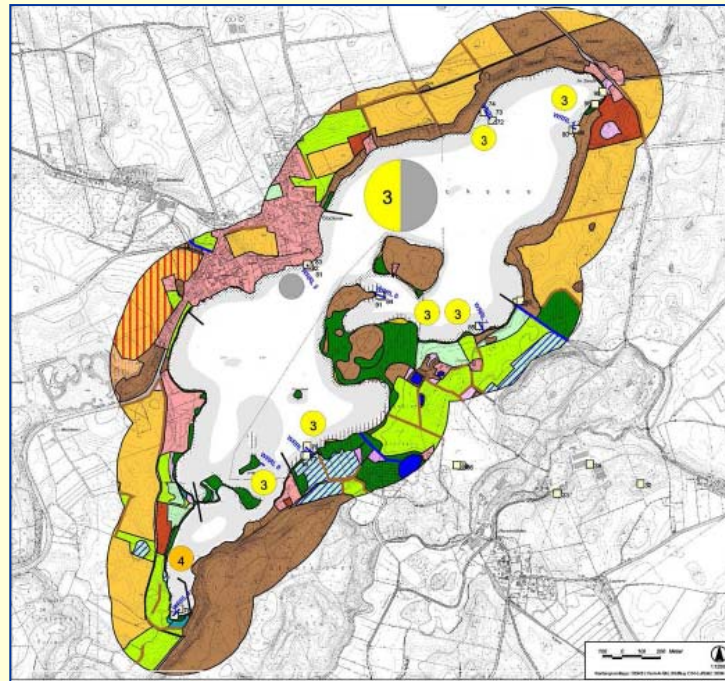


# Biological assessment of the ecological status of Schleswig-Holstein lakes

Dr. Mandy Bahnwart

State Agency for Agriculture, Environment and Rural Areas of Schleswig-Holstein  
Lake department



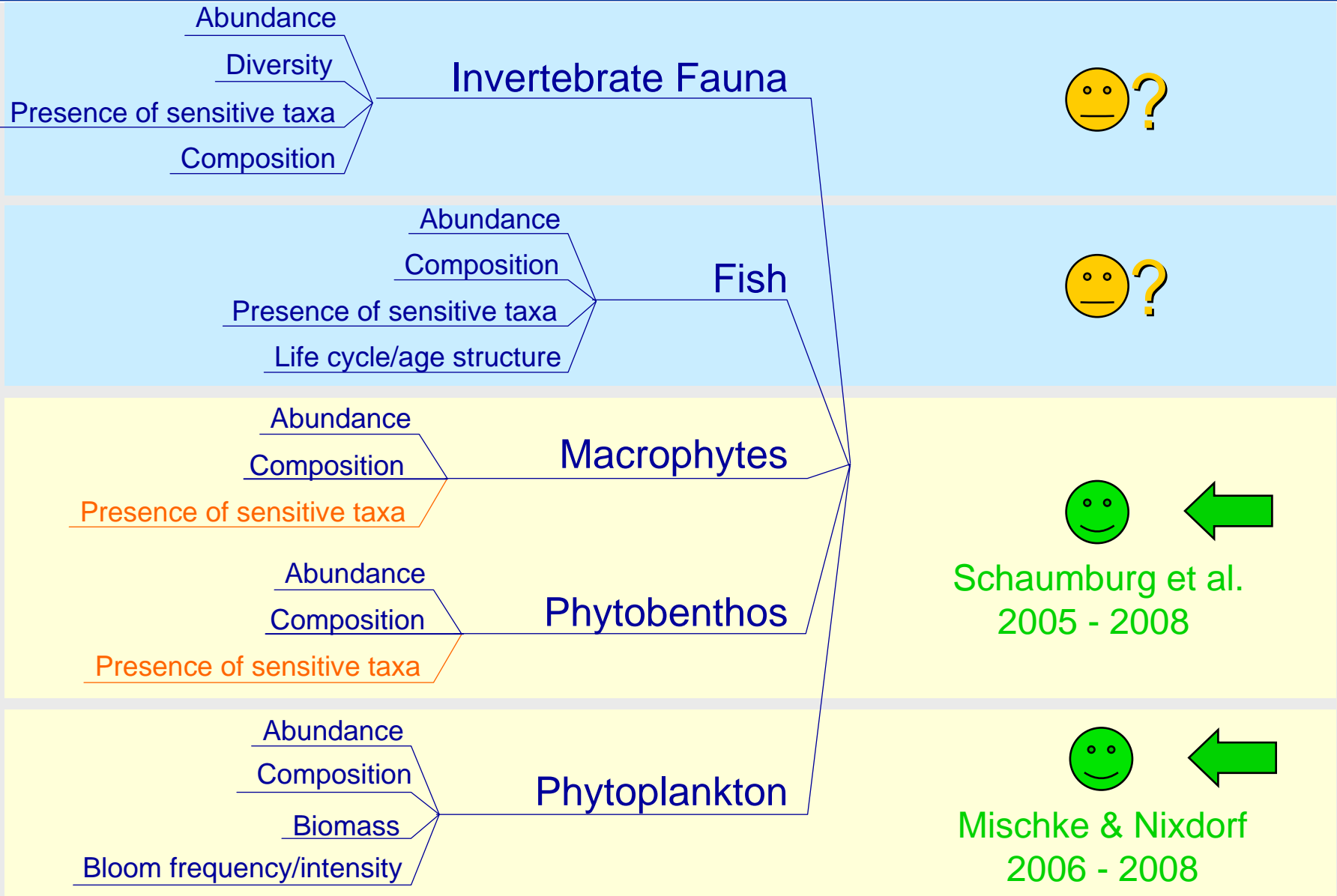
# Biological assessment of the ecological status of Schleswig-Holstein lakes

Dr. Mandy Bahnwart

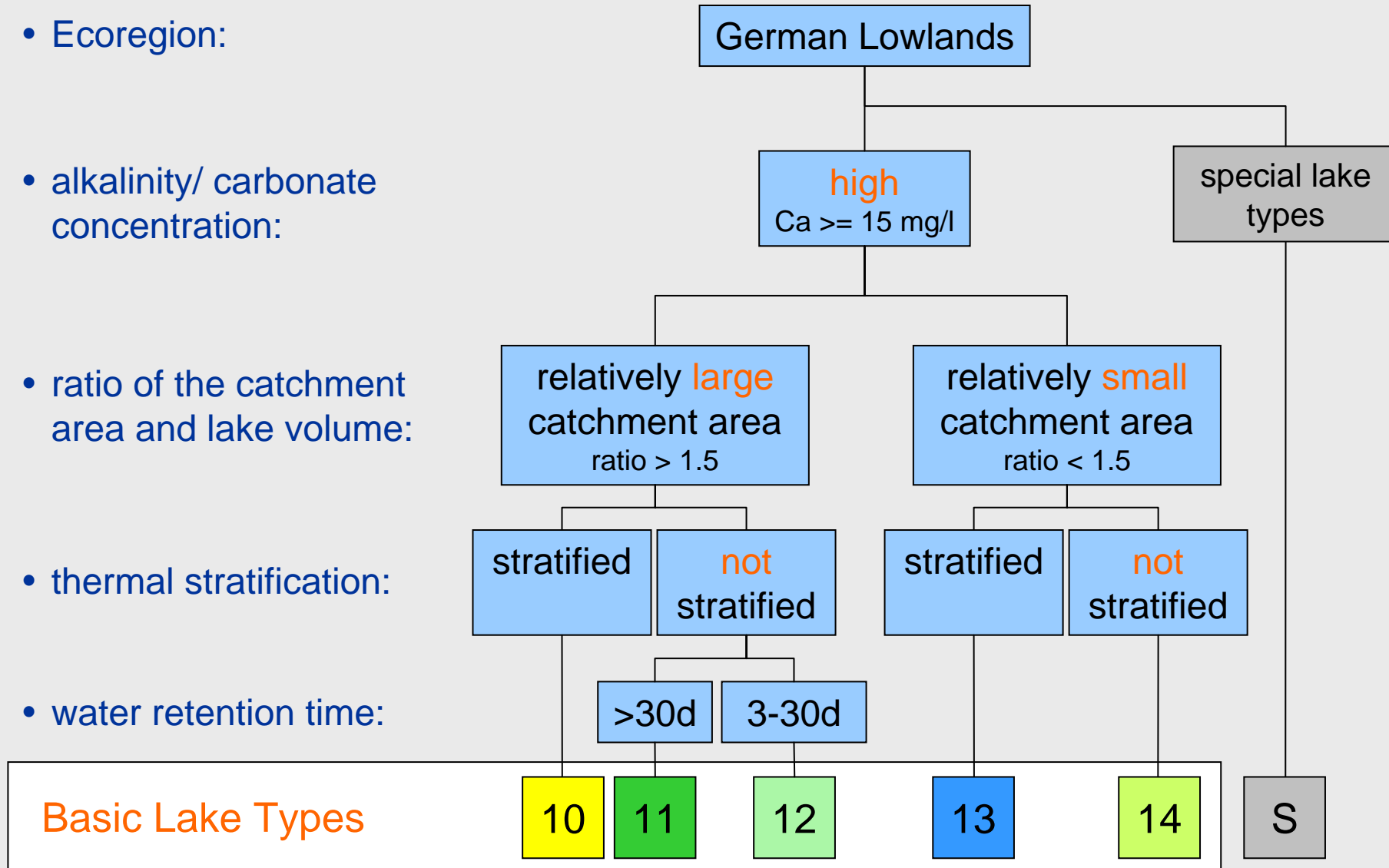
State Agency for Agriculture, Environment and Rural Areas of Schleswig-Holstein  
Lake department

