th PC	20		14		12	
90th PC	25.8		20		13	
EQR 75	0.70		0.68		0.64	
EQR 90	0.54		0.47		0.59	

Table C-1-3. Overview of lake characteristics of Central Baltic lake types for both reference and non reference lakes. Area (km^2), Depth (m), Residence time (y), Catchment (km^2), Conductivity (µS), Colour (mg Pt)

LCB1
Statistics

		Surface_area	Mean_depth	Max_depth	Residence_tim	Catchment_area	Conductivit	Colour
N	Valid	173,00	172,00	133,00	151,00	134,00	130,00	138,00
	Missing	6,00	7,00	46,00	28,00	45,00	49,00	41,00
Percentiles	5,00	0,12	3,00	5,44	0,16	0,89	184,20	8,00
	10,00	0,16	3,16	7,08	0,31	1,67	210,10	9,98
	25,00	0,43	4,20	9,55	0,80	3,92	250,25	11,28
	50,00	1,03	5,85	15,00	2,00	12,20	304,00	18,55
	75,00	2,71	9,08	30,25	5,00	48,28	361,88	47,58
	90,00	14,40	12,97	44,30	10,00	574,65	435,90	85,00
	95,00	127,00	15,11	50,86	16,41	4408,75	618,35	120,75

LCB1_REF
Statistics

		Surface_area	Mean_depth	Max_depth	Residence_tim	Catchment_area	Conductivit	Colour
N	Valid	16,00	15,00	16,00	14,00	16,00	14,00	10,00
	Missing	0,00	1,00	0,00	2,00	0,00	2,00	6,00
Percentiles	5,00	0,32	4,00	6,38	0,50	1,20	137,00	10,00
	10,00	0,44	4,06	6,95	0,65	1,21	157,50	10,00
	25,00	0,75	6,80	14,85	1,91	2,06	197,75	10,00
	50,00	1,00	7,80	27,40	4,90	10,40	220,50	10,00
	75,00	6,58	11,40	39,93	13,40	19,78	289,38	12,63
	90,00	12,37	16,28	53,13	22,50	66,95	355,50	56,05
	95,00	12,86	18,20	65,10	25,00	145,00	360,00	60,00

LCB2
Statistics

		Surface_area	Mean_depth	Max_depth	Residence_tim	Catchment_area	Conductivit	Colour
N	Valid	93,00	92,00	82,00	78,00	89,00	86,00	72,00
	Missing	5,00	6,00	16,00	20,00	9,00	12,00	26,00
Percentiles	5,00	0,07	0,37	1,02	0,02	0,00	159,43	12,13
	10,00	0,10	0,64	1,26	0,05	0,70	187,80	15,42
	25,00	0,26	1,13	2,20	0,09	2,50	251,00	26,00
	50,00	0,68	1,80	3,50	0,30	14,50	314,72	50,00
	75,00	2,42	2,30	4,58	0,74	69,20	453,25	75,75
	90,00	25,75	2,69	6,50	1,79	380,00	1314,07	159,25
	95,00	170,20	2,80	8,71	2,25	1807,00	2932,64	240,50

LCB2_REF
Statistics

		Surface_area	Mean_depth	Max_depth	Residence_tim	Catchment_area	Conductivit	Colour
N	Valid	6,00	6,00	4,00	6,00	6,00	4,00	3,00
	Missing	0,00	0,00	2,00	0,00	0,00	2,00	3,00
Percentiles	5,00	0,07	0,30	0,50	0,08	0,69	193,00	16,40
	10,00	0,07	0,30	0,50	0,08	0,69	193,00	16,40
	25,00	0,21	0,68	0,75	0,15	1,67	236,20	16,40
	50,00	0,80	0,90	1,55	0,34	4,14	375,24	20,00
	75,00	1,76	1,40	2,50	0,77	32,08	606,17	152,00
	90,00	3,30	2,00	2,80	1,50	77,50	680,00	152,00
	95,00	3,30	2,00	2,80	1,50	77,50	680,00	152,00

LCB3
Statistics

		Surface_area	Mean_depth	Max_depth	Residence_tim	Catchment_area	Conductivit	Colour
N	Valid	60,00	60,00	60,00	54,00	60,00	54,00	53,00
	Missing	0,00	0,00	0,00	6,00	0,00	6,00	7,00
Percentiles	5,00	0,01	0,65	1,11	0,15	0,00	17,50	10,00
	10,00	0,02	0,80	1,60	0,24	0,10	19,65	15,00
	25,00	0,09	1,23	2,13	0,49	0,60	28,75	27,50
	50,00	0,16	2,35	5,00	1,10	1,60	49,50	75,00
	75,00	0,40	3,90	7,90	3,22	4,76	93,75	195,00
	90,00	1,27	8,99	29,19	5,88	10,10	124,50	418,80
	95,00	3,89	9,49	33,14	7,75	13,94	141,50	762,50

Annex C - Part 2 - Good-Moderate Boundary Setting Procedure

2.1. Introduction

Eutrophication is a wide spread phenomenon in European lakes. Eutrophication starts with load of nutrients to the water, and is here defined as induced by human activity. As consequence, abiotic conditions in the water change and, eventually, the composition and abundance of organisms living in or connected to the water are affected. Because organisms are influencing each other, and biological components affect abiotic conditions vice versa, causes and effects in the eutrophication process are difficult to unravel. In our milestone report we present a very simple model using five steps for describing eutrophication (Fig C-2-1a). The intercalibration work has paid attention to the steps from changes in abiotic conditions to the first biological effect (i.e. chlorophyll-a) and the step where the increase of chlorophyll-a affects other biological parameters, also known as secondary effects. The other steps are not part of the intercalibration exercise. So, no work is done on the estimation of the load to the lakes and how this affects the concentration.

General:
human activity → load / pressure→ change of abiotic conditions in water→ biological effect 1→biological effect 2
GIG example:
use of water (e.g. by households) → discharge of polluted water (e.g. waste water) → higher tP concentration →higher chlorophyll-a →decrease macrophytes

Fig C-2-1a. Simple conceptual model of eutrophication presenting causes and effects in general (above) and an example of our GIG (below).

Based on this model the GIG expects that an increase of nutrient related human activities lead to an increase of nutrient availability in the water, and as consequence, to biological effects. The GIG expects that the effect of nutrient enrichment may not be the same for all types. Some relationships may be discontinuous due to complex interactions between ecosystem components. These discontinuities can be considered as a sign of ecosystem stability, and is well known to occur in very shallow lakes. Retention time and water depth have also a large impact on how eutrophication manifests. According the Vollenweider models, lakes with a high retention time (generally the deeper lakes) will have a lower nutrient concentration than the lakes with a very low retention time (generally the shallower ones). Also the conversion from nutrients to chlorophyll-a differs amongst lake types. Several studies made very clear that light is getting a limiting factor for chlorophyll-a concentration in very eutrophic lakes, but importantly, also in deep lakes (e.g. Scheffer, 1998). In very shallow lakes it has been clearly demonstrated that relatively low chlorophyll-a concentrations can occur due to top down control (e.g. Jeppesen, 1998). This top-down control is closely related with the presence of submerged macrophytes.

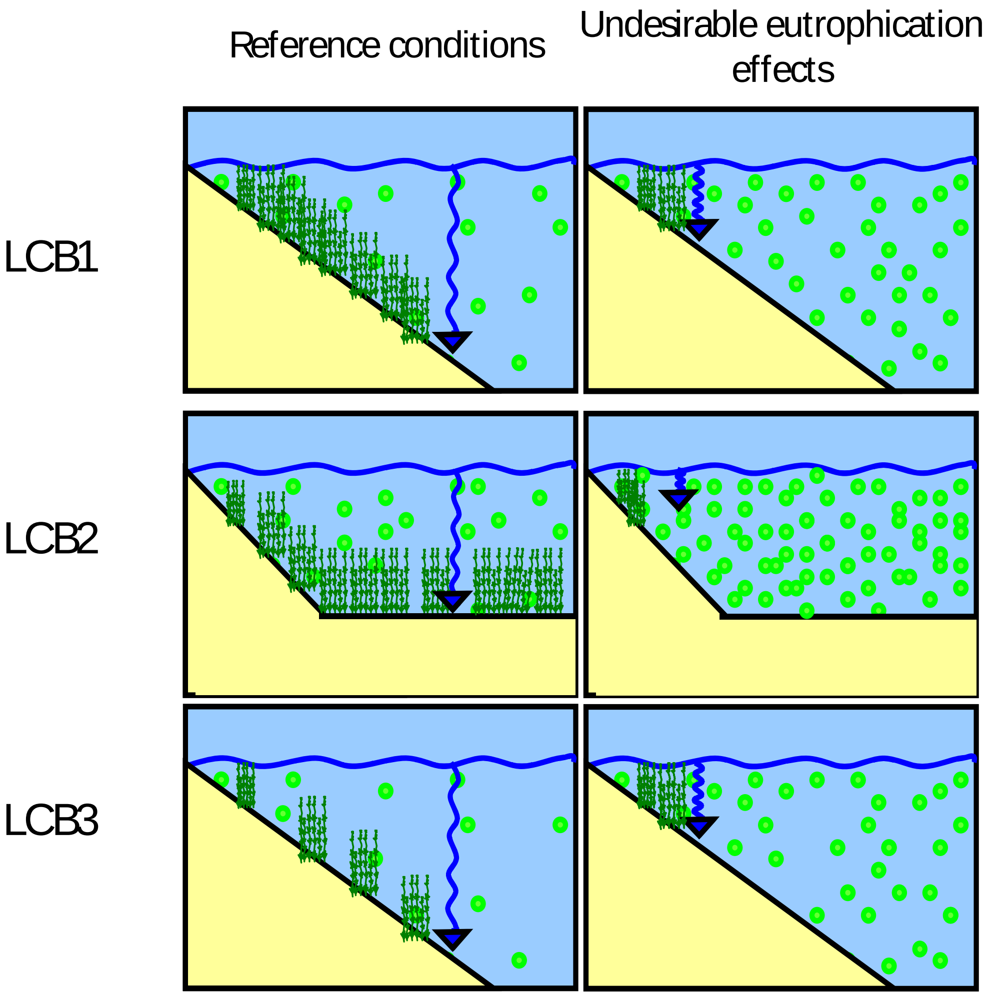


Fig. C-2.1b. Schematic Central Baltic lake types in reference conditions and poor condition (undesirable effects are likely to occur). The figure illustrates the change in abundance of macrophytes, transparency, abundance of phytoplankton and maximum colonised depth of submerged macrophytes as consequence of eutrophication.

The increase of chlorophyll-a concentration may have several secondary effects which can be considered as undesirable at a certain level. Undesirable effects can be used for boundary setting, because undesirable disturbances to the balance of organisms resulting from accelerated algae growth are not allowed to occur according the definition of good phytoplankton status in the WFD Annex V. The GIG has made agreements on the definition of undesirable, and the probability with which undesirable events may occur in Good Status. It may be argued that the probability of having undesirable effects should be zero according the definition of Good Status, but our biological data show that this is not realistic. Lake types are very broad, which causes large variation in the data. Moreover, some lakes in our data base have been manipulated which may cause ecological unstable situations. For example, lakes suffering from eutrophication may show resistance, and may contain macrophytes for a long time, though abiotic conditions show effects of sever eutrophication. On the other hand, measures reducing eutrophication may have a fast effect on abiotic conditions in the water, but the biological parameters show often a delay in their response. This results in exceptional combinations of abiotic and biotic conditions, by which 100 % confidence limits in dose-effect relationships are neither scientifically right nor useful. In line with the Eutrophication Guidance we propose values representing negligible probability of having undesirable effects (e.g. 5 or 10 %), or alternatively, as a slight increase in probability of having undesirable effects as compared to estimated reference conditions.

An increase of chlorophyll-a may have huge consequences to the balance in organisms in lakes. Our hypothesis focuses on only a very limited number of parameters, and excludes indirect effects on macro-invertebrates, fish and birds (Fig C-2.1b). High concentrations of chlorophyll-a as compared to the type specific reference conditions may induce:

- a decrease in maximum depth inhabited by submerged macrophytes. The decrease in maximum inhabited depth occurs over a large gradient of Secchi depths and is more or less linear (Blindow, 1991; Middelboe & Markager, 1997). This relationship is explained by the fact that submerged macrophytes need a minimum amount of light at the sediment for maintaining growth. This critical amount of light at sediment is reported to be between 2 and 16 % of surface light and is depending on growth form and latitude. In lakes less than 3 m the colonized depth is a less sensitive indicator because macrophytes can grow to the light, and can compensate for lower light conditions. In our data we did not provide data on growth form.
- a shift from macrophytes / benthic dominated community with clear water to a phytoplankton dominated community with turbid water. This relationship is expected to be non-linear in individual very shallow alkaline lakes (Scheffer, 1998). A criterion for dominance by macrophytes is proposed where macrophytes are abundant (at least class 2.5 on a 5 class system). At reference values of chlorophyll-a the majority of alkaline lakes is expected to have abundant macrophytes, while an undesirable effect is defined where the majority of the lakes have a low macrophyte cover or even absent. The GIG has collected data for species and different growth forms (e.g. Charophytes, submerged macrophytes, Lemnids, Nympheaids), except for Denmark where data were only available as percentage submerged macrophytes total. The growth forms charophytes and submerged macrophytes are expected to be more sensitive to eutrophication than the other groups.
- a shift in phytoplankton composition to light competitors (cyanobacteria). Some groups of cyanobacteria are notorious dominating in situations of low light and low concentrations of dissolved nutrients. Also from the socio-economic point of view, blooms of cyanobacteria are considered as undesirable, because they may produce toxins dangerous for various organisms. Some representatives of the cyanobacteria, however, can be characteristic for natural conditions. Rebecca has proposed to use the indicator share of cyanobacteria (biovolume basis), but excluding the Chroococcales, except *Microcystis* sp.
- shift from sensitive macrophytes species to tolerant hydrophyte species. A common indicator is missing, but REBECCA may come up with a proposal for a common indicator. Besides this, the GIG proposed to start with exchange of data and assessments methods to make a pilot for the option 3 of intercalibration. Relationships with a certain species may show thresholds for human pressure above which they cannot occur. For indicators based on sensitive and impact species a more gradual relationship with pressures is expected (REBECCA). No harmonization is proposed yet for this year, due to large noise in the data

set, and due to fundamental differences in approaches of national assessment methods. This work needs to be extended in the second round of intercalibration.

Besides the effect of chlorophyll-a on other components in the ecosystem, also the change of chlorophyll-a itself can be used for setting standards. This is possible by using equal classes between the values of type specific reference and the worst values. At first sight this might have no ecological meaning, but this is not completely true. At least the maximum concentration of chlorophyll-a has an ecological meaning i.e. the value where other resources are limiting than nutrients. Several authors have reported that the maximum chlorophyll-a is eventually directly dependent on the light availability. When the minimum light amount for maintaining growth of phytoplankton is a constant value, and lakes have a similar background turbidity, the maximum chlorophyll-a is directly dependent on the depth of the lake (see Fig C-2-1d). In other words, chlorophyll-a in deep lakes is more diluted as it is in shallow ones (see Fig C-2-1c for empirical evidence). Thus, dividing the chlorophyll-a values in equal classes between the H/G boundary and the worst situation is type specific and has ecological meaning in terms of light limitation of phytoplankton growth. The division of equal classes has to be carried out on basis of log transformed data, because the distribution of chlorophyll-a values is very skewed and would, if not transformed, result in statistically inhomogeneous classes.

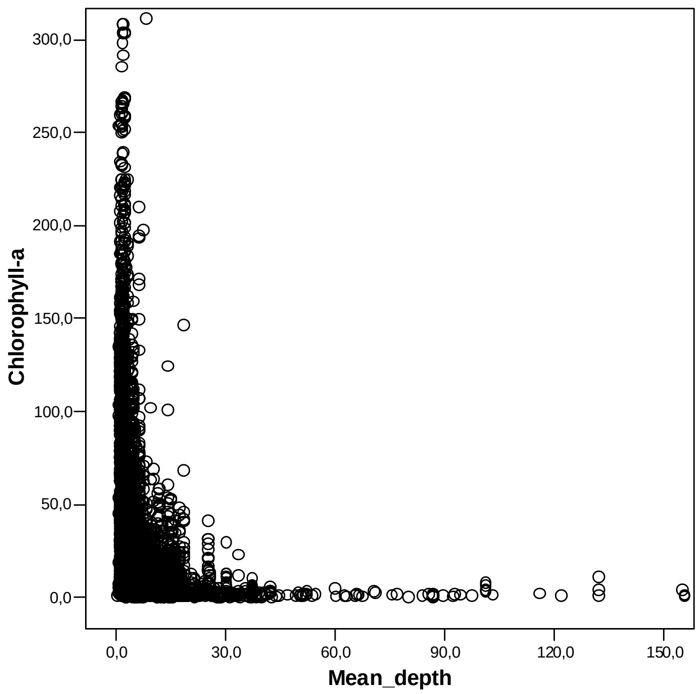


Fig C-2-1c. Relationship between depth (m) and averaged concentration chlorophyll-a (µg l^{-1}) for European lakes in the Rebecca data base (n≈5000).

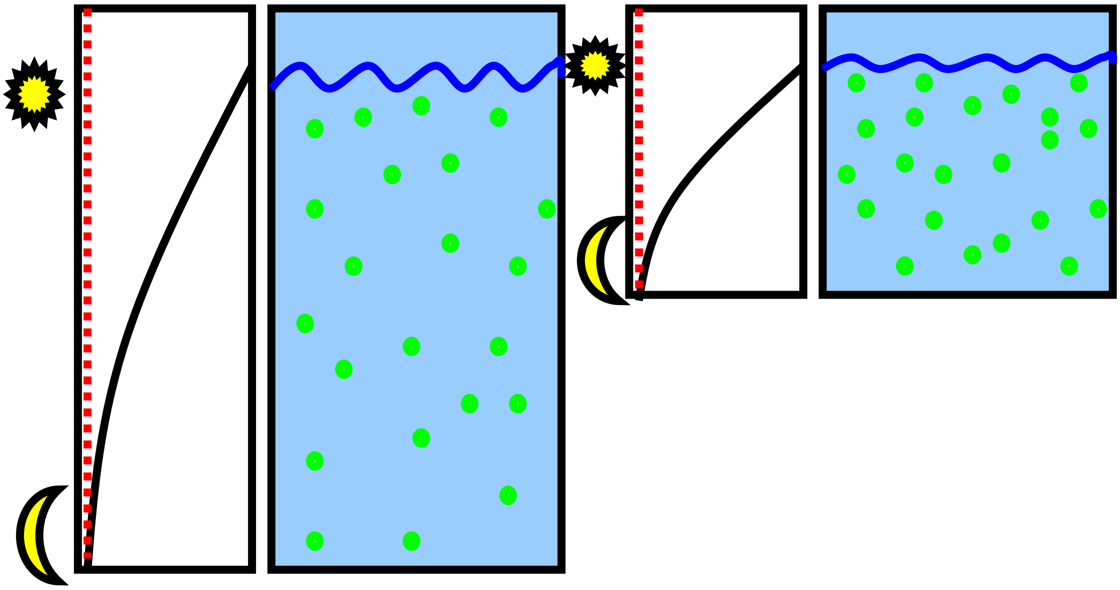


Fig C-2-1d. A schematic deep (left) and shallow lake (right) with indicative concentration chlorophyll-a (green dots) and the resulting light gradient (black line) assuming that phytoplankton has a constant compensation point for light (red dotted line), the background turbidity is comparable and that nutrients are not limiting. The result is that the biomass of phytoplankton per m^2 is similar for both lakes, but the concentration is much lower in the deeper lake.

2.2. Relationships between chlorophyll-a and nutrients

Based on literature the GIG hypothesizes that the chlorophyll-a concentration is positively related with the nutrient concentration. A number of studies have provided models on the estimation of chlorophyll-a based on TP and or TN. The expected relationship is that the nutrients set the maximum chlorophyll-a concentration. This can be explained by the fact that other factors than nutrients may limit the chlorophyll-a concentration (e.g. light limitation, top-down control).

From our data (CB general data base) it is clear that low phosphorus concentrations are related with low summer averages of chlorophyll-a (Fig C-2-2a). The other way round is less clear: high TP values are associated with high maximum values of summer averages of chlorophyll-a, but also relatively low values can occur. These relatively low chlorophyll-a values may be due to limiting factors other than phosphorus, e.g. light, nitrogen or top-down control by zooplankton. Therefore we decided not to describe this relationship by linear regression, but by estimation of the maximum value of the chlorophyll-a. This is carried out by determining the percentile distribution of the ratio between chlorophyll-a and tP (both vegetation season), where the 90th percentile is chosen as representing the upper limit of chlorophyll-a at a given tP value (Table C-2-2a).

In Fig C-2-2a is shown how chlorophyll-a is related with tP for different types including the type specific line at which 90% of the samples does not exceed the expected concentration for a given tP value. For type 3 the median value and the distribution of chlorophyll-a-TP ratios is very similar to type 1, but deviates around the 75th percentile. The data of LCB3 have a much smaller range in both chlorophyll-a and tP values as compared to the other types. Because only very limited data are available, the type 1 distribution is assumed to be valid for type 3. Shallow lakes show a lower ratio of chlorophyll-a tP ratio than very shallow lakes. This is probably due to the effect of the higher extent of light limitation in shallow lakes. Member States can use the chlorophyll-a tP relationships for setting their standards for nutrient concentrations. The GIG stresses, however, that more specific information (e.g. abundance of macrophytes, lake depth, or even individual characteristics) will have a large effect on the relationships between chlorophyll-a and tP and thus, determines also the standards using those relationships. Standardization of nutrient concentrations is not part of the GIGs mandate.

Table C-2-2a. Percentile distribution of Chlorophyll-a (μg l^{-1}) – total Phosphorus (mg l^{-1}) ratios for different types. LCB3 is also combined with LCB1 in figure C-2-2a.

	LCB1	LCB2	LCB3	LCB1 and LCB3 (>3m)
10th percentile	74.4	100	85.8	75.9
50th percentile	220	318	271	226
90th percentile	534	787	695	564
n	639	378	115	754

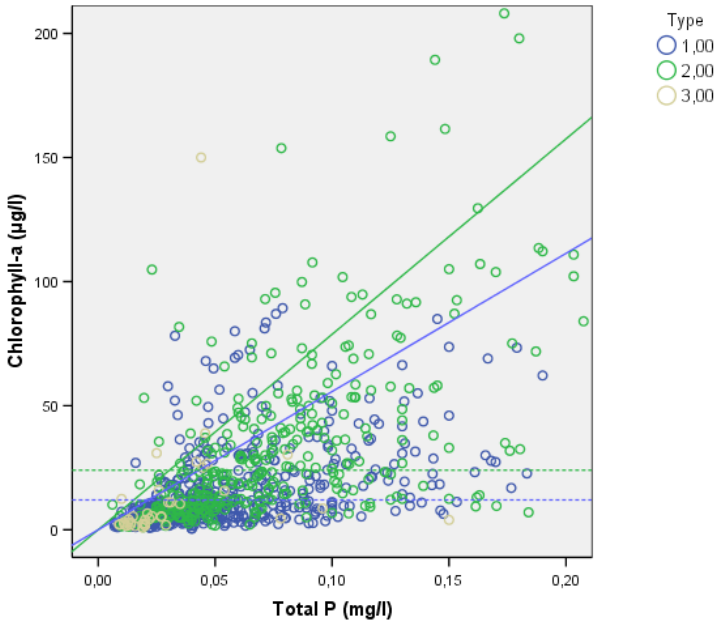


Fig C-2-2a. Relationship between chlorophyll-a and tP (maximum in Fig is set at 0,2 mg/l) for Central-Baltic Lake types. Solid lines represent the type specific line below which 90% of the chlorophyll-a values are located. The dotted lines represent the proposed G/M boundary of chlorophyll-a.

From our data (bloom data base) it is clear that low nitrogen concentrations are related with low values of chlorophyll-a (Fig C-2-2b). The other way round is less clear: high N values are associated with high maximum values of summer averages of chlorophyll-a, but also relatively low values are present. These relative low chlorophyll-a values may be due to other limiting factors than nitrogen, e.g. light, phosphorus or top-down control by zooplankton. Therefore we decided not to describe this relationship by linear regression, but by estimation of the maximum value of the chlorophyll-a. This is carried out by determining the percentile distribution of the ratio between chlorophyll-a and N (mostly single observation during summer), where the 90th percentile is chosen as representing the upper limit of chlorophyll-a at a given N value.

Table C-2-2b. Percentile distribution of Chlorophyll-a (µg l^{-1}) – total Nitrogen (mg l^{-1}) ratios for different types. No data available for LCB3. Values are mostly single samples.

percentile	L-CB1	L-CB2
10	2.6	2.7
50	7.8	14.0
90	34.0	44.9
n total	167	213

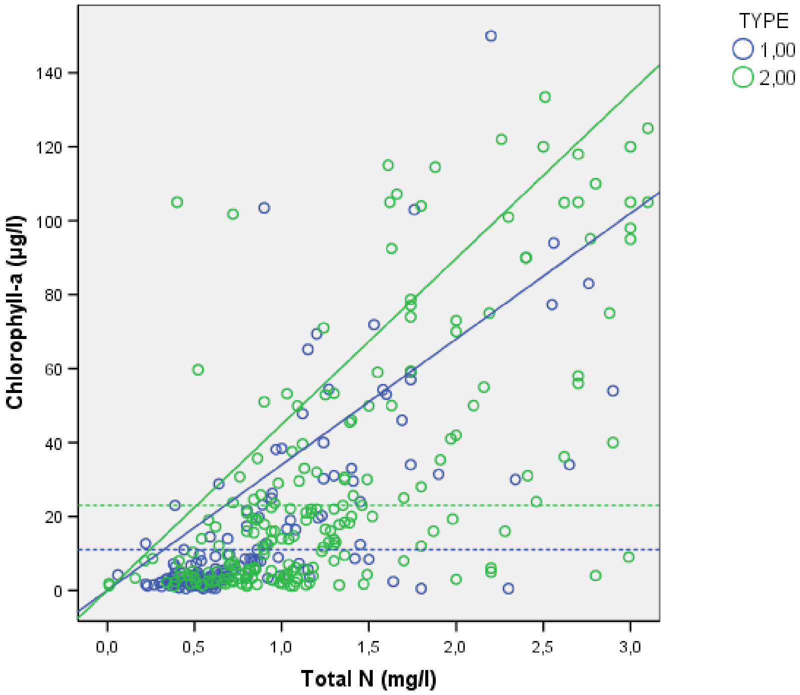


Figure C-2-2b Relationship between chlorophyll-a and tN (maximum in Figure is set at 3,0 mg/l) for Central-Baltic Lake types. Solid lines represent the type specific line below which 90% of the chlorophyll-a values are located. The dotted lines represent the proposed G/M boundary of chlorophyll-a.

2.3 General approach in G/M boundary setting

Officially, only chlorophyll-a G/M boundaries are harmonised. But we have applied the definition of phytoplankton in the WFD Annex V as much as possible by agreeing on allowable risks of having undesirable effects induced by chlorophyll-a for:

- abundance of submerged macrophytes
- maximum colonised depth of submerged macrophytes
- proportion of cyanobacteria.

The undesirable effects are compared with the values for these parameters at reference conditions. In most cases, the deviation from reference conditions as well as the probability of having poor status is taken into consideration for boundary setting. Besides the secondary impact parameters equal classes between type specific H/G values and the worst values is used to set G/M boundary.

Based on the reference values of chlorophyll-a values the reference conditions of the secondary effect parameters are estimated. This indirect procedure may not be fully compliant with the WFD, and should be considered as the best approximation of a reference value. Because of the lack of real reference values we have focussed on the change of the secondary impact parameters rather than to provide full assessment procedure for the secondary impact parameters or as separate quality element. Thus, the harmonised chlorophyll-a values ensure ecological functioning from eutrophication point of view, especially for macrophytes and phytoplankton. As other components are very dependent on these elements, we expect that these values will also be close to the values needed for Good status of fish and macro-invertebrates and other (biological) parameters. This needs to be tested with real data in the next round of intercalibration.

2.4. Derivation of chlorophyll-a boundaries based on change in submerged macrophytes abundance

Introduction

This chapter deals with the determination of boundary values for chlorophyll-a based on secondary effects on the abundance of submerged macrophytes. It is based on the assumption that enhanced algal growth resulting in an increased chlorophyll-a concentration reduces the light conditions at the lake bottom, and thus causes a reduction in the abundance of submerged macrophytes as an undesirable secondary effect. It does not consider composition of the submerged macrophytes on a species level, but based on growth form.
A direct relationship between chlorophyll-a and macrophyte abundance is the most straightforward way to assess boundaries for chlorophyll-a based on its secondary effects on macrophyte growth. These effects are usually non linear in very shallow lakes, and transitions in macrophyte abundance often occur in jumps. The method has the advantage that it is transparent and leads directly to class boundaries for chlorophyll-a.

Methods

The method is empirical and based on the data collected for the Central/Baltic GIG. From the data provided by the Member States abundance classes were calculated for individual lake-years. Each Member State has converted their data per species using the ECOFRAME abundance scale. The calculation of abundance classes is described in Annex C Part 2.8. Species data are converted in groups differing in growth form. Abundance was calculated in classes ranging from 0-5 and are averaged for submerged macrophytes and charophytes. The number of lake years per country is given in Table C-2-4a. The table shows that the set of LCB2 lakes is presently dominated by Dutch lakes, and to a lesser extent by lakes from Denmark and Latvia.

Table C-2-4-a. Number of lake-years (very shallow lakes LCB2) for different countries with data on chlorophyll-a and macrophyte abundance.

Country	# lake years
NL	254
DK	63
LV	50
HU	23
RO	18
UK	7
EE	1
BE	1
total	417

The number of lake years per country for LCB1 lakes is given in Table C-2-4b. The shows that the set of LCB2 lakes is presently dominated by Latvian and Dutch lakes, and to a lesser extent by lakes from Denmark.

Table C-2-4-b. Number of lake-years (shallow lakes LCB1) for different countries with data on chlorophyll-a and macrophyte abundance.

Country	# lake years
LV	58
NL	45
DK	21
PL	5
LT	5
UK	3
EE	2
BE	1
total	140

To calculate the G/M boundary, the lake years were sorted in increasing order of chlorophyll-a concentrations, and the fractions of lake years complying with three possible target abundances (≥ 1.5, ≥2.5 ≥ 3.5) was calculated as the moving average of the 30 nearest data points (where each point had value 1 (abundance ≥ target) or 0 (abundance < target). This was done for L-CB1 and L-CB2, and not for L-CB3 according the hypothesis.

Results

A scatter plot of summer mean chlorophyll-a concentrations versus abundance classes of submerged macrophytes shows a decrease of chlorophyll-a concentrations with increasing macrophyte abundance (Fig C-2-4a). This is reflected in the 50-, 75- and 90- percentiles of the chlorophyll-a distributions for lumped macrophyte abundance classes.

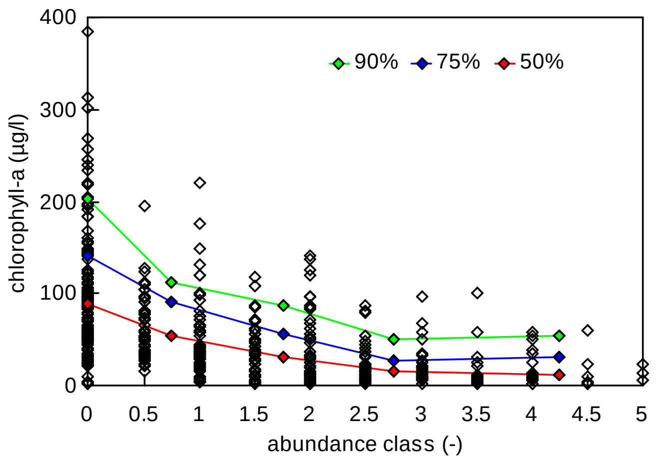


Fig C-2-4a. Scatter plot for chlorophyll-a versus macrophyte abundance classes and 50-, 75- and 90-percentiles of chlorophyll-a for lumped abundance classes (0, 0.5-1, 1.5-2, 2.5-3, 3.5-5)

The fractions of lake years with various macrophyte abundance classes within 20% ranges of chlorophyll-a were calculated for LCB2 (Figure C-2-4-b). In the lowest 20% range (with chl-a < 12 µg/l), there were only very few lakes with complete absence of macrophytes (abundance class zero), and 60% of lake years had an abundance of 3 or higher. In the highest 20% chlorophyll-a range (with chl-a > 95 µg/l) only a few % of lake years had an abundance of 3 or higher.

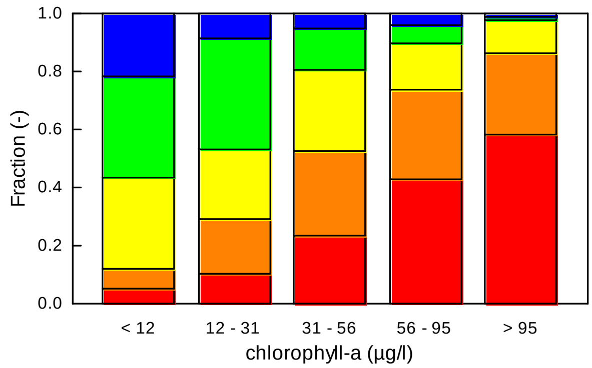


Figure C-2-4b. Fractions of abundance classes for macrophytes in 20% ranges of chlorophyll-a for very shallow lakes L-CB2.

Figure C-2-4c shows the fraction of lakes complying with three target macrophyte abundances (≥ 1.5, ≥ 2.5 and ≥ 3.5 respectively) in relation to chlorophyll-a. At low chlorophyll-a concentrations (near the reference value) the fraction with an abundance ≥ 1.5 is ca 0.9, indicating that also at reference chlorophyll-a conditions macrophyte abundances < 1.5 can occur. At chlorophyll-a concentrations less than 20 µg/l the fraction of lake years with an abundance ≥ 2.5 is between 0.6 and 0.7, and this fraction declines steeply between 20 and 30 µg/l chlorophyll-a.

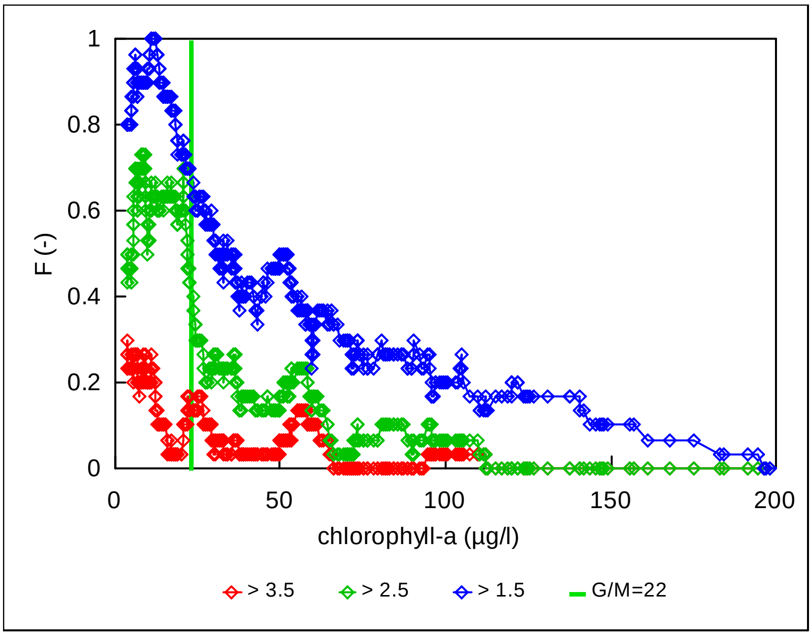


Fig C-2-4c. Fraction of lakes with a macrophyte abundances of >1.5, > 2.5 and > 3.5 in relation to chlorophyll-a (very shallow lakes L-CB2, moving average of 30 data points, 381 lake-years)

Figure C-2-4c shows that for both abundances ≥ 2.5 and ≥1.5 several transitions, where significant effects on macrophytes occur in relation to chlorophyll-a, can be distinguished. These are the steep parts in the curves. The steep part in the green curve (where the fraction with abundance ≥ 2.5 falls below 0.5) occurs at 21 µg/l. The fraction of lakes with abundance ≥ 1.5 (blue line) is on average 0.9 at reference chlorophyll-a concentrations. The chlorophyll-a concentration where the blue curve declines to below 75% of its original value (0.7) is 23 µg/l. These two values are similar, and their average of 22 µg/l is proposed as the G/M boundary (vertical green line in figure C-2-4c).

As the transitions occur in the steep part of the curves, a chlorophyll-a boundary based on these transitions where the fraction of lakes complying falls below a chosen critical value is not very sensitive to the exactly which value is chosen as the critical fraction. For example, setting this critical fraction of lakes with abundance ≥ 1.5 at 0.6 instead of 0.7 would yield a chlorophyll-a concentration of 27 instead of 23 µg/l. Basing the G/M boundary on high abundance (≥ 3.5, red line in figure C-2-4c) is less accurate, as even at very low chlorophyll-a concentrations the fraction of lakes complying to this high abundance is still small, and transitions are not very pronounced.

For L-CB1, the fractions of lake years with macrophyte abundances ≥ 3.5, ≥ 2.5 and ≥ 1.5 in relation to chlorophyll-a are shown in figure C-2-4d. The most pronounced transition occurs for an abundance ≥ 1.5 (blue line) at a chlorophyll-a concentration of 11 µg/l, where the fraction of lakes that comply decreases sharply from about 0.8 to below 0.5. This value is therefore proposed as the G/M boundary for L-CB1.

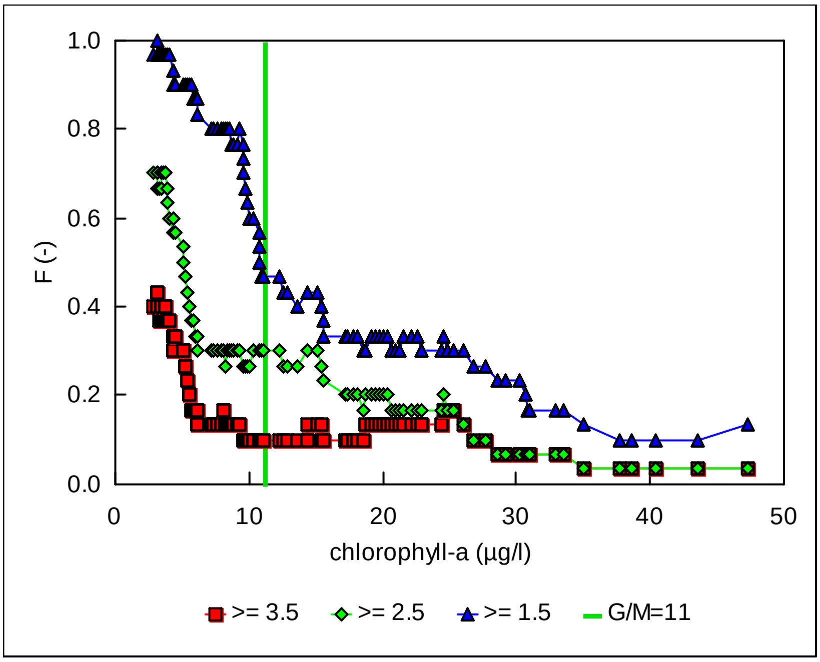


Figure C-2-4d. Fraction of lake years with macrophyte abundances ≥3.5, ≥2.5 and ≥1.5 in relation to chlorophyll-a for LCB1 lakes (shallow lakes 3-15 m) calculated as the moving average of 30 nearest data points (140 lake years).

Discussion

- The G/M boundaries were determined as the chlorophyll-a concentrations where deviations from an unimpacted state occur. This unimpacted state was determined from the more or less horizontal parts of the curves in figures C-2-4c and C-2-4d at low chlorophyll-a concentrations. This remains an arbitrary choice.

- The CB-GIG macrophyte data set is dominated by a few countries, especially the Netherlands (L-CB2 lakes) and to lesser extent Latvia (L-CB1) and Denmark. Even within the GIG region differences in lake characteristics between countries can occur. Dutch and Hungarian lakes in the database generally have a higher turbidity than Danish and Latvian lakes (number of lakes from other countries was too small to do such an analysis). Comparing the subsets of Dutch and Danish lakes (results not shown) gave differences between these two countries in the chlorophyll-a concentrations where the transition in macrophyte abundances occur. Naturally turbid lakes can have less chlorophyll-a before impacts on macrophytes become visible.

- It was anticipated that total turbidity, including both the contribution from living algae as that from other components, would be a better indicator for impacts on macrophytes. However, the use of Secchi depth as a measure of total turbidity is limited when bottom vision occurs regularly. Data on extinction on the other hand were not available. Therefore, and because the comparison of method 1 and 2 indicated better results for the former, the direct relationship between macrophyte abundance and chlorophyll-a was preferred .
- A separate analysis on rooted macrophytes (excluding nuisance species like *Ceratophyllum*) and charophytes was also carried out for L-CB2 lakes (results not shown). The relationships with chlorophyll-a differed between these two, with a sharper decrease of charophytes with increasing chlorophyll-a. Because this would further complicate the derivation of chlorophyll-a boundaries, we decided to stick to an analysis using the average abundance of

both groups. This is due to the fact that only for a limited part of the data set species composition is known.

- In this paper the G/M boundaries for chlorophyll-a were derived using multi lake data sets. However, characteristics of individual lakes can be so specific that a general boundary derived from a multi lake analysis may not be applicable to this particular lake. The options to include specific lake characteristics to deviate from a general ´default´ boundary should be further discussed.

2.5 Derivation of chlorophyll-a boundaries based on changes to maximum depth distribution of submerged macrophytes

Introduction

It is assumed that an increase in chlorophyll-a (Chla) concentration will cause a reduction in light penetration and thus the maximum depth of colonisation (Zc_{max}) of submerged macrophytes. If a relationship between Chla and Zc_{max} can be determined this can be used to assess the 2nd impact of an increase in phytoplankton biomass on the growth and distribution of macrophytes. This relationship can be used to establish boundary criteria for Chla.

Methods

Data description
Data for Zc_{max} and Chla have been provided from several sources, also from other GIGs. Some data sets reported Zc_{max} values for different groups of macrophytes. This analysis has not attempted to look at differences between the response from different macrophyte groups and thus where information was provided the maximum value for Zc_{max} from Angiosperms or Charophytes was used. Plotting all of the data (Fig. C-2-5a) showed substantial numbers of outliers and a data screening exercise was undertaken to exclude some sites. Where known outliers that could be identified as reservoirs were removed on the assumption that water level fluctuation was likely to make Zc_{max} data unreliable. Sites where estimated max depth (mean depth/0.4) was less than the Zc_{max} predicted from Chla were excluded. Finally outliers where the residual were greater than 3 standard deviations were identified and considered for removal (excluded sites are identified in the summary data file). After screening 379 pairs of data were available for analysis from 8 countries (Denmark, Great Britain, Northern Ireland, Ireland, Netherlands, Norway, Poland and Germany) and are shown in Fig. C-2-5b.

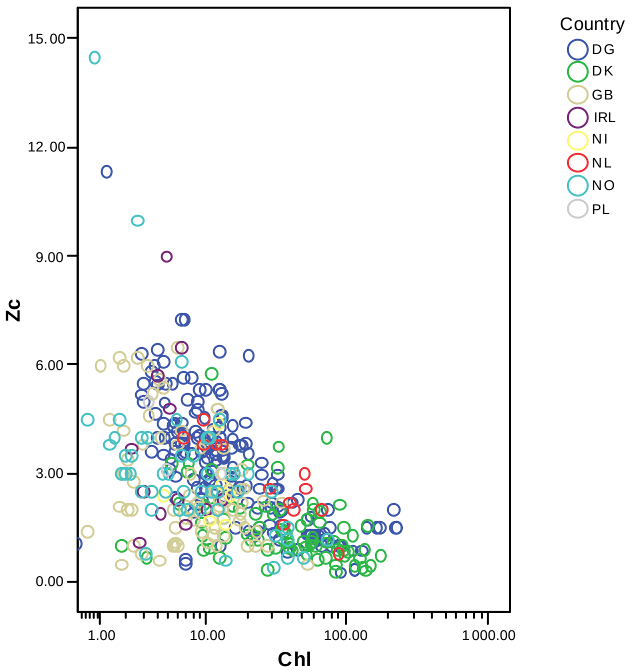


Fig C-2-5a. Scatter plot maximum depth colonisation Zc_{max} (m) and growing season mean Chla (μg L^{-1}), all available data identified by country

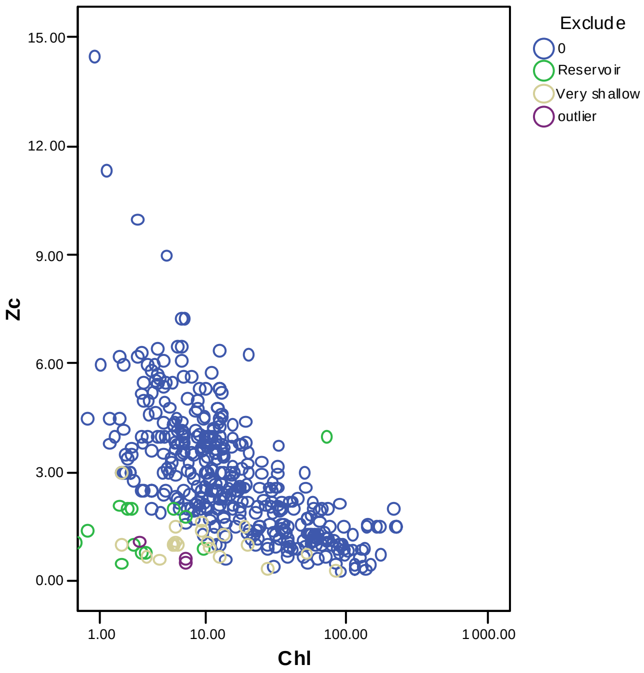


Fig C-2-5b. Scatter plot maximum depth colonisation Zc_{max} (m) and growing season mean Chla ($\mu g\ L^{-1}$), showing sites excluded from subsequent analysis.

The data set covered a range of lake depth types, mainly very shallow and shallow lakes (Fig. C-2-5c). Not all data sets contained lake depth data and it was decided not to attempt a type (depth) specific analysis. The conclusions presented could thus be applied to all lake types, boundaries only differing as a result of different reference criteria. It is recognised that macrophytes exhibit different growth forms, that latitude will have significant influences on light availability, but it is proposed that the general relationships generated can be used to support the establishment of Chla boundary criteria by demonstrating the probability of 2^{nd} effects on macrophytes. One advantage of using macrophyte data over measures such as secchi disc transparency is their averaging effect. There are few datasets with frequent secchi depth measurements and thus it is difficult to determine water transparency with any accuracy. The maximum depth of colonisation can be determined from a single lake survey and provides a direct measure of a key 2^{nd} effect of eutrophication caused by phytoplankton biomass.

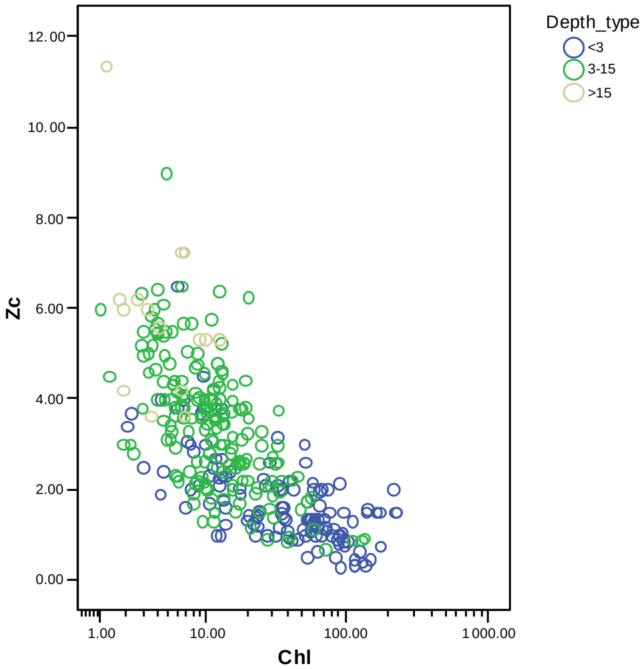


Fig C-2-5c. Scatter plot maximum depth colonisation Zc_{max} (m) and growing season mean Chla (µg L^{-1}) showing distribution of depth types in screened data set.

