Phytoplankton Trends in the Baltic Sea

By

- **Norbert Wasmund, Leibniz-Institute for Baltic Sea Research, D-18119 Warnemünde, Germany**
- **Jarno Tuimala, Finnish Red Cross Blood Service, FI-00310 Helsinki, Finland**
- **Leen Vandepitte, Flanders Marine Institutem, InnovOcean site, B-8400 Oostende, Belgium**
- **Alexandra Kraberg, Biologische Anstalt Helgoland, Alfred Wegener Institute for Polar and Marine Research, D-27483 Helgoland, Germany**

Data from the Monitoring Programme COMBINE of HELCOM and various research projects of the IOW.
HELCOM data are free, but latest data, not available from the data bank, were contributed by

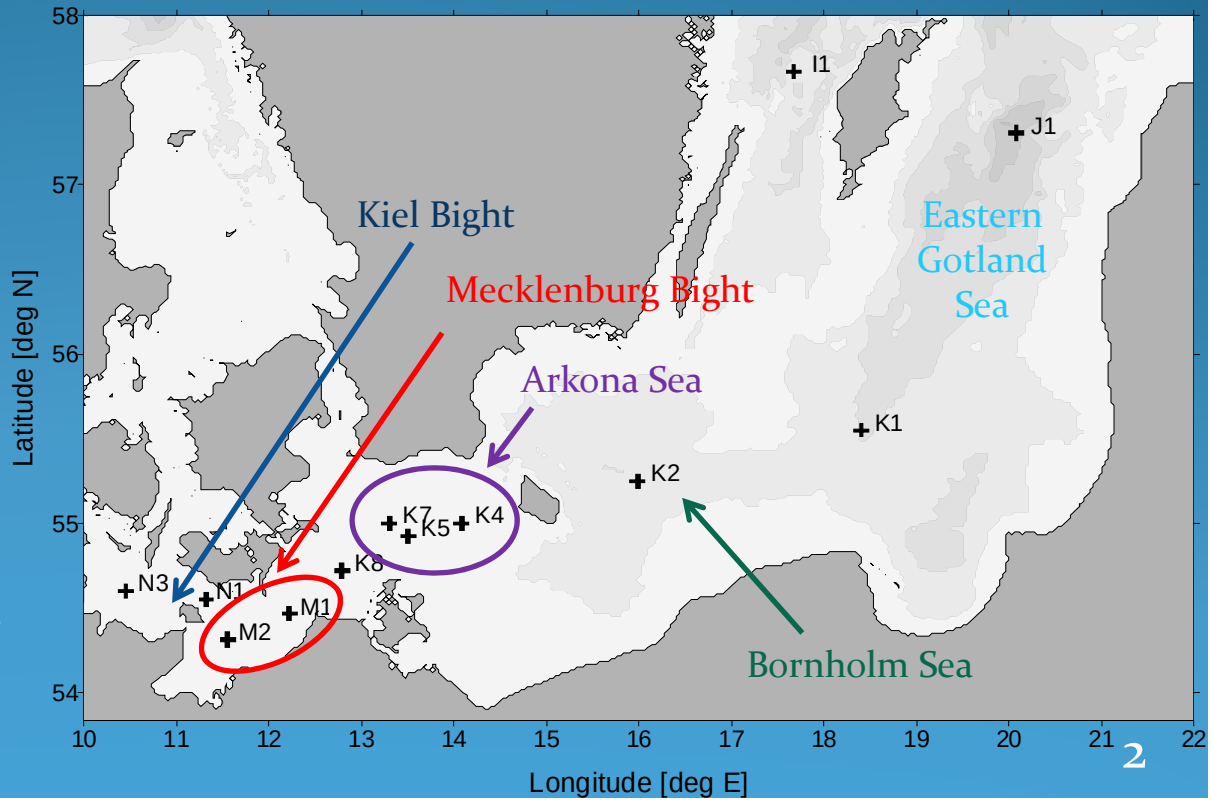
- Susanna Hajdu and Svante Nyberg (Stockholm University),
- Slawomira Gromisz and Janina M. Kownacka (MIR Gdynia, PL),
- Henrik Jespersen (Bornholms Regionskommune, DK) and Bente Brix Madsen (Orbicon, DK),
- Irina Olenina (Centre of Marine Research Klaipeda, LT).

Data contributed to the Project **LargeNet** within the European Network of Excellence "Marine Biodiversity and Ecosystem Functioning" (MarBEF).