- Overview about available biological assessment systems for lowland lakes (ecoregion 14)
- Introduction to the basic lake typology german lowlands and related biological lake types
- Introduction to methods for assessment systems for biological QE, current results and unresolved problems of assessment:
  - QE macrophytes/phytobenthos
  - QE phytoplankton
- Ecological status of schleswig-holstein lakes (overall results)
- Longterm trends in eutrophication (Großer Plöner See, Dobersdorfer See)
- Summary

# Current status of available assessment systems for lakes



- Ecoregion:
- alkalinity/ carbonate concentration:
- ratio of the catchment area and lake volume:
- thermal stratification:
- water retention time:



## Basic lake types: (acc. Mathes et al. 2002)

### stratified lakes

Type 10  
stratified lakes  
VQ > 1,5

Type 13  
stratified lakes  
VQ < 1,5

### unstratified, polymictic lakes

Type 12  
flushed lakes  
Retention time  
< 30 d

Type 11  
unstratified lakes  
VQ > 1,5

Type 14  
unstratified lakes  
VQ < 1,5

## Phytoplankton types:



Type 10.1  
VQ < 1,5...15

Type 10.2  
VQ > 15

Type 13  
VQ < 1,5

Type 12  
flushed lakes  
Retention time  
< 30 d

Type 11.1  
mean depth > 3m

Type 11.2  
mean depth < 3m

Type 14  
unstratified lakes  
VQ < 1,5

## Macrophyte types:



same class boundaries

TKg 10  
VQ > 1,5

TKg13  
VQ < 1,5

same class boundaries

TKp 12  
Retention time  
< 30 d

TKp 11  
VQ > 1,5

TKp 14  
VQ < 1,5

## Phytobenthos types:



same class boundaries

DS 10.1  
Ret. time > 1 y

DS 10.2  
Ret. time < 1 y

DS 13.2  
Ret. time > 1 < 10 y

DS 13.1  
Ret. time > 10 y

DS 12  
Retention time  
< 30 d

DS 11.1  
VQ > 0.75 < 5

DS 11.2  
VQ > 5

DS 14  
Retention time  
> 10 y



- Overview about available biological assessment systems for lowland lakes (ecoregion 14)
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- QE macrophytes/phytobenthos
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## PHYLIB – Makrophyten und Phytobenthos für ein leitbildbezogenes Bewertungsverfahren



Schaumburg et al. 2005 -2008;  
Bayerisches Landesamt für Umwelt



### Biological QE:

- Macrophytes (submerged + floating)
- Diatoms (other benthic algae are not considered because of lack of data)



### Indicating impact:

- trophic conditions
- structural degradation of the lake shore (recreational use, bathing, cattle, bank fixation, camping places...)

⇒ system developed only for natural freshwater lakes

## Metric: „Reference Index“ (RI) - deviation from the reference community

Field mapping of transects



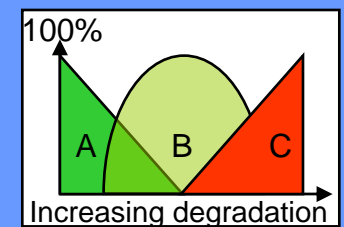
species composition, mean depth distribution of species



List of typespecific species, 3 classes according to their ability to tolerate different level of degradation:



- **Taxa class A:** species, dominating exclusively at reference sites
- **Taxa class B:** species with a wide ecological tolerance range (indifferent), species occurring at moderately impacted sites
- **Taxa class C:** species, occurring mostly at degraded sites and only in low number at reference sites



Calculation RI:

$$RI = \frac{\sum \text{Taxa class A} - \sum \text{Taxa class B}}{\sum \text{taxa classes A+B+C}} \times 100$$

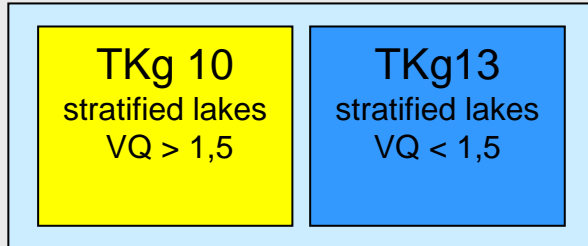
$\Sigma$  = quantity (relative macrophyte abundance<sup>3</sup>)

Calculation macrophyte index:

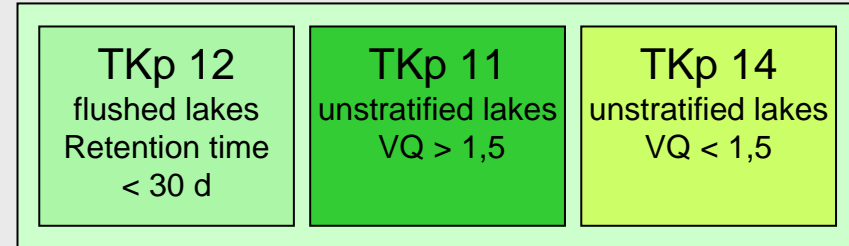
$$M_{MP} = \frac{(RI + 100) * 0,5}{100}$$



lake type: stratified lakes



polymictic lakes



Additional and /or downgrading criteria of Ecological Quality Class (EQC):

- Mass development of dominant taxa (>80%): → **RI -50%**
  - *Elodea canadensis/ nuttallii* or
  - *Myriophyllum spicatum* or
  - *Najas marina subsp. intermedia* or
  - *Potamogeton pectinatus* or
  - *Ceratophyllum demersum/submersum*
- Mean lower depth distribution:  
TKg10: <5m → **RI -50%**;  
TKg13: <5-8m → **RI -20%**; <5m  
→ **RI -50%**
- EQC 5: no macrophytes at all



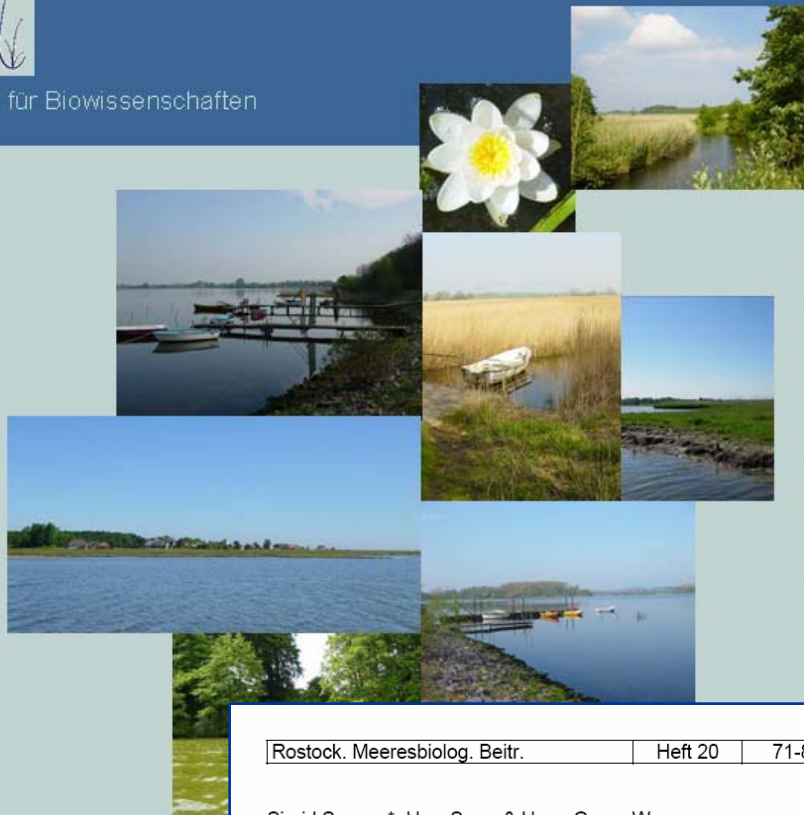
- Mass development of dominant taxa (>80%): **RI-50%**
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  - *Najas marina subsp. intermedia* or
  - *Potamogeton pectinatus* or
  - *Ceratophyllum demersum/submersum*
- Mean lower depth distribution:  
TKp: <3m → **RI -50%** (if max. lake depth >3m)
- EQC 5: no macrophytes at all



Institut für Biowissenschaften



Universität Rostock



## Bewertung von Strandseen anhand der Qualitätskomponenten Makrophyten und Phytoplankton

2006-2007



Rostock. Meeresbiolog. Beitr.	Heft 20	71-89	Rostock 2008
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Sigrid SAGERT\*, Uwe SELIG & Hans-Georg WAGNER

\*Universität Rostock, Institut für Biowissenschaften, Albert Einstein Str. 3, 18051 Rostock  
sigrid.sagert@uni-rostock.de

**Bewertung von Strandseen anhand von Makrophyten**

**Biological assessment of macrophyte in non-tidal coastal lakes along the  
Western Baltic Sea (Germany)**

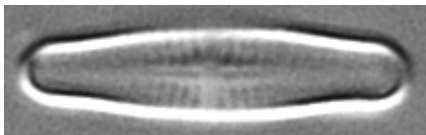
Sigrid Sagert  
Uwe Selig  
Hans-Georg Wagner