Models

1. Theoretical model

The initial approach was to fit a model based on the attenuation of light with depth. The model assumes a minimum % of surface irradiation is needed by submerged vegetation and this value was set at 10%. The model has 2 parameters, one determining the contribution of chlorophyll to the light extinction coefficient (k_c) and the background extinction coefficient (K_b).

Light attenuation follows Beer's law and the depth at which a given light intensity I_z occurs (e.g. the minimum needed for macrophyte survival) is given by:

$$z = \frac{LnI_0 - LnI_z}{K_d}$$

I_0= radiation at the surface (W/m^2)

I_z= radiation at depth z (W/m^2)

K_d = downward attenuation coefficient (m^{-1})

Z = depth (m)

K_d is the downward attenuation coefficient (m^{-1}) and can be split into the attenuation due to background absorption and scattering in the water in the absence of phytoplankton (K_b) and that due to chlorophyll (K_{chl}):

$$K_d = K_b + K_{chl}$$

K_{chl} can be estimated fro the product of the chlorophyll concentration and the chlorophyll-specific attenuation coefficient (k_c)

$$K_{chl} = k_c \; x \; Chl$$

Thus if we assume that the subsurface light intensity is 95%, allowing for 5% reflection (Middelboe & Markager 1997) the maximum depth of colonisation is given by the following function.

$$z = \frac{Ln(95) - LnI_z}{K_b + (k_c \times Chl)} \qquad \text{Eqn 1}$$

Maberley (unpubl) reviewed values for the parameters in the above equation and proposed that they could be used to establish potential chlorophyll boundaries.

Light needed at max depth of colonisation (Iz)	2 – 16% , proposed 10% as a typical value
Background attenuation coefficient (Kb)	0.2 – 1.5 proposed as a range
Chlorophyll specific attenuation coefficient (kc)	0.01-0.03, proposed 0.02

The non linear model (Eqn1) was fitted after setting Iz to 10 using a non-linear regression. The resulting parameter values are shown in Table C-2-5a. These are shown in (Fig C-2-5d) together with curves derived from different values of background attenuation Kb.

Table C-2-5a. Non-linear model descriptives

	Background attenuation coefficient	Chl attenuation coefficient	
Best fit (all data)	Kb = 0.43 (± 0.019)	kc = 0.024 (±0.002)	$R^2 = 0.432$
Model 1	Kb = 1.0	kc = 0.024	
Model 2	Kb = 0.2	kc = 0.024	

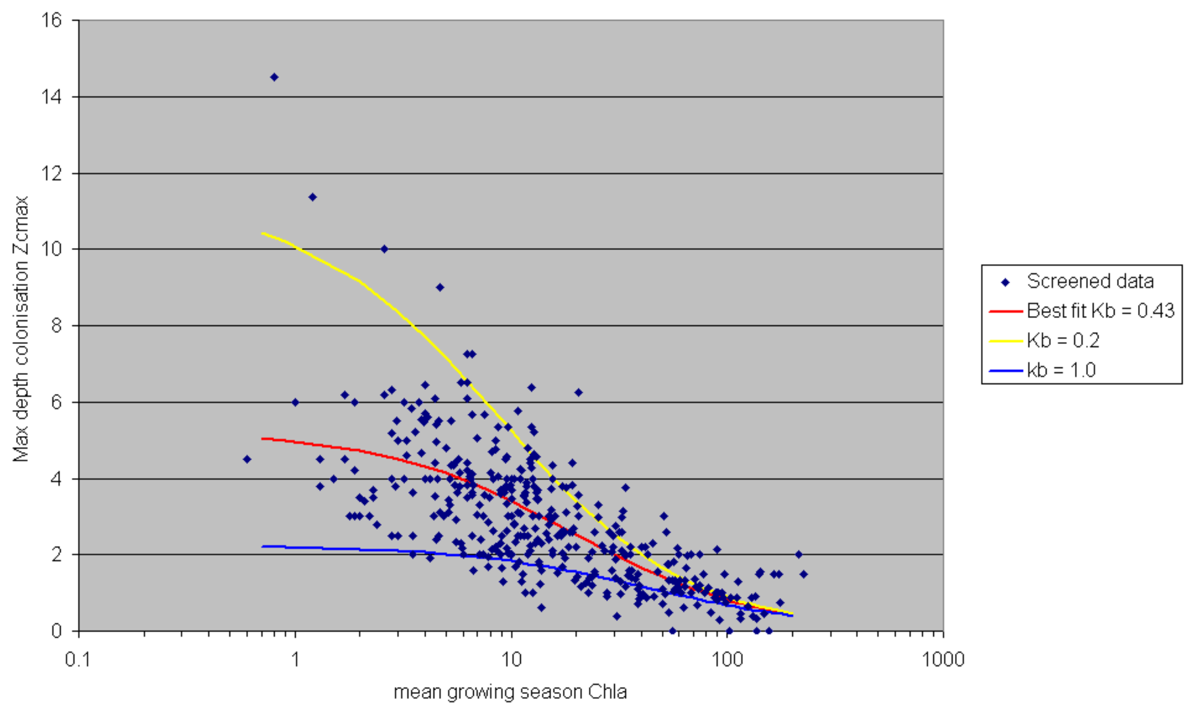


Fig C-2-5d. Non-linear model with different background attenuation values (Kb)

The values of kc derived from the best fit model are very close to literature values and Kb is within the expected range, so it is concluded that this is a reasonable model of these data. However, Fig C-2-5d demonstrates the importance of background turbidity (Kb) in the model. With current data this parameter cannot be estimated, and it is clear that this is the most significant unknown influencing model fit.

From Fig C-2-5d it is clear that the model residuals are much greater at low values of chl-a and thus it is not possible to determine confidence intervals for the model. As a consequence the following transformation for linear regression analysis were considered (Log Chl v $1/Zc_{max}$; Log Chl v Log Zc_{max}; Log Chl v Sqrt Zc_{max}). The reciprocal transformation, despite being related to the non linear model did not provide uniform residuals across the range of Chla values and was rejected. Both Log and square root transformations of Zc produced normally distributed random residuals, but as the root transformation was the closest match to the non-linear model it was selected.

Alternatively, logistic regression was applied to the data. These results are presented in Annex C - Part 2.11.

G/M boundary

In the last section several important steps are presented to develop the G/M boundary:

- Determine a relationship between mean growing season Chla and Zc_{max} by linear regression after square root transformation of Zc_{max} and log transformation of Chla.
- Use value of reference Chla to estimate reference Zc_{max}
- Based on eutrophication guidance assume that Poor status is defined by an undesirable change in Zc_{max} and that Moderate status is a transition class between Good and Poor.
- Identify Poor status as a point where it is likely to have a undesirable change in Zc_{max}. Check whether there is sufficient space for Bad status. The worst situation in Bad status is Zc_{max} of 0, meaning no macrophytes present
- Check status of High/Good boundary determined from distribution of reference sites is compatible with above (i.e. is there sufficient space for Good status). If not modify definition of Poor status and repeat.
- Determine the Good/Moderate boundary for Chla (and Zc_{max}) as a point where there is a low probability of (Zc_{max}) being at Poor status.

Results

Chla to Z_{cmax} relationship

Based on the previous paragraph the following relationship is used:

Sqrt Zc = 2.489(±0.044) – 0.732(±0.035) Log (Chla) $R^2 = 0.539$ $p<0.001$

The back-transformed fitted model together with confidence intervals from p +0.05 to p –0.05, and for reference, the best fit non-linear model are shown in Fig C-2-5e

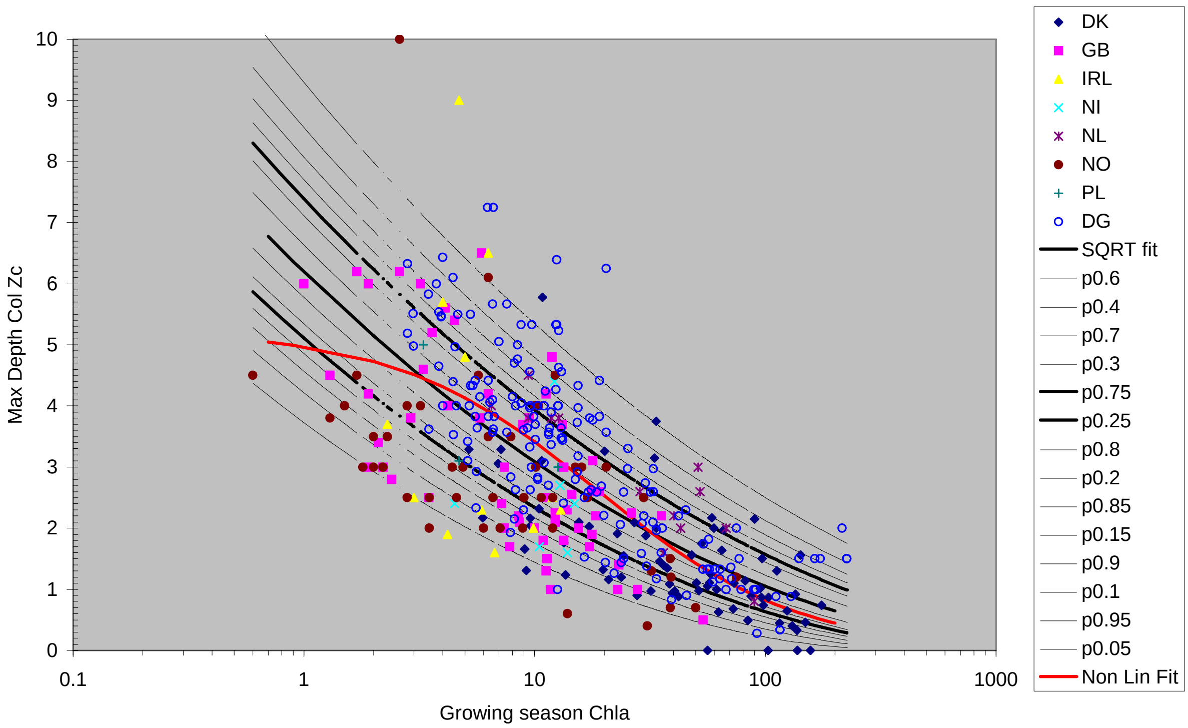


Fig C-2-5e. Back-transformed linear fit of square root Zc_{max} versus Log transformed Chla for screened data, together with confidence intervals, some data are off scale. Red line shows non-linear model fit for reference.

It is proposed that for the purpose of determining chlorophyll boundaries the effect of background turbidity is ignored and boundaries are determined in a probabilistic way using the above model fit. Boundaries for different lake types will vary based on their reference conditions and expert judgement to determine what value(s) of Zc_{max} represents Poor status. Probabilities of exceeding different categories of Zc_{max} are shown graphically in annex C – Part 2.11. .

Boundary determination

Two sets of boundaries have been derived. One for all the Central Baltic shallow lakes regardless of geological type. (L-CB1 and L-CB3), a second for the very shallow lake type (L-CB2).
Resulting boundaries are set out in Table C-2-5b. The following procedure was used, described for L-CB1 type.

1. Reference Chla for L-CB1 = 3.1 μgL^{-1} giving a modelled Zc_{max} of 4.6 m. This represents the mid point of High status.
2. Projecting along the y axis at Chla = 3.1 to the p0.25 and p0.75 confidence limits provides Zc_{max} values of 3.6 and 5.6 m. **Conclude High status for Zc_{max} is 3.6-5.6m and HG boundary is 3.6m.**
3. Projecting along the x axis at Zc_{max} = 4.6 m to the p0.75 confidence limits provides Chla value of 6 μgL^{-1}. This would be the H/G boundary and is almost identical to the H/G boundary derived from the 75th percentile of reference site Chla values.
4. Assume[1] that middle of Poor status is represented by a Zc_{max} of 1.5m^{-1} giving a modelled Chla of 53 μgL^{-1}. Project along the y axis to the p0.25 and p0.75 confidence limits to determine the range of Zc_{max} for Poor status. **Conclude that Poor status for Zc_{max} is 1.0-2.1m and that Mod/Poor boundary for Zc_{max} is 2.1m**

[1] Derived by iteration after consideration to sufficient space to fit Good and Moderate on one side and for Poor status on the other side along the pressure gradient

5. Project along the x axis for Zc_{max} = 1.5m (mid point of Poor) to the p0.25 and p0.75 confidence limits for Chla. **Conclude that Poor status for Chla is 26 – 104 μgL^{-1} and thus the Mod/Poor boundary is 26 μgL^{-1}**.
6. Having established the position of High and Poor status it is now necessary to divide the space between these 2 classes with the Good and Moderate status. Guidance to achieve this is that Good status should represent "slight" change from reference (ie High status) and that the Good/Moderate boundary is defined as a point at which the probability of Poor status occurring is low.
7. Project along the x axis for Zc_{max} = 1.5m (mid point of Poor) to intersect with the p0.10 confidence limit (low confidence of being Poor) to determine a Good/Mod Chla value of 13 μgL^{-1}. **Conclude that at a probability of p0.1 for Zc_{max} being in Poor status is an appropriate definition of Good/Mod boundary, this is most likely to occur (p0.5) and thus the Good/Mod boundary for Chla is 13 μgL^{-1}**
8. Project along the y axis for Chla = 13μgL^{-1} (the G/M boundary) to regression line to determine a Good/Moderate boundary for Zc_{max} of 2.8m. **Conclude that Moderate status for Zc_{max} is from 2.1-2.8m and that the Good/Moderate boundary is 2.8m. Conclude that Good status for Zc_{max} is from 2.8-3.6m.**

These values are shown in Fig C-2-5f and summarised in Table C-2-5b, together with values for L-CB2

Table C-2-5b. Summary of proposed mean growing season chlorophyll a and maximum depth of colonisation (Zc_{max}) boundary criteria for high alkalinity shallow and very shallow lakes (L-CB1, L-CB2).

		Zc_{max} (m)	Chla (μgL^{-1})	EQR Chla	Comments
L-CB1	Reference	4.6	3.1		From reference site analysis (median ref sites)
	H/G boundary	3.6	5.8	0.53	5.8 from reference analysis. (round up value)
	Mid Good				
	G/M boundary	2.8	13.0	0.24	p0.1 that Zc_{max} =1.5(mid poor status) & p0.2 that Zc_{max} = 2.1 (M/P boundary)
	Mid Moderate				
	M/P boundary	2.1	26.0	0.12	p0.25 that Zc_{max} = 1.5 (mid poor status) & p0.5 that Zc_{max} = 2.1 (M/P boundary)
	Mid Moderate	1.5	53.0	0.06	
	P/B boundary	1.0	104.0	0.03	p0.75 that Zc_{max} = 1.5 (poor status)
L-CB2	Reference	3.5	6.8		From reference site analysis (median ref sites)
	H/G boundary	3.0	10.8	0.63	Chla H/G From reference analysis, thus HG Zc_{max} higher than predicted from p0.25 confidence line. (Taking p0.25 would give Zc_{max} of 2.7m and a Chl value of 18 – considered too high to represent slight change)
	Mid Good				
	G/M boundary	2.0	28	0.24	p0.1 that Zc_{max} =1.0 (mid poor status) & p0.25 that Zc_{max} = 1.6 (M/P boundary)
	Mid Moderate				
	M/P boundary	1.6	52	0.13	p0.25 that Zc_{max} = 1.0 (mid poor status) & p0. 5 that Zc_{max} = 1.6 (M/P boundary)
	Mid Moderate	1.0	100	0.07	
	P/B boundary	0.6	215	0.03	p0.75 that Zc_{max} = 1.5 (poor status)

Note that the proposed Chla values are very close to a geometric series. The G/M & M/P boundary values are very similar to those derived from dividing the distance between the HG boundary and

the maximum value for mean growing season chlorophyll a for the lake type taken from the REBECCA database (Annec C – Part 2.6). ie 12, 28, 67 in comparison to the above 13, 26, 104.
A similar process was applied to very shallow lakes (L-CB2). The result is shown in fig C-2-5g and table C-2-5b.

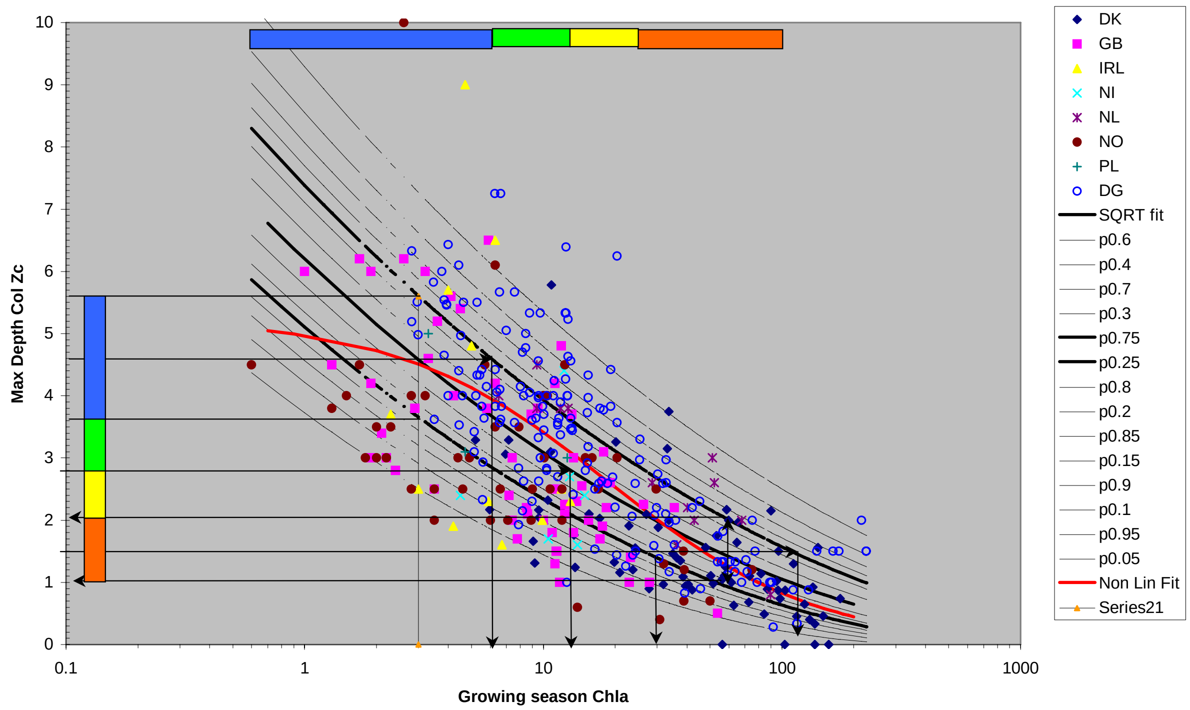


Fig C-2-5f. Proposed boundary criteria for shallow high alkalinity lakes L-CB1 derived from relationship between growing season chlorophyll a and maximum depth of colonisation.

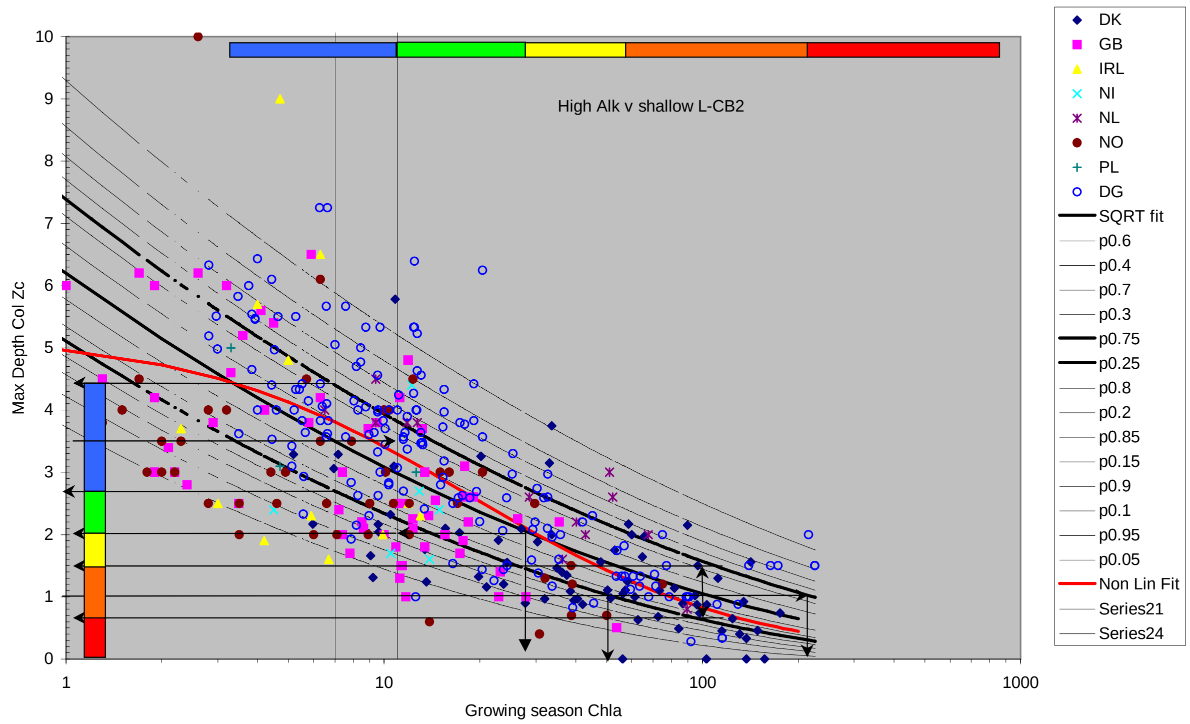


Fig C- 2-5g. Proposed boundary criteria for very shallow high alkalinity lakes L-CB2 derived from relationship between growing season chlorophyll a and maximum depth of colonisation.

As for L-CB1 the proposed Chla boundary values are very close to a geometric series. The G/M & M/P boundary values are very similar to those derived from dividing the distance between the HG boundary and the maximum value for mean growing season chlorophyll a for the lake type taken from the REBECCA database (Annex C – Part 2.6).

Discussion

- More detailed information on the lakes like latitude and background turbidity will improve the relationship between macrophytes maximum colonised depth and Secchi depth. This improvement enables more confident statements about the probability of 'being not in poor'.
- In the milestone 6 report also the probability of 'not being poor' is presented at 5% confidence level.

2.6 Logarithmic division to establish boundaries

If relationships with other quality elements cannot be determined and there are no obvious discontinuities in metrics when plotted against pressure the only option for boundary setting is to create essentially arbitrary boundaries. Although the work reported above proposes boundaries based on 2nd impacts it is proposed that these boundaries should be taken into account with the simplest approach of regular divisions along the pressure gradient. According the hypothesis, the equal classes division is based on the worst case scenario of chlorophyll-a, which is related to light limitation of phytoplankton growth.

The REBECCA database was used to determine the maximum growing season mean Chla value for lakes in the core intercalibration typology. The 95th percentile is assumed to represent the "worst" status, for most lakes assumed to be in Bad condition. This considers also lakes outside the Central Baltic GIG, because the number of data within the GIG does not ensure that the real maximum is achieved. The proposed High/Good boundary was taken from reference sites and the distance between the H/G and the worst situation is divided into equal logarithmic intervals. Results are shown in Table C-2-6a .

The worst value is also determined for different classes of depth within the type. Especially for L-CB1 different depth classes show different 95th percentiles. Deeper lakes within the L-CB1 type have relatively low maximum values (see also chapter 1 for theoretical explanation), and therefore also low G/M boundary values are found as compared to shallower lakes within the L-CB1 type.

Table C-2-6a Potential boundaries for CGIG lakes based on geometric divisions of chlorophyll between the HG boundary (derived from distribution of Reference conditions) and the maximum observed mean chlorophyll value in the Rebecca summary database.

Proposed boundaries for CGIG																
							Boundaries at geometric intervals									
Ref	HG	Num bound between HG and Max							GM	MP	PB		HG	GM	MP	PB
Chlorophyll a ug/L				N all lakes	N Ref Lake year	Max							EQR			
shallow Lakes	0.376	4	High alk shallow L-CB1	195	96	160	3	6	13	30	70		0.53	0.23	0.10	0.04
	0.204	4	Mod alk lobelia L-CB3	10	18	33	3	5	8	13	20		0.60	0.38	0.23	0.15
	0.255	4	Mod alk shallow L-N1	73	21	52	3	5	9	16	29		0.58	0.32	0.18	0.10
	0.386	4	High alk very shallow L-CB2	177	40	419	7	11	27	67	168		0.63	0.25	0.10	0.04
	0.315	4	High alk very shallow L-CB2	177	40	219*	7	11	23	50	103		0.63	0.30	0.14	0.07

*95th percentile, not maximum

Table C-2-6b Boundary setting of chlorophyll-a based on equal intervals based on 95th percentile values and for different depth classes within the type determined based on Rebecca data base (also containing lakes outside cb gig)

	Depth range	Worst value (95th percentile)	Ref	H/G	G/M	M/P	P/B
High alk shallow L-CB1	3-15	160	3	6	13	30	70
	3-6	81	3	6	12	22	42
	6-10	30	3	6	9	14	20
	10-15	23	3	6	8	12	16
High alk very shallow L-CB2	<3	235	7	11	23	50	109
	<1	216	7	11	23	48	102
	1-2	254	7	11	24	52	115
	2-3	184	7	11	22	45	91
	<1.5	226	7	11	23	49	106
	1.5-3	258	7	11	24	53	117

2.7 Derivation of chlorophyll-a boundaries based on changes in the dominance of cyanobacteria

Introduction

It is assumed that an increase in chlorophyll-a (Chla) concentration will cause shade, which is a competitive advantage for cyanobacteria. If a relationship between Chla and the share of cyanobacteria can be determined, this can be used to assess the 2nd impact of an increase in phytoplankton biomass on the balance of phytoplankton groups. The resulting relationship can be used to establish boundary criteria for Chla.

Methods

Data were collected after the Warsaw meeting (April) for the proportion of cyanobacteria and some eutrophication parameters and general lake characteristics (Table C-2-7a). Earlier data analysis of our GIG had shown that cyanobacteria have the best relationship with eutrophication. The total biovolume of all phytoplankton groups and the biovolume of cyanobacteria was determined on single samples in high summer. According a proposal of the Rebecca project, not all cyanobacteria were included. Small cyanobacteria represented in the Chroococcales group were excluded, except for *Microcystis* species. For Denmark and Germany, only summer averages were available.
Logistic modelling is used for describing the relationships for four definitions of a bloom: >10%, >25%, >50% and >75% cyanobacteria of total biovolume. Logistic regression estimates the most likely probability of an event as function of one or more independent variables. The basic data needs to be in presence and absence format. Our data is according the bloom criteria transformed, where '1' means fulfilment of bloom criteria and '0' no fulfilment of bloom criteria. The procedure of the boundary setting is a separate paragraph in the results section.

Table C-2-7a. Data availability for cyanobacteria for Member States and different types.

Member State	L-CB1	L-CB2	L-CB3
DE	22	3	
DK	29	16	
GB	19	32	2
LV	139	147	23
NL	23	87	
PL	27	1	
Total	259	286	25

Results

Chlorophyll-a, tN, Secchi depth and tP values showed significant correlations with the fraction of cyanobacteria (Table C-2-7b). Colour was expected to be related, but in this database only minor relationship can be shown and was therefore not taken into consideration for further analysis. Depth was also expected to be related with the share of cyanobacteria, but only indirect relationships were found (correlation of depth with chlorophyll-a, and of depth with Secchi depth). The relationship between chlorophyll-a and share of cyanobacteria was therefore not split for the types, though for boundary setting different criteria were used.

Table C-2-7b. Pearson product-moment correlation matrix for the fraction of cyanobacteria, lake characteristics and eutrophication parameters (depth, secchi depth, chlorophyll-a, Total P, Total N, colour).

		DEPTH	SD	CHLFA	TOTP	TOTN	COLOUR	FRAC_CYANO
DEPTH	Pearson	1	,610(**)	-,214(**)	-,122(**)	-,101(*)	-,347(**)	-,026
	Sig.		,000	,000	,005	,050	,000	,540
	N	570	451	535	523	382	304	561
Secchi	Pearson	,610(**)	1	-,506(**)	-,463(**)	-,449(**)	-,464(**)	-,380(**)
	Sig.	,000		,000	,000	,000	,000	,000
	N	451	454	451	447	314	277	445
CHLFA	Pearson	-,214(**)	-,506(**)	1	,236(**)	,475(**)	,073	,549(**)
	Sig.	,000	,000		,000	,000	,207	,000
	N	535	451	539	524	383	305	531
TOTP	Pearson	-,122(**)	-,463(**)	,236(**)	1	,537(**)	,087	,140(**)
	Sig.	,005	,000	,000		,000	,134	,001
	N	523	447	524	527	381	300	518
TOTN	Pearson	-,101(*)	-,449(**)	,475(**)	,537(**)	1	,101	,393(**)
	Sig.	,050	,000	,000	,000		,100	,000
	N	382	314	383	381	386	264	377
COLOUR	Pearson	-,347(**)	-,464(**)	,073	,087	,101	1	-,111
	Sig.	,000	,000	,207	,134	,100		,052
	N	304	277	305	300	264	307	307
FRAC_CYANO	Pearson	-,026	-,380(**)	,549(**)	,140(**)	,393(**)	-,111	1
	Sig.	,540	,000	,000	,001	,000	,052	
	N	561	445	531	518	377	307	565

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Chlorophyll-a shows the strongest correlation with the share of cyanobacteria. Other factors like nitrogen, Secchi depth, and phosphorus were for sake of simplicity not used in the further analysis, though these factors are correlated with proportion of cyanobacteria. Another reason is that most of these factors are highly correlated with chlorophyll-a.

At very low values of chlorophyll-a the share of cyanobacteria is low (Fig C-2-7a). At high values of chlorophyll-a the average proportion of cyanobacteria increased. The frequency of dense blooms (>50%) is less than 10 % in the range reference chlorophyll-a concentration and increases to more than 90 % at chlorophyll-a levels above 90 µg/l (Fig C-2-7b). Logistic modelling is used for describing the relationships for four definitions of a proportion of cyanobacteria: >10 %, >25 %, >50 % and >75% cyanobacteria (v/v, biovolume). Logistic regression shows significant relationships for all bloom criteria in relation to chlorophyll-a concentration (P<0.001).

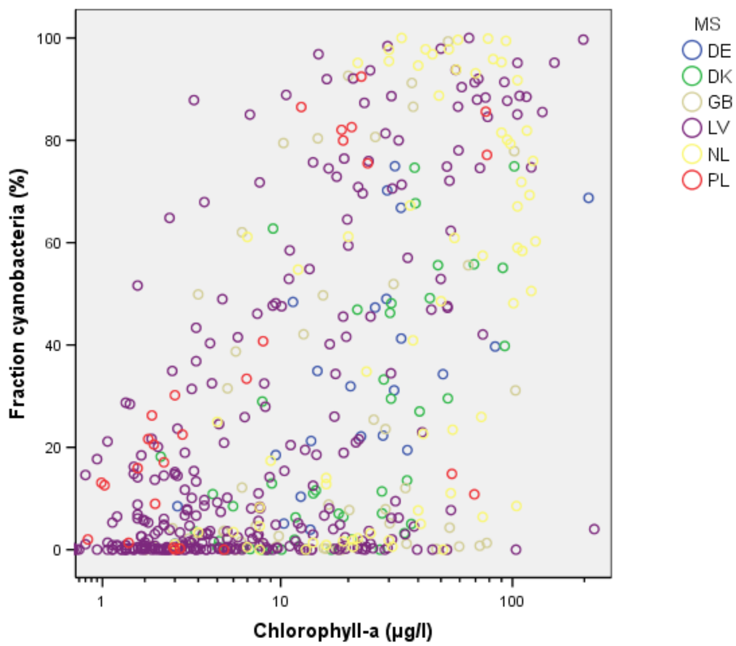


Fig C-2-7a. Relationship between chlorophyll-a and fraction of cyanobacteria. MS= Member States.

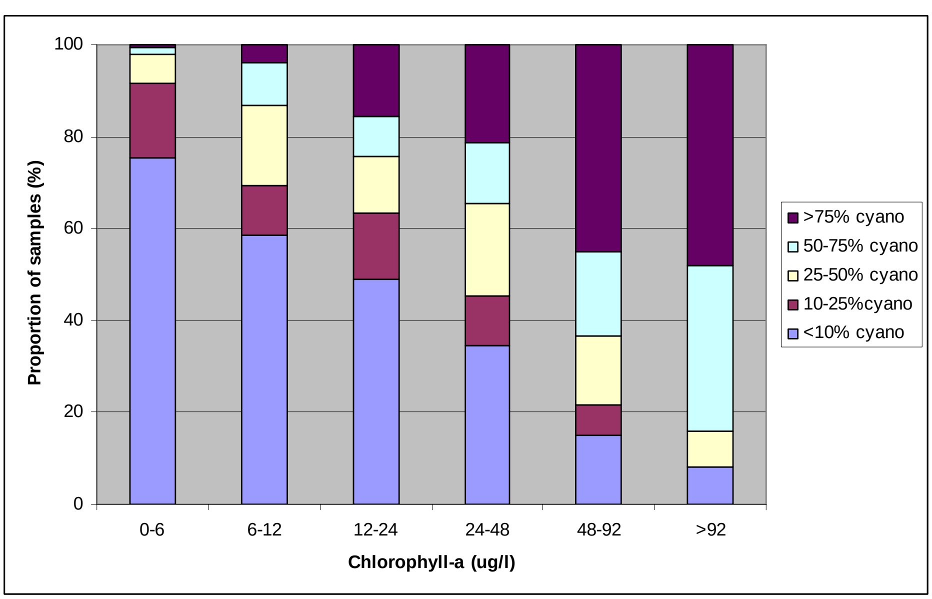


Fig C-2-7b. Observed frequencies for different proportions of cyanobacteria in relation to chlorophyll-a, based on data in Fig C-2-7a.

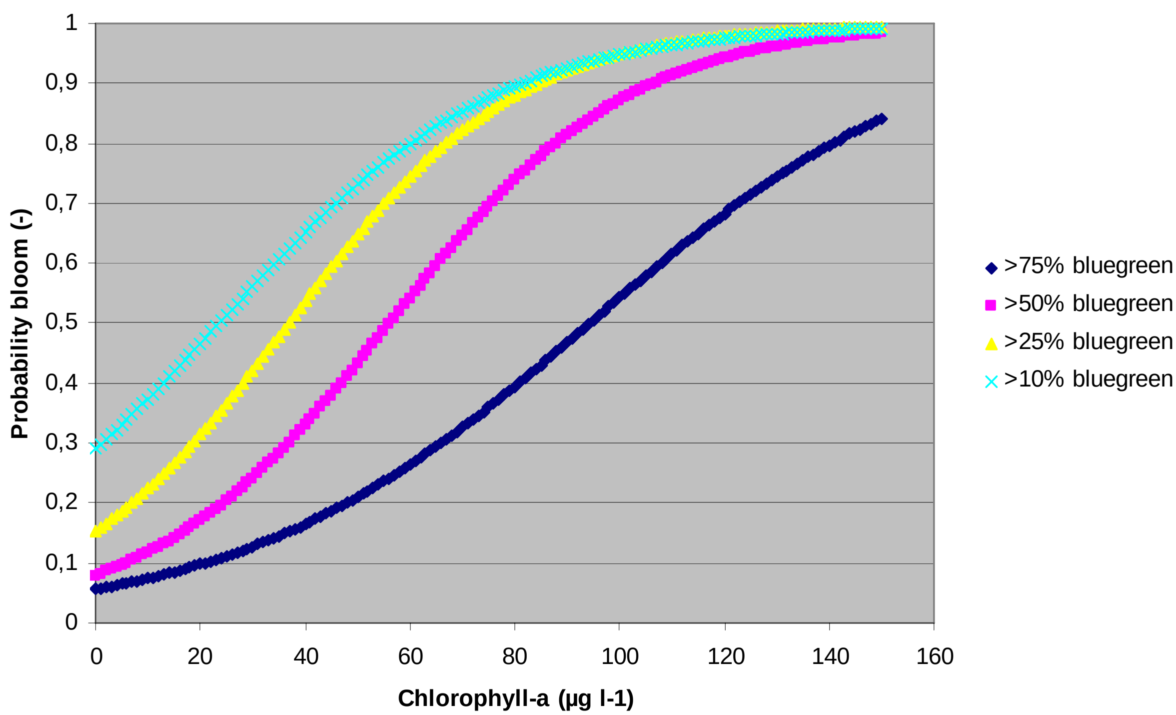


Fig C-2-7c. Modelled probability of a bloom with cyanobacteria according four different criteria in relation to chlorophyll-a concentration. Models are presented in Table C-2-7c.

Table C-2-7c. Estimates of logistic models predicting the probability of four types of blooms as function of chlorophyll-a. For each model the percentages of well predicted cases as measure for goodness of fit is presented. The general expression is: p = exp (factor chlorophyll-a * [chlorophyll-a] + constant)/ (1 + exp (factor chlorophyll-a * [chlorophyll-a] + constant)). Standard errors of estimates within parenthesis.

Criteria for bloom with cyanobacteria	Factor chlorophyll-a	Constant	Well predicted cases 'no bloom'(cut level 0.5)	Well predicted cases 'bloom'(cut level 0.5)
>10%	0,0380 (0,00495)	-0,896 (0,127)	86 %	50 %
>25%	0,0463 (0,00509)	-1,706 (0,149)	93 %	46 %
>50%	0,0437 (0,00457)	-2,456 (0,180)	97 %	42 %
>75%	0,0299 (0,00382)	-2,822 (0,204)	97 %	19 %

At low chlorophyll-a values the probability of having any of the blooms is less than 30%. Larger proportions of 50% cyanobacteria occur rarely at low chlorophyll-a values. The models are better predicting absence of a bloom (86 to 97 % well predicted cases) than predicting presence of a bloom (19 to 50 % well predicted cases, Table C-2-7c).

Boundary setting

Four important consideration are made to set the boundary setting of chlorophyll-a based on the change in proportion of cyanobacteria.

- The proportion of 50% and 75% cyanobacteria were judged as most suitable indicator for having a bloom or not. These fractions of cyanobacteria are relatively stable reference chlorophyll-a values, and are judged as an undesirable if frequently occurring in a lake. For L-CB1 50% of cyanobacteria is considered as undesirable, while for L-CB2 75% is proposed. This is because chlorophyll-a values are negatively related with depth (see also Fig C-2-1c), and thus a lower proportion of cyanobacteria can be expected in deeper lakes.
- The reference proportion of cyanobacteria is estimated. For L-CB1 the model predicts a probability of ca. 8.9 to 10.4 % that a single sample taken during summer has a more than 50% of cyanobacteria at reference values of chlorophyll-a. For L-CB2 these values are ca. 6.6 to 7.6 % for more than 75% of cyanobacteria.
- Mid poor status is assumed where an undesirable effect is likely to occur. Here we propose that poor status is where half of the single samples taken during high summer is expected to exceed the cyanobacterial proportion threshold (50 % for L-CB1 and 75 % for L-CB2). This corresponds with 56 µg/1 chlorophyll-a for L-CB1 and with 94 µg/1 chlorophyll-a in L-CB2. Likewise the procedure with maximum colonised depth, poor status is arbitrary chosen, but checked with the reference status and by ensuring enough space for bad on the one hand and good-moderate status on the other.

- Good status is only a slight deviation from reference, and Good status is where undesirable effects are unlikely to occur. For L-CB2 we proposed to allow maximally 10 % of the samples with a bloom of more than 75 % cyanobacteria (6-8 % at reference condition). For L-CB1 10 % is a too low number as threshold, because this is still in the range for reference values. Therefore, we proposed to use 12.5 % as a critical probability for G/M status.

Table C-2-7d Summary of the boundary setting procedure.

	Ref chlorophyll-a	H/G chlorophyll-a	modelled probability of fraction cyanobacteria >50% at reference chlorophyll-a	modelled probability fraction cyanobacteria >75% at reference chlorophyll-a	definition of poor status	definition of G/M	corresponding Chlorophyll-a value with definition of G/M
L-CB1	3.1	6.8	8.9-10.4 %	6.1 – 6.8 %	50 % of samples have >50% proportion cyanobacteria	12.5 % of samples have >50% proportion cyanobacteria	12
L-CB2	5.8	10.8	10.0-12.0 %	6.6 – 7.6 %	50 % of samples have >75% proportion cyanobacteria	10 % of samples have >75% proportion cyanobacteria	21

Discussion

- other lake characteristics can be taken into consideration, e.g. residence time is a well known factor for determining the dominance of cyanobacteria but is not considered here
- proportion of cyanobacteria might be higher at low chlorophyll-a values than might be expected. A difference with other studies may be that this analysis is mainly carried out with single observations, and not with averaged values.
- although these limitations, the values derived for chlorophyll-a are very similar to the other methods, and it is proposed to use this value for G/M chlorophyll-a

- L-CB1 and L-CB3 are combined, because the number of L-CB3 lakes is too low

2.8. Calculation of macrophyte abundance

Table C-2-8a. Description of the abundance scale of the CB GIG macrophyte data base. Each Member State has converted their data per species using this Ecoframe abundance scale. Scaling is based on EU ECOFRAME project.

0: no plants visible, nothing on rake
1: some plants visible but sparse, some plants on rake

2: plants present, many rakes produce plants samples (up to 70%) and plant do not interfere with boat movement (plant invested water volume to c. 25%) 3: plants obvious with most rakes producing plant samples (>70%), plants may interfere with boat movement in places (plant invested water volume > 25%)

Table C-2-8b. Transformation from species abundances to one macrophyte indicator. The rooting and non floating plants are listed in Table C-2-8c. The overall macrophyte abundance is calculated as the average of the rooted macrophytes abundance code and the charophyte abundance code: Overall macrophyte indicator = (code abundance charophytes + code abundance of rooting submerged macrophyte) / 2

CGIG data base / Rebecca data base sum of abundances rooting and non floating submerged plants	CGIG data base / Rebecca data base sum of abundances of charophytes	Submerged macrophytes abundance code rooting and non floating submerged plants (code rooting submerged macrophytes)	Submerged macrophytes abundance code charophytes (code charophytes)
0	0	0	0
1	1	1	1
2-3	2-3	2	2
4-5	4-5	3	3
5-9	5-9	4	4
>=10	>=10	5	5

Table C-2-8c.. Indicative meaning of GIG macrophyte indicator and in comparison to Danish abundance scale.

Danish data, scale percentage	GIG Submerged macrophytes code	Indicative meaning
<1	0	no plants visible
1-10	1	plants visible but sparce, some plants on rake, low number of rooting macrophyte species (< 2)
10-25	2	plants present, many rakes produce plants samples (up to 70%) and plants do not interfere with boat movement (plant invested water volume to c. 25%); number of rooting submerged macrophytes is usually not more than 4, charophytes may be present.
25-50	3	plants obvious with most rakes producing plant samples (>70%), plants may interfere with boat movement in places (plant invested water volume > 25%). Charophytes are present.
50-75	4	plants obvious with most rakes producing plant samples (>70%), plants may interfere with boat movement in places (plant invested water volume > 25%); moderate number of species. Charophytes are abundant.
>=75%	5	plants obvious with most rakes producing plant samples (>70%), plants may interfere with boat movement in places (plant invested water volume > 25%); number of species rooting macrophytes is more than 8. Charophytes are very abundant.

Table C-2-8d.. Danish scale for measuring abundance of macrophytes (pers. comm. M. SØndergaard)

Percentage of lake (%)	Description
0-5	sparce (spredt)
5-25	relative sparce (ret spredt
25-50	commen (almindelig)
50-75	abundant (rigelig)
75-95	covering (dækkende)
95-100	completely covering (fuldstændigt dækkende)

2.9. Overview of macrophytes species and their division in groups

Table C-2-9 Overview of macrophytes species and their division in groups (1: charophytes, 2: isoetids, 3: rooting submerged plants 4: rooting floating leaved plants 5: floating and/or non rooting plants), species code according REBECCA.

SppCode	Species name	GROUP
ALG1ZZZ1	Filamentous algae	5
BAL1RAN1	Baldellia ranunculoides	
CAL1COP1	Callitriche cophocarpa	3
CAL1HAM1	Callitriche hamulata Kutz ex W.D.J. Koch	3
CAL1HER1	Callitriche hermaphroditica L.	3
CAL1PAL1	Callitriche palustris L.	3
CAL1STA1	Callitriche stagnalis Scop.	3
CER1DEM1	Ceratophyllum demersum L.	5
CHA1ASP1	Chara aspera Deth. Ex Wild.	1
CHA1BAL1	Chara baltica	1
CHA1CON1	Chara connivens SALZM.	1
CHA1CON2	Chara contraria A. Br.	1
CHA1DEL1	Chara delicatula Ag.	1
CHA1FIL1	Chara filiformis	1
CHA1FRA1	Chara fragilis	1
CHA1GLO1	Chara globularis Thuill.	1
CHA1HIS1	Chara hispida L.	1
CHA1INT1	Chara intermedia A. Braun	1
CHA1RUD1	Chara rudis	1
CHA1STR1	Chara strigosa A. Braun	1
CHA1TOM1	Chara tomentosa	1
CHA1VUL1	Chara vulgaris L.	1
CHA1ZZZ1	Chara sp. L. ex Vaillant	1
CHA2ZZZ1	Charophyta	1
CRA2AQU1	Crassula aquatica	3
ELA1HEX1	Elatine hexandra (Lapierre) DC	3
ELA1HYD1	Elatine hydropiper L.	3
ELA1ORT1	Elatine orthosperma Duben	3
ELA1TRI1	Elatine triandra Schkuhr	3
ELE1ACI1	Eleocharis acicularis (L) Roem et Schult	3
ELO1CAN1	Elodea canadensis Michx.	3
ELO1NUT1	Elodea nuttallii (Planch.) H. St. John	3
ERI2AQU1	Eriocaulon aquaticum (Hill) Druce	3
HYD1VER1	Hydrilla verticillata L.	3
HYD2MOR1	Hydrocharis morsus-ranae L.	5
ISO1ECH1	Isoetes echinospora Durieu	2
ISO1LAC1	Isoetes lacustris L.	2
LEM1GIB1	Lemna gibba L.	5
LEM1MIN1	Lemna minor L.	5
LEM1TRI1	Lemna trisulca L.	5

LIM1AQU1	Limosella aquatica	2
LIT1UNI1	Littorella uniflora (L.) Ascherson	2
LOB1DOR1	Lobelia dortmanna L.	2
LYT1POR1	Lythrum portula	
MYR1ALT1	Myriophyllum alterniflorum DC.	3
MYR1SIB1	Myriophyllum sibiricum	3
MYR1SPI1	Myriophyllum spicatum L.	3
MYR1VER2	Myriophyllum verticillatum L.	3
NAJ1FLE1	Najas flexilis (Willd.) Rostk. & W.L.E. Schmidt	3
NAJ1MAR1	Najas marina L.	3
NAJ1TEN1	Najas tenuissima (A. Braun) Magnus	3
NIT1CON1	Nitella confervacea	1
NIT1FLE1	Nitella flexilis L. C.Ag.	1
NIT1MUC1	Nitella mucronata (A. Br.) Miquel	1
NIT1OPA1	Nitella opaca Ag.	1
NIT1TRA1	Nitella translucens (Pers.) Ag	1
NIT1WAH1	Nitella wahlbergiana	1
NIT2OBT1	Nitellopsis obtusa (Desv.) J. Groves	1
NUP1LUT1	Nuphar lutea (L.) Sibth. & Sm.	4
NUP1PUM1	Nuphar pumila (Timm) DC.	4
NUP1SPE1	Nuphar x spenneriana Gaudin	4
NYM1ALB1	Nymphaea alba L.	4
NYM1ALX1	Nymphaea candida x tetragona	4
NYM1CAN1	Nymphaea candida Presl	4
NYM1TET1	Nymphaea tetragona Georgi.	4
NYM1XAL1	Nymphaea alba x candida	4
NYM2PEL1	Nymphoides peltata (S. G. Gmelin) O. Kuntze	4
PER1AMP1	Persicaria amphibia (L.) Gray	4
POT1ACU1	Potamogeton acutifolius Link	3
POT1ALP1	Potamogeton alpinus Balbis	3
POT1BER1	Potamogeton berchtoldii Fieber	3
POT1COM1	Potamogeton compressus L.	3
POT1CRI1	Potamogeton crispus L.	3
POT1FIL1	Potamogeton filiformis Pers.	3
POT1FRI1	Potamogeton friesii Rupr.	3
POT1GRA1	Potamogeton gramineus L.	3
POT1LUC1	Potamogeton lucens L.	3
POT1NAT1	Potamogeton natans L.	4
POT1OBT1	Potamogeton obtusifolius Mert. & Koch	3
POT1PEC1	Potamogeton pectinatus L.	3
POT1PER1	Potamogeton perfoliatus L.	3
POT1POL1	Potamogeton polygonifolius Pourret	4
POT1PRA1	Potamogeton praelongus Wulfen	3
POT1PUS1	Potamogeton pusillus L.	3
POT1RUT1	Potamogeton rutilus Wolfg.	3
POT1TRI1	Potamogeton trichoides Cham. & Schltdl	3
POT1VAG1	Potamogeton vaginatus Turcz.	3

POT1XGR2	Potamogeton x nitens Weber	3
POT1XSP1	Potamogeton x sparganiifolius Laestad ex Fries	3
POT1XSU2	Potamogeton x suecicus K. Richt.	3
POT1XZI1	Potamogeton x zizii	3
RAN1AQU1	Ranunculus aquatilis L.	3
RAN1BAU1	Ranunculus baudotii Godron	3
RAN1CIR1	Ranunculus circinatus Sibth	3
RAN1CON1	Ranunculus confervoides	3
RAN1PEL1	Ranunculus peltatus Schrank.	3
RAN1PEN1	Ranunculus penicillatus Dum	3
RAN1REP2	Ranunculus reptans	3
SAG1NAT1	Sagittaria natans	3
SAG1XSA1	Sagittaria sagittifolia x natans	3
SAL1NAT1	Salvinia natans (L.) All.	5
SPA1ANG1	Sparganium angustifolium	3
SPA1GRA1	Sparganium gramineum	3
SPA1HYP1	Sparganium hyperboreum	3
SPA1NAT1	Sparganium natans	3
SPA1XAN1	Sparganium angustifolium x gramineum	3
SPI1POL1	Spirodela polyrhiza (L.) Schleid	5
STR1ALO1	Stratiotes aloides L.	5
SUB1AQU1	Subularia aquatica L.	2
TOL1CAN1	Tolypella canadensis	1
TOL1GLO1	Tolypella glomerata	1
TRA1NAT1	Trapa natans L.	5
UTR1AUS1	Utricularia australis Thor	3
UTR1INT1	Utricularia intermedia Hayne	3
UTR1MIN1	Utricularia minor L.	3
UTR1OCH1	Utricularia ochroleuca R. Hartman	3
UTR1VUL1	Utricularia vulgaris L.	3
UTR1ZZZ1	Utricularia	3
ZAN1PAL1	Zannichellia palustris L.	3

2.10. Alternative methodology relating macrophyte abundance with chlorophyll-a

Initially, two methods for deriving chlorophyll-a boundaries are explored, of which method 1 appeared the most suitable one. In this chapter the other methods is also presented.

