Environmental Geochemistry K2010 Workshops

Monitoring the wellbeing of Lake Kinneret (Sea of Galilee), Israel

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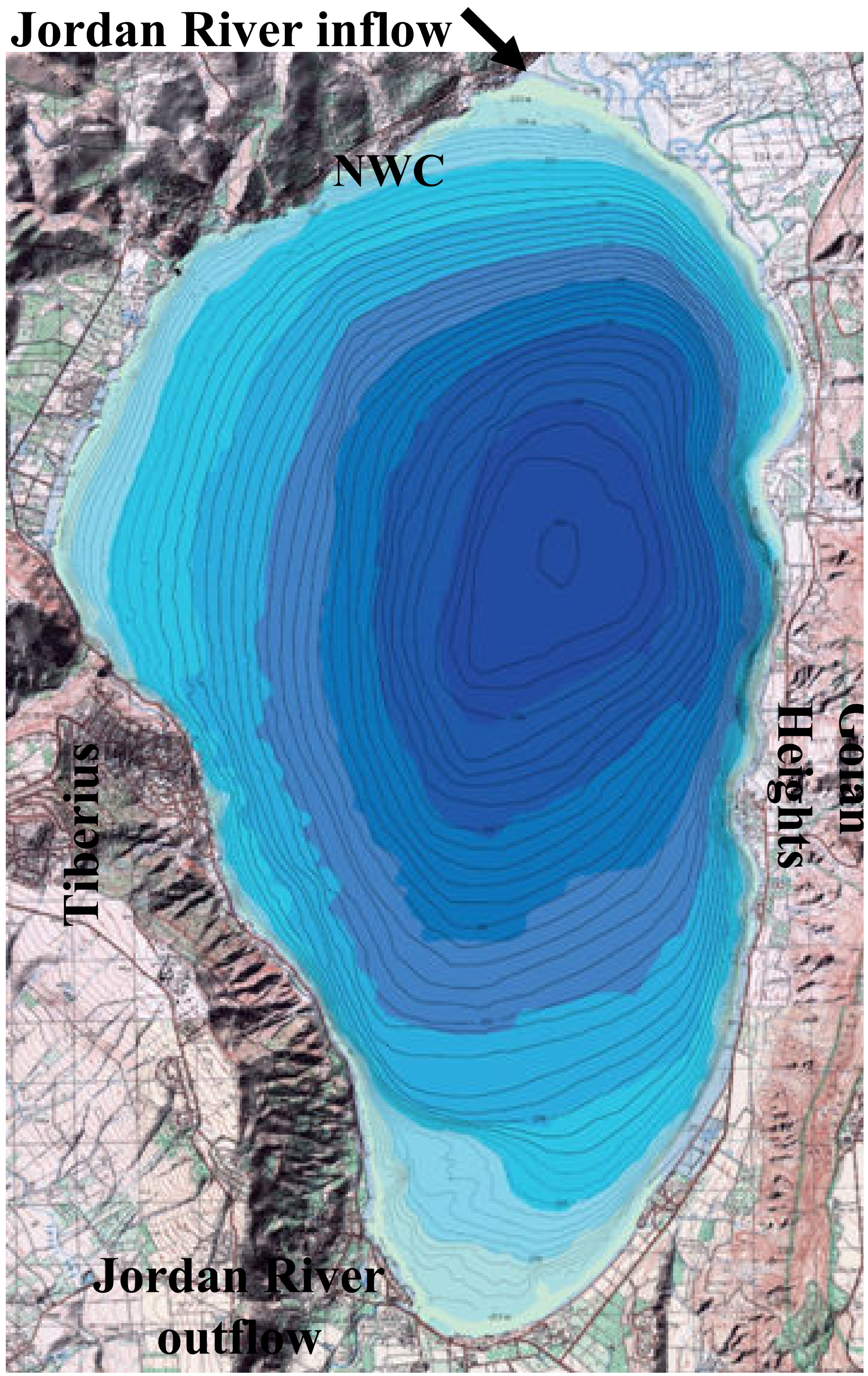
Lake Kinneret (Sea of Galilee) - physical features

Physical

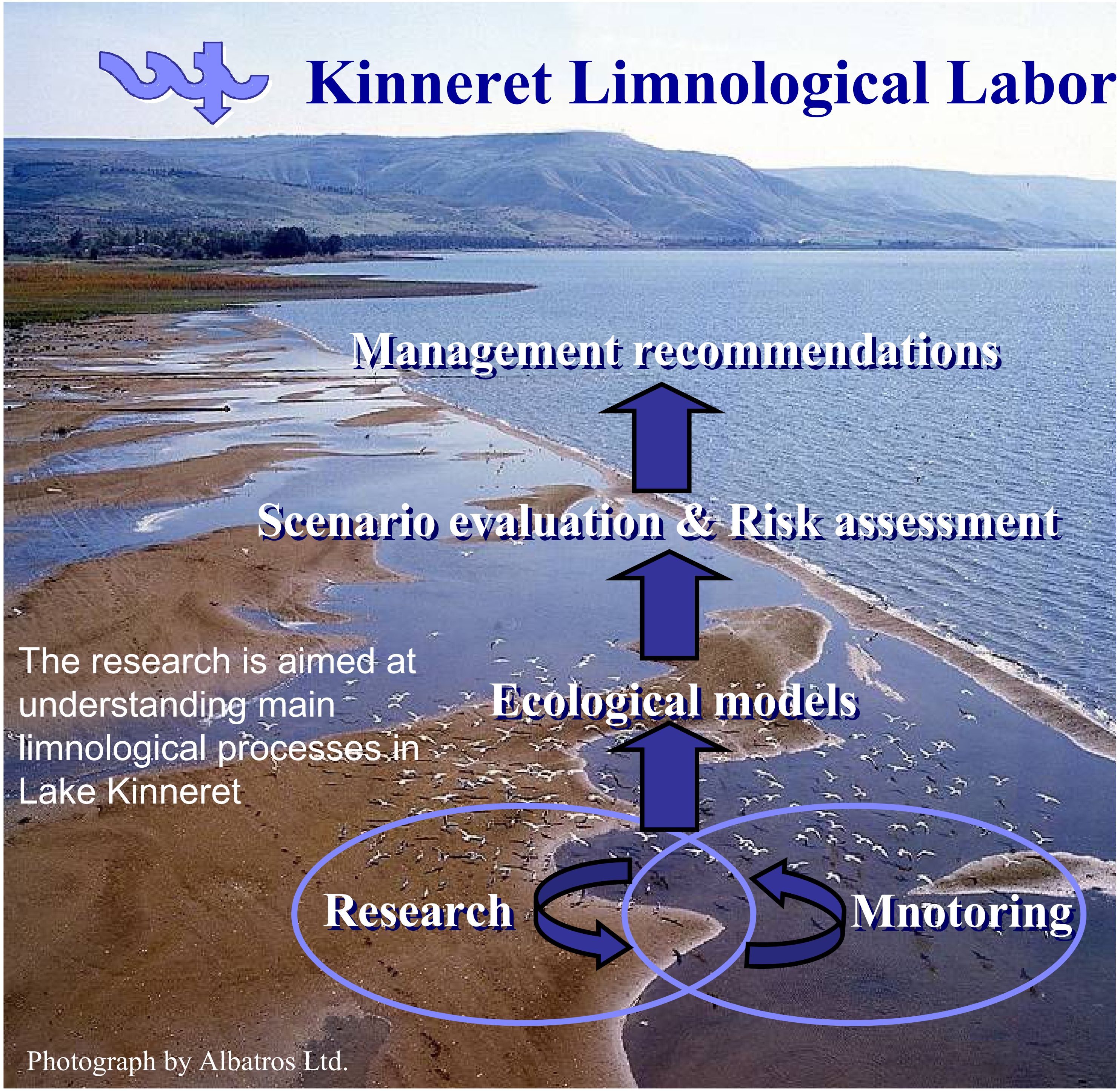
• Total area (at -209m)	168.7 km^2
• Circumference	56 km
• Length	21 km
• Depth	25 m (42 max)
• Volume	4.3 10^9 m^3
• Elevation	-211 ± 2 m ASL
• Annual water inflow	400 - 600 10^6 m^3
• Annual water outflow	300 - 500 10^6 m^3
• Water retention time	8 yrs
• water sources	Jordan 66% Other 34%

Morphological

- Area to Circumference ratio - Low
- Drainage basin to lake volume - Low (0.6)



Kinneret Limnological Laboratory



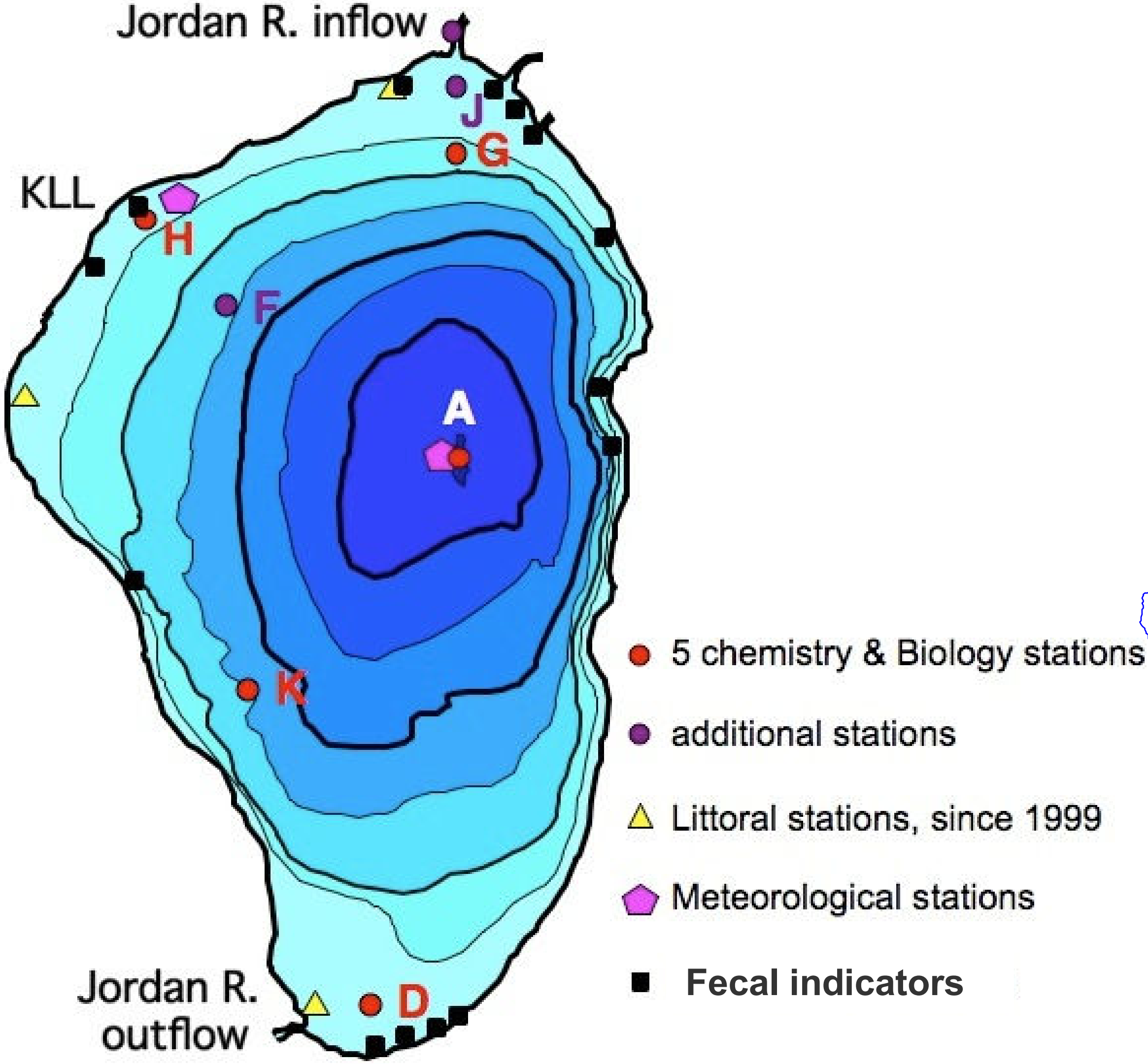
Inter-disciplinary monitoring program provides a close surveillance after changes in the lake ecosystem

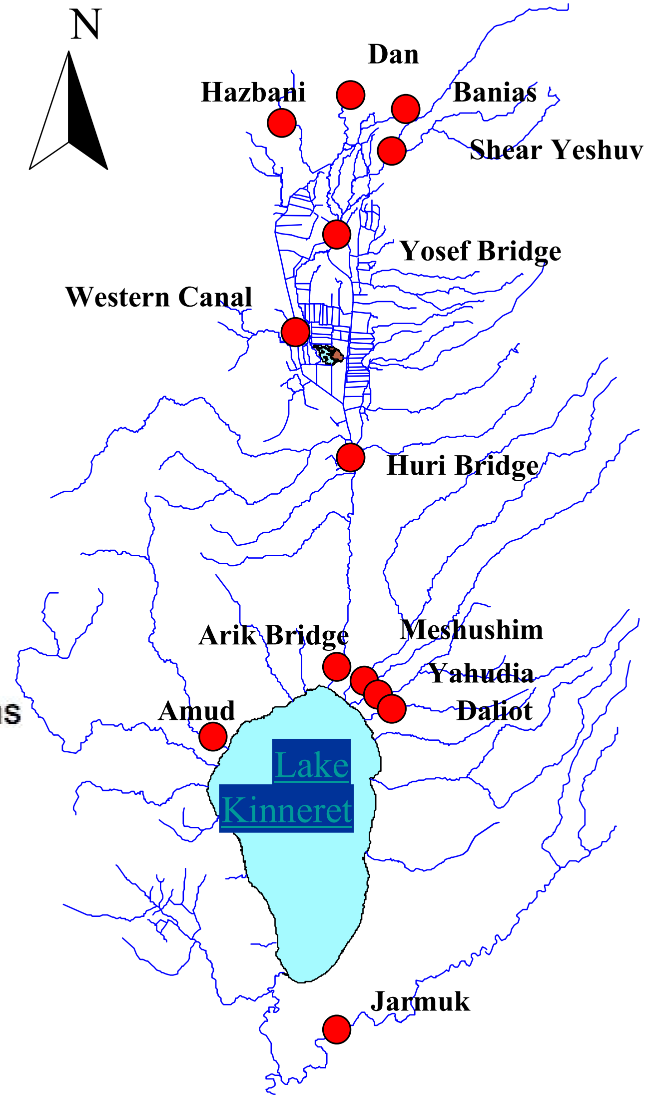
Lake Kinneret monitoring program

Monitoring goals

- Collection of limnological data
- Establishment and maintenance of multi-annual data base
- Identification quantification and elucidation of limnological processes and their effect on water quality
- Awareness and alerts of water authorities on short and long term changes in water quality
- Analysis of long term records to support scientifically based management decisions
- Periodic report on Lake Kinneret conditions

Monitoring station in Lake Kinneret and its Catchment Basin



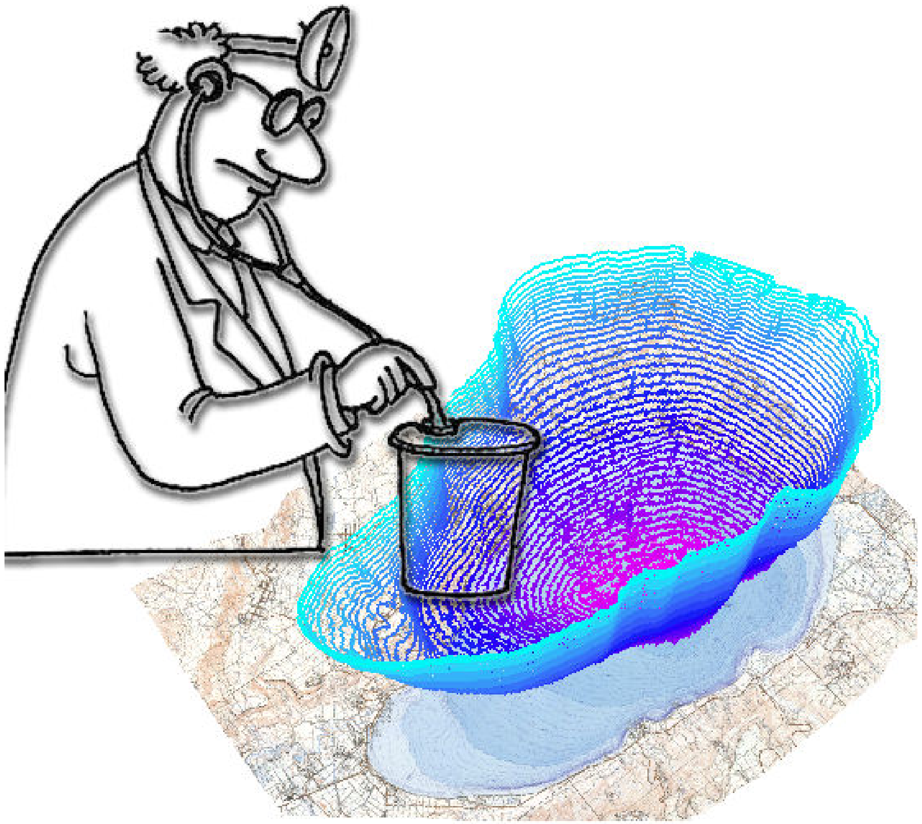


Lake Kinneret monitoring 1969- present

Parameters

- Meteorological
- Physical
- Chemical (concentration & rates)
- Biological (concentration & rates)
- Sanitation
- Continuous, real time measurements