Auftraggeber: Landesamt für  
Umwelt Schleswig-Holstein

## 1. Metric: Trophic index ( $TI_{Nord}$ ) according to Schönfelder (2008): How does it work?

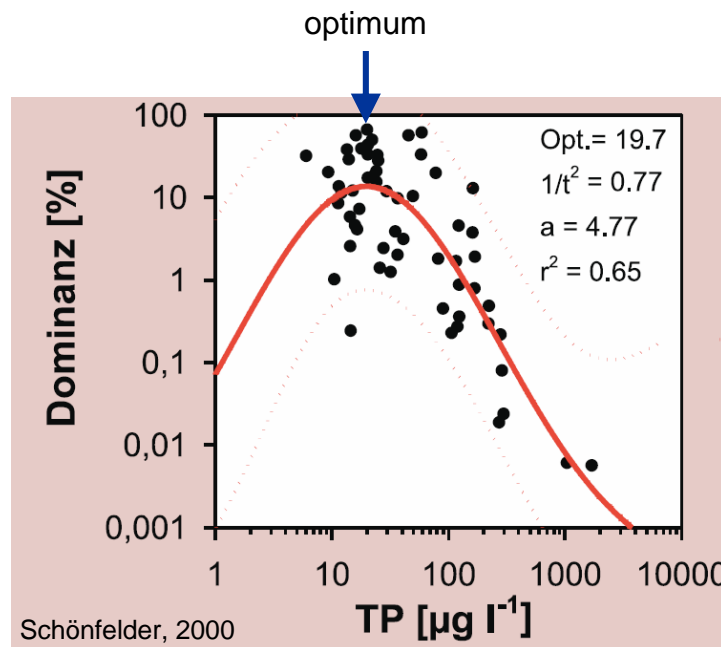
Calculation = relative percentage of valves + **trophic indication value (optimum)**

Example for an  
oligotrophic species  
in rivers



*Achnanthes minutissima*

Trophic index	1.2
Trophic state	oligotroph
Trophic weight	1

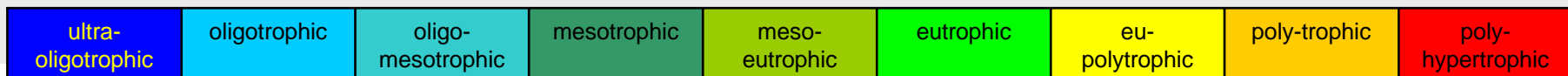


→ wide Amplitude  
= trophic tolerant taxa  
= bad / unsuitable indicator

→ small amplitude  
= sensitive taxa  
= good indicator

Problem:  
with increasing nutrients  
tolerant species with a wide  
amplitude dominate

Increasing nitrogen and phosphorus concentration



## 1. Metric: Trophic index ( $TI_{Nord}$ ): Ecological boundary classes

Diatom type	Geomorphologischer Seetyp	Ecological quality				
		Very good	good	moderate	poor	bad
DS 13.1	Geschichtete Seen mit einer Verweilzeit über zehn Jahren	< 1,75	1,75-2,24	2,25-2,74	2,75-3,24	> 3,24
DS 13.2/10.1	Geschichtete Seen mit einer Verweilzeit zwischen zehn Jahren und einem Jahr (P-limitiert)	< 2,25	2,25-2,74	2,75-3,24	3,25-3,74	> 3,74
DS 10.2	Geschichtete Seen mit einer Verweilzeit unter einem Jahr (N-limitiert)	< 2,75	2,75-3,24	3,25-3,74	3,75-4,24	> 4,24
DS 14	Ungeschichtete Seen mit einer Verweilzeit über zehn Jahren	< 2,00	2,00-2,49	2,50-2,99	3,00-3,49	> 3,49
DS 11	Ungeschichtete Seen mit einer Verweilzeit über 30 Tagen	< 2,50	2,50-2,99	3,00-3,49	3,50-3,99	> 3,99
DS 12	Flussseen mit einer Verweilzeit unter 30 Tagen	< 3,00	3,00-3,49	3,50-3,99	4,00-4,49	> 4,49

### 2. Metric: Ratio of reference species number (RAQ)

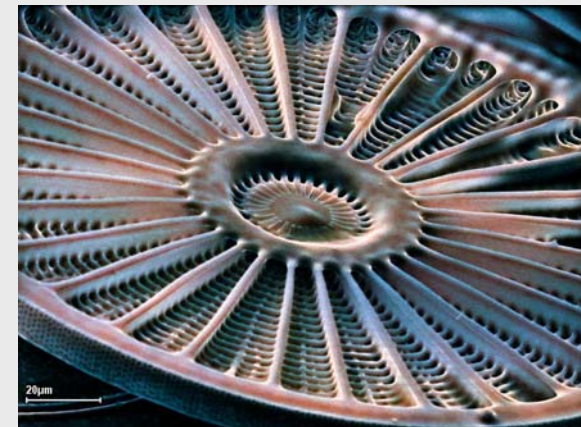
- indicator species were arranged in 2 classes (type-specific) according to their ability to tolerate different level of degradation:

- Taxa class A:** typespecific „reference species“
- Taxa class C:** typespecific „degradation species“

- calculation of a type-specific ratio, based on species number (value number doesn't matter) in the two different classes:

$$\text{RAQ} = \frac{\sum \text{Taxa class A} - \sum \text{Taxa class C}}{\sum \text{taxa classes A+C}}$$

⇒ **Diatom assessment:** arithmetical mean of both metrics  $\text{TI}_{\text{Nord}}$  and RAQ, no worst-case



⇒ Calculation and ecological quality class boundaries for PHYLIB:

Index for  
evaluation =  
of EQC

$$\frac{\text{Index Macrophytes (RI)} + \text{Index Diatoms (TI+RAQ)}}{2}$$

(no worst case)

- Ecological classes defined for three cases:



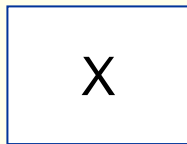
+



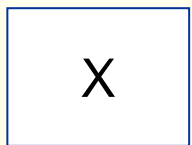
⇒ data of both communities (M+D) at a measuring site available



+



⇒ just data of macrophytes at a measuring site available (lack of diatoms)

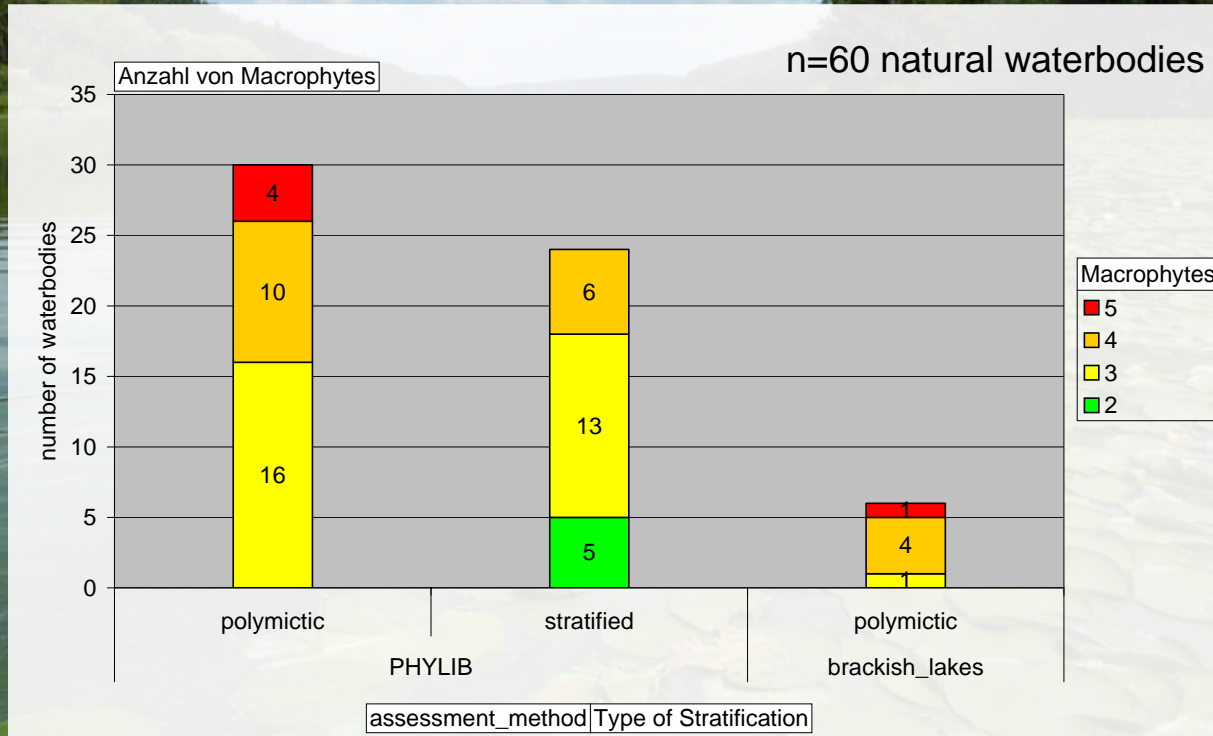
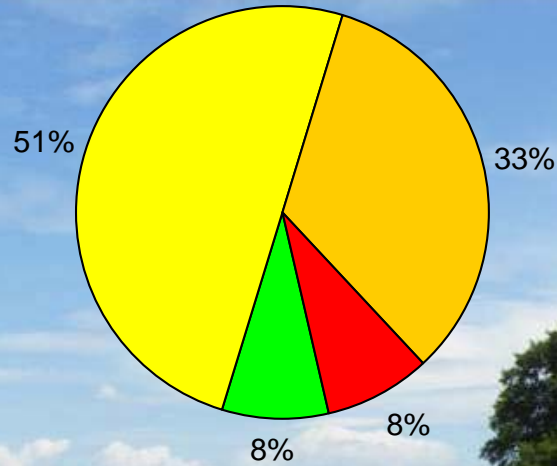