<u>1.Direct relation between macrophyte abundance and chlorophyll-a</u>
A direct relationship between chlorophyll-a and macrophyte abundance is the most straightforward way to assess boundaries for chlorophyll-a based on its secondary effects on macrophyte growth. These effects are usually non linear in very shallow lakes, and transitions in macrophyte abundance often occur in jumps. The method has the advantage that it is transparent and leads directly to class boundaries for chlorophyll-a.

<u>2.Relation between macrophyte coverage and total turbidity and corrected for lake depth</u>
In very shallow lakes, turbidity by other components than living algae can be important. Some lakes are naturally turbid and this affects the amount of chlorophyll-a that the lake ecosystem can have before impacts on submerged macrophytes occur. Also, the depth of a lake determines the sensitivity of macrophyte growth for changes in light conditions, especially in the depth range of 1-3 m. Taking also into account the effect on macrophyte abundance of turbidity by other components than living algae may improve the assessment.

The methods are empirical, and are based on the data collected for the Central/Baltic GIG. From the data provided by the Member States abundance classes were calculated for individual lake-years. Each Member State has converted their data per species using the ECOFRAME abundance scale. The calculation of abundance classes is described in Annex C – Part 2.8 Abundance classes 0-5 for both rooted submerged macrophytes and charophytes were averaged.

Basic results

<u>Direct relation between macrophyte coverage and chlorophyll-a</u>
A scatter plot of summer mean chlorophyll-a concentrations versus abundance classes of submerged macrophytes shows a decrease of chlorophyll-a concentrations with increasing macrophyte abundance (Figure C-2-10a). This is reflected in the 50-, 75- and 90- percentiles of the chlorophyll-a distributions for lumped macrophyte abundance classes.

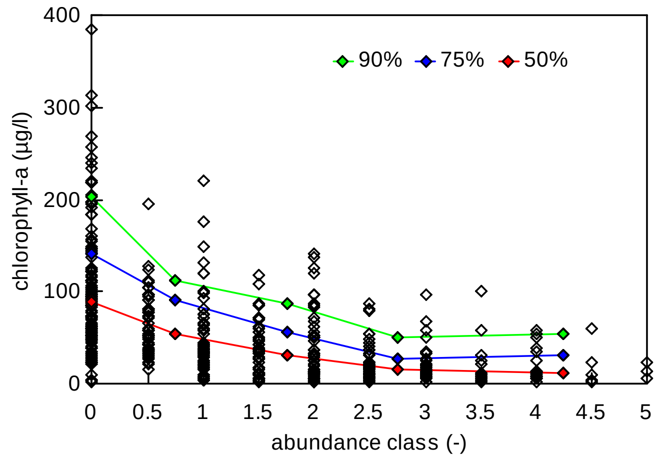


Figure C-2-10a. Scatter plot for chlorophyll-a versus macrophyte abundance classes and 50-, 75- and 90- percentiles of chlorophyll-a for lumped abundance classes (0, 0.5-1, 1.5-2, 2.5-3, 3.5-5)

Method 2.Relation between macrophyte coverage and total turbidity

It was expected that taking into account - besides chlorophyll-a only as in method 1 – also the contribution of non-algal turbidity (turbidity by components other than living algae, such as suspended solids and humic substances) and lake depth to the light climate at the lake bottom, could improve the predictability of macrophyte abundance.

As data on extinction were not available, the reciprocal Secchi depth 1/SD (m-1) was used as a measure for total turbidity. This reciprocal Secchi depth is including both the contribution of chlorophyll-a and non-algal turbidity, and multiplying it with lake depth yields a dimensionless measure - the depth/SD ratio - for the light climate at the lake bottom.

Figure C-2-10b shows, analogous to Figure C-2-10a, a decrease of depth/SD with increasing macrophyte abundance, but this decrease is less pronounced than that of chlorophyll-a.

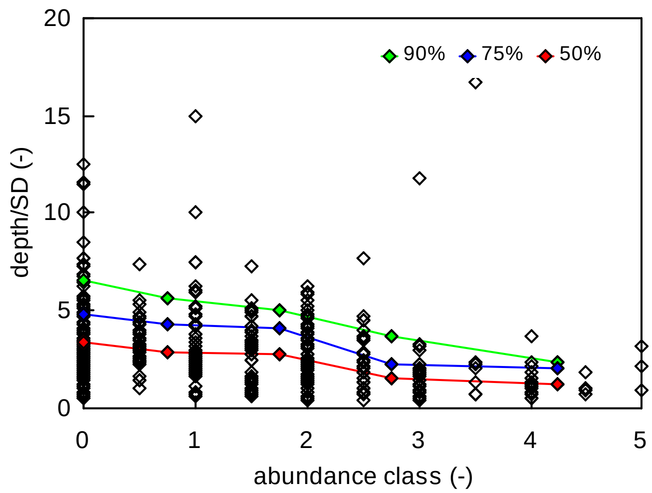


Figure C-2-10b. 50-, 75- and 90- percentiles of the ratio of lake depth : Secchi depth for lumped abundance classes (0, 0.5-1, 1.5-2, 2.5-3, 3.5-5).

To further compare method 1 and method 2, the fractions of lake years with various macrophyte abundance classes within 20% ranges of chlorophyll-a were calculated (Figure C-2-10c). In the lowest 20% range (with chl-a < 12 µg/l), there were only very few lakes with complete absence of macrophytes (abundance class zero), and 60% of lake years had an abundance of 3 or higher. In the highest 20% chlorophyll-a range (with chl-a > 95 µg/l) only a few % of lake years had an abundance of 3 or higher. Figure C-2-10c also indicates that method 1 (using just chlorophyll-a) performs better than method 2: it shows a more pronounced and smooth decrease of macrophytes with chlorophyll-a than with depth/SD. The use of measured Secchi depths might be a problem for very shallow lakes, especially in case of regular bottom vision (indicated by a depth / SD ratio < 1).

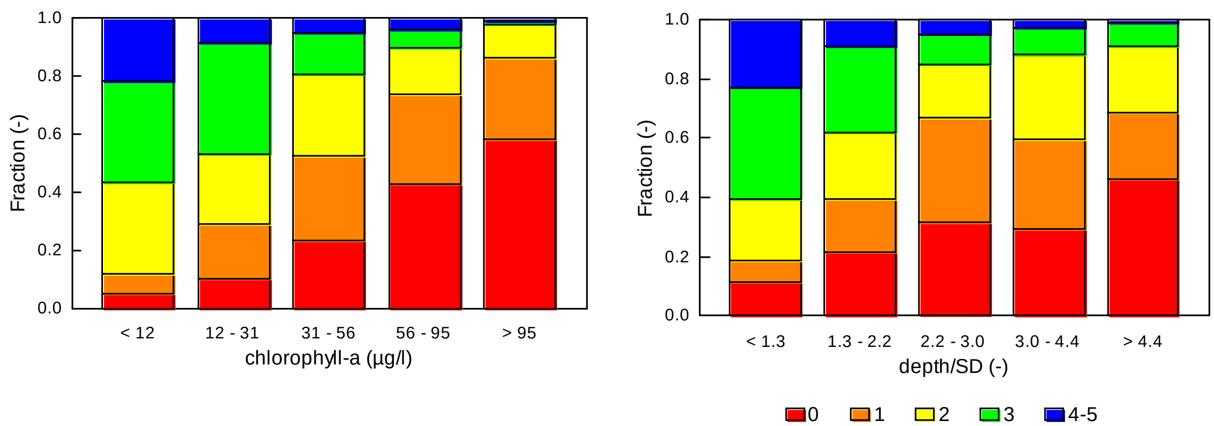


Figure C-2-10c. Fractions of abundance classes for macrophytes in 20% ranges of chlorophyll-a (method 1) and depth/SD (method 2) for very shallow lakes LCB2.

2.11. Alternative approach for relating macrophyte maximal colonized depth Zmax with chlorophyll-a using logistic regression

An alternative approach to modelling these data was explored using logistic regression:

- Data for macrophyte maximal colonized depth Zmax were classified into binary variables defining if a site had a value of Zmax greater than a critical threshold value;
- Zmax categories were arbitrarily defined as >1, >2,>3,>4,>5m;
- Logistic regression was then undertaken and the resulting models are shown in Table C-2-11 and Figs C-2-11a and C-2-11b.

$$p[Zc\max > Y] = \frac{1}{1+e^{-[-b_0+b_1 Chla]}}$$

where Zc_{max} = maximum depth of colonisation (m)
Chla - mean growing season chlorophyll (μgL^{-1})
p[Zc_{max}] probability that maximum depth of colonisation (Zc_{max} m) are exceeded

Table C-2-11. Logistic regression model showing probability that maximum depth of colonisation (Zc_{max} m) are exceeded as a function of mean growing season chlorophyll (Chl a μgL^{-1}).

Zc_{max}		b	SE	Wald Statistic	Significance
Zc>1	Constant	2.891	0.24	42.8	p<0.001
	Chla	-0.024	-0.004	145.3	p<0.001
Zc>2	Constant	2.333	0.213	119.9	p<0.001
	Chla	-0.064	0.007	73.2	p<0.001
Zc>3	Constant	1.861	0.24	60.4	p<0.001
	Chla	-0.135	0.018	58.6	p<0.001
Zc>4	Constant	0.896	0.027	39.8	p<0.001
	Chla	-0.171	0.26	11.9	p 0.001

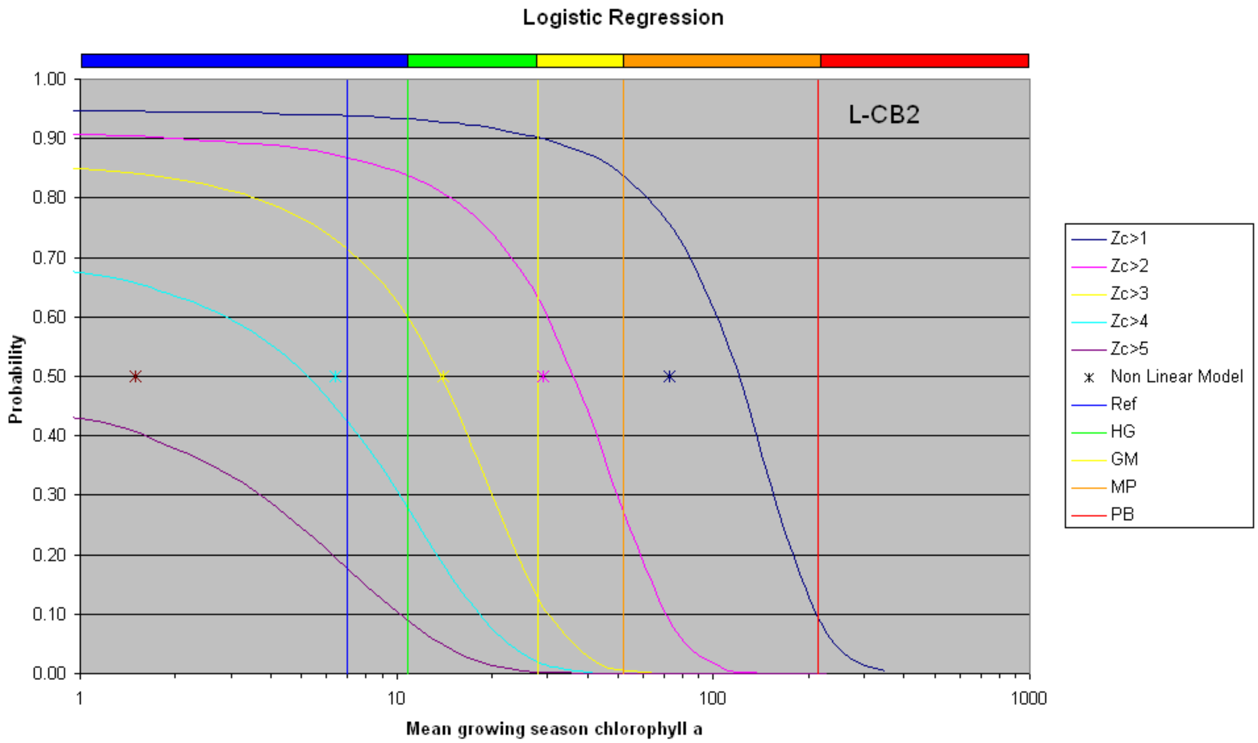


Fig C-2-11a Logistic regression showing probability that maximum depth of colonisation (Zc_{max} m) are exceeded as a function of mean growing season chlorophyll (Chl a μgL^{-1}). Boundaries marked are those derived from linear regression models for high alkalinity shallow lakes (L-CB1). Crosses mark value of Chl a for each value of Zc_{max} derived from non-linear model fit.

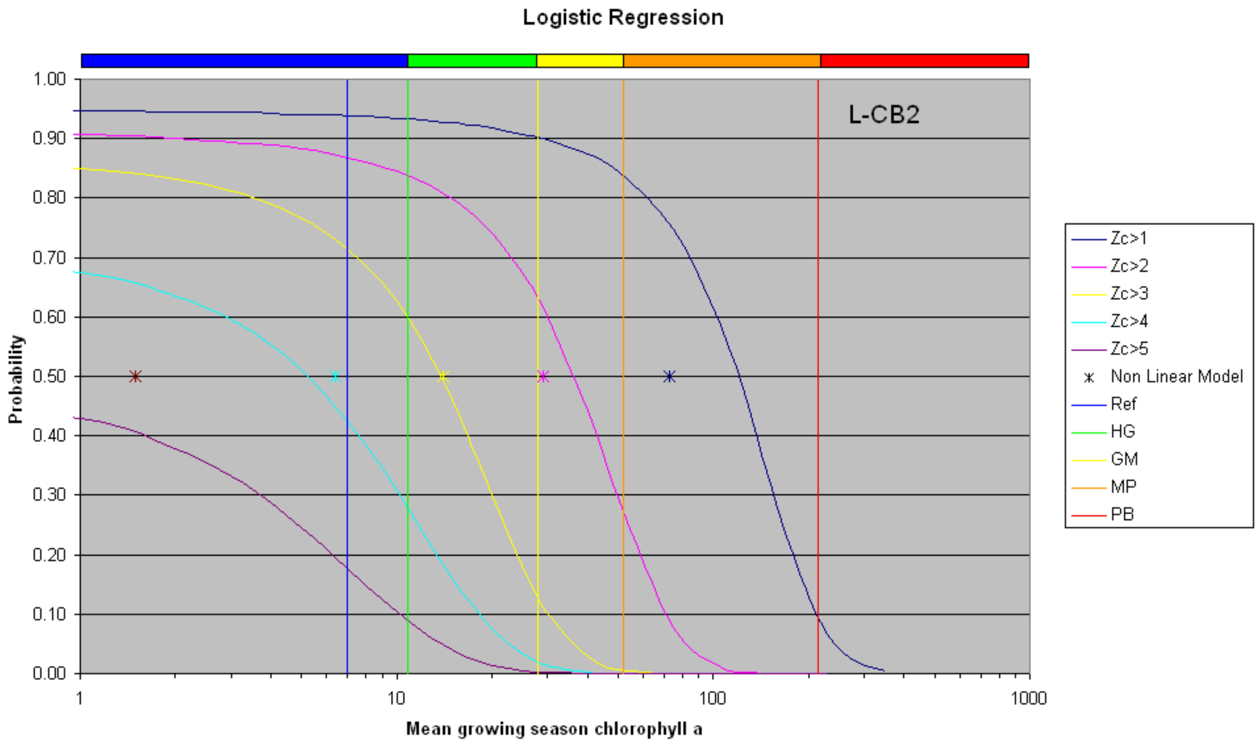


Fig C-2-11b Logistic regression showing probability that maximum depth of colonisation (Zc_{max} m) are exceeded as a function of mean growing season chlorophyll (Chla μgL^{-1}). Boundaries marked are those derived from linear regression models for high alkalinity very shallow lakes (L-CB2). Crosses mark value of Chla for each value of Zc_{max} derived from non-linear model fit.

As the logistic regression is applied to binary categorical data it is potentially less powerful than the linear regression on transformed data. However, given that the objective of this analysis is to determine changes in probability of different status classes occurring it is an approach that is worth considering, if only to confirm that the boundaries derived previously are appropriate.

Conclusions for LCB1 type:

- As expected probability of finding macrophytes at a given depth decreases with increasing chlorophyll;
- At reference conditions in shallow lakes (e.g. L-CB1) there is a >0.8 probability of Zc_{max} being >3m and 0.6 for >4m;
- At the high/good boundary Pr[Zc_{max}>4m] is only just below 0.5, observations that support the conclusion from regression analysis that the high/good boundary can be defined by Zc_{max} >3.5m.
- At the good/moderate boundary there are only slight reductions in the probability of the two lower categories of Zc_{max} (>1m & >2m). This seems consistent with the definition of only a low probability of undesirable change (ie Zc_{max} <2m).
- By the moderate poor boundary (Chla 26 μgL^{-1}) Pr[Zc_{max}>2] has only reduced to 0.66 which might not be considered a high probability of undesirable change. However,

the high status criteria ($Pr[Zc_{max}>3]$) has reduced to 0.15 demonstrating a clear ecological change which could be considered undesirable.

Similar conclusions can be drawn from the very shallow lakes:

- At high status $Pr[Zc_{max}>3] = 0.6$ supporting the proposed high/good boundary of 3m;
- As for shallow lakes at the good/moderate boundary there is little evidence that poor conditions ($Zc_{max} < 1.0$m) could occur ($Pr[Zc_{max}>1] = 0.9$);
- Although at the good/moderate boundary the probability of reference conditions occurring is low, $Pr[Zc_{max}>2m]$ is still >0.5;
- By the moderate/poor boundary $Pr[Zc_{max}>2]$ has reduced to 0.25 and the lowest category of Zc_{max} (>1m) is starting to reduce, all conditions which could be described as representing undesirable change;
- For very shallow lakes the poor/bad boundary is set at a point where macrophyte growth is on the verge of extinction with $Pr[Zc_{max}>1] = 0.1$.

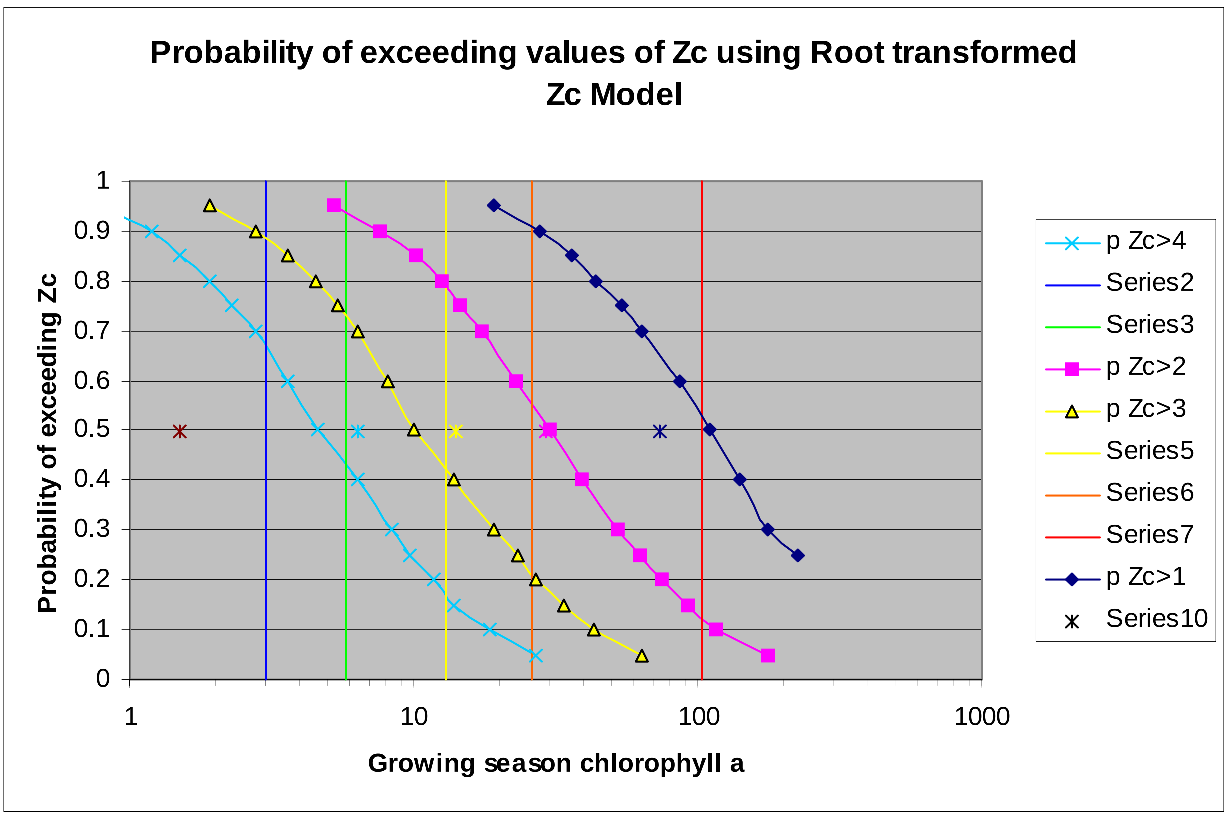


Fig C-2-11c Probability of exceeding given categories of Zc_{max} for range of values of mean growing season chlorophyll a. Vertical lines represent proposed boundaries for shallow high alkalinity lakes L-CB1

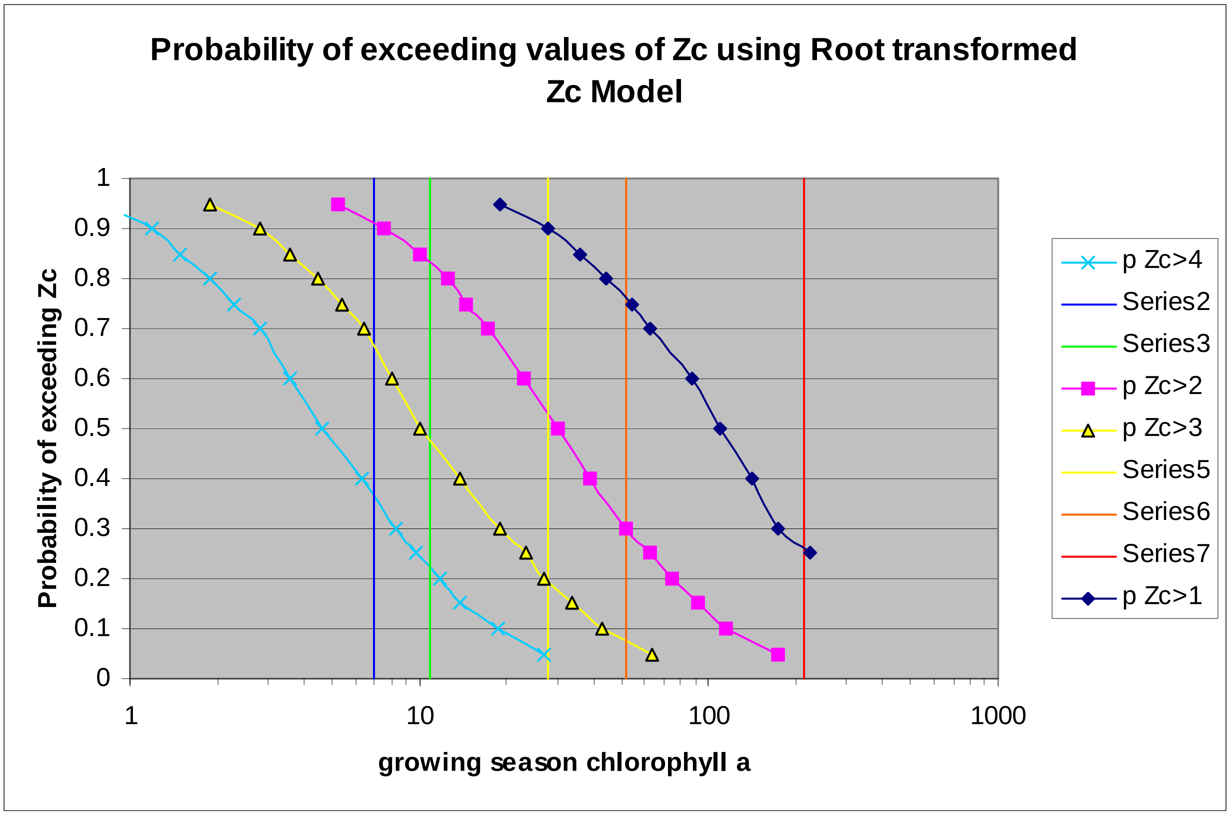


Fig C-2-11d Probability of exceeding given categories of Zc_{max} for range of values of mean growing season chlorophyll a. Vertical lines represent proposed boundaries for very shallow high alkalinity lakes L-CB2

Annex C - Part 3 - Member states Lake Typologies

Table C-3. National typologies of the countries in the Central/Baltic GIG

Belgium-FL					
	pH	DIC (mg l^{-1})	Conductivity ($\mu S\ cm^{-1}$)	Sediment / Geology	Depth (m)
Ai	>7.5	>25	>700	no sand (polders & alluvia)	<6
Ami-e, Ami-om	>7.5	<25	<700	-	<6
Awe, Awom*	>7.5	-	-	-	>6
Cb	6.5-7.5	>3.3	-	no clay	-
* Awom – Kempen region, Awe- elseat which					
Germany					

Type	Mixing type (depth)	Schindler's ratio (catchment area / lake volume)	Alkalinity (HCO_3mg l^{-1})	Size (km^2)	Retention time (days)	Mean depth (m)
11.2	polymictic	>1.5	>23	>0.5	>30	≤3
10	stratified	>1.5	>23	>0.5		
13	stratified	<1.5	>23	-		

Denmark

Type	Alkalinity (meq l^{-1})	Colour (mg Pt l^{-1})	Salinity (promille)	Depth (m)
2	<0.2	<60	<0.5	>3
4	<0.2	>60	<0.5	>3
6	>0.2	<60	<0.5	<3
7	>0.2	<60	<0.5	>3
9	>0.2	>60	<0.5	<3
10	>0.2	>60	<0.5	>3

Estonia

Type	Mixing type (depth)	Alkalinity (HCO_3 mg l^{-1})	Size (km^2)	Colour (mg Pt l^{-1})
2	polymictic	80 - 240	-	<80
3	stratified	80 - 240	-	<80
5	-	<80	-	<80

	France
Type	Geology / Region
A6b	Reservoir, lowland, non-calcareous, deep (with littoral macrophytes)
A7b	Reservoir, lowland, calcareous, shallow (with littoral macrophytes)
A7a	Reservoir, lowland, calcareous, deep (with littoral macrophytes)
A13a	Reservoir, lowland, regularly emptied out
A13b	Reservoir, lowland, water level controlled
A14	Reservoir, hard stone, not emptied out
A15	Reservoir, stratified, deep, small littoral zone
A16	Reservoir, shallow, littoral zone
N8	Natural, lowland, hills of South-West France
N9	Natural, lowland, Atlantic littoral zone (South-West, bay of Biscay), deep, monomictic
N12	Other lowland lakes

Hungary

Type	Depth (m)	Size (km^2)	Sediment type	Water cover
1	3-15	>100	calcareous	perennial
6	<4	0.5–10	calcareous-	perennial

			organic	
9	<3	0.5–10	calcareous-organic	perennial

Lithuania

	Altitude	Mean depth	Surface area	Geology
1	< 200 m	<3	> 0.5 km2	Calcareous
2		3-9		
3		>9		

Latvia

Type	Depth (m)	Conductivity (μS/cm)	Colour (mg Pt l-1)
1	0 - 2	> 165	< 80
2	0 - 2	> 165	> 80
5	2 - 9	> 165	< 80
6	2 - 9	> 165	> 80
7	2 - 9	< 165	< 80
8	2 - 9	< 165	> 80
9	>9	> 165	< 80

The Netherlands

Type	Salinity (mg Cl l^{-1})	Depth (m)	Alkalinity (meq l^{-1})	Size (km^2)	Sediment type	River influence
M5	0-0.3	0-3	1-4	-	mineral - sand	yes
M14	0-0.3	0-3	1-4	0.5-100	mineral	no
M20	0-0.3	>3	1-4	0.5-100	mineral	no
M21	0-0.3	>3	1-4	>100	mineral	no
M23	0-0.3	0-3	1-4	0.5-100	calcareous	no
M27	0-0.3	0-3	1-4	0.5-100	peat	no

Poland

Type	Geographic region	Geology	Ca (mg l^{-1})	Schindler's ratio	Mixing type
1a	Niż Środkowopolski	Postglacial deposits	< 25	Not applicable	stratified
1b	Niż Środkowopolski	Postglacial deposits	< 25	Not applicable	unstratified.
2a	Niż Środkowopolski	Postglacial deposits	> 25	≤ 2	stratified
2b	Niż Środkowopolski	Postglacial deposits	> 25	≤ 2	unstratified.
3a	Niż Środkowopolski	Postglacial deposits	> 25	> 2	stratified
3b	Niż Środkowopolski	Postglacial deposits	> 25	> 2	unstratified.
4	Niż Środkowopolski	Postglacial deposits	> 25	Coastal lakes under the influence of saline waters	-
5a	Niziny Wschodniobałtycko-Białoruskie	Postglacial deposits	>25	≤ 2	stratified

5b	Niziny Wschodniobałtycko-Białoruskie	Postglacial deposits	>25	≤ 2	unstratified.
6a	Niziny Wschodniobałtycko-Białoruskie	Postglacial deposits	>25	> 2	stratified
6b	Niziny Wschodniobałtycko-Białoruskie	Postglacial deposits	>25	> 2	unstratified.
7a	Niziny Wschodniobałtycko-Białoruskie	Polesie province	>25	Not applicable	stratified
7b	Niziny Wschodniobałtycko-Białoruskie	Polesie province	>25	Not applicable	unstratified.

UK				
Type	Region	Depth (m)	Alkalinity (meq l^{-1})	
HAS	England Scotland Wales	3-15	>1.0	% Peat < 75%
HAVS		<3	>1.0	% Peat < 75%
NI5	Northern Ireland	<4	0.4-2	Size <50 ha
NI6		<4	0.4-2	Size >50 ha
NI9		<4	>2.0	Size <50 ha
NI10		<4	>2.0	Size >50 ha

Annex D Mediterranean GIG

ANNEX D - Part 1 -Changes of Lake Mediterranean GIG Intercalibration Types

The reason for splitting the siliceous reservoirs, once merged as LM (5+7), in siliceous from “Wet areas” and siliceous from “Arid areas”, stems from the differences in some variables concerning precipitation, temperature and residence time:

- If we consider the **IC reservoirs from “Arid areas”,** all of them have a precipitation <800 mm, an annual mean temperature >15 ºC and a water residence time >7 months;
- Furthermore, most of the IC reservoirs in these areas are used for irrigation or water supply, and none for hydroelectric use. For this reason, the residence time is higher in these reservoirs, and the annual hydrological pattern distinct;
- On the other hand, most of the reservoirs located in **“Wet areas”** have a precipitation higher than 800 mm, an annual mean temperature below 15ºC and a residence time lower than 7 months, with only few exceptions.
- Most of the reservoirs considered in these areas, are used for hydroelectric power generation. The figures given below show the differences between both types.

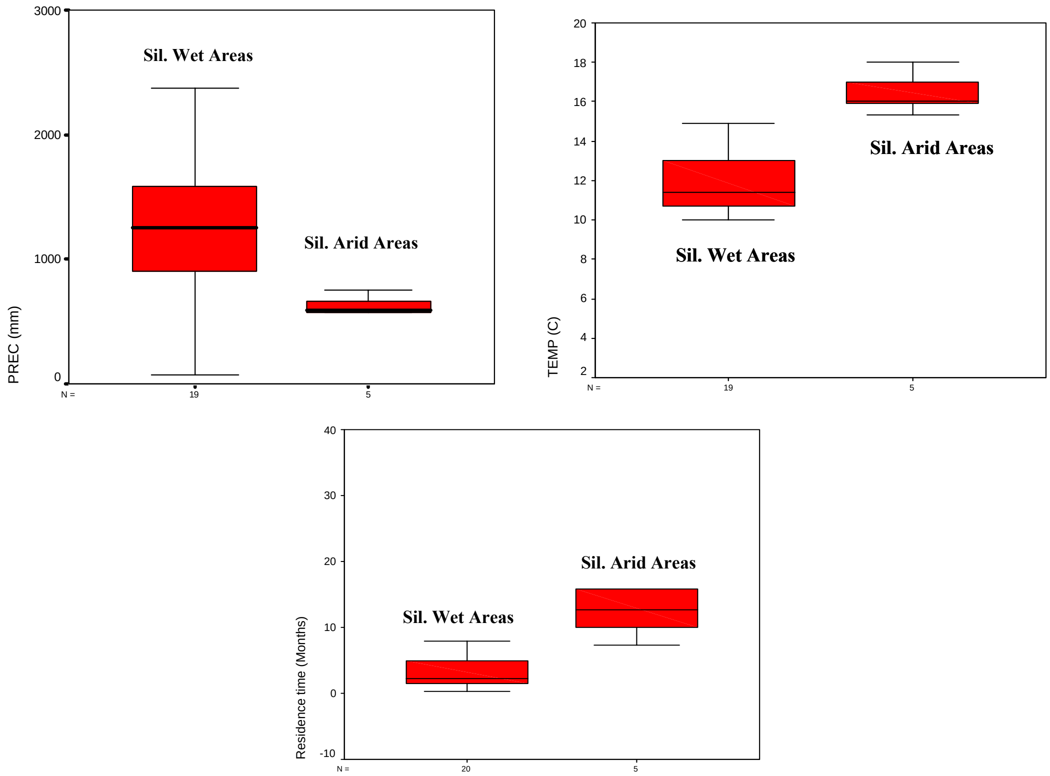


Figure D-1: Box plots: Differences between Med GIG Lake Intercalibration types (precipitation, temperature, residence time)

ANNEX D - Part 2 - Analyse methods

Method agreed for analyses of chlorophyll-a concentration and phytoplankton biomass in the lake-Mediterranean GIG, within the intercalibration exercise.

1. Chlorophyll-a concentration:

The method used by for a chlorophyll analyses is the one recommended by APHA, AWWA, WPCF, (20th Edition) “Standard Methods for the Examination of Water and Wastewater”. This method is compatible with the Standard ISO 10260:1992 “Water quality– Measurement of biochemical parameters – Spectrometric determination of the chlorophyll-a concentration”, except that it recommends the use of ethanol as extraction reagent which was not used by the Mediterranean GIG - 90% acetone was used instead.

2. Phytoplankton Biomass:

For the analysis of phytoplankton Biomass the Utermöhl method was used with inverted Microscope following the CEN standard for counting cells: **CEN TC 230/WG 2/TG 3/N83** (Working draft stage) Water quality- Guidance standard for the routine analysis of phytoplankton abundance and composition using inverted microscopy (Utermöhl technique).

Annex D Part 3 - Reference criteria for selection of reference lakes

In general, no specific values were adopted to set thresholds for “very minor” alterations, but the criteria adopted by the L-M GIG countries are described as below:

- **Cyprus**: Based on CORINE, 90% of land in the catchment area is covered by semi-natural coniferous forest; 8% is agricultural land. No industry, nor significant human settlements.

- **France**: Reference sites have been defined using land cover types within different buffer zones (Corine Land Cover analyses): an index based on coefficients allocated for cover types (including inputs of pesticides, phosphorus, hydrocarbons and heavy metals and soil impermeability) was calculated for each scale. For each site these indices were combined to form an overall impact index. Lakes with the lowest total index value were considered as reference sites (Lafage 2004).

- **Greece**:
  - Land use: The coverage of natural areas is high (91%) and agriculture forms only 7% of the catchment area. There are no artificial surfaces upstream;
  - Pressures: There are no major pressures in the area. Nutrient loading is considered as very low;
  - Trophic status: Based on results of chl –*a* and biovolume, the reservoir is considered as oligotrophic.

- **Portugal**:
  - Sites with less than 20% of the catchment for agricultural use and the rest remaining as natural or semi-natural coverage (Corine Land Cover, 1990);
  - Additionally, boundary values for some chemical parameters and checked with historical records of chlorophyll were taken into account, as well as low/moderate level fluctuations (0-20m) and absence of Cyanobacteria blooms after historical records;
  - Low/moderate fishing and navigation pressures (expert opinion) were also taken into account. The Castelo de Bode Reservoir was considered as *Best available*, not Reference due to navigation use and some nutrient pressure, as well as upstream dams.

- **Romania**: - more than 70% of the catchment size classified as natural;
  - historical records of Cyanophycea blooms taken into account;
  - historical records of Total Phosphorous and Nitrogen forms taken into account
  - low fishing and low navigation

- **Spain**:
  - Demand of water for different uses, as indicator of the most important anthropogenic activities that can affect to the waterbodies. This indicator is accumulated throughout all points in the catchment area. (“*Selección preliminar de posibles tramos fluviales de la red de referencia*”. CEDEX, January 2004).
  - Upstream accumulated demand of water for agricultural irrigation being <10%, was used as indicator of agricultural use.

- Upstream accumulated demand of water for industrial use being < 1,5 %, was used as indicator of industrial use.
- Upstream accumulated demand of water for domestic being <3% of annual loading, was used as indicator of population upstream
- "Naturality" of the catchment according to CORINE using 70% of the catchment area classified as "natural areas" (forest, autochthonous vegetation etc) as percentage for less alteration sites.

None of the reservoirs selected in the GIG are located downstream from an upper dam, except Castelo de Bode.

Annex D Part 4 - Reference sites

Table D-4. Overview on reference lakes and phytoplankton biomass metric values in the Med GIG database. (Mean summer (June-September) values, photic layer integrated values, based on the 2005 summer sampling programme).

Reservoir Name	COUNTRY	TYPE	Chlorophyll-*a* (mg/m^3)	Total Biovolume (mm^3/l)
Arenós	Spain	Calcareous	1,92	0,84
Castelo De Bode*	Portugal	Siliceous in "Wet areas"	1,37	0,27
Eugui	Spain	Calcareous	1,81	0,65
La Ribeira	Spain	Siliceous in "Wet areas"	2,61	2,28
Lefkara	Cyprus	Calcareous	0,38	0,56
Sacele	Romania	Calcareous	0,54	0,81
Saint Cassien	France	Calcareous**	2,53	-
Salime	Spain	Siliceous in "Wet areas"	3,73	0,69
Tehniti Limni Tavropou	Greece	Siliceous in "Wet areas"	1,10	0,36
Vilarinho Das Furnas	Portugal	Siliceous in "Wet areas"	0,74	0,07

* Best Available
** Formerly considered as "Siliceous" but later on moved to the Calcareous Type, because the main tributary drains a calcareous catchnment area, despite the submerged basin being siliceous.

Annex D - Part 5 - Calculation of ranges for chlorophyll *a* values

As mentioned before, the chlorophyll boundary values obtained as the result of the IC approach should not be considered as fixed values. First of all, these results were obtained during a single sampling campaign (2005 summer). There can be a great variability of the chlorophyll values from one year to the other due to many ecological reasons. In the Mediterranean countries, this variability might be even wider as a consequence of the climatic differences among years.

In order to cope with this problem, previously available data from Mediterranean reservoirs in Spain, Portugal and Italy have been gathered and analysed:

- 75 reservoirs have been selected where more than one chlorophyll value were available for different years (summer average mean values);
- The variation coefficient of each reservoir temporal serial was calculated as the ratio between standard deviation and the mean value of the temporal serial;
- Reservoirs with chlorophyll data higher than 8 mg/m^3 were disregarded, keeping in mind that eutrophic reservoirs could undergo wider variability in chlorophyll *a* concentration due to different pressures;
- The median of the whole variation coefficient was calculated for 23 "Calcareous" (from Spain and Italy) and 21 "Siliceous wet" reservoirs (from Spain and Portugal) separately. The results are shown in the following table:

Table D-5-1. Overview on calculation of Interannual variation coefficient

Type	Median value of Interannual variation coefficient of Chlorophyll a	Countries and datasets
Siliceous from "Wet areas"	0,45	Spain and Portugal data, 21 reservoirs, 2 - 11 years
Calcareous	0,45	Spain and Italy data, 23 reservoirs, 2-12 years

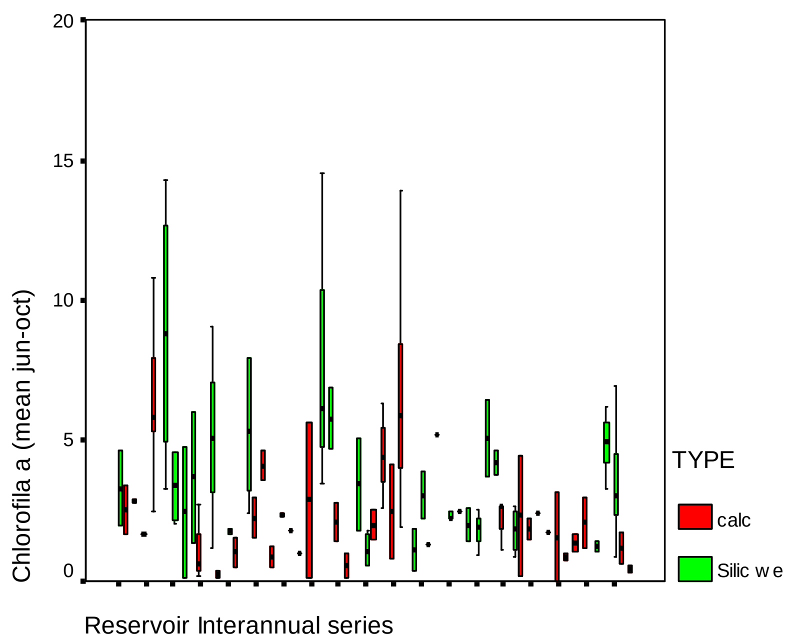


Figure D-5-1: Interannual variation of Summer mean chlorophyll values in Mediterranean reservoirs

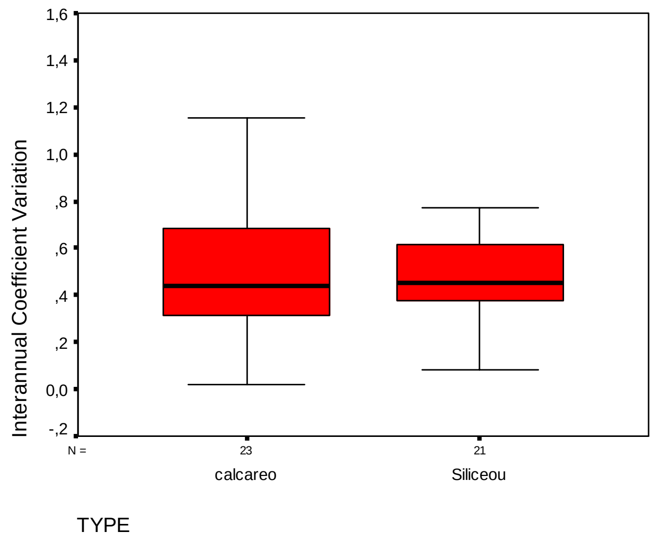


Figure D-5-1:: Interannual variation of Summer mean chlorophyll values in Mediterranean reservoir: Box plots for Calcareus and Siliceous "Wet" types

The variation coefficient can be used to establish a range for the fixed values of the RC and G/M boundaries. If we consider that summer mean chlorophyll *a* values could vary around 45 %, then the ranges would be the following:

Table D-5-2. Overview on calculation of minimal and maximal values of chlorophyll a reference conditions

Type		Fixed value minus 45% (min value)	Fixed value	Fixed value plus 45% (max value)
Siliceous wet	Ref	0,77 (not considered)	1.4	2.0
Calcareous	Ref	0,99 (not considered)	1.8	2,6

Fixed values for the EQRs were calculated as ratio between reference value and GM boundary value (Table D-5-3)

Table D-5-3. Overview on calculation of EQRs for chlorophyll GM boundaries

Type	RC	GM	EQR (ratio between RC and GM)
Siliceous wet	1.4	6.7	0.21
Calcareous	1.8	4.2	0.43

The minimal G/M values are calculated as a ratio between minimal value of RC and EQR and max value as a ratio between maximal value of RC and EQR (Table D-5-4).

Table D-5-4. Overview on calculation of ranges for chlorophyll GM boundaries

Type	Min value of RC	Max value of RC	EQR	Min (ratio between RCmin/EQR)	Max (ratio between max RCmax/EQR)
Siliceous wet	0.77	2.0	0.21	3,6	9,5
Calcareous	0.99	2.6	0.43	2,3	26,0

Thus, the following ranges for Chlorophyll G/M boundary values were acquired (Table D-5-5).