Periodic / Monthly / weekly / daily **check up**



Blood Chemistry

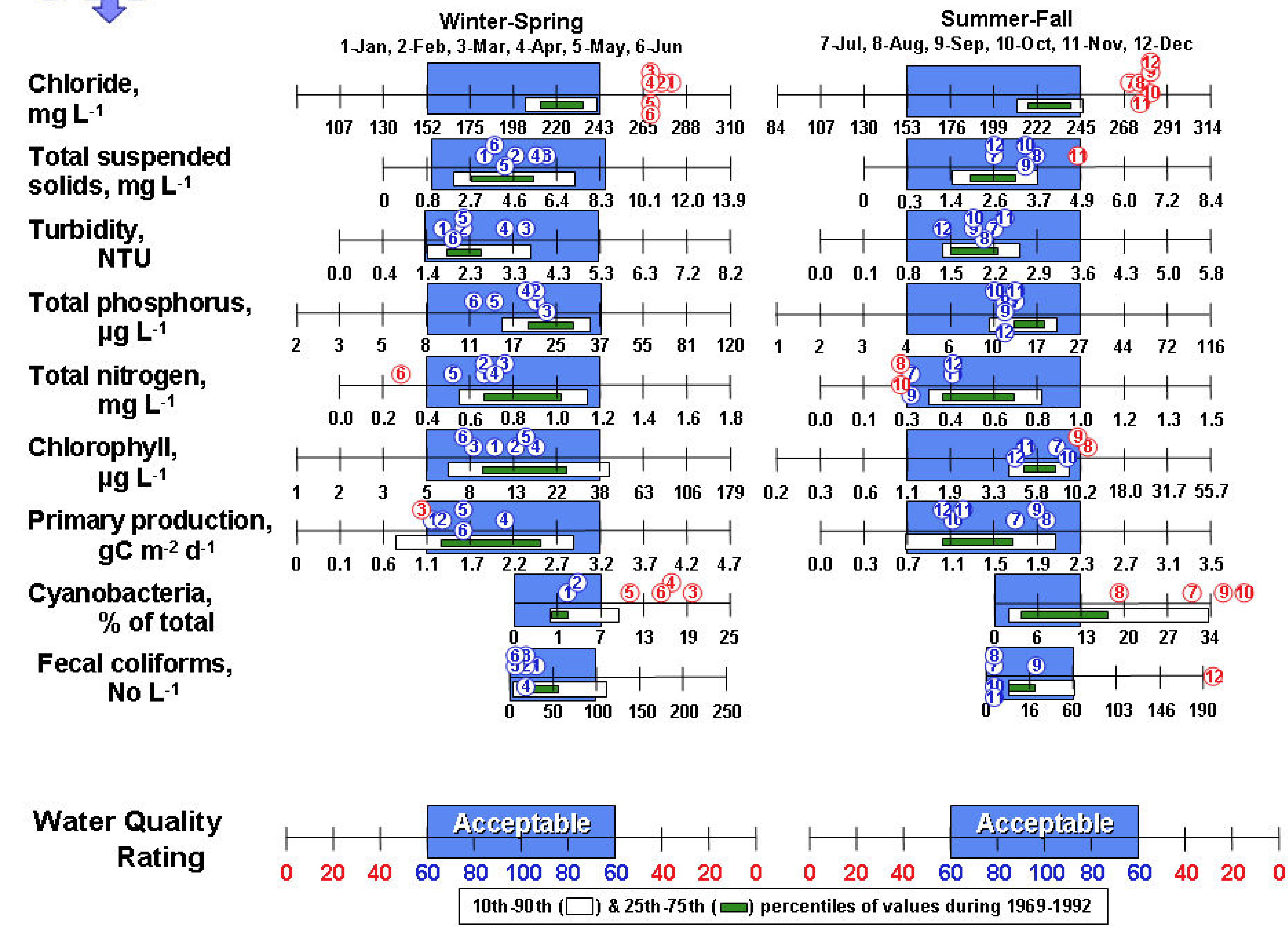
Specimen Draw Date: 5/15/2008
Practitioner: John Smith

The % Status is the weighted deviation of the laboratory result relative to the range.

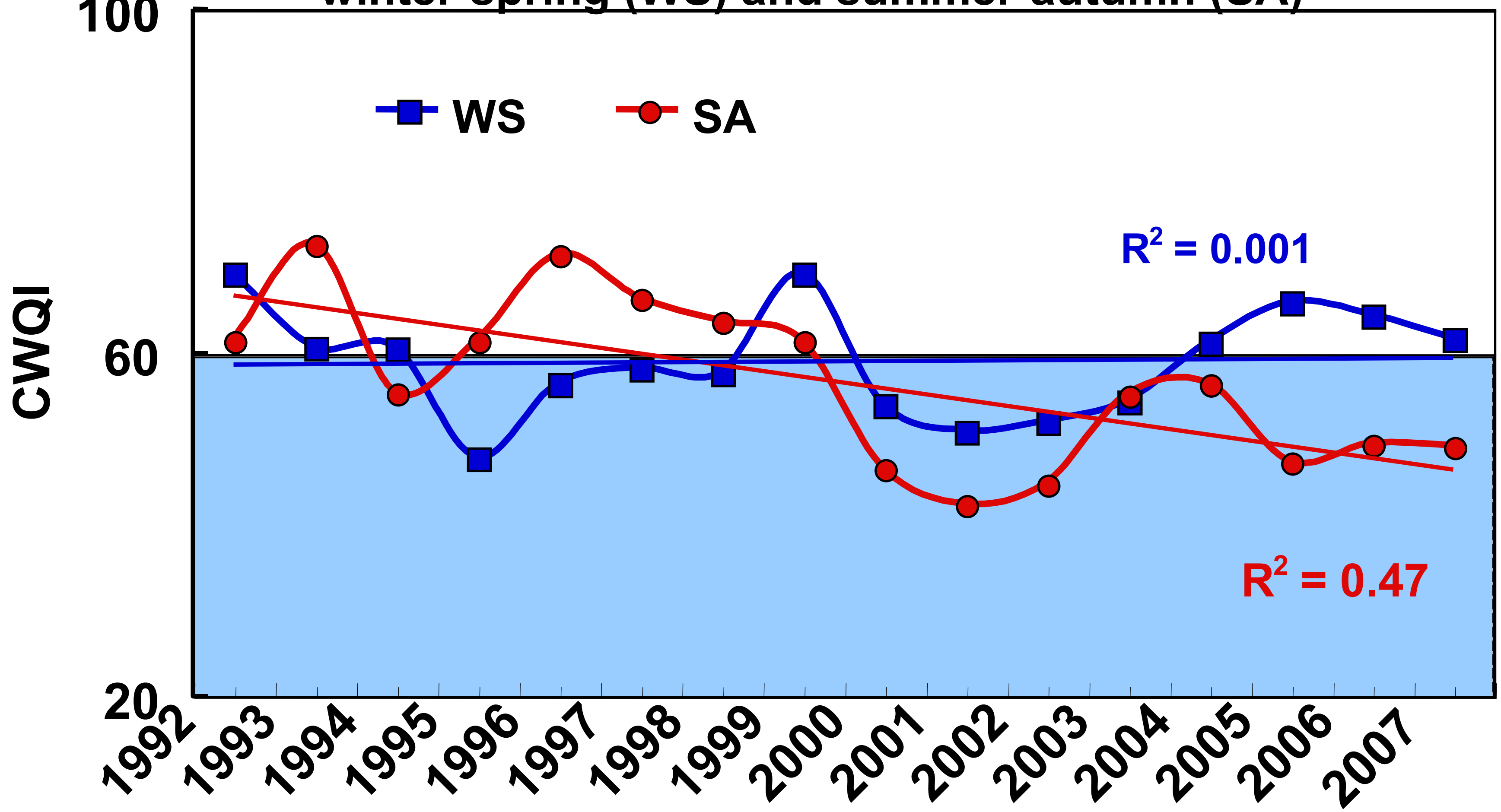
Name of Test	% Status		Result	Low	High
A/G Ratio	**-34.82**	L	1.31	1.10	2.50
Albumin	-15.00		4.20	3.50	5.50
Alkaline Phosphatase	**-25.20**	L	56.00	25.00	150.00
Basophil Count	**-50.00**	L	0.00	0.00	200.00
Bilirubin Total	-13.64		0.50	0.10	1.20
Blood Urea Nitrogen (BUN)	-23.68		13.00	8.00	27.00
BUN/Creatinine Ratio	-16.08		14.44	8.00	27.00
Calcium	7.14		9.70	8.50	10.60
Chloride	22.73		105.00	97.00	108.00
Cholesterol	**-37.78**	L	156.00	145.00	235.00
Creatinine	-10.00		0.90	0.50	1.50
Eosinophil Count	**-27.00**	L	165.00	50.00	550.00
Globulin	6.67		3.20	1.50	4.50
Hematocrit (Hct)	-7.14		42.00	36.00	50.00
Hemoglobin (Hgb)	-3.33		14.60	12.50	17.00
High Density Lipids (HDL)	**-52.22**	L	34.00	35.00	80.00
Low Density Lipids (LDL)	23.53		112.00	62.00	130.00
Lymphocyte Count	**-28.75**	L	1650.0	800.00	4800.0
Mean Cell Hemoglobin (MCH)	17.14		31.70	27.00	34.00
Mean Corpuscular Hemoglobin (MCHC)	20.00		34.80	32.00	36.00
Mean Corpuscular Volume (MCV)	11.11		91.00	80.00	98.00
Monocyte Count	-23.33		440.00	200.00	1100.0
Neutrophil Count	**-26.69**	L	3245.0	1800.0	8000.0
Platelets	-22.00		217.00	140.00	415.00
Potassium	20.59		4.70	3.50	5.20
Protein Total	6.00		7.40	6.00	8.50
RDW	-7.58		13.10	11.70	15.00
Red Blood Cell Count	-16.00		4.61	4.10	5.60
SGOT (AST) Aspartate aminotransferase	0.00		20.00	0.00	40.00
SGPT (ALT) Alanine aminotransferase	-15.45		19.00	0.00	55.00
Sodium	**40.00**	H	144.00	135.00	145.00
Sodium Potassium Ratio	-11.35		30.64	26.00	38.00
Triglycerides	**-51.00**	L	49.00	50.00	150.00
White Blood Cell Count	**-26.92**	L	5.50	4.00	10.50

Your BodyBio Blood Chemistry Report: The data you entered (the Results, Low and High) is on the last three columns. The bar graphs on the left show how your results differ from what is considered "optimal" which is represented by the "0" line. Your lower results are to the left of "0", the higher results are to the right. The length of the bar represents how low or how high your results are, how far they are from the midpoint (the "O" line). The percentage of that difference also appears in the "% Status" column. The column right after "% Status" indicates if your results are high by a red "H", low by a red "L", or within a normal range by a green "Box".

Water Quality in Lake Kinneret: 2009



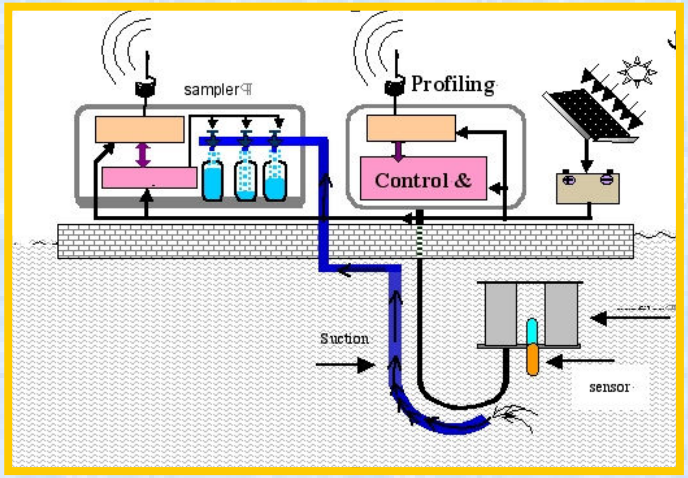
CWQI[100] 1992-2007, semiannual: winter-spring (WS) and summer-autumn (SA)

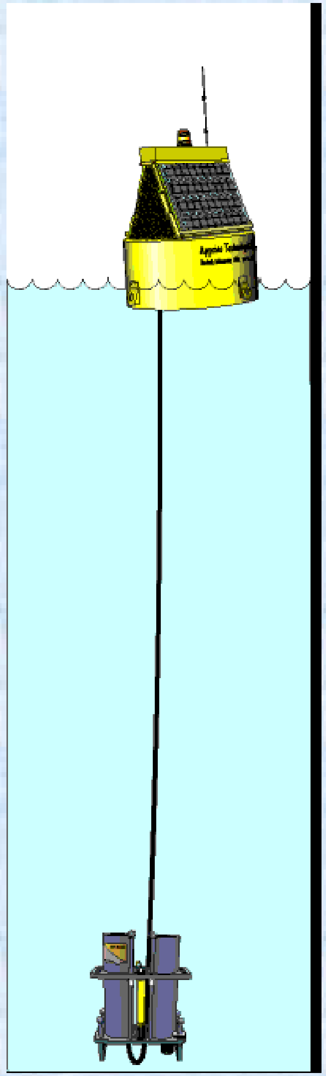



Ecoraft
Monitoring and research
in-lake platform
4 profiles/day:
•Temperature
•Conductivity
•pH
•Dissolved oxygen
•Chlorophyll
•Turbidity

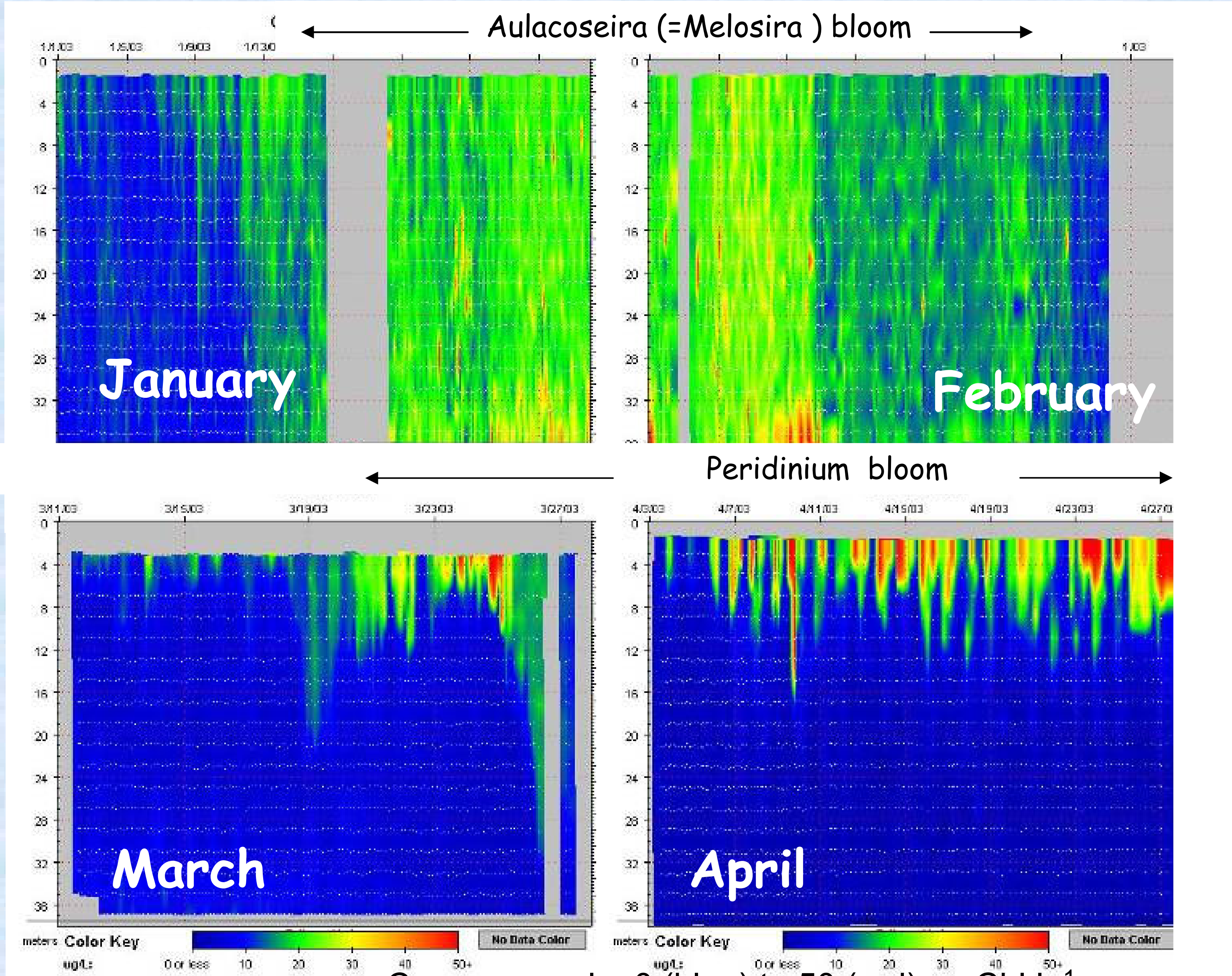
•Met station
•Dust samplers
•Current meter