What is HELCOM ?
Baltic Marine Environment Protection Commission (Helsinki Commission)
1974: Helsinki Convention signed by the Baltic coastal states.
1979: Start of the joint Baltic Monitoring Programme.
Data go to national data banks and finally to ICES.

Various components of the ecosystem
⇒ only Phytoplankton

Whole Baltic Sea
⇒ only Kiel and Mecklenburg Bight, Central and southern Baltic Proper



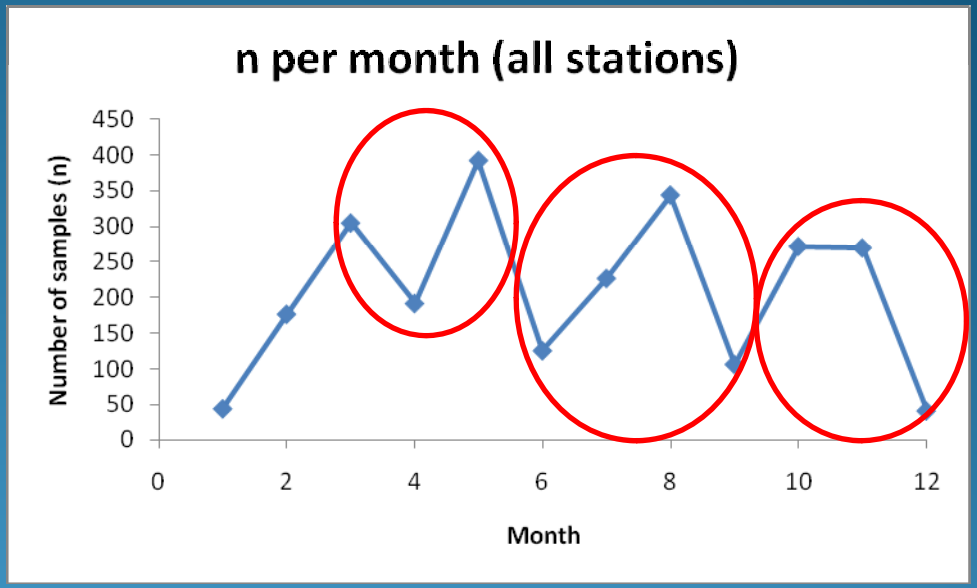
Data Source

Which data are available ?

Station name	Period of data series	Number of samples (n)
BMP I1	1979-1996	82
BMP J1	1979-2005	320
BMP K1	1979-2005	186
BMP K2	1979-2006	366
BMP K4	1979-2005	
BMP K5	1981-2005	567*
BMP K7	1979-2002	
BMP K8	1989-2005	112
BMP M1	1980-2005	
BMP M2	1980-2005	398**
BMP N1	1979-1997	203
BMP N3	1986-2000	86

* Station K4, K5 and K7 combined
** Station M1 and M2 combined

How are the data distributed ?



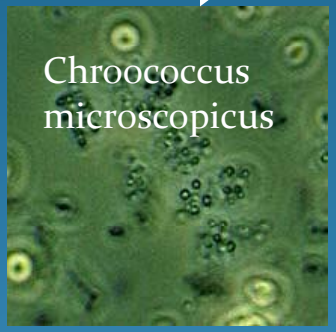
Definition of seasons according to the HELCOM

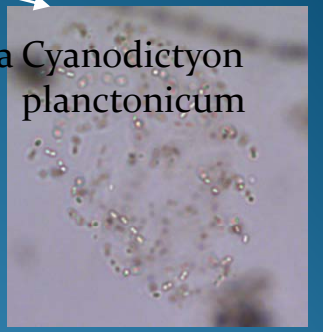
Season	Belt Sea	Baltic Proper
Spring	February-April	March-May
Summer	May-August	June-September
Autumn	September-November	October-December

Data set was split into 4 parts according to the seasons. Winter was not analysed.