Table D-5-5. Overview on established ranges for chlorophyll GM boundaries

Type	Min value (Fixed value minus 45%)	Fixed value	Max value (Fixed value plus 45%)	Range of GM boundaries
Siliceous wet	3,7 (not considered)	6.7	9.5	6.7-9.5
Calcareous	2.3 (not considered)	4.2	6.0	4.2-6.0

These results come to be similar to applying the 45% to the G/M boundary value. However, taking into account the whole analysis developed to validate the boundaries as summarized in paragraph 3, expert judgment suggests that the lower limit described as the *fixed value minus 45% of interannual variability* should be discarded for limit positioning. This assumption is based upon different arguments:

- Firstly, the selected reservoirs for the intercalibration analysis at the Mediterranean GIG show a significant statistical skew. According to the historical database that has been consulted, the reservoirs included in the IC register appear to be deviated from the G/M boundary, so their ecological status seem to be much better than those in between both categories. In other words, they seem to be rather biased towards oligotrophy;
- On the other hand, by comparing the limnological parameters used for boundary validation (algal taxons, hypolimnetic dissolved oxygen concentration and Secchi depth, see Annex D – Part 8)) with the chlorophyll *a* gradient it can be noted that a remarkable ecological change takes place at around 5 mg/m^3;
- For these reasons, it seems advisable to withhold the *fixed value*, acting as the lower limit for the G/M boundary, while keeping the *fixed value plus 45% of interannual variability* as the upper limit.

A similar approach would apply to the other phytoplankton indices (biovolume and composition), but, unlike chlorophyll *a* concentration, and as pointed out above, no sufficient data were available to proceed likewise. This is therefore a pending refinement to be undertaken in an immediate future, as soon as enough data are collected by monitoring programmes.

Summary of foundation of the ranges

- A coefficient of interannual variability was used, bearing in mind that the reference conditions and G/M boundary values were assessed on a set of data collected from one single year during the IC process;
- Thus, the ranges obtained are intended to cover variability from on year to another, rather than differences between potential sub-types. Therefore, this is NOT a confidence range of whatever % intended to account for other kind of statistical variability.

Annex D- Part 6 - Data used for GM boundary setting

Table D-6. Overview on lakes and phytoplankton biomass metric values in the Med GIG database. (Mean summer (June-September) values, photic layer integrated values, based on the 2005 summer sampling programme).

Reservoir	Type	Country	Clh-a (*)(mg/m3)	Biov phyto (*)(mm3/l)
Agavanzal	Siliceous "wet "	Spain	5,2	0,94
Agueda	Siliceous "wet "	Spain	5,8	1,01
Aguieira	Siliceous "wet "	Portugal	28,1	8,77
Albarellos	Siliceous "wet "	Spain	4,6	1,39
Aldeadavila	Calcareous	Spain	19,1	3,70
Alto Lindoso	Siliceous "wet "	Portugal	3,3	0,40
Asprokremmos	Calcareous	Cyprus	2,0	0,62
Bao	Siliceous "wet "	Spain	3,5	0,89
Bezid	Calcareous	Romania	1,7	2,60
Bradisor	Siliceous "wet "	Romania	5,4	13,27
Caniçada	Siliceous "wet "	Portugal	8,0	0,84
Colibita	Siliceous "wet "	Romania	2,4	1,10
Fronhas	Siliceous "wet "	Portugal	3,5	0,39
Guadalest	Calcareous	Spain	2,2	1,16
Guadalmellato	Siliceous "arid "	Spain	4,3	1,61
Izvoru Munt.	Calcareous	Romania	1,4	4,27
Kouris	Calcareous	Cyprus	1,8	1,19
La Ribeira	Siliceous "wet "	Spain	2,6	2,28

Loriguilla	Calcareous	Spain	3,2	2,63
Maranhão	Siliceous "arid "	Portugal	9,3	1,59
Medio Flumend.	Calcareous	Italy	2,6	1,22
Monte Da Rocha	Siliceous "arid "	Portugal	4,5	1,41
Mulargia	Calcareous	Italy	1,9	1,00
Negratin	Calcareous	Spain	1,3	1,02
Pálmaces	Calcareous	Spain	5,2	0,73
Paltinu	Calcareous	Romania	1,7	2,06
Portodemouros	Siliceous "wet "	Spain	17,4	41,47
Sainte Croix	Calcareous	France	1,3	
San Esteban	Siliceous "wet "	Spain	4,6	1,45
Sau	Calcareous	Spain	44,0	9,70
Siriu	Calcareous	Romania	2,0	4,03
Sos Canales	Siliceous "arid "	Italy	3,4	0,73
Talarn O Tremp	Calcareous	Spain	2,4	0,70
Valparaiso	Siliceous "wet "	Spain	5,0	0,96
Vidraru	Siliceous "wet "	Romania	1,7	0,01
Vilasouto	Siliceous "wet "	Spain	2,7	1,53
Yeguas, El	Siliceous "arid "	Spain	1,8	0,66

Annex D - Part 7 - Reservoirs excluded from the analysis

To set the G/M boundaries for biomass metrics the 95th %-iles were calculated data using Med GIG data set.. For this calculation, data were disregarded for those reservoirs appearing to behave as outliers:

- Aguieira, Bradisor y Portodemouros Reservoirs of the siliceous-wet type;
- Aldeadávila and Sau Reservoirs of the calcareous-arid type.

These 5 reservoirs are eutrophic or they had a phytoplankton bloom during the sampling summer. They were not considered in the analysis neither for biomass parameters nor for composition parameters analysis.

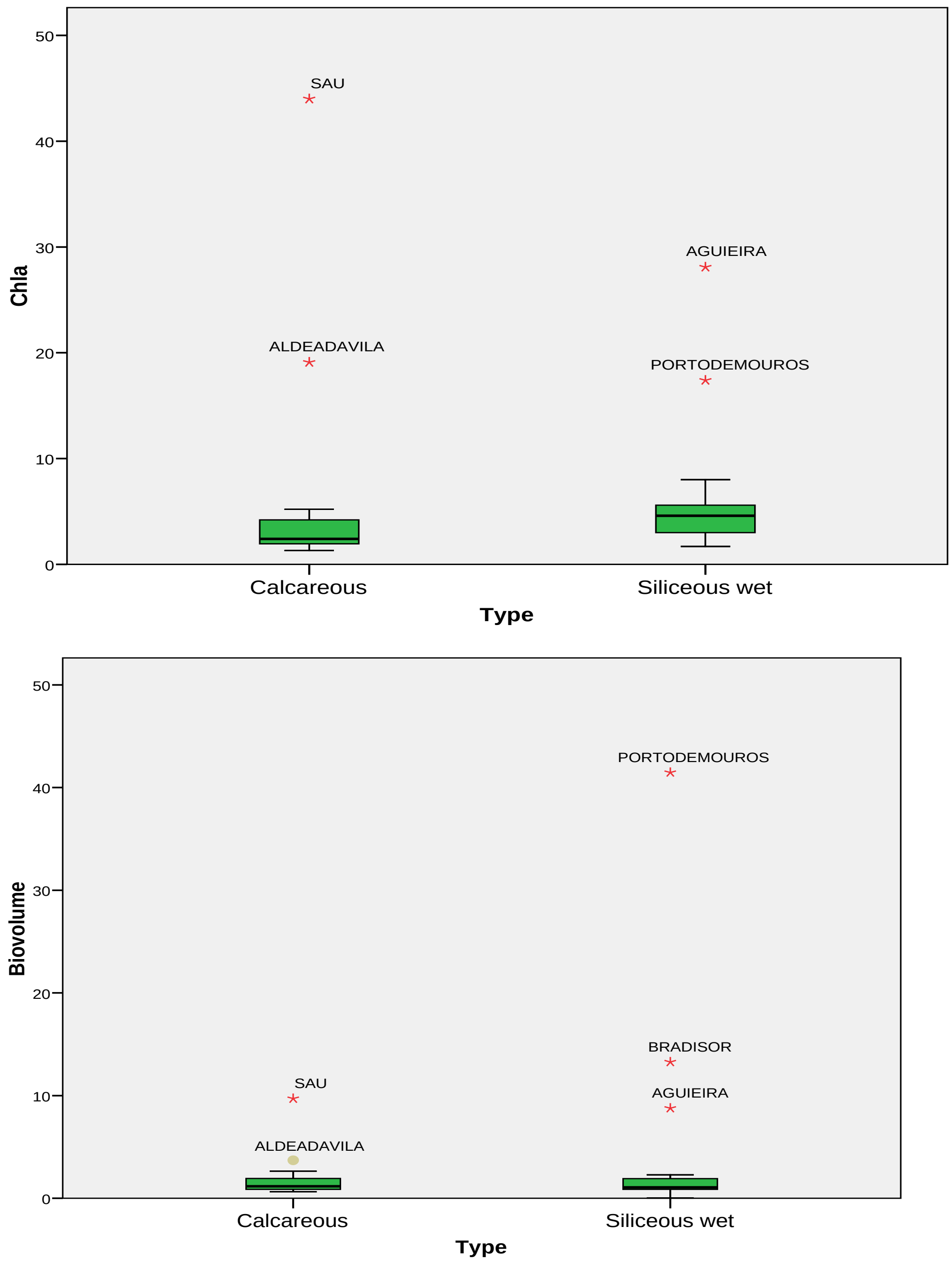


Figura D-7-1. Box plots for summer average chlorophyll-a concentration and total biovolume.

Furthermore, four Romanian reservoirs of the calcareous type were removed from the percentile calculations, because their relationship between both biomass indices was not consistent with the other data. They are Bezid, Izvoru, Paltinu, and Siriu Resevoirs.

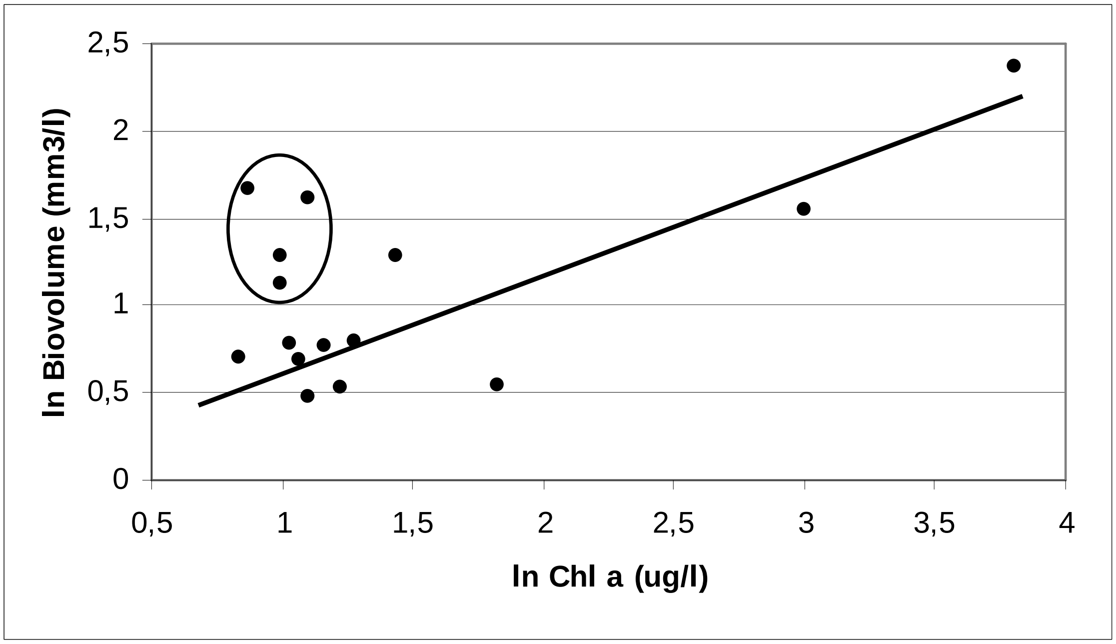


Figura D-7-2. Relationship between the chlorophyll-a and total biovolume data. Regression line between Chlorophyll a and Biovolume of the calcareous reservoir without the 4 marked points.

ANNEX D- Part 8 - Validation of boundary setting

8.1 Dataset used for the validation of boundary setting

The additional data set collected used with the purpose to expand the information along the whole gradient of pressures and to identify the behavior of some groups of algae in relation to eutrophication process. This approach allows analyzing whether the narrow range of G/M boundary values according to the IC sites corresponds with the changes in the taxonomic composition as described in the conceptual model of the WFD normative definitions. It is also important to analyze the possible discontinuities or changes in physical parameters as indicators of undesirable disturbance

For this purpose, a dataset was collected and analysed:

- Relation phytoplankton biomass metrics with the eutrophication pressure (Total phosphorus 33 Spanish reservoirs/ 33 reservoirs-years;
- Relationships between chlorophyll a and different groups of algae: 33 Spanish reservoirs/ 33 reservoirs-years;
- Relationships between chlorophyll a and oxygen: 114 Spanish reservoirs/ 160 reservoirs-years;
- Relationships between chlorophyll and Secchi disk 52 Spanish reservoirs + 28 Portuguese reservoirs/ 564 paired samples;
- Relationships between biovolume and different groups of algae: 33 Spanish reservoirs + 35 Italian reservoirs/ 68 reservoirs-years;

8.2 Relation of the phytoplankton biomass metrics with the eutrophication pressue

As referred to above, two phytoplankton biomass metrics were selected for the IC exercise in the Lakes Mediterranean GIG: chlorophyll-*a* concentration and total biovolume.

They were also applied to a set of data on Spanish reservoirs in order to know their suitability for the Mediterranean reservoirs (C. de Hoyos, 2005). The metrics show a significant relationship with Total Phosphorus (TP) as indicator of the eutrophication pressure.

D-8. Correlations between the phytoplankton biomass metrics selected for the IC exercise in L-M GIG and Total Phosphorus for 33 Spanish Reservoirs (C.de Hoyos, 2005)

Phytoplankton metric	r	r^2	F	p	Standard error
Chlorophyll *a*	0.858	0.736	83.8	0	0.055
Biovolume	0.881	0.777	104.94	0	0.051

If this dataset from sampled reservoirs during summer 2005 is included in the analysis, then correlation significance decreases. This should not be surprising, bearing in mind that the agreed data sampling programme did not intend to cover the whole gradient of impact.

8.3 Validation of chlorophyll *a* boundaries

In their general boundary setting protocol, Pollard & van de Bund (2005) suggest to use discontinuities in the gradients of impact for the definition of the G/M boundary. Various metrics have been tested for discontinuities in the correlations between phytoplankton biomass metrics and pressure metrics in order to validate boundaries:

- For chlorophyll values:
    - Relationships between chlorophyll a and the different algal groups (Cyanobacteria, Chrysophyta);
    - Relationships between chlorophyll *a* and dissolved oxygen at the bottom;
    - Relationships between chlorophyll *a* and Secchi depth;
- For phytoplankton biovolume values:
    - Relationships between chlorophyll a and the different algal groups (Cyanobacteria, Chrysophyta).

8.3.1 Relationships between chlorophyll a and the different algal groups

Regressions of Chlorophyll *a versus* biovolume percentage of indicator algae groups were determined and fulfil statistical criteria required in this kind of analysis. The data was transformed using neperian logarithmic expression.

Following relations were shown:

- As chlorophyll *a* concentration increases, Cyanobacteria biovolume percentage also increases;

- Chrysophyta and central diatoms biovolumes decrease along eutrophication gradient;
- The chlorophyll values at which regression lines intersect are 6.7 µg/l (between Cyanobacteria and Chrysophyta) and 12.2 µg/l (between Cyanobacteria and central diatoms).
- These two values can be considered as the limits of a range for the G/M boundary of Spanish reservoirs (Mediterranean reservoirs).

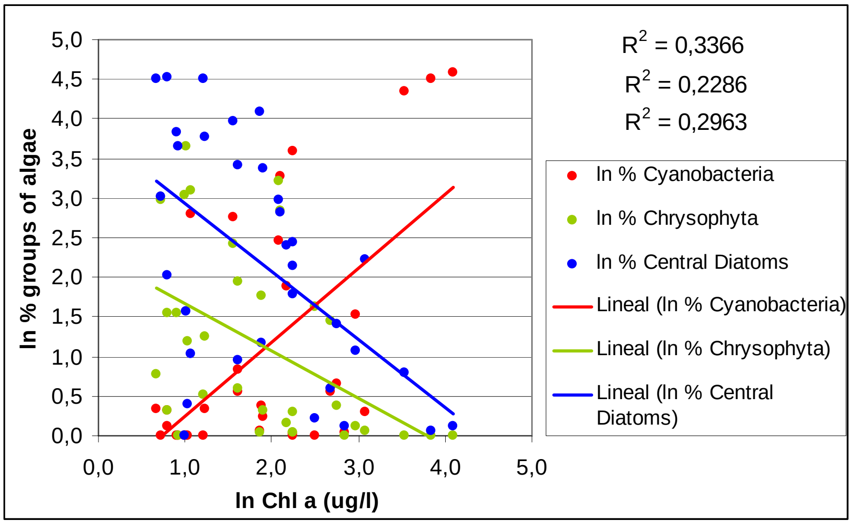


Figure D-8-3a: Relationship between Chl a and groups of algae(linear regression).

If the method of nonparametric regression is applied to study the variations of the percentage of each group of algae with the eutrophication, it can be seen that:

- Cyanobacteria fitting grows very quickly at around 14 µg/l of chlorophyll;
- Chrysophyta and central diatoms start decreasing at around 3.5 and 5 µg/l of chlorophyll;
- This would mean that this method gives a range wider than the precedent for the G/M boundary of Spanish reservoirs (Mediterranean reservoirs).

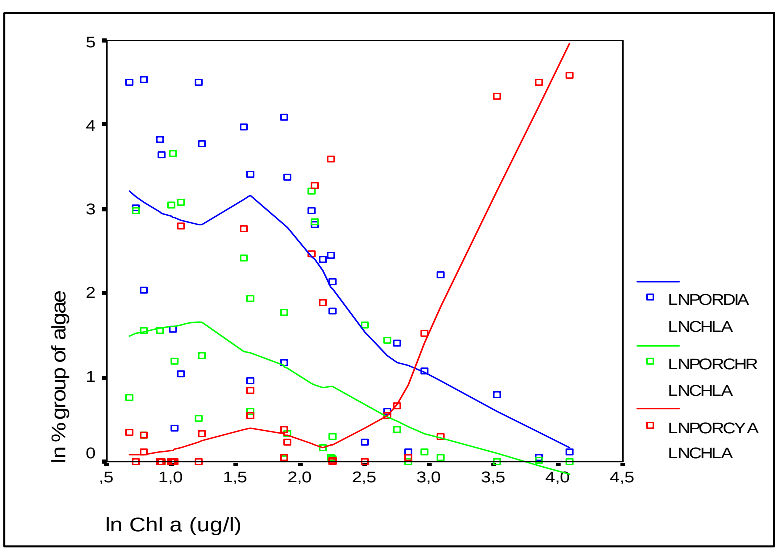


Figure D-8-3b: Relationship between Chl a and groups of algae(non parametric regression)

8.3.2. Relationships between chlorophyll *a* and dissolved oxygen at the bottom

The same method (nonparametric regression) was applied in order to study how the dissolved oxygen (from 20 m depth to the bottom) varies with eutrophication. The slope of the curve abruptly changes at chlorophyll concentration of 5-13 µg/l.

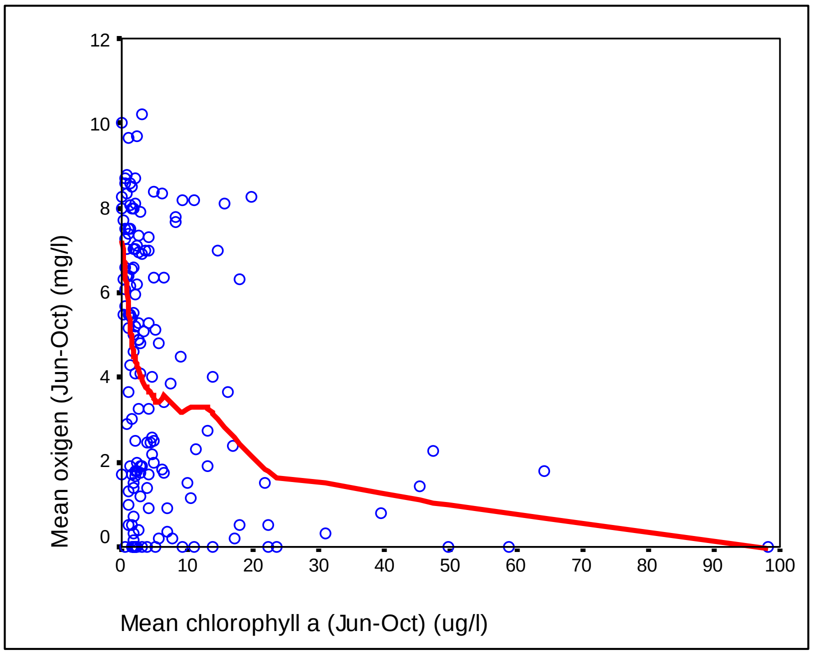


Figure D-8-3c: Relashionship between Clh a and oxygen at the bottom

8.3.3. Relationships between chlorophyll *a* and Secchi depth

- The same change in the slope of the curve happens at chlorophyll *a* concentration of around 7 µg/l if we consider the variation of Secchi depth along the eutrophication gradient (Spanish data, calc and "siliceous wet" reservoirs)
- Based on a dataset from Portuguese and Spanish "siliceous wet" reservoirs (April to September), an inflexion in the Secchi depth *vs* Chlorophyll *a* curve was observed between 4 and 12 µg/l, with a mean inflexion value of 8 µg/l.
- These values are coherent with the range established in the paragraph 3.2.4

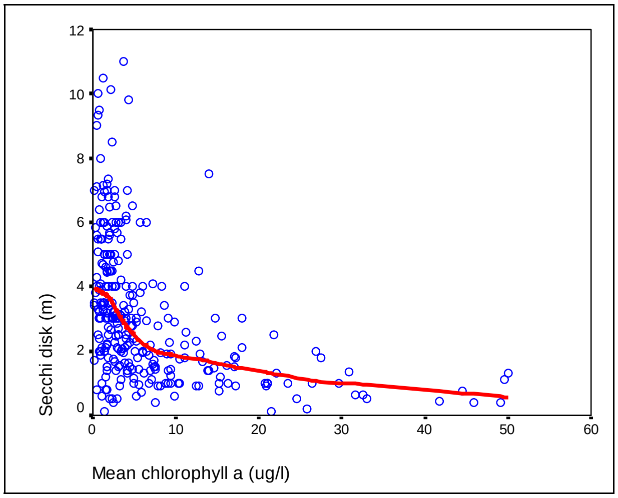


Figure D-8-3d: Relationship between Chl a and Secchi depth with Spanish data, calcareous and siliceous types

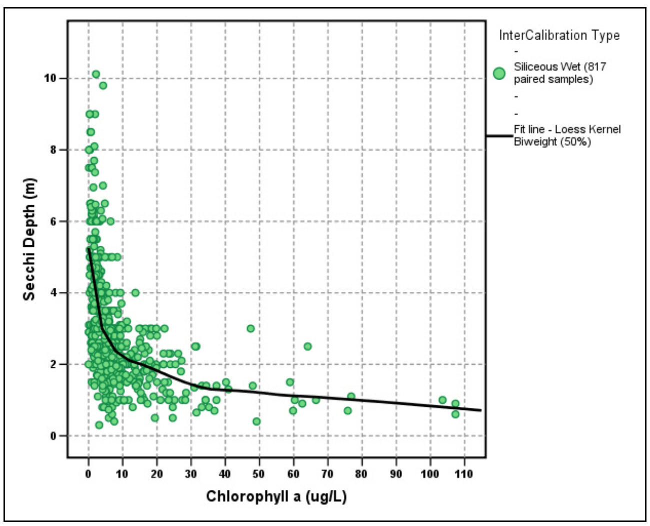


Figure D-8-3e: Relationship between Chl a and Secchi depth with Spanish and Portuguese data for the Siliceous Wet type

8.3.4 Validation of Biovolume (based on Spanish and Italian data)

Regressions between biovolume and percentage of group of indicator algae have been made. The best fitting found was to transform both biovolume and percentage of group of algae in a logarithmic way and to calculate linear regressions. The regressions between Biovolume and Cyanobacteria and Biovolume and Chysophytes meet all the statistical criteria required for this type of analysis. The regression between Biovolume and Central diatoms does not meet the statistical criteria (residuals were not normal and R^2 was very low), so this validation was made just with two groups of algae.

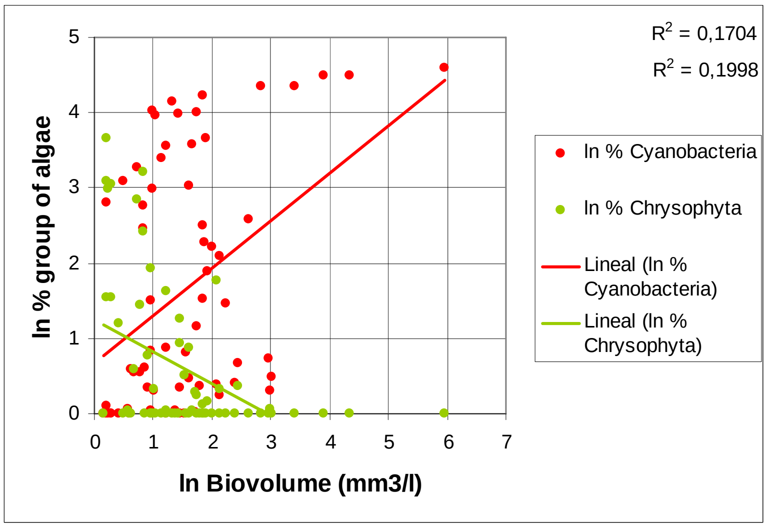


Figure D-8-3f: Relationship between biovolume and group of algae

The percentage of cyanobacteria increased and the percentage of chrysophyte decreased as eutrophication increased. The levels of biovolume at which the regression lines crossed is 1,82 mm^3/l µg/l (crossing point between cyanobacteria and chrysophytes). This value is inside the range of biovolume calculated just with Spanish reservoirs (see above) and is very similar to the results of G/M boundary of the IC exercise.

Conclusions:
With all these results in mind, we can give a broad range for the G/M chlorophyll boundary value for the Spanish reservoirs, and a more probable narrower range within it:

5 – 6.7 – 12.2 – 14 µg/l

According to these three approaches, it can be concluded that the G/M boundary value obtained in the calcareous type could be result strict in some cases

ANNEX D – Part 9 Calculation of normalised EQRs

Two lineal equations are considered for EQR normalisation:

- EQR 0 value corresponds to the converted EQR 0;
- EQR G/M boundary value corresponds to 0.6;
- EQR 1 value corresponds to the converted EQR 1.

Example: Chlorophyll for the calcareous Mediterranean reservoirs included in the IC exercise (Fig D-9)

- EQR 0 value corresponds to the converted EQR 0;
- EQR G/M boundary value 0.43 corresponds to 0.6;
- EQR 1 value corresponds to the converted EQR

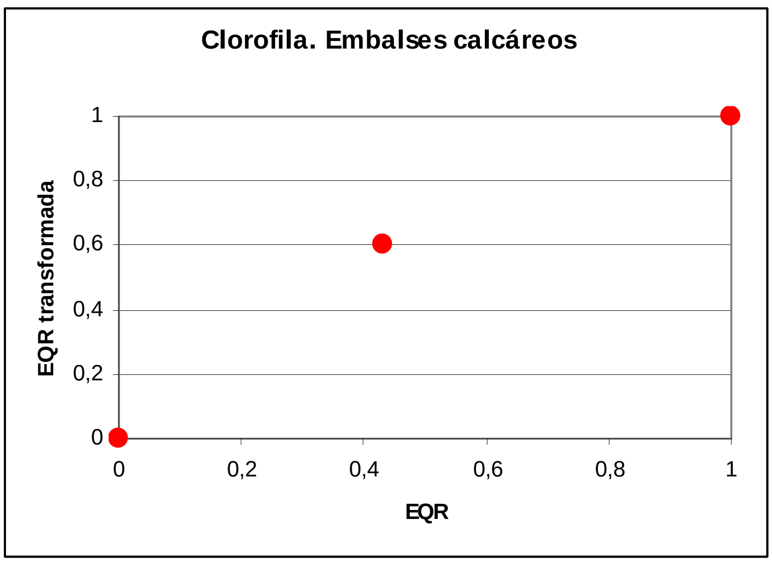


Figure D – 9. Normalization of Chlorophyll EQRs for the calcareous Mediterranean reservoirs

Two lineal equations describe normalisation of EQRs for calcareous reservoirs:

- Where $x>0{,}43$, $y = 0{,}7018x + 0{,}2982$;
- Where $x<0{,}43$, $y = 1{,}3953x$.

Applying the same approach to the other metrics, the equations for normalize the EQR values are as follows, based on the data collected in 2005 for all the Mediterranean reservoirs included in the IC exercise:

Table D-9. Normalization of Chlorophyll and biovolume EQRs for Mediterranean reservoirs

		Siliceous “wet” type	Calcareous type
Chlorophyll	x>0,21	y = 0,5063x + 0,4937	
	x<0,21	y = 2,8571x	
	x>0,43		y = 0,7018x + 0,2982
	x<0,43		y = 1,3953x
Biovolume	x>0,19	y = 0,4938x + 0,5062	
	x<0,19	y = 3,1579x	
	x>0,36		y = 0,625x + 0,375
	x<0,36		y = 1,6667x

Based on the above equations, it is possible to calculate, in the respective metric units, all quality class boundary values for all biological metrics of concern.

ANNEX D – Part 10 - Correspondence of the intercalibration types to national types.

Table D-10a. Correspondence of IC reservoirs to Spanish national typology

IC TYPE MED-GIG	NAME		COUNTRY	NATIONAL TYPOLOGY (proposal)	DESCRIPTION
Siliceous wet	AGUEDA		Spain	1	Siliceous, wet, catchment area < 1000 km2
Siliceous wet	ALBARELLOS		Spain	1	
Siliceous wet	BAO		Spain	1	
Siliceous wet	LA RIBEIRA	Reference	Spain	1	
Siliceous wet	VALPARAISO		Spain	1	
Siliceous wet	VILASOUTO		Spain	1	
Siliceous wet	AGAVANZAL		Spain	3	Siliceous, wet, catchment area > 1000 km2
Siliceous wet	PORTODEMOUROS		Spain	3	
Siliceous wet	SALIME	Reference	Spain	3	
Siliceous wet	SAN ESTEBAN		Spain	3	
Siliceous arid	YEGUAS, EL		Spain	4	Siliceous, arid, catchment area < 1000 km3
Siliceous arid	GUADALMELLATO		Spain	5	Siliceous, arid, catchment area > 1000 km2
Calcareous	EUGUI	Reference	Spain	7	Calcareous, wet, catchment area < 1000 km2
Calcareous	PÁLMACES		Spain	7	
Calcareous	SAU		Spain	9	Calcareous, wet, catchment area > 1000 km2
Calcareous	TALARN		Spain	9	
Calcareous	GUADALEST		Spain	10	Calcareous, arid, catchment area < 1000 km2
Calcareous	ARENÓS	Reference	Spain	11	Calcareous, arid, catchment area > 1000 km2
Calcareous	LORIGUILLA		Spain	11	
Calcareous	NEGRATÍN		Spain	11	
Calcareous	ALDEADÁVILA		Spain	12	Calcareous, arid, catchment area > 25000 km2

Table D-10b. Correspondence of IC reservoirs to Portugese national typology

IC TYPE MED-GIG	NAME		COUNTRY	NATIONAL RESERVOIRS TYPOLOGY
Siliceous wet	AGUIEIRA		Portugal	Reservoirs are part of Cold Waters
Siliceous wet	ALTO LINDOSO		Portugal	
Siliceous wet	CANICADA		Portugal	
Siliceous wet	CASTELO DE BODE	Reference	Portugal	
Siliceous wet	FRONHAS		Portugal	
Siliceous wet	VILARINHO DAS FURNAS	Reference	Portugal	
Siliceous arid	MARANHAO		Portugal	Reservoirs are part of Warm Waters
Siliceous arid	MONTE DA ROCHA		Portugal	

Table D-10c. Correspondence of IC reservoirs to French national typology

Gig Type		lake name		Country	HER1	geol	temp. (France)	temp. (world)	precipit.	Zmax	Zmean	National Type
Siliceous	wet	Roujanel	IC affected	France	8	gran	10,7085	8,1408	890,3			A10
Siliceous	wet	Calacuccia (de -)	IC affected	France	16	gran	NA	9,2327	918,5	68	19	A10
Siliceous	wet	Tolla	IC affected	France	16	gran	NA	12,1893	755,1	88	30	A10
Siliceous	wet	Salagou	IC affected	France	8	gran	13,8295	12,6578	741,2	51,5	15	A12
Siliceous	wet	Caramany (de -)	IC affected	France	6	hetero	14,6495	12,9087	741,6	43	14	A12
Siliceous	wet	Codole (de -)	IC affected	France	16	gran	NA	13,9821	793	25	9	A12
Siliceous	arid	Alesani (de l'-)	IC affected	France	16	gran	NA	14,0995	689,3	60	18	A12
Siliceous	arid	Verne (de la -)	IC affected	France	6	hetero	15,4135	14,2528	789,8		14	A12
Siliceous	arid	Villeneuve de la Raho (de -)	IC affected	France	6	hetero	16,45	14,6951	615,7	11	9	A11
Siliceous	arid	Teppe Rosse (de -)	IC affected	France	16	gran	NA	16,0032	607,9	15	7	A8
Calcareous		Avène (d'-)	IC affected	France	8	gran	12,1405	10,5239	863,6	57	17	A10
Calcareous		Quinson	IC affected	France	6	hetero	12,81	12,068	791,5	50	10	A3
Calcareous		**Sainte Croix**	**IC exercise**	**France**	**6**	**hetero**	**12,8555**	**10,7463**	**874,2**	**83**	**35**	**A3**
Calcareous		Esparron	IC affected	France	6	hetero	12,997	12,2344	755,7	54	24	A3
Calcareous		Bimont (du -)	IC affected	France	6	hetero	13,338	12,7034	716,7	65	27	A8
Calcareous		Réaltor (du -)	IC affected	France	6	hetero	14,487	13,5583	606,6	10	2	A8
Calcareous		**Saint Cassien**	**IC exercise (ref)**	**France**	**6**	**hetero**	**15,312**	**13,6639**	**828,4**	**50**	**16**	**A12**
Calcareous		Carcès (de -)	IC affected	France	6	hetero	14,8975	13,9582	756,3	43	14	A12

Table D-10d. Correspondence of IC reservoirs to Romanian national typology

IC TYPE MED-GIG	NAME		COUNTRY	NATIONAL RESERVOIRS TYPOLOGY (proposal)	GEOLOGY TYPE CATCHMENTS AREA
Siliceous wet	BRADISOR		Romania	ROLA 08	Siliceous, catchments area 775 km2, altitude, 458 m
Siliceous wet	COLIBITA		Romania	ROLA 08	Siliceous, catchments area 113 km2, altitude, 797 m
Siliceous wet	VIDRARU		Romania	ROLA 12	Siliceous, catchments area 219 km2, altitude, 830 m
Calcareous	BEZID	-	Romania	ROLA 10	Siliceous, catchments area 150 km2, altitude 366 m
Calcareous	IZVORUL MUNTELUI	-	Romania	ROLA 08	Siliceous-Calcareous catchment area 4078 km2, altitude 516 m
Calcareous	PALTINU		Romania	ROLA 08	Siliceous-Calcareous catchments area 279 km2, altitude, 652 m
Calcareous	SACELE (Tarlung)	Reference	Romania	ROLA 06	Calcareous catchment area 169 km2, altitude 739,5 m
Calcareous	SIRIU		Romania	ROLA 08	Siliceous, catchments area 534 km2, altitude 589 m

Table D-10e. Correspondence of IC reservoirs to Italian national typology

IC TYPE MED-GIG	COUNTRY	NATIONAL RESERVOIRS TYPOLOGY
Siliceous wet	Italy	ME-5
Calcareous	Italy	ME-4

Annex E – Northern GIG

Annex E – Part 1 - National classification methods

Norway:
The existing national classification method (SFT 1997) is related to the OECD-scheme, adapted to Norwegian conditions. This is not type-specific, and do no relate to different reference conditions in different lake types, although a guidance on natural conditions for broad lakes types (not NGIG types) exist (Bratli 1995), and suggest natural water quality class based on chlorophyll and total phosphorus for humic lakes and lowland lakes.

In 2003, the development of a more WFD-compliant classification system was initiated, through the project BIOKLASS, proposing possible chlorophyll boundaries as well as boundaries for % cyanophytes and % chrysophytes, based on new analyses of national monitoring datasets (Lyche-Solheim et al. 2004). This new classification system will be adjusted according to the results from the NGIG work. For most Norwegian lake types, the minimum values within the range for each lake type will be used as national boundaries, because most Norwegian lakes probably are best represented by the lower end of the range in all the typology factors (low alkalinity, low colour and lower retention times), see **Annex E – Part 7**

Sweden:
The national classification method for phytoplankton is incorporated in regulations from the Swedish Environmental Protection Agency (NFS 2008:1)

For the intercalibration of chlorophyll *a* (chl *a*) Sweden has used the national classification system for chl *a*. As there are limited number of chl *a*-data in Sweden, a correlation between chl *a* and the biovolume has been made from the significantly larger dataset of biovolume. The suggested boundaries from those calculations are supported by the available chl *a* data.

More information is available in guidance document *Handbok 2007:4* from the Swedish Environmental Protection Agency and in background reports of Willén (2007) and Sonesten (2007).

Finland:

The national classification methods are under development. This was started in early 2000s, firstly regarding typology (e.g. Pilke *et al* 2002). Data sets have been compiled for defining reference status and classification and are still developed further. A review of the basis and state-of-the-art of various quality elements was compiled in year 2005 and published this year (Vuori *et al* 2006)- The assessment methods will be finalised for several elements and most national types. Chlorophyll classification is based on statistical analysis of existing sites for most national types.

UK:

The UK has no current national classification method and a new method is currently being developed. The metric for phytoplankton biomass will be mean annual chlorophyll a concentration. The method has been approved by the UK as a national system, lake specific reference chlorophyll a concentrations are predicted from reference total phosphorus using type specific regression equations provided by the REBECCA project (Phillips et al 2008) or from data collated by Central GIG. The H/G and G/M boundaries for each lake will then be determined using the type specific EQR values agreed by the GIGs. In this way each lake will have a unique reference and boundary value, but all will fall within the range defined by the GIG for the particular lake type. A lake specific, rather than a type specific approach is used as the UK believes that there is a continuum of lake conditions which cannot be adequately reflected by a simple typology.

The UK method will determine current chlorophyll concentration using regular sampling and will summarize condition using the annual average concentration. The annual average is used as many lakes in UK have significant phytoplankton biomass during the winter months. To determine errors, and thus the confidence of the classification, the data will be log transformed (to ensure normal distributions) and the resulting standard error will be used to establish the confidence of the classification. In determining class it is proposed to apply correction factors to reduce errors (of the mean) caused by seasonality and the use of geometric rather than arithmetic means which were used by the GIGs to establish boundaries..

Ireland:

Currently lake status is assessed based on max. annual chlorophyll values using a modified version of the OECD scheme (Toner et al., 2005). This system is likely to be replaced taking the outcome of IC into account. A preliminary phytoplankton tool – multimetric index- was developed under an ERTDI research project (Free et al, 2006 under review), which incorporated chl a as a surrogate for phytoplankton biomass. This has yet to be validated and evaluated against other tools as they become available. There is no other national classification method regarding phytoplankton composition under development. Ireland is awaiting the outcome of the UK SNIFFER funded phytoplankton classification tool, as another potential assessment system .

Annex E – Part 2 - Criteria for selection of reference sites

Table E2. Criteria for selection of reference sites use by the Northern GIG countries

Criteria	Finland	Sweden (Willén, E., 2006; page 10)	Norway	UK	Ireland
Pressure criteria					
Agriculture[1)]	In data sets at present mainly ≤ 10 %	<10% of catchment	<5%	< 10% arable or intensive grazing	
Point sources	No major point sources	No major point sources	No major point sources		No major point sources
Urbanised area		<0.1% of catchment			No urbanisation ie villages/ towns <1%
Population density			< 5 p.e./km2	<10 p.e./km2	
Other pressures		Annual mean ≥pH 6, For pH < 6 a correction factor for natural acidity has been used		No fish farms	No intensive use of lake ie abstractions
Impact criteria					
Total P		<10 ug/L, or higher if high colour	<11 ug/L, or higher if high colour		
Chlorophyll			< 4 ug/L (low alk. clear types) (<6 for other types)		
Biovolume phytoplankton					
Paleodata				No significant change in diatom community compared to bottom of sediment core (if available	Selection of some sites subsequently evaluated from paleodata on diatoms
Expert judgement	Yes, partly, based on available information of	no	yes	Yes	yes

	the site				

1) Agriculture: This is mainly judged from visual observation of GIS land use data.

The reference lakes and their chlorophyll and phosphorus mean values are given in the NGIG REBECCA-data.xls file, which is available at the IC Circa web-site (NGIG lakes folder). The file is based on the REBECCA database, and has been compiled by Geoff Phillips, UK.

When calculating the mean TP and chla for the reference lakes, many Irish reference sites were omitted because the sampling frequency was too low. There are Irish reference lakes for types LN1, LN2, LN3a and LN8a.

Additional national datasets from Sweden and Finland are also available at the same circa web-site

Annex E – Part 3 - Need of range of reference values

Further specification of rationale for the results of chlorophyll boundaries in the N GIG lakes (need of range of reference values)

1) Varying geographical conditions inside the N GIG area.
   - In Finland and in eastern parts of Middle and Northern Sweden the bedrock is very old, whereas in Norway the bedrock is mostly younger. This has implications for the water quality.
   - High relief in the western part, low in the eastern part. This difference influences significantly the conditions in surface waters.
   - Overall retention of water in river basins is longer in the eastern than in the western parts of the NGIG area. Retention time of lakes varies a lot, mostly due to topographic and climatic differences. Norwegian lakes have, for example, generally shorter retention time than lakes in Sweden and Finland.
   - Coverage of mires is significant in the eastern part, especially to the east and north of the Gulf of Bothnia in Finland and in parts of Northern Sweden.
2) Climate
   - The duration of winter varies. In the Scandinavian countries the period of ice coverage is usually from 4 to more than 6 months, whereas in Great Britain from 0-1 month. Thus, the growing season in the north is usually from May to September/October, in the southern parts longer. Further work is needed to establish the differences between summary data based on growing season means in different parts of the GIG.
   - In all the Scandinavian countries the north-south climate gradient affects the growing season to a large extent. Lakes in the Northern boreal areas have shorter growing seasons and lower mean water temperatures during the growth season. L-N5 can thus also be used for lowland lakes in high latitudes (Northern part of Scandinavia). Reference lakes in this type are mainly found in high Northern

latitudes. Mid-altitude lakes (between 200-400m) in the Southernmost latitudes of the NGIG should rather use the LN2a values for classification.

3) Monitoring practises
   - Sampling depths vary significantly, from an integrated sample of 0 – 2 meters to sampling of an integrated sample in the whole epilimnion. This has some influence on the chlorophyll data as well as on the biovolume and the taxonomic composition.
   - Because of varying duration of the growing season also the times of sampling vary. In Sweden and Finland a part of the chlorophyll data and most of the phytoplankton taxonomic composition data are from mid or late summer and not the full growing season, which might affect the values.
4) Because of geographical and climatic conditions the basic water chemistry is significantly different in the eastern and western part, e.g. alkalinity and humic content of water even in same IC type.
5) In many humic lakes (LN-3,6,8) in Finland and Sweden the raphidophycean alga *Gonyostomum semen* is common. Probably due to its mixotrophic abilities and vertical migration, which enables it to take up nutrients and organic carbon from the more nutrient rich bottom waters, this alga can build up high biomass and chlorophyll levels even in reference lakes. By using only chlorophyll measurements, it will not be possible to tell whether the lake is in high/good status, but dominated by *Gonyostomum,* or whether it is in poor or bad status. These chlorophyll boundaries are therefore not representative for lakes with dominance of *Gonyostomum*. If high chlorophyll content occurs in lakes, otherwise expected to be in good status, the taxonomic composition of the phytoplankton should be investigated, to check whether the high chlorophyll is due to dominance of Gonyostomum or not (cf. also Annex E – Part 7, type L-N3a .

It should be emphasised that the chlorophyll reference values and class boundaries for N GIG represent an aggregated value for a lake or a water body and for the whole season. Individual chlorophyll values from occasional observations or restricted parts of a lake cannot, without evaluation, be used in assessment of status.

Annex E – Part 4 – Conceptual model of degradation of phytoplankton BQE along the eutrophication gradient

Table E4a. Degradation of NGIG clearwater lakes (LN1, LN2a, LN2b, LN5) upon eutrophication

The following descriptions were developed as expert judgement by the GIG to assist in determining boundary values. As the GIG have only been able to agree on specific boundary criteria for Chlorophyll a, these descriptions would need to be re-considered during the intercalibraton of other metrics. They should not be taken as an agreed desciption which would subsequently determine boundaries for these metrics.

INDICATOR	CLASSIFICATION				
	HIGH	GOOD	MODERATE	POOR	BAD
Taxonomic Composition Phytoplankton	Proportion of reference taxa exceeds the proportion of impact taxa. Dominance of reference taxa, such as chrysophytes, Impacted taxa, such as Cyanobacteria, are in low abundance	Significant decrease in relative biomass of sensitive taxa, but they are still present in higher abundance than impact taxa. Early warning indicators, such as pennate diatoms, become apparent in the phytoplankton community	Large changes occurring in the phytoplankton community: The sensitive taxa are still present, but in low abundance, the early warning indicators are often dominant, whereas the impact indicators increase to relatively high abundance	Very low proportion of sensitive phytoplankton species. Early warning taxa are replaced by impact taxa, which now dominates the phytoplankton community	Phytoplankton totally dominated by impact taxa producing harmful algal blooms. Sensitive species less than 1 percent of total biomass.
Biomass Phytoplankton	Concentration of chlorophyll is low.	Increase is not sufficient to cause more than slight changes in depth distribution of reference taxa of submerged macrophyte (most sensitive for type). No increase in oxygen depletion.	Sufficient to restrict depth distribution of submerged macrophytes Sufficient biomass to reduce oxygen during periods of stratification. Could have implications for most sensitive fish species.	Phytoplankton biomass sufficient to inhibit growth of sensitive submerged macrophytes (isoetids). Phytoplankton biomass is high enough to cause oxygen depletion in surface sediments and bottom waters, and sufficient to cause detrimental impacts on fish.	Macrophytes disappear due to light inhibition. Oxygen depletion common in bottom waters Fish kills may occur

Table E4b Degradation of NGIG humic lakes (LN3a, 6a, 8a) upon eutrophication

The following descriptions were developed as expert judgement by the GIG to assist in determining boundary values. As the GIG have only been able to agree on specific boundary criteria for Chlorophyll a, these descriptions would need to be re-considered during the intercalibraton of other metrics. They should not be taken as an agreed desciption which would subsequently determine boundaries for these metrics.

INDICATOR	CLASSIFICATION				
	HIGH	GOOD	MODERATE	POOR	BAD
Taxonomic Composition Phytoplankton	There are very minor effects of human impact on phytoplankton diversity, reference taxa vs. impact taxa, their abundance and biomass. Dominance of reference taxa.. Impact taxa in low abundance.	A significant decrease in relative biomass of reference taxa, but they are still prominent compared to impact taxa. Note: Impact taxa are a mixture of cyanobacteria, diatoms, green algae, and euglenoids	Relative proportion of impact taxa prominent. REF taxa relatively low in abundance, but still occur. Note: Impact taxa are a mixture of cyanobacteria diatoms, green algae, and euglenoids	Proportion of impact taxa very prominent and low abundance of REF phytoplankton taxa.	Phytoplankton totally dominated by impact taxa. REF species in very low percentages of biomass. No desmids.
Biomass Phytoplankton	Biomass and concentration of chlorophyll is low, corresponding to type-specific reference conditions. However, the biomass is usually higher than in high status clear-water lakes. Oxygen-depletion in the bottom water may occur, but then as a natural condition (due to the humic substances)	Increase in biomass is noticeable, but does not cause significant aggravation of the type-specific oxygen depletion in the bottom water , nor to cause other negative impacts on other biota.	Biomass is sufficient to cause some impacts on other biota (e.g. on depth distribution of submerged macrophytes), and significantly aggravates the oxygen depletion, having negative impact on bottom fauna and fish	Phytoplankton biomass is high enough to cause non-type-specific severe anoxia in profundal sediments and bottom waters and cause enhanced internal P-loading. Sufficient to largely inhibit growth of submerged macrophytes. and to cause detrimental impacts on fish.	Phytoplankton biomass is so high that macrophytes disappear due to light inhibition and widespread non-type-specific anoxia of the deeper water layers.
Incidence of Algal Blooms (meaning obvious aggregations of phytoplankton, typically cyanobacteria)	Nuisance blooms never or rarely reported by public. If present, short lived (seen on calm days) and minor in extent.	Blooms may be present but mostly only minor in extent compared to reference conditions.	Persistent nuisance blooms may occur given suitable conditions. Blooms may last for more than one week (duration may be weeks).	Persistent nuisance blooms of harmful algae for > 1 month during summer. Down wind shore likely to have marked aggregation of scums.	Nuisance blooms extensive, reports of death of other animals attributed to algal toxins.