+

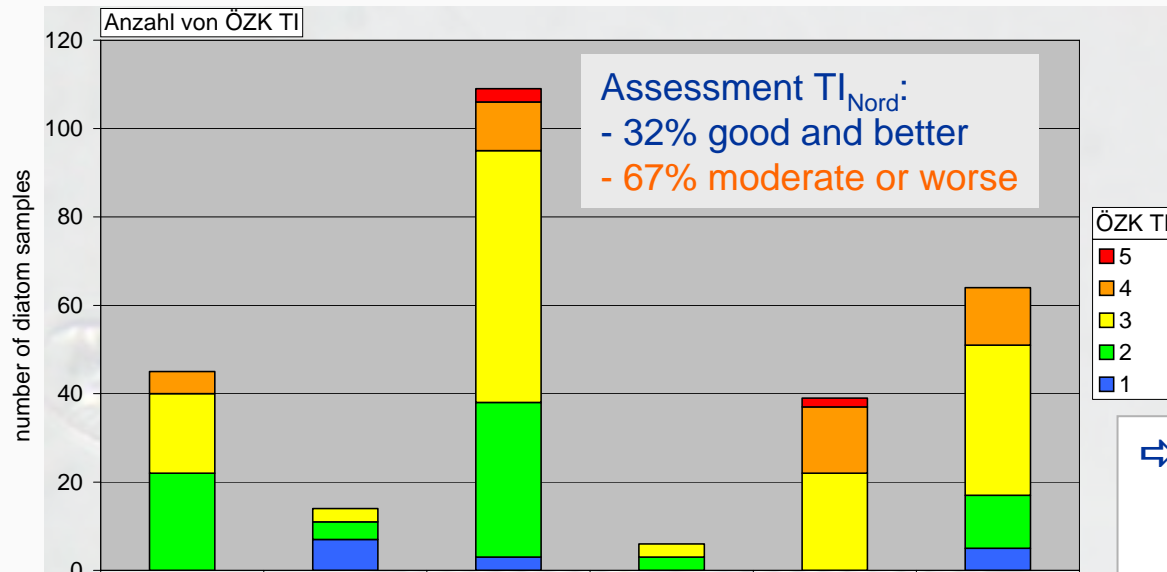


⇒ just data of diatoms at a measuring site available (naturally lack of macrophytes)

# Ecological status of Macrophytes: Current results



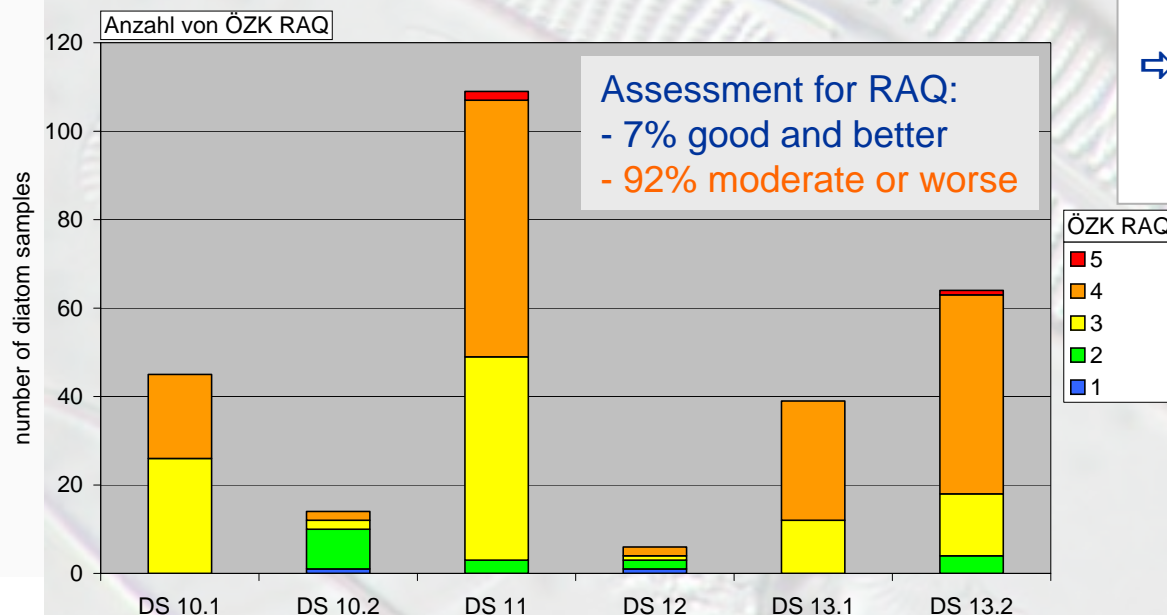
# Ecological status of Diatoms: Current results



ÖZK TI	
1	5%
2	27%
3	49%
4	16%
5	2%

⇒ Ecological status is judged by RAQ for more than 62% of all samples **one or two classes worse** than by TI

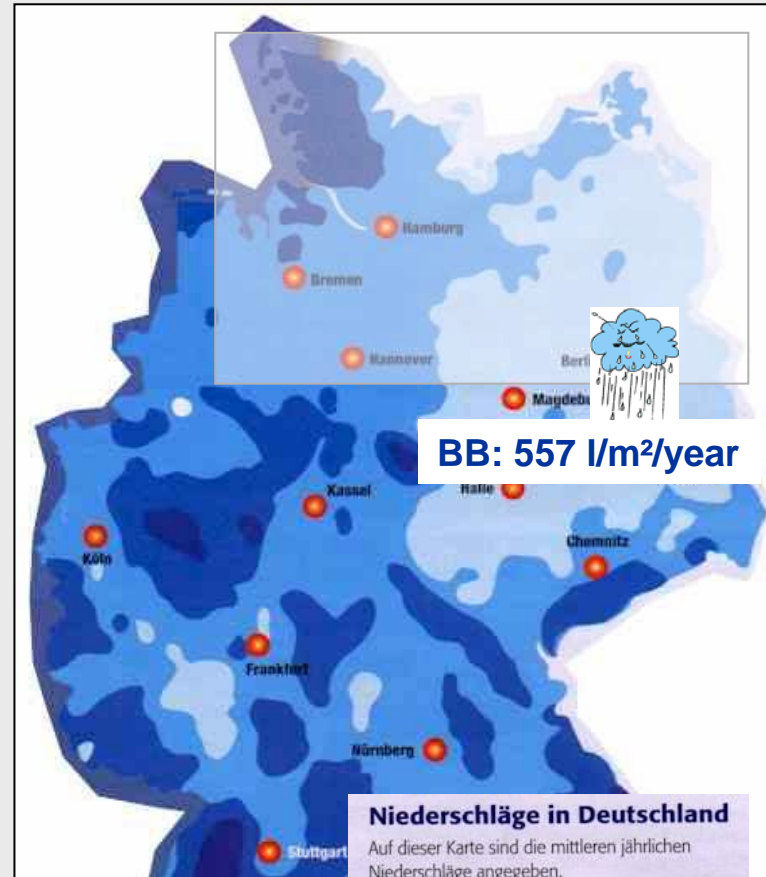
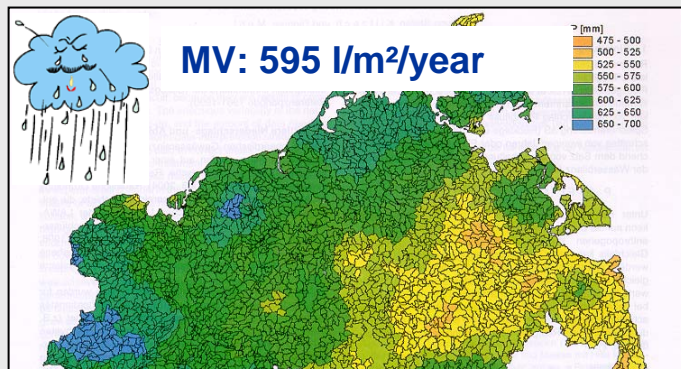
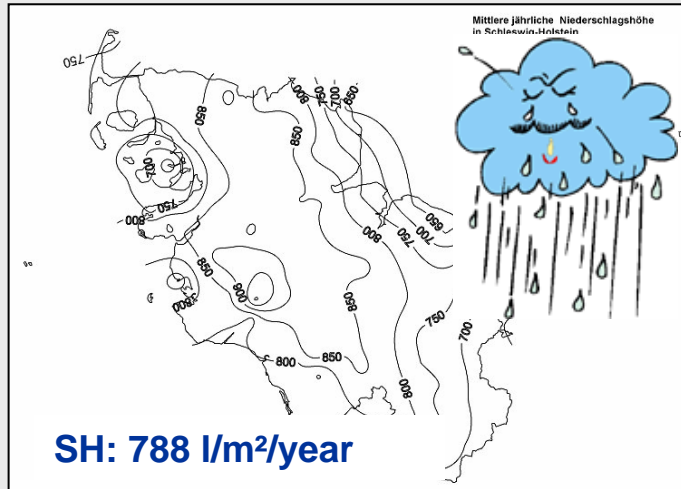
⇒ Need for validation of reference species inventory in lakes of SH!



