Section 3 - Phytoplankton biomass metrics ANNEXES

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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.

Additional data were used in the development of the $PTI_{species}$ in Italy (Salmaso *et al.* 2006) and for the PTSI in Germany (Nixdorf *et al.* 2006).

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

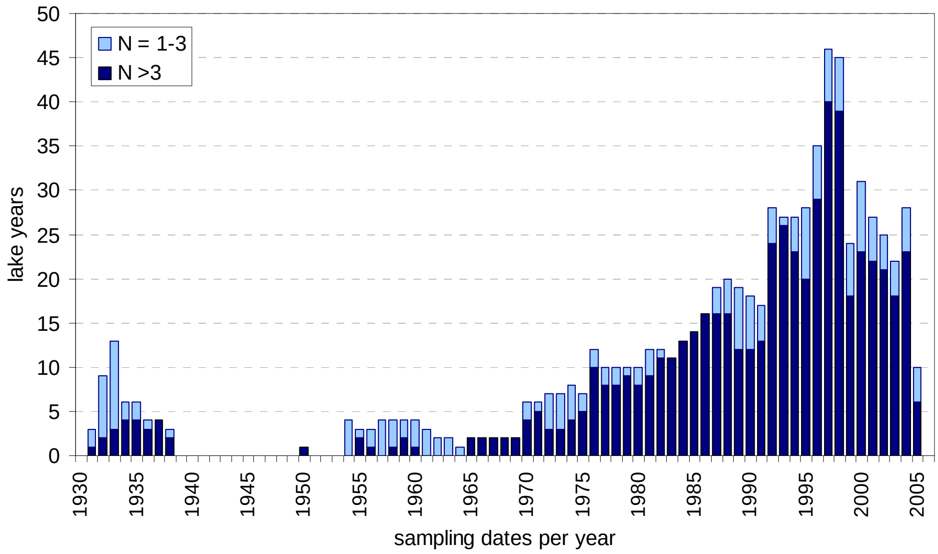


Figure A-1a. Number of data ('lake years', sampling sites within one lake treated separately) per year between 1931 and 2005. Light blue bars = lake years with less than 4 sampling dates per year, dark blue bars = lake years with 4–42 sampling dates per year.

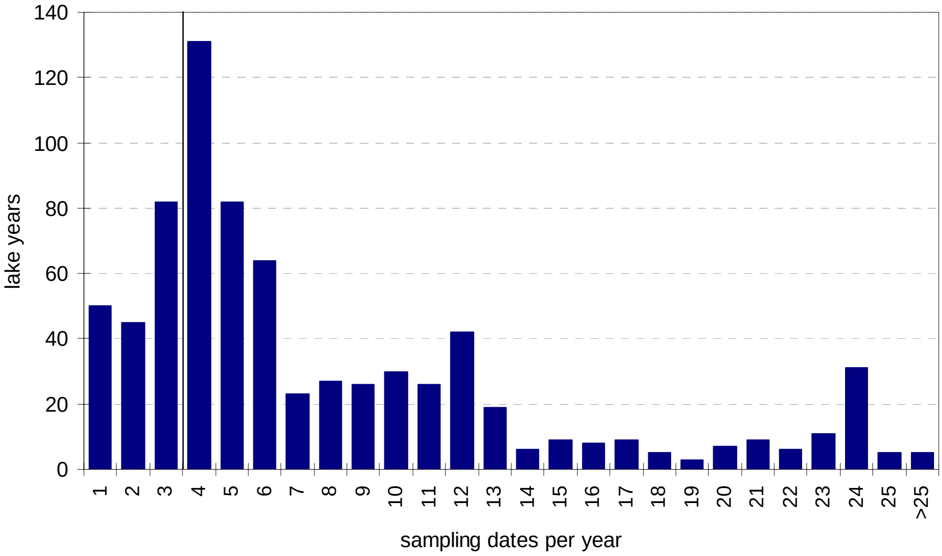


Figure A-1b. Number of lake years with different sampling dates per year.

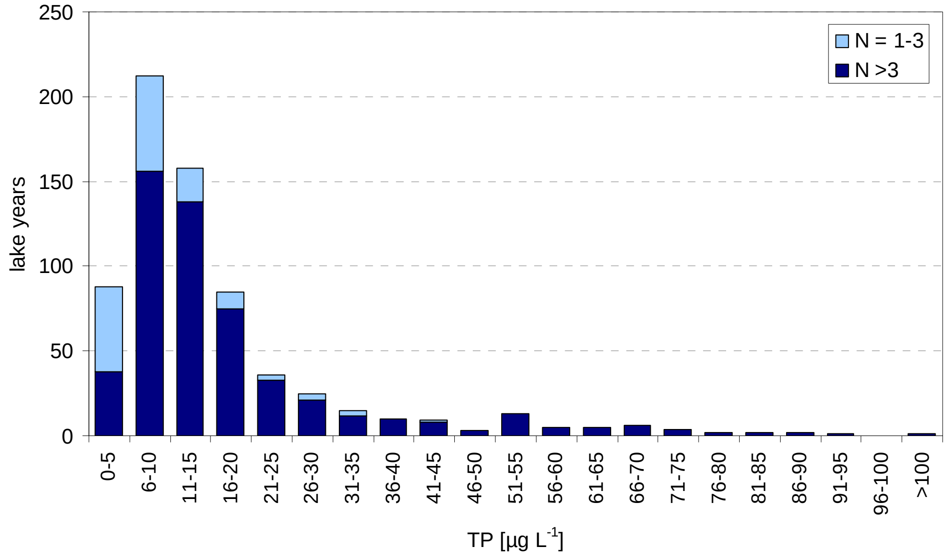


Figure A-1c Distribution of Alpine lakes years along a gradient of TP concentration. Light blue bars indicate lake years with less than 4 sampling dates per year.

Data for developing the PTSI in Germany

The base of the German assessment was a qualified dataset (240.000 taxa findings, about 12.000 samples in 450 water bodies) with the following criteria:

- Minimum 4 sampling dates in one lake year;
- Minimum 20 taxa per lake and year and 10 taxa per sample.

In the Alpine ecoregion, the data set contains of 1.600 samples (about 35.000 taxa findings) in 165 lake years and 90 lakes.
Finally the search of indicator taxa was based on a dataset with the maximum dominance (square root-transformed) of the potential taxa in one lake year.

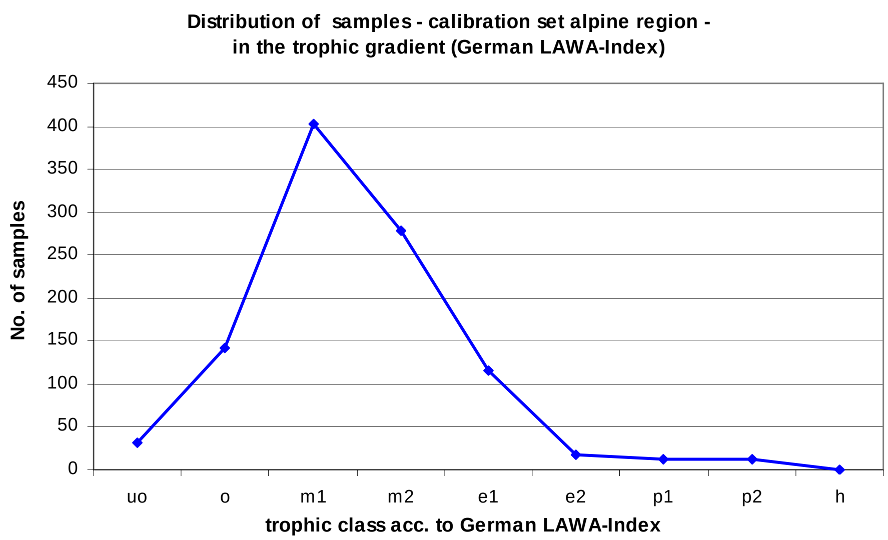


Figure A-1d. Distribution of samples in the trophic gradient and stress of the Alpine calibration data set.

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, 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 Sub-alpine 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 µg L^{-1}. Besides, monitoring data indicate that the taxonomic composition of planktonic algae changes along a *TP* gradient of 5 to 10 µg L^{-1} (Fricker 1980, BMGU & BMWF 1983, Malicky 1987, IGKB 2004a, b) Hence, for L-AL3 lakes, a *TP* threshold value of ≤8 µg L^{-1} is suggested to select reference sites. For the shallow (pre-)Alpine lakes of IC type L-AL4 a threshold value of TP ≤12 µg 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.

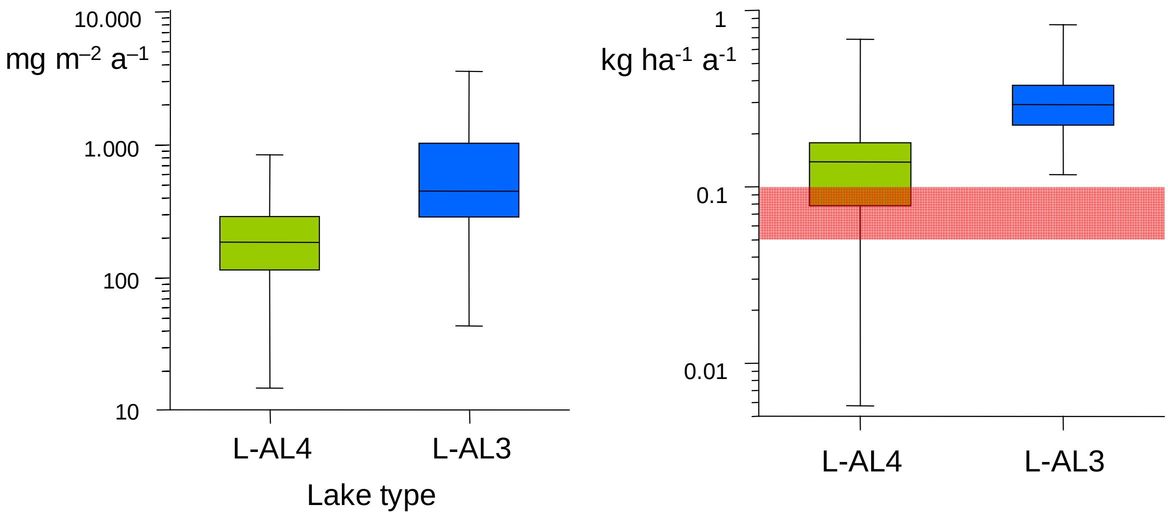


Figure A-3. Critical *TP* load per lake area after Vollenweider [mg m^{-2} a^{-1}] (left) and critical *TP* export rate from the catchment area [kg ha^{-1} a^{-1}] in the two Alpine lake types L-AL3 (mean depth >15 m) and L-AL4 (mean depth 3–15 m). The red-shaded bar in the right diagram indicates the 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:

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

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:

$$ER_c = L_c \frac{A}{E} 100 \tag{2}$$

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	
FR	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
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	

MS	*Lake*	*IC type*	*Mean depth [m]*	*TP [µg L^{-1}]*	*Year(s)*	*comment*
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: Description of national trophic indices

5.1. Brettum index (AT)

Calculation of trophic scores for indicator taxa for Brettum index

The Brettum index is a trophic index, based on a set of indicator taxa. Each taxon is given a taxon-specific trophic score, which consists of 10 points distributed over 6 trophic classes (<5 µg L^{-1}, 5–8 µg L^{-1}, 8–15 µg L^{-1}, 15–30 µg L^{-1}, 30–60 µg L^{-1}, >60 µg L^{-1}). The points are derived following Brettum (1989) and can be interpreted as the probability p_{ij} that the taxon *i* occurs in a trophic class *j* with a relative biovolume b_i:

$$p_{ij} = \frac{n_{ij}}{N_j} b_i$$

n_{ij} = number of occurrence of taxon *i* in the trophic class *j* (presence/absence)

N_j = total number of lake years in the trophic class *j*

b_i = mean relative proportion of taxon *i* of the total biovolume in the trophic class *j* („dominance“)

$\frac{n_{ij}}{N_j}$ = occurrence

Different to the original calculations of Brettum (1989), the six values of the trophic classes p_{ij} were re-scaled to 10 points, giving new values x_{ij} (Dokulil 2001, Wolfram *et al.* 2006).

Calculation of the Brettum index

For the calculation of the Brettum index of a given sample, the scores of the taxa x_{ij} are multiplied with their relative biovolume v_i. This gives six summary indices I_j, one for each trophic class:

$$I_j = \frac{\sum_{i=1}^{n} v_i x_{ij}}{\sum_{i=1}^{n} v_i}$$

Finally, a weighted average of the 6 classes is calculated with the following weights T_j: the first class (≤5 µg L^{-1}) = 6, the second class = 5 … the last class = 1. The final index thus ranges theoretically from 1 to 6.

$$BI = \frac{\sum_{j=1}^{5} I_j T_j}{\sum_{j=1}^{5} I_j}$$

Indicator taxa used for Brettum index

Table A-5.1. Phytoplankton indicator taxa, calculated from the whole GIG data set, used for the Brettum index.

