Water Level Decline in Lakes: the Diferrence Between Disaster and Welfare

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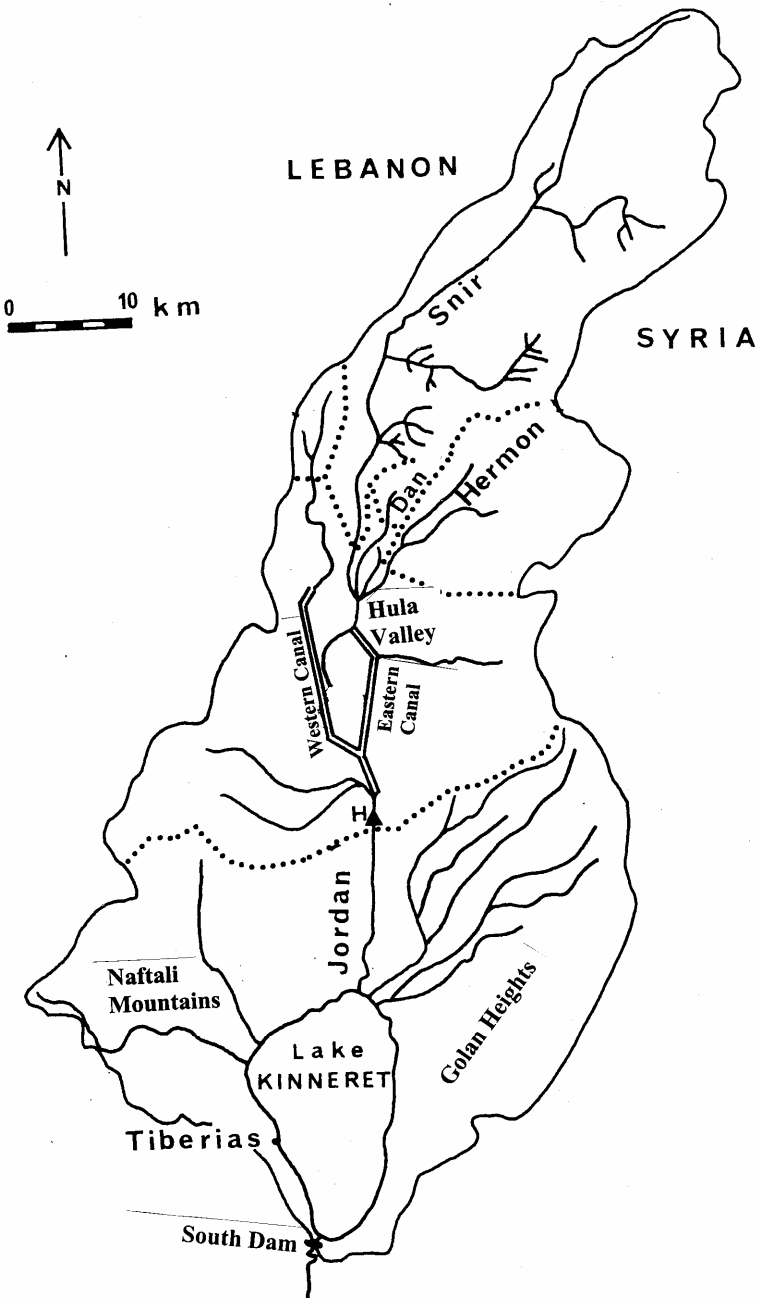
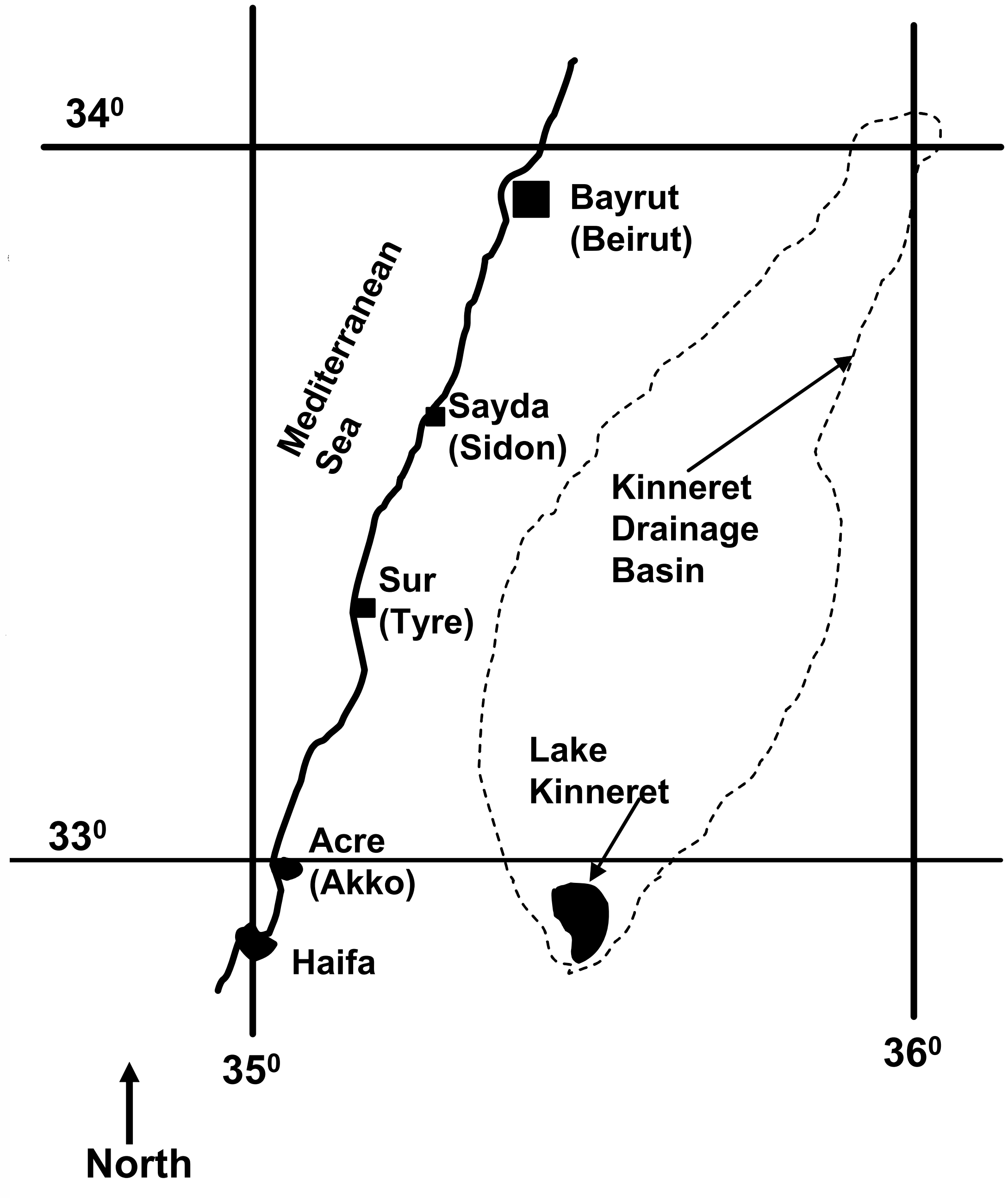