Revision of taxa names, examples:

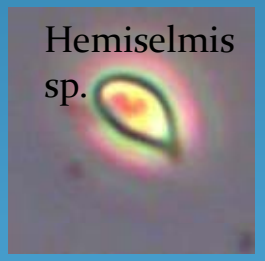
„Microcystis reinboldii“ or „Microcystis sp.“ or „Chroococcales unid.“





„Gomphosphaeria pusilla“

„Rhodomonas minuta“



(D. Hill)

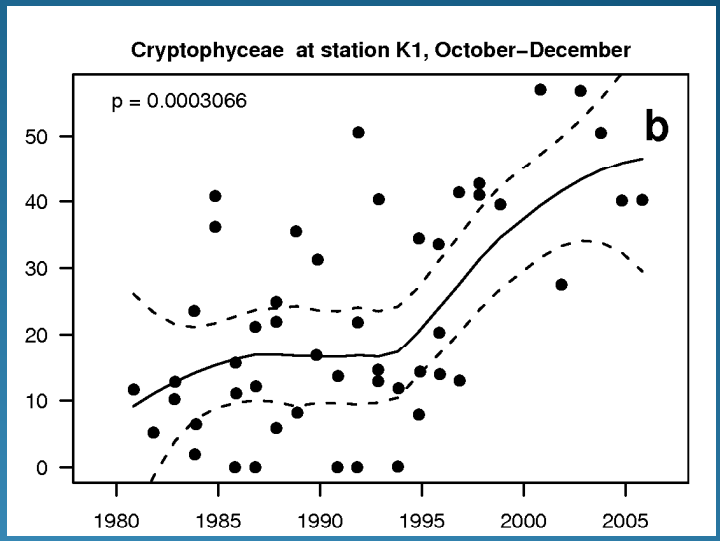
„Chaetoceros danicus“

(K. Jensen)

Statistical analyses

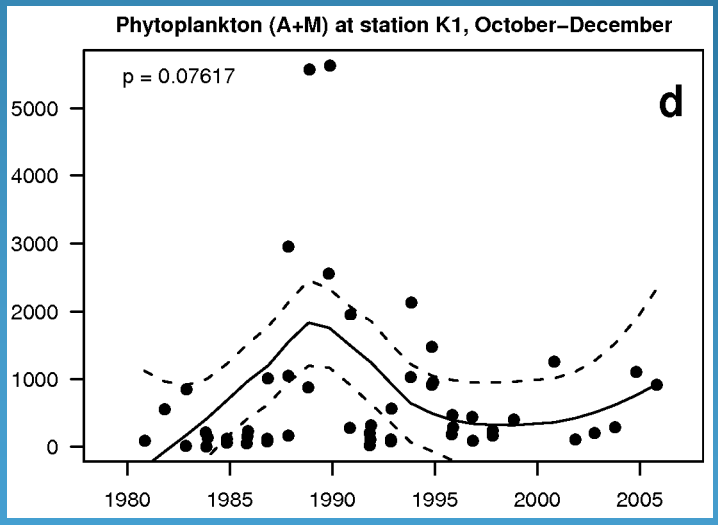
Only taxa that contain at least 10 observations per station and season were used for the statistical analyses