Taxon_ID	Accepted name	Nr of Lakes					TP scores					
		AT	FR	GE	IT	SI	≤5	5-8	8-15	15-30	30-60	>60
R0042	Cyclotella comensis	15	0	22	7	2	9	1	0	0	0	0
G0053	Cyclotella (excl. ocellata,meneghin.,radiosa)	17	1	24	8	1	4	4	1	1	0	0
R0040	Cyclotella bodanica	13	0	8	0	0	1	9	0	0	0	0
G0495	Botryococcus	18	0	6	0	1	1	5	3	1	0	0
G1161	Bitrichia	18	0	26	1	2	1	5	3	1	0	0
G1168	Chrysolykos	11	0	17	0	0	0	7	1	1	1	0
G0177	Cymbella	11	0	16	2	0	0	4	5	1	0	0
G1675	Ceratium	25	1	34	9	2	3	2	2	1	1	1
R1070	Dinobryon cylindricum	10	0	13	0	0	0	5	2	2	1	0
G1654	Gymnodinium	25	1	36	12	2	0	4	3	2	1	0
R0223	Fragilaria crotonensis	23	1	34	12	2	0	4	3	2	1	0
R0076	Stephanodiscus alpinus						1	3	4	2	0	0
R1438	Chroococcus limneticus						1	3	3	2	1	0
R0249	Fragilaria ulna v. angustissima	20	0	31	0	0	0	3	4	2	1	0
G1151	Uroglena	19	0	23	5	1	0	3	3	3	1	0
R0442	Tabellaria flocculosa						0	2	7	1	0	0
R1443	Chroococcus minutus						1	1	6	1	1	0
R0025	Aulacoseira islandica						0	1	5	3	1	0
R1209	Cosmarium depressum	14	0	17	1	0	0	1	5	2	1	1
G1432	Aphanothece	13	0	22	6	2	1	1	3	2	2	1
R1617	Planktothrix rubescens	22	1	14	10	1	1	2	3	4	0	0
R1066	Dinobryon bavaricum	13	0	15	1	2	1	1	4	4	0	0
R1069	Dinobryon crenulatum	8	0	28	0	0	0	1	4	4	1	0
R1413	Aphanocapsa delicatissima	8	0	14	4	1	0	1	4	4	1	0
G1423	Aphanocapsa (excl. delicatissima)	15	0	25	9	1	0	1	2	5	2	0
R0440	Tabellaria fenestrata	22	1	24	9	1	0	0	5	5	0	0
R0033	Aulacoseira subarctica						0	0	5	3	2	0
R1083	Dinobryon sociale	18	1	32	3	1	0	0	4	3	3	0
G0637	Koliella	16	0	4	3	2	0	0	3	5	1	1
R0530	Coelastrum reticulatum						0	0	4	2	2	2
R0083	Stephanodiscus neoastraea	14	1	13	4	1	0	0	3	4	3	0
G0607	Eutetramorus	12	0	27	0	2	0	0	3	3	3	1
G0976	Phacotus (excl. lenticularis)						0	0	2	6	2	0
R1081	Dinobryon sertularia	8	0	26	0	1	0	0	1	6	3	0
R1100	Mallomonas caudata	11	0	20	7	1	0	0	1	5	4	0
R0792	Scenedesmus linearis						0	0	1	5	3	1
R0571	Dictyosphaerium pulchellum						0	0	2	4	4	0
R1097	Mallomonas akrokomos	8	0	18	6	0	0	0	2	3	3	2
R0051	Cyclotella radiosa	13	1	23	3	1	0	0	1	3	5	1
G0491	Ankyra	7	0	21	5	1	0	0	1	3	5	1
R0848	Tetraedron minimum	10	0	21	9	0	0	0	1	3	5	1
R0550	Crucigenia tetrapedia						0	0	2	2	6	0
R1288	Staurastrum gracile						0	0	0	4	6	0
R1414	Aphanocapsa elachista	5	0	19	0	0	0	0	1	3	5	1
G0682	Monoraphidium	12	0	24	6	0	0	0	1	1	7	1
G0030	Aulacoseira (excl. islandica, subarctica, granulata)	12	1	24	10	0	0	0	2	2	3	3
R1096	Mallomonas acaroides	4	0	17	6	0	0	0	1	3	4	2
R1620	Pseudanabaena catenata	8	0	3	4	0	0	1	1	1	3	4
G0531	Coelastrum (excl. reticulatum)	10	0	23	7	0	0	0	1	3	3	3
G0582	Didymocystis	11	0	2	0	0	0	0	0	2	8	0
G1309	Staurastrum (excl. gracile)	17	1	26	9	2	0	0	0	3	6	1
R0923	Carteria	15	0	10	4	1	0	0	1	1	6	2
R0023	Aulacoseira granulata						0	0	0	4	3	3
G1141	Synura	10	0	14	1	0	0	0	0	4	3	3

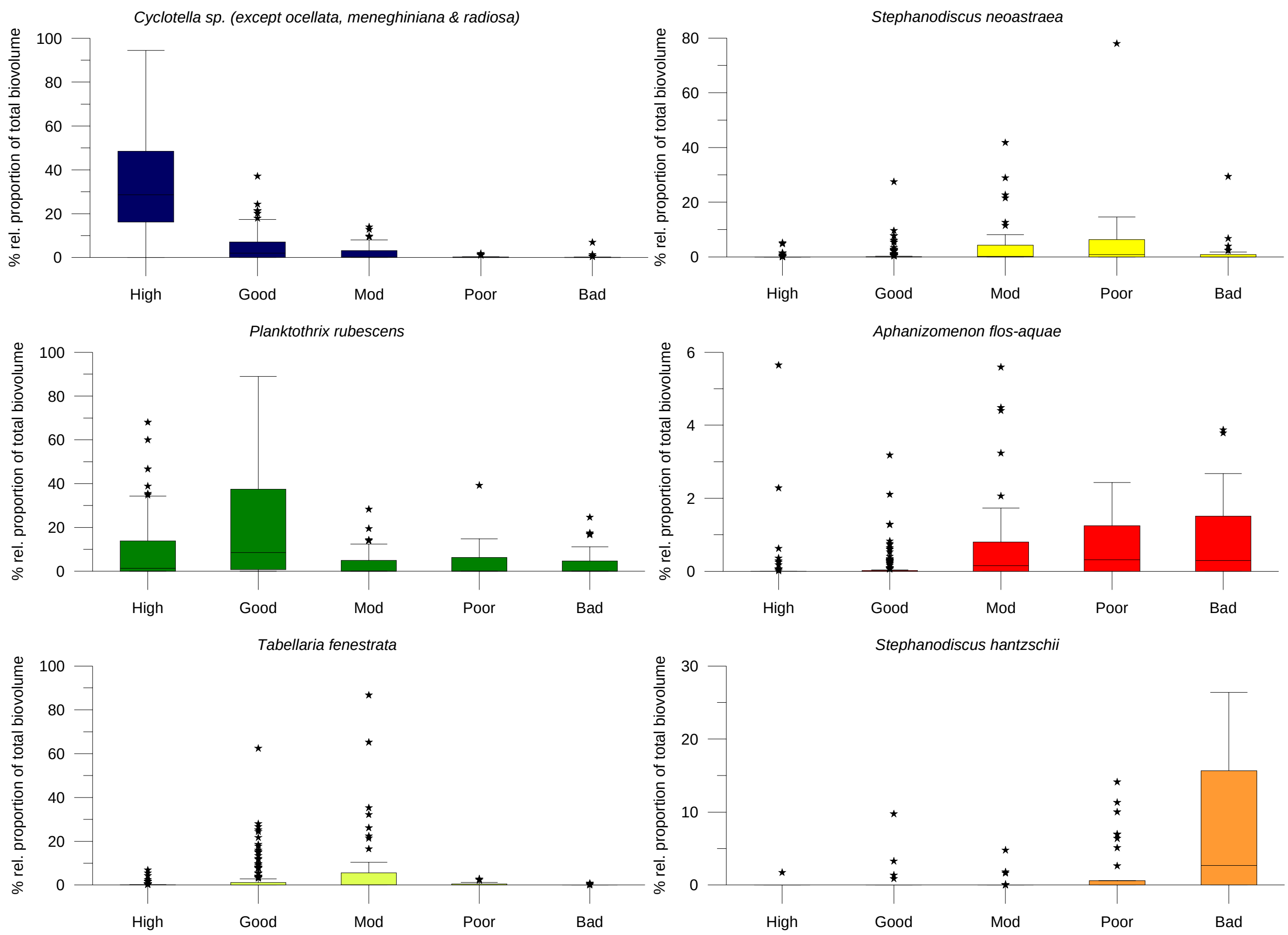
Taxon_ID	Accepted name	Nr of Lakes					TP scores					
		AT	FR	GE	IT	SI	≤5	5-8	8-15	15-30	30-60	>60
R0048	Cyclotella ocellata	2	0	6	5	1	**0**	**0**	**0**	**3**	**5**	**2**
G1003	Mougeotia	1	1	6	7	0	**0**	**0**	**0**	**3**	**5**	**2**
G0633	Kirchneriella	5	0	5	5	0	**0**	**0**	**0**	**2**	**6**	**2**
G0745	Quadrigula	3	0	19	1	0	**0**	**0**	**0**	**1**	**8**	**1**
G0811	Scenedesmus (excl. linearis)	17	0	30	10	1	**0**	**0**	**0**	**2**	**6**	**2**
G0821	Schroederia	2	0	5	8	0	**0**	**0**	**0**	**2**	**6**	**2**
R1191	Closterium limneticum						**0**	**0**	**0**	**2**	**6**	**2**
R0975	Phacotus lenticularis	8	0	22	1	2	**0**	**0**	**1**	**2**	**6**	**1**
R0062	Melosira varians	10	0	7	5	0	**0**	**0**	**0**	**1**	**7**	**2**
R0713	Pediastrum boryanum	11	1	26	7	0	**0**	**0**	**0**	**1**	**7**	**2**
R1181	Closterium acutum v. variabile	2	0	23	1	0	**0**	**0**	**0**	**1**	**7**	**2**
R0079	Stephanodiscus hantzschii	4	0	5	1	0	**0**	**0**	**0**	**3**	**3**	**4**
G1562	Aphanizomenon (excl. flos-aquae)	15	1	16	7	1	**0**	**0**	**1**	**1**	**3**	**5**
R0024	Aulacoseira granulata v. angustissima	0	0	10	4	0	**0**	**0**	**0**	**2**	**4**	**4**
R0082	Stephanodiscus minutulus	5	1	17	4	0	**0**	**0**	**0**	**2**	**4**	**4**
G0705	Oocystis	17	0	27	11	2	**0**	**0**	**0**	**1**	**6**	**3**
G0723	Pediastrum (excl. boryanum & duplex)	12	1	27	8	0	**0**	**0**	**0**	**1**	**6**	**3**
R0993	Sphaerocystis schroeteri	8	0	4	10	1	**0**	**0**	**0**	**2**	**3**	**5**
G0964	Eudorina	6	0	16	9	0	**0**	**0**	**0**	**2**	**2**	**6**
R0527	Coelastrum microporum	6	0	17	7	0	**0**	**0**	**1**	**2**	**2**	**5**
R1558	Aphanizomenon flos-aquae	13	1	14	6	1	**0**	**0**	**0**	**1**	**4**	**5**
R0024	Aulacoseira granulata var. angustissima	4	0	10	6	0	**0**	**0**	**0**	**2**	**4**	**4**
G0086	Stephanodiscus (other species)	17	1	24	6	1	**0**	**0**	**0**	**1**	**3**	**6**
G1201	Closterium (excl. acutum & limneticum)	13	1	26	12	0	**0**	**0**	**0**	**1**	**3**	**6**
R1178	Closterium acutum						**0**	**0**	**1**	**1**	**3**	**5**
G0574	Dictyosphaerium	11	0	10	6	1	**0**	**0**	**0**	**1**	**2**	**7**
G0973	Pandorina	8	0	10	4	1	**0**	**0**	**0**	**1**	**2**	**7**
G1450	Coelosphaerium	11	0	13	3	0	**0**	**0**	**0**	**1**	**2**	**7**
R1610	Planktolyngbya limnetica	2	0	7	0	0	**0**	**0**	**0**	**0**	**4**	**6**
R0716	Pediastrum duplex	8	0	16	5	0	**0**	**0**	**0**	**0**	**3**	**7**
G0484	Ankistrodesmus	12	0	9	4	1	**0**	**0**	**0**	**0**	**2**	**8**
G0503	Chlorella	6	0	5	4	2	**0**	**0**	**0**	**0**	**2**	**8**
R1544	Anabaena planctonica	1	0	2	5	0	**0**	**0**	**0**	**0**	**2**	**8**
G1583	Limnothrix	0	0	5	6	0	**0**	**0**	**0**	**0**	**2**	**8**

Validation of boundary setting for Brettum index

Following Section 1.1.2 in Annex V of the WFD, at good ecological status "there are slight changes in the composition … of planktonic taxa compared to the type-specific communities". A typical feature of deep Alpine lakes at reference status is the dominance of sensitive *Cyclotella* species. They decrease at good status. More tolerant taxa, which may be present also under reference conditions in low relative proportion, tend to increase (for instance *Planktothrix rubescens*, which was present in oligotrophic Wörthersee in the 1930ies in low numbers). This taxonomic shift – a change in relative proportion, but with the characteristic taxa still present – is interpreted as 'slight change' according to the WFD.

Under moderate conditions, 'reference taxa' are not dominant anymore, and other taxa, which are usually missing at high status (e.g. *Stephanodiscus neoastraea*, *Aphanizomenon flos-aquae*), reach higher relative proportions of total biovolume. This shift in species composition is interpreted as 'moderate change' according to the WFD. Strong blooms, e.g. of *Limnothrix redekei*, occur beyond moderate status.

The following diagrams illustrate that slight and moderate change correspond to the ecological classes defined for the Brettum index. It has to be stressed that the index is based on a high standard analytical method (quantitative counting on species level), which may thus bear various methodological difficulties. They may account for the variation in the plots.



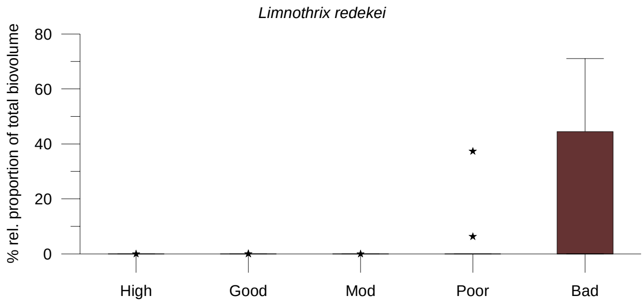


Figure A-5.1. Validation of the EQR boundaries with the relative proportion of sensitive to tolerant phytoplankton taxa (box-whisker-plots).

5. 2. PTSI (GE)

Calculation of the PTSI (trophic classification)

The following parameters are used to calculate the PTSI for each sample:

$$PTSI = \frac{\sum(Abundance\ category_i \times TAW_i \times Stenökiefaktor_i)}{\sum(Abundance\ category_i \times Stenökiefaktor_i)}$$

PTSI	Phytoplankton-Taxa-Seen-Index [Phytoplankton taxa lake index] per sample or lake year
Abundance category$_i$	Abundance category of the indicator taxon (approx. log-10-transformation of total biovolume)
TAW$_i$	Trophic score of the indicator taxon with the index i
Stenökiefaktor$_i$	Stenoecy factor of the indicator taxon with the index i

List of indicator taxa of PTSI

Table A-5.2. PTSI-Taxa list for the ecoregion Alps and Alpine Foreland (AVA), trophic scores and stenoecy weighting factors (modified list from June 2007).