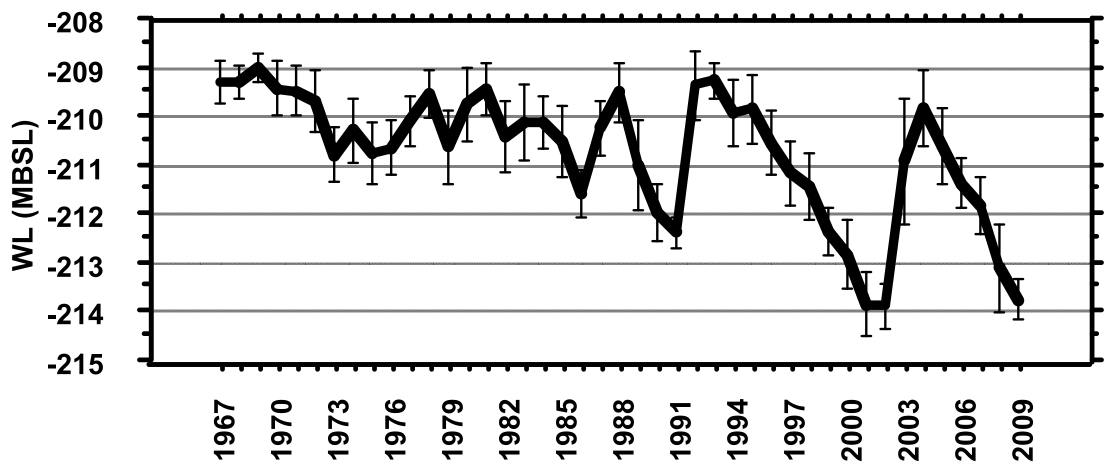
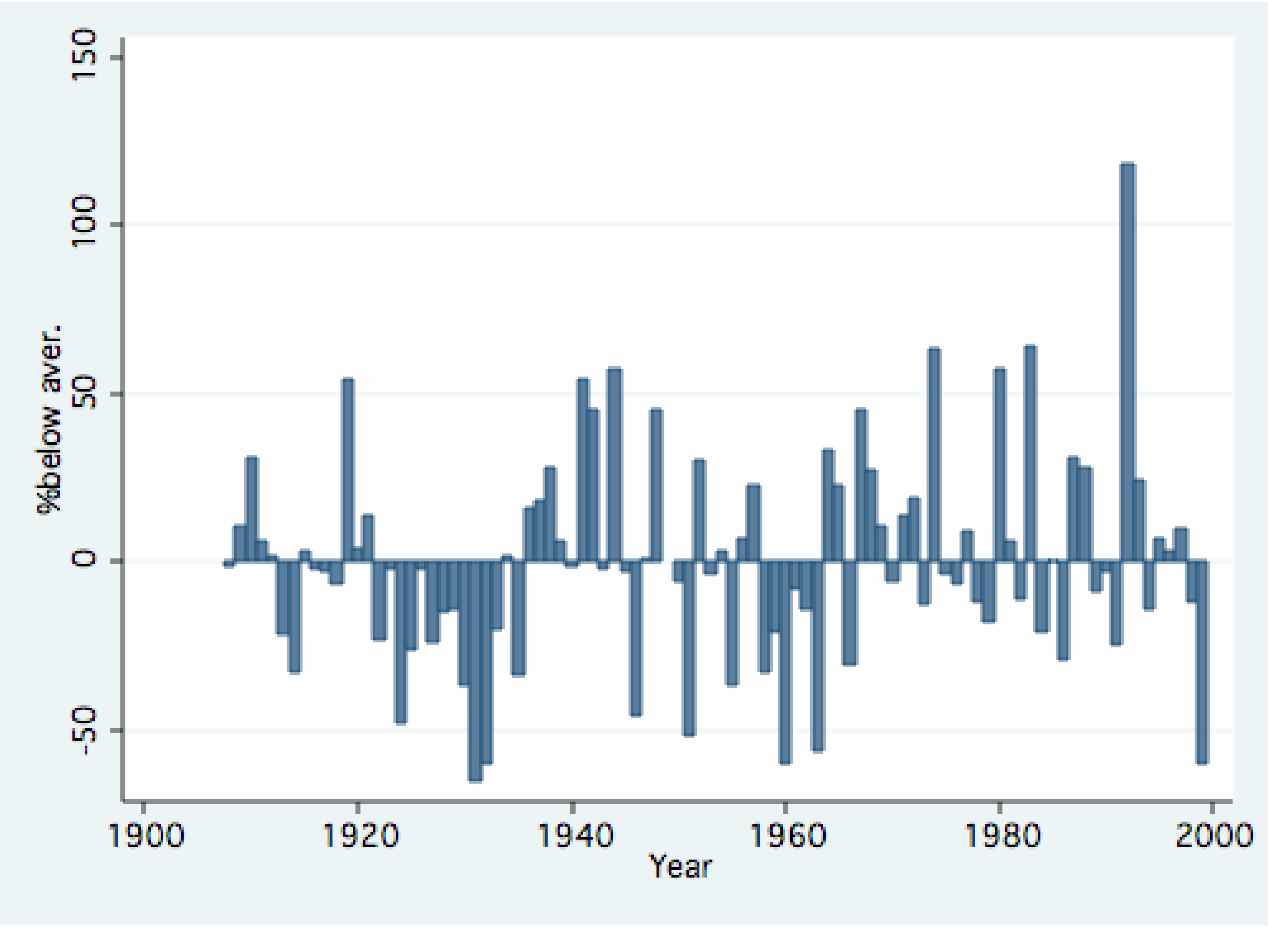