Lake Kinneret Ecoraft - Real-time on line monitoring platform





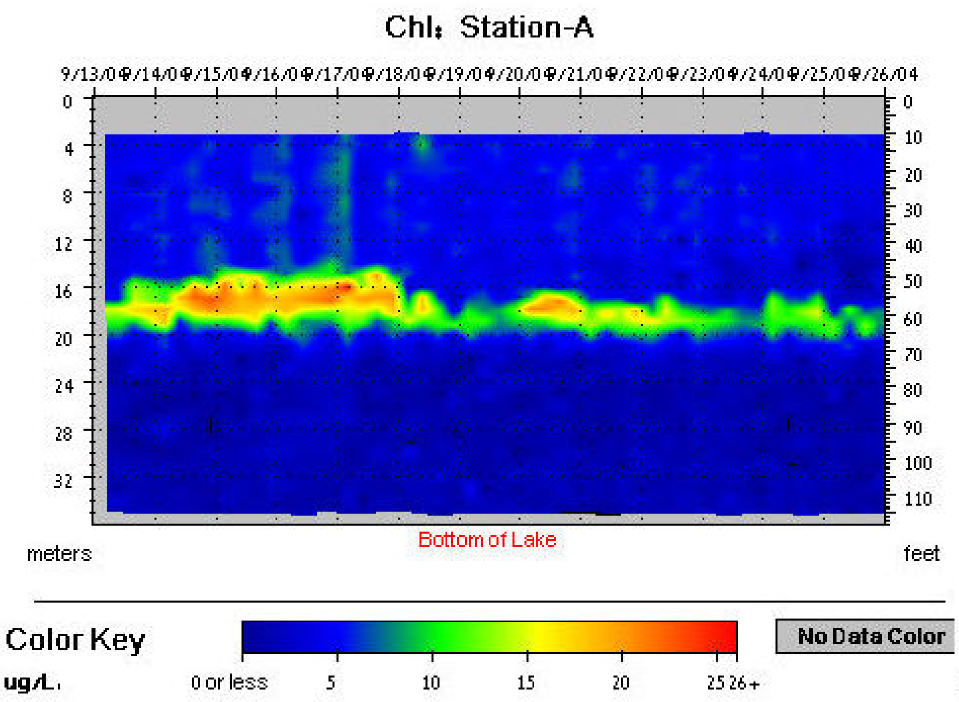
Phytoplankton bloom dynamics, Jan-Apr 2003

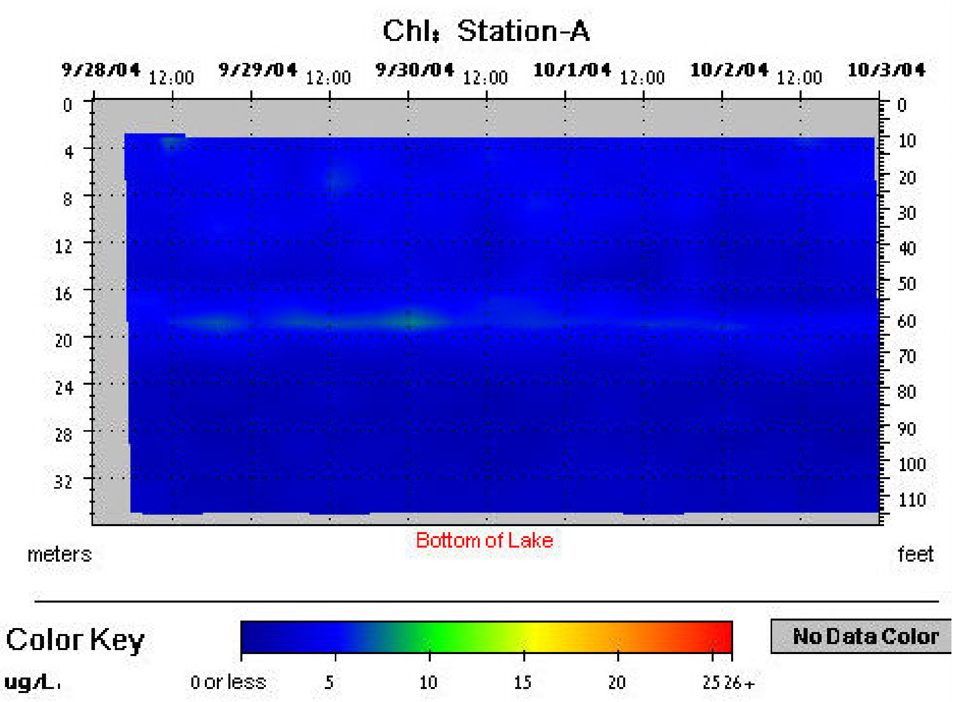


Common scale: 0 (blue) to 50 (red) ug Chl L^{-1}

Source: T. Zohary

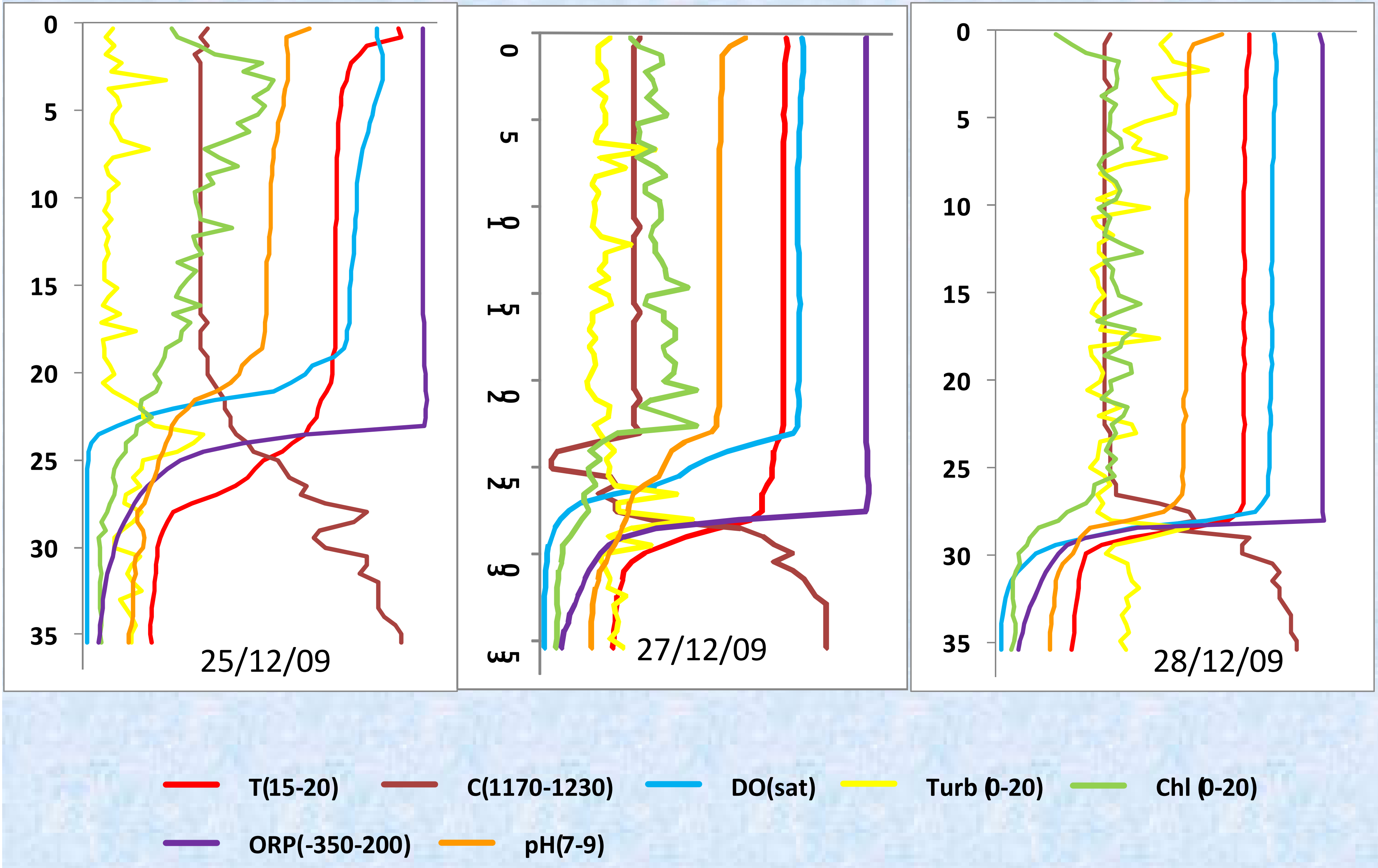
Fluorescence signal of photosynthetic bacteria in the metalimnion - Sep 2004

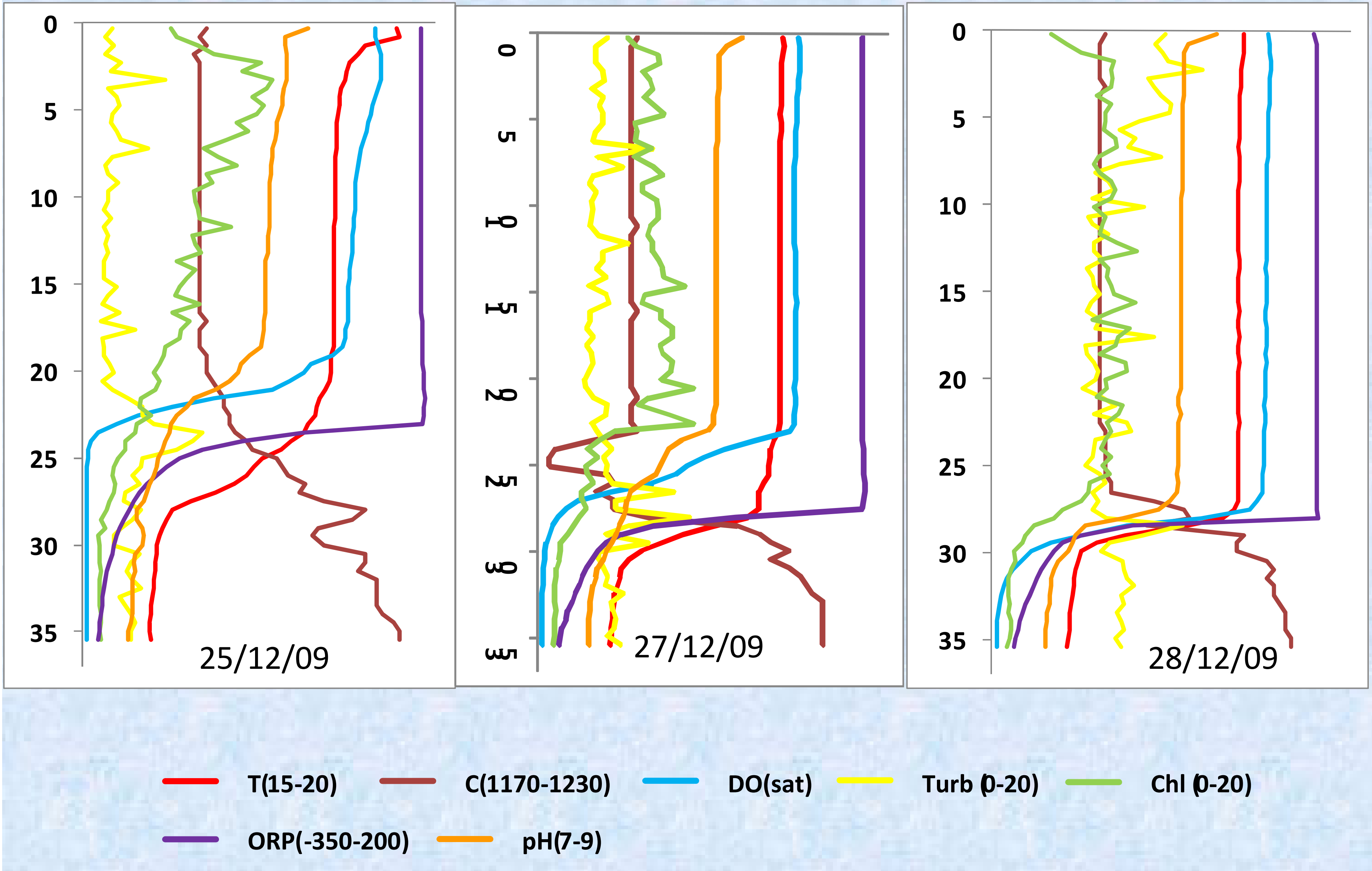




AutoReel - The new generation

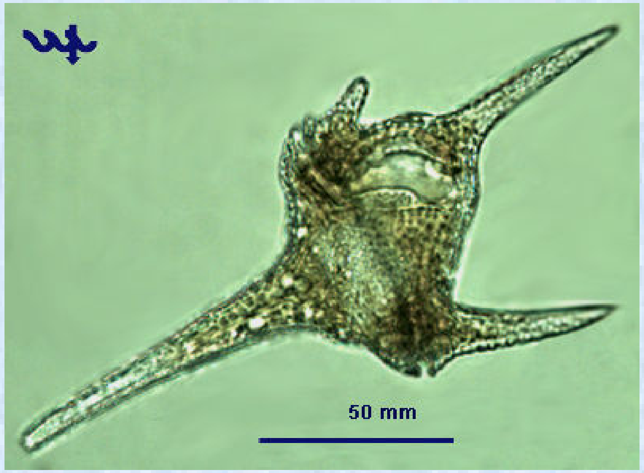
AutoReel profiles - December 2009

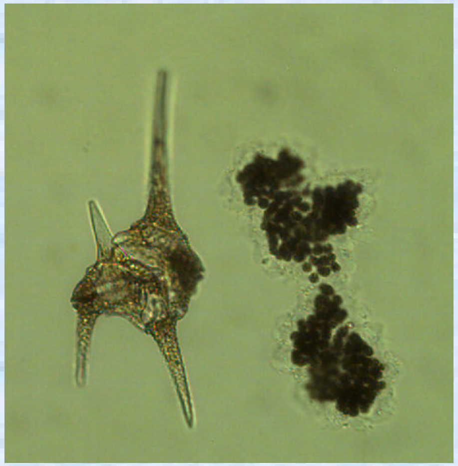


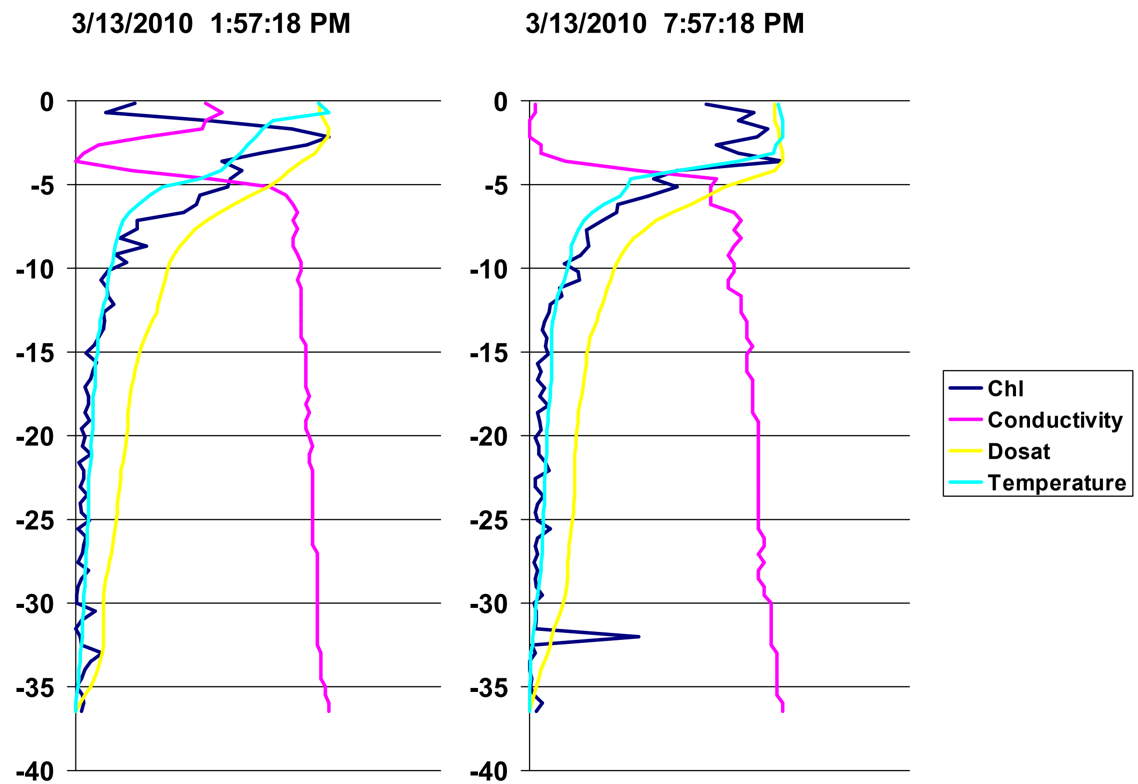


Data: W. Eckert , KLL

March 2010, dominant population of *Ceratium hirundinella*







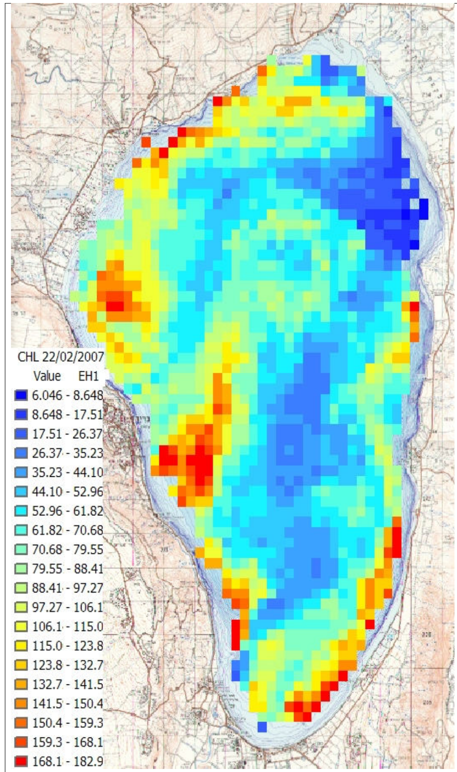
parameter	min	max
Chl	2.91	27.11
Conductivity	1106	1170
Dosat	21.7	192
Temperature	16.23	21.73

parameter	min	max
Chl	2.87	30.4
Conductivity	1128	1170
Dosat	17.4	204.9
Temperature	16.24	20.94