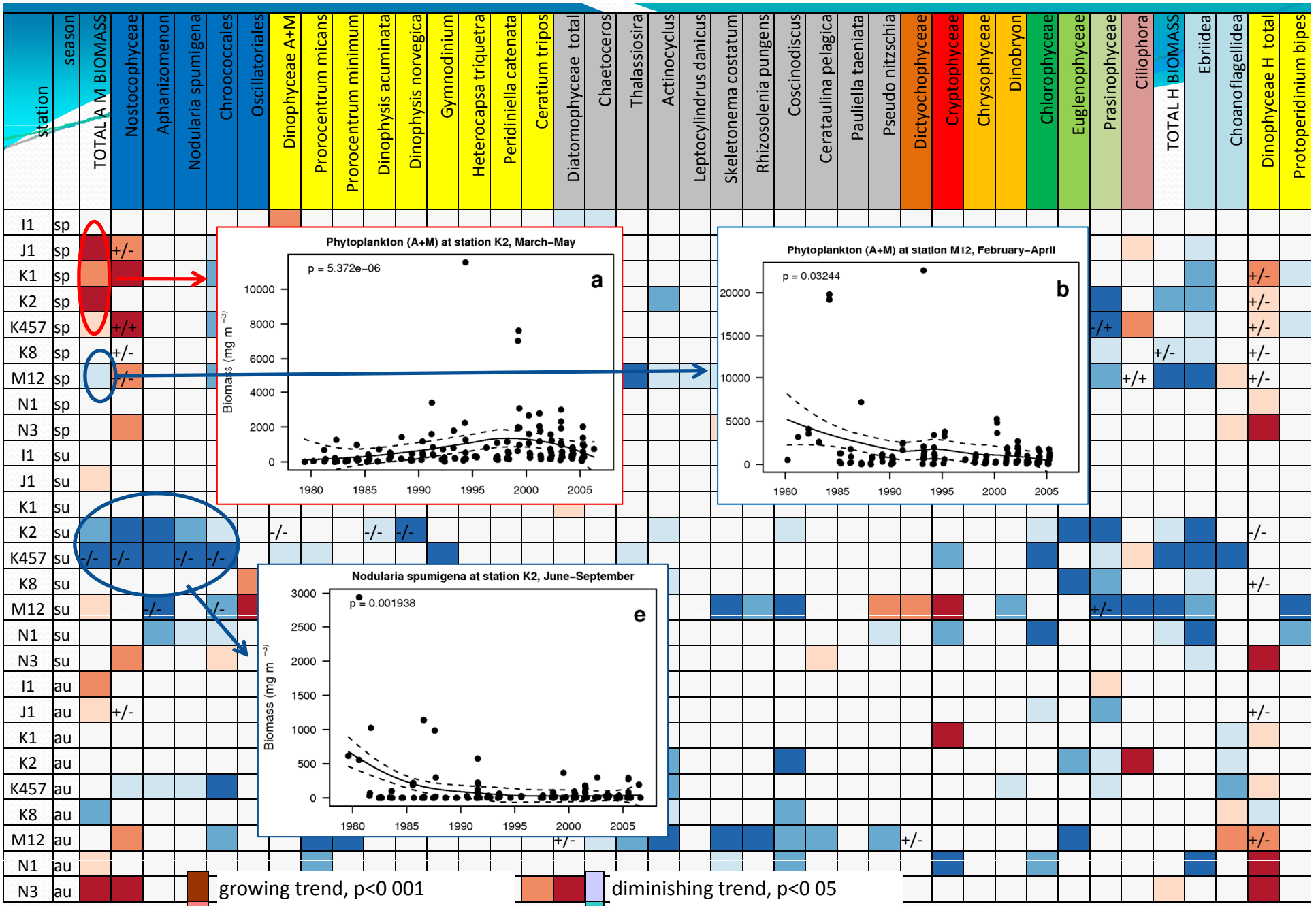
Mann-Kendall test used for detecting monotonous linear trends:
non-parametric, no assumptions on the shape of distribution.