Indicator taxon (AVA)	trophic score (TAW)	Stenoecy factor
Amphora ovalis	0,82	2
Anabaena flos-aquae/solitaria	1,35	1
Anabaena planctonica	2,97	2
Anabaena spiroides	1,10	1
Ankistrodesmus	3,00	2
Ankyra ancora	2,70	1
Ankyra judayi	2,72	2
Ankyra lanceolata	2,65	2
Aphanizomenon	2,75	1
Aphanizomenon flos-aquae	2,67	2
Aphanizomenon gracile	2,85	2
Aphanocapsa delicatissima	1,63	1
Aphanocapsa elachista	2,17	1
Aphanothece clathrata	1,61	1
Aulacoseira ambigua	3,35	3
Aulacoseira granulata	2,95	1
Aulacoseira islandica	1,11	1
Aulacoseira subarctica	1,74	2
Bitrichia chodatii	0,86	3
Botryococcus braunii	0,75	2
Carteria	2,75	2
Ceratium cornutum	0,59	3
Characium	2,87	2
Chlamydocapsa planctonica	2,42	1
Chlorella	3,55	2
Chroococcus limneticus	1,13	2
Chroococcus minutus	1,14	2
Chroococcus turgidus	0,63	2
Chrysolykos planctonicus	1,33	1
Chrysolykos skujae	0,77	2
Closterium aciculare	1,90	2
Closterium acutum	2,40	2
Closterium acutum var. variabile	2,95	2
Closterium limneticum	3,10	1
Coelastrum astroideum	3,07	1
Coelastrum microporum	2,20	2
Coelastrum pseudomicroporum	2,87	2
Coelastrum reticulatum	2,37	1
Cosmarium bioculatum	2,35	1
Cosmarium depressum	1,68	2
Crucigenia quadrata	2,85	4
Crucigenia tetrapedia	2,80	1
Crucigeniella rectangularis	1,41	2
Cryptomonas >35µm, curvata/rostratiformis	2,00	2
Cyclotella bodanica	0,95	2
Cyclotella comensis	0,88	2
Cyclotella cyclopuncta	1,32	1
Cyclotella delicatula	0,91	1
Cyclotella distinguenda	1,72	1
Cyclotella glomerata	0,67	2

Indicator taxon (AVA)	trophic score (TAW)	Stenoecy factor
Cyclotella ocellata	2,50	1
Cyclotella pseudostelligera	1,02	4
Cymatopleura solea	0,72	2
Diatoma tenuis	1,16	2
Diatoma vulgaris	0,79	2
Dinobryon bavaricum	1,95	1
Dinobryon divergens	1,18	1
Dinobryon sertularia	2,22	1
Dinobryon sociale	1,61	1
Eudorina elegans	2,77	2
Euglena	3,40	1
Fragilaria capucina	1,39	2
Fragilaria cyclopum	1,19	3
Fragilaria ulna danica - Sippen	1,19	4
Fragilaria ulna var. ulna	1,19	1
Golenkinia radiata	3,30	1
Gymnodinium	1,21	1
Gymnodinium uberrimum	0,92	1
Gyrosigma attenuatum	1,59	2
Lagerheimia ciliata	3,12	1
Lagerheimia subsalsa	3,02	1
Leptolyngbya tenuis	1,23	2
Limnothrix redekei	4,25	2
Mallomonas akrokomos	2,90	2
Mallomonas caudata	2,25	2
Merismopedia	2,55	1
Micractinium pusillum	3,45	2
Microcystis aeruginosa	3,20	2
Microcystis flos-aquae	2,82	1
Microcystis wesenbergii	4,50	2
Monoraphidium griffithii	3,05	1
Monoraphidium komarkovae	1,77	1
Monoraphidium minutum	3,60	2
Mougeotia	2,45	1
Nephrocytium agardhianum	1,75	2
Nitzschia palea	0,99	1
Oocystis marssonii	3,15	1
Pediastrum duplex	3,02	2
Pediastrum simplex	2,60	2
Pediastrum tetras	3,05	3
Peridinium aciculiferum	2,62	1
Peridinium bipes	2,27	2
Peridinium umbonatum-Komplex	1,23	1
Peridinium willei	1,05	2
Phacotus lendneri	2,30	1
Phacus longicauda	3,75	1
Planctonema lauterbornii	0,94	2
Planktolyngbya contorta	3,70	2
Planktolyngbya limnetica	3,65	2
Planktothrix rubescens	1,55	2
Pseudanabaena limnetica	2,32	2
Pseudopedinella erkensis	1,25	1
Rhabdogloea smithii	2,57	3
Scenedesmus	3,25	1

Indicator taxon (AVA)	trophic score (TAW)	Stenoecy factor
Scenedesmus linearis	1,63	1
Schroederia	2,47	1
Snowella	1,57	1
Staurastrum paradoxum	2,92	2
Staurastrum tetracerum	3,50	2
Stelexomonas dichotoma	2,05	3
Stephanodiscus hantzschii	1,04	1
Stephanodiscus neoastraea	2,97	3
Synechococcus	1,67	3
Synura uvella	1,25	3
Tabellaria fenestrata	3,00	3
Tabellaria flocculosa	1,62	2
Tetrachlorella alternans	1,26	3
Tetraselmis cordiformis	1,80	3
Tetrastrum triangulare	1,26	4
Trachelomonas volvocina	1,59	1
Uroglena	2,15	2
Volvox	1,82	1
Willea irregularis	2,52	3
Woronichinia naegeliana	1,37	2

5. 3. $\mathbf{PTI_{species}}$ and $\mathbf{PTI_{ot}}$ (IT)

Calculation of the trophic scores for the indicator taxa

$PTI_{species}$

The distribution of algal species/orders in relation to some environmental variables (TP, alkalinity, transparency, chl-a) was analysed by CCA. Before computation, the biovolumes were log-transformed in order to reduce the weight of the most important taxa. On the basis of the results obtained by the CCA, a trophic score was assigned to the single algal orders/species, in relation to their position on the trophic gradient.

PTI_{ot}

The weighted average (niche centroid; ter Braak *et al.* 1995) of the species **k** with respect to the gradient of TP concentration for all the lakes was calculated. These values could represent the optimum environmental concentration for TP for each **k** species: we indicate them as TP_{opt}. Before the calculation of PTI_{ot}, TP concentration was transformed in LOG 10 values and rescaled from 1 to 5.

$$PTIot = \sum_{i=1}^{n} \frac{Yik}{Y_{+k}} TPi$$

Where
Yik = abundance (= biovolume fraction) of species k at site i
Y_{+k} = total biovolume of the species k across n lakes
TPi = total phosphorus concentration at site i

Tolerance represents the weighted standard deviation of a species. It can be seen as a measure of niche-breadth and was calculated as

$$t_k = \sqrt{\sum_{i=1}^{n} \frac{Yik}{Y_{+k}} (TPi - PTIot)^2}$$

On the basis of the ratio between tolerance (t) and TP_{opt} (mg L^{-1} of TP), we obtain a trophic score for each species (Table A-5-3b). These scores have been rescaled from 1 to 4 as follows: when the ratio is higher than 0.8, then v_i=1; when it is within the range 0.8 – 0.6, then v_i=2; within the range 0.4 – 0.6 v_i=3; at values <0.4 v_i=4.
The indicator values will be used to calculate PTI_{ot} for each lake year, as explained in 3.4.

List of indicator taxa $PTI_{species}$

Table A-5-3a. List of indicator taxa used in $PTI_{species}$.

Code	Taxon (species or order)	Trophic Score
Chrooc	*Chroococcales*	3.5
Aphanot	Aphanocapsa/Aphanothece	4
Gomp la	Gomphosphaeria lacustris	5
Snow sp	Snowella spp.	1
Oscill	*Oscillatoriales*	4
Plan ru	Planktothrix rubescens/agardhii	4
Pseu li	Pseudanabaena limnetica	5
Limnotr	*Limnotrichoideae*	5
Plan li	*Leptolyngbyoideae*	2
Nostoc	*Nostocales*	1.5
Apha fl	Aphanizomenon flos-aquae	2
Chloro	*Chlorococcales*	1.5
Oocy sp	Oocystis spp.	1
Coel sp	Coelastrum spp.	2
Spha sp	Sphaerocystis schroeteri	3
Dict pu	Dictyosphaerium pulchellum	1
Mono sp	Monoraphidium spp.	3
Scen sp	Scenedesmus spp.	1
Chlamy	*Chlamydomonadales*	1.5
Cart sp	Carteria spp.	2
Volvoc	*Volvocales*	1
Pand mo	Pandorina morum—P.minodi	1
Desmid	*Desmidiales*	1.5
Clos ac	Closterium aciculare	2
Stau sp	Staurastrum spp.	2
Zygnem	*Zygnemales*	3.5
Moug sp	Mougeotia sp.	3
Centra	*Centrales*	3.5
Aula gr	Aulacoseira granulata—A. ambigua	4
Aula is	Aulacoseira islandica	3
Cycl sp	Cyclotella spp.	4
Melo va	Melosira varians	1
Step sp	Stephanodiscus spp.	4
Pennal	*Pennales*	4
Aste fo	Asterionella formosa	4
Frag cr	Fragilaria crotonensis	4
Diat te	Diatoma tenuis	4
Tabe fe	Tabellaria fenestrata—T. flocculosa	4
Ochrom	*Ochromonadales*	5
Dino so	Dinobryon sociale	5
Ochromo	*Ochromonadaceae*	4

Code	Taxon (species or order)	Trophic Score
Mall sp	Mallomonas spp.	4
Urog sp	Uroglena spp.	5
Prymne	*Prymnesiales*	5
Chry pa	Chrysochromulina parva	5
Tribon	*Tribonematales*	1
Trib sp	Tribonema sp.	1
Peridi	*Peridiniales*	4
Cera hi	Ceratium hirundinella	4
Gymn he	Gymnodinium helveticum	4
Gymn sp	Gymnodinium sp.	5
Crypto	*Cryptomonadales*	3.5
Cryp sp	Cryptomonas spp.	3
Rhod mi	Rhodomonas minuta	4

List of indicator taxa PTI_{ot}

Table A-5-3b. List of indicator taxa used in PTI_{ot}. These values was obtained using Log TP rescaled from 1 to 5.

Taxa	PTI [mg L^{-1} TP]	t [mg L^{-1} TP]	Trophic scores	Frequencies
Amphora	0.020	0.0123	2	11
Amphora ovalis	0.014	0.0039	4	25
Anabaena	0.017	0.0154	1	73
Anabaena circinalis	0.026	0.0215	1	18
Anabaena flos-aquae	0.020	0.0165	1	221
Anabaena planctonica	0.050	0.0178	4	46
Anabaena solitaria	0.069	0.0110	4	5
Anabaena sphaerica	0.014	0.0042	4	3
Anabaena spiroides	0.012	0.0070	3	75
Anabaena viguieri	0.042	0.0089	4	5
Ankistrodesmus	0.026	0.0223	1	67
Ankyra ancora	0.032	0.0076	4	44
Ankyra judayi	0.033	0.0095	4	56
Ankyra lanceolata	0.027	0.0168	2	60
Aphanizomenon	0.016	0.0243	1	68
Aphanizomenon flos-aquae	0.037	0.0229	2	204
Aphanizomenon gracile	0.023	0.0139	3	16
Aphanocapsa	0.019	0.0129	2	58
Aphanocapsa delicatissima	0.015	0.0090	2	143
Aphanocapsa elachista	0.023	0.0170	2	97
Aphanocapsa holsatica	0.031	0.0046	4	4
Aphanothece	0.013	0.0067	3	90
Aphanothece clathrata	0.022	0.0140	2	87
Asterionella formosa	0.018	0.0163	1	659
Aulacoseira	0.013	0.0061	3	38
Aulacoseira ambigua	0.023	0.0020	4	13
Aulacoseira granulata	0.035	0.0200	3	98
Aulacoseira granulata v. angustissima	0.031	0.0154	3	74
Aulacoseira islandica	0.018	0.0111	2	116
Aulacoseira islandica v. helvetica	0.041	0.0015	4	5
Aulacoseira italica	0.067	0.0403	3	11
Aulacoseira subarctica	0.011	0.0057	3	19
Bitrichia chodatii	0.010	0.0053	3	184
Botryococcus	0.037	0.0142	4	7
Botryococcus braunii	0.019	0.0189	1	180
Carteria	0.028	0.0185	2	147
Ceratium	0.009	0.0067	2	47

Ceratium cornutum	0.007	0.0032	3	33
Ceratium furcoides	0.052	0.0085	4	5
Ceratium hirundinella	0.016	0.0147	1	657
Chamaesiphon	0.036	0.0002	4	4
Chlamydocapsa planktonica	0.065	0.0226	4	19
Chlamydomonas	0.015	0.0138	1	384
Chlamydomonas globosa	0.027	0.0071	4	23
Chlamydomonas reinhardtii	0.051	0.0218	3	37
Chlorella	0.045	0.0260	3	68
Chlorella vulgaris	0.033	0.0151	3	62
Chlorolobion	0.011	0.0041	4	62
Choricystis	0.016	0.0045	4	14
Choricystis chodatii	0.016	0.0150	1	12
Chromulina	0.020	0.0148	2	151
Chroococcus	0.011	0.0030	4	118
Chroococcus limneticus	0.014	0.0118	1	122
Chroococcus minimus	0.014	0.0089	2	6
Chroococcus minutus	0.012	0.0087	2	82
Chroococcus turgidus	0.014	0.0035	4	19
Chroomonas	0.017	0.0138	1	86
Chrysidiastrum catenatum	0.012	0.0041	4	51
Chrysochromulina	0.017	0.0095	3	3
Chrysochromulina parva	0.024	0.0152	2	150
Chrysococcus	0.015	0.0092	2	29
Chrysococcus minutus	0.016	0.0049	4	5
Chrysococcus rufescens	0.020	0.0064	4	21
Chrysolykos	0.012	0.0072	2	69
Closterium aciculare	0.021	0.0211	1	61
Closterium acutum	0.027	0.0191	2	107
Closterium acutum v. variabile	0.035	0.0173	3	96
Cocconeis placentula	0.025	0.0096	4	31
Coelastrum	0.022	0.0065	4	62
Coelastrum astroideum	0.043	0.0203	3	28
Coelastrum microporum	0.033	0.0273	1	117
Coelastrum pseudomicroporum	0.037	0.0124	4	20
Coelastrum reticulatum	0.018	0.0137	2	74
Coelosphaerium	0.019	0.0089	3	33
Coelosphaerium kuetzingianum	0.035	0.0225	2	53
Coenochloris	0.011	0.0029	4	22
Coenocystis	0.030	0.0025	4	4
Cosmarium	0.019	0.0176	1	191
Cosmarium bioculatum	0.018	0.0104	3	30
Cosmarium depressum	0.018	0.0263	1	145
Crucigenia	0.029	0.0098	4	36
Crucigenia quadrata	0.023	0.0128	3	20
Crucigenia tetrapedia	0.030	0.0101	4	103
Crucigeniella	0.014	0.0103	2	21
Crucigeniella rectangularis	0.020	0.0142	2	49
Cryptomonas	0.015	0.0115	2	606
Cryptomonas	0.027	0.0029	4	3
Cryptomonas curvata	0.021	0.0080	4	38
Cryptomonas erosa	0.025	0.0206	1	201
Cryptomonas erosa var. reflexa	0.033	0.0160	3	8
Cryptomonas marssonii	0.023	0.0222	1	339
Cryptomonas obovata	0.008	0.0037	3	63
Cryptomonas ovata	0.029	0.0223	2	263
Cryptomonas reflexa	0.038	0.0219	3	42