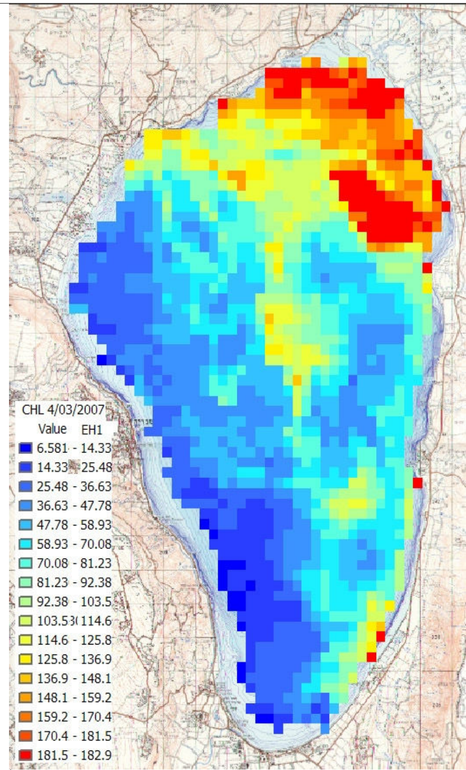
Data: W. Eckert , KLL

Lateral distribution of *Peridinium* (dinoflagellate) in Lake Kinneret

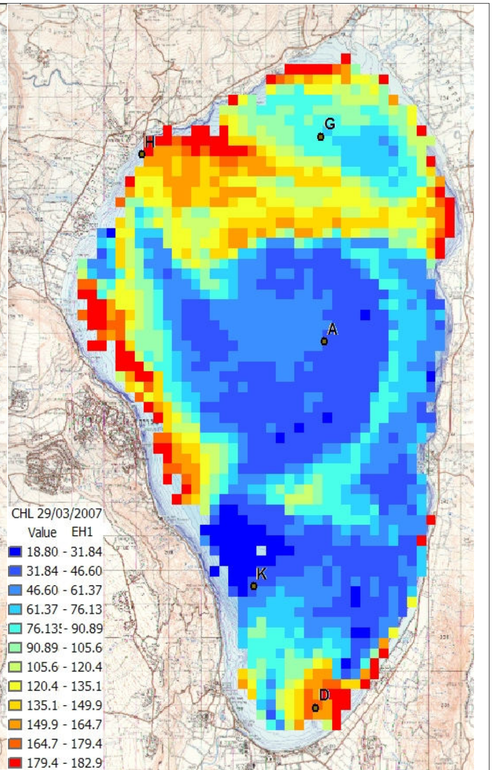
Chlorophyll distribution in winter spring 2007 calculated from spectral images collected by MERIS satellite and processed by SISCAL system.



February 4, 2007



March 4, 2007

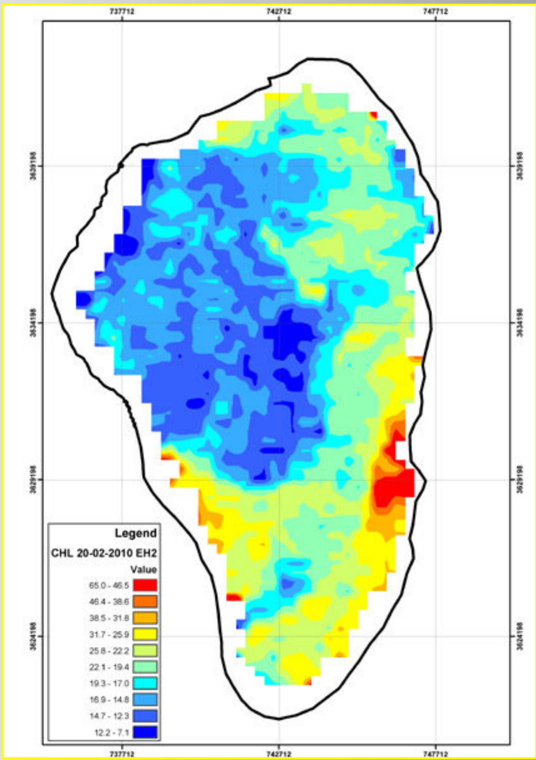


March 29, 2007

(Source: Dr. G. Tibor)

The vision – automated un-manned monitoring aircraft

Develop real time monitoring capabilities based on automated un-manned aircraft (AUA) and spectral data analysis assisted by SISCAL technology.

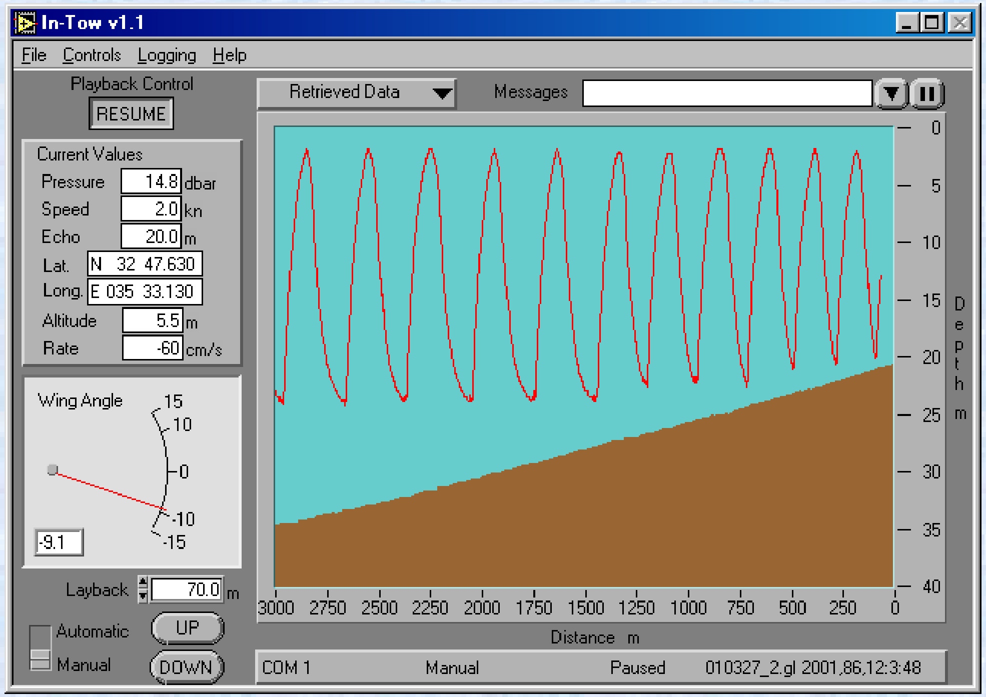


Chlorophyll concentration Feb 20, 2010

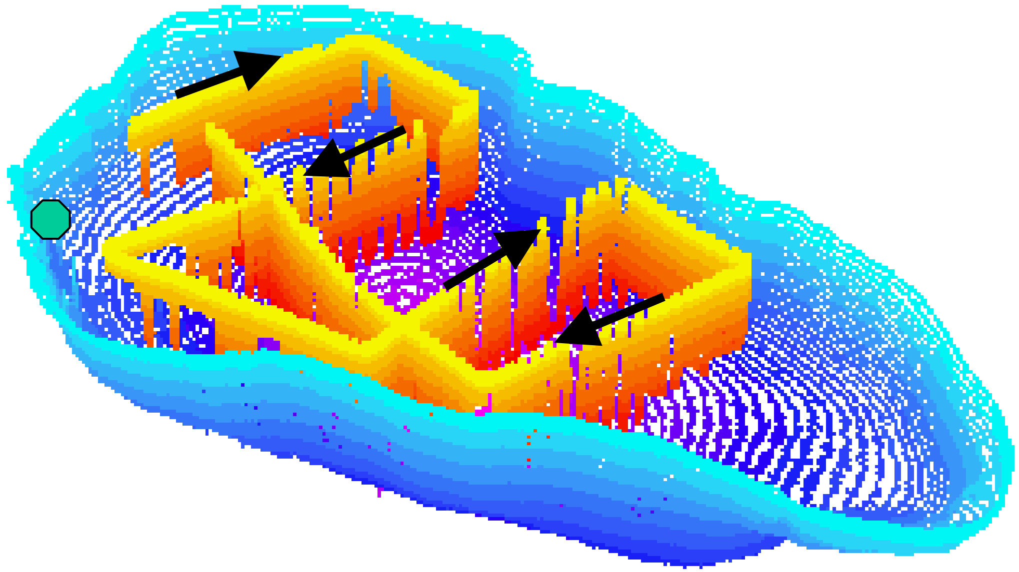
Micocystis bloom, Feb 2, 2010 western shoreline of Lake Kinneret (Photo: Idan Shaked)

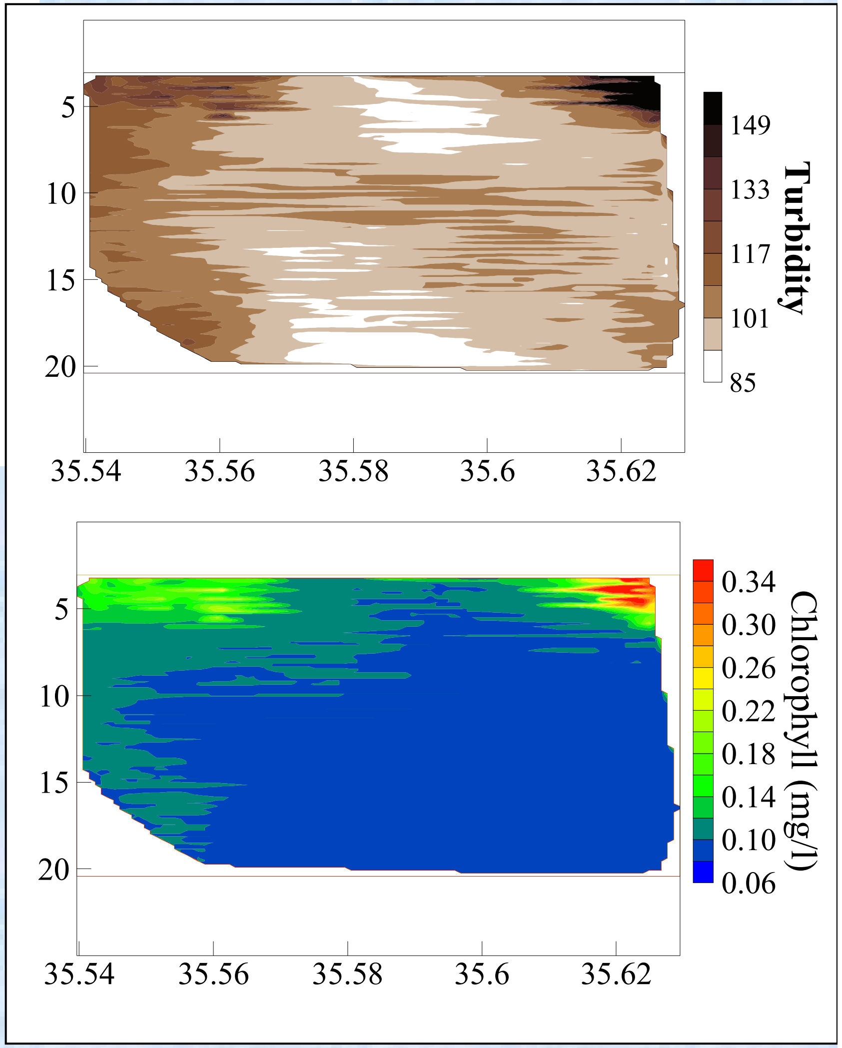
Tibor 2010

Underwater, Towed Undulating Monitoring System (U-TUMS)