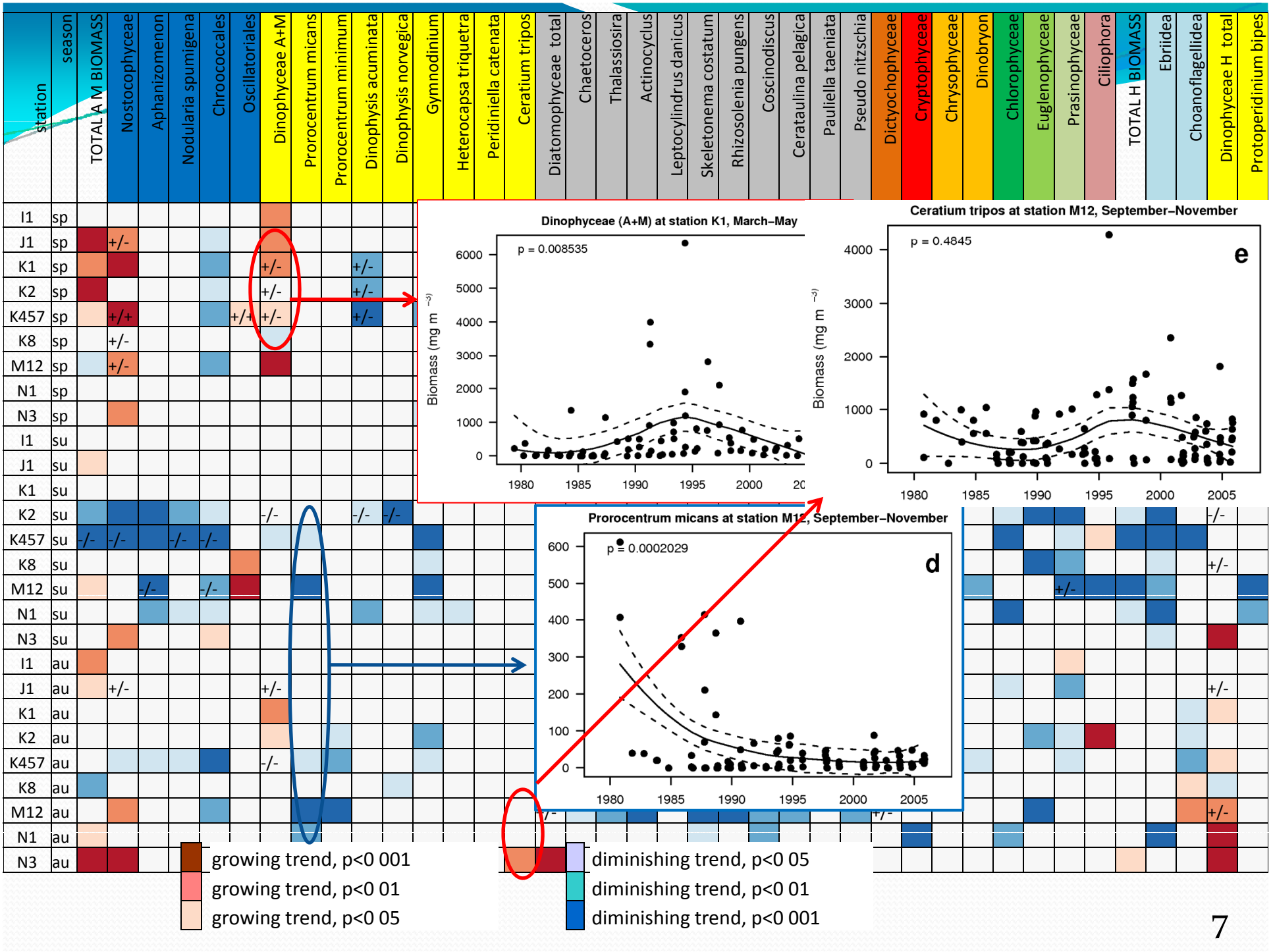


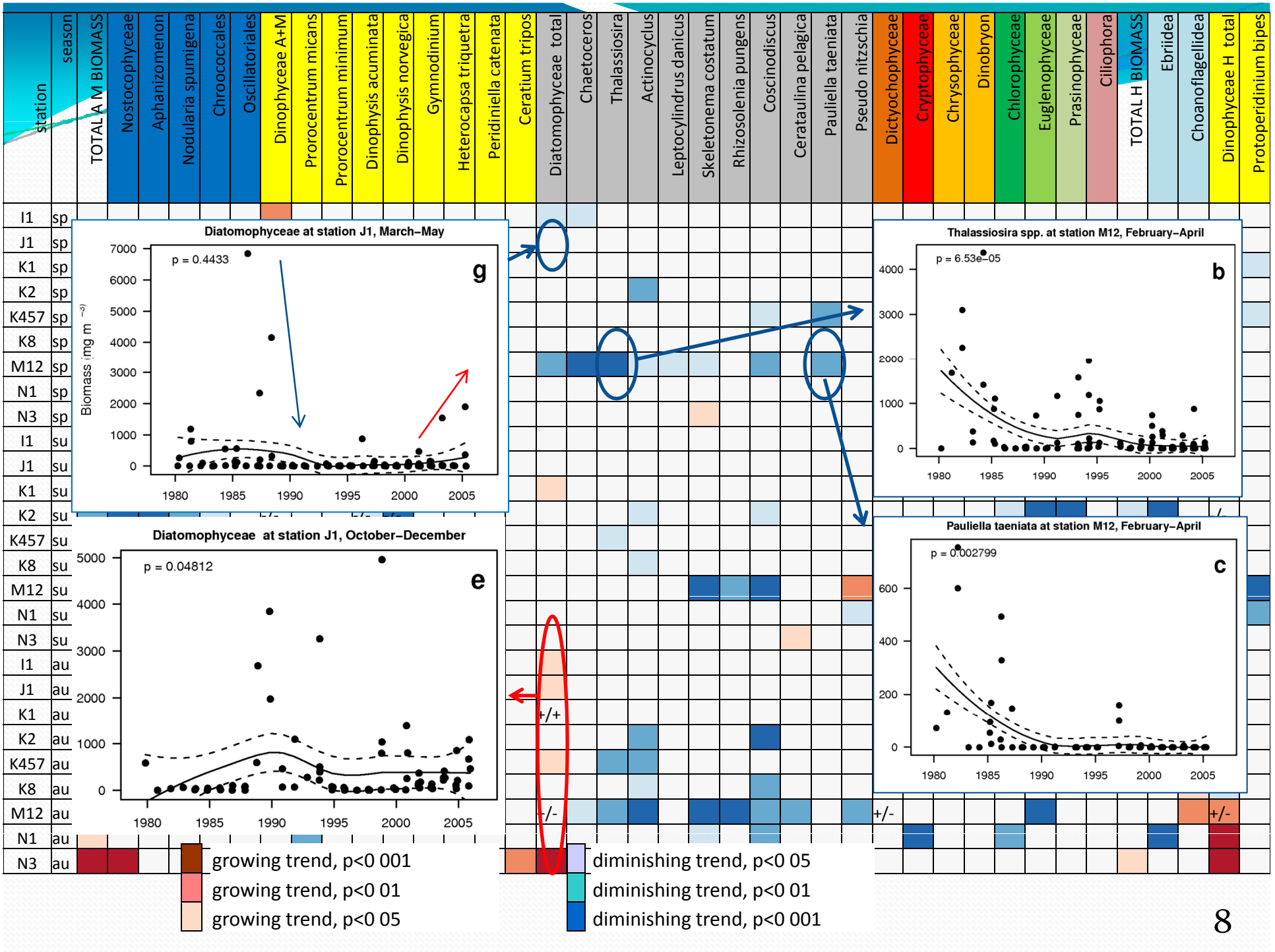
If the phytoplankton biomass showed both growing and decreasing phases:
special trend break analysis:

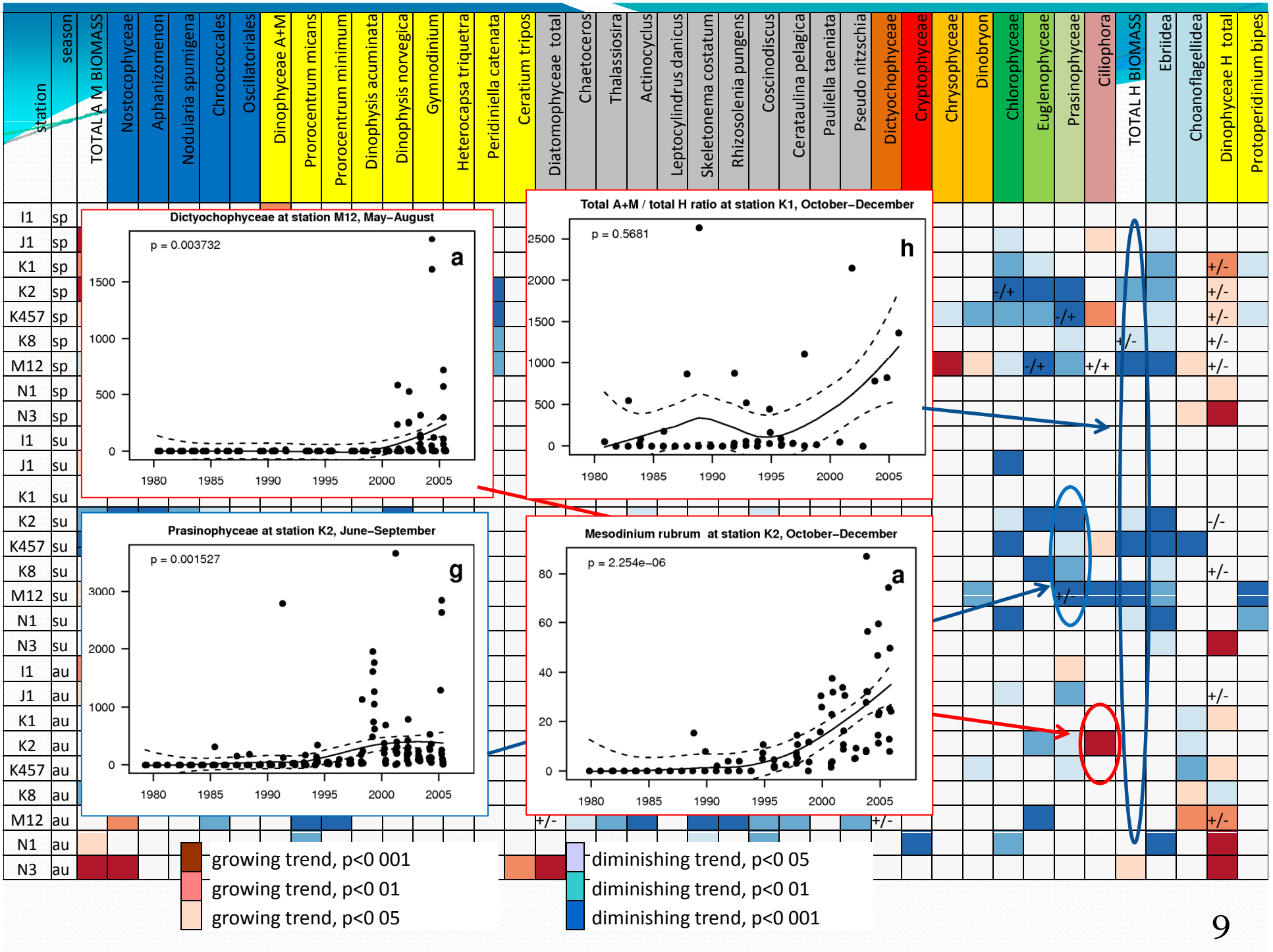
1. detecting the break point (for every taxon/station/season)
2. for further analyses, the breakpoints were averaged on the station/season level
3. testing for a linear trend in the parts before and after the break point