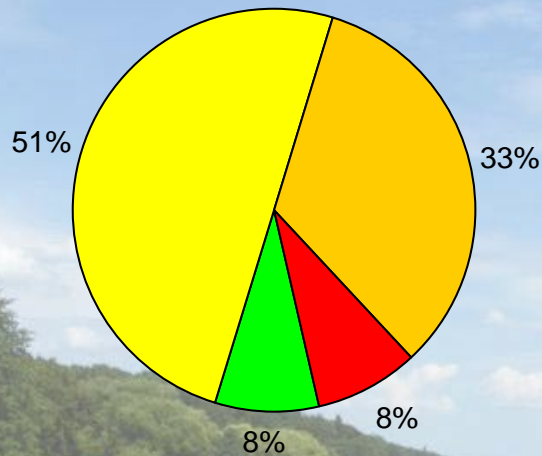
ÖZK RAQ	
1	1%
2	6%
3	36%
4	55%
5	1%

## Another reason for validation of diatom assessment system:

⇒ Steep gradient of annual rainfall from NW-SO of ecoregion 14 (german lowlands)

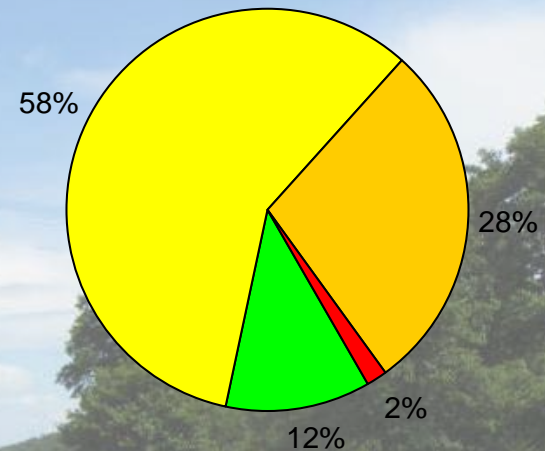


- Region of Schleswig-Holstein: higher annual rainfall → lower retention times → almost all lakes are flushed by small rivers → higher phosphorus-retention in the lake ecosystems
- defined retention times for the diatom types have to be checked as well as the class boundaries



Macrophytes

2	3	4	5
---	---	---	---




Diatoms

2	3	4	5
---	---	---	---

- ⇒ Results of diatoms are slightly better than those from macrophytes
- ⇒ assessment system for diatoms is actually under revision; therefore we don't calculate the mean EQC for macrophytes and diatoms for our lakes in Schleswig-Holstein
- ⇒ only results for the macrophytes are integrated in the overall judgement of the ecological status



- Overview about available biological assessment systems for lowland lakes (ecoregion 14)
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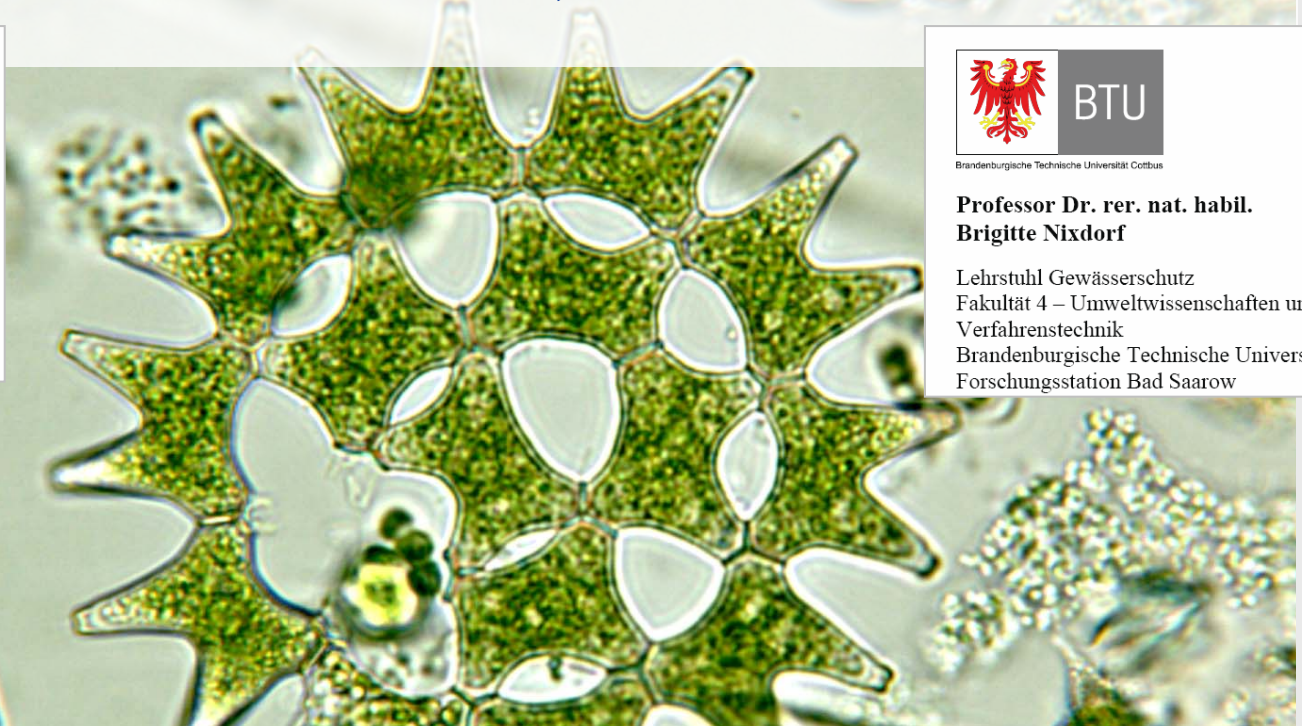


## Mischke, U. & Nixdorf, B. (Hrsg.), 2008, Gewässerreport (Nr. 10): „Bewertung von Seen mittels Phytoplankton zur Umsetzung der EU-Wasserrahmenrichtlinie“, BTUC-AR 2/2008.



**Dr. Ute Mischke**

Leibniz-Institut für Gewässerökologie  
und Binnenfischerei (IGB) im  
Forschungsverbund Berlin e.V.  
Abt. 2, Limnologie von Flusseen



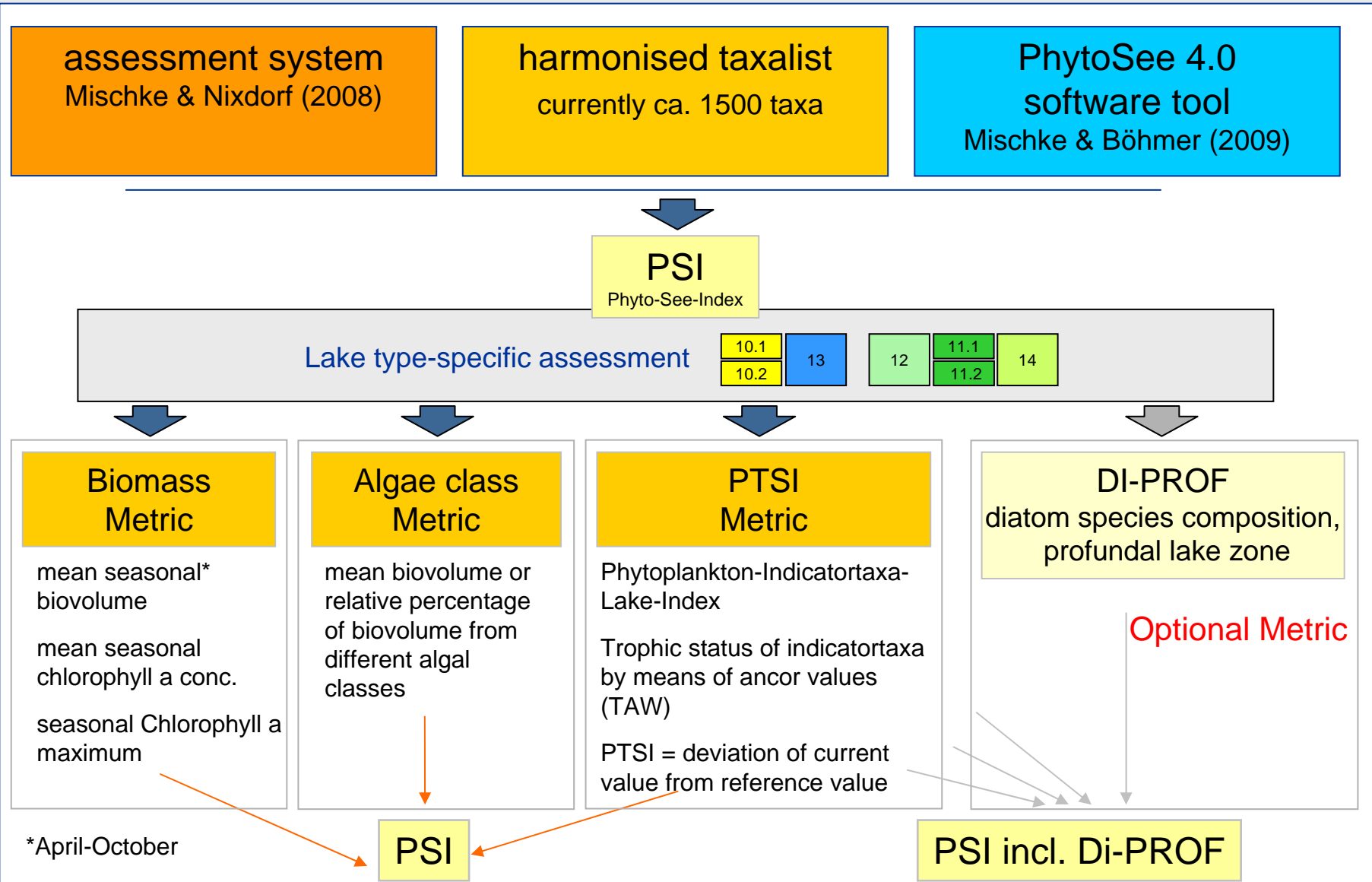
Brandenburgische Technische Universität Cottbus

**Professor Dr. rer. nat. habil.  
Brigitte Nixdorf**

Lehrstuhl Gewässerschutz  
Fakultät 4 – Umweltwissenschaften und  
Verfahrenstechnik  
Brandenburgische Technische Universität Cottbus  
Forschungsstation Bad Saarow



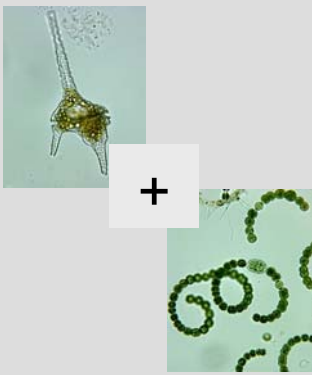


*Ute Mischke, Ursula Riedmüller, Eberhard Hoehn, Ilka Schönfelder & Brigitte Nixdorf*  
Description of the German system for phytoplankton-based assessment of lakes  
for implementation of the EU Water Framework Directive (WFD)..... 117