Cryptomonas rostratiformis	0.029	0.0173	3	127
Cryptomonas tetrapyrenoidosa	0.042	0.0042	4	3
Cyanodictyon planktonicum	0.012	0.0038	4	11
Cyclotella	0.010	0.0059	2	467
Cyclotella bodanica	0.010	0.0101	1	92
Cyclotella comensis	0.009	0.0068	2	197
Cyclotella comta	0.043	0.0176	3	3
Cyclotella glomerata	0.008	0.0053	2	27
Cyclotella meneghiniana	0.015	0.0105	2	16
Cyclotella ocellata	0.027	0.0162	2	40
Cyclotella pseudostelligera	0.013	0.0040	4	19
Cyclotella radiosa	0.022	0.0151	2	192
Cyclotella stelligera	0.010	0.0050	3	8
Cymatopleura elliptica	0.007	0.0089	1	11
Cymatopleura solea	0.006	0.0026	3	23
Cymbella	0.012	0.0107	1	54
Cymbella prostrata	0.009	0.0020	4	32
Diatoma	0.041	0.0215	3	43
Diatoma ehrenbergii	0.022	0.0046	4	9
Diatoma tenuis	0.018	0.0135	2	68
Diatoma vulgaris	0.022	0.0151	2	69
Dictyosphaerium	0.046	0.0317	2	45
Dictyosphaerium pulchellum	0.018	0.0106	2	42
Didymocystis	0.031	0.0132	3	77
Dinobryon	0.011	0.0047	3	324
Dinobryon bavaricum	0.013	0.0066	3	107
Dinobryon crenulatum	0.014	0.0086	3	109
Dinobryon cylindricum	0.013	0.0079	2	62
Dinobryon divergens	0.017	0.0129	2	417
Dinobryon divergens v. schauinslandii	0.014	0.0013	4	13
Dinobryon sertularia	0.020	0.0093	3	107
Dinobryon sociale	0.018	0.0120	2	244
Dinobryon sociale v. americanum	0.025	0.0063	4	15
Dinobryon sociale v. stipitatum	0.011	0.0031	4	52
Elakatothrix	0.017	0.0156	1	150
Elakatothrix gelatinosa	0.029	0.0200	2	132
Elakatothrix genevensis	0.011	0.0077	2	33
Erkenia subaequiciliata	0.023	0.0193	1	117
Eudorina	0.058	0.0270	3	14
Eudorina elegans	0.044	0.0336	2	77
Euglena	0.017	0.0173	1	76
Euglena acus	0.035	0.0095	4	24
Eunotia	0.027	0.0182	2	20
Eutetramorus	0.020	0.0126	2	31
Eutetramorus fottii	0.023	0.0171	2	133
Eutetramorus planktonicus	0.010	0.0022	4	22
Fragilaria	0.014	0.0099	2	132
Fragilaria berolinensis	0.009	0.0013	4	6
Fragilaria capucina	0.020	0.0152	2	81
Fragilaria construens	0.017	0.0147	1	43
Fragilaria crotonensis	0.015	0.0152	1	538
Fragilaria ulna	0.018	0.0167	1	134
Fragilaria ulna v. acus	0.014	0.0108	2	501
Fragilaria ulna v. angustissima	0.014	0.0086	2	432
Fragilaria virescens	0.052	0.0108	4	11
Glenodinium	0.010	0.0046	3	122
Gloeocapsa	0.003	0.0009	4	5

Gloeococcus	0.004	0.0007	4	4
Gloeocystis	0.044	0.0110	4	21
Golenkinia radiata	0.026	0.0127	3	10
Gomphonema	0.015	0.0048	4	26
Gomphosphaeria	0.007	0.0060	1	46
Gomphosphaeria aponina	0.031	0.0166	3	39
Gomphosphaeria lacustris	0.014	0.0023	4	5
Gymnodinium	0.013	0.0110	1	428
Gymnodinium fuscum	0.012	0.0038	4	12
Gymnodinium helveticum	0.018	0.0161	1	576
Gymnodinium lantzschii	0.022	0.0160	2	113
Gymnodinium ordinatum	0.012	0.0049	3	5
Gymnodinium uberrimum	0.011	0.0050	3	276
Gyrosigma acuminatum	0.013	0.0049	4	3
Gyrosigma attenuatum	0.014	0.0054	4	13
Katablepharis	0.015	0.0091	3	29
Kephyrion	0.014	0.0114	1	158
Kirchneriella	0.027	0.0117	3	51
Korshikoviella	0.007	0.0071	1	22
Lagerheimia	0.012	0.0142	1	42
Lagerheimia subsalsa	0.037	0.0101	4	14
Limnothrix	0.026	0.0094	4	14
Limnothrix redekei	0.016	0.0024	4	10
Lyngbya	0.009	0.0069	2	17
Lyngbya limnetica	0.017	0.0212	1	18
Mallomonas	0.020	0.0186	1	344
Mallomonas acaroides	0.019	0.0124	2	80
Mallomonas akrokomos	0.018	0.0103	3	102
Mallomonas caudata	0.026	0.0120	3	116
Mallomonas crassisquama	0.014	0.0123	1	4
Mallomonas elongata	0.021	0.0189	1	71
Mallomonas tonsurata	0.014	0.0037	4	13
Melosira varians	0.029	0.0154	3	80
Merismopedia	0.020	0.0179	1	45
Merismopedia glauca	0.017	0.0075	3	8
Merismopedia tenuissima	0.044	0.0203	3	60
Merispomedia tenuissima	0.018	0.0006	4	4
Micractinium pusillum	0.043	0.0180	3	21
Microcystis	0.013	0.0082	2	157
Microcystis aeruginosa	0.019	0.0150	2	173
Microcystis firma	0.015	0.0107	2	5
Microcystis flos-aquae	0.019	0.0117	2	47
Microcystis incerta	0.021	0.0035	4	10
Microcystis viridis	0.021	0.0039	4	3
Microcystis wesenbergii	0.026	0.0222	1	23
Monoraphidium arcuatum	0.022	0.0049	4	43
Monoraphidium contortum	0.017	0.0177	1	63
Monoraphidium griffithii	0.032	0.0201	2	22
Monoraphidium komarkovae	0.015	0.0111	2	42
Monoraphidium minutum	0.049	0.0131	4	29
Mougeotia	0.052	0.0499	1	63
Mougeotia thylespora	0.029	0.0108	4	29
Navicula	0.016	0.0088	3	118
Navicula cryptocephala	0.016	0.0040	4	14
Navicula radiosa	0.017	0.0092	3	17
Nephrocytium	0.017	0.0109	2	56
Nephrocytium agardhianum	0.029	0.0125	3	56

Nephrocytium lunatum	0.011	0.0014	4	5
Nitzschia	0.037	0.0210	3	61
Nitzschia acicularis	0.027	0.0243	1	110
Nitzschia fruticosa	0.022	0.0070	4	22
Ochromonas	0.019	0.0214	1	213
Oedogonium	0.032	0.0040	4	11
Oocystis	0.016	0.0140	1	191
Oocystis borgei	0.050	0.0170	4	3
Oocystis lacustris	0.023	0.0177	2	163
Oocystis marssonii	0.046	0.0176	4	78
Oocystis parva	0.030	0.0216	2	21
Oocystis solitaria	0.023	0.0077	4	7
Oscillatoria	0.028	0.0279	1	104
Oscillatoria limosa	0.030	0.0238	1	22
Pandorina	0.072	0.0110	4	15
Pandorina morum	0.028	0.0161	3	116
Pediastrum	0.025	0.0065	4	20
Pediastrum boryanum	0.037	0.0184	3	221
Pediastrum duplex	0.036	0.0267	2	142
Pediastrum simplex	0.012	0.0146	1	23
Peridiniopsis	0.015	0.0046	4	14
Peridinium	0.012	0.0095	2	471
Peridinium aciculiferum	0.023	0.0220	1	61
Peridinium bipes	0.016	0.0045	4	7
Peridinium cinctum	0.018	0.0085	3	80
Peridinium inconspicuum	0.014	0.0064	3	139
Peridinium palatinum	0.025	0.0029	4	5
Peridinium pusillum	0.008	0.0035	3	55
Peridinium willei	0.018	0.0194	1	187
Phacotus	0.031	0.0130	3	46
Phacotus lendneri	0.024	0.0167	2	70
Phacotus lenticularis	0.029	0.0144	3	43
Phacus	0.023	0.0037	4	6
Phacus tortus	0.023	0.0183	1	25
Phytodinium globosum	0.039	0.0144	4	7
Pinnularia	0.013	0.0037	4	8
Planktonema	0.007	0.0030	3	13
Planktonema lauterbornii	0.018	0.0016	4	7
Planktosphaeria gelatinosa	0.018	0.0165	1	103
Planktothrix agardhii	0.014	0.0045	4	18
Planktothrix prolifica	0.057	0.0062	4	8
Planktothrix rubescens	0.015	0.0113	2	424
Pseudanabaena catenata	0.024	0.0231	1	58
Pseudanabaena limnetica	0.022	0.0054	4	18
Pseudoanabaena	0.021	0.0014	4	6
Pseudokephyrion	0.014	0.0102	2	24
Pseudosphaerocystis lacustris	0.017	0.0089	3	128
Quadrigula lacustris	0.028	0.0192	2	35
Quadrigula pfitzeri	0.036	0.0133	4	18
Radiocystis geminata	0.011	0.0007	4	14
Rhabdogloea	0.015	0.0097	2	35
Rhizosolenia	0.052	0.0023	4	5
Rhizosolenia longiseta	0.027	0.0037	4	16
Rhodomonas	0.011	0.0098	1	301
Rhodomonas lacustris	0.020	0.0212	1	413
Rhodomonas lens	0.023	0.0181	2	200
Rhodomonas minuta	0.025	0.0123	3	22

Scenedesmus	0.033	0.0160	3	193
Scenedesmus acutus	0.032	0.0040	4	12
Scenedesmus costato-granulatus	0.031	0.0060	4	3
Scenedesmus ecornis	0.039	0.0187	3	37
Scenedesmus linearis	0.022	0.0143	2	45
Scenedesmus obtusus	0.040	0.0126	4	42
Scenedesmus quadricauda	0.026	0.0170	2	127
Schroederia setigera	0.035	0.0226	2	47
Snowella	0.011	0.0015	4	3
Snowella lacustris	0.010	0.0074	2	216
Sphaerocystis	0.033	0.0129	4	19
Sphaerocystis schroeteri	0.030	0.0143	3	125
Sphaerozosma	0.017	0.0057	4	28
Spirulina	0.015	0.0008	4	8
Staurastrum	0.024	0.0168	2	196
Staurastrum chaetoceras	0.013	0.0021	4	26
Staurastrum cingulum	0.039	0.0107	4	23
Staurastrum gracile	0.030	0.0101	4	50
Staurastrum paradoxum	0.032	0.0111	4	59
Staurastrum tetracerum	0.036	0.0168	3	20
Stephanodiscus	0.020	0.0132	2	38
Stephanodiscus alpinus	0.014	0.0150	1	74
Stephanodiscus binderanus	0.050	0.0197	4	39
Stephanodiscus hantzschii	0.059	0.0206	4	57
Stephanodiscus minutulus	0.027	0.0173	2	99
Stephanodiscus neoastraea	0.018	0.0121	2	205
Stephanodiscus parvus	0.039	0.0278	2	9
Synechococcus	0.040	0.0212	3	42
Synedra acus	0.032	0.0032	4	7
Synedra ulna	0.026	0.0090	4	6
Synura	0.026	0.0188	2	49
Synura uvella	0.027	0.0100	4	22
Tabellaria	0.052	0.0283	3	11
Tabellaria fenestrata	0.015	0.0094	2	282
Tabellaria flocculosa	0.011	0.0030	4	56
Tabellaria flocculosa v.asterionelloides	0.017	0.0046	4	5
Tetrachlorella	0.041	0.0167	3	16
Tetraedron	0.013	0.0047	4	70
Tetraedron caudatum	0.022	0.0121	3	43
Tetraedron incus	0.008	0.0034	3	4
Tetraedron minimum	0.025	0.0133	3	221
Tetraselmis cordiformis	0.025	0.0133	3	33
Tetrastrum triangulare	0.020	0.0035	4	26
Trachelomonas	0.019	0.0123	2	125
Trachelomonas oblonga	0.022	0.0019	4	3
Trachelomonas volvocina	0.026	0.0110	3	95
Tribonema	0.038	0.0024	4	4
Ulothrix	0.062	0.0104	4	21
Ulothrix subconstricta	0.029	0.0109	4	16
Uroglena	0.014	0.0081	3	293
Uroglena americana	0.030	0.0154	3	51
Uroglena volvox	0.018	0.0092	3	22
Volvox aureus	0.050	0.0104	4	17
Willea irregularis	0.014	0.0057	3	56
Woronichinia naegeliana	0.024	0.0159	2	33

Calculation of the $PTI_{species}$ and PTI_{ot}

$PTI_{species}$

The scores (weights) of the indicator taxa were used to compute the PTI indices as follows:

$$PTI_{species} = \Sigma\, w_i\, b_i \,/\, \Sigma\, b_i$$

where w_i is the trophic weight assigned to each algal order/species and b_i the corresponding annual averages of the algal biovolumes. The w_i values were assigned to five classes in the interval 1–5, to obtain a classification comparable to the five quality classes indicated by the WFD.

PTI_{ot}

The PTI_{ot} is calculated for every single lake year:

$$PTIot - lake = \frac{\sum a_{i} PTI_{i} v_{i}}{\sum a_{i} v_{i}}$$

Where:
a_i = abundance of i^{th} taxon at the site
TP_{opt} = optimum of i^{th} taxon respect to TP
v_i = indicator value of i^{th} taxon (from 1 to 4)

Concluding remark on PTI_{ot}

The PTI_{ot} will be improved further as soon as more data are available. The main critical points that we have found so far are:

- The Alpine Lakes GIG dataset is composed mainly of oligo-mesotrophic lakes and PTI_{ot} values are strongly influenced by this loss of balance.
- Many dominant species are euryecious and thus have high values of tolerance. They are thus bad trophic indicators. In order to avoid an overestimation of the ecological quality of the lake, the tolerance values will have to be calibrated, e.g. by giving euryecious taxa less weight in the calculation of the PTI.
- The validation of PTI_{ot} was done for a limited number of Italian lakes. It is necessary to extend the application of the index to a significant number of Italian Alpine lakes belonging to all different national lake types.

Annex A – Part 6: Correlation of the national trophic indices with trophic status

In this part of Annex A some 'key diagrams' on the correlation of trophic pressure (total phosphorus (TP) concentration, phytoplanktonm biovolume) and phytoplankton response (trophic indices) are presented:

- TP and Brettum index (Figure A-6-1 and Figure A-6-2);
- Phytoplanktonm biovolume and Brettum index (Figure A-6-3);
- TO and PTSI (Figure A-6-4);
- TP and PTI_{ot} (Figure A-6-5).

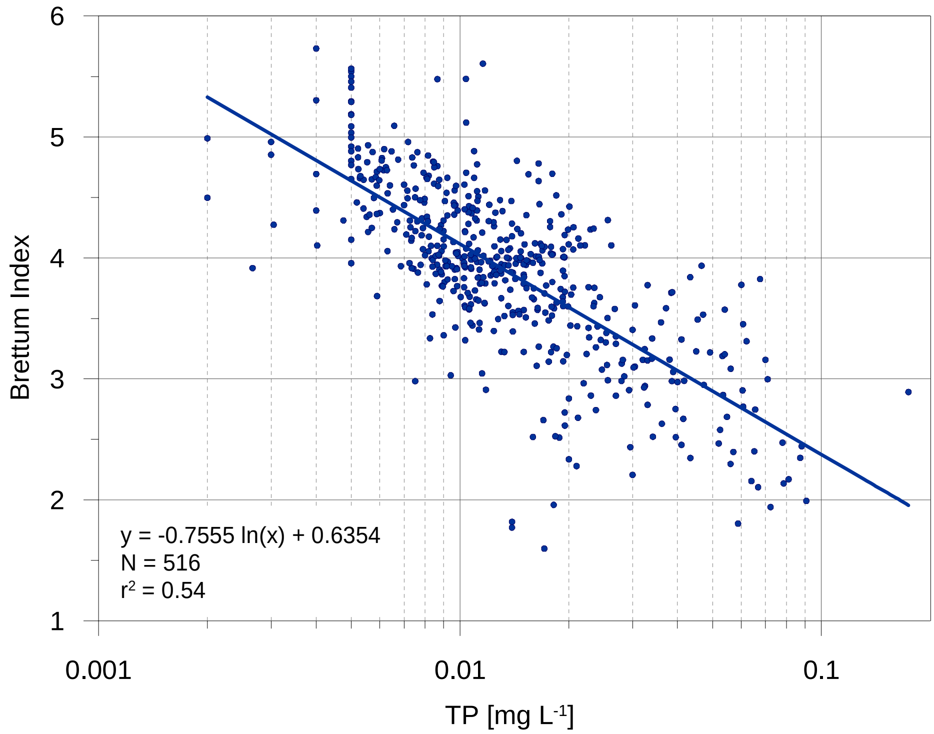


Figure A-6-1. Correlation between the TP concentration and the Brettum Index. Each point corresponds to a single lake year.