Annex E – Part 5
Taxonomic indicator groups and Plots with response curves for all lake types:

This annex contains:
- Taxonomic indicator groups of phytoplankton for clearwater lakes and for humic lakes (based on REBECCA data)
- Plots with response curves for all NGIG types, and suggested boundaries.

1. Taxonomic indicator groups of phytoplankton (based on REBECCA data):
Low and Moderate Alkalinity Clearwater lakes (not applicable to high alkalinity lakes):

Class level indicator groups have been selected for these lake types, these are based on samples mainly from Scandinavian countries and it remains to be confirmed if all of the findings can be applied to countries in other eco-regions. Specific examples of this are noted below.

Reference taxa:
- **Chrysophytes minus *Synura* and *Uroglena*;**
- The chrysophytes are normally found to dominate in oligotrophic lakes in the Nordic countries, and are known to be mixotrophic, able to supplement their nutrition by feeding on bacteria;
- They do not seem to be so common in UK and Ireland, for reasons not known (maybe related to temperature), so this metric does not apply to all countries in the NGIG, only to Norway, Sweden and Finland;
- The two genera *Synura* and *Uroglena* have been subtracted before calculating the relative biomass of chrysophytes, because these taxa normally occur more in the middle of the eutrophication gradient and not so much in the oligotrophic clear water lakes. *Uroglena* may however occur in some reference lakes in late summer, according to experience in Sweden and Finland (Willén and Lepistö pers. comm.)

Early warning taxa:
- Pennate diatoms are used as early warning indicators in clearwater lakes, since this group of phytoplankton taxa often is the first symptom of eutrophication in this lake type during spring and early summer.
- This is especially relevant for deep lakes, but also in shallow lakes.

Impact taxa:
- Cyanobacteria excluding Chroococcales, but including *Microcystis*;
- Most Cyanobacteria (bluegreens) show positive relationship with eutrophication in NGIG clearwater lakes, except the taxa belonging to the Chroococcales (*Merismopedia, Aphanocapsa, Aphanotece* and others);
- *Microcystis* is clearly an impact indicator, so although it belongs to the Chroococcales, it has still been included among the impact Cyanobacteria in this analysis.

The lists below show the different genera included in the three indicator groups:

Indicator taxa (class level) for clearwater lakes

Ref. group: Chrysophytes (minus Uroglena, Synura)

class	genus
Chrysophyceae	Bitrichia
Chrysophyceae	Chromulina
Chrysophyceae	Chrysamoeba
Chrysophyceae	Chrysidiastrum
Chrysophyceae	Chrysococcus
Chrysophyceae	Chrysolykos
Chrysophyceae	Chrysosphaera
Chrysophyceae	Chrysosphaerella
Chrysophyceae	Chrysostephanosphaera
Chrysophyceae	Dinobryon
Chrysophyceae	Epipyxis
Chrysophyceae	Hydrurus
Chrysophyceae	Kephyrion
Chrysophyceae	Kephyriopsis
Chrysophyceae	Lepochromulina
Chrysophyceae	Mallomonas
Chrysophyceae	Monas
Chrysophyceae	Monochrysis
Chrysophyceae	Ochromonas
Chrysophyceae	Paraphysomonas
Chrysophyceae	Phaeaster
Chrysophyceae	Pseudokephyrion
Chrysophyceae	Pseudopedinella
Chrysophyceae	Rhizochrysis
Chrysophyceae	sp.
Chrysophyceae	Spiniferomonas
Chrysophyceae	Stichogloea
Chrysophyceae	Stokesiella
Chrysophyceae	Syncrypta

Early warning group: Pennate diatoms

class	order	genus
Bacillariophyceae	Pennales	Achnanthes
Bacillariophyceae	Pennales	Actinella
Bacillariophyceae	Pennales	Amphiprora
Bacillariophyceae	Pennales	Amphora
Bacillariophyceae	Pennales	Asterionella
Bacillariophyceae	Pennales	Ceratoneis
Bacillariophyceae	Pennales	Cocconeis
Bacillariophyceae	Pennales	Cymatopleura
Bacillariophyceae	Pennales	Cymbella
Bacillariophyceae	Pennales	Denticula
Bacillariophyceae	Pennales	Diatoma
Bacillariophyceae	Pennales	Entomoneis
Bacillariophyceae	Pennales	Eunotia
Bacillariophyceae	Pennales	Fragilaria
Bacillariophyceae	Pennales	Frustulia
Bacillariophyceae	Pennales	Gomphonema
Bacillariophyceae	Pennales	Gyrosigma
Bacillariophyceae	Pennales	Meridion
Bacillariophyceae	Pennales	Navicula
Bacillariophyceae	Pennales	Nitzschia
Bacillariophyceae	Pennales	Peronia
Bacillariophyceae	Pennales	Pinnularia
Bacillariophyceae	Pennales	Rhoicosphenia
Bacillariophyceae	Pennales	Rhopalodia
Bacillariophyceae	Pennales	sp.
Bacillariophyceae	Pennales	Stenopterobia
Bacillariophyceae	Pennales	Surirella
Bacillariophyceae	Pennales	Tabellaria

Impact group: Cyanobacteria (minus Croococcales + Microcystis)

class	order	genus
Cyanophyceae	Oscillatoriales	Achroonema
Cyanophyceae	Nostocales	Anabaena
Cyanophyceae	Nostocales	Aphanizomenon
Cyanophyceae	Nostocales	Cylindrospermopsis
Cyanophyceae	Nostocales	Gloeotrichia
Cyanophyceae	Oscillatoriales	Limnothrix
Cyanophyceae	Oscillatoriales	Lyngbya
Cyanophyceae	Oscillatoriales	Oscillatoria
Cyanophyceae	Oscillatoriales	Phormidium
Cyanophyceae	Oscillatoriales	Planktolyngbya
Cyanophyceae	Oscillatoriales	Planktothrix
Cyanophyceae	Oscillatoriales	Pseudanabaena
Cyanophyceae	Nostocales	sp.
Cyanophyceae	Oscillatoriales	sp.
Cyanophyceae	sp.	sp.
Cyanophyceae	Oscillatoriales	Tychonema
Cyanophyceae	Chroococcales	Microcystis
Cyanophyceae	Chroococcales	Woronichinia

Figure E-5-1. Reference, early warning and impacted state indicator for Northern GIG clear water lakes (color , 30 mg Pt/l)

Humic lakes:
In humic lakes, the indicators were found to be different from those in clearwater lakes. The new indicators groups were identified according to the following explanation:

Three groups of indicators at the genus level have been identified from their abundance peak along the pressure gradient:
- Reference taxa (marked in blue);
- Early warning taxa (marked in yellow);
- Impact taxa (marked in red).

Indicators were selected based on following criteria
- Abundant (occurring in minimum 10 lakes or sites within the type);
- Identified in all counties where the lake type is common;
- Well defined peak along pressure gradient.

For each lake type there are two figures:
- one gives the list of indicators for the type;

- the other shows the response curve with confidence limits for the main trend line, as well as the single lake data for each indicator group (small coloured circles)

The boundaries between the indicator groups (indicated with blue and red lines in the indicator list) are based on the overall distribution and change-points seen from a site-score plot.

The low-alkalinity lake types (LN3 and LN6) were found to have different indicators than the moderate alkalinity lake type (LN8).
These different humic lake types are therefore treated separately, and two different sets of indicator groups are used:
- indicator taxa for humic low alkalinity lakes (Figure E-5-2);
- indicator taxa for humic moderate alkalinity lakes (Figure E-5-3);

Indicator taxa for humic low-alkalinity lakes

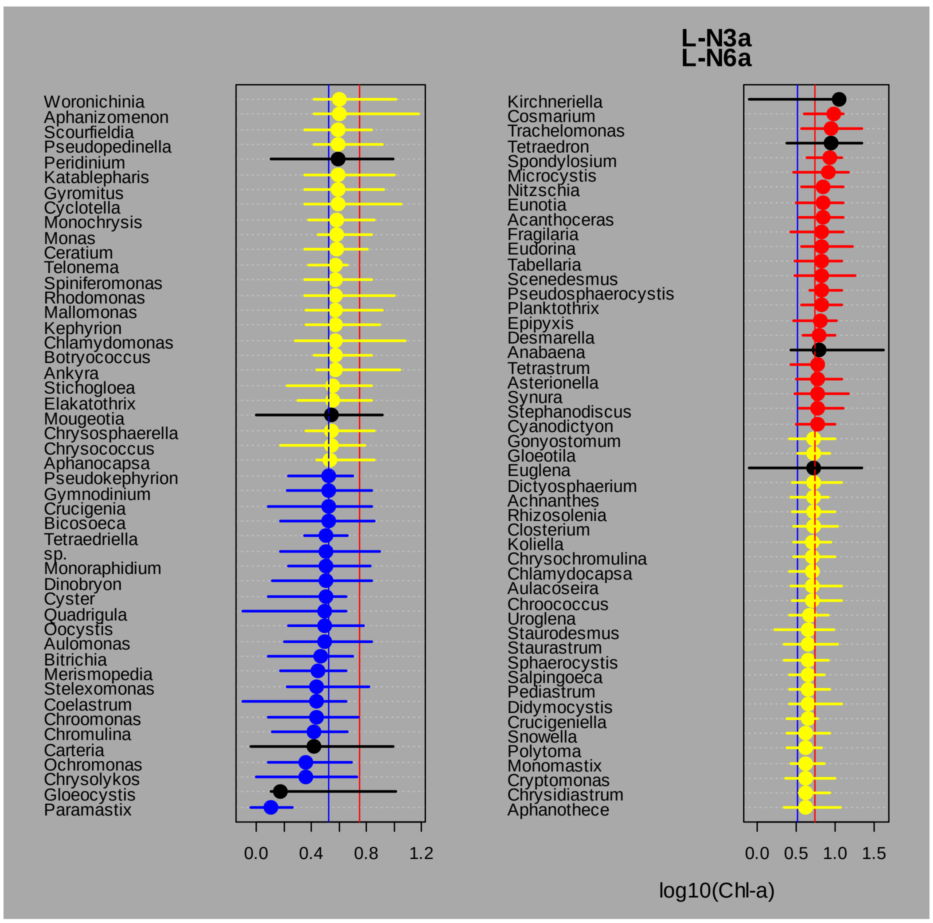


Figure E-5-2. Reference, early warning and impacted state indicator for Northern GIG humic low alkalinity lakes (alkalinity < 0.2 meq/l)

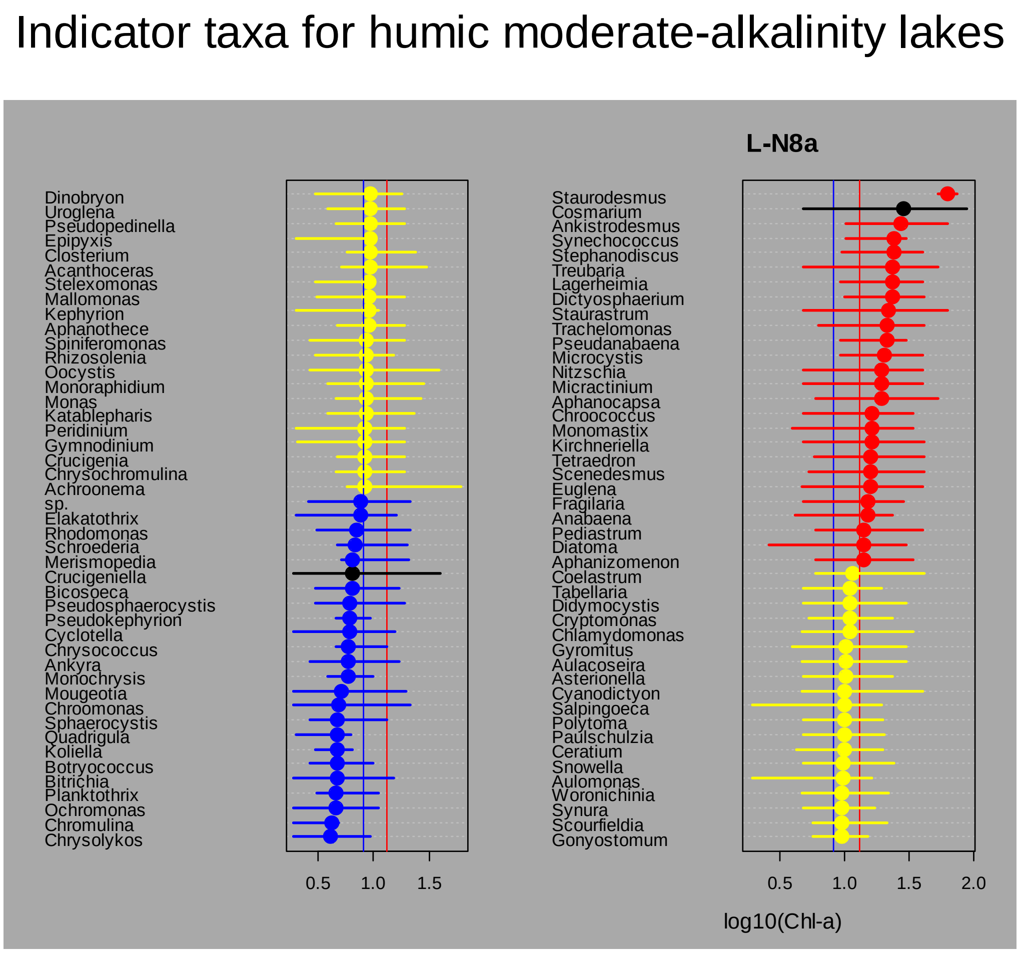


Figure E-5-3. Reference, early warning and impacted state indicator for Northern GIG humic moderate alkalinity lakes (alkalinity 0.2-1 meq/l)

Plots with response curves for all lake types

Phytoplankton taxonomic composition plots reproduced from Ptacnik et al. 2006.:

- All analyses are based on data of the REBECCA phytoplankton composition database;
- Single samples instead of averages for both for the taxonomic indicators were used, as well as for the chlorophyll values;
- The samples are from various years, all July-Sept, except for pennate diatoms, which was calculated from samples May-July.

Figure E-5-4 shown for Northern lake type LN1: Moderate alkalinity, shallow, clearwater lakes. Indicator groups (shown as proportion of total phytoplankton biomass) have been identified from their occurrence along the pressure gradient (total P or chlorophyll gradient) for the different types (see above):

- Reference indicators (blue lines),
- Early warning indicators (yellow lines),
- Impact indicators (red lines). D
- Dashed lines are confidence limits for the curves (not for the single samples).
- The distribution of samples along the gradient are shown at the top and bottom.

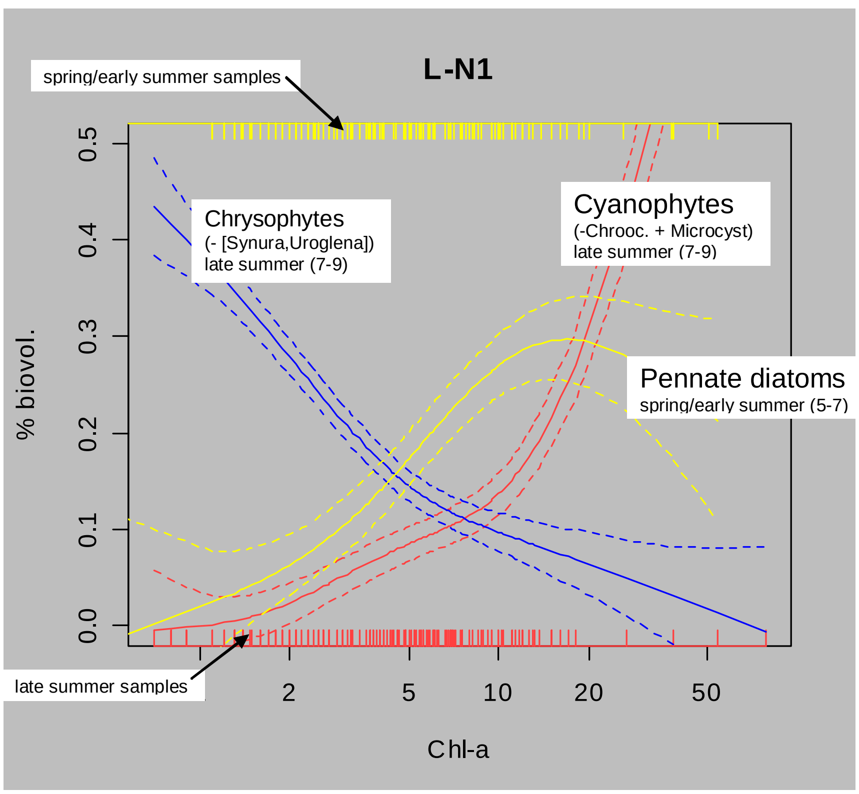


Figure E-5-4. Phytoplankton taxonomic composition response curves for LN1 type

The following plots show also all the single samples used. The y-axis is prolonged to show all samples. The vertical lines are the proposed boundaries, using only the plots: Black for reference value, blue for H/G boundary and green for G/M boundary.

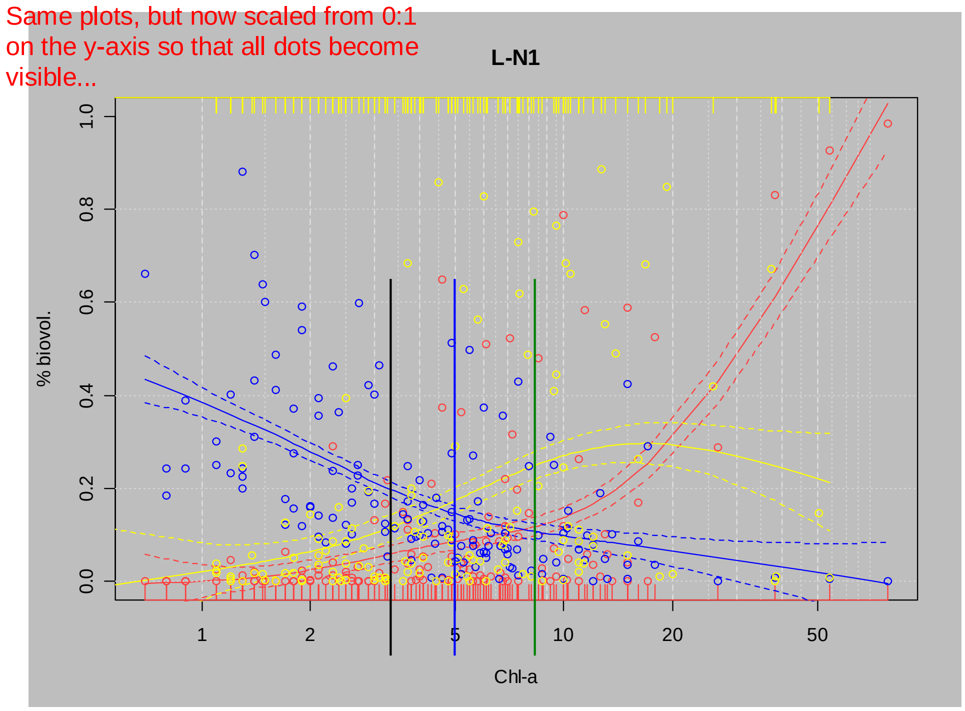


Figure E-5-5. Phytoplankton taxonomic composition response curves for LN1 type_ with proposed class boundaries (black line – reference value, blue line HG boundary, green line – GM boundary)

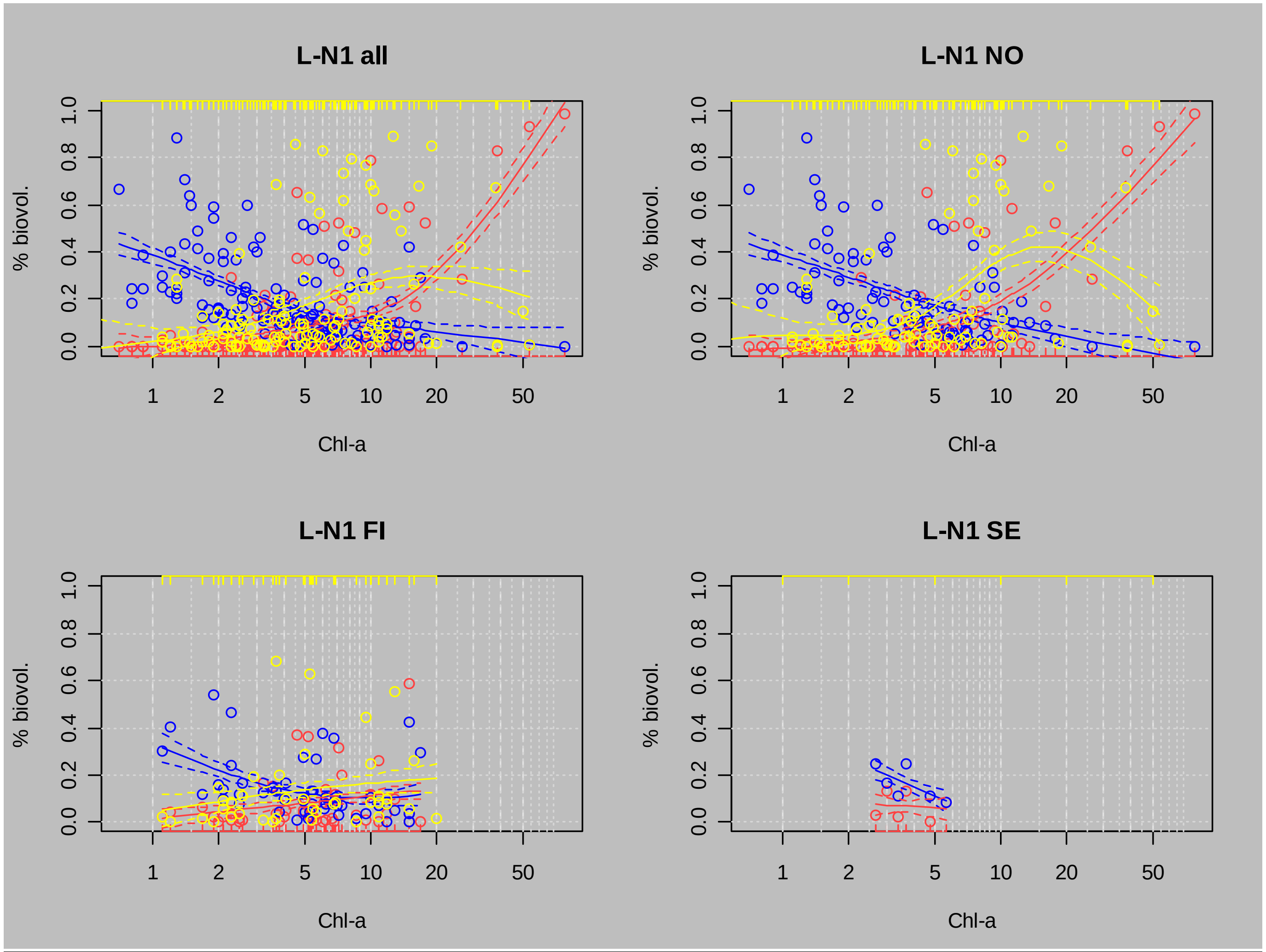


Figure E-5-6. Phytoplankton taxonomic composition response curves for LN1 type (all countries together and countries specific plots)

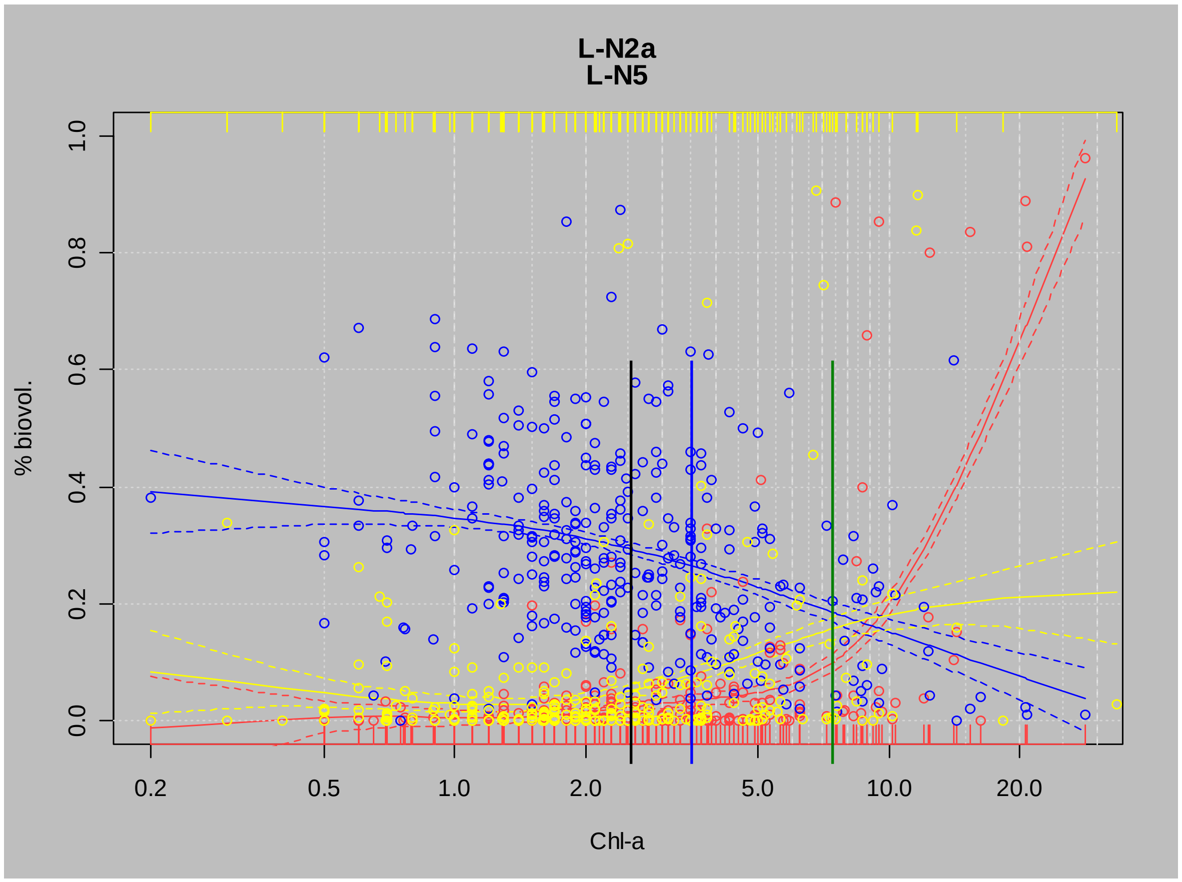


Figure E-5-7. Phytoplankton taxonomic composition response curves for LN2a+LN5 type_ with proposed class boundaries (black line – reference value, blue line HG boundary, green line – GM boundary)

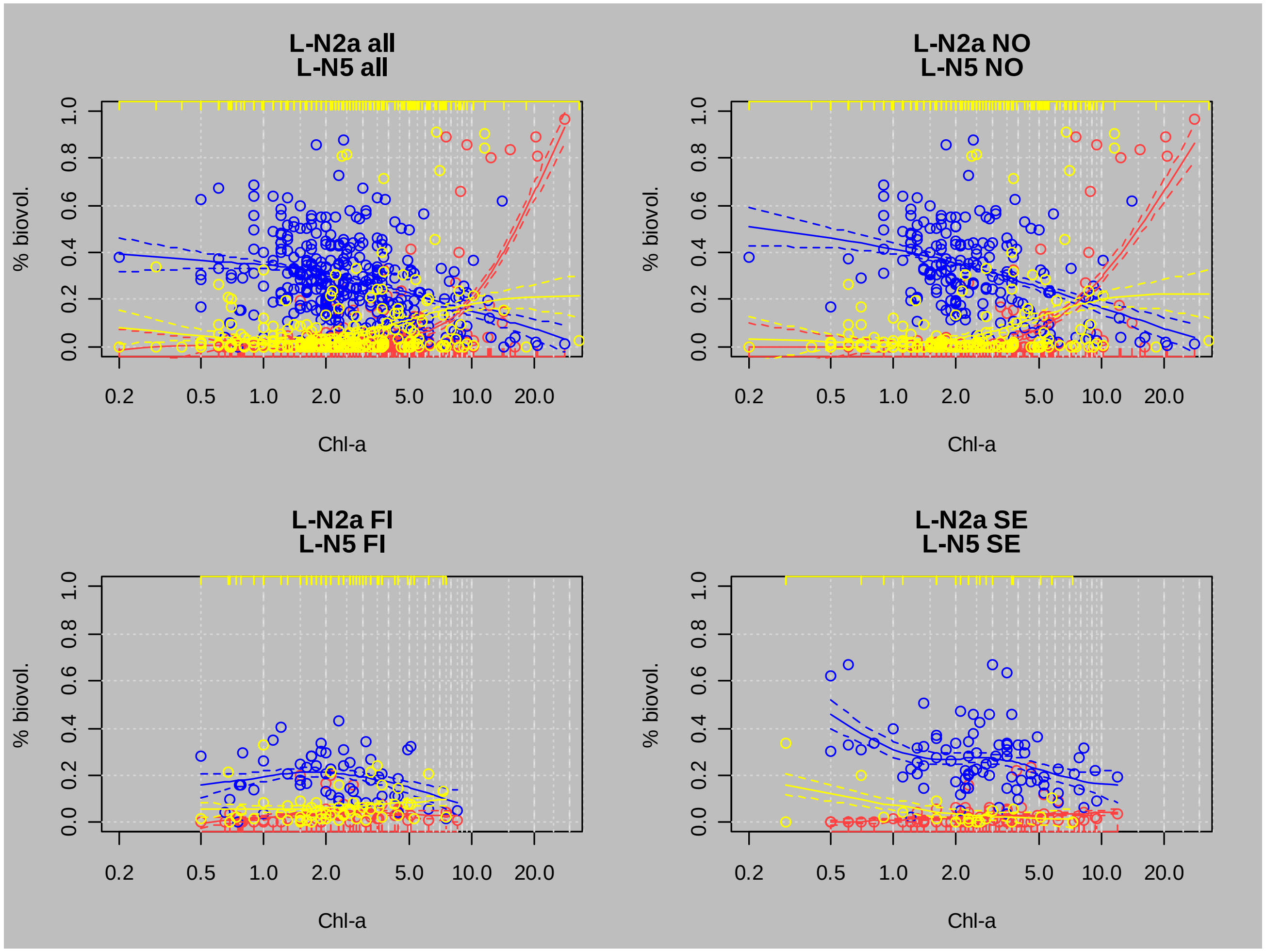


Figure E-5-8. Phytoplankton taxonomic composition response curves for LN2a+LN5 type (all countries together and countries specific plots)

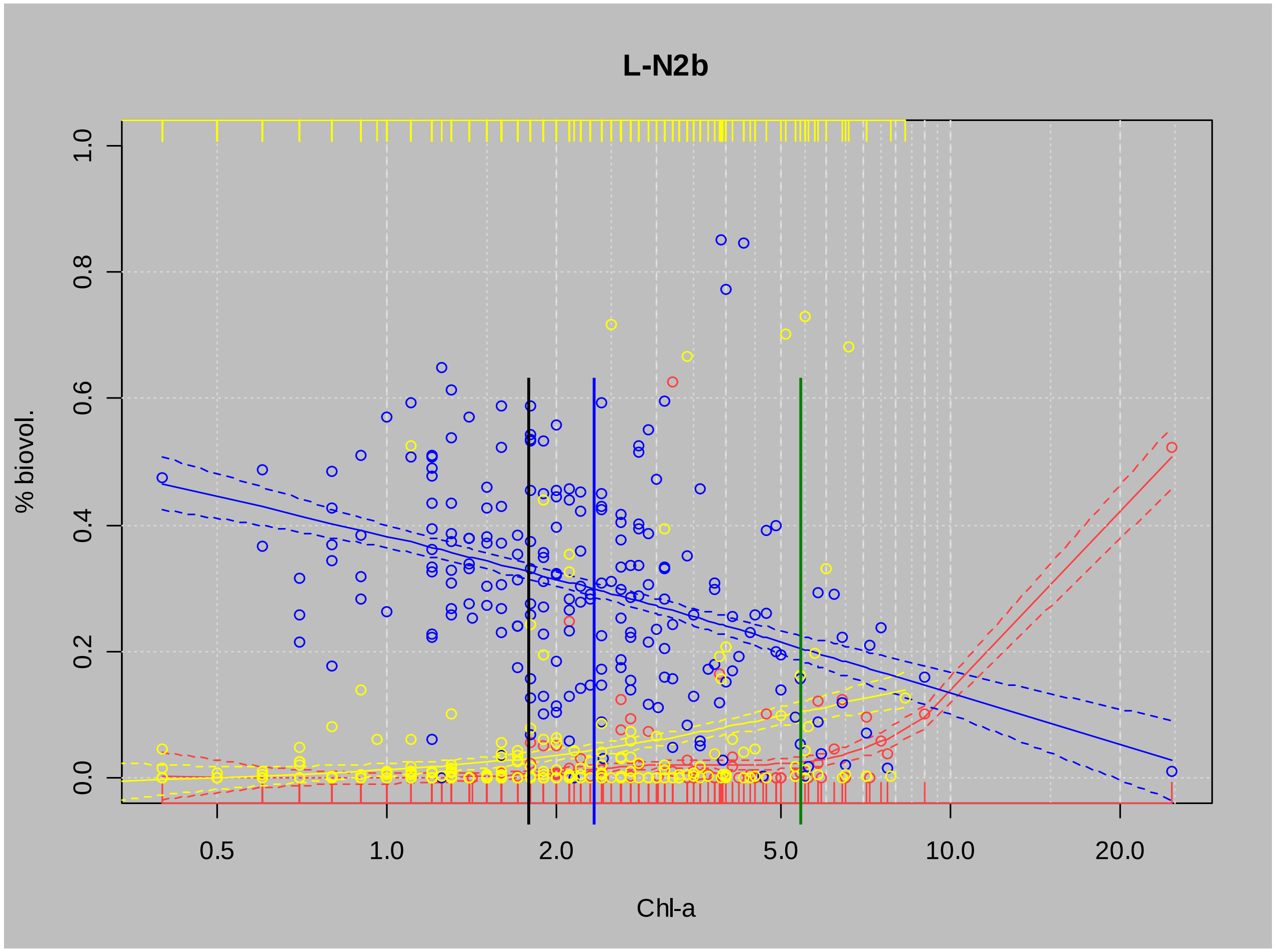


Figure E-5-9. Phytoplankton taxonomic composition response curves for LN2b type (black line – reference value, blue line HG boundary, green line – GM boundary)

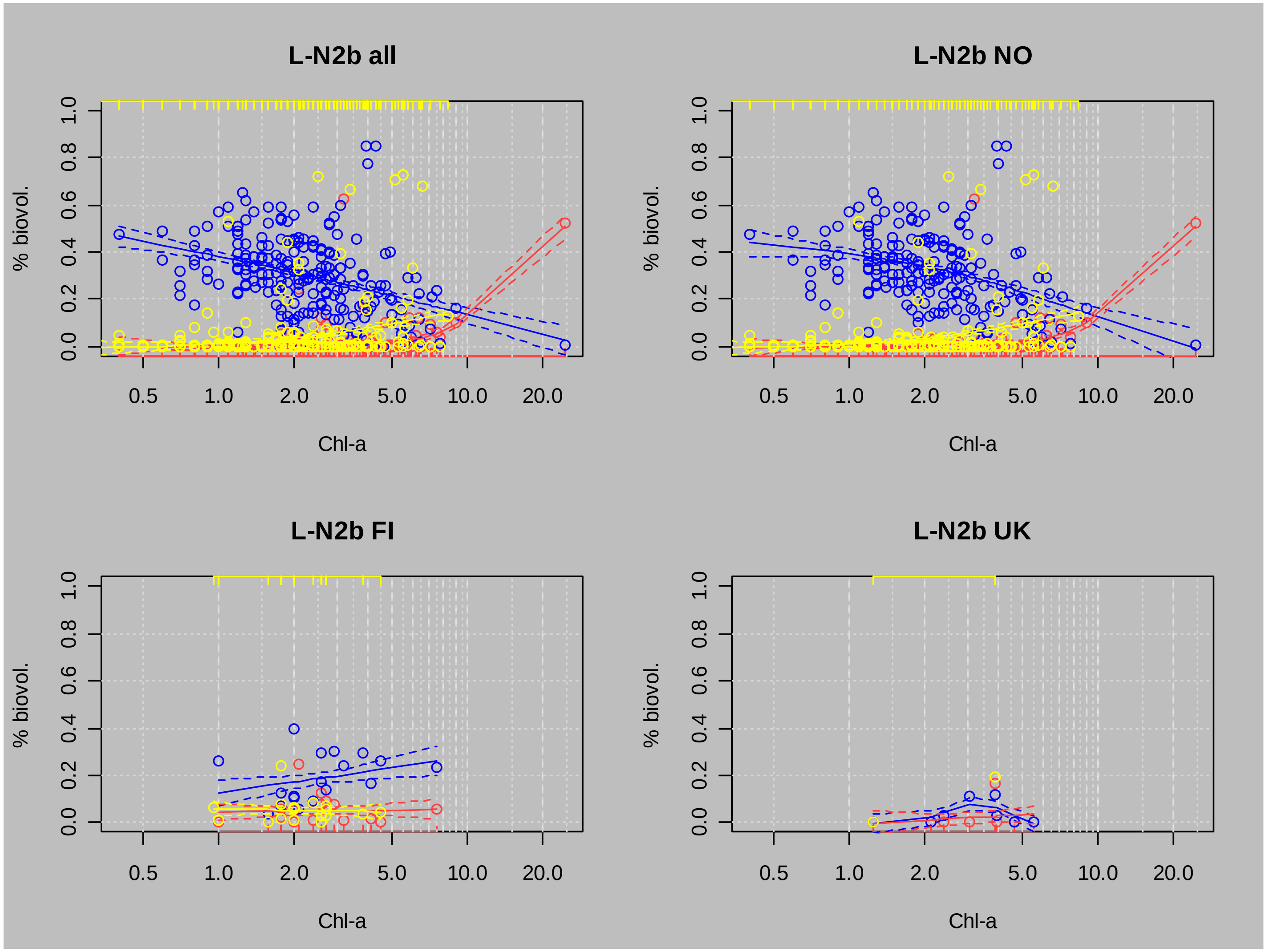


Figure E-5-10. Phytoplankton taxonomic composition response curves for LN2b type with proposed class boundaries (all countries together and countries specific plots)

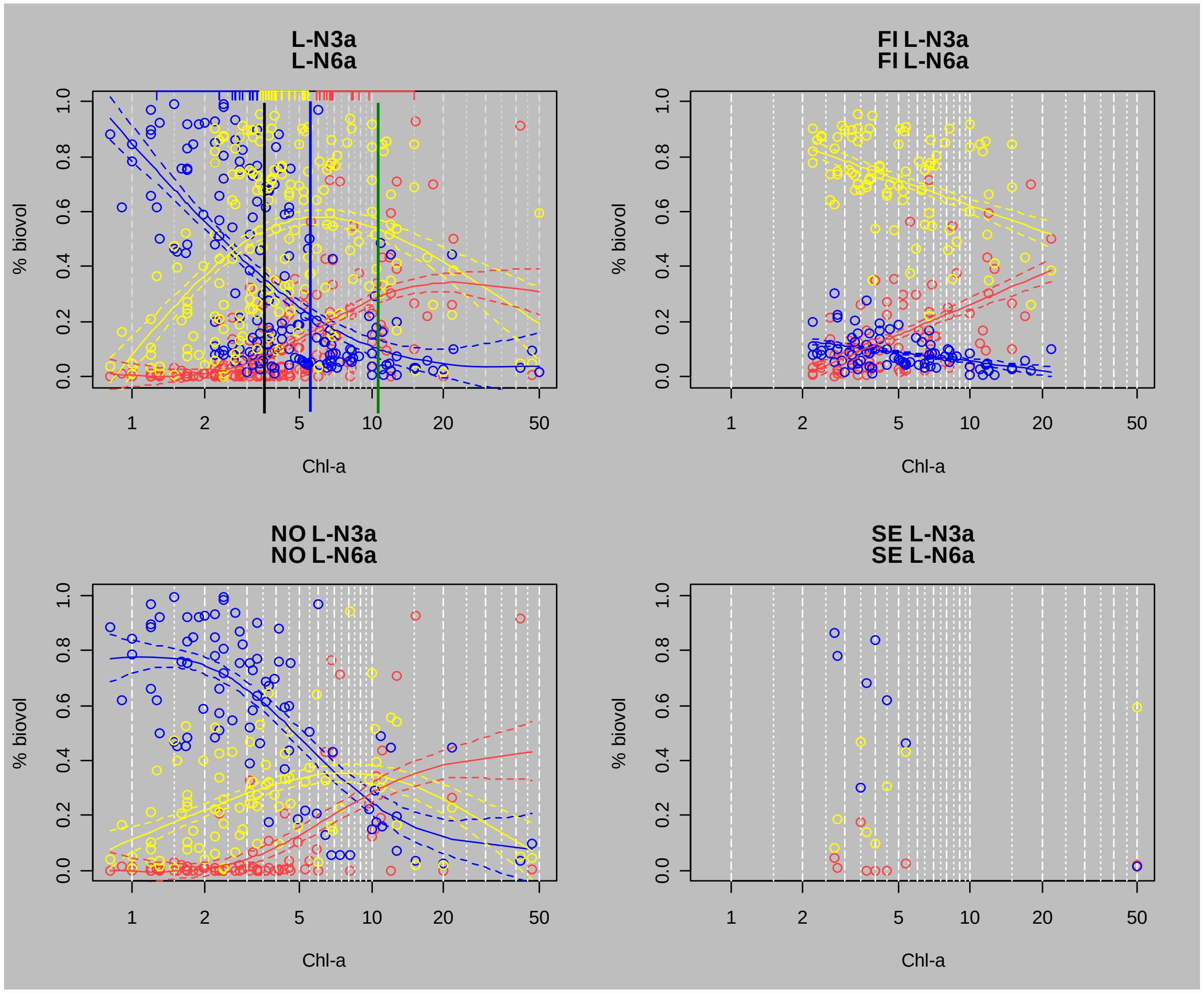


Figure E-5-11. Phytoplankton taxonomic composition response curves for LN3a and LN6a type with proposed class boundaries (black line – reference value, blue line HG boundary, green line – GM boundary, all countries together and countries specific plots).

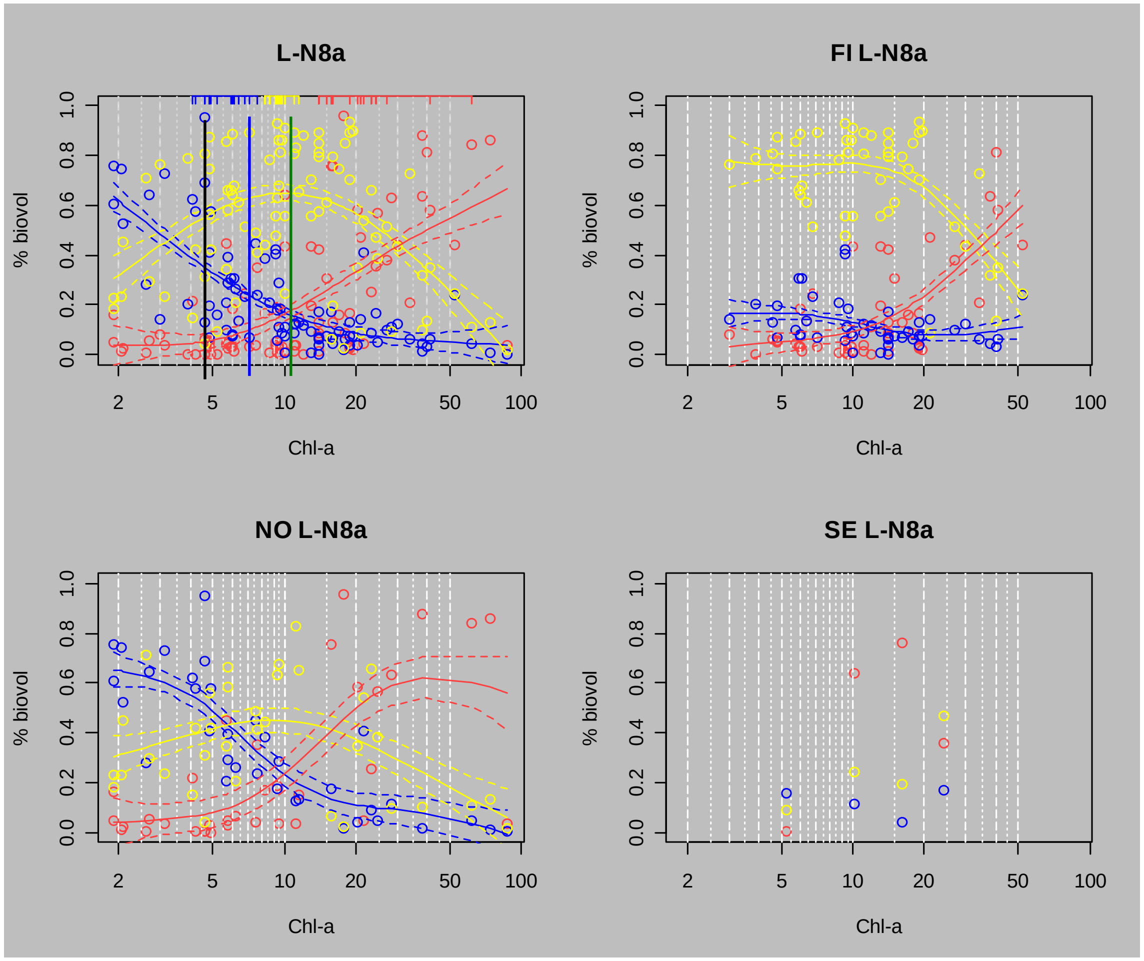


Figure E-5-12. Phytoplankton taxonomic composition response curves for LN8a with proposed class boundaries (black line – reference value, blue line HG boundary, green line – GM boundary, all countries together and countries specific plots).