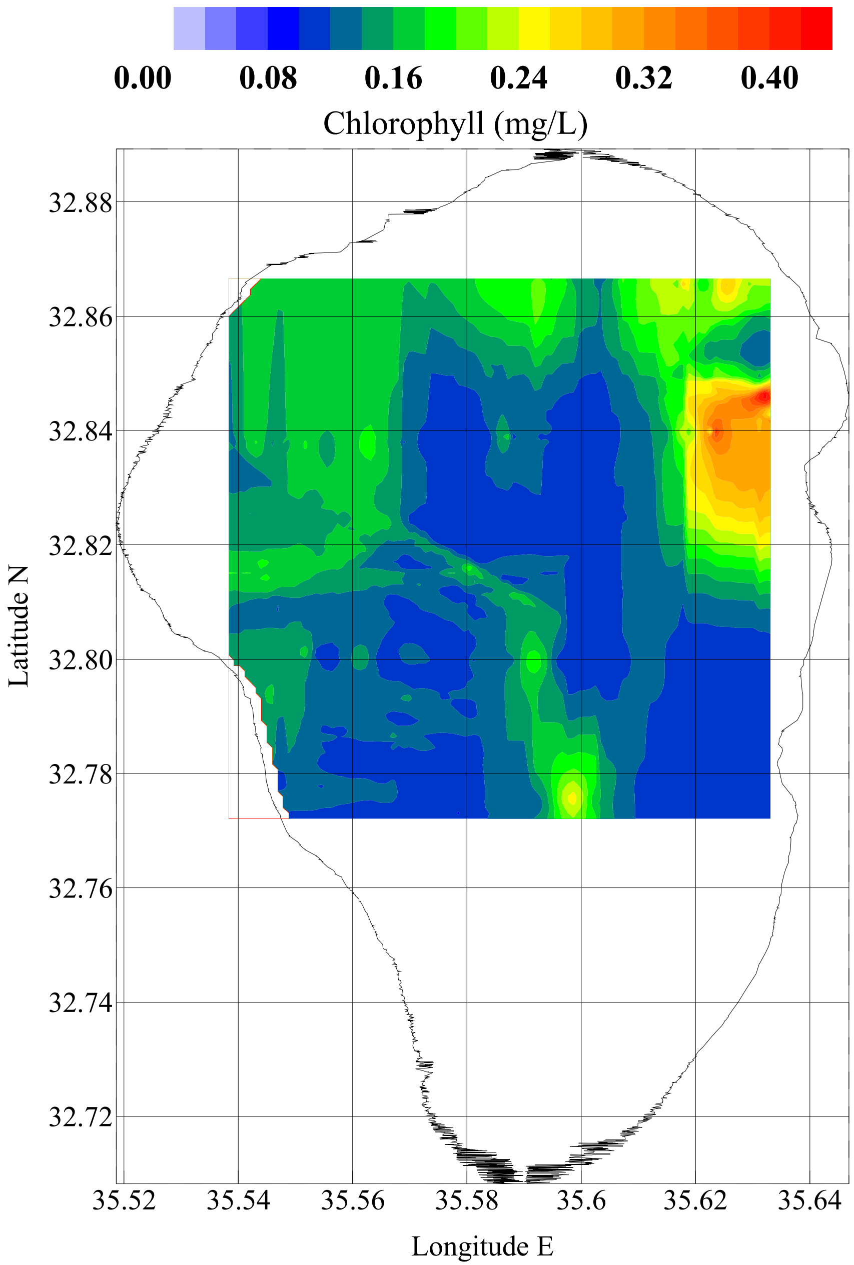


Underwater, Towed Undulating Monitoring System (U-TUMS) - April 2003

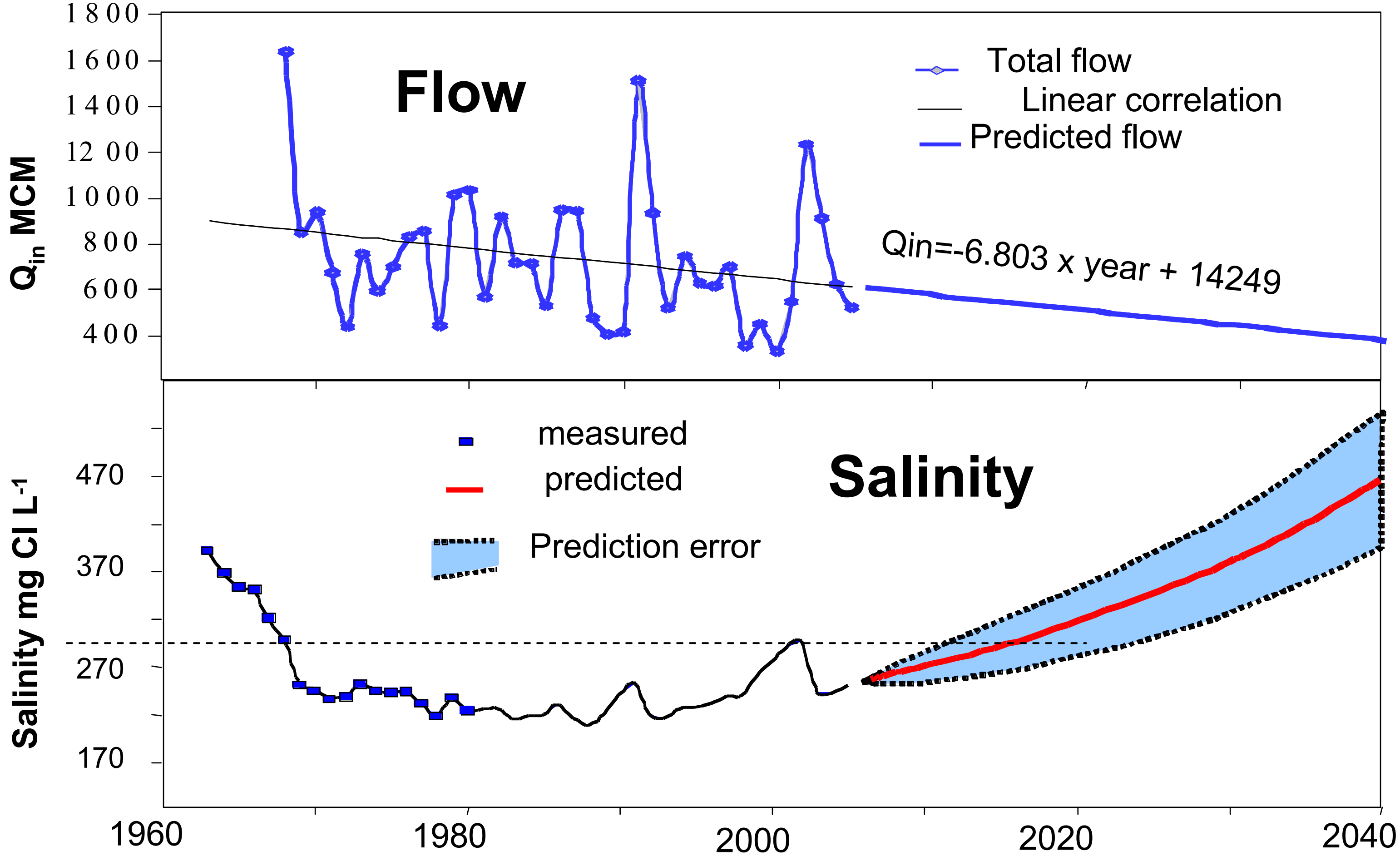




Underwater, Towed Undulating Monitoring System (U-TUMS) - April 2003
Chlorophyll distribution at a 4 m depth layer



Changes in ecological driving forces



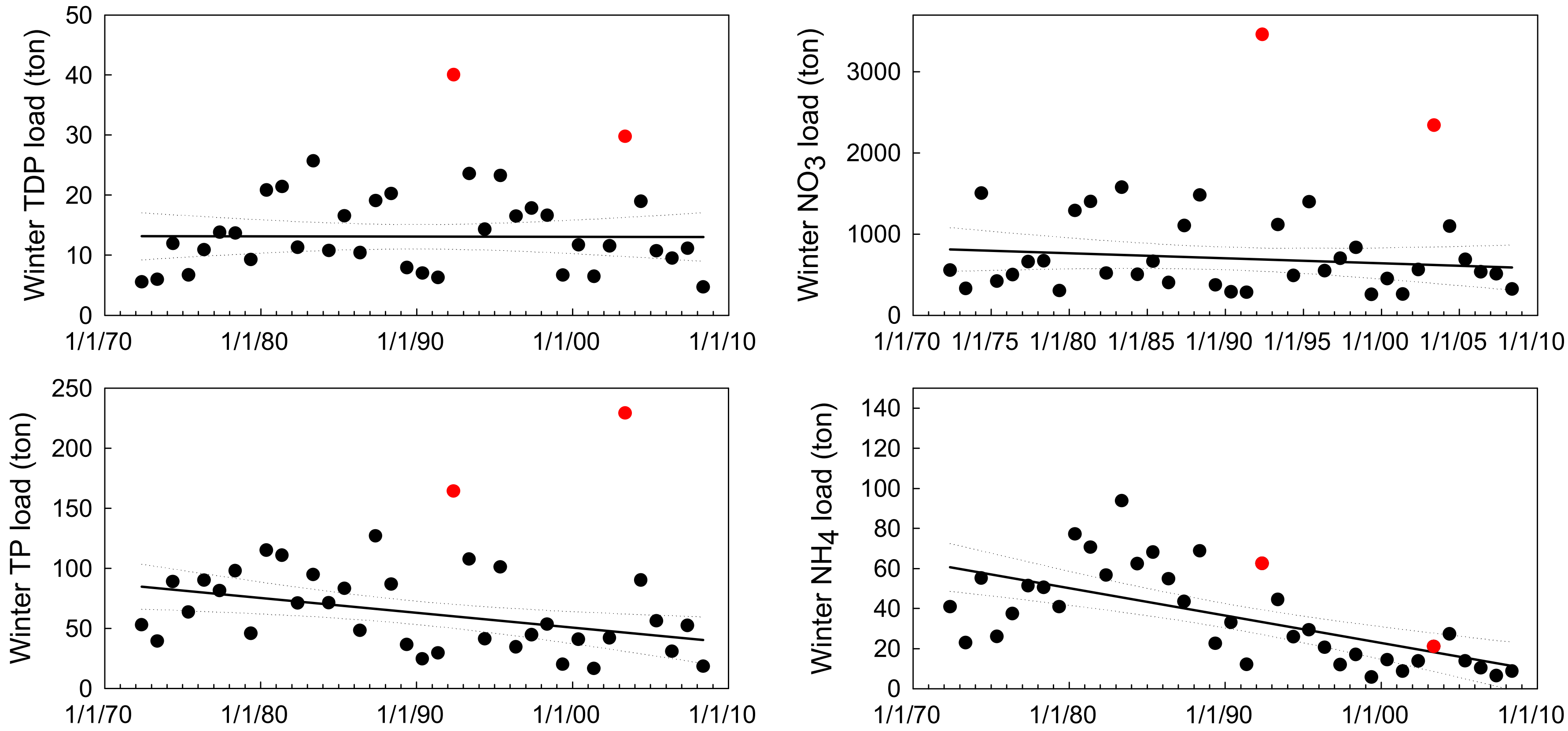
In lake responses:

- Deterioration of WQ
- Changes in biological diversity

Data source: A. Rimer - KLL

Hydrological service, Mekorot

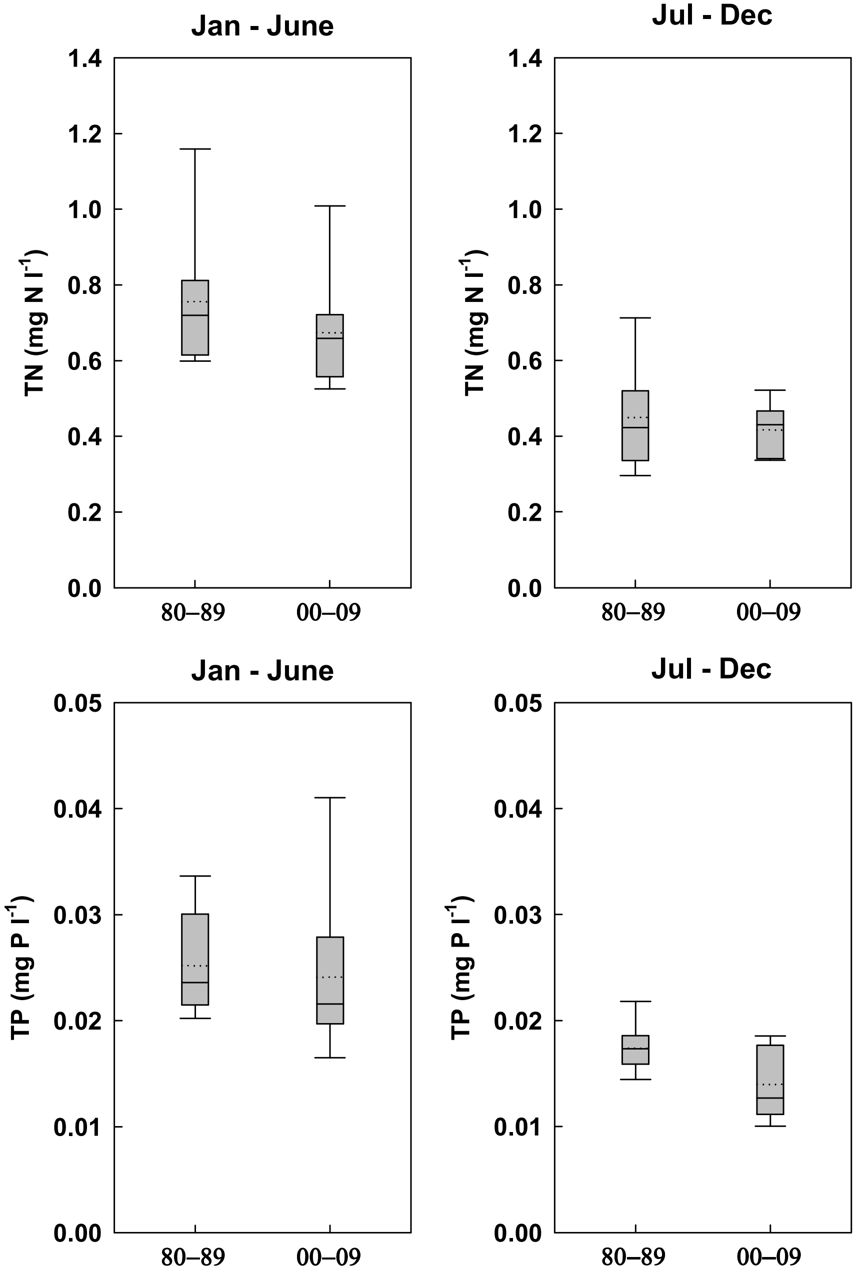
Changes in ecological driving forces – N & P loads



Data source: Mekorot/ KLL/ Water Authority

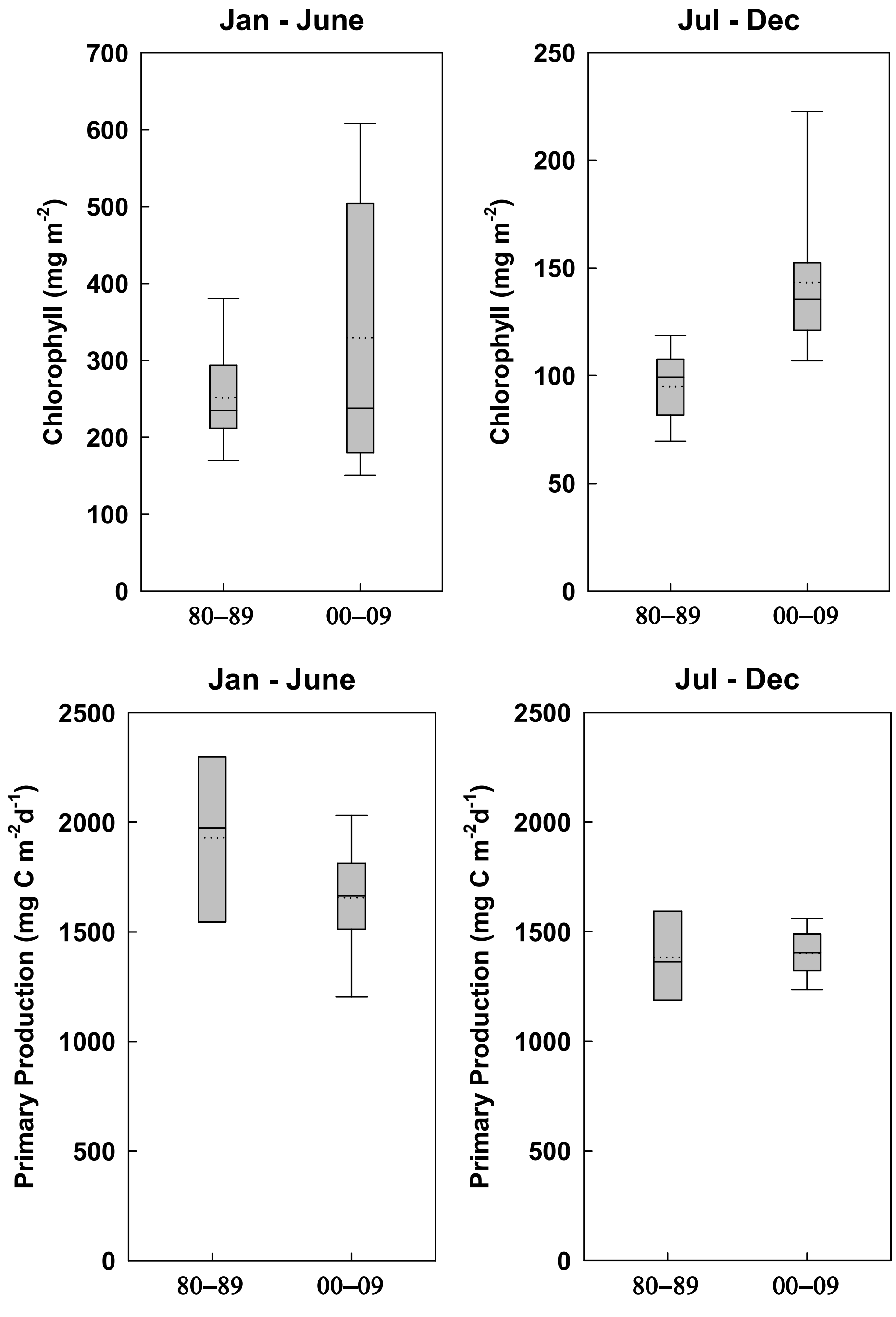
Changes in ecological parameters
In Lake Kinneret (TN & TP)