*Brigitte Nixdorf, Eberhard Hoehn, Ursula Riedmüller, Ute Mischke, Ilka Schönfelder & Mandy Bahnwart*  
Anforderungen an Probenahme und Analyse der Phytoplanktonbiozönosen in Seen zur  
ökologischen Bewertung gemäß der EU-WRRL..... 147



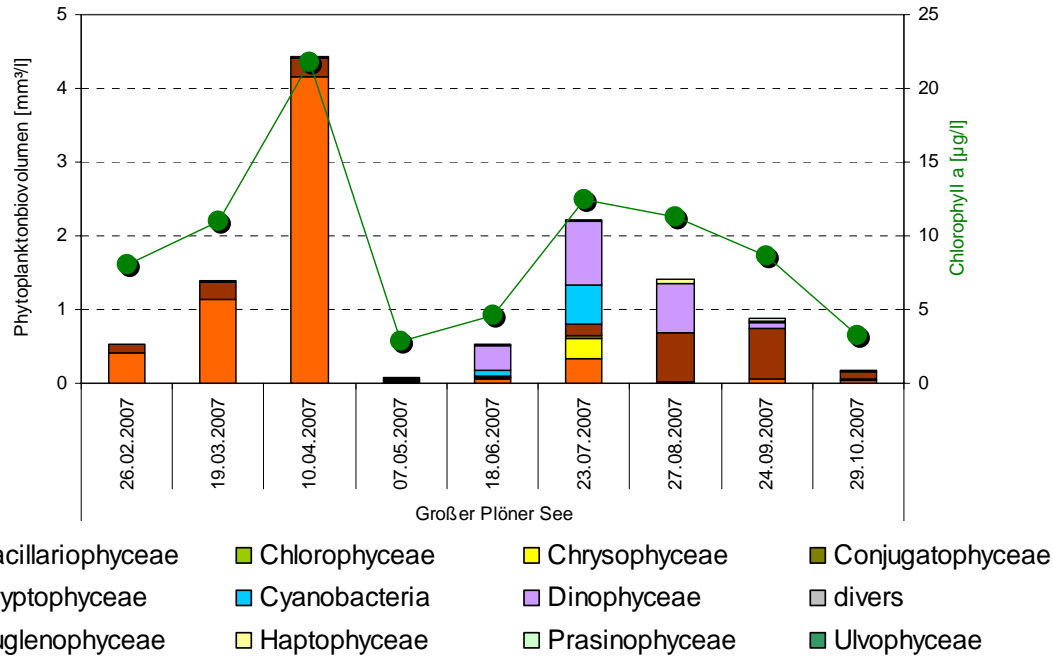
## Ecological class boundaries for algae class metric

### Typespecific algae class metric (Example: german lowlands)

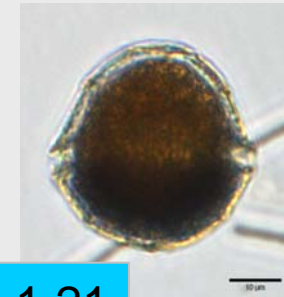
	CHLORO						CYANO			DIN_CYAN				DINO		CHRYSO		
																		
period	Jul-Oct						Jul-Oct			Jul-Oct				Jul-Oct		Season (Apr-Oct)		
unit	BV						BV			BV				%		%		
Type	10.1	10.2	13	11.2	12	14	11.1	11.2	12	10.1	10.2	13	14	11.2		10.1	10.2	13
H_G	0.11		0.15				1.52	1.50	4.60	0.90		1.10		10.00		2.50		
G_M	0.20		0.40				3.03	3.50	7.00	2.00		2.29		5.00		1.20		
M_P	0.38		1.12				6.00	8.00	10.80	4.40		4.75		2.50		0.60		
P_B	0.72		3.00		1.00		12.00	19.00	16.40	10.00		9.90		1.25		0.30		

# Phytoplankton: Metrics for assessment (Example)

⇒ Algae class metric and biomass metric



- Dominant algae groups and trophic anchor values for dominant indicator species for Lake Großer Plöner See, 2007



1,21



4,17



1,94



X



3,38



3,25



1,74



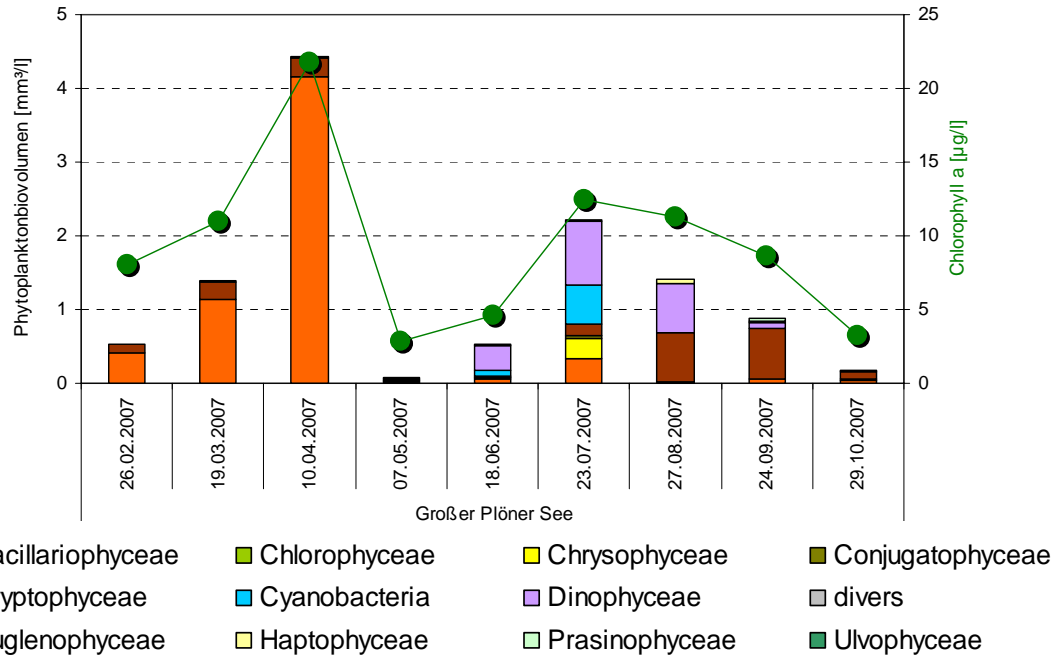
2,55



1,81

⇒ PTSI metric

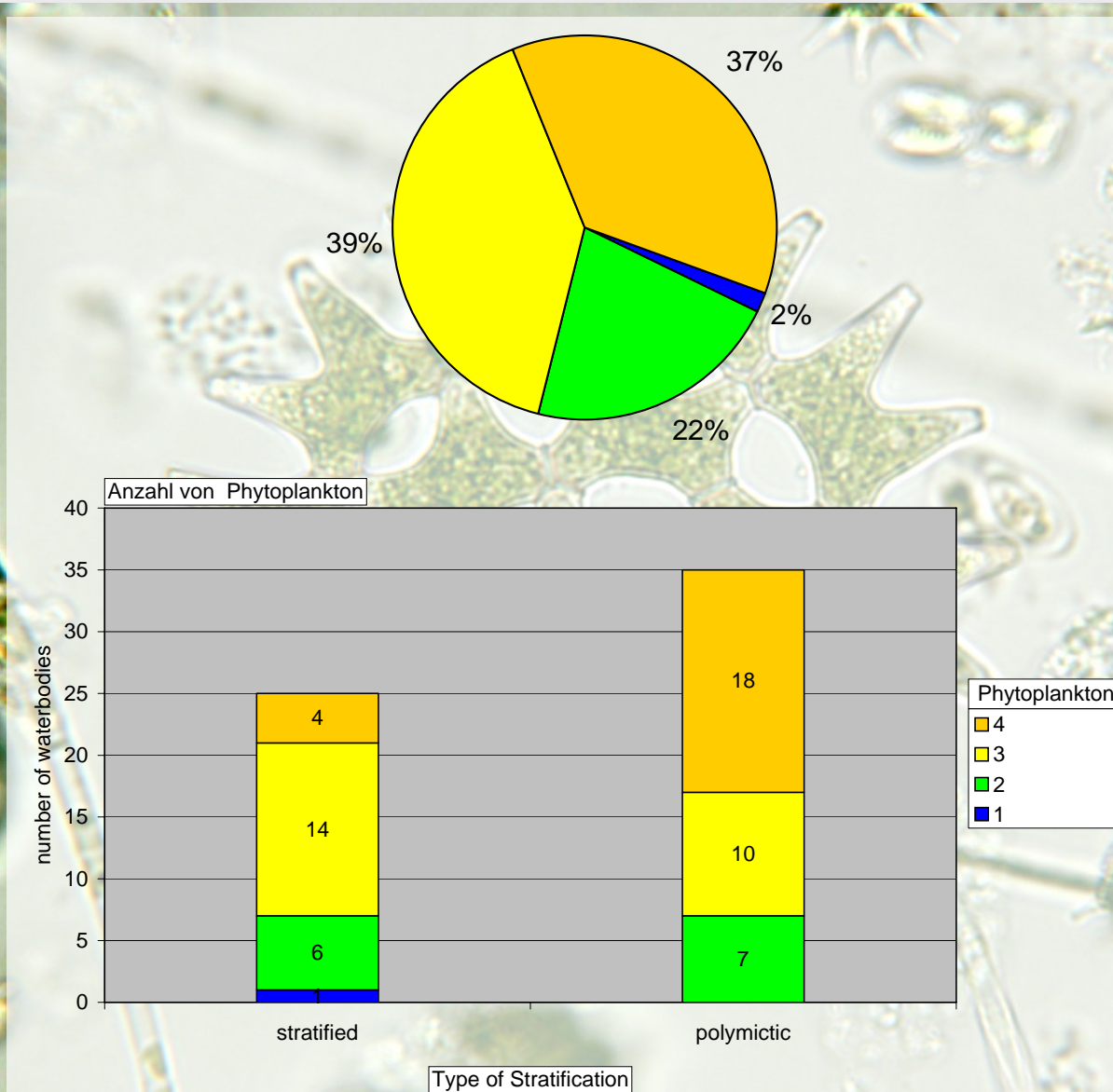
# Phytoplankton: Metrics for assessment (Example)