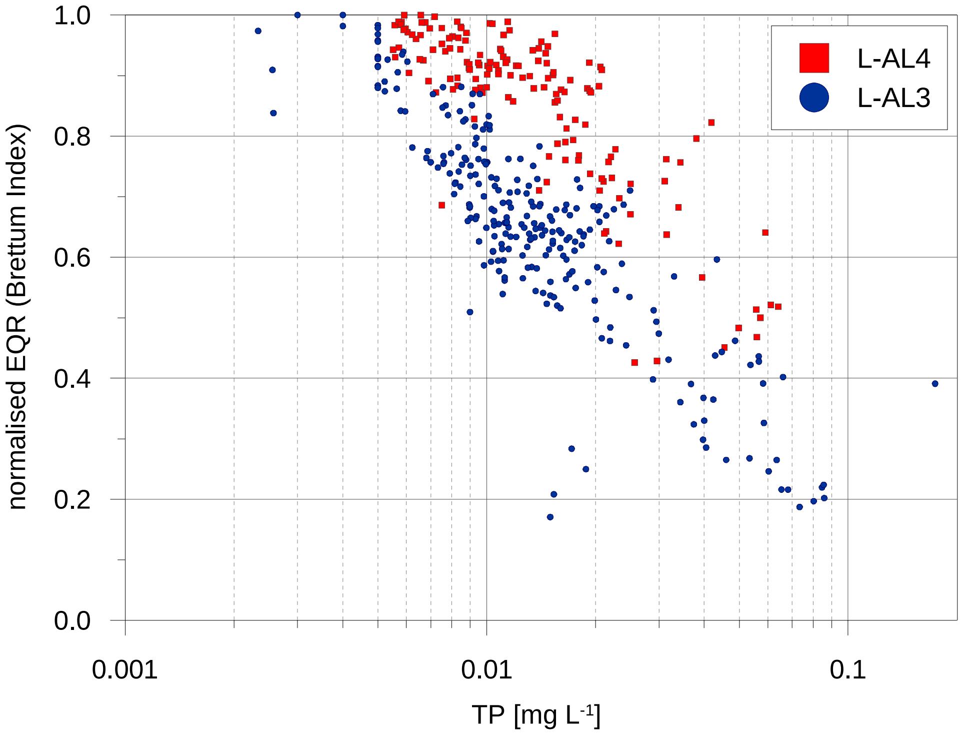


Figure A-6-2. Correlation between the TP concentration (usually volume weighted annual mean or spring overturn) and the normalised EQR of the Brettum Index. Each point corresponds to the arithmetic mean of thre subsequent years. Where only data from 1 or 2 years are available, each corrseponds to 2-yrs average or single year data.

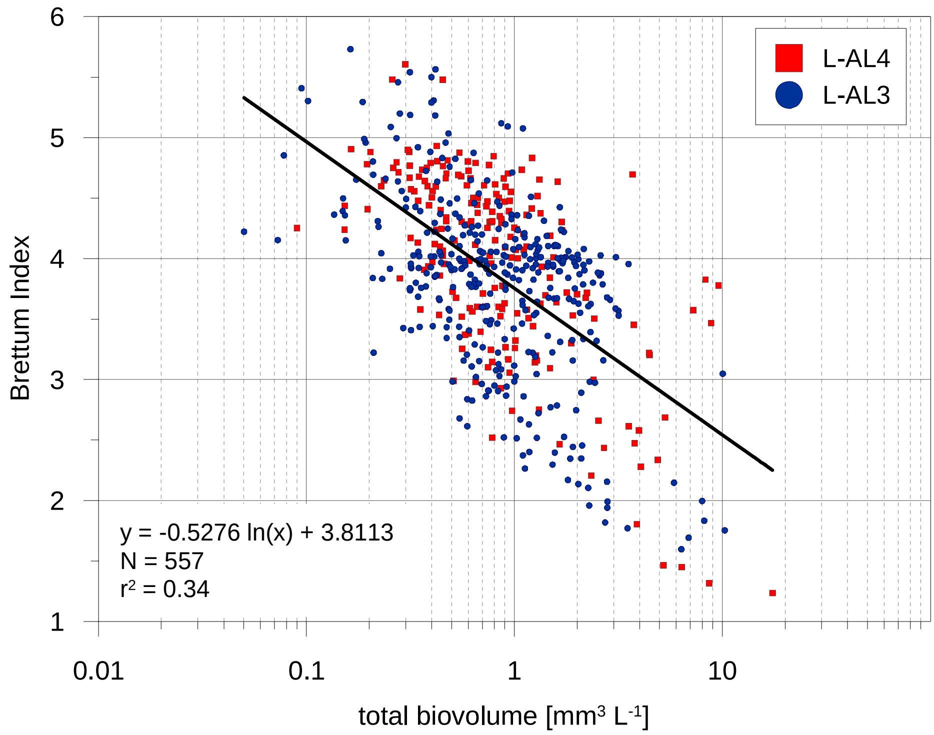


Figure A-6-3. Correlation between the annual mean total biovolume and the Brettum Index. Each point corresponds to a single lake year. The regression was calculated from the whole data set of L-AL3 and L-AL4.

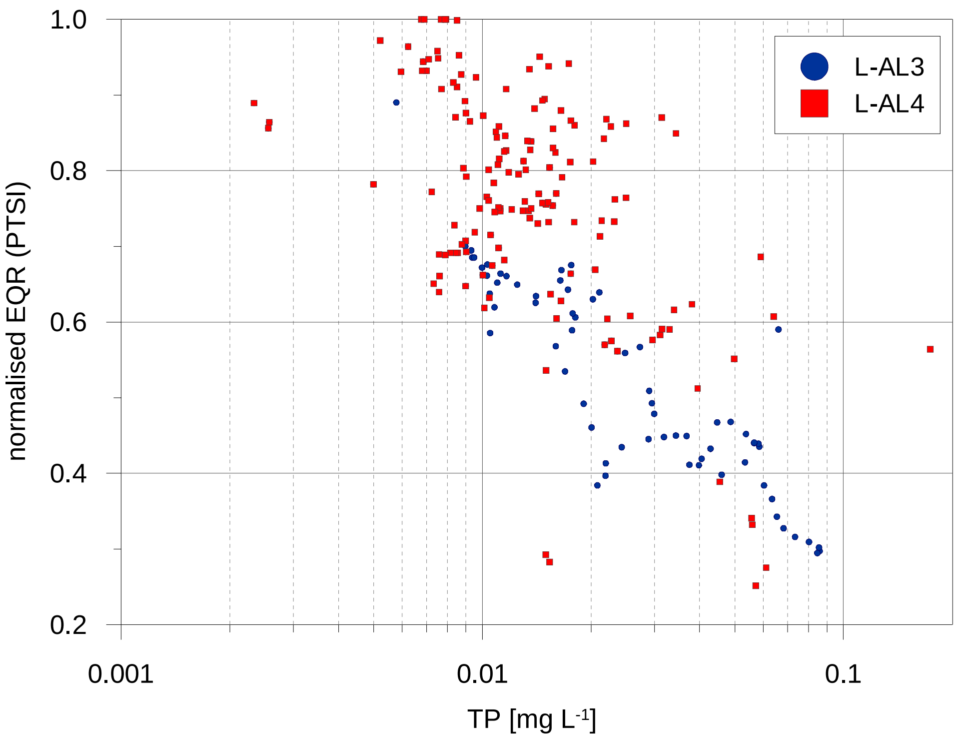


Figure A-6-4. Correlation between the TP concentration (usually volume weighted annual mean or spring overturn) and the normalised EQR of the PTSI. Each point corresponds to the arithmetic mean of thre subsequent years. Where only data from 1 or 2 years are available, each corrseponds to 2-yrs average or single year data.

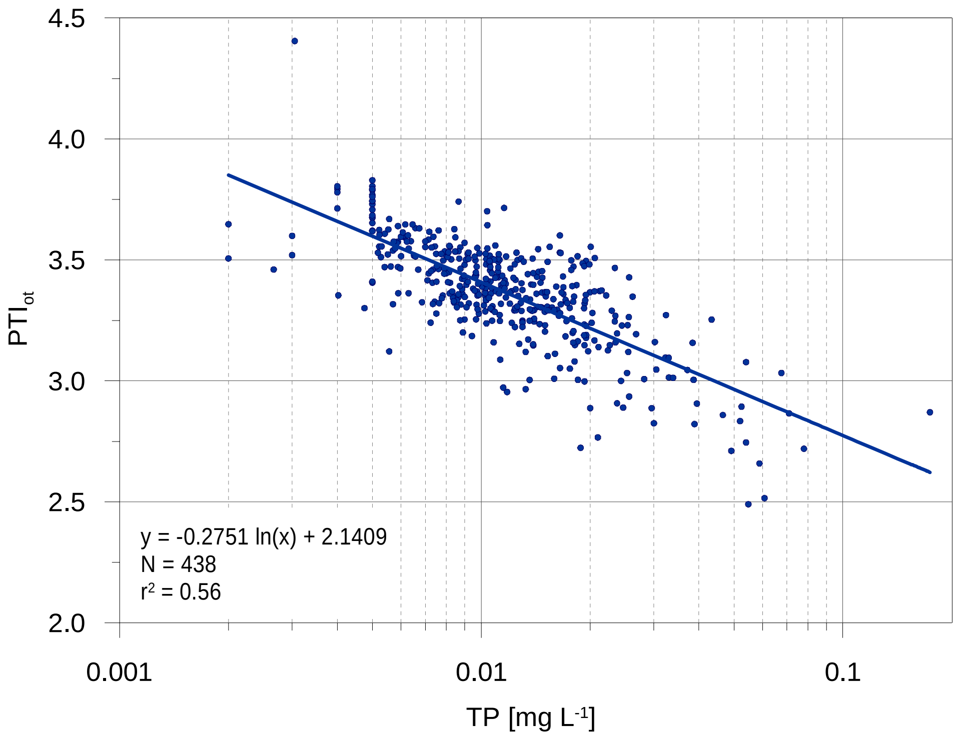


Figure A-6-5. Correlation between the TP concentration (usually volume weighted annual mean or spring overturn) and the PTI_{ot}

Annex A – Part 7: Harmonization of the Brettum index, the $PTI_{ot}/PTI_{species}$ and the PTSI

7.1. Principle approach

The harmonization of the three national trophic indices was done in the following steps:

The **EQR**s of three national indices were **normalized** to get comparable class boundaries with linear scale, equidistant class widths and the following boundaries for EQR_{norm}:

H/G $EQR_{norm} = 0.8$
G/M $EQR_{norm} = 0.6$
M/P $EQR_{norm} = 0.4$
P/B $EQR_{norm} = 0.2$

	Brettum Index L-AL3					
	BI	range type			EQR	
		1	2	3	ratio	norm.
Ref	4,40–4,62	4,62	4,50	4,40	1,00	
H/G	4,12–4,34	4,34	4,23	4,12	0,94	0,80
G/M	3,64–3,83	3,83	3,74	3,64	0,83	0,60
M/P	3,12–3,28	3,28	3,20	3,12	0,71	0,40
P/B	2,62–2,77	2,77	2,70	2,64	0,60	0,20

	Brettum Index L-AL4					
	BI	range type			EQR	
		1	2	3	ratio	norm.
Ref	3.94–4.12	4,12	4,02	3,94	1,00	
H/G	3.96–3.87	3,87	3,78	3,69	0,94	0,80
G/M	3.20–3.34	3,34	3,26	3,20	0,81	0,60
M/P	2.68–2.80	2,80	2,73	2,68	0,68	0,40
P/B	2.18–2.27	2,27	2,21	2,18	0,55	0,20

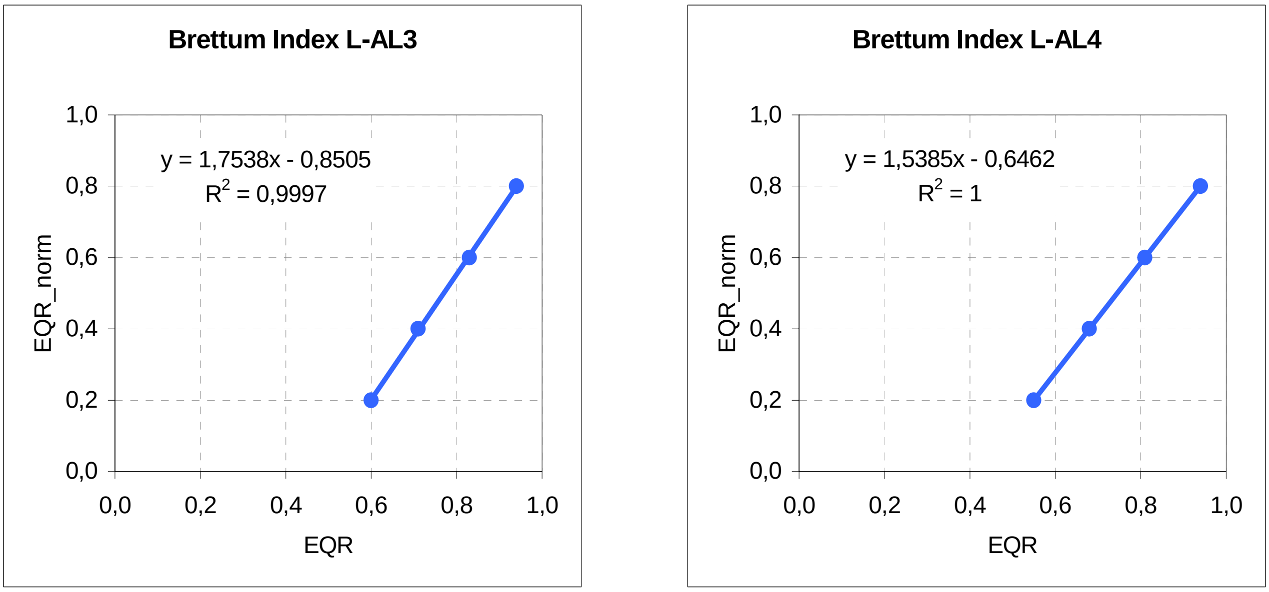


Figure A-7-1a. Normalizatioon of EQR for Brettum index (L-AL3 and L-AL4)

	PTI_sp L-AL3 (very large/deep)		
	PTI_sp	EQR	
		ratio	norm.
Ref	4,30	1,00	
H/G	4,00	0,93	0,80
G/M	3,50	0,81	0,60
M/P	3,06	0,71	0,40
P/B	2,60	0,60	0,20