1980-1989 vs 2000-2009

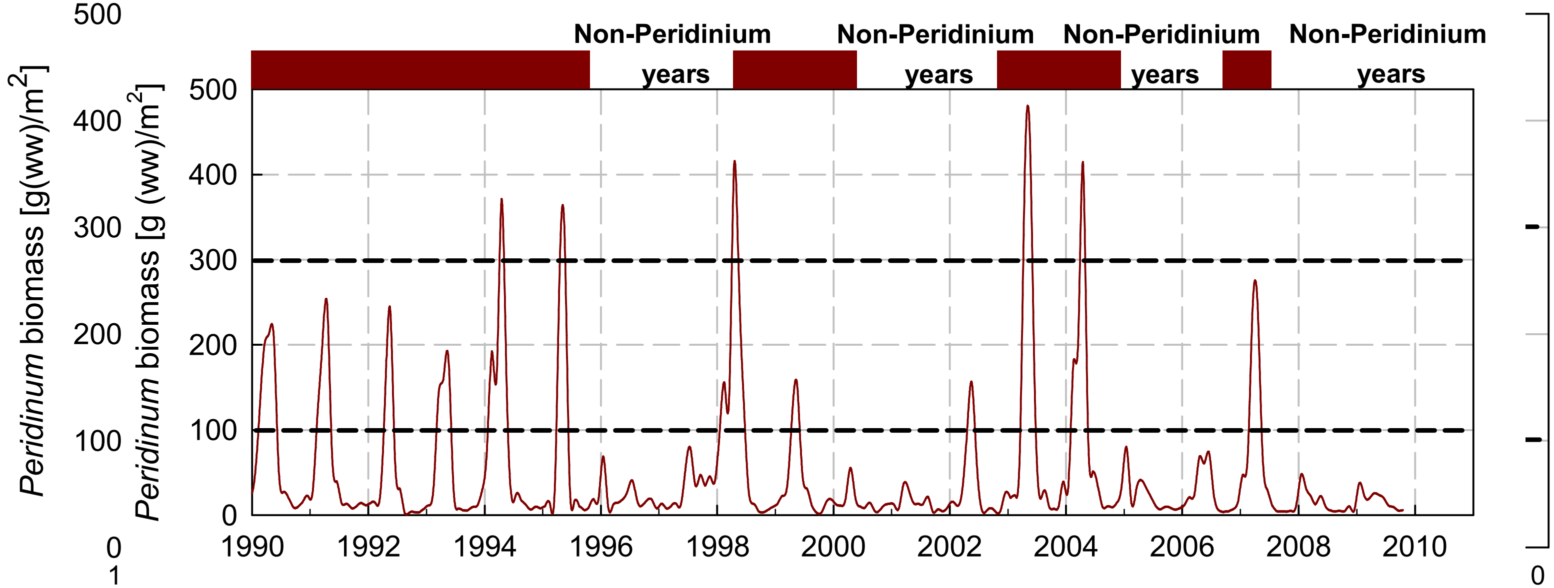


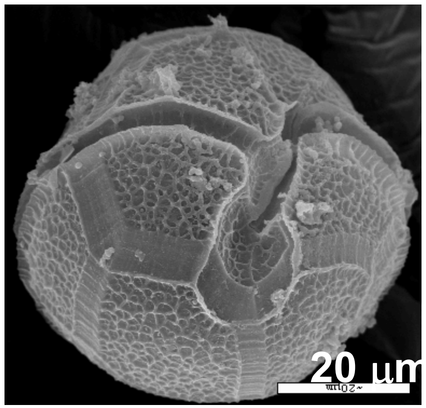
Changes in ecological parameters
In Lake Kinneret (Chl & PP)

1980-1989 vs 2000-2009

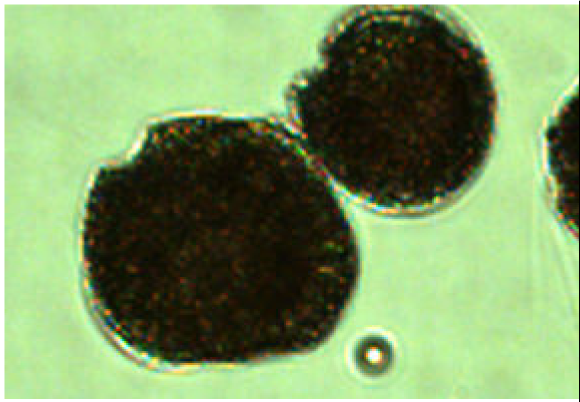


Winter spring blooms of the dinoflagellate *Peridinium gatunense* in Lake Kinneret became a rare event during the last 15 years





Peridinium gatunense Nygaard – a thecate dinoflagellate from Lake Kinneret (A. Alster).



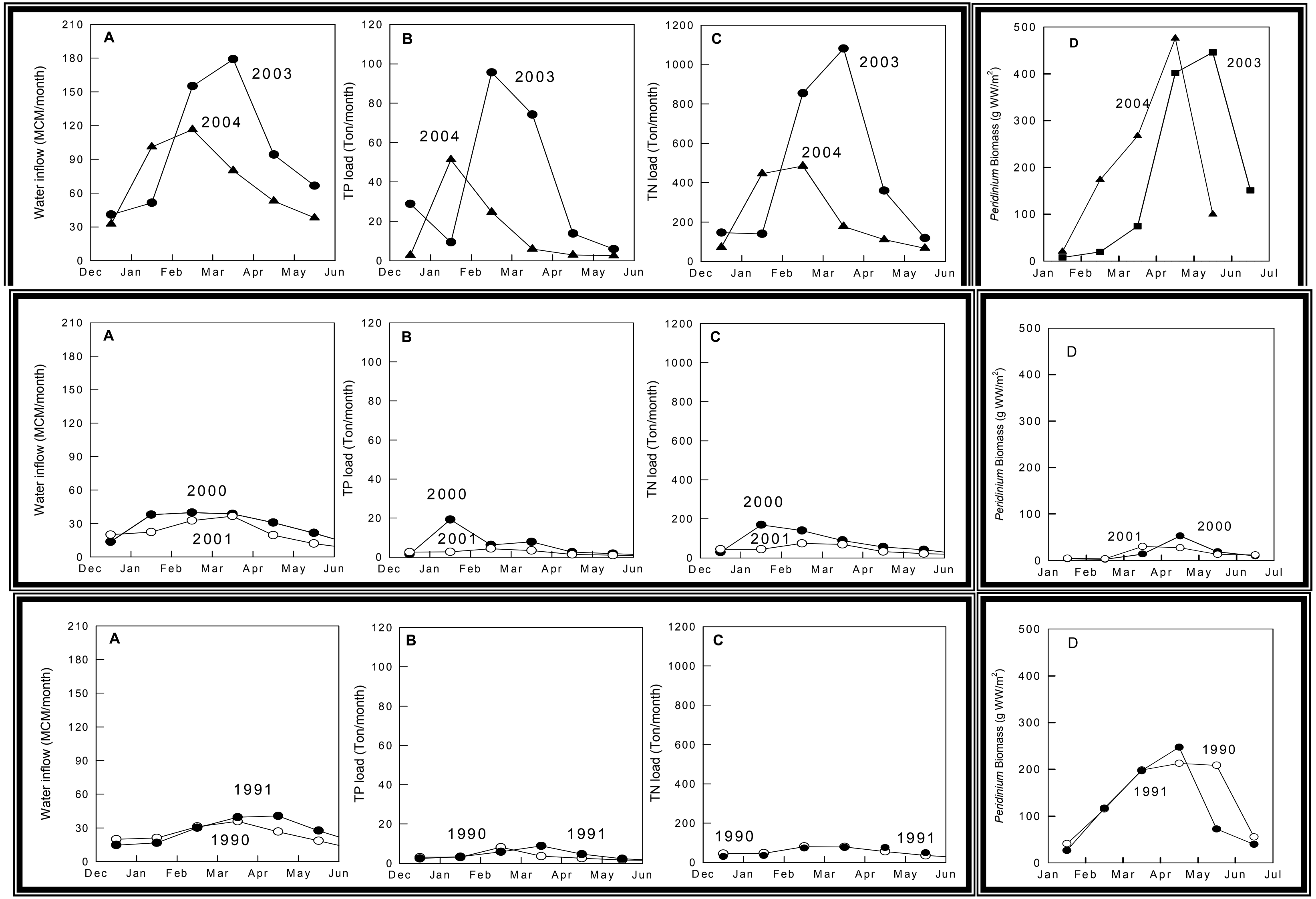
Peridinium gatunense Nygaard populati sizes (A. Alster).

Biomass above 300 g/m²	Biomass Below 100 g/m²
1994	1996
1995	1997
1998	2000
2003	2001
2004	2005
	2006
	2008
	2009

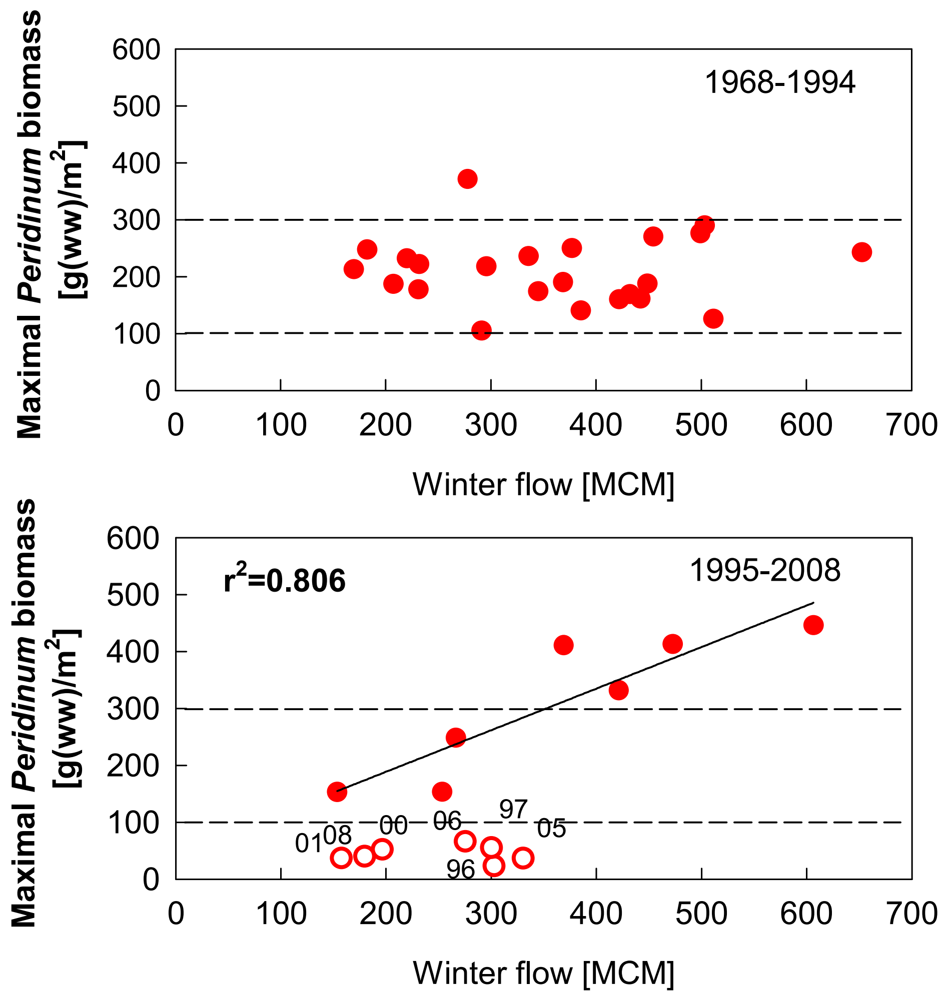
From Lake Kinneret data base – Dr. T. Zohary

The relationships between water inflow or nutrient loads and the seasonal bloom of *Peridinium* in Lake Kinneret

Water inflow Phosphate load Nitrogen load *Peridinium* biomass



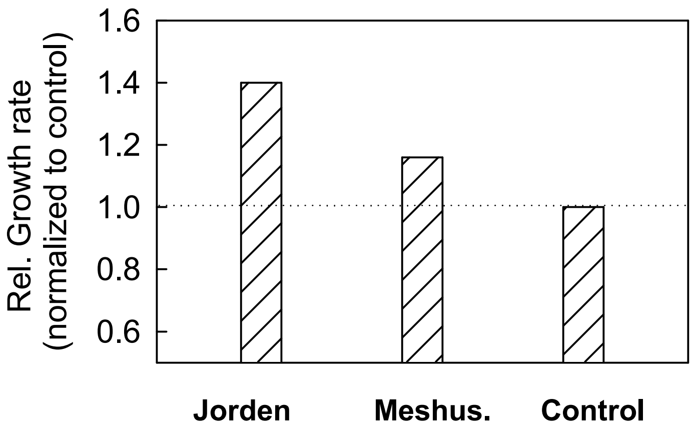
Relationships between winter water flow and maximal *Peridinium* biomass in Lake Kinneret

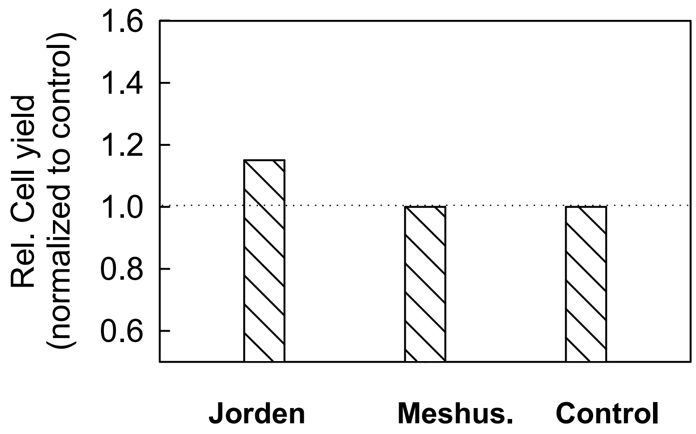


From Lake Kinneret data base

Does Jordan River water affect *Peridinium* bloom events ? Evidence from Laboratory experiments

The effect of flood water from Jordan River and Meshushim tributary on the growth of *Peridinium* –
Lindstrom X1 medium complemented with 25% water collected from either Jordan River or Meshushim river

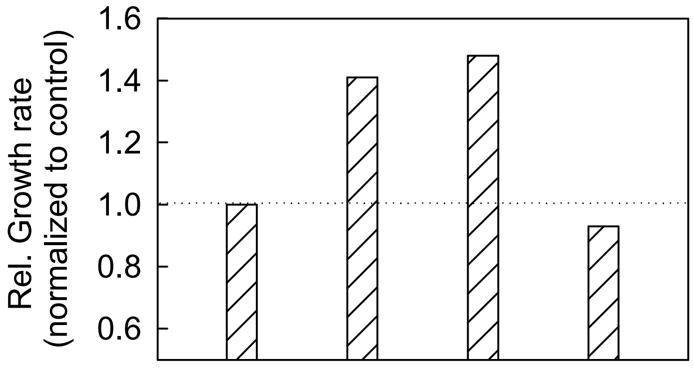


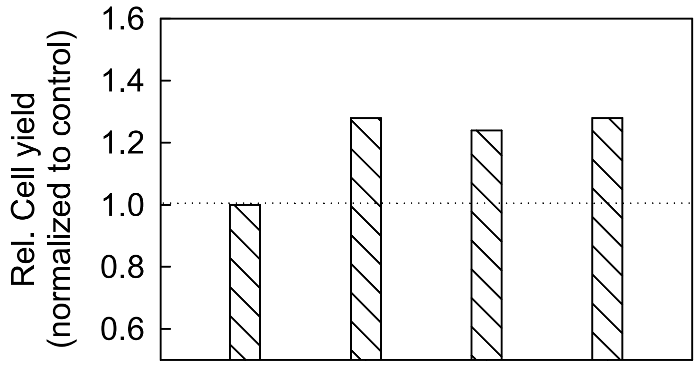


Data source : Jessica Simler

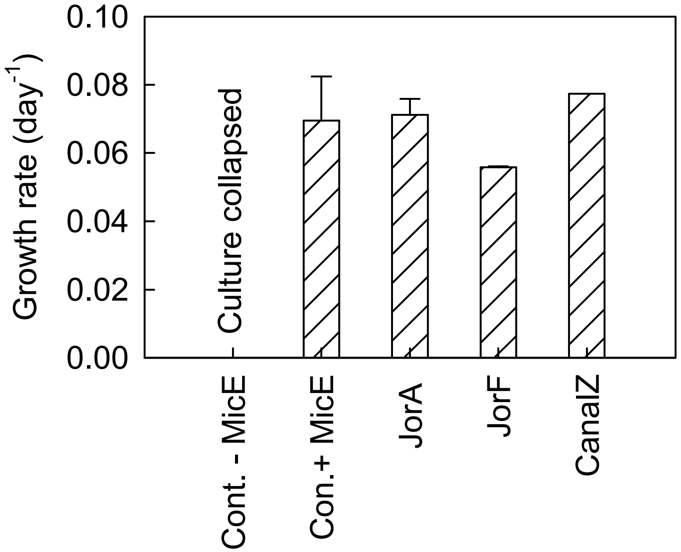
The effect of water collected from the Hula valley on the growth of *Peridinium*

Lindstrom X1 medium complemented with water collected from Agamon reconstructed wet land: Jordan (entrance) Canal Z (entrance of pit drainage water) Agamon Ex. (water outflow)