station
season
TOTAL A M BIOMASS
Nostocophyceae
Aphanizomenon
Nodularia spumigena
Chroococcales
Oscillatoriales
Dinophyceae A+M
Prorocentrum micans
Prorocentrum minimum
Dinophysis acuminata
Dinophysis norvegica
Gymnodinium
Heterocapsa triquetra
Peridiniella catenata
Ceratium tripos
Diatomophyceae total
Chaetoceros
Thalassiosira
Actinocyclus
Leptocylindrus danicus
Skeletonema costatum
Rhizosolenia pungens
Coscinodiscus
Cerataulina pelagica
Pauliella taeniata
Pseudo nitzschia
Dictyochophyceae
Cryptophyceae
Chrysophyceae
Dinobryon
Chlorophyceae
Euglenophyceae
Prasinophyceae
Ciliophora
TOTAL H BIOMASS
Ebriidea
Choanoflagellidea
Dinophyceae H total
Protoperidinium bipes
I1 sp
J1 sp +/-
K1 sp
K2 sp
K457 sp +/+
K8 sp +/-
M12 sp +/-
N1 sp
N3 sp
I1 su
J1 su
K1 su
K2 su -/- -/- -/-
K457 su -/- -/- -/- -/-
K8 su
M12 su -/- -/-
N1 su
N3 su
I1 au
J1 au +/-
K1 au
K2 au
K457 au
K8 au
M12 au +/-
N1 au
N3 au
Phytoplankton (A+M) at station K2, March–May
p = 5.372e–06
a
Biomass (mg m⁻³)
Phytoplankton (A+M) at station M12, February–April
p = 0.03244
b
Nodularia spumigena at station K2, June–September
p = 0.001938
e
growing trend, p<0 001
growing trend, p<0 01
growing trend, p<0 05
diminishing trend, p<0 05
diminishing trend, p<0 01
diminishing trend, p<0 001


station
season
TOTAL A M BIOMASS
Nostocophyceae
Aphanizomenon
Nodularia spumigena
Chroococcales
Oscillatoriales
Dinophyceae A+M
Prorocentrum micans
Prorocentrum minimum
Dinophysis acuminata
Dinophysis norvegica
Gymnodinium
Heterocapsa triquetra
Peridiniella catenata
Ceratium tripos
Diatomophyceae total
Chaetoceros
Thalassiosira
Actinocyclus
Leptocylindrus danicus
Skeletonema costatum
Rhizosolenia pungens
Coscinodiscus
Cerataulina pelagica
Pauliella taeniata
Pseudo nitzschia
Dictyochophyceae
Cryptophyceae
Chrysophyceae
Dinobryon
Chlorophyceae
Euglenophyceae
Prasinophyceae
Ciliophora
TOTAL H BIOMASS
Ebriidea
Choanoflagellidea
Dinophyceae H total
Protoperidinium bipes
I1 sp
J1 sp
K1 sp
K2 sp
K457 sp
K8 sp
M12 sp
N1 sp
N3 sp
I1 su
J1 su
K1 su
K2 su
K457 su
K8 su
M12 su
N1 su
N3 su
I1 au
J1 au
K1 au
K2 au
K457 au
K8 au
M12 au
N1 au
N3 au
Dinophyceae (A+M) at station K1, March–May
p = 0.008535
Biomass (mg m⁻³)
Ceratium tripos at station M12, September–November
p = 0.4845
e
Prorocentrum micans at station M12, September–November
p = 0.0002029
d
growing trend, p<0 001
growing trend, p<0 01
growing trend, p<0 05
diminishing trend, p<0 05
diminishing trend, p<0 01
diminishing trend, p<0 001