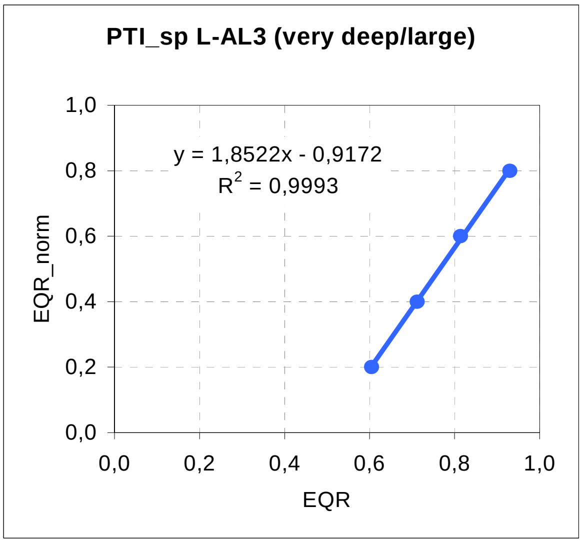
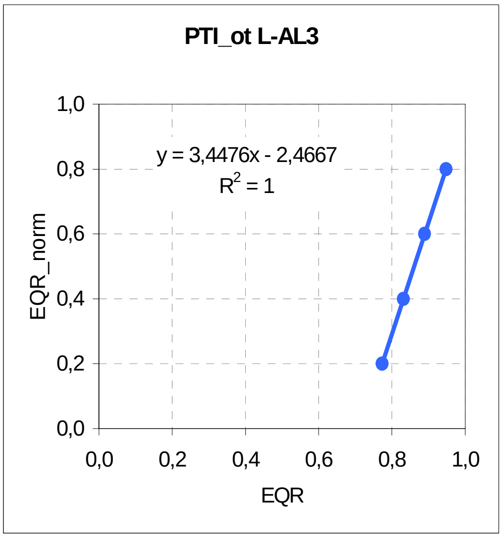


Figure A-7-1b. Normalizatioon of EQR for $PTI_{species}$ (L-AL3 type)

	PTI_ot L-AL3		
	PTI_ot	EQR	
		ratio	norm.
Ref	3,62	1,00	
H/G	3,43	0,95	0,80
G/M	3,22	0,89	0,60
M/P	3,01	0,83	0,40
P/B	2,80	0,77	0,20

	PTI_ot L-AL4		
	PTI_ot	EQR	
		ratio	norm.
Ref	3,54	1,00	
H/G	3,37	0,95	0,80
G/M	3,01	0,85	0,60
M/P	2,64	0,75	0,40
P/B	2,28	0,64	0,20



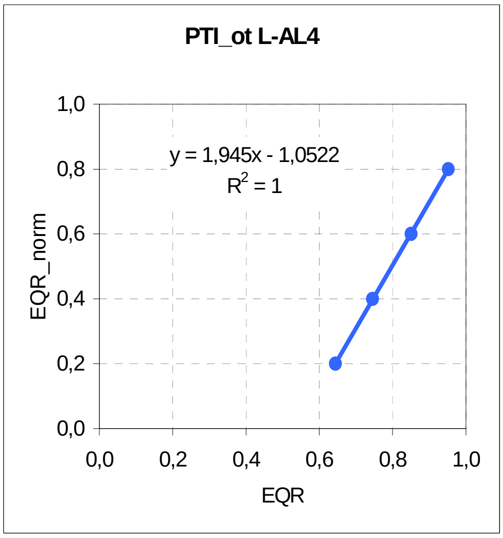
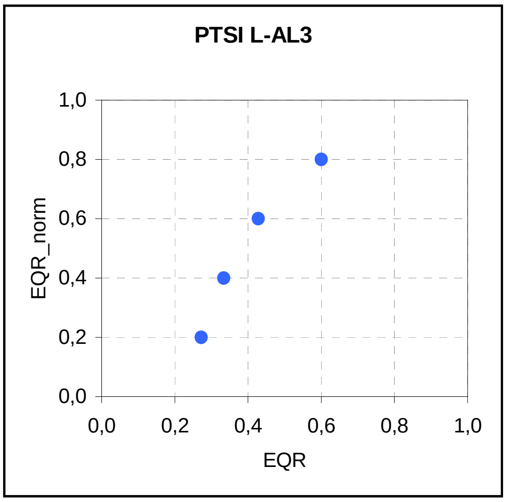


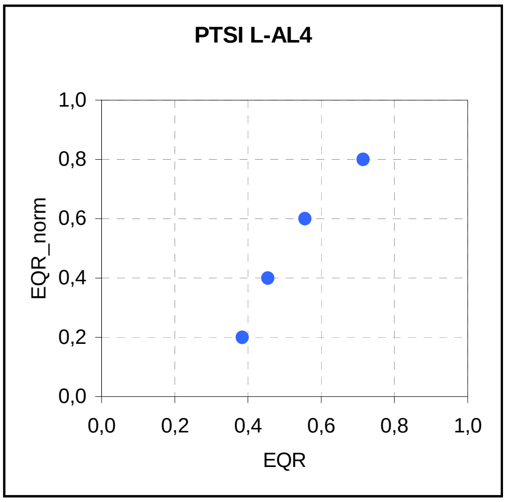
Figure A-7-1c. Normalizatioon of EQR for $\underline{PTI_{ot}}$ (L-AL3 and L-AL4 types)

PTSI

	PTSI L-AL3		
	PTSI	EQR	
		ratio	norm.
Ref	0,75	1,00	
H/G	1,25	0,60	0,80
G/M	1,75	0,43	0,60
M/P	2,25	0,33	0,40
P/B	2,75	0,27	0,20

	PTSI L-AL4		
	PTSI	EQR	
		ratio	norm.
Ref	1,25	1,00	
H/G	1,75	0,71	0,80
G/M	2,25	0,56	0,60
M/P	2,75	0,45	0,40
P/B	3,25	0,38	0,20





Inverse linear regression (calculated in SPSS)

AL3 EQR_norm = 1,3012 - 0,3007/EQR
AL4 EQR_norm = 1,4979 - 0,4986/EQR

equation type: y = bo+(b1/x)

Figure A-7-1d. Normalizatioon of EQR for PTSI (L-AL3 and L-AL4 types)

The arithmetic mean of the normalised EQRs of the three national indices was calculated for those lake years, where all three national classifications were available. Both the normalised EQRs of the indices and their mean follow a linear scale with equal class widths. The arithmetic mean works as a common metric (option 2+3).

- Calculation of normalised EQRs and selection of lakes, where the mean of the normalised EQRs is 0.8±0.05 (H/G) or 0.6±0.05 (G/M)
- Calculation of the mean of the national norm.EQRs for lakes selected according to ii), based on single years as well as based on 3-yrs-averages (for reducing interannual variation)

7.2. Harmonization using single years data

The following table gives the statistics on the harmonization process when single years data are used. With one exception, all values lie within the acceptable band of 0.05 EQR. The Alpine GIG proposes to accept this slight deviation. The classification methods are considered sufficiently robust to enable comparable national classifications. Further improvements will be made after new data from the national monitoring programmes 2007ff are included.

Table A-7-2. Statistics for the harmonization of the three national trophic indices. BI = Brettum index (AT), PTI_{ot} = phytoplankton trophic index_optimum tolerance (IT), PTSI = Phytoplankton-Trophie-Seen-Index (GE).

	L-AL3						L-AL4					
	H/G			G/M			H/G			G/M		
	BI	PTI_{ot}	PTSI	BI	PTI_{ot}	PTSI	BI	PTI_{ot}	PTSI	BI	PTI_{ot}	PTSI
avg	0.82	0.81	0,76	0.58	0.67	0.60	0.81	0.76	0.77	0.56	0.63	0.62
±95%C.I.	0.04	0.03	0.05	0.02	0.03	0.02	0.04	0.02	0.03	0.07	0.02	0.09
N	14	14	14	33	33	33	13	13	13	10	10	10

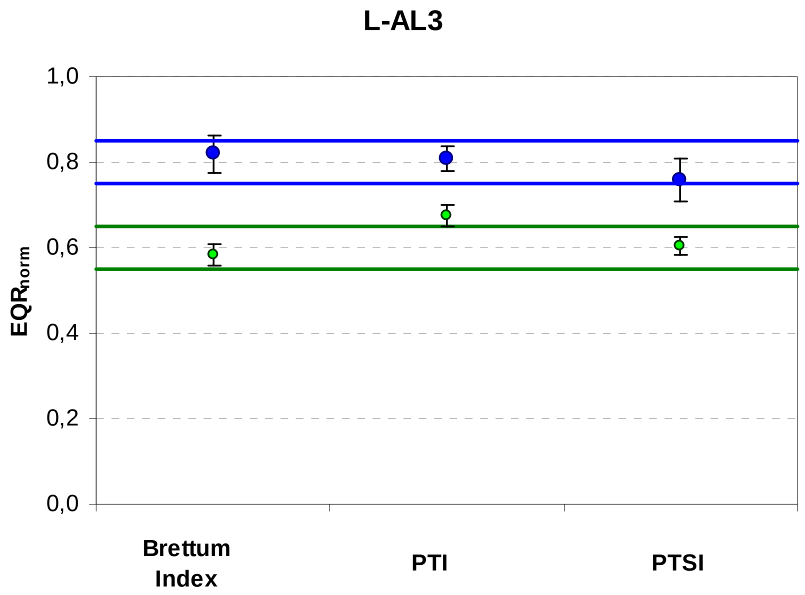


Figure A-7-2a. Harmonization of the three national trophic indices from AT, GE and IT for L-AL3 lakes (single years data).

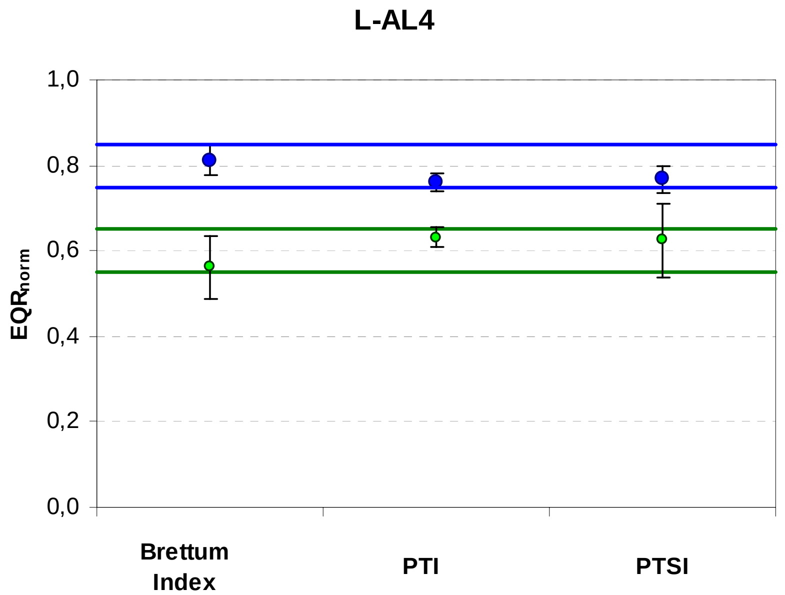


Figure A-7-2b. Harmonization of the three national trophic indices from AT, GE and IT for L-AL4 lakes (single years data).

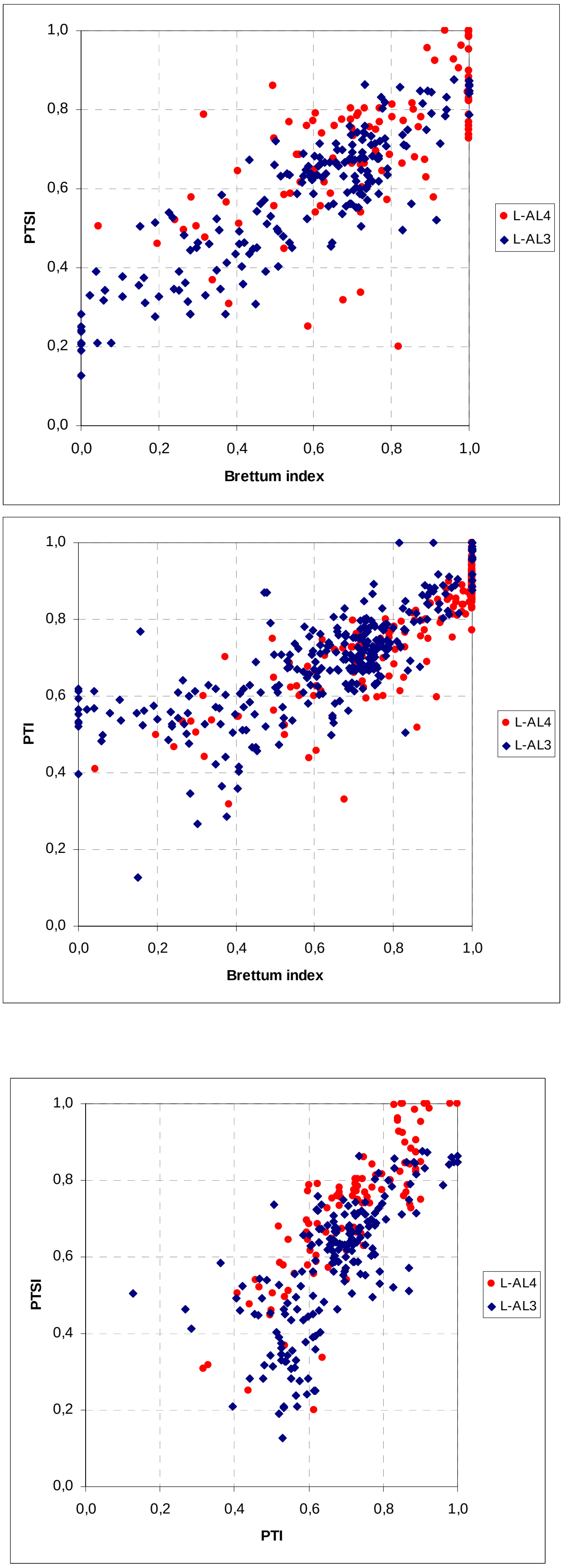


Figure A-7-2c. Correlations between the three national trophic indices (single years data).

3. Harmonization using three years avergaes

In order to compensate for interanual variations, the harmonization calculations were carried out also on three years averages (where available). The results are shown in Table **A-7-3** and Figures **A-7-3a to A-7-3c**. The slight devation shown in Table **A-7-2** is clearly reduced. All national boundaries lie within the acceptable band.

Table A-7-3. Statistics for the harmonization of the three national trophic indices. BI = Brettum index (AT), PTI_{ot} = phytoplankton trophic index_optimum tolerance (IT), PTSI = Phytoplankton-Trophie-Seen-Index (GE). Data were lumped to three years averages (where available) in order to compensate for interannual variations.