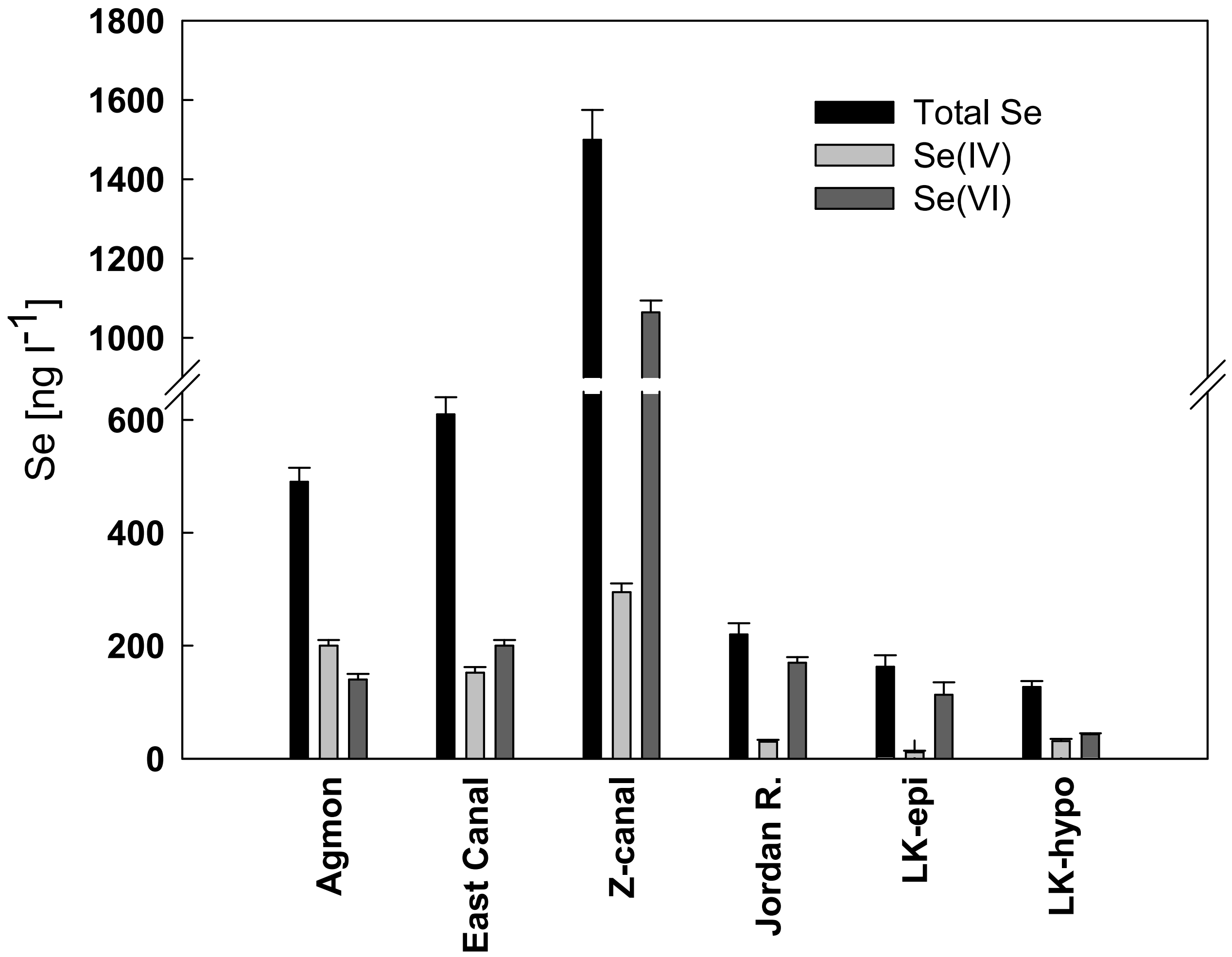


Micro-element depleted *Peridinium* culture incubated in Lindstrom X1 medium complemented with either micro-element solution (Cont+ MicE) or water collected from Agamon reconstructed wet land (JorA) Jordan floods (JorF) or Canal Z (pit drainage water)



Data source : Jessica Simler

Selenium is postulated as an essential trace element that is originated from the pit soil of Hula Valley and required to support the spring bloom of *Peridimium*



Why the *Peridinium* bloom became an irregular event ?

- Changes is winter floods - timing and intensity
- Changes in the relative contribution of different regions in the water shade area of nutrients micro- elements (Se) and agricultural pollutants
- Interactions with other phytoplankton populations
- Other environmental constrains, i.e. temp, salinity?

What happens in the absence of *Peridinuim* ?

- In the absence of *Peridinium* the substituting populations never reach its enhanced biomass
- Short blooms of chlorophytes with temporary domination – i.e. *Mougeotia* (30 g ww m^{-2})
- Enhanced population of *Microcystis* – A toxic cyanabacterium

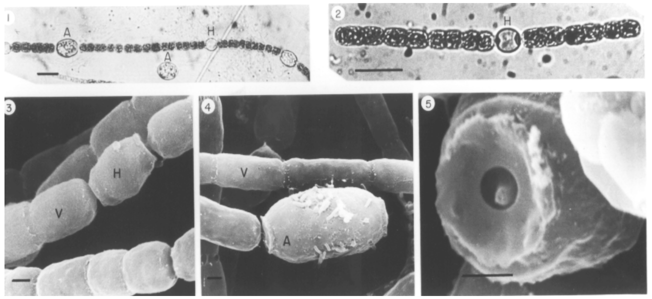
Invader species

Species	Group	First occurred	Current situation
Aphanizomenon ovalisporum	cyanobacteria	12/9/1994	Blooms every summer
Staurastrum mansfeldti	desmid	13/5/1997	Common every fall
Staurastrum contortum	desmid	5/7/1998	Common every fall
Tetraedron minimum (new form)	chlorophyte	1/11/1998	Was abundant in winter-spring till ~ 03
Cylindrospermopsis raciborskii	cyanobacteria	Summer 2000	New N_2-fixer, common every summer
Mougeotia gracillima	Chlorophyte	May 1998	Huge bloom, May 2005
Euastrum sp.	Chlorophyte	Jan 2006	common

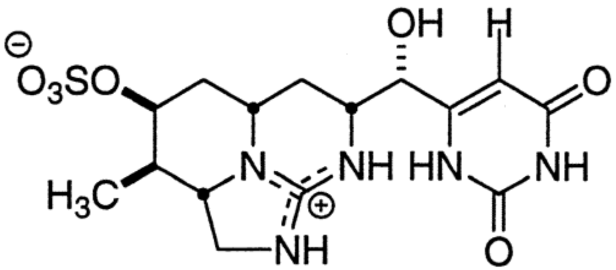
Data: T. Zohary - KLL

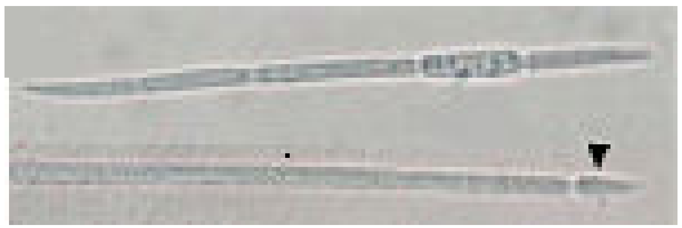
Toxic cyanobacteria in Lake Kinneret

Summer - Fall populations



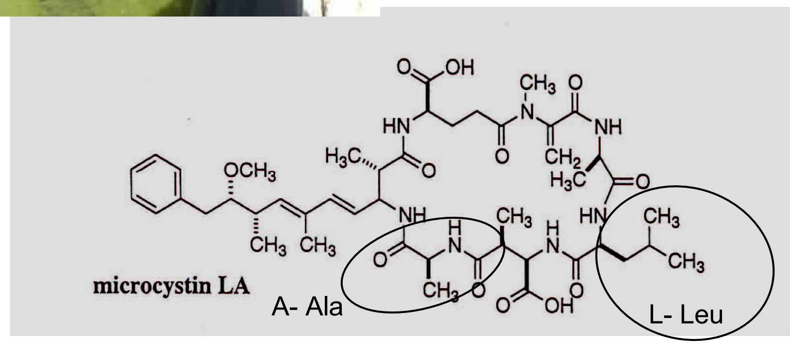
Aphanizomenon ovalisporum



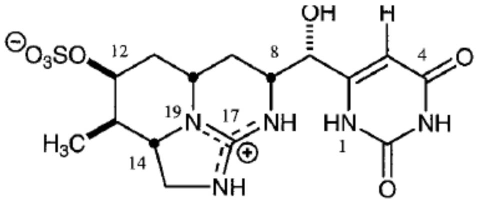


Cylindrospermopsis raciborskii

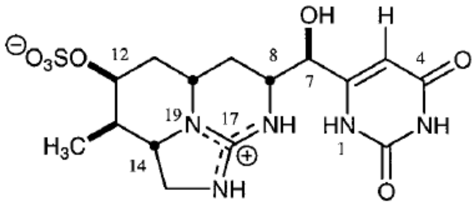
Winter - Spring populations



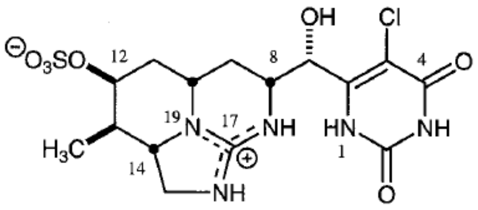
Toxicity of clyndrospermopsin and its derivatives



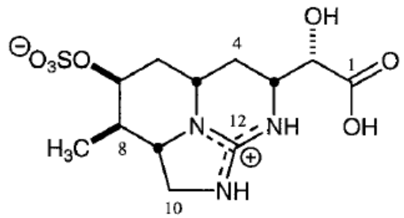
1 Cylindrospermopsin



2 7-epi-Cylindrospermopsin



3 5-Chloro-Cylindrospermopsin



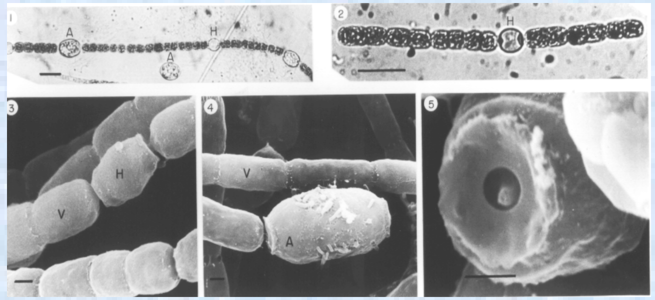
4 Cylindrospermic acid

TABLE 1. Toxicity of Cylindrospermopsin and Its Derivatives

Compound	Toxicity, LD50 (μg/kg)
Cylindrospermopsin (**1**)	200 (ip)
7-*epi*-Cylindrospermopsin (**2**)	200 (ip)
5-Chloro-cylindrospermopsin (**3**)	>10,000 (ip)
Cylindrospermic acid (**4**)	>10,000 (ip)

Note. LD50 values were estimated 5 d after toxin administration (ip).

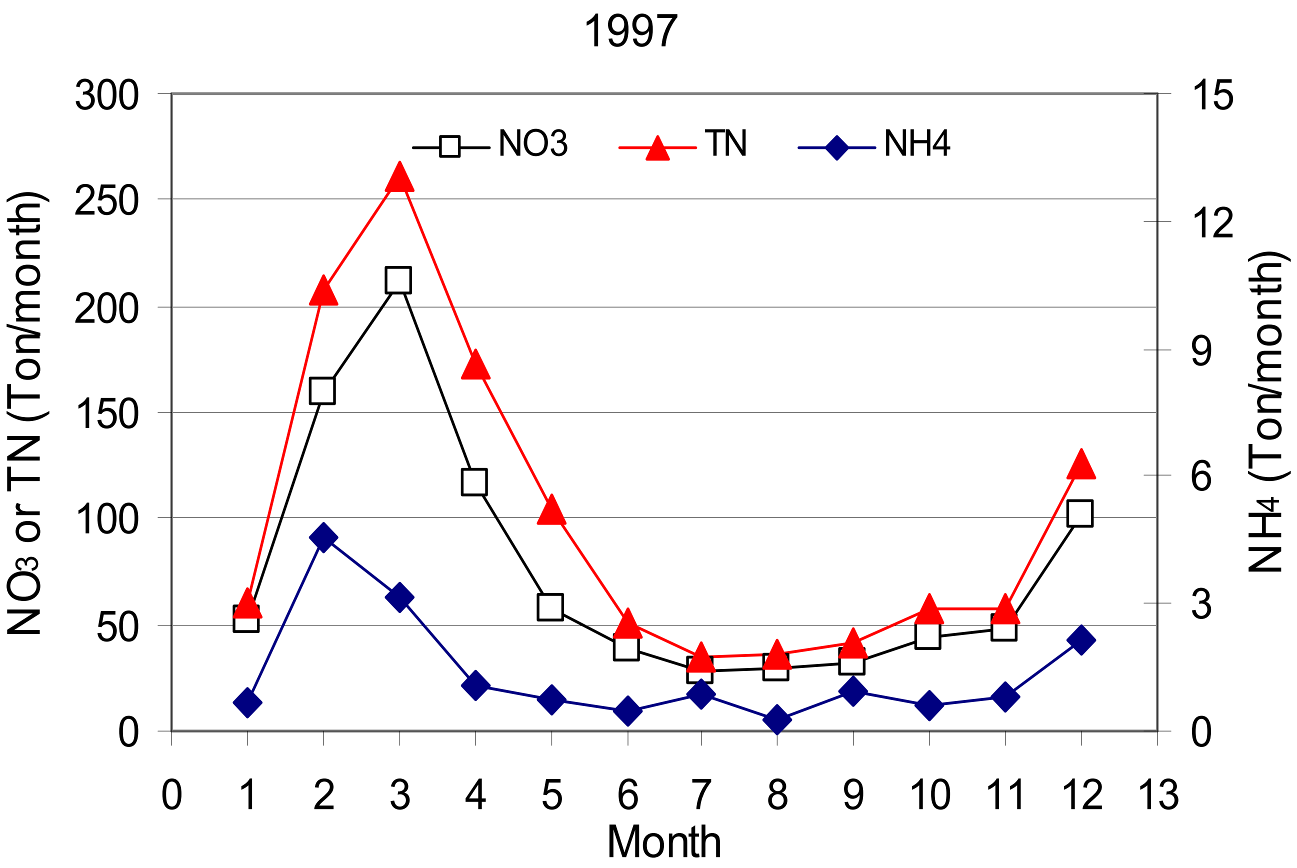
Summer – Fall toxic blooms



Cylindrospermopsin in Lake Kinneret

Time	Cylindrospermopsin	
	$\mu g\ g^{-1}$ (dw)	$\mu g\ L^{-1}$
07/2001	-	2.2
09/2001	-	1.6
10/2001	-	1.8
11/2001	-	1.2
10/2004	210-780	0.6
06/2005	35	-
07/2005	14	-
09/2008	7.8	2.1
10/2008	-	1.8-3.0
11/2008	-	2.3

Monthly loads (tons) of DIN species in 1997 from River Jordan to Lake Kinneret.



This is a typical pattern that describes well other years.