station
season
TOTAL A M BIOMASS
Nostocophyceae
Aphanizomenon
Nodularia spumigena
Chroococcales
Oscillatoriales
Dinophyceae A+M
Prorocentrum micans
Prorocentrum minimum
Dinophysis acuminata
Dinophysis norvegica
Gymnodinium
Heterocapsa triquetra
Peridiniella catenata
Ceratium tripos
Diatomophyceae total
Chaetoceros
Thalassiosira
Actinocyclus
Leptocylindrus danicus
Skeletonema costatum
Rhizosolenia pungens
Coscinodiscus
Cerataulina pelagica
Pauliella taeniata
Pseudo nitzschia
Dictyochophyceae
Cryptophyceae
Chrysophyceae
Dinobryon
Chlorophyceae
Euglenophyceae
Prasinophyceae
Ciliophora
TOTAL H BIOMASS
Ebriidea
Choanoflagellidea
Dinophyceae H total
Protoperidinium bipes
I1 sp
J1 sp
K1 sp
K2 sp
K457 sp
K8 sp
M12 sp
N1 sp
N3 sp
I1 su
J1 su
K1 su
K2 su
K457 su
K8 su
M12 su
N1 su
N3 su
I1 au
J1 au
K1 au
K2 au
K457 au
K8 au
M12 au
N1 au
N3 au
Diatomophyceae at station J1, March–May
p = 0.4433
g
Biomass (mg m⁻³)
Thalassiosira spp. at station M12, February–April
p = 6.53e−05
b
Diatomophyceae at station J1, October–December
p = 0.04812
e
Pauliella taeniata at station M12, February–April
p = 0.002799
c
+/+
+/-
growing trend, p<0 001
growing trend, p<0 01
growing trend, p<0 05
diminishing trend, p<0 05
diminishing trend, p<0 01
diminishing trend, p<0 001


station
season
TOTAL A M BIOMASS
Nostocophyceae
Aphanizomenon
Nodularia spumigena
Chroococcales
Oscillatoriales
Dinophyceae A+M
Prorocentrum micans
Prorocentrum minimum
Dinophysis acuminata
Dinophysis norvegica
Gymnodinium
Heterocapsa triquetra
Peridiniella catenata
Ceratium tripos
Diatomophyceae total
Chaetoceros
Thalassiosira
Actinocyclus
Leptocylindrus danicus
Skeletonema costatum
Rhizosolenia pungens
Coscinodiscus
Cerataulina pelagica
Pauliella taeniata
Pseudo nitzschia
Dictyochophyceae
Cryptophyceae
Chrysophyceae
Dinobryon
Chlorophyceae
Euglenophyceae
Prasinophyceae
Ciliophora
TOTAL H BIOMASS
Ebriidea
Choanoflagellidea
Dinophyceae H total
Protoperidinium bipes
I1 sp
J1 sp
K1 sp
K2 sp
K457 sp
K8 sp
M12 sp
N1 sp
N3 sp
I1 su
J1 su
K1 su
K2 su
K457 su
K8 su
M12 su
N1 su
N3 su
I1 au
J1 au
K1 au
K2 au
K457 au
K8 au
M12 au
N1 au
N3 au
Dictyochophyceae at station M12, May–August
p = 0.003732
a
Total A+M / total H ratio at station K1, October–December
p = 0.5681
h
Prasinophyceae at station K2, June–September
p = 0.001527
g
Mesodinium rubrum at station K2, October–December
p = 2.254e–06
a
growing trend, p<0 001
growing trend, p<0 01
growing trend, p<0 05
diminishing trend, p<0 05
diminishing trend, p<0 01
diminishing trend, p<0 001

Conclusions:

- Phytoplankton reveals trends in total biomass and the biomass of different important taxa.
- Analyses for linear trends are useful tools if changes in phytoplankton occur more or less continuosly, e.g. due to eutrophication which is the main threat in the Baltic.
- However, non-monotonous trends occur which might require other statistical methods.
- The linear trend analyses do not detect sudden jumps in the ecosystem (regime shifts)
- Data basis has to be improved (better coverage of blooms, quality assurance, data validation).