- Dominant algae groups and trophic ancor values for dominant indicator species for Lake Großer Plöner See, 2007

Type	LAWA (Trophie- index)	PSI	biomass metric	algae- class metric	PTSI		DI-PROF	PSI incl. DI-PROF
13	m (2,5)	2,50	2,65	0,90	3,01		3,98	2,83

# Ecological status of Phytoplankton: Current results





## New results derived from paleolimnological sediment coring and diatom-inferred TP-reconstruction

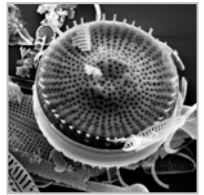
Hydrobiologia  
DOI 10.1007/s10750-009-9819-4

PALAEOLIMNOLOGY



### A multi-proxy paleolimnological reconstruction of trophic state reference conditions for stratified carbonate-rich lakes in northern Germany

Thomas Hübener · Sven Adler · Petra Werner ·  
Manuela Schult · Helmut Erlenkeuser ·  
Hinrich Meyer · Mandy Bahnwart



- Results showed, that the **trophic reference status** of almost all investigated lakes (7 stratified, 5 polymictic lakes) **was lower (i.e. higher TP-background concentration)** than previously assumed for the phytoplankton assessment system!

**Table 6** Anticipated and diatom-inferred trophic state conditions in the oldest sediments of the study lakes (starting conditions)

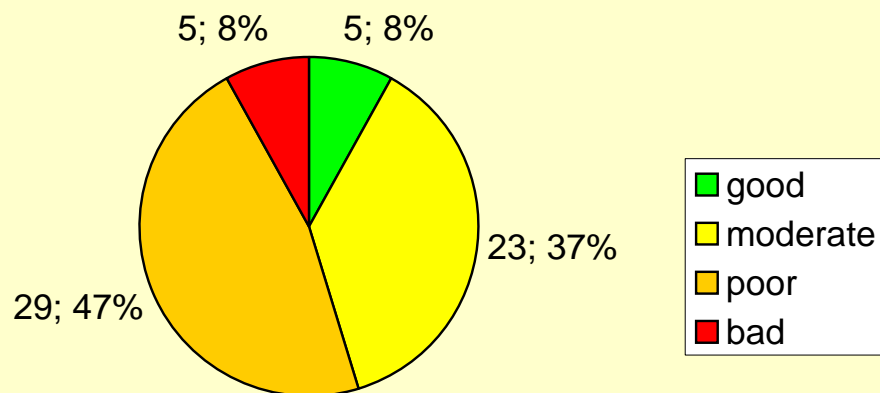
Name of the lake	Subtype/anticipated reference acc. Schaumburg et al. (2007) –Mischke et al. (2007)	Starting conditions inferred/until
Bistensee	10.1/m–10.1/lm	lm/1375
Kellersee	10.1/m–10.1/lm	o–lm/1525
Stolper See	10.2/e–10.1/lm	e/1960
Tresdorfer See	10.2/e–10.1/lm	o/1700
Kleiner Plöner See	10.2/e–10.2/m	m/1900
Gudower See	10.2/e–10.2/m	e/1950



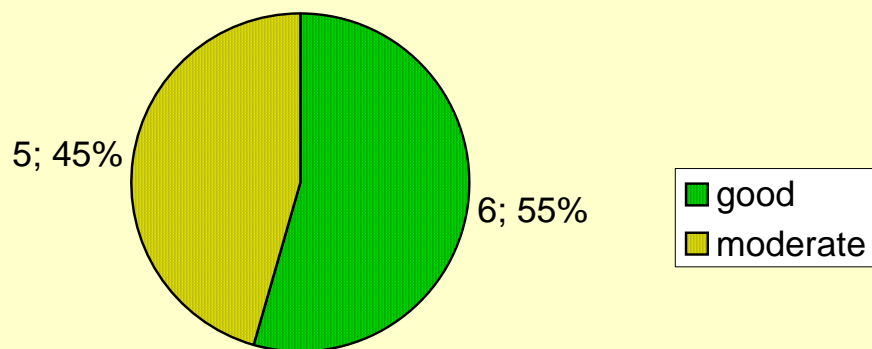
- Overview about available biological assessment systems for lowland lakes (ecoregion 14)
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- **Summary**



## Ecological status of natural WB



## Ecological potential of artificial WB



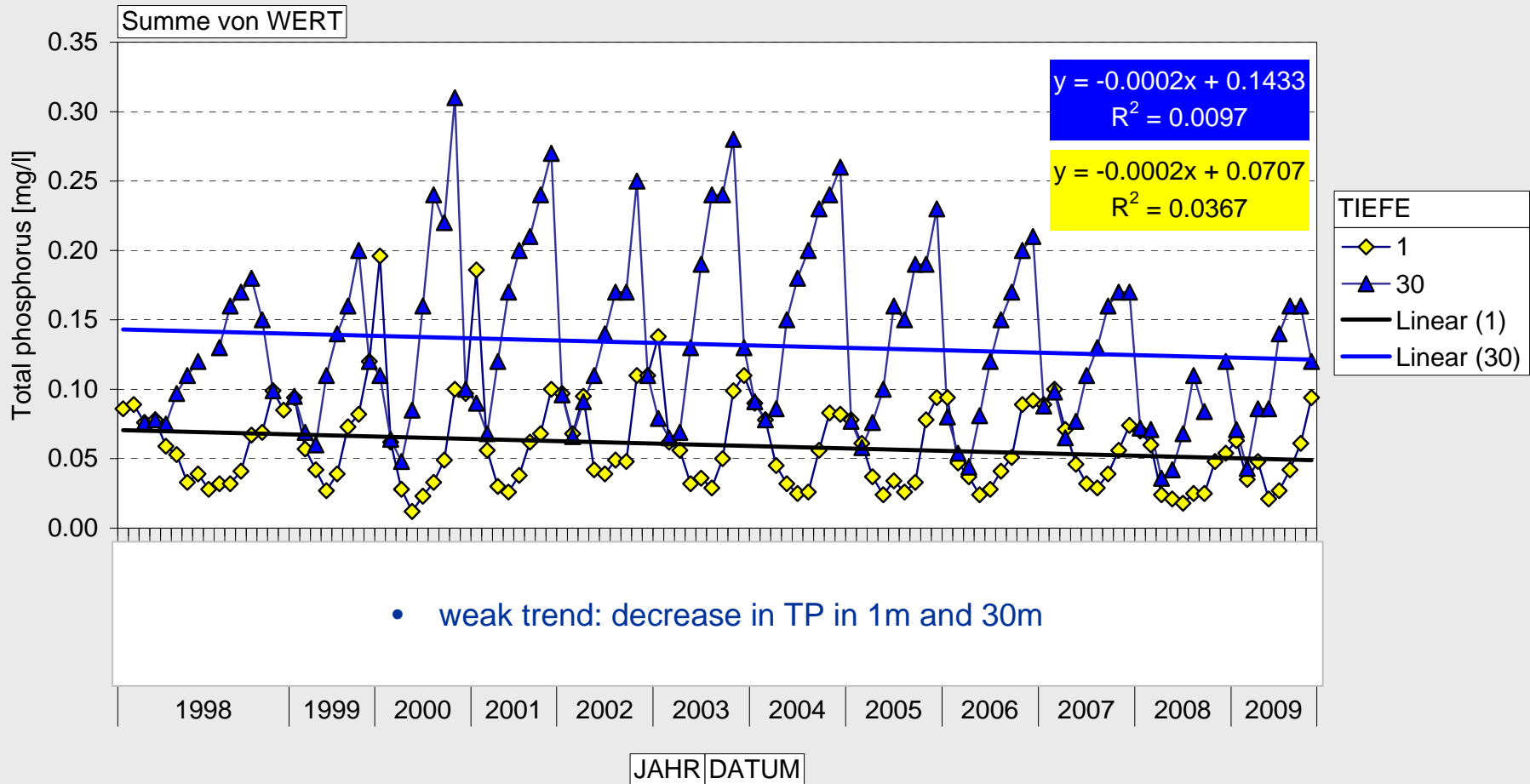
## Natural waterbodies:

- only 5 (2010: just 4) lakes will presumably achieve the good ecological status in 2015: *Suhrer See, Schöhsee, Selenter See, Schluensee*
- 23 lakes, i.e. more than one third of all natural lakes are in moderate status; almost half of the lakes are in poor condition
- 5 lakes are judged as to be bad due to absence of macrophytes