Annex E – Part 6
NGIG Phytoplankton chlorophyll a boundaries (Whole NGIG)

Method 1: Chla Distribution Equal Classes				Method 2: Taxonomic Group Indicators (TCI)							Final boundaries agreed			
				boundaries proposed from different countries are also based on other national datasets										
L-N1 Mod Alk Shallow Clear, lowland														
N_{all}	73			NGIG	FI	SE	NO	UK	IE					
N_{ref}	21			mean								mean	min	maks
Ref	2,9			3,3			3	4	2,9		Ref	3	2,5	3,5
HG	5,9	(90th %ile)		4,8			4,5	5	4,8		HG	6	5	7,0
GM	10,2			8,3			7,5	10	7,5		GM	9	7,5	10,5
MP	17,5			19,0			19		19		MP			
EQR HG	0,49			0,69			0,67	0,8	0,60		EQR HG	0,50	0,50	0,50
EQR GM	0,28			0,40			0,40	0,4	0,39		EQR GM	0,33	0,33	0,33
EQR MP	0,17			0,17			0,16		0,15		EQR MP			
L-N2a Low Alk Shallow Clear, lowland														
N_{all}	89			NGIG	FI	SE	NO	UK	IE					
N_{ref}	61			mean								mean	min	maks
Ref	2,3			2,5	3	3	2	2			Ref	2	1,5	2,5
HG	4,0	(90th %ile)		3,5	4	4	3	3			HG	4	3,0	5,0
GM	6,9			7,3	7	10	6	6			GM	7	5,2	8,6
MP	11,7			12,5		16	9				MP			
PB	20,1										PB			
EQR HG	0,58			0,71	0,75	0,75	0,67	0,67			EQR HG	0,50	0,50	0,50

EQR GM	0,33			0,34	0,43	0,30	0,33	0,33			EQR GM	0,29	0,29	0,29
EQR MP	0,20			0,20		0,19	0,22				EQR MP			
L-N2b Low Alk Deep Clear, lowland														
N_{all}	96			NGIG	FI	SE	NO	UK	IE					
N_{ref}	71			mean								mean	min	maks
Ref	2			1,8			2	1,5			Ref	2	1,5	2,5
HG	4	(90th %ile)		2,3			2,5	2			HG	4	3,0	5,0
GM	6,3			5,5			6	5			GM	6	4,5	7,5
MP	10			9,0			10	8			MP			
PB	15,8			13,0				13			PB			
EQR HG	0,50			0,78			0,80	0,75			EQR HG	0,50	0,50	0,50
EQR GM	0,32			0,32			0,33	0,30			EQR GM	0,33	0,33	0,33
EQR MP	0,20			0,19			0,20	0,19			EQR MP			
EQR PB	0,13			0,12				0,12			EQR PB			
L-N3a Low Alk Shallow, Humic, lowland														
N_{all}	104			NGIG	FI	SE	NO	UK	IE					
N_{ref}	48			mean								mean	min	maks
Ref	4,2			3,6	4,9	3	2,5		4		Ref	3,0	2,5	3,5
HG	6,5	(75th%ile)		5,5	7	4,5	4,4		6		HG	6,0	5,0	7,0
GM	9,1			10,3	12	10	9		Not enough data		GM	10,0	8,0	12,0
MP	12,7										MP			
PB	17,7										PB			
											mean mg Pt/L	50-70	30-50	70-90
											retention time			long

EQR HG	0,71			0,65	0,70	0,66	0,57		0,67		EQR HG	0,50	0,50	0,50
EQR GM	0,46			0,35	0,41	0,45	0,28				EQR GM	0,30	0,31	0,29
EQR MP	0,33										EQR MP			
EQR PB	0,24										EQR PB			
L-N8a Mod Alk Shallow, Humic														
N_{all}	68			NGIG	FI	SE	NO	UK	IE					
N_{ref}	8			mean								mean	min	maks
Ref	7,8	4	5th %ile of the whole population	4,6	5,7		4		4		Ref	4	3,5	5
HG	11,1			7,2	8,5		6		7		HG	8	7	10
GM	16,3			11,3	14		10		10		GM	12	10,5	15
MP	23,7			16,0			16				MP			
PB	34,6										PB			
EQR HG	0,70			0,64	0,67		0,67		0,7		EQR HG	0,50	0,50	0,50
EQR GM	0,48			0,41	0,41		0,40				EQR GM	0,33	0,33	0,33
EQR MP	0,33			0,29			0,25				EQR MP			
EQR PB	0,23										EQR PB			
L-N5 Low Alk Shallow, clear, boreal														
N_{all}	49					SE								
N_{ref}	37											mean	min	maks
Ref	1,7					1,5					Ref	1,5	1	2
HG	3,1	(90th %ile)				2,8					HG	3	2	4
GM	4,9					4,5					GM	4,5	3	6
MP	7,8					6					MP			
PB	12,5					7					PB			
EQR HG	0,55										EQR HG	0,50	0,50	0,50

EQR GM	0,35										EQR GM	0,33	0,33	0,33
EQR MP	0,22										EQR MP			
EQR PB	0,14										EQR PB			
L-N6 Low Alk Shallow, humic, boreal														
N_{all}	21					SE								
N_{ref}	7											mean	min	maks
Ref	3,8					2					Ref	2,5	2	3
HG	4					3,8					HG	5	4	6
GM	7,9					6					GM	7,5	6	9
MP	11,5					7,5					MP			
PB	17					9					PB			
EQR HG	0,95										EQR HG	0,50	0,50	0,50
EQR GM	0,48										EQR GM	0,33	0,33	0,33
EQR MP	0,33										EQR MP			
EQR PB	0,22										EQR PB			

* For LN3a the median of the type-specific statistical distribution of reference lakes is close to the max value given in the table above. This was caused by domination of Finnish lakes, which have higher colour values and higher ref. chlorophyll values than the other countries. Therefore the H/G boundary was set, using the 75th %ile of the ref. lake population, and not the 90th %ile, as for the clearwater lake types.

** For LN8 the median value for the 8 reference lakes was as high as 7.8 µg/L, mainly due to two Finnish lakes. The plots from REBECCA showing the changes in phytoplankton taxonomic composition along the chlorophyll gradient (see Annex C), indicate that the impact taxa has started to increase already at 6 µg/L, and the reference taxa decrease significantly beyond 5 µg/L. The max reference value was therefore set to 5 µg/L and the mean value to 4 µg/L, since the general expert opinion in the GIG was that LN8 with moderate alkalinity should have higher reference values than LN3 with low alkalinity.

Annex E – Part 7 - Common IC Type specifications and Country specific comments to the NGIG typology

Table E-7. Common IC Type specifications

Type	Type description	Comments	Countries participating,
LN1	Lowland (<200 m), shallow (3-15 m), moderate alkalinity (0.2-1 mekv/L), clear (<30 mg Pt/L)	The reference conditions in clearwater lakes will differ according to different natural conditions in the different NGIG countries. There is a gradient from west to east going from a wetter to a drier climate, and there are also topographical differences (from hilly landscapes to flatter terrain). These natural differences affects the both the mean depth and the retention time of lakes, and thus also the chlorophyll levels, since shallow lakes or lakes with long retention times tend to have more phytoplankton than deeper lakes or lakes with shorter retention times. The NGIG has therefore chosen to apply a range of reference conditions, rather than a fixed value across the GIG.	NO, UK, IE
LN2a	Lowland (<200 m), shallow (3-15 m), low alkalinity (<0.2 mekv/L), clear (<30 mg Pt/L)	See LN1 comments	NO, SE, FI, UK, IE
LN2b	Lowland (<200 m), deep (>15 m), low alkalinity (<0.2 mekv/L), clear (<30 mg Pt/L)	See LN1 comments	NO, UK
LN3a	Lowland (<200 m), shallow (3-15 m), low alkalinity (<0.2 mekv/L), humic (30-90 mg Pt/L)	The humic lake types (LN3, 6 and 8) have been split into two sub-types: mesohumic and polyhumic lakes, since polyhumic lakes have much higher TP than mesohumic lakes and different plankton composition. Also within the remaining mesohumic lakes (LN3a, 6a and 8a), there are significant differences in colour increasing from west to east across the Nordic countries (see Skjelkvåle et al. 2001). Thus the absolute values of reference conditions and boundaries for these lake types will increase from Norway to Sweden to Finland, since both total P and chlorophyll are positively correlated with colour (Phillips et al. in prep). This difference adds on to the other differences described for Clearwater lakes above. The NGIG has therefore chosen to apply a range of reference conditions, rather than a fixed value across the GIG, also for the humic lake types. Further work will be required in UK to determine a reliable sub-division of clear and humic water types due to a current lack of data. In many humic lakes in Sweden and Finland there is dominance of *Gonyostumum semen* which affects the chlorophyll content to a large extent. These lakes cannot be separated from the population of humic lakes without data on species composition, which is not always available. Thus, because these lakes cannot be excluded from the dataset, they contribute to	NO, SE, FI, UK, IE

		increase the reference chlorophyll values as well as the H/G chlorophyll boundaries for the humic lake types. In the analyses of taxonomic composition changes, the lakes with high abundance of Gonyostomum were excluded from the analyses, so the G/M boundaries which are at least partly based on these plots are not so much affected by this.	
LN3b	Lowland (<200 m), shallow (3-15 m), low alkalinity (<0.2 mekv/L), polyhumic (> 90 mg Pt/L)	The polyhumic lake types occur mainly in Finland, and will not be intercalibrated	FI (no intercalibration, due to lack of data from other countries)
LN5a	Mid-altitude (200-800 m), shallow (3-15 m), low alkalinity (<0.2 mekv/L), clear (<30 mg Pt/L)	See LN1 comments. L-N5 can also be used for lowland lakes in high latitudes (Northern part of Scandinavia). Reference lakes in this type are mainly found in high Northern latitudes. Mid-altitude lakes (between 200-400m) in the Southernmost latitudes of the NGIG should rather use the LN2a values for classification.	NO, SE,
LN6a	Mid-altitude (200-800 m), shallow (3-15 m), low alkalinity (<0.2 mekv/L), humic (30-90 mg Pt/L)	See LN3 a L-N6a can also be used for lowland lakes in high latitudes (Northern part of Scandinavia). Reference lakes in this type are mainly found in high Northern latitudes. Mid-altitude lakes (between 200-400m) in the Southernmost latitudes of the NGIG should rather use the LN3a values for classification.	NO, SE,
LN6b	Mid-altitude (200-800 m), shallow (3-15 m), low alkalinity (<0.2 mekv/L), polyhumic (> 90 mg Pt/L)	The polyhumic lake types occur mainly in Finland, and will not be intercalibrated	FI (no intercalibration, see LN3b)
LN8a	Lowland (<200 m), shallow (3-15 m), moderate alkalinity (0.2-1 mekv/L), humic (30-90 mg Pt/L)	See LN3a	NO, SE (?), FI, UK, IE
LN8b	Lowland (<200 m), shallow (3-15 m), moderate alkalinity (0.2-1 mekv/L), polyhumic (>90 mg Pt/L)	The polyhumic lake types occur mainly in Finland, and will not be intercalibrated	FI (no intercalibration, see LN3b)

Country specific comments to the NGIG typology

1) LN1 type - Lowland (<200 m), shallow (3-15 m), moderate alkalinity (0.2-1 meq/L), clear (<30 mg Pt/L):

- Finland: Type occurs in Finland, but the alkalinity in Finnish lakes is only a little above the lower alkalinity boundary of the type (0.2 mekv/L). The Finnish lakes technically in this type thus are not very typical of this moderate alkalinity type;
- Sweden: data from LN1 lakes in Sweden (mainly in Southern Sweden) have not been available for use in intercalibration due to lack of reference lakes. In the proposed national classification system they are right now handled together with LN2a but work is made to be able to separate them;

2) LN2a - Lowland (<200 m), shallow (3-15 m), low alkalinity (<0.2 meq/L), clear (<30 mg Pt/L):

- Sweden: difference between LN2a and LN5a. In Sweden the division instead is made by the biogeographical and climatic boundary “Limes norrlandicus”, which is a Swedish vegetation border between the southern, temperate climate zone and the northern Taiga zone. It is defined to closely follow the northern limit of the oak trees at about latitude 60° North (Fransson, 1965). The LN2a-lakes at high latitudes are instead using the boundaries for LN5a and the mid-altitude lakes (between 200-400m) of LN5a-lakes situated at low latitudes are using the boundaries for LN2a;
- Norway: Lakes in the lowlands of Northern Norway should rather use the boundaries for LN5a;

3) LN3a - Lowland (<200 m), shallow (3-15 m), low alkalinity (<0.2 mekv/L), humic (30-90 mg Pt/L):

- Sweden: No major difference between LN3a and LN6a. In Sweden the division instead is made by the biogeographical and climatic boundary “Limes norrlandicus”, which is a Swedish vegetation border between the southern, temperate climate zone and the northern Taiga zone. It is defined to closely follow the northern limit of the oak trees at about latitude 60° North (Fransson S, 1965). The LN3a-lakes at high latitudes are instead using the boundaries for LN6a and the mid-altitude lakes (between 200-400m) of LN6a-lakes situated at low latitudes are using the boundaries for LN3a;
- Norway: Lakes in the lowlands of Northern Norway should rather use the boundaries for LN6a;
- UK: Currently not possible to reliably identify which lakes fall into this type but likely to be a very few sites;

4) LN5a - Mid-altitude (200-800 m), shallow (3-15 m), low alkalinity (<0.2 mekv/L), clear (<30 mg Pt/L):

- Finland: Mid-altitude lakes occur in Finland, but data is low in number, because the area of occurrence is rather small and having low pressures. In national typology this group is not separated, because the limit of 200 m is not considered to be relevant in Finnish natural conditions.
- Sweden: difference between LN2a and LN5a. In Sweden the division instead is made by the biogeographical and climatic boundary “Limes norrlandicus”, which is a Swedish vegetation border between the southern, temperate climate zone and the northern Taiga zone. It is defined to closely follow the northern limit of the oak trees at about latitude 60° North (Fransson, S., 1965). The LN2a-lakes at high latitudes are instead using the boundaries for LN5a and the mid-altitude lakes (between 200-400m) of LN5a-lakes situated at low latitudes are using the boundaries for LN2a;
- Norway: Should also be used in lowland lakes (<200 m) at high latitudes (Northern Norway;

5) LN6a - Mid-altitude (200-800 m), shallow (3-15 m), low alkalinity (<0.2 mekv/L), humic (30-90 mg Pt/L):

- Finland: Mid-altitude lakes occur in Finland, but data is low in number, because the area of occurrence is rather small and having low pressures. In national typology this group is not separated, because the limit of 200 m is not considered to be relevant in Finnish natural conditions.
- Norway Should also be used in lowland lakes (<200 m) at high latitudes (Northern Norway);

6) LN8a - Lowland (<200 m), shallow (3-15 m), moderate alkalinity (0.2-1 mekv/L), humic (30-90 mgPt/l) :

- UK Currently not possible to reliably identify which lakes fall into this type but likely to be a very few sites.

Annex E – Part 8 - Data underlying the analysis

Country	lake_name	lake_code	site_nr	ref-lake (1)	sample date	GIG-type	TotP (µg/L)	Chla (µg/L)	% Cyano
FI	Hormajärvi	19624	1196	0	10/07/02	L-N1	10.5	1.2	4.5%
FI	Katumajärvi	20791	1682	0	08/07/02	L-N1	28.0	11.0	26.1%
FI	Lievestuoreenjärvi	14854	25398	0	09/07/96	L-N1	11.0	3.8	0.1%
FI	Lievestuoreenjärvi	14854	25398	0	09/07/98	L-N1	10.5	2.1	5.5%
FI	Lievestuoreenjärvi	14854	25398	0	06/07/00	L-N1	10.0	4.9	3.9%
FI	Lohjanjärvi	19576	1096	0	08/07/96	L-N1	19.5	15.0	0.0%
FI	Lohjanjärvi	19576	1096	0	05/08/96	L-N1	21.0	15.0	4.0%
FI	Lohjanjärvi	19576	1096	0	10/07/02	L-N1	24.5	11.0	0.0%
FI	Lohjanjärvi	19576	1096	0	22/08/02	L-N1	26.0	12.0	3.4%
FI	Lohjanjärvi	19576	1114	0	01/08/96	L-N1	29.0	17.0	0.0%
FI	Lohjanjärvi	19576	1123	0	08/07/96	L-N1	21.0	12.0	9.6%
FI	Lohjanjärvi	19576	1123	0	01/08/96	L-N1	17.0	13.0	10.0%
FI	Lohjanjärvi	19576	1123	0	07/08/02	L-N1	25.0	6.7	1.7%
FI	Lohjanjärvi	19576	1175	0	01/08/96	L-N1	17.0	5.2	36.5%
FI	Lohjanjärvi	19576	1175	0	16/07/02	L-N1	21.0	9.5	1.0%
FI	Lohjanjärvi	19576	1175	0	07/08/02	L-N1	16.0	7.4	19.7%
FI	Lohjanjärvi	19576	1175	0	09/09/02	L-N1	19.0	6.2	13.8%
FI	Puujärvi	19603	1164	0	10/07/02	L-N1	9.0	3.2	16.7%
FI	Pyhäjärvi	20349	6396	0	17/08/95	L-N1	22.0	6.1	8.5%
FI	Pyhäjärvi	20349	6396	0	09/07/97	L-N1	15.0	4.0	2.5%
FI	Pyhäjärvi	20349	6396	0	08/07/98	L-N1	31.0	3.6	15.0%
FI	Pyhäjärvi	20349	6396	0	12/07/99	L-N1	16.5	5.0	10.1%
FI	Pyhäjärvi	12501	11673	0	09/07/96	L-N1	15.0	6.8	0.0%
FI	Pyhäjärvi	12501	11673	0	07/07/97	L-N1	11.0	5.5	2.5%
FI	Roine (N60 84.20)x3	23080	9103	0	08/07/02	L-N1	12.0	5.4	4.9%
FI	Urajärvi	12536	11643	0	13/08/02	L-N1	17.0	7.2	31.6%
FI	Vanajavesi (N60 79.40)x1	20760	7770	0	09/07/02	L-N1	17.0	10.0	12.0%
FI	Vanajavesi (N60 79.40)x1	20760	7770	0	10/07/02	L-N1	17.0	6.9	12.0%
FI	Vesijärvi	13986	138	0	09/07/96	L-N1	18.0	4.1	5.3%
FI	Vesijärvi	13986	138	0	10/07/97	L-N1	18.0	2.5	0.6%
FI	Vesijärvi	13986	138	0	08/07/02	L-N1	15.0	5.3	2.6%
FI	Vesijärvi	13986	150	0	03/07/01	L-N1	27.0	8.7	2.8%
FI	Vesijärvi	13986	150	0	20/08/01	L-N1	45.0	4.6	37.3%
FI	Vesijärvi	13986	44067	0	12/09/94	L-N1	16.0	7.0	9.3%
FI	Vesijärvi	13986	44067	0	22/08/95	L-N1	18.0	6.0	0.4%
FI	Vesijärvi	13986	44067	0	25/08/98	L-N1	16.0	6.3	1.0%
FI	Vesijärvi	13986	44067	0	28/08/03	L-N1	12.0	4.9	5.2%
FI	Vitträsk	55013	2733	0	16/09/02	L-N1	19.0	15.0	58.8%
IE	Lough Akibbon	IEZZ_00_002		0	15/07/05	L-N1	13.0	1.6	99.7%
IE	Lough Anaserd	IEWE_31_211		0	15/08/05	L-N1	8.9	3.2	9.4%
IE	Lough Graney	IESH_25_190		0	15/07/05	L-N1	18.0	8.1	57.4%
IE	Lough Lickeen	IEZZ_00_012		0	15/07/05	L-N1	20.0	19.3	98.9%
IE	Lough Moher	IEZZ_00_015		0	15/07/05	L-N1	9.0	3.7	0.0%
NO	Finnfjordvatnet	TROIFIN	267	0	09/07/88	L-N1	4.0	2.1	1.3%
NO	Finnfjordvatnet	TROIFIN	267	0	01/08/88	L-N1	3.0	0.8	0.0%
NO	Finnfjordvatnet	TROIFIN	267	0	28/08/88	L-N1	4.0	1.3	1.3%
NO	Fossemvatnet	NTRIFOS	228	0	27/07/88	L-N1	7.0	3.0	0.0%
NO	Fossemvatnet	NTRIFOS	228	0	28/07/89	L-N1	5.0	3.1	1.9%
NO	Fossemvatnet	NTRIFOS	228	0	03/09/89	L-N1	4.0	1.8	0.0%
NO	Fossemvatnet	NTRIFOS	228	0	11/09/91	L-N1	7.0	1.3	0.0%
NO	Frøylandsvatnet syd	ROGIFRS	55	0	20/07/88	L-N1	49.0	38.2	83.0%
NO	Frøylandsvatnet syd	ROGIFRS	55	0	14/07/92	L-N1	25.0	17.9	52.5%
NO	Frøylandsvatnet syd	ROGIFRS	55	0	21/07/97	L-N1	28.0	10.0	78.7%
NO	Frøylandsvatnet syd	ROGIFRS	55	0	18/08/97	L-N1	41.0	26.6	28.7%

NO	Gaustadvatnet	STRIGAU	210	0	25/07/88	L-N1	26.0	12.6	1.0%
NO	Gaustadvatnet	STRIGAU	210	0	20/08/88	L-N1	13.0	16.1	16.9%
NO	Gaustadvatnet	STRIGAU	210	0	17/07/92	L-N1	46.0	13.6	0.0%
NO	Gaustadvatnet	STRIGAU	210	0	20/08/92	L-N1	15.0	9.2	0.0%
NO	Goksjø	VESIGOK	7	0	15/07/88	L-N1	28.0	10.2	0.3%
NO	Goksjø	VESIGOK	7	0	11/08/92	L-N1	22.0	4.6	0.5%
NO	Goksjø	VESIGOK	7	0	14/07/97	L-N1	15.0	4.4	0.0%
NO	Goksjø	VESIGOK	7	0	01/09/99	L-N1	17.0	10.4	0.6%
NO	Hålandsvatn	ROGIHÅL	58	0	20/07/88	L-N1	20.0	5.7	7.7%
NO	Hålandsvatn	ROGIHÅL	58	0	13/07/92	L-N1	12.0	6.6	8.5%
NO	Hålandsvatn	ROGIHÅL	58	0	21/07/97	L-N1	10.0	3.3	21.8%
NO	Hålandsvatn	ROGIHÅL	58	0	18/08/97	L-N1	12.0	4.3	20.9%
NO	Hittersjøen	STRIHIT	604	0	05/07/95	L-N1	3.5	1.5	0.0%
NO	Horpestadvatnet	ROGIHOR	56	0	20/07/88	L-N1	90.0	54.1	92.7%
NO	Horpestadvatnet	ROGIHOR	56	0	21/08/88	L-N1	110.0	78.2	98.5%
NO	Hostadvatnet	MROIHOS	201	0	19/08/88	L-N1	13.0	5.1	0.6%
NO	Hostadvatnet	MROIHOS	201	0	26/07/89	L-N1	14.0	5.8	0.0%
NO	Hostadvatnet	MROIHOS	201	0	31/08/89	L-N1	15.0	8.8	0.3%
NO	Hostadvatnet	MROIHOS	201	0	31/07/91	L-N1	14.0	7.5	0.0%
NO	Kasfjordvatnet	TROIKAS	254	0	08/07/88	L-N1	18.0	7.5	9.5%
NO	Kasfjordvatnet	TROIKAS	254	0	31/07/88	L-N1	18.0	6.1	50.9%
NO	Kasfjordvatnet	TROIKAS	254	0	27/08/88	L-N1	18.0	11.4	58.2%
NO	Kasfjordvatnet	TROIKAS	254	0	11/08/92	L-N1	17.0	2.2	0.0%
NO	Kyllesvatnet	ROGIKYL	62	0	21/07/88	L-N1	16.0	8.5	47.9%
NO	Kyllesvatnet	ROGIKYL	62	0	22/08/88	L-N1	21.0	6.9	21.9%
NO	Langfjordvatnet	FINILAF	332	0	01/08/88	L-N1	8.0	3.7	11.0%
NO	Langvatnet	FINILAN	328	0	07/08/88	L-N1	5.0	2.1	3.6%
NO	Laugen	STRILAU	212	0	25/07/88	L-N1	18.0	10.3	4.8%
NO	Laugen	STRILAU	212	0	21/08/88	L-N1	15.0	11.6	5.7%
NO	Laugen	STRILAU	212	0	17/07/92	L-N1	8.0	8.2	0.9%
NO	Lutsivatnet	ROGILUT	61	0	21/07/88	L-N1	14.0	7.1	52.2%
NO	Lutsivatnet	ROGILUT	61	0	19/07/89	L-N1	16.0	2.3	28.9%
NO	Lutsivatnet	ROGILUT	61	0	21/08/89	L-N1	12.0	8.0	14.7%
NO	Lutsivatnet	ROGILUT	61	0	27/07/91	L-N1	11.0	3.8	5.7%
NO	Lynvatnet	NTRILYN	367	0	16/07/92	L-N1	15.0	5.9	1.2%
NO	Lynvatnet	NTRILYN	367	0	20/08/92	L-N1	11.0	6.9	0.8%
NO	Nervatnet	TROINER	262	0	09/07/88	L-N1	1.0	1.6	0.0%
NO	Nervatnet	TROINER	262	0	01/08/88	L-N1	5.0	1.4	0.0%
NO	Nervatnet	TROINER	262	0	28/08/88	L-N1	3.0	1.1	0.0%
NO	Ruskebukta (Ruskevatn)	FINIRUS	333	0	07/08/88	L-N1	10.0	4.6	65.0%
NO	Steinsfjorden	BUSISTE	106	0	25/07/88	L-N1	14.0	9.4	7.0%
NO	Steinsfjorden	BUSISTE	106	0	26/08/88	L-N1	11.0	4.4	10.4%
NO	Stikkilen	STRISTI	608	0	05/07/95	L-N1	4.0	2.7	0.0%
NO	Stokkavatnet	ROGISTK	59	0	20/07/88	L-N1	11.0	4.0	0.9%
NO	Stokkavatnet	ROGISTK	59	0	21/08/88	L-N1	12.0	4.2	2.9%
NO	Stokkavatnet	ROGISTK	59	0	19/07/89	L-N1	9.0	2.6	0.0%
NO	Stokkavatnet	ROGISTK	59	0	31/08/91	L-N1	7.0	3.2	0.4%
NO	Svanevatn	FINISVA	331	0	07/09/88	L-N1	9.0	2.9	0.0%
NO	Vestvannet	ØSTIVES	287	0	28/07/88	L-N1	14.0	5.2	3.7%
NO	Vestvannet	ØSTIVES	287	0	27/08/88	L-N1	14.0	5.6	0.0%
NO	Vestvannet	ØSTIVES	287	0	23/07/89	L-N1	12.0	6.0	0.0%
NO	Vestvannet	ØSTIVES	287	0	22/07/91	L-N1	12.0	4.1	0.3%
SE	Björken	1010	1	0	15/08/01	L-N1	8.0	4.8	0.2%
SE	Björken	1010	1	0	14/08/02	L-N1	6.0	3.4	2.4%
SE	Björken	1010	1	0	13/08/03	L-N1	5.0	2.7	3.1%
SE	Björken			0	(august)	L-N1	6.8	2.7	7.1%
SE	Grycken			0	(august)	L-N1	9.0	NA	0.7%
SE	N. Yngern			0	(august)	L-N1	13.5	4.2	17.7%

SE	Tärnan	1132	1	0	15/08/01	L-N1	10.0	5.6	8.3%
SE	Tärnan	1132	1	0	14/08/02	L-N1	8.0	3.0	13.0%
SE	Tärnan	1132	1	0	12/08/03	L-N1	5.0	3.7	13.2%
SE	Ymsen			0	(august)	L-N1	69.8	28.5	22.3%
UK	Bassenthwaite Lake	28847	1	0	03/09/04	L-N1	32.0	13.2	5.7%
UK	Esthwaite	UK29328		0	15/07/04	L-N1	33.0	28.5	72.3%
UK	Esthwaite	UK29328		0	15/08/04	L-N1	12.0	21.2	91.0%
UK	Loch of Lowes	UK23559		0	15/09/04	L-N1	19.3	23.5	0.2%
UK	Stithians Reservoir	UK46501		0	15/09/04	L-N1	13.0	19.1	0.0%
UK	Stithians Reservoir	UK46501		0	15/08/05	L-N1	27.0	10.5	1.0%
UK	The Loe	UK46556		0	15/09/04	L-N1	93.0	15.0	89.8%
UK	The Loe	UK46556		0	15/08/05	L-N1	98.0	70.4	88.2%
FI	Iso-Roine	23732	1851	1	10/07/02	L-N1	10.0	5.6	0.9%
FI	Kivijärvi	13208	11784	1	11/07/95	L-N1	7.0	2.1	2.4%
FI	Kukkia	23790	9576	1	11/07/94	L-N1	6.0	2.3	1.1%
FI	Kukkia	23790	9576	1	11/07/02	L-N1	9.0	2.6	0.8%
FI	Mallasvesi (N60 84.20)x1	23073	9053	1	11/07/94	L-N1	3.0	2.0	0.1%
FI	Mallasvesi (N60 84.20)x1	23073	9053	1	09/07/97	L-N1	8.0	1.9	2.3%
FI	Mallasvesi (N60 84.20)x1	23073	9053	1	11/07/02	L-N1	11.0	3.7	3.7%
FI	Pyhäjärvi	6474	22953	1	08/07/96	L-N1	6.0	2.3	4.0%
FI	Pyhäjärvi	6474	22953	1	10/07/97	L-N1	8.0	1.1	2.6%
FI	Pyhäjärvi	6474	22953	1	15/07/98	L-N1	4.0	2.5	1.9%
FI	Pyhäjärvi	6474	22953	1	21/07/99	L-N1	5.0	1.7	6.2%
NO	Andsvatnet	TROIAND	266	1	09/07/88	L-N1	0.5	1.9	0.8%
NO	Andsvatnet	TROIAND	266	1	02/08/88	L-N1	3.0	0.8	0.0%
NO	Andsvatnet	TROIAND	266	1	30/08/88	L-N1	2.0	0.9	0.0%
NO	Drevvatnet	NORIDRE	241	1	05/07/88	L-N1	2.0	2.4	0.0%
NO	Drevvatnet	NORIDRE	241	1	29/07/88	L-N1	3.0	1.7	0.0%
NO	Drevvatnet	NORIDRE	241	1	24/08/88	L-N1	2.0	1.4	2.0%
NO	Hostovatnet	STRIHOS	209	1	25/07/88	L-N1	7.0	5.5	0.0%
NO	Hostovatnet	STRIHOS	209	1	20/08/88	L-N1	7.0	4.9	0.0%
NO	Langvatnet	MROILAN	200	1	24/07/88	L-N1	6.0	1.3	0.0%
NO	Langvatnet	MROILAN	200	1	26/07/89	L-N1	3.0	1.2	0.0%
NO	Langvatnet	MROILAN	200	1	31/08/89	L-N1	7.0	1.9	0.0%
NO	Langvatnet	MROILAN	200	1	31/07/91	L-N1	9.0	2.0	0.0%
NO	Nosvatnet	MROINOS	202	1	26/07/89	L-N1	7.0	1.8	0.0%
NO	Nosvatnet	MROINOS	202	1	31/08/89	L-N1	10.0	7.0	0.0%
NO	Nosvatnet	MROINOS	202	1	31/07/91	L-N1	11.0	3.9	0.1%
NO	Nosvatnet	MROINOS	202	1	06/09/91	L-N1	11.0	4.9	0.0%
NO	Øvrevatnet	TROIØVR	261	1	09/07/88	L-N1	2.0	1.3	0.0%
NO	Øvrevatnet	TROIØVR	261	1	01/08/88	L-N1	4.0	0.7	0.0%
NO	Øvrevatnet	TROIØVR	261	1	28/08/88	L-N1	2.0	0.9	0.0%
NO	Røyrbakvatnet	TROIRØY	263	1	09/07/88	L-N1	2.0	1.4	0.0%
NO	Røyrbakvatnet	TROIRØY	263	1	01/08/88	L-N1	6.0	1.6	0.0%
NO	Røyrbakvatnet	TROIRØY	263	1	28/08/88	L-N1	4.0	1.5	0.0%
NO	Sagelvvatnet	TROISAG	273	1	02/08/88	L-N1	8.0	2.6	0.0%
NO	Sagelvvatnet	TROISAG	273	1	29/08/88	L-N1	5.0	1.8	0.0%
NO	Sagelvvatnet	TROISAG	273	1	10/09/89	L-N1	6.0	2.7	0.0%
NO	Sagelvvatnet	TROISAG	273	1	09/09/99	L-N1	7.0	2.9	0.0%
FI	Iso-Löytäne	23292	9279	0	08/07/02	L-N2a	12.0	2.4	3.2%
FI	Jääsjärvi	17496	14825	0	06/07/00	L-N2a	6.2	2.0	0.9%
FI	Längelmävesi	23159	9261	0	08/07/96	L-N2a	9.7	1.6	7.4%
FI	Längelmävesi	23159	9261	0	07/07/98	L-N2a	12.0	12.9	78.5%
FI	Längelmävesi	23159	9261	0	10/07/00	L-N2a	17.0	4.0	0.5%
FI	Längelmävesi	23159	9261	0	08/07/02	L-N2a	4.8	2.6	0.9%
FI	Mutusjärvi	50321	39306	0	13/07/00	L-N2a	11.7	4.0	0.3%
FI	Päijänne (kesk. N60+78.10)	13356	24658	0	12/07/93	L-N2b	11.2	4.9	3.0%
FI	Päijänne (kesk. N60+78.10)	13356	24658	0	29/07/96	L-N2b	5.5	2.4	0.0%

FI	Päijänne (kesk. N60+78.10)	13356	24658	0	27/07/98	L-N2b	5.7	1.8	0.0%
FI	Päijänne (kesk. N60+78.10)	13356	24658	0	12/07/99	L-N2b	8.8	4.1	3.6%
FI	Pyhäjärvi	18450	15467	0	12/07/01	L-N2a	8.7	NA	7.0%
FI	Siikajärvi	23503	9518	0	15/07/02	L-N2a	2.5	1.4	0.0%
FI	Simijärvi eli Iso-Simi	55141	2987	0	08/07/02	L-N2b	3.3	NA	0.5%
FI	Vesijärvi	23334	9384	0	11/07/02	L-N2a	4.7	2.8	0.6%
IE	Lough Atorick	IEZZ_00_004		0	15/08/05	L-N2	15.2	7.4	1.2%
IE	Lough Doo CE	IESH_28_82		0	15/08/05	L-N2	10.3	5.5	7.7%
IE	Lough Dunglow	IENS_38_692		0	15/07/05	L-N2	5.0	NA	0.0%
IE	Lough Guitane	IESW_22_172		0	15/07/05	L-N2	3.5	1.4	0.4%
IE	Lough Shindilla	IEWE_31_171		0	15/07/05	L-N2	8.5	3.5	7.3%
NO	Andestadvatnet	MROIAND	182	0	01/07/88	L-N2a	8.0	3.5	3.1%
NO	Andestadvatnet	MROIAND	182	0	25/07/88	L-N2a	3.8	1.5	3.3%
NO	Andestadvatnet	MROIAND	182	0	23/08/88	L-N2a	5.3	4.4	11.8%
NO	Bogstadvannet	OSLIBOG	285	0	06/07/88	L-N2a	7.9	1.2	0.0%
NO	Bogstadvannet	OSLIBOG	285	0	10/09/88	L-N2a	7.4	2.8	6.9%
NO	Bogstadvannet	OSLIBOG	285	0	07/09/93	L-N2a	13.0	3.7	2.5%
NO	Bogstadvannet	OSLIBOG	285	0	29/09/93	L-N2a	18.0	6.2	1.1%
NO	Edlandsvatnet	ROGIEDL	53	0	20/07/88	L-N2a	8.5	2.3	3.1%
NO	Edlandsvatnet	ROGIEDL	53	0	21/08/88	L-N2a	13.0	7.6	4.3%
NO	Farstadvann	NORIFAR	250	0	30/07/88	L-N2a	6.0	1.7	0.1%
NO	Farstadvann	NORIFAR	250	0	26/08/88	L-N2a	7.0	4.9	0.8%
NO	Farstadvann	NORIFAR	250	0	23/07/97	L-N2a	12.0	8.6	1.2%
NO	Farstadvann	NORIFAR	250	0	11/08/97	L-N2a	5.0	4.4	5.7%
NO	Hjørdalsvatnet	MROIHJØ	179	0	24/07/88	L-N2a	11.0	3.7	7.5%
NO	Hjørdalsvatnet	MROIHJØ	179	0	22/08/88	L-N2a	7.0	3.1	0.0%
NO	Lilandsvann	NORILIL	248	0	06/07/88	L-N2a	6.0	2.2	0.0%
NO	Lilandsvann	NORILIL	248	0	30/07/88	L-N2a	5.0	2.3	26.9%
NO	Lilandsvann	NORILIL	248	0	26/08/88	L-N2a	12.0	10.2	0.2%
NO	Lilandsvann	NORILIL	248	0	11/08/97	L-N2a	8.0	3.8	32.8%
NO	Limavatnet	ROGILIM	52	0	19/07/89	L-N2a	8.0	5.3	12.6%
NO	Limavatnet	ROGILIM	52	0	20/08/89	L-N2a	25.0	4.7	0.0%
NO	Limavatnet	ROGILIM	52	0	27/07/91	L-N2a	10.0	3.8	15.6%
NO	Limavatnet	ROGILIM	52	0	31/08/91	L-N2a	9.0	5.1	0.0%
NO	Nordre Kornsjø	ØSTINKO	291	0	27/08/88	L-N2a	20.0	20.6	89.0%
NO	Nordre Kornsjø	ØSTINKO	291	0	23/08/89	L-N2a	10.0	8.9	65.9%
NO	Nordre Kornsjø	ØSTINKO	291	0	22/07/91	L-N2a	12.0	9.5	85.4%
NO	Nordre Kornsjø	ØSTINKO	291	0	26/08/91	L-N2a	14.0	8.4	27.2%
NO	Ostadvann	NORIOST	249	0	07/07/88	L-N2a	29.0	4.3	0.0%
NO	Ostadvann	NORIOST	249	0	30/07/88	L-N2a	10.0	2.7	0.0%
NO	Ostadvann	NORIOST	249	0	26/08/88	L-N2a	21.0	10.3	3.0%
NO	Søndre Storavatn	ROGISST	137	0	20/07/89	L-N2a	13.0	12.4	80.1%
NO	Søndre Storavatn	ROGISST	137	0	22/08/89	L-N2a	14.0	12.3	17.7%
NO	Søndre Storavatn	ROGISST	137	0	28/07/91	L-N2a	9.0	8.6	0.0%
NO	Søndre Storavatn	ROGISST	137	0	01/09/91	L-N2a	7.0	2.0	0.0%
NO	Vatnevatnet	MROIVAT	176	0	24/07/88	L-N2a	8.0	3.3	17.1%
NO	Vatnevatnet	MROIVAT	176	0	25/07/89	L-N2a	7.0	3.5	14.5%
NO	Vatnevatnet	MROIVAT	176	0	30/07/91	L-N2a	18.0	7.2	0.6%
NO	Vatnevatnet	MROIVAT	176	0	05/09/91	L-N2a	9.0	2.0	0.0%
NO	Vatsvatn	ROGIVAT	135	0	20/07/89	L-N2a	14.0	14.1	10.4%
NO	Vatsvatn	ROGIVAT	135	0	21/08/89	L-N2a	18.0	4.5	0.0%
NO	Vatsvatn	ROGIVAT	135	0	28/07/91	L-N2a	9.0	5.7	9.9%
NO	Vatsvatn	ROGIVAT	135	0	01/09/91	L-N2a	8.0	16.2	0.0%
NO	Bilstadvatnet	ROGIBIL	46	0	19/07/88	L-N2b	7.0	5.2	0.0%
NO	Bilstadvatnet	ROGIBIL	46	0	20/08/88	L-N2b	11.0	4.6	4.8%
NO	Bjørkedalsvatnet	MROIBJØ	175	0	24/07/88	L-N2b	8.0	5.6	13.0%
NO	Bjørkedalsvatnet	MROIBJØ	175	0	25/07/89	L-N2b	19.0	4.0	4.9%
NO	Bjørkedalsvatnet	MROIBJØ	175	0	31/08/89	L-N2b	12.0	8.7	0.0%

NO	Bjørkedalsvatnet	MROIBJØ	175	0	05/09/91	L-N2b	7.0	5.9	0.0%
NO	Emhjellevatnet	SFJIEMH	165	0	23/07/88	L-N2b	10.0	9.5	5.1%
NO	Emhjellevatnet	SFJIEMH	165	0	21/08/88	L-N2b	7.0	5.6	12.0%
NO	Espelandsvatnet	SFJIESP	153	0	22/07/88	L-N2b	16.0	8.7	39.9%
NO	Espelandsvatnet	SFJIESP	153	0	19/08/88	L-N2b	8.0	5.7	0.0%
NO	Flubegfjorden, Randsfjorden	OPPIFLU	1557	0	23/08/88	L-N2b	12.0	3.8	0.0%
NO	Flubegfjorden, Randsfjorden	OPPIFLU	1557	0	17/07/89	L-N2b	21.0	5.9	0.0%
NO	Flubegfjorden, Randsfjorden	OPPIFLU	1557	0	21/08/90	L-N2b	10.0	5.1	41.1%
NO	Flubegfjorden, Randsfjorden	OPPIFLU	1557	0	08/07/91	L-N2b	15.0	15.4	83.7%
NO	Gjerdesdalsvatnet	ROGIGJE	134	0	19/07/88	L-N2b	27.0	20.7	81.0%
NO	Gjerdesdalsvatnet	ROGIGJE	134	0	16/08/88	L-N2b	8.0	5.3	11.7%
NO	Grungstadvatnet	NTRIGRU	232	0	28/07/88	L-N2b	11.0	5.3	1.0%
NO	Grungstadvatnet	NTRIGRU	232	0	01/07/89	L-N2b	21.0	6.2	0.7%
NO	Grungstadvatnet	NTRIGRU	232	0	04/07/91	L-N2b	13.0	9.6	1.4%
NO	Grungstadvatnet	NTRIGRU	232	0	05/08/91	L-N2b	20.0	11.9	0.5%
NO	Kviteseidvatn	TELIKVI	119	0	17/07/88	L-N2b	10.0	2.3	0.7%
NO	Kviteseidvatn	TELIKVI	119	0	14/08/88	L-N2b	5.0	2.9	5.2%
NO	Lykkjebøvatnet	SFJILYK	164	0	23/07/88	L-N2b	9.0	2.5	0.0%
NO	Lykkjebøvatnet	SFJILYK	164	0	21/08/88	L-N2b	9.0	3.7	1.0%
NO	Lyseren	AKEILYS	306	0	06/08/88	L-N2b	14.0	7.4	0.5%
NO	Lyseren	AKEILYS	306	0	18/09/88	L-N2b	16.0	7.9	1.7%
NO	Lyseren	AKEILYS	306	0	25/07/00	L-N2b	15.5	4.3	0.3%
NO	Lyseren	AKEILYS	306	0	16/08/00	L-N2b	10.0	2.1	2.7%
NO	Oldevatnet	SFJIOLD	171	0	24/07/88	L-N2b	10.0	6.2	8.8%
NO	Oldevatnet	SFJIOLD	171	0	21/08/88	L-N2b	4.0	1.3	0.5%
NO	Øvre Øydnavatnet	VAGIØØY	35	0	19/07/88	L-N2b	6.0	2.7	0.5%
NO	Øvre Øydnavatnet	VAGIØØY	35	0	20/08/88	L-N2b	4.0	3.2	0.0%
NO	Øvre Øydnavatnet	VAGIØØY	35	0	26/07/91	L-N2b	5.0	2.5	0.5%
NO	Øvre Øydnavatnet	VAGIØØY	35	0	30/08/91	L-N2b	9.0	2.6	2.2%
NO	Rovatnet	STRIROV	206	0	25/07/88	L-N2b	4.0	2.1	0.0%
NO	Rovatnet	STRIROV	206	0	27/07/89	L-N2b	17.0	12.6	0.4%
NO	Rovatnet	STRIROV	206	0	02/09/89	L-N2b	10.0	13.6	0.7%
NO	Rovatnet	STRIROV	206	0	01/08/91	L-N2b	13.0	4.9	1.0%
NO	Selbusjøen	STRISEL	221	0	02/07/88	L-N2b	27.0	26.6	0.0%
NO	Selbusjøen	STRISEL	221	0	26/07/88	L-N2b	21.0	13.0	45.4%
NO	Selbusjøen	STRISEL	221	0	22/08/88	L-N2b	11.5	12.1	15.2%
NO	Strandavatnet	SFJIMYK	156	0	22/07/88	L-N2b	11.0	14.3	15.2%
NO	Strandavatnet	SFJIMYK	156	0	20/08/88	L-N2b	7.0	1.6	0.3%
NO	Tarvatnet	VAGITAR	33	0	19/08/88	L-N2b	37.0	5.5	0.1%
NO	Tarvatnet	VAGITAR	33	0	19/07/89	L-N2b	6.0	9.0	20.2%
NO	Tarvatnet	VAGITAR	33	0	20/08/89	L-N2b	20.0	12.2	0.9%
NO	Tarvatnet	VAGITAR	33	0	26/07/91	L-N2b	16.0	17.6	52.1%
NO	Tveitavatnet	HORITVE	151	0	21/07/88	L-N2b	37.0	5.0	0.1%
NO	Tveitavatnet	HORITVE	151	0	19/08/88	L-N2b	19.0	9.3	5.7%
NO	Tyrifjorden	BUSITYR	107	0	25/07/88	L-N2b	5.0	8.0	0.0%
NO	Tyrifjorden	BUSITYR	107	0	26/08/88	L-N2b	17.8	23.9	2.8%
NO	Vigdarvatnet	HORIVIG	140	0	20/07/88	L-N2b	8.3	6.8	0.0%
NO	Vigdarvatnet	HORIVIG	140	0	17/08/88	L-N2b	21.2	10.1	4.2%
NO	Vostervatnet	ROGIVOS	65	0	22/08/88	L-N2b	20.0	7.1	0.0%
NO	Vostervatnet	ROGIVOS	65	0	19/07/89	L-N2b	16.0	5.2	2.5%
NO	Vostervatnet	ROGIVOS	65	0	21/08/89	L-N2b	24.0	15.8	2.4%
NO	Vostervatnet	ROGIVOS	65	0	28/07/91	L-N2b	28.0	4.7	0.0%
NO	Ytre Øydnavatnet	VAGIYØY	34	0	19/07/88	L-N2b	38.0	15.1	28.3%
NO	Ytre Øydnavatnet	VAGIYØY	34	0	19/07/89	L-N2b	34.0	8.0	11.4%
NO	Ytre Øydnavatnet	VAGIYØY	34	0	26/07/91	L-N2b	13.0	2.1	4.2%
NO	Ytre Øydnavatnet	VAGIYØY	34	0	30/08/91	L-N2b	7.0	1.5	19.7%
SE	Allgjuttern			0	(august)	L-N2	4.5	0.8	2.2%
SE	Bysjön			0	(august)	L-N2	6.5	1.7	3.0%