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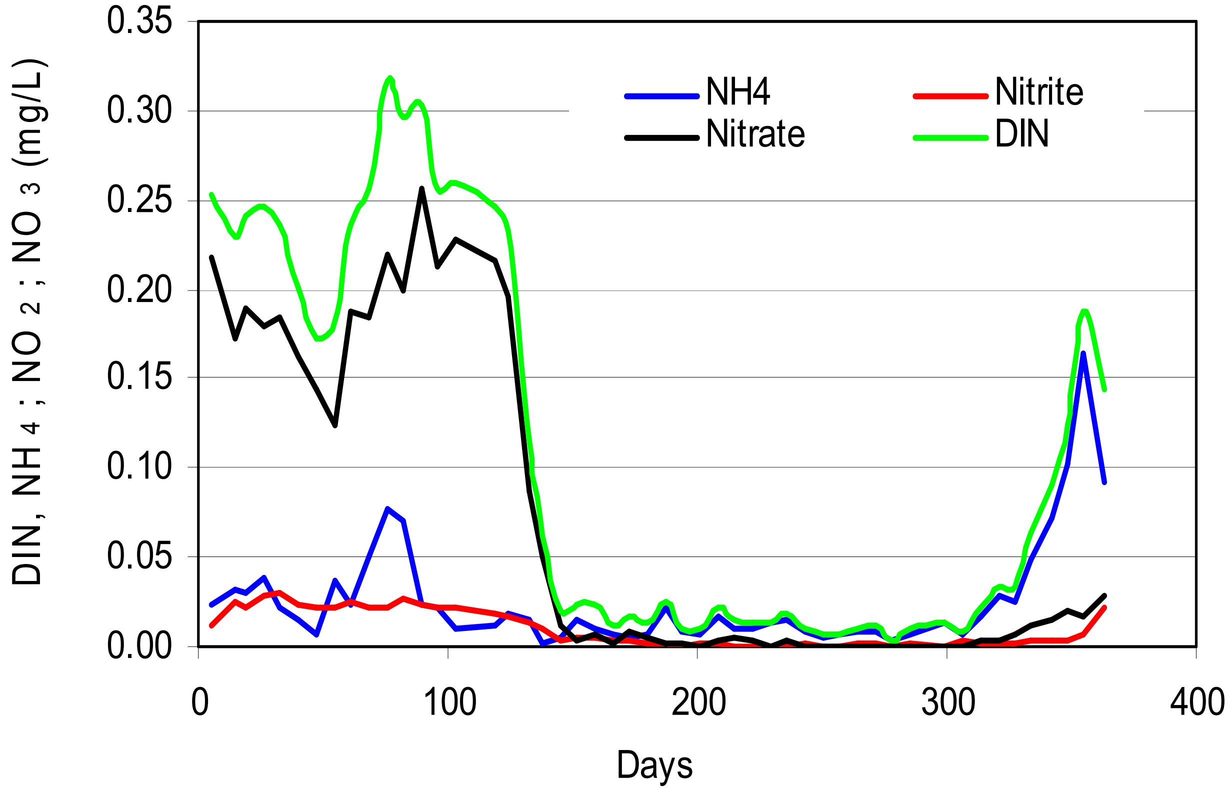
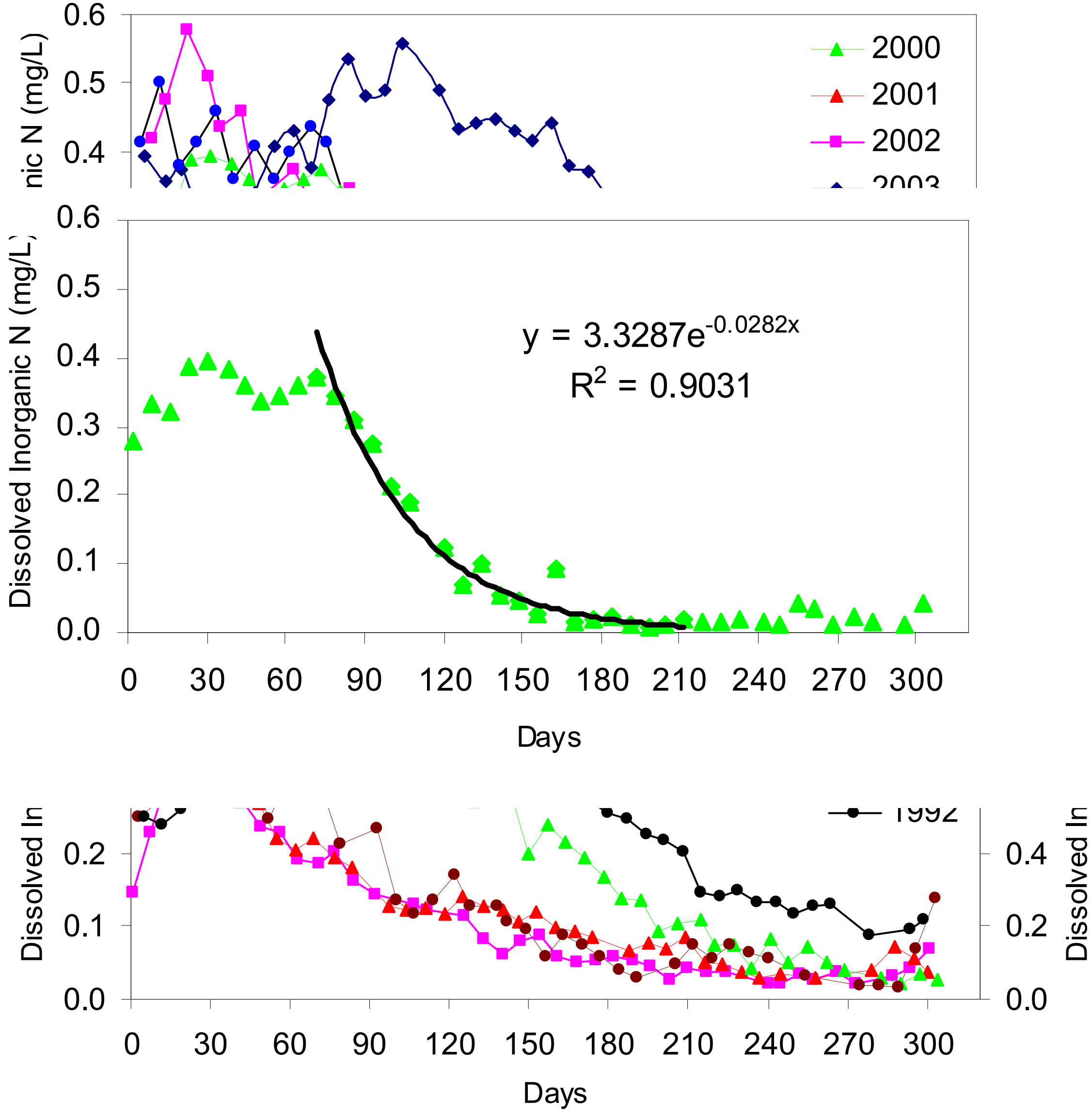
Seasonal variations in the concentrations of DIN species (Nitrate, Nitrite and Ammonium) and in total DIN in the upper water layer of Lake Kinneret (1997)



Multi-annual and seasonal variations in the concentrations of DIN in the upper water layer of Lake Kinneret for the years 1990-1994 and 2004-2000



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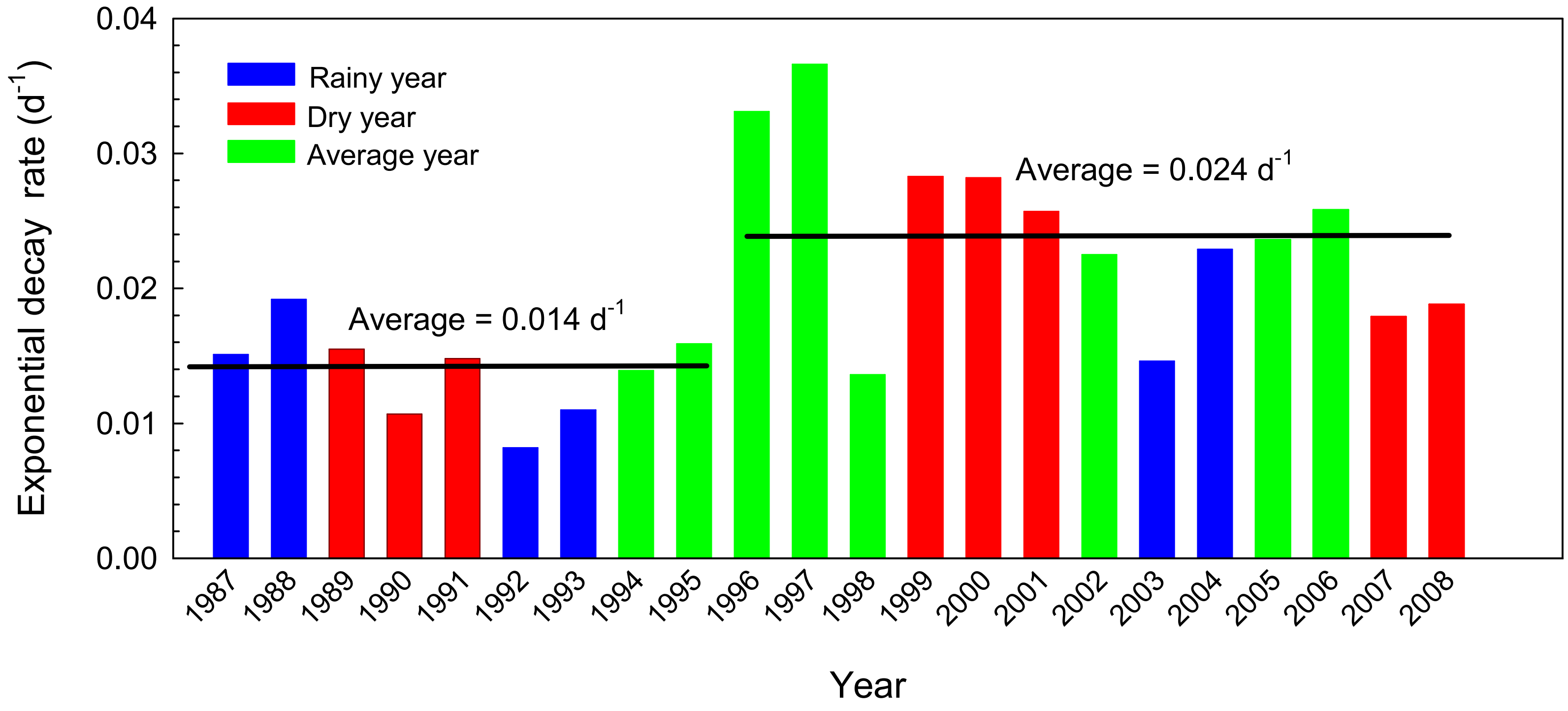
Summary of exponential decay rate of DIN calculated for every year for the spring-summer period based on seasonal variations in DIN concentration in the upper water layer in Lake Kinneret



- Rainy year –monthly water inflow exceeded 80 MCM at least during one winter month.
- Average year - monthly water inflow ranged between 40 and 80 MCM at least during one month.
- Dry year - monthly water inflow never exceeded 40 MCM during the winter months.

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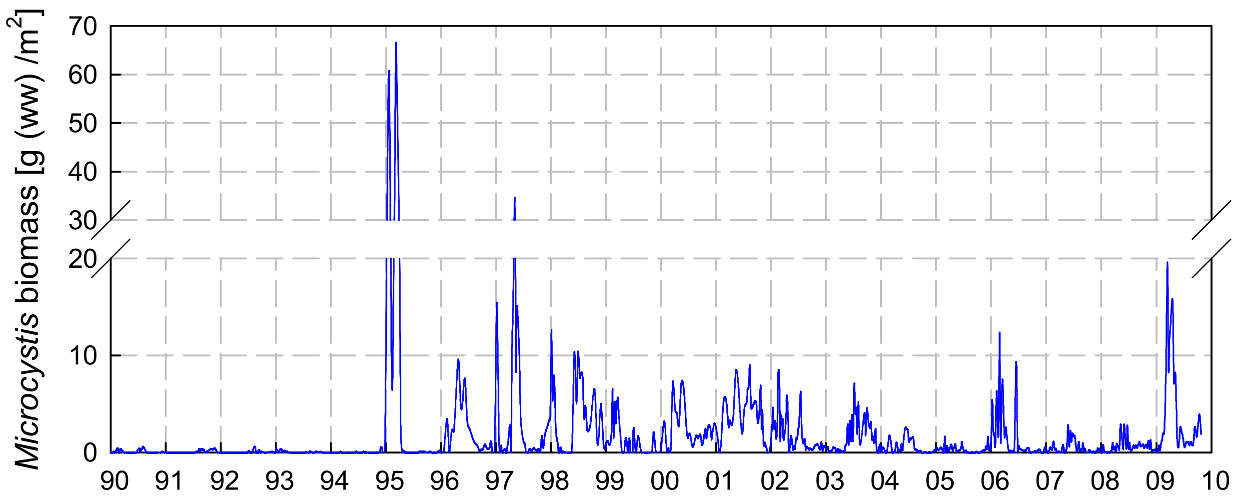
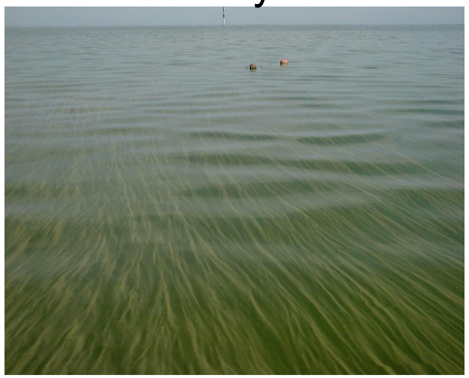
While *Peridinium* population was characterized by high biomass concentrations, *Microcystis* biomass is much lower. It is organized in relatively large colonies that float to the water surface during the day when calm and warm conditions prevail

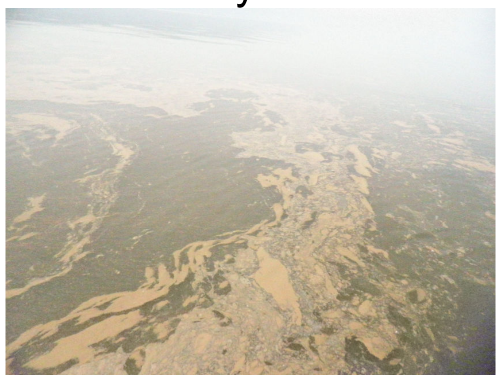


February 2002

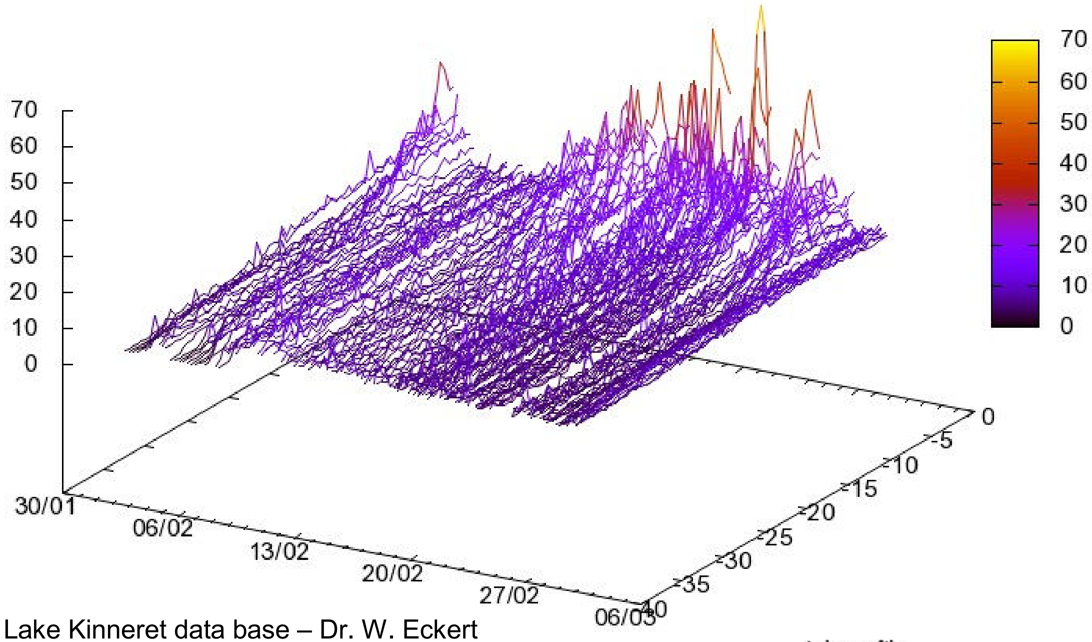


March 2009

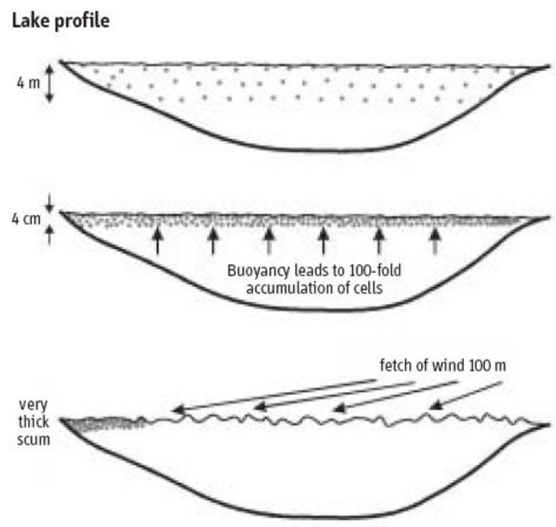
February 2010

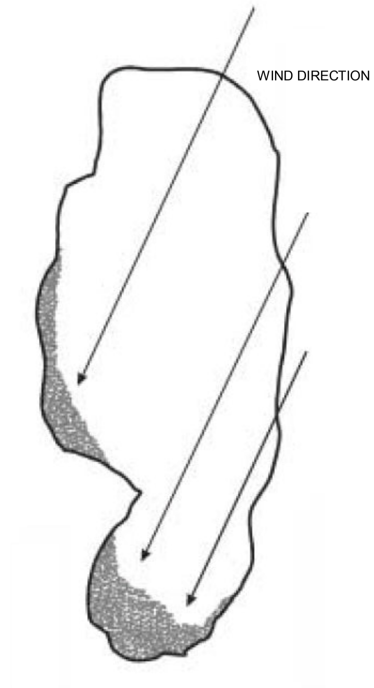


The development of *Microcystis* scum Lake Kinneret - February 2010



From Lake Kinneret data base – Dr. W. Eckert





Feb 2010

Photo: Idan Shaked

At early stages of ecosystem deterioration, variables reflecting ecosystem functioning such as primary production, nutrient levels, and respiration are not altered, and are thus poor indicators of early stress;

Among the earliest responses to stress would be changes in species composition of small, rapidly reproducing organisms with wide dispersal powers, such as phytoplankton,

There is a need for long-term records in order to learn about the response of ecosystems to natural versus anthropogenic perturbations.

Schindler D.W. (1987) Detecting ecosystem responses to anthropogenic stress. *Canadian Journal of Fisheries and Aquatic Sciences*, 44, 6–25.

Thank you

Acknowledgements:

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