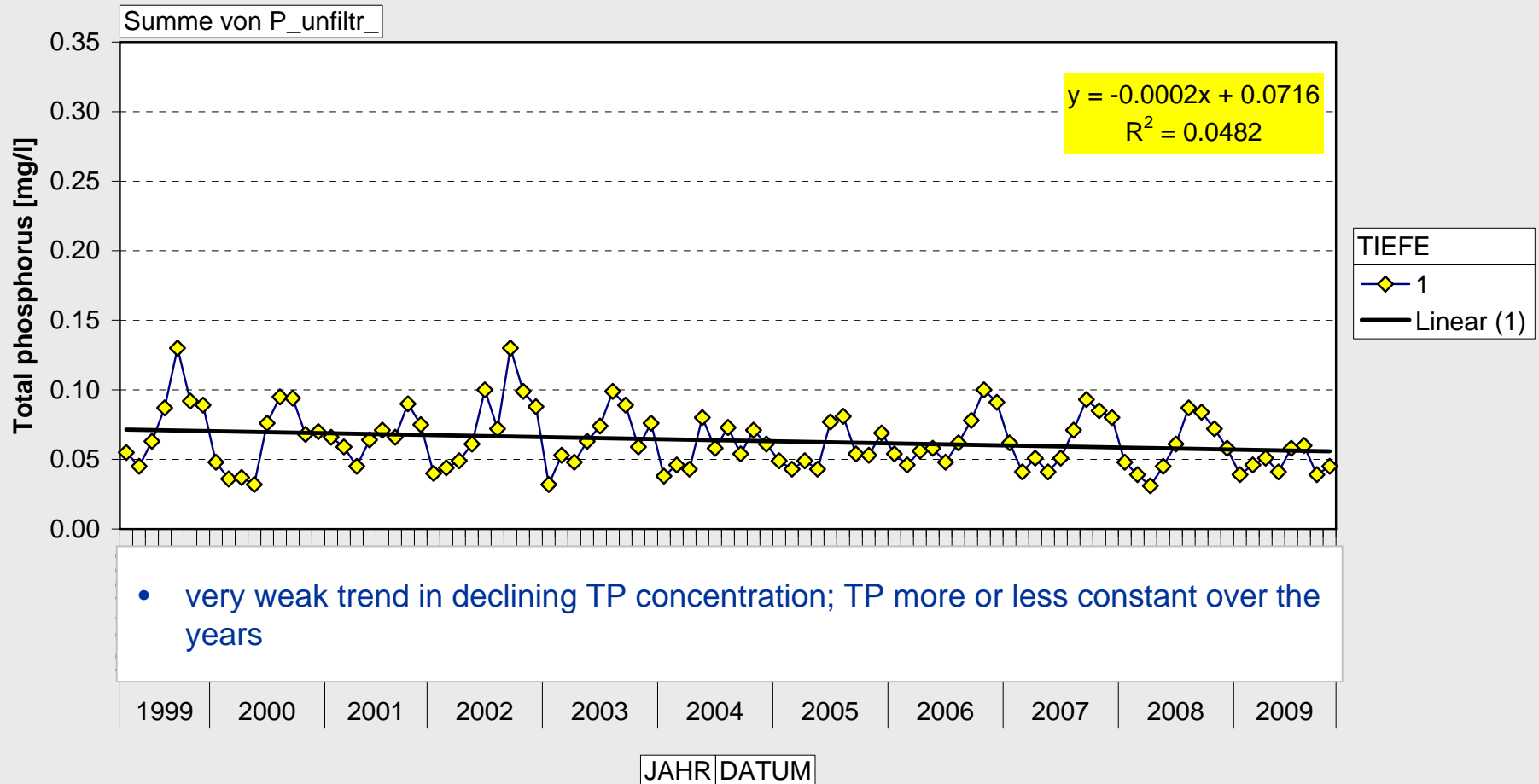
## Artificial waterbodies:

- artificial reservoirs at the north sea coast (including lagoons) with small catchment areas are judged as good, cause no management action plans for improvement are possible / reasonable
- artificial lakes and polders with large catchment are assessed as moderate

## Gr. Plöner See 1998-2009



## Dobersdorfer See 1999-2009

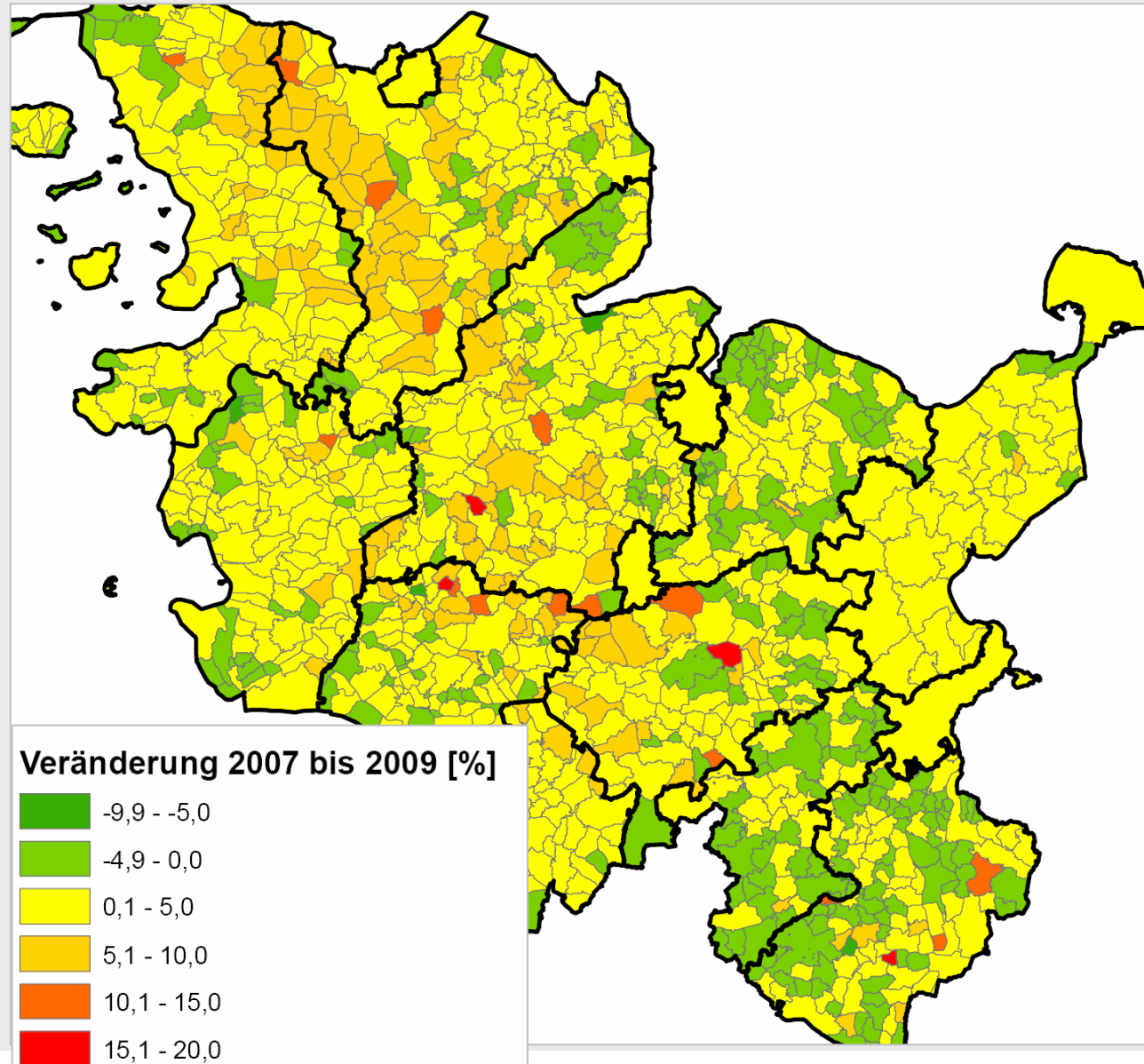




Change of relative  
proportion of land use for  
Maize in Schleswig-  
Holstein (2007 bis 2009)  
(Abschätzung auf Grundlage der  
Feldblöcke, Stand Mai 2009)

## Input of

- **nutrients**
- **sediments**
- **pesticides**



- **Methods:** Reliable assessment methods for biological quality elements are available for phytoplankton and macrophytes/phytobenthos; methods for fish and benthos have not yet been developed or are in progress
- **Typology:** assessment systems are mostly attributed to all types of natural freshwater lakes, but have rarely been conducted to special lake types (only brackish lakes) and fail for artificial lakes
- **Need for validation:** all assessments should further revised with regard to the trophic reference conditions (e.g. regional gradient of rainfall, consideration of background TP concentration given by palaeolimnology)
- **Results** of the ecological status of 73 schleswig-holstein lakes, reported for the water framework directive:
  - QE Macrophytes: **5 lakes (8%) good; 92% moderate or worse**
  - QE Phytoplankton: **14 lakes (23%) good or better; 76 % moderate or worse**
  - Overall assessment (natural lakes): **5 lakes (8%) good; 92% moderate or worse**  
macrophytes seem to be the most sensitive quality element at the moment
  - Overall assessment (artificial lakes): small catchment: “good”; large catchment “moderate”
- **Longterm trends** in eutrophication show a decline in total phosphorus in our lakes; although the trends are weak it gives us a cause to stay optimistic to achieve the good ecological status for some more lakes in the next 20 years



- Assessment system „PHYLIB“ (Makrophytes/Phytobenthos)  
[http://www.lfu.bayern.de/wasser/forschung\\_und\\_projekte/phylib\\_englisch/index.htm](http://www.lfu.bayern.de/wasser/forschung_und_projekte/phylib_englisch/index.htm)
- Assessment system for macrophytes in brackish lakes of the Baltic Sea coast  
*SAGERT, Sigrid, SELIG, Uwe & WAGNER, Hans-Georg (2008): Bewertung von Strandseen anhand von Makrophyten*  
[http://www.biologie.uni-rostock.de/oekologie/literature/RMB/RMB 20/RMB\(20\) 71-90.pdf](http://www.biologie.uni-rostock.de/oekologie/literature/RMB/RMB_20/RMB(20)_71-90.pdf)
- Assessment system for Phytoplankton  
[http://www-docs.tu-cottbus.de/gewaesserschutz/public/aktuelle\\_reihe/2008\\_ar\\_10.pdf](http://www-docs.tu-cottbus.de/gewaesserschutz/public/aktuelle_reihe/2008_ar_10.pdf)  
<http://www.igb-berlin.de/abt2/mitarbeiter/mischke/#Downloads>
- More information about lakes in Schleswig-Holstein  
<http://www.umweltdaten.landsh.de/public/seen/seenalle.php>  
<http://www.wasser.sh/>