	L-AL3						L-AL4					
	H/G			G/M			H/G			G/M		
	BI	PTI_{ot}	PTSI	BI	PTI_{ot}	PTSI	BI	PTI_{ot}	PTSI	BI	PTI_{ot}	PTSI
avg	0.83	0.81	0.80	0.59	0.64	0.60	0.84	0.76	0.77	0.60	0.63	0.63
±95%C.I.	0.03	0.05	0.04	0.02	0.02	0.03	0.03	0.02	0.06	0.03	0.05	0.03
N	9	9	9	29	29	29	8	8	8	10	10	10

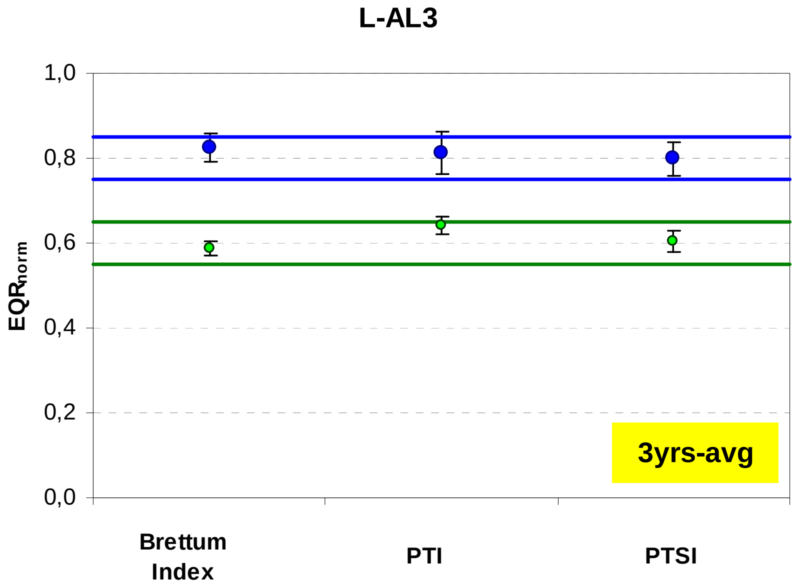


Figure A-7-3a. Harmonization of the three national trophic indices from AT, GE and IT for L-AL3 lakes. Data were lumped to three years averages (where available) in order to compensate for interannual variations.

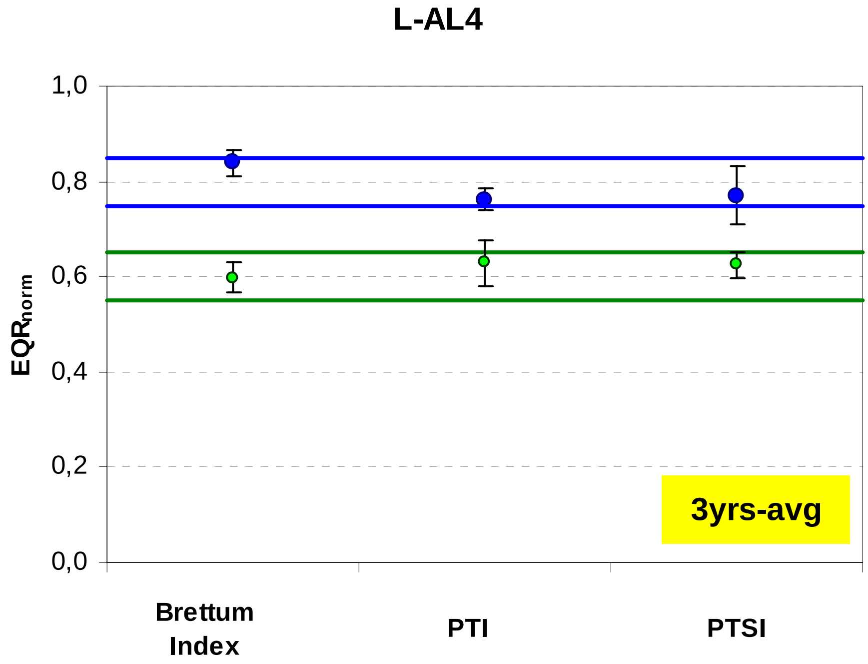
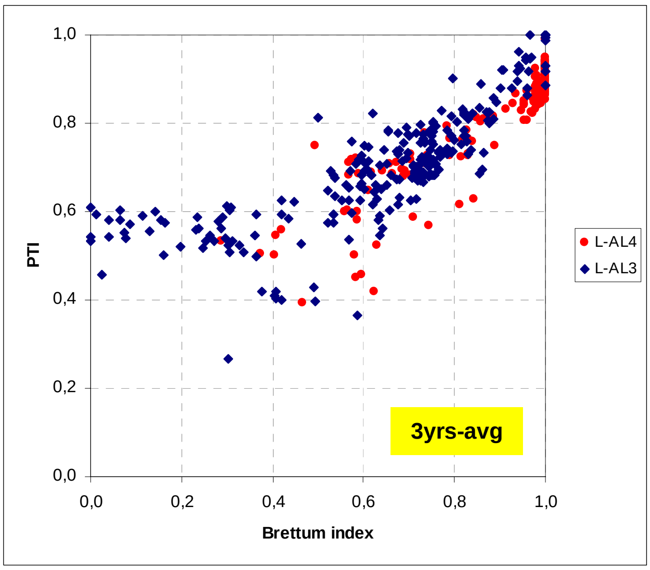
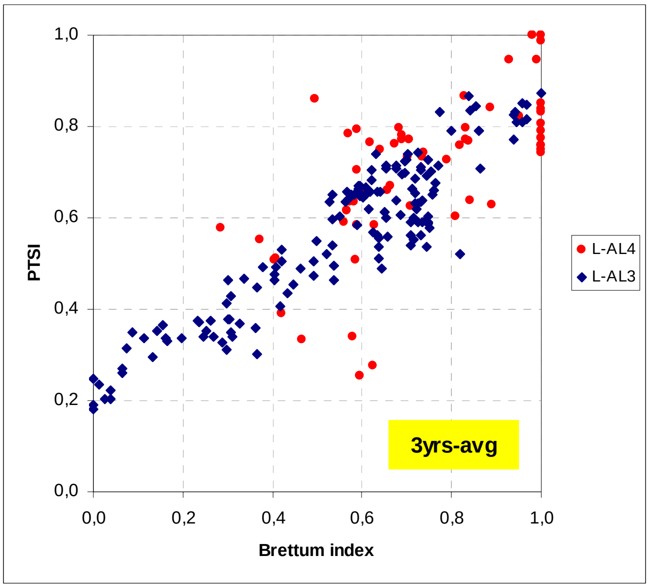


Figure A-7-3b. Harmonization of the three national trophic indices from AT, GE and IT for L-AL4 lakes. Data were lumped to three years averages (where available) in order to compensate for interannual variations.





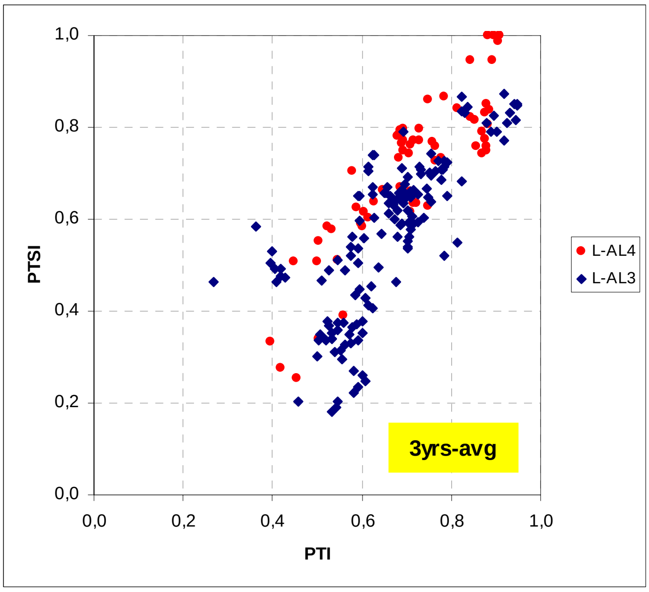


Figure A-7-3c. Correlations between the three national trophic indices. Data were lumped to form 3-yrs-averages of lake years (where available) in order to compensate for interannual variations.

Annex B - Mediterranean GIG

ANNEX B - 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.

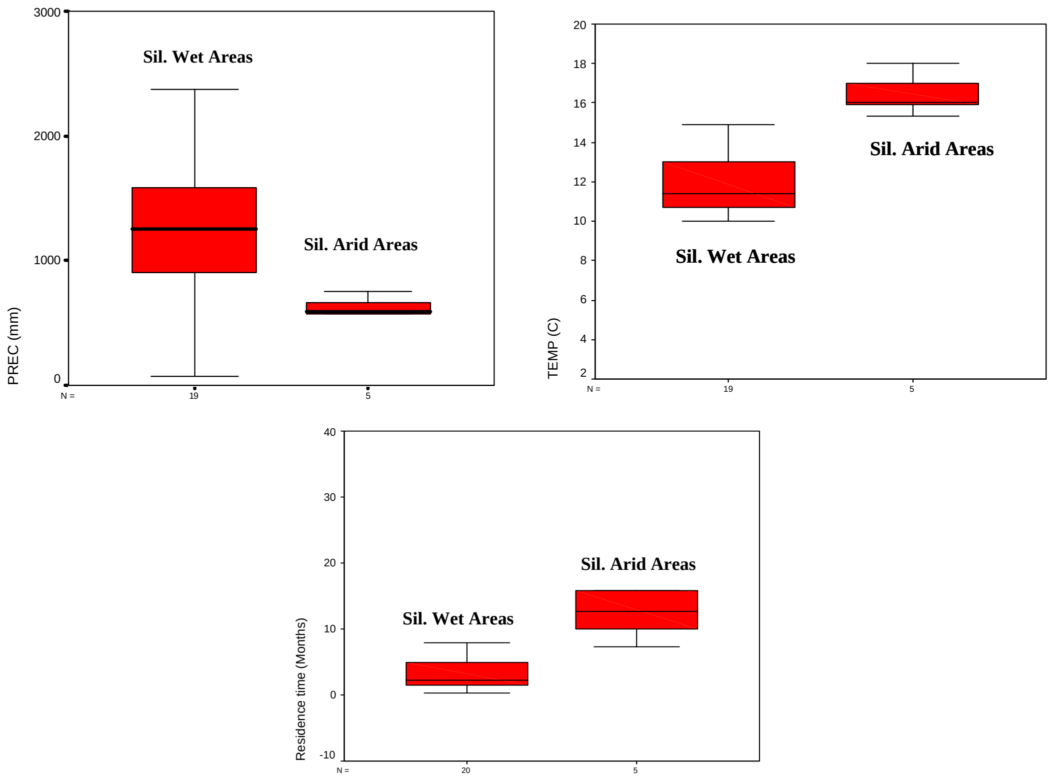


Figure B-1: Box plots: Differences between Med GIG Lake Intercalibration types (precipitation, temperature, residence time)

ANNEX B - 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).

3. Calculation % Cyanobacteria

Table B-2. Cyanobacteria species included and excluded from the analysis

Species Included	Species Excluded
Chroococcales	**Chroococcales**
Gomphosphaeria lacustris	*Aphanocapsa holsatica*
Gomphosphaeria aponina	*Aphanocapsa incerta*
Microcystis aeruginosa	*Aphanocapsa* sp
Microcystis viridis	*Aphanothece clathrata*
Microcystis wesenbergii	*Aphanothece* sp
Microcystis sp	*Chroococcus* sp
Woronichinia compacta	*Coelosphaerium aerugineum*
Woronichinia naegeliana	*Coelosphaerium kuetzingianum*
Woronichinia sp.	*Coelosphaerium* sp.
	Merismopedia elegans
	Merismopedia punctata
	Merismopedia tenuissima
	Merismopedia trolleri
	Merismopedia warmingiana
	Merismopedia sp
	Radiocystis geminata
	Synechococcus sp
	Snowella sp.
Oscillatoriales	**Oscillatoriales**
Oscillatoria limnetica	*Limnothrix* sp
Oscillatoria granulata	*Psedanabaena* sp
Oscillatoria rubescens	
Oscillatoria sp	
Planktothrix agardii	
Nostocales	
Anabaena flos-aquae	
Anabaena mendotae	
Anabaena planctonica	
Anabaena sigmoidea	
Anabaena spiroides	
Aphanizomenon elenkinii	
Apahnizomenon flos-aquae	
Aphanizomenon gracile	
Aphanizomenon issatschenkoi	
Aphanizomenon ovalisporum	
Aphanizomenon sp	

Annex B - 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;

- **Portuga**l:
  - Sites with less than 20% of the catchment for agricultural use and the rest remaining as natural or semi-natural coverage (Corine Land Cover);
  - 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 (CEDEX, 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 B - Part 4 - Reference sites

Table B-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	IC type	% Cyanobacteria Biovolume	IGA Index	MedPTI
Arenós	Spain	Calcareous	0,00	1,09	3,09
Castelo De Bode*	Portugal	Siliceous in “Wet areas”	0,00	0,02	3,19
Eugui	Spain	Calcareous	0,00	1,41	3,17
La Ribeira	Spain	Siliceous in “Wet areas”	0,00	0,11	-
Lefkara	Cyprus	Calcareous	0,13	0,13	3,04
Sacele	Romania	Calcareous	0,00	0,02	
Saint Cassien	France	Calcareous**	-	-	-
Salime	Spain	Siliceous in “Wet areas”	0,00	0,63	3,19
Tehniti Limni Tavropou	Greece	Siliceous in “Wet areas”	0,00	0,11	3,03
Vilarinho Das Furnas	Portugal	Siliceous in “Wet areas”	1,17	0,76	-

***** 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 B - Part 5 - Data used for GM boundary setting

Table B-5. Overview on lakes and phytoplankton composition metric values in the Med GIG database. (Mean summer (June-September) values, photic layer integrated values, 2005 sampling programme)

Annex B - Part 6 - Reservoirs excluded from the analysis

Reservoir	Type	Country	% Bloom Cyano	AGI index	MedPTI
Maranhão	Siliceous "arid areas"	Portugal	49,6	9,5	2,62
Monte Da Rocha	Siliceous "arid areas"	Portugal	41,4	41,7	2,66
Guadalmellato	Siliceous "arid areas"	Spain	12,5	2,5	2,77
Yeguas, El	Siliceous "arid areas"	Spain	8,8	0,7	2,80
Sos Canales	Siliceous "arid areas"	Italy	2,2	1,9	2,41
Aguieira	Siliceous "wet areas"	Portugal	0,4	0,8	3,17
Fronhas	Siliceous "wet areas"	Portugal	11,4	0,5	2,37
Alto Lindoso	Siliceous "wet areas"	Portugal	0,0	0,2	3,11
Caniçada	Siliceous "wet areas"	Portugal	0,0	12,0	3,02
Bradisor	Siliceous "wet areas"	Romania	0,0	0,8	-
Colibita	Siliceous "wet areas"	Romania	0,0	0,6	-
Vidraru	Siliceous "wet areas"	Romania	30,6	5,0	
Agavanzal	Siliceous "wet areas"	Spain	0,1	1,5	3,05
Albarellos	Siliceous "wet areas"	Spain	0,0	1,0	3,01
Portodemouros	Siliceous "wet areas"	Spain	0,0	2,0	3,01
Bao	Siliceous "wet areas"	Spain	0,6	1,7	3,05
La Ribeira	Siliceous "wet areas"	Spain	0,0	0,1	3,07
Valparaiso	Siliceous "wet areas"	Spain	0,4	0,7	3,05-
Vilasouto	Siliceous "wet areas"	Spain	0,0	0,6	2,94
San Esteban	Siliceous "wet areas"	Spain	0,2	25,1	3,07
Agueda	Siliceous "wet areas"	Spain	0,6	3,2	2,94
					-
Bezid	Calcareous	Romania	5,3	0,4	-
Izvoru Munt.	Calcareous	Romania	0,5	0,0	-
Paltinu	Calcareous	Romania	2,1	1,2	
Siriu	Calcareous	Romania	0,9	2,1	
Asprokremmos	Calcareous	Cyprus	0,6	1,0	3,06
Kouris	Calcareous	Cyprus	0,1	0,3	3,02
Sainte Croix	Calcareous	France			
Medio Flumend.	Calcareous	Italy	32,8	2,6	-
Mulargia	Calcareous	Italy	19,1	5,2	2,94
Aldeadavila	Calcareous	Spain	0,1	2,3	2,86
Guadalest	Calcareous	Spain	1,8	0,1	2,91
Loriguilla	Calcareous	Spain	0,4	0,2	2,86
Negratin	Calcareous	Spain	0,7	0,1	2,98
Pálmaces	Calcareous	Spain	27,5	7,2	2,18
Sau	Calcareous	Spain	7,4	3,7	2,53
Talarn O Tremp	Calcareous	Spain	7,6	8,1	2,91

To set the G/M boundaries for composition metrics the 90th %-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.