N
0
10 km
LEBANON
SYRIA
Snir
Dan
Hermon
Hula Valley
Western Canal
Eastern Canal
H
Jordan
Naftali Mountains
Lake KINNERET
Golan Heights
Tiberias
South Dam

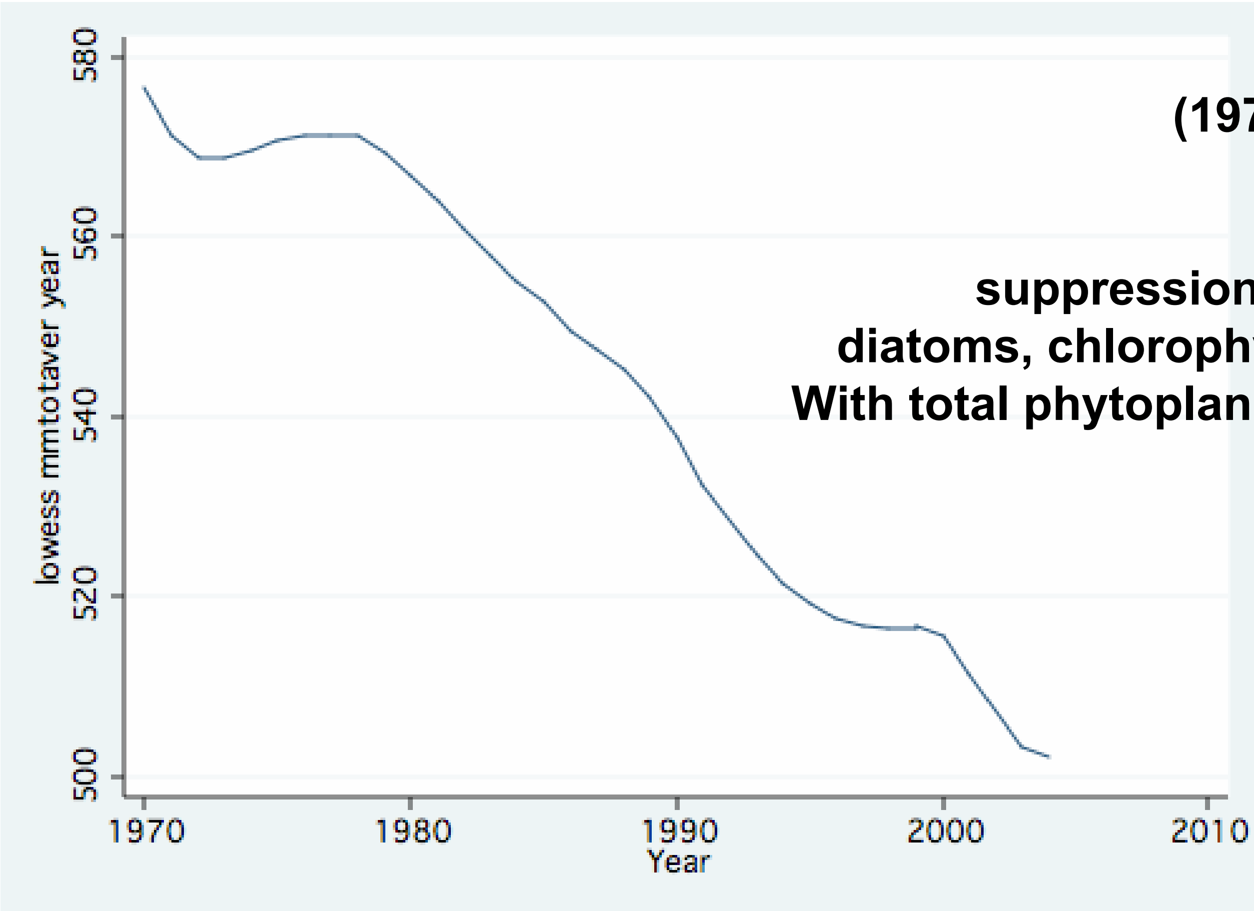

34^0
33^0
35^0
36^0
Bayrut (Beirut)
Mediterranean Sea
Sayda (Sidon)
Sur (Tyre)
Kinneret Drainage Basin
Lake Kinneret
Acre (Akko)
Haifa
North

WL in Lake Kinneret during 1967 - 2009 (September)
Annual Averages (SD's bars are shown).
Lowest: -214.87 (2001)
Total amplitude: 5 m.