SE	Gopen			0	(august)	L-N2	4.0	1.0	0.0%
SE	Härsvatten			0	(august)	L-N2	2.0	0.8	0.1%
SE	Hökesjön			0	(august)	L-N2	7.0	1.2	0.2%
SE	Humsjön			0	(august)	L-N2	3.0	0.8	0.4%
SE	Lilla Öresjön			0	(august)	L-N2	2.0	0.7	0.0%
SE	Lillesjö			0	(august)	L-N2	5.0	1.1	0.0%
SE	Mäsen			0	(august)	L-N2	6.5	1.8	1.7%
SE	Rogsjön			0	(august)	L-N2	5.0	2.6	3.3%
SE	Sännen			0	(august)	L-N2	13.0	3.3	3.5%
SE	Skärsjön			0	(august)	L-N2	8.0	2.1	19.6%
SE	SKURDALSSJÖN			0	(august)	L-N2	8.0	2.6	0.0%
SE	Spjutsjön			0	(august)	L-N2	7.0	2.4	7.9%
SE	St Skärsjön			0	(august)	L-N2	7.0	2.0	5.8%
SE	Tängersjö			0	(august)	L-N2	7.0	2.4	2.9%
SE	Västra Solsjön			0	(august)	L-N2	4.0	0.7	3.4%
SE	Bysjön	1044	1	0	21/08/01	L-N2a	3.0	1.5	0.5%
SE	Bysjön	1044	1	0	20/08/02	L-N2a	6.0	1.3	1.7%
SE	Bysjön	1044	1	0	27/08/03	L-N2a	4.0	0.9	0.4%
SE	Dagarn	1048	1	0	14/08/01	L-N2a	5.0	1.6	3.7%
SE	Dagarn	1048	1	0	11/08/02	L-N2a	5.0	1.6	1.5%
SE	Dagarn	1048	1	0	12/08/03	L-N2a	3.0	0.8	0.0%
SE	Gryten	1102	1	0	14/08/01	L-N2a	6.5	1.5	2.0%
SE	Gryten	1102	1	0	19/08/02	L-N2a	6.0	3.3	2.1%
SE	Gryten	1102	1	0	25/08/03	L-N2a	9.0	2.0	16.8%
SE	Hökesjön	1061	1	0	21/08/02	L-N2a	6.5	5.1	3.0%
SE	Hökesjön	1061	1	0	18/08/03	L-N2a	9.0	4.4	5.3%
SE	Lilla Öresjön	1022	1	0	12/08/02	L-N2a	6.0	2.8	2.0%
SE	Lilla Öresjön	1022	1	0	12/08/03	L-N2a	9.0	4.4	3.7%
SE	Siggeforasjön	959	1	0	09/08/01	L-N2a	5.0	3.5	1.8%
SE	Siggeforasjön	959	1	0	12/08/02	L-N2a	5.0	2.3	3.8%
SE	Siggeforasjön	959	1	0	29/08/03	L-N2a	7.0	4.3	3.0%
SE	Skärsjön	967	1	0	06/08/01	L-N2a	5.0	1.9	0.1%
SE	Skärsjön	967	1	0	20/08/02	L-N2a	6.0	1.9	0.5%
SE	Skärsjön	967	1	0	11/08/03	L-N2a	6.0	3.6	1.6%
SE	Täftesträsket	1100	1	0	14/08/01	L-N2a	3.0	1.0	0.9%
SE	Täftesträsket	1100	1	0	12/08/02	L-N2a	11.0	2.7	15.6%
SE	Täftesträsket	1100	1	0	12/08/03	L-N2a	4.0	1.5	1.8%
SE	Valasjön	964	1	0	20/08/02	L-N2a	6.0	2.3	3.1%
UK	Bassenthwaite Lake	UK28847		0	15/07/04	L-N2a	6.0	2.0	3.0%
UK	Bassenthwaite Lake	UK28847		0	15/09/04	L-N2a	5.0	2.9	4.3%
UK	Bassenthwaite Lake	UK28847		0	15/07/05	L-N2a	11.0	3.1	6.3%
UK	Bassenthwaite Lake	UK28847		0	15/09/05	L-N2a	5.0	1.3	0.0%
UK	Derwent Water	UK28965		0	15/08/04	L-N2a	3.0	1.7	0.0%
UK	Derwent Water	28965	1	0	31/08/04	L-N2a	4.0	2.0	0.0%
UK	Derwent Water	UK28965		0	15/07/05	L-N2a	0.5	1.2	0.0%
UK	Derwent Water	UK28965		0	15/09/05	L-N2a	3.0	0.2	0.0%
UK	Grasmere	UK29184		0	15/07/04	L-N2a	3.0	1.3	2.4%
UK	Grasmere	UK29184		0	15/08/04	L-N2a	4.0	2.4	0.0%
UK	Grasmere	UK29184		0	15/07/05	L-N2a	7.0	2.4	0.0%
UK	Grasmere	UK29184		0	15/09/05	L-N2a	8.0	0.9	0.0%
UK	Llyn Padarn	UK33730		0	15/07/04	L-N2a	4.0	1.4	0.0%
UK	Llyn Padarn	33730	1	0	30/07/04	L-N2a	6.0	3.7	0.0%
UK	Llyn Padarn	UK33730		0	15/08/04	L-N2a	5.0	2.0	0.0%
UK	Llyn Padarn	UK33730		0	15/08/05	L-N2a	4.0	3.7	0.5%
UK	Loch Brora	UK11611		0	15/08/04	L-N2a	4.0	1.1	0.0%
UK	Loweswater	UK28986		0	15/08/04	L-N2a	5.0	1.2	0.0%
UK	Loweswater	UK28986		0	15/09/04	L-N2a	10.0	1.9	0.0%
UK	Loweswater	UK28986		0	15/07/05	L-N2a	6.0	2.0	0.0%

UK	Loweswater	UK28986		0	15/09/05	L-N2a	5.0	1.2	0.0%
UK	Coniston Water	UK29321		0	15/07/04	L-N2b	5.0	2.3	0.0%
UK	Coniston Water	UK29321		0	15/08/04	L-N2b	12.0	5.0	0.0%
UK	Coniston Water	UK29321		0	15/09/04	L-N2b	7.0	2.2	0.0%
UK	Coniston Water	UK29321		0	15/07/05	L-N2b	5.0	2.4	0.0%
UK	Coniston Water	UK29321		0	15/09/05	L-N2b	6.0	2.5	0.0%
UK	Ennerdale Water	29062	1	0	20/08/04	L-N2b	5.0	2.1	0.0%
UK	Ennerdale Water	29062	1	0	16/09/04	L-N2b	3.0	1.1	0.0%
UK	Llyn Cwellyn	UK34002		0	15/07/04	L-N2b	2.0	0.6	0.0%
UK	Llyn Cwellyn	34002	1	0	16/07/04	L-N2b	4.0	1.2	0.0%
UK	Llyn Cwellyn	UK34002		0	15/08/04	L-N2b	7.0	1.9	0.0%
UK	Llyn Cwellyn	34002	1	0	10/09/04	L-N2b	6.0	2.8	0.0%
UK	Llyn Cwellyn	UK34002		0	15/09/04	L-N2b	3.0	1.8	0.2%
UK	Llyn Cwellyn	UK34002		0	15/08/05	L-N2b	3.0	0.9	0.0%
UK	Llyn Tegid or Bala Lake	UK34987		0	15/08/04	L-N2b	8.0	1.4	0.0%
UK	Llyn Tegid or Bala Lake	UK34987		0	15/09/04	L-N2b	7.0	3.3	0.0%
UK	Llyn Tegid or Bala Lake	UK34987		0	15/08/05	L-N2b	4.0	1.2	0.0%
UK	Thirlmere	UK29021		0	15/09/04	L-N2b	6.0	2.7	0.1%
UK	Thirlmere	UK29021		0	15/07/05	L-N2b	4.0	1.2	0.0%
UK	Thirlmere	UK29021		0	15/09/05	L-N2b	7.0	3.3	1.0%
IE	Lough Doo MO	IEWE_32_490		1	15/08/05	L-N2	5.0	1.5	0.0%
IE	Lough Easky	IEWE_32_136		1	15/07/05	L-N2	4.0	1.7	0.0%
IE	Lough Veagh	IEZZ_00_018		1	15/07/05	L-N2	7.0	1.9	0.0%
FI	Ala-Keitele (N60+99.50)	14884	25448	1	10/07/95	L-N2a	3.0	0.9	0.0%
FI	Ala-Keitele (N60+99.50)	14884	25448	1	13/07/98	L-N2a	9.0	2.5	0.0%
FI	Ala-Keitele (N60+99.50)	14884	25448	1	10/07/00	L-N2a	8.0	2.1	0.1%
FI	Enonvesi (Saimaa N60+75.80)	3911	14077	1	05/07/01	L-N2a	3.0	3.3	11.4%
FI	Höytiäinen	10873	23819	1	13/07/95	L-N2a	5.0	3.0	0.0%
FI	Höytiäinen	10873	23819	1	15/07/97	L-N2a	6.0	2.2	0.0%
FI	Höytiäinen	10873	23819	1	07/07/99	L-N2a	7.0	4.3	0.0%
FI	Inarijärvi l. Anarjävri	47221	39162	1	12/07/94	L-N2a	7.0	5.8	0.1%
FI	Inarijärvi l. Anarjävri	47221	39162	1	02/08/94	L-N2a	8.0	1.6	0.0%
FI	Inarijärvi l. Anarjävri	47221	39162	1	11/07/00	L-N2a	3.0	1.2	0.5%
FI	Inarijärvi l. Anarjävri	47221	39173	1	13/07/00	L-N2a	5.7	3.9	5.9%
FI	Inarijärvi l. Anarjävri	47221	39203	1	14/07/93	L-N2a	6.0	2.4	0.0%
FI	Inarijärvi l. Anarjävri	47221	39203	1	12/07/94	L-N2a	10.0	2.2	0.1%
FI	Inarijärvi l. Anarjävri	47221	39203	1	03/08/94	L-N2a	6.0	3.7	0.0%
FI	Inarijärvi l. Anarjävri	47221	39203	1	28/07/97	L-N2a	5.0	2.7	0.0%
FI	Juojärvi	10261	19842	1	14/07/98	L-N2a	6.0	2.7	0.0%
FI	Kermajärvi	5264	14350	1	11/07/95	L-N2a	7.0	2.4	0.0%
FI	Kermajärvi	5264	14350	1	09/07/97	L-N2a	10.0	3.1	0.0%
FI	Kermajärvi	5264	14350	1	10/07/01	L-N2a	40.0	3.3	2.0%
FI	Konnevesi	16518	26012	1	13/07/93	L-N2a	15.0	1.9	0.4%
FI	Konnevesi	16518	26012	1	12/07/94	L-N2a	8.0	2.2	0.0%
FI	Konnevesi	16518	26012	1	08/07/98	L-N2a	6.0	4.6	0.0%
FI	Konnevesi	16518	26012	1	10/07/00	L-N2a	3.0	1.4	1.2%
FI	Kuolimo	2671	10748	1	12/07/95	L-N2a	5.0	3.2	0.0%
FI	Kuolimo	2671	10748	1	08/07/97	L-N2a	7.0	3.5	0.0%
FI	Kuorinka	5940	22231	1	09/07/01	L-N2a	0.8	3.2	2.0%
FI	Kynsivesi-Leivonvesi	14683	25263	1	09/07/00	L-N2a	6.0	2.5	0.0%
FI	Pihlajavesi (Saimaa)	1930	13265	1	17/07/01	L-N2a	10.0	4.5	0.0%
FI	Puruvesi (Saimaa)	3465	13807	1	14/07/94	L-N2a	9.0	1.5	0.0%
FI	Puruvesi (Saimaa)	3465	13807	1	04/08/94	L-N2a	4.0	2.1	0.0%
FI	Puruvesi (Saimaa)	3465	13807	1	07/07/97	L-N2a	6.0	2.1	0.0%
FI	Puruvesi (Saimaa)	3465	13807	1	12/07/01	L-N2a	3.0	2.5	0.0%
FI	Puula	18027	15125	1	17/07/96	L-N2a	8.0	1.9	0.0%
FI	Puula	18027	15125	1	08/07/97	L-N2a	4.0	3.1	0.0%
FI	Puula	18027	15125	1	16/07/01	L-N2a	12.0	4.1	1.8%

FI	Pyhäjärvi	16469	26000	1	10/07/95	L-N2a	2.0	0.5	0.0%
FI	Pyhäjärvi	16469	26000	1	14/07/98	L-N2a	6.0	3.0	0.0%
FI	Pyhäjärvi	16469	26000	1	09/07/00	L-N2a	6.0	2.2	0.0%
FI	Pyhäjärvi	26059	27328	1	12/07/93	L-N2a	10.0	1.5	0.0%
FI	Pyhäjärvi	26059	27328	1	11/07/95	L-N2a	3.0	1.8	0.0%
FI	Pyhäjärvi	26059	27328	1	14/07/98	L-N2a	5.0	6.2	1.5%
FI	Pyhäjärvi	26059	27328	1	08/07/02	L-N2a	11.5	2.6	7.6%
FI	Suontee (N60 94.10)	17660	14849	1	17/07/96	L-N2a	4.0	2.0	0.0%
FI	Suontee (N60 94.10)	17660	14849	1	08/07/97	L-N2a	4.0	4.2	0.0%
FI	Suontee (N60 94.10)	17660	14849	1	16/07/01	L-N2a	16.0	5.6	2.0%
NO	Breidflå	AAGIBRE	27	1	18/07/88	L-N2a	19.0	7.1	9.6%
NO	Breidflå	AAGIBRE	27	1	19/08/88	L-N2a	13.0	1.2	0.0%
NO	Eidsvatnet	NTRIEID	231	1	03/07/88	L-N2a	3.0	1.6	0.1%
NO	Eidsvatnet	NTRIEID	231	1	23/08/88	L-N2a	6.0	3.8	0.0%
NO	Eidsvatnet	NTRIEID	231	1	01/07/89	L-N2a	5.0	3.6	0.0%
NO	Eidsvatnet	NTRIEID	231	1	05/08/91	L-N2a	16.5	3.1	0.0%
NO	Fetvatnet	MROIFET	183	1	01/07/88	L-N2a	12.0	3.2	1.1%
NO	Fetvatnet	MROIFET	183	1	25/07/88	L-N2a	3.0	2.0	0.0%
NO	Fetvatnet	MROIFET	183	1	23/08/88	L-N2a	5.0	1.8	0.0%
NO	Fotlandsvatnet	ROGIFLA	47	1	20/07/88	L-N2a	2.0	1.8	0.0%
NO	Fotlandsvatnet	ROGIFLA	47	1	21/08/88	L-N2a	11.0	5.4	0.7%
NO	Gagnåsvatnet	STRIGAG	213	1	25/07/88	L-N2a	7.0	5.9	0.0%
NO	Gagnåsvatnet	STRIGAG	213	1	21/08/88	L-N2a	4.0	1.2	0.0%
NO	Hafstadvatnet	MROIHAF	205	1	24/07/88	L-N2a	6.0	1.5	0.0%
NO	Hafstadvatnet	MROIHAF	205	1	20/08/88	L-N2a	11.0	5.8	2.2%
NO	Hanemsvatnet	MROIHAN	204	1	20/08/88	L-N2a	4.0	1.1	0.0%
NO	Hanemsvatnet	MROIHAN	204	1	26/07/89	L-N2a	4.0	1.8	0.0%
NO	Hanemsvatnet	MROIHAN	204	1	01/09/89	L-N2a	10.0	3.9	16.3%
NO	Hanemsvatnet	MROIHAN	204	1	31/07/91	L-N2a	6.0	9.7	15.2%
NO	Hetlandsvatnet	ROGIHET	66	1	21/07/88	L-N2a	8.0	4.1	3.2%
NO	Hetlandsvatnet	ROGIHET	66	1	22/08/88	L-N2a	3.0	1.2	0.0%
NO	Hetlandsvatnet	ROGIHET	66	1	21/08/89	L-N2a	10.0	5.8	12.1%
NO	Hetlandsvatnet	ROGIHET	66	1	01/09/91	L-N2a	5.0	3.0	0.3%
NO	Hjartsjåvatnet	TELIHJA	117	1	17/07/88	L-N2a	8.0	4.7	10.1%
NO	Hjartsjåvatnet	TELIHJA	117	1	14/08/88	L-N2a	10.0	6.5	0.0%
NO	Kvitebergsvatnet	HORIKVI	143	1	20/07/88	L-N2a	11.0	6.4	0.0%
NO	Kvitebergsvatnet	HORIKVI	143	1	17/08/88	L-N2a	10.0	3.4	0.0%
NO	Langvatnet ved Sulitjelma	NORILAS	243	1	12/07/88	L-N2a	20.0	2.3	0.0%
NO	Langvatnet ved Sulitjelma	NORILAS	243	1	04/08/88	L-N2a	8.0	4.9	0.0%
NO	Langvatnet ved Sulitjelma	NORILAS	243	1	31/08/88	L-N2a	6.0	2.2	0.0%
NO	Leksdalsvatnet	NTRILEK	226	1	13/07/88	L-N2a	8.0	5.3	0.5%
NO	Leksdalsvatnet	NTRILEK	226	1	04/08/88	L-N2a	37.0	1.7	0.0%
NO	Leksdalsvatnet	NTRILEK	226	1	31/08/88	L-N2a	3.0	0.7	0.0%
NO	Lønavatnet	HORILØN	73	1	22/07/88	L-N2a	7.0	5.4	0.6%
NO	Lønavatnet	HORILØN	73	1	23/08/88	L-N2a	17.0	3.2	62.6%
NO	Lysvatnet	TROILYS	269	1	09/07/88	L-N2a	6.0	2.1	1.5%
NO	Lysvatnet	TROILYS	269	1	01/08/88	L-N2a	21.0	7.7	3.9%
NO	Lysvatnet	TROILYS	269	1	28/08/88	L-N2a	6.0	2.2	0.0%
NO	Nøklevann	OSLINØK	311	1	16/07/88	L-N2a	10.0	2.1	0.0%
NO	Nøklevann	OSLINØK	311	1	17/08/88	L-N2a	4.0	1.9	0.0%
NO	Nøklevann	OSLINØK	311	1	18/09/88	L-N2a	12.0	3.5	1.1%
NO	Nøklevann	OSLINØK	311	1	24/07/00	L-N2a	1.3	2.6	2.1%
NO	Nome	TELINOM	113	1	16/07/88	L-N2a	6.0	2.4	0.0%
NO	Nome	TELINOM	113	1	13/08/88	L-N2a	14.0	2.8	0.0%
NO	Nordre Storavatn	HORINST	142	1	20/07/88	L-N2a	10.0	4.0	0.0%
NO	Nordre Storavatn	HORINST	142	1	17/08/88	L-N2a	7.0	3.1	0.0%
NO	Nordre Storavatnet	ROGINST	136	1	20/07/89	L-N2a	14.0	2.2	0.0%
NO	Nordre Storavatnet	ROGINST	136	1	22/08/89	L-N2a	12.0	9.0	10.1%

NO	Nordre Storavatnet	ROGINST	136	1	01/09/91	L-N2a	6.0	5.5	0.0%
NO	Nordre Storavatnet	ROGINST	136	1	14/08/96	L-N2a	1.3	3.0	27.0%
NO	Øyvatnet	NTRIØYV	233	1	03/07/88	L-N2a	2.0	2.4	0.0%
NO	Øyvatnet	NTRIØYV	233	1	27/07/88	L-N2a	8.0	6.2	4.5%
NO	Øyvatnet	NTRIØYV	233	1	23/08/88	L-N2a	5.0	2.3	0.1%
NO	Rotevatnet	MROIROT	177	1	24/07/88	L-N2a	6.0	3.0	0.0%
NO	Rotevatnet	MROIROT	177	1	22/08/88	L-N2a	3.0	1.2	0.0%
NO	Sigernessjøen	HEDISIG	315	1	07/08/88	L-N2a	19.0	3.8	0.0%
NO	Sigernessjøen	HEDISIG	315	1	03/09/88	L-N2a	3.0	1.8	0.0%
NO	Sigernessjøen	HEDISIG	315	1	24/07/89	L-N2a	5.0	2.1	0.0%
NO	Sigernessjøen	HEDISIG	315	1	28/08/91	L-N2a	25.0	8.7	9.2%
NO	Skagestadvatnet	VAGISKA	32	1	18/07/88	L-N2a	13.0	2.9	0.0%
NO	Skagestadvatnet	VAGISKA	32	1	19/08/88	L-N2a	6.0	2.7	0.3%
NO	Skogsfjordvatnet	TROISKO	276	1	02/08/88	L-N2a	15.0	2.7	0.0%
NO	Skogsfjordvatnet	TROISKO	276	1	29/08/88	L-N2a	6.0	1.3	0.0%
NO	Snipsøyrvatnet	MROISNI	178	1	22/08/88	L-N2a	4.0	7.2	0.0%
NO	Snipsøyrvatnet	MROISNI	178	1	25/07/89	L-N2a	4.0	1.5	0.0%
NO	Snipsøyrvatnet	MROISNI	178	1	31/08/89	L-N2a	28.0	4.3	11.2%
NO	Snipsøyrvatnet	MROISNI	178	1	30/07/91	L-N2a	10.0	3.9	16.3%
NO	Søndre Storavatn	HORISST	141	1	20/07/88	L-N2a	8.0	3.9	0.0%
NO	Søndre Storavatn	HORISST	141	1	17/08/88	L-N2a	20.0	24.6	52.3%
NO	Stølsvatnet	MROISTØ	203	1	24/07/88	L-N2a	13.0	6.4	12.3%
NO	Stølsvatnet	MROISTØ	203	1	20/08/88	L-N2a	5.5	0.8	0.0%
NO	Svelavatnet	ROGISVE	48	1	20/07/88	L-N2a	11.0	5.0	0.0%
NO	Svelavatnet	ROGISVE	48	1	21/08/88	L-N2a	6.0	4.9	0.0%
SE	Västra Solsjön	1127	1	1	27/08/01	L-N2a	7.0	3.6	0.0%
SE	Västra Solsjön	1127	1	1	15/08/02	L-N2a	18.0	6.1	7.3%
SE	Västra Solsjön	1127	1	1	11/08/03	L-N2a	5.0	2.4	0.0%
UK	Loch Druidibeag	UK18682		1	15/08/04	L-N2a	28.0	6.5	18.0%
UK	Loch Lubnaig	UK24459		1	15/08/03	L-N2a	14.3	3.0	0.0%
UK	Loch Meadie	UK5222		1	15/07/04	L-N2a	15.0	10.0	0.0%
UK	Loch Naver	UK6405		1	15/07/04	L-N2a	102.0	2.6	0.0%
UK	Loch Osgaig	UK11189		1	15/09/03	L-N2a	20.1	7.1	2.4%
UK	Loch Stack	UK5350		1	15/07/04	L-N2a	25.0	4.2	0.0%
FI	Saimaa	1069	10379	1	01/08/96	L-N2b	8.0	7.5	5.7%
FI	Saimaa	1069	10379	1	22/08/96	L-N2b	5.0	2.9	7.4%
FI	Saimaa	1069	10379	1	12/07/99	L-N2b	5.0	2.6	12.4%
FI	Saimaa	1069	10379	1	10/07/00	L-N2b	5.0	2.1	24.7%
FI	Saimaa	1069	10407	1	14/07/94	L-N2b	4.0	1.8	5.4%
FI	Saimaa	1069	10407	1	08/07/97	L-N2b	7.0	2.0	5.0%
FI	Saimaa	1069	13021	1	10/07/01	L-N2b	7.0	3.8	3.8%
FI	Saimaa	1069	13136	1	10/07/97	L-N2b	7.0	2.0	0.6%
FI	Saimaa	1069	13136	1	18/07/01	L-N2b	5.0	2.4	1.3%
FI	Vuohijärvi	17772	12105	1	13/07/94	L-N2b	8.0	1.8	2.1%
FI	Vuohijärvi	17772	12105	1	11/07/95	L-N2b	7.0	2.7	9.3%
FI	Vuohijärvi	17772	12105	1	09/07/96	L-N2b	7.0	2.0	0.5%
FI	Vuohijärvi	17772	12105	1	07/07/97	L-N2b	5.0	1.0	0.4%
NO	Aksdalsvatnet	ROGIASK	138	1	20/07/88	L-N2b	7.0	1.6	0.0%
NO	Aksdalsvatnet	ROGIASK	138	1	16/08/88	L-N2b	5.0	2.1	0.0%
NO	Aksdalsvatnet	ROGIASK	138	1	28/07/91	L-N2b	5.0	1.7	0.0%
NO	Aksdalsvatnet	ROGIASK	138	1	01/09/91	L-N2b	5.0	5.6	0.0%
NO	Årdalsvatnet, hovedstasjon	SFJIÅRD	79	1	23/07/88	L-N2b	7.0	1.9	0.0%
NO	Årdalsvatnet, hovedstasjon	SFJIÅRD	79	1	24/08/88	L-N2b	7.0	1.4	0.0%
NO	Askevatnet	HORIASK	149	1	21/07/88	L-N2b	2.0	1.8	0.0%
NO	Askevatnet	HORIASK	149	1	18/08/88	L-N2b	3.0	1.3	0.0%
NO	Bandak	TELIBAN	123	1	18/07/88	L-N2b	5.0	1.8	0.0%
NO	Bandak	TELIBAN	123	1	15/08/88	L-N2b	5.0	1.8	0.0%
NO	Barstadvatnet	ROGIBAR	45	1	19/07/88	L-N2b	6.0	1.5	0.0%

NO	Barstadvatnet	ROGIBAR	45	1	20/08/88	L-N2b	6.0	2.6	0.0%
NO	Bjøreimsvatnet	ROGIBJØ	64	1	21/07/88	L-N2b	4.0	1.6	0.6%
NO	Bjøreimsvatnet	ROGIBJØ	64	1	22/08/88	L-N2b	7.0	1.7	0.2%
NO	Breimsvatnet	SFJIBRE	169	1	24/07/88	L-N2b	5.0	1.3	0.0%
NO	Breimsvatnet	SFJIBRE	169	1	21/08/88	L-N2b	5.0	2.7	0.0%
NO	Brusdalsvatnet	MROIBRU	180	1	25/07/88	L-N2b	4.0	1.2	0.0%
NO	Brusdalsvatnet	MROIBRU	180	1	20/08/88	L-N2b	3.0	0.9	0.0%
NO	Byrkjelandsvatnet	ROGIBYR	50	1	20/07/88	L-N2b	4.0	0.9	0.0%
NO	Byrkjelandsvatnet	ROGIBYR	50	1	21/08/88	L-N2b	6.0	2.1	0.0%
NO	Eidsfjordvatnet	HORIEID	69	1	22/07/88	L-N2b	5.0	1.2	0.0%
NO	Eidsfjordvatnet	HORIEID	69	1	23/08/88	L-N2b	5.0	0.8	0.0%
NO	Eidsvatnet	ROGIEID	44	1	19/07/88	L-N2b	10.0	1.4	0.0%
NO	Eidsvatnet	ROGIEID	44	1	20/08/88	L-N2b	13.0	1.4	0.0%
NO	Endestadvatnet	SFJIEND	163	1	23/07/88	L-N2b	7.0	4.3	0.0%
NO	Endestadvatnet	SFJIEND	163	1	21/08/88	L-N2b	7.0	3.6	0.0%
NO	Engsetvatnet	MROIENG	181	1	25/07/88	L-N2b	5.0	1.9	0.0%
NO	Engsetvatnet	MROIENG	181	1	31/08/89	L-N2b	6.0	2.6	0.0%
NO	Engsetvatnet	MROIENG	181	1	05/09/91	L-N2b	6.0	2.9	0.0%
NO	Engsetvatnet	MROIENG	181	1	21/08/96	L-N2b	3.0	1.4	0.0%
NO	Espedalsvatnet	ROGIESP	63	1	21/07/88	L-N2b	3.0	0.4	0.0%
NO	Espedalsvatnet	ROGIESP	63	1	22/08/88	L-N2b	5.0	0.6	0.0%
NO	Evangervatnet	HORIEVA	71	1	22/07/88	L-N2b	6.0	2.7	0.0%
NO	Evangervatnet	HORIEVA	71	1	23/08/88	L-N2b	7.0	2.3	0.0%
NO	Flåvatnet	TELIFLÅ	115	1	17/07/88	L-N2b	8.0	2.8	0.0%
NO	Flåvatnet	TELIFLÅ	115	1	14/08/88	L-N2b	2.0	2.1	0.0%
NO	Fustvatnet	NORIFUS	240	1	05/07/88	L-N2b	3.0	1.2	0.0%
NO	Fustvatnet	NORIFUS	240	1	29/07/88	L-N2b	3.0	1.2	0.0%
NO	Fustvatnet	NORIFUS	240	1	24/08/88	L-N2b	2.0	1.6	0.0%
NO	Gjønavatnet	HORIGJØ	146	1	21/07/88	L-N2b	2.0	1.2	0.0%
NO	Gjønavatnet	HORIGJØ	146	1	18/08/88	L-N2b	3.0	1.9	0.0%
NO	Granvinvatnet	HORIGRA	70	1	22/07/88	L-N2b	7.0	1.8	0.0%
NO	Granvinvatnet	HORIGRA	70	1	23/08/88	L-N2b	8.0	2.7	0.0%
NO	Hæstadfjorden	SFJIHÆS	157	1	22/07/88	L-N2b	5.0	1.4	0.0%
NO	Hæstadfjorden	SFJIHÆS	157	1	20/08/88	L-N2b	5.0	2.4	0.0%
NO	Hafslovatnet	SFJIHAF	77	1	23/07/88	L-N2b	7.0	1.5	0.0%
NO	Hafslovatnet	SFJIHAF	77	1	23/08/88	L-N2b	7.0	0.8	0.0%
NO	Henangervatn	HORIHEN	144	1	21/07/88	L-N2b	6.0	2.4	0.0%
NO	Henangervatn	HORIHEN	144	1	18/08/88	L-N2b	10.0	3.7	0.6%
NO	Hofreistævatnet	ROGIHOF	49	1	20/07/88	L-N2b	4.0	1.1	0.0%
NO	Hofreistævatnet	ROGIHOF	49	1	21/08/88	L-N2b	1.0	1.6	0.0%
NO	Holsavatnet	SFJIHOL	161	1	23/07/88	L-N2b	6.0	2.6	0.0%
NO	Holsavatnet	SFJIHOL	161	1	20/08/88	L-N2b	7.0	2.8	0.0%
NO	Hornindalsvatnet	SFJIHOR	174	1	24/07/88	L-N2b	2.0	1.2	0.0%
NO	Hornindalsvatnet	SFJIHOR	174	1	22/08/88	L-N2b	2.0	1.2	0.0%
NO	Hovlandsdalsvatnet	SFJIHOD	154	1	22/07/88	L-N2b	8.0	2.4	0.0%
NO	Hovlandsdalsvatnet	SFJIHOD	154	1	19/08/88	L-N2b	8.0	3.1	0.0%
NO	Hovlandsvatnet	SFJIHOV	155	1	22/07/88	L-N2b	8.0	2.0	0.0%
NO	Hovlandsvatnet	SFJIHOV	155	1	19/08/88	L-N2b	10.0	1.7	0.0%
NO	Hovsvatnet	ROGIHOV	43	1	19/07/89	L-N2b	3.0	1.3	0.0%
NO	Hovsvatnet	ROGIHOV	43	1	20/08/89	L-N2b	5.0	1.9	0.0%
NO	Hovsvatnet	ROGIHOV	43	1	27/07/91	L-N2b	5.0	1.6	0.0%
NO	Hovsvatnet	ROGIHOV	43	1	31/08/91	L-N2b	11.0	1.3	0.0%
NO	Hurdalssjøen	AKEIHUR	327	1	16/07/88	L-N2b	3.0	2.0	0.0%
NO	Hurdalssjøen	AKEIHUR	327	1	12/08/88	L-N2b	3.0	1.7	2.7%
NO	Hurdalssjøen	AKEIHUR	327	1	06/09/88	L-N2b	4.0	1.9	5.0%
NO	Kalandsvatnet	HORIKAL	147	1	21/07/88	L-N2b	11.0	1.6	0.0%
NO	Kalandsvatnet	HORIKAL	147	1	18/08/88	L-N2b	14.0	4.4	0.4%
NO	Krøderen	BUSIKRØ	102	1	25/07/88	L-N2b	8.0	3.1	0.0%

NO	Krøderen	BUSIKRØ	102	1	25/08/88	L-N2b	15.0	2.9	0.0%
NO	Lauvavatnet	SFJILAU	159	1	22/07/88	L-N2b	5.0	1.5	0.0%
NO	Lauvavatnet	SFJILAU	159	1	20/08/88	L-N2b	5.0	2.5	0.0%
NO	Lovatnet	SFJILOV	172	1	24/07/88	L-N2b	9.0	1.6	0.0%
NO	Lovatnet	SFJILOV	172	1	22/08/88	L-N2b	5.0	3.2	0.0%
NO	Lundevatnet	ROGILUN	42	1	19/07/88	L-N2b	5.0	2.8	0.0%
NO	Lundevatnet	ROGILUN	42	1	20/08/88	L-N2b	6.0	1.8	0.0%
NO	Lygne	VAGILYN	37	1	19/07/88	L-N2b	12.0	4.2	0.0%
NO	Lygne	VAGILYN	37	1	19/07/89	L-N2b	6.0	1.7	0.0%
NO	Lygne	VAGILYN	37	1	20/08/89	L-N2b	7.0	2.6	0.0%
NO	Lygne	VAGILYN	37	1	30/08/91	L-N2b	5.0	1.9	0.0%
NO	Movatnet	SFJIMOV	162	1	23/07/88	L-N2b	5.0	2.6	0.0%
NO	Movatnet	SFJIMOV	162	1	20/08/88	L-N2b	8.0	2.8	0.0%
NO	Norsjø	TELINOR	112	1	16/07/88	L-N2b	9.0	2.4	0.0%
NO	Norsjø	TELINOR	112	1	13/08/88	L-N2b	6.0	3.4	2.7%
NO	Sandnesvatnet	NORISAN	246	1	06/07/88	L-N2b	2.0	0.8	0.0%
NO	Sandnesvatnet	NORISAN	246	1	30/07/88	L-N2b	2.0	0.7	0.0%
NO	Sandnesvatnet	NORISAN	246	1	26/08/88	L-N2b	2.0	1.3	0.0%
NO	Sandvinvatnet	HORISAN	68	1	22/07/88	L-N2b	6.0	0.6	0.0%
NO	Sandvinvatnet	HORISAN	68	1	22/08/88	L-N2b	7.0	0.8	0.0%
NO	Seljordvatnet	TELISEL	116	1	17/07/88	L-N2b	7.0	3.1	0.0%
NO	Seljordvatnet	TELISEL	116	1	14/08/88	L-N2b	4.0	2.2	3.1%
NO	Selura	VAGISEL	40	1	19/07/88	L-N2b	4.0	0.7	0.0%
NO	Selura	VAGISEL	40	1	20/08/88	L-N2b	7.0	0.9	0.0%
NO	Skogseidvatn	HORISKO	145	1	21/07/88	L-N2b	9.0	2.2	0.0%
NO	Skogseidvatn	HORISKO	145	1	18/08/88	L-N2b	9.0	5.0	0.0%
NO	Snåsavatnet	NTRISNÅ	230	1	03/07/88	L-N2b	4.0	3.5	0.0%
NO	Snåsavatnet	NTRISNÅ	230	1	27/07/88	L-N2b	4.0	2.4	0.0%
NO	Snåsavatnet	NTRISNÅ	230	1	23/08/88	L-N2b	6.0	1.9	0.0%
NO	Stordalsvatnet	HORISTO	133	1	19/07/88	L-N2b	4.0	1.3	0.0%
NO	Stordalsvatnet	HORISTO	133	1	16/08/88	L-N2b	4.0	1.5	0.0%
NO	Stordalsvatnet	STRISTD	217	1	21/08/88	L-N2b	12.0	4.7	0.0%
NO	Stordalsvatnet	STRISTD	217	1	27/07/89	L-N2b	5.0	3.6	0.4%
NO	Stordalsvatnet	STRISTD	217	1	01/07/91	L-N2b	8.0	1.3	0.0%
NO	Stordalsvatnet	STRISTD	217	1	07/09/91	L-N2b	10.0	3.0	0.0%
NO	Strynevatnet	SFJISTR	173	1	24/07/88	L-N2b	6.0	3.1	0.0%
NO	Strynevatnet	SFJISTR	173	1	22/08/88	L-N2b	4.0	2.0	0.0%
NO	Suldalsvatnet	ROGISUL	67	1	22/07/88	L-N2b	3.0	1.0	0.0%
NO	Suldalsvatnet	ROGISUL	67	1	22/08/88	L-N2b	4.0	1.4	0.0%
NO	Sundkilen	TELISUN	118	1	17/07/88	L-N2b	10.0	2.2	0.0%
NO	Sundkilen	TELISUN	118	1	14/08/88	L-N2b	7.0	2.8	2.1%
NO	Svardalsvatnet	SFJISVA	166	1	23/07/88	L-N2b	6.0	2.9	0.0%
NO	Svardalsvatnet	SFJISVA	166	1	20/08/88	L-N2b	7.0	4.0	0.0%
NO	Tinnsjø	TELITIØ	127	1	18/07/88	L-N2b	4.0	2.0	0.0%
NO	Tinnsjø	TELITIØ	127	1	15/08/88	L-N2b	3.0	1.8	0.0%
NO	Tyrivatnet	TELITYR	114	1	16/07/88	L-N2b	4.0	1.3	0.0%
NO	Tyrivatnet	TELITYR	114	1	14/08/88	L-N2b	2.0	1.9	0.0%
NO	Vangsvatnet, øvre basseng	HORIVØV	72	1	22/07/88	L-N2b	7.0	2.6	0.0%
NO	Vangsvatnet, øvre basseng	HORIVØV	72	1	23/08/88	L-N2b	8.0	2.4	0.0%
NO	Vassbygdvatnet	SFJIVAS	76	1	23/07/88	L-N2b	4.0	0.9	0.0%
NO	Vassbygdvatnet	SFJIVAS	76	1	23/08/88	L-N2b	6.0	1.3	0.0%
NO	Veitastrondvatnet	SFJIVEI	78	1	23/07/88	L-N2b	7.0	2.0	0.0%
NO	Veitastrondvatnet	SFJIVEI	78	1	24/08/88	L-N2b	6.0	1.4	0.0%
NO	Viksdalsvatnet	SFJIVIK	158	1	22/07/88	L-N2b	8.0	1.2	0.0%
NO	Viksdalsvatnet	SFJIVIK	158	1	20/08/88	L-N2b	4.0	3.1	0.0%
UK	Buttermere	29052	1	1	15/09/04	L-N2b	5.0	3.9	0.0%
UK	Buttermere	UK29052		1	15/09/04	L-N2b	14.5	3.7	0.0%
UK	Buttermere	UK29052		1	15/07/05	L-N2b	19.1	2.3	0.1%

UK	Buttermere	UK29052		1	15/09/05	L-N2b	33.0	2.3	0.0%
UK	Crummock Water	29000	1	1	15/09/04	L-N2b	5.0	4.6	0.0%
UK	Crummock Water	UK29000		1	15/09/04	L-N2b	1.3	5.2	0.0%
UK	Crummock Water	UK29000		1	15/07/05	L-N2b	20.0	2.9	0.2%
UK	Crummock Water	UK29000		1	15/09/05	L-N2b	40.0	4.0	3.1%
UK	Ennerdale Water	UK29062		1	15/08/04	L-N2b	1.3	3.0	0.3%
UK	Ennerdale Water	UK29062		1	15/09/04	L-N2b	1.3	2.4	0.0%
UK	Ennerdale Water	UK29062		1	15/07/05	L-N2b	15.3	1.8	0.7%
UK	Ennerdale Water	UK29062		1	15/09/05	L-N2b	25.0	2.2	0.4%
UK	Loch Hope	UK2490		1	15/07/04	L-N2b	0.8	4.9	4.1%
UK	Loch Maree	UK14057		1	15/09/04	L-N2b	1.9	2.3	0.9%
UK	Wast Water	29183	1	1	21/07/04	L-N2b	22.0	1.3	0.0%
UK	Wast Water	29183	1	1	03/09/04	L-N2b	26.0	2.1	0.0%
UK	Wast Water	UK29183		1	15/07/04	L-N2b	22.0	1.3	4.0%
UK	Wast Water	UK29183		1	15/09/04	L-N2b	13.6	2.1	0.0%
UK	Wast Water	UK29183		1	15/07/05	L-N2b	9.2	1.7	0.0%
UK	Wast Water	UK29183		1	15/09/05	L-N2b	40.0	1.5	1.0%
FI	Änättijärvi	29745	34949	0	12/07/00	L-N3a	11.0	8.2	1.0%
FI	Haukkajärvi	21435	8380	0	09/07/02	L-N3a	10.0	8.3	0.0%
FI	Iijärvi	26830	32042	0	10/07/00	L-N3a	16.0	9.1	0.7%
FI	Iso Arajärvi	20930	8000	0	09/07/02	L-N3a	13.0	3.7	3.3%
FI	Iso Lamujärvi	26261	28028	0	11/07/00	L-N3a	13.0	8.1	0.5%
FI	Juurusvesi-Akonv.	9118	18644	0	12/07/94	L-N3a	23.0	11.0	3.2%
FI	Juurusvesi-Akonv.	9118	18644	0	14/07/98	L-N3a	24.0	7.1	2.1%
FI	Kiantajärvi	29242	34398	0	11/07/00	L-N3a	20.0	6.8	3.2%
FI	Kiantajärvi (N43 199.30)	27435	32778	0	18/07/00	L-N3a	17.0	6.3	1.1%
FI	Kuohattijärvi	8168	23561	0	09/07/01	L-N3a	10.0	2.8	3.2%
FI	Kyrösjärvi	22238	8713	0	08/07/96	L-N3a	24.0	10.0	9.0%
FI	Kyrösjärvi	22238	8713	0	08/07/97	L-N3a	25.0	15.0	2.9%
FI	Kyrösjärvi	22238	8713	0	11/07/02	L-N3a	20.0	18.0	6.0%
FI	Lappajärvi	25273	4996	0	14/07/93	L-N3a	33.0	17.0	14.5%
FI	Lappajärvi	25273	4996	0	03/08/99	L-N3a	24.5	8.2	20.3%
FI	Lappajärvi	25273	4996	0	24/08/99	L-N3a	25.0	15.0	9.4%
FI	Lappajärvi	25273	4996	0	10/07/01	L-N3a	23.0	4.8	3.5%
FI	Leppävesi	14471	25115	0	17/08/98	L-N3a	17.5	8.9	0.9%
FI	Leppävesi	14471	25115	0	12/07/99	L-N3a	15.0	5.2	0.6%
FI	Leppävesi	14471	25115	0	16/08/99	L-N3a	13.0	6.5	3.0%
FI	Leppävesi	14471	25115	0	14/08/00	L-N3a	15.0	6.1	0.0%
FI	Oulujärvi (N43 122.20)x1	26552	31230	0	15/07/98	L-N3a	10.0	3.3	8.6%
FI	Oulujärvi (N43 122.20)x1	26552	31230	0	10/07/00	L-N3a	15.0	7.2	7.4%
FI	Oulujärvi (N43 122.20)x1	26552	31230	0	21/08/00	L-N3a	14.0	6.8	10.1%
FI	Oulujärvi (N43 122.20)x1	26552	31230	0	21/08/01	L-N3a	15.0	8.8	10.2%
FI	Oulujärvi (N43 122.20)x2	26594	31415	0	10/07/00	L-N3a	17.0	10.0	9.0%
FI	Oulujärvi (N43 122.20)x3	26606	31669	0	08/07/98	L-N3a	18.0	3.9	0.0%
FI	Oulujärvi (N43 122.20)x3	26606	31669	0	17/08/98	L-N3a	19.0	4.9	1.9%
FI	Oulujärvi (N43 122.20)x3	26606	31669	0	11/07/00	L-N3a	12.0	5.4	5.5%
FI	Puhosjärvi	33431	29403	0	13/07/00	L-N3a	13.0	8.4	1.1%
FI	Pyhäselkä (Saimaa N60+75.80)	5952	22255	0	12/07/01	L-N3a	8.0	2.4	2.6%
FI	Pyhäselkä (Saimaa N60+75.80)	5952	22270	0	11/07/96	L-N3a	10.0	3.8	27.0%
FI	Pyhäselkä (Saimaa N60+75.80)	5952	22270	0	07/07/97	L-N3a	10.0	3.0	5.9%
FI	Pyhäselkä (Saimaa N60+75.80)	5952	22270	0	20/07/99	L-N3a	12.0	6.8	4.2%
FI	Tarjanne	21550	8447	0	10/07/02	L-N3a	16.0	6.7	0.2%
FI	Unari	37224	37572	0	05/07/00	L-N3a	24.0	6.9	7.4%
FI	Vatianjärvi	14585	25166	0	14/08/00	L-N3a	21.0	11.0	0.1%
FI	Ylä-Keitele (N60 99.50)	15148	43407	0	10/07/00	L-N3a	10.5	5.4	4.2%
NO	Kilevatnet	TELIKIL	13	0	16/07/88	L-N3a	6.0	2.4	0.0%
NO	Kilevatnet	TELIKIL	13	0	18/08/88	L-N3a	7.0	2.9	0.3%
NO	Langåsdammen	NTRILAN	369	0	16/07/92	L-N3a	11.0	5.3	0.0%

NO	Langåsdammen	NTRILAN	369	0	20/08/92	L-N3a	17.0	4.9	0.0%
NO	Langen	AKEILAN	308	0	17/07/88	L-N3a	6.0	10.9	0.2%
NO	Langen	AKEILAN	308	0	17/08/88	L-N3a	15.0	9.7	19.0%
NO	Langen	AKEILAN	308	0	18/09/88	L-N3a	17.0	10.4	0.4%
NO	Langmovatn	NORILØY	393	0	24/07/97	L-N3a	59.0	46.9	84.2%
NO	Langmovatn	NORILØY	393	0	14/08/97	L-N3a	57.0	21.8	4.2%
NO	Langmovatn	NORILØY	393	0	07/08/00	L-N3a	42.0	20.0	95.5%
NO	Langmovatn	NORILØY	393	0	09/09/00	L-N3a	69.0	3.7	12.0%
NO	Liavatnet	STRILIA	215	0	01/07/88	L-N3a	12.0	8.1	0.0%
NO	Liavatnet	STRILIA	215	0	26/07/88	L-N3a	16.0	3.4	0.0%
NO	Liavatnet	STRILIA	215	0	21/08/88	L-N3a	27.0	12.0	0.0%
NO	Longumvatnet	AAGILON	21	0	18/07/88	L-N3a	10.0	4.5	0.7%
NO	Longumvatnet	AAGILON	21	0	18/08/88	L-N3a	12.0	14.5	0.0%
NO	Mjær	AKEIMJÆ	307	0	08/07/88	L-N3a	9.0	12.7	0.3%
NO	Mjær	AKEIMJÆ	307	0	06/08/88	L-N3a	21.0	10.4	0.0%
NO	Mjær	AKEIMJÆ	307	0	18/09/88	L-N3a	20.0	8.4	0.0%
NO	Mjermen	AKEIMJE	302	0	28/08/88	L-N3a	5.0	1.7	0.0%
NO	Mjermen	AKEIMJE	302	0	24/07/89	L-N3a	4.0	1.8	0.0%
NO	Mjermen	AKEIMJE	302	0	21/07/91	L-N3a	5.0	2.6	1.1%
NO	Mjermen	AKEIMJE	302	0	27/08/91	L-N3a	5.0	1.7	5.7%
NO	Ørsjøen	ØSTIØRS	290	0	04/07/88	L-N3a	3.0	1.3	0.0%
NO	Ørsjøen	ØSTIØRS	290	0	27/07/88	L-N3a	7.0	1.0	0.0%
NO	Ørsjøen	ØSTIØRS	290	0	27/08/88	L-N3a	4.0	1.2	0.0%
NO	Råsen	HEDIRÅS	324	0	11/07/88	L-N3a	7.0	5.5	0.0%
NO	Råsen	HEDIRÅS	324	0	12/08/88	L-N3a	10.0	4.3	0.0%
NO	Råsen	HEDIRÅS	324	0	06/09/88	L-N3a	16.0	1.6	0.0%
NO	Rødbyvannet	BUSIRØD	284	0	24/07/88	L-N3a	25.0	10.1	0.0%
NO	Rødbyvannet	BUSIRØD	284	0	22/08/88	L-N3a	20.0	11.1	0.0%
NO	Sæbyvatnet	ØSTISÆB	278	0	27/07/88	L-N3a	33.0	10.2	0.0%
NO	Sæbyvatnet	ØSTISÆB	278	0	25/08/88	L-N3a	41.0	11.9	0.0%
NO	Skulerudvatnet	AKEISKU	300	0	07/07/88	L-N3a	18.0	12.8	2.9%
NO	Skulerudvatnet	AKEISKU	300	0	31/07/88	L-N3a	41.0	41.9	0.6%
NO	Skulerudvatnet	AKEISKU	300	0	28/08/88	L-N3a	31.0	5.9	20.2%
NO	Storsjøen i Odalen	HEDISTO	325	0	11/07/88	L-N3a	7.0	4.3	1.3%
NO	Storsjøen i Odalen	HEDISTO	325	0	12/08/88	L-N3a	6.0	4.5	0.0%
NO	Storsjøen i Odalen	HEDISTO	325	0	06/09/88	L-N3a	8.0	3.1	1.4%
NO	Temse	AAGITEM	23	0	18/07/88	L-N3a	20.0	14.2	8.8%
NO	Temse	AAGITEM	23	0	18/08/88	L-N3a	21.0	26.9	0.5%
NO	Ubergsvatnet	AAGIUBE	19	0	17/07/88	L-N3a	10.0	2.7	0.0%
NO	Ubergsvatnet	AAGIUBE	19	0	18/08/88	L-N3a	9.0	3.5	0.0%
NO	Vansjø	ØSTIVAN	279	0	27/07/88	L-N3a	25.0	6.8	3.8%
NO	Vansjø	ØSTIVAN	279	0	25/08/88	L-N3a	17.0	6.4	14.7%
SE	Bäen	961	1	0	14/08/01	L-N3a	20.0	43.8	0.1%
SE	Bäen	961	1	0	13/08/02	L-N3a	19.0	20.0	0.0%
SE	Bäen	961	1	0	12/08/03	L-N3a	13.0	4.1	0.0%
SE	Bäen			0	(august)	L-N3a	16.7	12.9	0.2%
SE	Brännträsket			0	(august)	L-N3a	9.3	4.1	6.3%
SE	Dagarn			0	(august)	L-N3a	8.7	5.0	2.3%
SE	Degervattnet			0	(august)	L-N3a	8.0	2.3	2.1%
SE	Fagertärn			0	(august)	L-N3a	12.3	14.2	0.6%
SE	Flen			0	(august)	L-N3a	10.5	NA	5.0%
SE	Fräcksjön			0	(august)	L-N3a	10.8	6.0	0.5%
SE	Granvattnet			0	(august)	L-N3a	20.5	9.4	0.7%
SE	Grissjön			0	(august)	L-N3a	12.0	3.2	0.0%
SE	Hagasjön			0	(august)	L-N3a	10.2	5.0	0.5%
SE	Hällsjön			0	(august)	L-N3a	5.7	2.8	1.7%
SE	Hällvattnet			0	(august)	L-N3a	6.4	2.8	4.6%
SE	Hinnasjön			0	(august)	L-N3a	14.3	22.1	0.6%