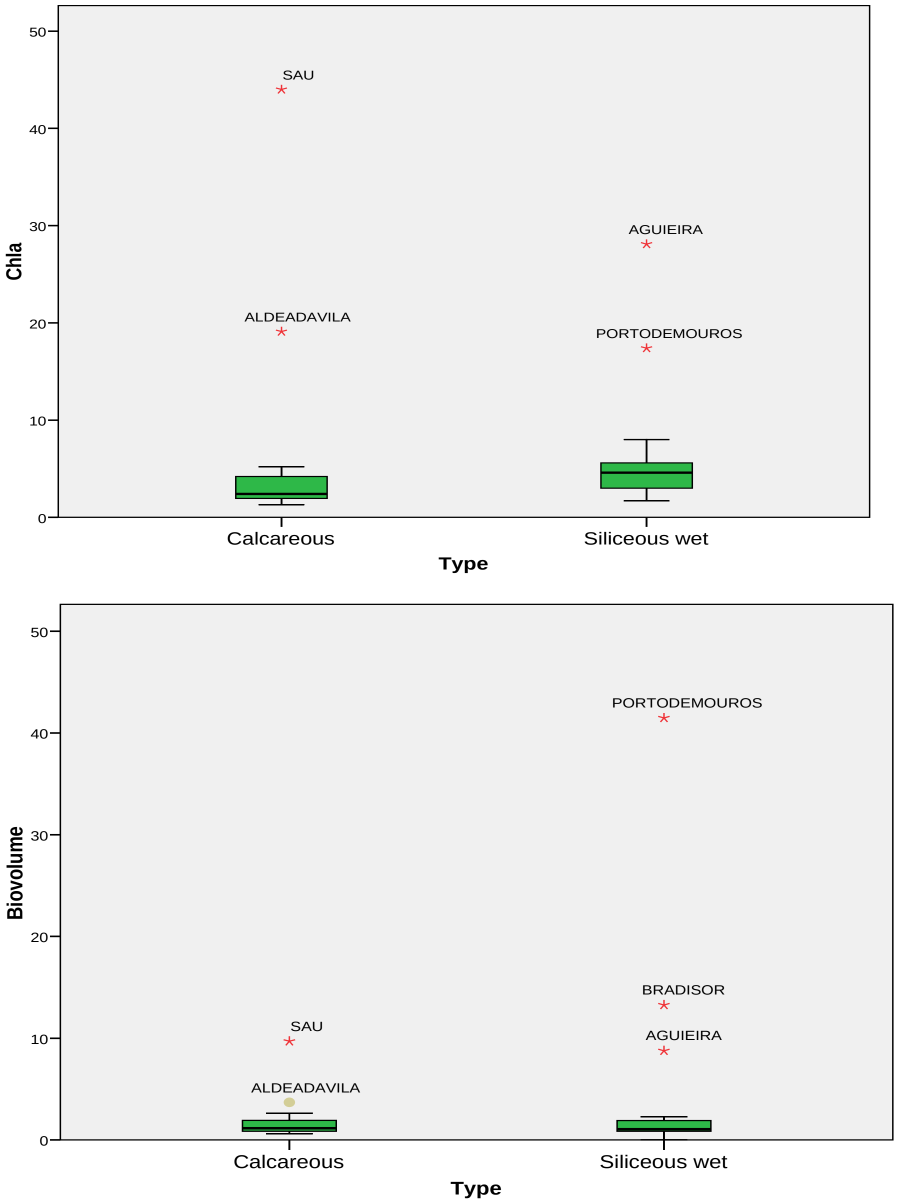


Figura B-6-1. Box plots for summer average chlorophyll-a concentration and total biovolume.

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.

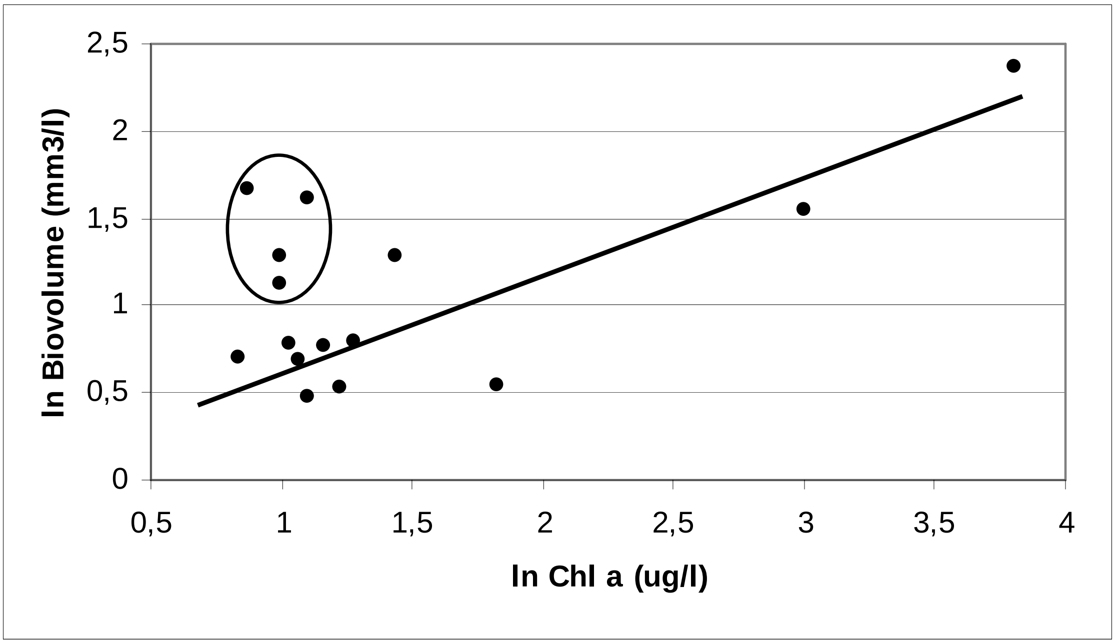


Figura B-6-2. Relationship between the chlorophyll-a and total biovolume data. Regression line between Chlorophyll a and Biovolume of the calcareous reservoir without the 4 marked points.

ANNEX B- Part 7 - Validation of boundary setting

7.1 Dataset used for the validation of boundary setting

The additional data sets were used with the purpose to expand the information along the whole gradient of pressures and to identify the behavior of the **phytoplankton composition metrics** in relation to eutrophication process. For this purpose, a dataset was collected and analysed:

- Relationships between the phytoplankton composition metrics and the eutrophication pressure - 33 Spanish reservoirs/ 33 reservoirs-years (Part 7.2);
- Relationships between phytoplankton composition metrics and chlorophyll a concentrations - 33 Spanish reservoirs/ 33 reservoirs-years (Part 7.3 and 7.4);
- Relationship between MedPTI index and mean annual total P concentrations in the 31 Sardinian reservoirs used for the calibration of MedPTI (Part 7.5)

7.2 Relation of the phytoplankton composition metrics with the eutrophication pressure

As referred to above, two phytoplankton **composition** metrics were selected for the IC exercise in the Lakes Mediterranean GIG: % Cyanoabacteria and IGA index. They were also applied to a set of data on Spanish reservoirs in order to know their suitability for the Mediterranean reservoirs. The metrics show a significant relationship with Total Phosphorus (TP) as indicator of the eutrophication pressure.

Table B-7-2. Correlations between the phytoplankton composition metrics selected for the IC exercise in L-M GIG and Total Phosphorus for 33 Spanish reservoirs.

Phytoplankton composition metric	r	r^2	F	p	Standard error
% Cyanobacteria	0.747	0.559	38.08	0.000001	0.072
I. Catalán’s GAI	0.910	0.828	144.82	0	0.045

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.

7.3 Validation of Percentage of Cyanobacteria

The best regression between chlorophyll *a* and % Cyanobacteria, which observes all the statistical criteria, is this linear equation:

$$\% \text{ Cyanobacteria} = 1{,}7044 \text{ Chl } a \ (\mu g/l) - 5{,}4125 \qquad R^2 = 0{,}7453$$

The ranges of % Cyanobacteria obtained for the G/M (from the chlorophyll ranges obtained with the above criteria) are:

Table 7.3. Correspondence between chlorophyll a values abd % Cyanobacteria (summer mean values)

Chl a (µg/l)	% Cyanobacteria
4,90	2,94
6,70	6,01
12,20	15,38
14,15	18,70

The regression equation between chlorophyll and percentage of cyanobacteria gives values of % of Cyanobacteria similar to the G/M boundaries of % of Cyanobacteria obtained in the intercalibration exercise for “Siliceus Wet”. The G/M boundary results for “Calcareous” are higher than the values obtained with this regression equation.

7.4 Validation of IGA index

The best regression between chlorophyll *a* and GAI, which meets all the statistical criteria, is this lineal regression between the nepperian logarithm of both variables:

$$\ln GAI = 0{,}9367 \ln Chl\ a(\mu g/l) - 0{,}2641 \qquad R^2 = 0{,}3581$$

Table 7.3. Correspondence between chlorophyll a values and IGA index (summer mean values)

Chl a (µg/l)	IGA index
4,90	3,40
6,70	4,56
12,20	8,00
14,15	9,19

The boundaries results of the intercalibration exercise for GAI are a bit low if we compare them with those obtained from the regression above, but are both (Calcareous and Siliceous Wet) nearly inside this range.

7.5 MedPTI Validation

The good-moderate boundary effectively separates oligomesotrophic lakes from eutrophic lakes, and has the meaning of a natural discontinuity in the index distribution, as shown by the following figure B-7-5.

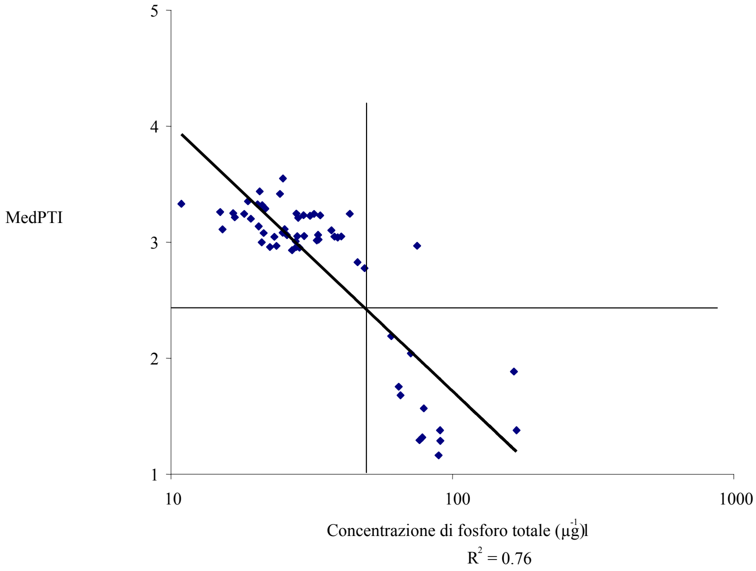


Figure B-7-5. Relationship between MedPTI index and mean annual total P concentrations in the 31 Sardinian reservoirs used for the calibration of MedPTI (60 lake year data)

During the intercalibration exercise, the reference values calculated for the two lake types (3.08 and 3.09) were very close to each other and to the national limit of 3.08 assuring that the national limit can be considered compliant with the IC exercise.

As for the Good/ Moderate boundary, in the IC exercise values of 2.32, 2.38 and 2.63 were calculated for the different typologies. They compare well with the National boundary value of 2.45, which was calculated on the whole set of IC "boundary" sites, in order to have a larger pool of data.
Given the close similarity between the values, we can assume that there is no reason to modify the Italian limit, choosing different limits for reservoirs in calcareous and siliceous catchments

ANNEX B – Part 8 - 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 B-8)

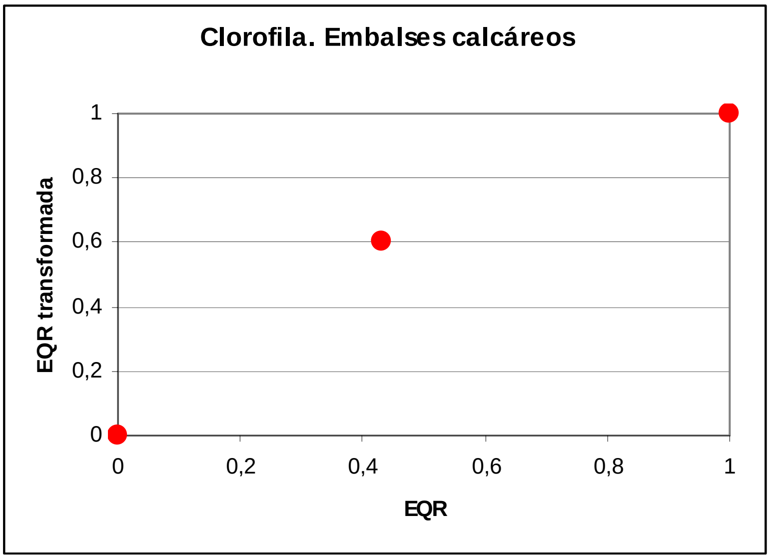


Figure B - 8. Normalization of Chlorophyll EQRs for the calcareous Mediterranean reservoirs

Two linear 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 normalization the EQR values are as follows, based on the data collected in 2005 for all the Mediterranean reservoirs included in the IC exercise:

Table B-8. Normalization of phytoplankton composition metrics EQRs for Mediterranean reservoirs.

Composition metrics	IC Type	Siliceous "wet" type	Calcareous type
% Cyanobacteria	x>0,91	y = 4,4444x - 3,4444	
	x<0,91	y = 0,6593x	
	x>0,72		y = 1,4286x - 0,4286
	x<0,72		y = 0,8333x
IGA (Catalan Index	x>0,9737	y = 15,234x - 14,233	
	x<0,9737	y = 0,6162x	
	x>0,9822		y = 22,533x - 21,533
	x<0,9822		y = 0,6108x

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 B – Part 9 - Correspondence of the intercalibration types to national types.

Table B-9a. 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 B-9b. 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 B-9c. 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 B-9d. 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 B-9e. 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