SE	Orsasjön			0	(august)	L-N3a	7.4	NA	1.0%
SE	Örsjön			0	(august)	L-N3a	10.0	6.0	0.1%
SE	Överudssjön	1026	1	0	22/08/01	L-N3a	97.0	20.5	1.2%
SE	Överudssjön	1026	1	0	20/08/02	L-N3a	39.0	50.2	86.2%
SE	Överudssjön	1026	1	0	26/08/03	L-N3a	53.0	56.7	36.5%
SE	Överudssjön			0	(august)	L-N3a	51.8	31.2	46.3%
SE	Sännen	974	1	0	28/08/01	L-N3a	14.0	16.0	0.0%
SE	Sännen	974	1	0	13/08/02	L-N3a	18.0	23.0	0.4%
SE	Sännen	974	1	0	20/08/03	L-N3a	11.0	5.4	0.0%
SE	Skärgölen			0	(august)	L-N3a	9.5	5.2	0.1%
SE	Skattungen			0	(august)	L-N3a	5.5	NA	1.6%
SE	Stora Envättern			0	(august)	L-N3a	7.2	3.2	3.1%
SE	Storsiljan			0	(august)	L-N3a	5.8	NA	12.4%
SE	Svärdsjön			0	(august)	L-N3a	10.5	NA	1.7%
SE	Svinarydsjön			0	(august)	L-N3a	17.5	5.8	0.0%
SE	Täftesträsket			0	(august)	L-N3a	11.3	5.6	0.9%
SE	Valasjön			0	(august)	L-N3a	12.2	NA	1.0%
FI	Haukivesi (Saimaa N60+75.80)	3695	13900	1	11/07/01	L-N3a	13.0	4.5	1.5%
FI	Haukivesi (Saimaa N60+75.80)	3695	14037	1	10/07/95	L-N3a	14.0	3.4	1.7%
FI	Haukivesi (Saimaa N60+75.80)	3695	14037	1	07/07/99	L-N3a	7.0	2.8	5.4%
FI	Haukivesi (Saimaa N60+75.80)	3695	14037	1	09/07/01	L-N3a	10.0	2.3	5.2%
FI	Haukivesi (Saimaa N60+75.80)	3695	14037	1	10/07/02	L-N3a	8.0	2.6	2.2%
FI	Kallavesi (N60 81.70)	4829	17065	1	15/07/96	L-N3a	23.0	4.5	4.0%
FI	Kallavesi (N60 81.70)	4829	17065	1	15/07/98	L-N3a	19.0	5.8	3.3%
FI	Kallavesi (N60 81.70)	4829	17124	1	18/07/95	L-N3a	19.0	3.5	0.0%
FI	Kallavesi (N60 81.70)	4829	17124	1	14/08/95	L-N3a	19.0	11.6	2.0%
FI	Keurusselkä (N60 105.40)x1	22720	26169	1	09/07/96	L-N3a	15.0	6.5	0.2%
FI	Keurusselkä (N60 105.40)x1	22720	26169	1	15/07/98	L-N3a	18.0	10.0	6.4%
FI	Keurusselkä (N60 105.40)x1	22720	26169	1	05/07/00	L-N3a	16.0	6.5	2.8%
FI	Kiantajärvi (N43 199.30)	27350	32666	1	09/07/96	L-N3a	8.0	3.1	0.9%
FI	Kiantajärvi (N43 199.30)	27350	32666	1	13/07/00	L-N3a	13.0	3.9	2.9%
FI	Kivijärvi	15287	25570	1	11/07/95	L-N3a	10.5	2.8	6.9%
FI	Kivijärvi	15287	25570	1	06/07/98	L-N3a	10.5	2.8	11.9%
FI	Kivijärvi	15287	25570	1	11/07/00	L-N3a	12.0	5.1	2.5%
FI	Koitere	11408	24087	1	13/07/94	L-N3a	11.5	3.2	2.7%
FI	Koitere	11408	24087	1	22/08/94	L-N3a	13.5	4.3	0.9%
FI	Koitere	11408	24087	1	09/07/96	L-N3a	10.0	2.4	7.8%
FI	Koitere	11408	24087	1	07/07/97	L-N3a	12.0	3.4	3.0%
FI	Kolima	15571	25660	1	11/07/94	L-N3a	9.5	2.2	2.5%
FI	Kolima	15571	25660	1	14/07/98	L-N3a	9.0	5.3	2.4%
FI	Kolima	15571	25660	1	10/07/00	L-N3a	10.0	3.7	0.6%
FI	Kyyvesi	18359	15318	1	18/07/96	L-N3a	18.0	9.5	0.0%
FI	Kyyvesi	18359	15318	1	07/07/97	L-N3a	13.0	6.2	1.3%
FI	Kyyvesi	18359	15318	1	18/07/01	L-N3a	16.0	9.8	3.3%
FI	Lentua	29580	34787	1	12/07/95	L-N3a	11.0	3.2	1.5%
FI	Lentua	29580	34787	1	10/07/96	L-N3a	9.3	4.0	3.9%
FI	Lentua	29580	34787	1	12/07/00	L-N3a	13.0	6.7	1.0%
FI	Miekojärvi	42292	38796	1	17/07/00	L-N3a	19.0	10.0	1.1%
FI	Näsijärvi (N60 95.40)x1	20937	8103	1	10/07/02	L-N3a	25.0	3.7	8.2%
FI	Näsijärvi (N60 95.40)x1	20937	8141	1	08/07/97	L-N3a	10.0	3.3	3.3%
FI	Näsijärvi (N60 95.40)x1	20937	8141	1	10/07/02	L-N3a	13.0	3.4	3.3%
FI	Nilakka	16960	20848	1	17/07/96	L-N3a	12.0	3.8	8.6%
FI	Nilakka	16960	20848	1	16/07/98	L-N3a	12.0	7.2	1.3%
FI	Orivesi (Saimaa N60+75.80)	5802	22134	1	08/07/96	L-N3a	8.0	2.7	14.6%
FI	Orivesi (Saimaa N60+75.80)	5802	22134	1	10/07/97	L-N3a	8.0	2.2	25.9%
FI	Orivesi (Saimaa N60+75.80)	5802	22134	1	21/07/99	L-N3a	8.0	3.2	5.7%
FI	Pielavesi	17047	21002	1	10/07/95	L-N3a	11.0	2.7	4.3%
FI	Pielavesi	17047	21002	1	16/07/98	L-N3a	10.0	4.2	9.3%

FI	Pielinen	6579	23061	1	11/07/01	L-N3a	7.0	3.4	4.2%
FI	Pielinen	6579	23132	1	13/07/94	L-N3a	13.0	2.2	7.2%
FI	Pielinen	6579	23132	1	13/07/95	L-N3a	10.0	2.9	26.0%
FI	Pielinen	6579	23132	1	19/07/99	L-N3a	8.0	4.2	7.8%
FI	Pielinen	6579	23132	1	05/07/00	L-N3a	9.0	5.0	2.4%
FI	Pihlajavesi (Saimaa)	1930	13329	1	19/07/01	L-N3a	8.0	3.2	3.2%
FI	Punelia	19668	1317	1	09/07/02	L-N3a	8.0	5.0	2.9%
FI	Rehja-Nuasjärvi	29015	33947	1	11/07/00	L-N3a	21.0	2.6	5.7%
FI	Rehja-Nuasjärvi	29015	34018	1	11/07/00	L-N3a	15.0	7.9	2.8%
FI	Simojärvi (N43 176.00)x2	34080	36254	1	11/07/96	L-N3a	8.0	3.8	8.9%
FI	Simojärvi (N43 176.00)x2	34080	36254	1	17/07/00	L-N3a	8.0	5.9	0.6%
FI	Takkajärvi	33335	41959	1	17/07/00	L-N3a	11.0	3.9	0.1%
FI	Vuokkijärvi	28353	33362	1	13/07/00	L-N3a	17.0	7.6	4.6%
FI	Vuosjärvi	15235	25589	1	10/07/00	L-N3a	13.0	5.1	0.6%
NO	Dølisjøen	HEDIDØL	326	1	11/07/88	L-N3a	6.0	3.9	0.5%
NO	Dølisjøen	HEDIDØL	326	1	12/08/88	L-N3a	10.0	3.7	0.0%
NO	Dølisjøen	HEDIDØL	326	1	06/09/88	L-N3a	11.0	3.2	0.0%
NO	Gjerstadvatnet	AAGIGJE	18	1	17/07/88	L-N3a	8.0	0.8	0.0%
NO	Gjerstadvatnet	AAGIGJE	18	1	18/08/88	L-N3a	7.0	1.2	0.0%
NO	Heimsvatnet	STRIHEI	207	1	25/07/88	L-N3a	6.0	2.2	0.0%
NO	Heimsvatnet	STRIHEI	207	1	20/08/88	L-N3a	6.0	2.3	0.0%
NO	Hukusjøen	HEDIHUK	318	1	10/07/88	L-N3a	6.0	2.7	0.0%
NO	Hukusjøen	HEDIHUK	318	1	07/08/88	L-N3a	6.0	1.9	0.0%
NO	Hukusjøen	HEDIHUK	318	1	03/09/88	L-N3a	7.0	2.0	0.0%
NO	Hukusjøen	HEDIHUK	318	1	24/07/89	L-N3a	4.0	2.2	0.0%
NO	Nugguren	HEDINUG	317	1	10/07/88	L-N3a	9.0	3.3	0.0%
NO	Nugguren	HEDINUG	317	1	07/08/88	L-N3a	7.0	3.3	8.1%
NO	Nugguren	HEDINUG	317	1	03/09/88	L-N3a	8.0	1.7	0.0%
NO	Nugguren	HEDINUG	317	1	30/08/89	L-N3a	8.0	3.1	0.0%
NO	Tinnå (Kloumannsjøen)	TELITIÅ	111	1	16/07/88	L-N3a	5.0	2.3	0.0%
NO	Tinnå (Kloumannsjøen)	TELITIÅ	111	1	13/08/88	L-N3a	4.0	1.7	0.0%
NO	Trævatn	AAGITRÆ	22	1	18/07/88	L-N3a	9.0	1.2	0.0%
NO	Trævatn	AAGITRÆ	22	1	18/08/88	L-N3a	8.0	1.2	0.0%
NO	Venneslafjorden	VAGIVEN	30	1	18/07/88	L-N3a	6.0	1.3	0.0%
NO	Venneslafjorden	VAGIVEN	30	1	19/08/88	L-N3a	6.0	1.0	0.0%
FI	Sierramjavri	51740	39478	0	13/07/00	L-N5	4.0	0.5	0.2%
NO	Bergsjøen	BUSIBER	103	0	25/07/88	L-N5	6.0	2.5	0.0%
NO	Bergsjøen	BUSIBER	103	0	25/08/88	L-N5	5.0	2.9	0.0%
NO	Børstusjøen	HEDIBØR	5196	0	23/08/96	L-N5	5.6	1.3	0.7%
NO	Fjotlandsvatn	VAGIFJO	38	0	19/07/88	L-N5	25.0	9.2	0.0%
NO	Fjotlandsvatn	VAGIFJO	38	0	20/08/88	L-N5	22.0	3.8	0.0%
NO	Nord Mesna	HEDINME	190	0	02/07/88	L-N5	12.0	2.0	0.0%
NO	Nord Mesna	HEDINME	190	0	26/07/88	L-N5	17.0	3.7	0.0%
NO	Nord Mesna	HEDINME	190	0	26/08/88	L-N5	12.0	3.5	0.0%
NO	Olstappen	OPPIOLS	188	0	02/07/88	L-N5	5.0	1.3	0.0%
NO	Olstappen	OPPIOLS	188	0	26/07/88	L-N5	13.0	2.2	0.0%
NO	Olstappen	OPPIOLS	188	0	26/08/88	L-N5	5.0	1.5	0.0%
NO	Ottsjøen	HEDIOTS	5215	0	08/09/96	L-N5	5.6	2.8	0.0%
NO	Søndre Bølsjøen	HEDISBØ	5178	0	25/08/96	L-N5	4.5	2.1	0.2%
NO	Sør Mesna	HEDISME	192	0	03/07/88	L-N5	11.0	2.1	1.0%
NO	Sør Mesna	HEDISME	192	0	26/07/88	L-N5	12.0	1.9	0.0%
NO	Sør Mesna	HEDISME	192	0	26/08/88	L-N5	12.0	1.7	0.0%
NO	Storamos	ROGISTO	54	0	20/07/88	L-N5	49.0	7.5	88.6%
NO	Storamos	ROGISTO	54	0	21/08/88	L-N5	68.0	28.2	96.3%
NO	Strandafjorden	BUSISTR	90	0	24/07/88	L-N5	12.0	3.9	0.0%
NO	Strandafjorden	BUSISTR	90	0	24/08/88	L-N5	3.0	0.7	0.0%
NO	Vassfjorden	BUSIVAS	89	0	24/07/88	L-N5	18.0	8.7	0.1%
NO	Vassfjorden	BUSIVAS	89	0	24/08/88	L-N5	10.0	1.6	0.0%

SE	Abiskojaure			0	(august)	L-N5	4.0	0.8	0.0%
SE	Amungen			0	(august)	L-N5	3.7	NA	0.7%
SE	BREDSJÖN			0	(august)	L-N5	5.0	NA	0.0%
SE	Fiolen			0	(august)	L-N5	9.5	5.6	3.4%
SE	Försjön	1381	1	0	16/08/01	L-N5	7.0	6.2	2.8%
SE	Försjön	1381	1	0	22/08/02	L-N5	5.0	4.6	0.3%
SE	Försjön	1381	1	0	21/08/03	L-N5	7.0	4.9	3.1%
SE	GimmenO			0	(august)	L-N5	5.0	NA	4.2%
SE	Gipsjön	947	1	0	13/08/02	L-N5	10.0	4.1	0.0%
SE	Gipsjön	947	1	0	17/08/03	L-N5	11.0	3.7	0.0%
SE	GRANGEN			0	(august)	L-N5	14.0	NA	0.0%
SE	GUBBELN			0	(august)	L-N5	11.0	NA	0.7%
SE	Hällvattnet	955	1	0	22/08/02	L-N5	6.0	3.5	4.8%
SE	HÅSJÖN			0	(august)	L-N5	5.0	NA	0.0%
SE	HEHTENJAURE			0	(august)	L-N5	8.0	NA	0.0%
SE	Hjärtsjön	1034	1	0	14/08/01	L-N5	3.0	2.3	0.0%
SE	Hjärtsjön	1034	1	0	19/08/02	L-N5	4.0	1.1	0.0%
SE	Hjärtsjön	1034	1	0	18/08/03	L-N5	4.0	1.4	0.0%
SE	Hjärtsjön			0	(august)	L-N5	4.8	3.1	0.0%
SE	Holmeshultasjön	999	1	0	14/08/01	L-N5	10.0	9.3	2.2%
SE	Holmeshultasjön	999	1	0	21/08/02	L-N5	10.0	8.3	0.7%
SE	Holmeshultasjön	999	1	0	18/08/03	L-N5	12.0	7.8	1.5%
SE	Idresjön			0	(august)	L-N5	7.0	NA	1.4%
SE	LÅNGVATTNET			0	(august)	L-N5	9.0	NA	0.0%
SE	Limmingsjön	1057	1	0	23/08/01	L-N5	15.0	4.3	0.5%
SE	Limmingsjön	1057	1	0	12/08/02	L-N5	5.0	3.1	1.8%
SE	Limmingsjön	1057	1	0	18/08/03	L-N5	7.0	3.5	0.3%
SE	Limmingsjön			0	(august)	L-N5	7.8	3.4	2.3%
SE	Louvvajaure			0	(august)	L-N5	3.8	1.1	5.4%
SE	MANSJÖN			0	(august)	L-N5	5.0	NA	0.0%
SE	NORRA GRÅSJÖN			0	(august)	L-N5	8.0	NA	1.4%
SE	Örvattnet			0	(august)	L-N5	6.2	1.8	0.0%
SE	Pahajärvi			0	(august)	L-N5	7.8	3.9	9.8%
SE	Rällsjön			0	(august)	L-N5	8.0	NA	18.6%
SE	Stora Tresticklan	1075	1	0	13/08/01	L-N5	5.0	1.2	0.0%
SE	Stora Tresticklan	1075	1	0	29/08/02	L-N5	8.0	1.4	0.0%
SE	Stora Tresticklan	1075	1	0	19/08/03	L-N5	6.0	2.4	0.0%
SE	Stora Tresticklan			0	(august)	L-N5	5.3	1.6	0.0%
SE	Stor-Arasjön	1090	1	0	13/08/01	L-N5	8.0	4.0	0.7%
SE	Stor-Arasjön	1090	1	0	13/08/02	L-N5	6.0	3.7	0.0%
SE	Stor-Arasjön	1090	1	0	11/08/03	L-N5	5.0	2.3	4.6%
SE	STORJOUDAN			0	(august)	L-N5	5.0	NA	0.0%
SE	TJÄNAFJÄLLSJÖN			0	(august)	L-N5	8.0	NA	4.3%
SE	Tväringen	1151	1	0	13/08/01	L-N5	26.0	2.8	2.6%
SE	Tväringen	1151	1	0	12/08/02	L-N5	5.0	2.1	0.8%
SE	Tväringen	1151	1	0	12/08/03	L-N5	5.0	5.5	0.0%
SE	VÄRJAREN			0	(august)	L-N5	5.0	NA	1.2%
SE	VATTENSJÖN			0	(august)	L-N5	4.0	NA	0.0%
UK	Burrator Reservoir	UK46279		0	15/09/04	L-N5	23.0	3.0	0.0%
UK	Burrator Reservoir	UK46279		0	15/08/05	L-N5	11.0	5.0	0.4%
UK	Loch Insh	UK20860		0	15/08/03	L-N5	5.0	9.8	30.2%
UK	Loch Laidon	UK22839		0	15/07/04	L-N5	6.2	3.3	4.0%
NO	Espedalsvatnet	OPPIESP	189	1	02/07/88	L-N5	6.0	3.0	0.0%
NO	Espedalsvatnet	OPPIESP	189	1	26/07/88	L-N5	5.0	2.0	0.0%
NO	Espedalsvatnet	OPPIESP	189	1	26/08/88	L-N5	5.0	2.0	0.0%
NO	Galdalsvatnet	VAGIGAL	39	1	19/07/88	L-N5	12.0	1.9	0.0%
NO	Galdalsvatnet	VAGIGAL	39	1	20/08/88	L-N5	16.0	1.1	0.0%
NO	Grungevatnet	TELIGRU	130	1	18/07/88	L-N5	6.0	2.9	0.0%

NO	Grungevatnet	TELIGRU	130	1	16/08/88	L-N5	4.0	1.5	0.0%
NO	Hartevatnet	AAGIHAR	131	1	19/07/88	L-N5	3.0	0.9	0.0%
NO	Hartevatnet	AAGIHAR	131	1	16/08/88	L-N5	2.0	1.2	0.0%
NO	Heggefjorden	OPPIHEG	83	1	23/07/88	L-N5	7.0	1.8	0.0%
NO	Heggefjorden	OPPIHEG	83	1	24/08/88	L-N5	7.0	1.9	0.0%
NO	Holsfjorden	BUSIHOL	91	1	24/07/88	L-N5	7.0	1.7	0.0%
NO	Holsfjorden	BUSIHOL	91	1	24/08/88	L-N5	5.0	1.8	4.2%
NO	Hovsfjorden	BUSIHOV	92	1	24/07/88	L-N5	6.0	1.7	0.0%
NO	Hovsfjorden	BUSIHOV	92	1	24/08/88	L-N5	5.0	1.6	0.5%
NO	Langsjøen	HEDILAN	343	1	15/07/88	L-N5	5.0	2.3	0.0%
NO	Langsjøen	HEDILAN	343	1	08/08/88	L-N5	8.0	1.9	0.0%
NO	Langsjøen	HEDILAN	343	1	04/09/88	L-N5	6.0	1.3	0.0%
NO	Lenglingen	NTRILEN	236	1	04/07/88	L-N5	3.0	2.6	0.0%
NO	Lenglingen	NTRILEN	236	1	28/07/88	L-N5	3.0	1.6	1.8%
NO	Lenglingen	NTRILEN	236	1	24/08/88	L-N5	3.0	1.8	2.4%
NO	Narsjøen	HEDINAR	344	1	15/07/88	L-N5	5.0	2.3	0.0%
NO	Narsjøen	HEDINAR	344	1	08/08/88	L-N5	5.0	2.9	0.0%
NO	Narsjøen	HEDINAR	344	1	04/09/88	L-N5	5.0	2.0	0.0%
NO	Oftevatn	TELIOFT	124	1	18/07/88	L-N5	9.0	3.5	0.5%
NO	Oftevatn	TELIOFT	124	1	15/08/88	L-N5	7.0	1.8	0.0%
NO	Ørevatn	VAGIØRE	36	1	19/07/88	L-N5	9.0	2.9	0.0%
NO	Ørevatn	VAGIØRE	36	1	20/08/88	L-N5	7.0	0.9	0.0%
NO	Sæbufjorden	OPPISÆB	87	1	24/07/88	L-N5	8.0	1.7	0.0%
NO	Sæbufjorden	OPPISÆB	87	1	24/08/88	L-N5	7.0	1.7	0.0%
NO	Skjelbreidvatnet	NTRISKJ	234	1	03/07/88	L-N5	1.0	2.8	0.0%
NO	Skjelbreidvatnet	NTRISKJ	234	1	28/07/88	L-N5	3.0	1.3	0.0%
NO	Skjelbreidvatnet	NTRISKJ	234	1	24/08/88	L-N5	4.0	1.6	0.0%
NO	Skredvatnet	TELISKR	121	1	18/07/88	L-N5	8.0	1.4	0.0%
NO	Skredvatnet	TELISKR	121	1	14/08/88	L-N5	3.0	1.2	0.0%
NO	Skurdalsvatnet	BUSISKU	97	1	25/07/88	L-N5	9.0	2.0	0.0%
NO	Skurdalsvatnet	BUSISKU	97	1	25/08/88	L-N5	5.0	1.4	0.0%
NO	Steinsetfjorden	OPPISTE	88	1	24/07/88	L-N5	7.0	1.7	0.0%
NO	Steinsetfjorden	OPPISTE	88	1	24/08/88	L-N5	5.0	1.5	0.0%
NO	Sudndalsfjorden	BUSISUD	93	1	24/07/88	L-N5	7.0	1.6	0.0%
NO	Sudndalsfjorden	BUSISUD	93	1	24/08/88	L-N5	6.0	1.3	0.0%
NO	Ulen	NTRIULE	237	1	04/07/88	L-N5	2.0	1.7	0.0%
NO	Ulen	NTRIULE	237	1	28/07/88	L-N5	4.0	1.3	0.0%
NO	Ulen	NTRIULE	237	1	24/08/88	L-N5	3.0	1.2	0.6%
NO	Ustedalsfjorden	BUSIUSF	94	1	24/07/88	L-N5	10.0	1.5	0.0%
NO	Vinjevatnet	TELIVIN	129	1	18/07/88	L-N5	4.0	0.9	0.0%
NO	Vinjevatnet	TELIVIN	129	1	16/08/88	L-N5	3.0	1.2	0.0%
SE	Abiskojaure	1292	1	1	27/08/02	L-N5	5.0	0.6	0.0%
SE	Abiskojaure	1292	1	1	21/09/02	L-N5	3.0	0.6	0.0%
SE	Abiskojaure	1292	1	1	12/08/03	L-N5	2.7	0.5	0.0%
SE	Abiskojaure	1292	1	1	17/09/03	L-N5	2.3	0.7	0.0%
SE	Degervattnet	1111	1	1	18/08/01	L-N5	5.0	2.2	1.5%
SE	Degervattnet	1111	1	1	14/08/02	L-N5	11.0	2.3	2.3%
SE	Degervattnet	1111	1	1	19/08/03	L-N5	5.0	3.5	0.7%
SE	Dunnervattnet	1373	1	1	23/08/01	L-N5	4.0	1.4	0.0%
SE	Dunnervattnet	1373	1	1	11/09/02	L-N5	4.0	1.8	0.1%
SE	Dunnervattnet	1373	1	1	19/08/03	L-N5	3.0	1.3	4.4%
SE	Fiolen	1035	1	1	16/08/01	L-N5	10.7	12.0	3.7%
SE	Fiolen	1035	1	1	09/07/02	L-N5	13.3	8.3	4.3%
SE	Fiolen	1035	1	1	19/09/02	L-N5	13.3	6.7	0.0%
SE	Fiolen	1035	1	1	18/09/03	L-N5	10.3	5.3	3.6%
SE	Fjätsjön Övre	1147	1	1	04/09/01	L-N5	8.0	2.4	0.1%
SE	Fjätsjön Övre	1147	1	1	21/08/02	L-N5	7.0	3.0	0.9%
SE	Fjätsjön Övre	1147	1	1	27/08/03	L-N5	7.0	2.4	1.1%

SE	Jutsajaure	1145	1	1	19/09/02	L-N5	15.5	3.5	0.1%
SE	Jutsajaure	1145	1	1	09/07/03	L-N5	10.5	2.9	6.2%
SE	Jutsajaure	1145	1	1	13/08/03	L-N5	9.0	3.5	5.9%
SE	Jutsajaure	1145	1	1	10/09/03	L-N5	9.0	1.9	0.0%
SE	Louvvajaure	1141	1	1	20/08/01	L-N5	2.0	0.8	0.5%
SE	Louvvajaure	1141	1	1	22/08/02	L-N5	2.0	0.5	0.0%
SE	Louvvajaure	1141	1	1	13/08/03	L-N5	2.0	1.0	1.3%
SE	Pahajärvi	1148	1	1	20/08/01	L-N5	8.0	2.3	15.7%
SE	Pahajärvi	1148	1	1	13/08/02	L-N5	9.0	4.6	23.6%
SE	Pahajärvi	1148	1	1	12/08/03	L-N5	10.0	3.9	22.0%
SE	Remmarsjön	954	1	1	16/07/01	L-N5	10.7	1.6	5.7%
SE	Remmarsjön	954	1	1	19/08/02	L-N5	11.7	1.6	0.0%
SE	Remmarsjön	954	1	1	11/08/03	L-N5	8.0	3.2	0.0%
SE	Remmarsjön	954	1	1	15/09/03	L-N5	12.0	4.0	0.0%
SE	Sangen	1123	1	1	19/08/01	L-N5	10.0	4.1	6.4%
SE	Sangen	1123	1	1	20/08/02	L-N5	12.0	3.5	2.8%
SE	Sangen	1123	1	1	26/08/03	L-N5	11.0	2.2	6.5%
SE	Stensjön	1213	1	1	16/07/01	L-N5	7.7	3.0	0.6%
SE	Stensjön	1213	1	1	13/08/01	L-N5	9.0	3.5	0.0%
SE	Stensjön	1213	1	1	14/07/03	L-N5	6.0	2.0	6.1%
SE	Stensjön	1213	1	1	11/08/03	L-N5	7.3	2.2	0.5%
SE	Vuolgamjaure	1087	1	1	16/08/01	L-N5	11.0	2.0	2.3%
SE	Vuolgamjaure	1087	1	1	20/08/02	L-N5	4.0	1.3	1.8%
SE	Vuolgamjaure	1087	1	1	13/08/03	L-N5	4.0	1.6	1.4%
FI	Ala-Suolijärvi - Oivanjärvi	36018	37197	0	19/07/00	L-N6a	11.0	6.0	2.7%
FI	Irnijärvi - Ala-Irni	31925	28917	0	11/07/00	L-N6a	8.0	4.6	1.6%
FI	Kostonjärvi	32846	29247	0	10/07/96	L-N6a	11.0	5.2	0.0%
FI	Lokan tekojärvi	39952	38102	0	06/07/94	L-N6a	37.0	11.3	0.8%
FI	Lokan tekojärvi	39952	38102	0	14/07/94	L-N6a	33.0	12.0	1.9%
FI	Lokan tekojärvi	39952	38102	0	28/07/94	L-N6a	33.0	12.0	40.0%
FI	Lokan tekojärvi	39952	38102	0	25/08/94	L-N6a	32.0	22.0	2.2%
FI	Ounasjärvi	37465	37619	0	10/07/00	L-N6a	12.0	8.8	0.1%
FI	Porttipahdan tekojärvi	39714	38011	0	06/07/94	L-N6a	23.0	12.7	0.2%
FI	Porttipahdan tekojärvi	39714	38011	0	27/07/94	L-N6a	20.0	11.8	4.4%
FI	Porttipahdan tekojärvi	39714	38011	0	01/08/94	L-N6a	17.0	5.6	13.0%
FI	Porttipahdan tekojärvi	39714	38011	0	22/07/98	L-N6a	12.5	6.7	0.4%
NO	Bergesjøen	HEDIBER	5171	0	22/08/96	L-N6a	10.1	1.5	0.1%
NO	Bergsjøen	HEDIBRG	5212	0	03/09/96	L-N6a	12.0	1.3	0.0%
NO	Dokkfløyvatn, Dokka-Etna	OPPIDOF	1609	0	18/07/95	L-N6a	8.1	0.9	0.0%
NO	Dokkfløyvatn, Dokka-Etna	OPPIDOF	1609	0	04/09/95	L-N6a	6.6	1.7	2.3%
NO	Dokkfløyvatn, Dokka-Etna	OPPIDOF	1609	0	19/08/96	L-N6a	9.3	2.0	0.0%
NO	Dokkfløyvatn, Dokka-Etna	OPPIDOF	1609	0	25/07/00	L-N6a	7.0	1.5	14.9%
NO	Haugesjøen	BUSIHAU	100	0	25/07/88	L-N6a	10.0	2.4	0.0%
NO	Haugesjøen	BUSIHAU	100	0	25/08/88	L-N6a	7.0	1.5	0.0%
NO	Heivatnet	TELIHEI	12	0	16/07/88	L-N6a	5.0	1.7	0.0%
NO	Heivatnet	TELIHEI	12	0	16/08/88	L-N6a	5.0	2.4	0.0%
NO	Lisjøen	HEDILIS	5176	0	25/08/96	L-N6a	9.4	2.4	0.0%
NO	Rokosjøen	HEDIROK	321	0	11/07/88	L-N6a	12.0	10.3	7.0%
NO	Rokosjøen	HEDIROK	321	0	24/07/89	L-N6a	11.0	7.4	0.0%
NO	Rokosjøen	HEDIROK	321	0	30/08/89	L-N6a	13.0	15.3	0.2%
NO	Rokosjøen	HEDIROK	321	0	23/07/91	L-N6a	14.0	6.9	0.1%
NO	Sandlandsvatnet	VAGISAN	28	0	18/07/88	L-N6a	10.0	2.8	0.0%
NO	Sandlandsvatnet	VAGISAN	28	0	19/08/88	L-N6a	10.0	3.3	0.0%
NO	Trevatna	OPPITRE	196	0	03/07/88	L-N6a	9.0	3.6	0.0%
NO	Trevatna	OPPITRE	196	0	27/07/88	L-N6a	8.0	4.6	0.0%
NO	Trevatna	OPPITRE	196	0	27/08/88	L-N6a	8.0	2.2	0.0%
SE	Dunnervattnet			0	(august)	L-N6a	3.3	1.4	0.0%
SE	Dyversjön			0	(august)	L-N6a	5.0	NA	0.0%

SE	Fjärasjö			0	(august)	L-N6a	22.2	3.0	5.9%
SE	Fjätsjön Övre			0	(august)	L-N6a	6.6	1.8	0.6%
SE	Jutsajaure			0	(august)	L-N6a	9.8	2.3	0.9%
SE	LÅGSJÖN			0	(august)	L-N6a	5.0	NA	0.0%
SE	Nedre Rottensjön			0	(august)	L-N6a	6.0	NA	1.4%
SE	NILS JONSAVATTNET			0	(august)	L-N6a	18.0	NA	0.0%
SE	Översjön			0	(august)	L-N6a	5.2	3.4	0.0%
SE	Övre Rottensjön			0	(august)	L-N6a	8.0	NA	0.9%
SE	Övre Skärsjön	1049	1	0	14/07/02	L-N6a	7.7	2.8	0.0%
SE	Övre Skärsjön	1049	1	0	11/08/02	L-N6a	7.3	4.5	0.0%
SE	Övre Skärsjön	1049	1	0	09/09/02	L-N6a	7.0	3.7	0.0%
SE	Övre Skärsjön	1049	1	0	08/09/03	L-N6a	6.0	4.0	0.0%
SE	Övre Skärsjön			0	(august)	L-N6a	7.8	2.8	0.0%
SE	Sangen			0	(august)	L-N6a	11.0	NA	5.0%
SE	Särnasjön			0	(august)	L-N6a	6.0	NA	0.4%
SE	Stensjön			0	(august)	L-N6a	7.3	2.2	0.4%
SE	Stor-Arasjön			0	(august)	L-N6a	5.8	3.3	2.8%
SE	Stor-Björsjön			0	(august)	L-N6a	5.7	1.4	1.5%
SE	STORFULVURN			0	(august)	L-N6a	8.0	NA	0.0%
SE	STRAKKVATTNET			0	(august)	L-N6a	7.0	NA	0.0%
SE	Tväringen			0	(august)	L-N6a	8.8	2.6	2.2%
SE	Ulvsjön	1040	1	0	21/08/01	L-N6a	10.0	2.7	0.0%
SE	Ulvsjön	1040	1	0	20/08/02	L-N6a	10.5	3.5	1.6%
SE	Ulvsjön	1040	1	0	27/08/03	L-N6a	10.0	5.4	0.4%
SE	Ulvsjön			0	(august)	L-N6a	7.8	3.5	0.4%
SE	Venjansjön			0	(august)	L-N6a	12.2	NA	21.5%
SE	Vuolgamjaure			0	(august)	L-N6a	7.8	1.9	1.6%
FI	Älänne	9932	35879	1	17/07/00	L-N6a	12.0	4.2	0.5%
FI	Pesiöjärvi	27907	32959	1	17/07/00	L-N6a	12.0	4.6	2.6%
FI	Piispajärvi	28059	33075	1	18/07/00	L-N6a	14.0	2.9	2.4%
NO	Harasjøen	HEDIHAR	323	1	11/07/88	L-N6a	10.0	6.0	0.0%
NO	Harasjøen	HEDIHAR	323	1	12/08/88	L-N6a	10.0	4.1	0.0%
NO	Harasjøen	HEDIHAR	323	1	06/09/88	L-N6a	8.0	3.1	0.0%
NO	Vatnebrynnvatnet	BUSIVAT	99	1	25/07/88	L-N6a	10.0	4.1	0.0%
NO	Vatnebrynnvatnet	BUSIVAT	99	1	25/08/88	L-N6a	7.0	2.2	0.0%
NO	Vermunden	HEDIVER	319	1	10/07/88	L-N6a	7.0	3.6	0.0%
NO	Vermunden	HEDIVER	319	1	24/07/89	L-N6a	5.0	2.3	0.0%
NO	Vermunden	HEDIVER	319	1	30/08/89	L-N6a	9.0	2.8	0.0%
NO	Vermunden	HEDIVER	319	1	28/08/91	L-N6a	10.0	3.2	0.0%
FI	Kallavesi (N60 81.70)	5500	17473	0	12/07/94	L-N8a	30.0	9.2	0.7%
FI	Kallavesi (N60 81.70)	5500	17473	0	14/07/97	L-N8a	36.0	19.0	0.2%
FI	Kallavesi (N60 81.70)	5500	17473	0	06/07/98	L-N8a	25.0	9.6	0.2%
FI	Kallavesi (N60 81.70)	5500	17473	0	27/07/98	L-N8a	31.0	12.0	2.3%
FI	Kemijärvi (N43 146.50)x1	35118	36795	0	07/07/94	L-N8a	13.0	4.8	2.1%
FI	Kemijärvi (N43 146.50)x1	35118	36795	0	11/08/94	L-N8a	14.0	6.1	0.0%
FI	Kemijärvi (N43 146.50)x1	35118	36795	0	22/09/94	L-N8a	12.5	3.0	3.0%
FI	Kemijärvi (N43 146.50)x1	35118	36795	0	11/07/96	L-N8a	16.0	4.6	4.0%
FI	Lohjanjärvi	19576	1089	0	01/08/95	L-N8a	21.0	6.8	7.3%
FI	Lohjanjärvi	19576	1089	0	01/08/96	L-N8a	20.0	13.0	41.1%
FI	Lohjanjärvi	19576	1089	0	05/08/96	L-N8a	16.0	10.0	41.1%
FI	Lohjanjärvi	19576	1089	0	07/08/02	L-N8a	16.0	6.4	5.2%
FI	Lohjanjärvi	19576	1101	0	08/07/96	L-N8a	22.5	14.0	1.0%
FI	Lohjanjärvi	19576	1101	0	01/08/96	L-N8a	21.0	18.0	5.3%
FI	Lohjanjärvi	19576	1101	0	05/08/96	L-N8a	19.0	14.0	5.3%
FI	Lohjanjärvi	19576	1143	0	01/08/96	L-N8a	22.0	14.0	36.9%
FI	Lohjanjärvi	19576	1143	0	11/07/01	L-N8a	17.0	6.0	1.0%
FI	Lohjanjärvi	19576	1143	0	02/08/01	L-N8a	24.0	13.0	0.0%
FI	Lohjanjärvi	19576	1143	0	12/09/01	L-N8a	15.0	6.0	14.4%

FI	Lohjanjärvi	19576	1158	0	08/07/96	L-N8a	29.0	14.0	3.7%
FI	Lohjanjärvi	19576	1158	0	11/07/01	L-N8a	23.0	7.1	0.1%
FI	Lohjanjärvi	19576	1158	0	02/08/01	L-N8a	36.0	17.0	0.3%
FI	Lohjanjärvi	19576	1158	0	07/08/02	L-N8a	28.0	16.0	0.5%
FI	Lohjanjärvi	19576	1212	0	01/08/96	L-N8a	43.0	38.0	60.0%
FI	Pääjärvi	24121	2100	0	07/07/94	L-N8a	19.0	19.0	1.4%
FI	Pääjärvi	24121	2100	0	18/08/94	L-N8a	11.0	10.0	1.0%
FI	Pääjärvi	24121	2100	0	01/08/96	L-N8a	16.0	11.0	2.6%
FI	Pääjärvi	24121	2100	0	09/07/01	L-N8a	13.0	5.9	4.7%
FI	Pusulanjärvi eli Jäämäjärvi	19725	1360	0	11/07/02	L-N8a	38.0	34.0	0.5%
FI	Pyhäjärvi (N60 77.20)	20663	7591	0	11/07/02	L-N8a	35.0	27.0	21.1%
FI	Pyhäjärvi (N60 77.20)	20663	7635	0	11/07/95	L-N8a	27.0	19.0	3.0%
FI	Tiiläänjärvi	19258	366	0	09/07/02	L-N8a	51.0	30.0	19.8%
FI	Tuusulanjärvi	19482	842	0	04/07/95	L-N8a	102.5	52.0	9.4%
FI	Tuusulanjärvi	19482	842	0	18/09/95	L-N8a	88.5	40.0	75.7%
FI	Tuusulanjärvi	19482	842	0	21/08/96	L-N8a	110.0	41.0	42.7%
FI	Tuusulanjärvi	19482	842	0	20/09/99	L-N8a	49.0	21.0	41.6%
FI	Unnukka	4737	16364	0	13/07/98	L-N8a	14.0	9.8	3.7%
FI	Vanajavesi (N60 79.40)x2	20770	7833	0	11/07/94	L-N8a	27.0	11.0	1.1%
FI	Vanajavesi (N60 79.40)x2	20770	7833	0	09/07/97	L-N8a	22.5	19.5	1.5%
FI	Vanajavesi (N60 79.40)x2	20770	7833	0	09/07/02	L-N8a	24.0	16.0	12.6%
FI	Vanajavesi (N60 79.40)x2	20770	7833	0	10/07/02	L-N8a	28.0	14.0	12.6%
FI	Veckjärvi	19251	56559	0	09/07/02	L-N8a	32.0	9.2	2.0%
NO	Akersvatnet	VESIAKE	5	0	15/07/88	L-N8a	41.0	21.5	0.1%
NO	Akersvatnet	VESIAKE	5	0	17/08/88	L-N8a	45.0	38.2	0.1%
NO	Åsrumvatnet	VESIÅSR	8	0	15/07/88	L-N8a	14.0	4.6	0.0%
NO	Åsrumvatnet	VESIÅSR	8	0	17/08/88	L-N8a	24.0	9.7	5.2%
NO	Bergsvatnet i Eidsfoss	VESIBER	1	0	15/07/88	L-N8a	17.0	15.7	64.3%
NO	Bergsvatnet i Eidsfoss	VESIBER	1	0	17/08/88	L-N8a	19.0	17.7	91.4%
NO	Bjørkelangen	AKEIBJØ	313	0	07/07/88	L-N8a	16.0	23.3	22.0%
NO	Bjørkelangen	AKEIBJØ	313	0	06/08/88	L-N8a	33.0	24.7	10.5%
NO	Bjørkelangen	AKEIBJØ	313	0	03/09/88	L-N8a	48.0	5.7	43.8%
NO	Borrevatnet	VESIBOR	4	0	15/07/88	L-N8a	25.0	20.2	1.1%
NO	Borrevatnet	VESIBOR	4	0	17/08/88	L-N8a	25.0	11.5	0.3%
NO	Ertevannet	ØSTIERT	387	0	15/07/92	L-N8a	65.0	61.6	2.8%
NO	Ertevannet	ØSTIERT	387	0	12/08/92	L-N8a	64.0	73.4	2.6%
NO	Ertevannet	ØSTIERT	387	0	15/07/97	L-N8a	30.0	28.3	2.0%
NO	Ertevannet	ØSTIERT	387	0	14/08/97	L-N8a	35.0	87.7	0.8%
NO	Fiskumvatnet	BUSIFIS	109	0	16/07/88	L-N8a	13.0	1.9	0.0%
NO	Fiskumvatnet	BUSIFIS	109	0	13/08/88	L-N8a	5.0	1.9	15.8%
NO	Fiskumvatnet	BUSIFIS	109	0	10/07/97	L-N8a	5.0	2.0	0.0%
NO	Fiskumvatnet	BUSIFIS	109	0	16/09/97	L-N8a	5.0	2.1	0.1%
NO	Nesvatnet	NTRINES	368	0	16/07/92	L-N8a	13.0	7.6	0.0%
NO	Nesvatnet	NTRINES	368	0	20/08/92	L-N8a	20.0	6.3	0.9%
NO	Øgderen	AKEIØGD	304	0	08/07/88	L-N8a	9.0	8.3	15.5%
NO	Øgderen	AKEIØGD	304	0	06/08/88	L-N8a	19.0	11.1	6.3%
NO	Øgderen	AKEIØGD	304	0	28/08/88	L-N8a	16.0	7.7	33.1%
NO	Tunevannet	ØSTITUN	286	0	03/07/88	L-N8a	14.0	4.8	1.8%
NO	Tunevannet	ØSTITUN	286	0	28/07/88	L-N8a	30.0	9.5	2.1%
NO	Tunevannet	ØSTITUN	286	0	27/08/88	L-N8a	22.0	9.3	17.8%
NO	Visterflo	ØSTIVIS	281	0	27/07/88	L-N8a	18.0	5.8	4.7%
NO	Visterflo	ØSTIVIS	281	0	25/08/88	L-N8a	17.0	2.6	0.5%
SE	Dagstorpssjön			0	(august)	L-N8a	54.0	36.4	62.4%
SE	Edasjön			0	(august)	L-N8a	32.3	14.3	41.3%
SE	Ekholmssjön	1397	1	0	14/08/01	L-N8a	24.0	9.8	2.6%
SE	Ekholmssjön	1397	1	0	13/08/02	L-N8a	19.0	3.9	1.6%
SE	Ekholmssjön	1397	1	0	12/08/03	L-N8a	15.0	5.2	0.0%
SE	Ekholmssjön			0	(august)	L-N8a	22.0	11.4	0.9%

SE	Grönskogssjön			0	(august)	L-N8a	7.0	NA	0.0%
SE	Grumlan			0	(august)	L-N8a	17.5	NA	5.7%
SE	Hulingen			0	(august)	L-N8a	20.5	NA	0.8%
SE	Lillsjön			0	(august)	L-N8a	98.5	30.8	60.4%
SE	Narrvreten			0	(august)	L-N8a	11.5	NA	1.2%
SE	Nedre Svartsjön			0	(august)	L-N8a	32.5	NA	0.5%
SE	Rossen			0	(august)	L-N8a	8.5	NA	0.7%
SE	Rundbosjön	1378	1	0	15/08/01	L-N8a	85.0	24.2	19.5%
SE	Rundbosjön	1378	1	0	14/08/02	L-N8a	25.0	16.1	74.3%
SE	Rundbosjön	1378	1	0	13/08/03	L-N8a	12.0	10.1	43.2%
SE	Rundbosjön			0	(august)	L-N8a	41.5	14.7	34.0%
SE	Saljen			0	(august)	L-N8a	12.0	NA	4.1%
SE	Skirösjön			0	(august)	L-N8a	55.0	NA	86.7%
SE	Tärnan			0	(august)	L-N8a	13.7	4.7	10.6%
SE	V. Rännöbodsjön			0	(august)	L-N8a	12.6	4.6	1.9%
SE	Virserumssjön			0	(august)	L-N8a	10.5	NA	2.7%
FI	Haukivesi (Saimaa N60+75.80)	3695	13967	1	11/07/01	L-N8a	20.0	15.0	1.7%
FI	Kallavesi (N60 81.70)	4829	16643	1	16/07/96	L-N8a	15.0	9.3	1.7%
FI	Kallavesi (N60 81.70)	4829	16643	1	13/07/98	L-N8a	16.0	9.4	3.5%
FI	Orivesi (Saimaa N60+75.80)	5802	22196	1	09/07/01	L-N8a	14.0	5.7	0.9%
FI	Sotkamojärvi	29052	34136	1	11/07/00	L-N8a	35.0	15.0	32.1%
FI	Viinijärvi	6194	22677	1	11/07/95	L-N8a	16.0	8.7	1.4%
FI	Viinijärvi	6194	22677	1	15/07/97	L-N8a	12.0	3.9	0.5%
FI	Viinijärvi	6194	22677	1	21/07/99	L-N8a	17.0	4.8	1.8%
NO	Lømsen	NTRILØM	229	1	03/07/88	L-N8a	6.0	2.7	4.1%
NO	Lømsen	NTRILØM	229	1	27/07/88	L-N8a	11.0	5.8	2.6%
NO	Lømsen	NTRILØM	229	1	23/08/88	L-N8a	11.0	4.1	22.1%
NO	Storvatnet	STRISTO	214	1	01/07/88	L-N8a	6.0	4.9	24.0%
NO	Storvatnet	STRISTO	214	1	25/07/88	L-N8a	9.0	4.2	37.3%
NO	Storvatnet	STRISTO	214	1	27/07/89	L-N8a	8.0	3.1	51.2%
NO	Storvatnet	STRISTO	214	1	07/09/91	L-N8a	9.0	4.6	59.1%