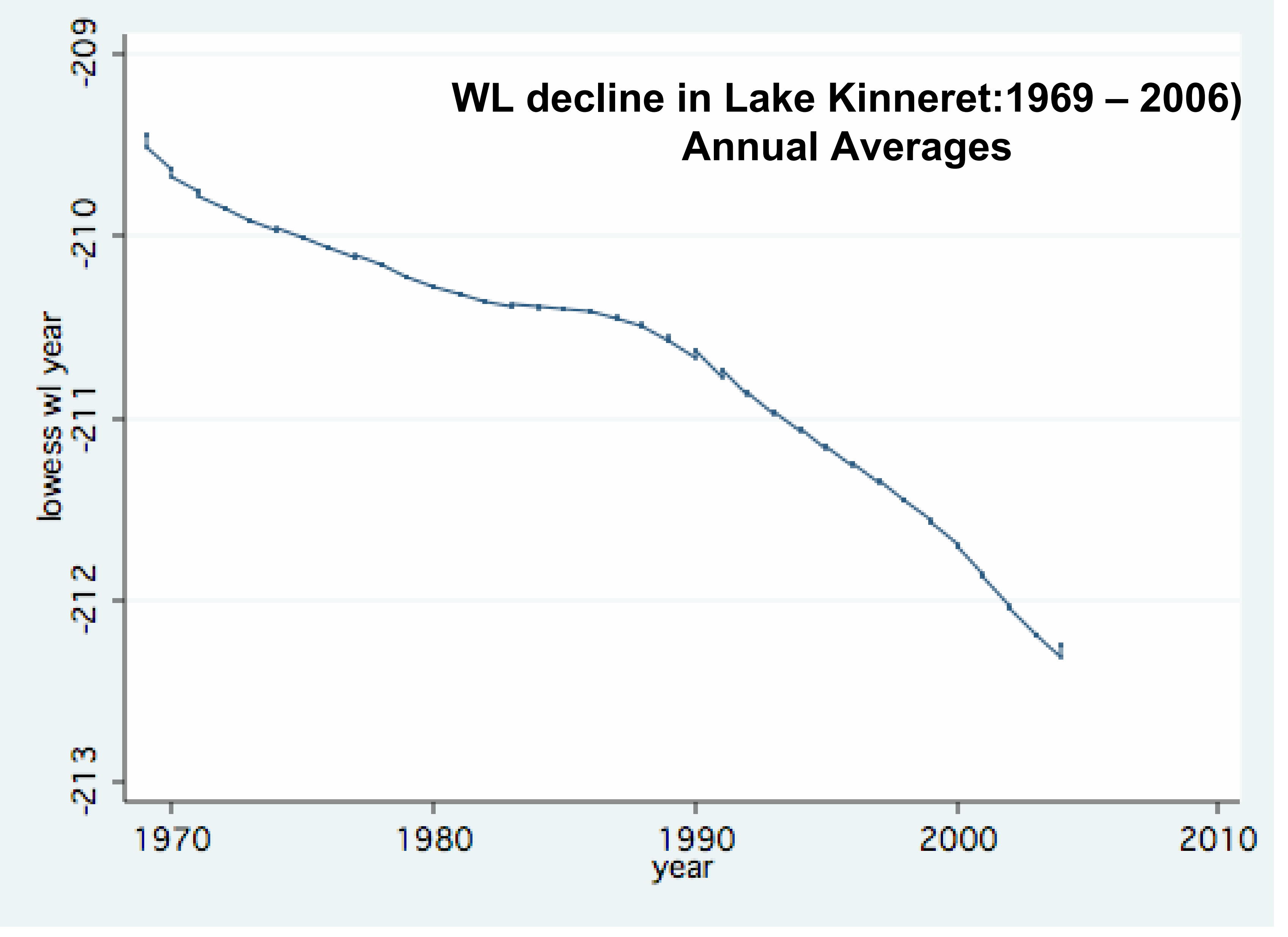


Lake Kinneret is located on the border between sub – tropical and desert regions. Therefore droughts are not un – common. 150 years of rainfall measurements. Zero=multiannual average, deviations from the mean are shown



WL decline of 1.5 m (1972 – 1975) resulted by rainfall decline caused Peridinium suppression and enhancement of diatoms, chlorophytes and cyanophytes With total phytoplankton biomass decline.

Positive impact on water quality As part of long term management policy. (Serruya & Pollongher 1977)


WL decline in Lake Kinneret:1969 – 2006)
Annual Averages
lowess wl year
-209
-210
-211
-212
-213
1970
1980
1990
2000
2010
year

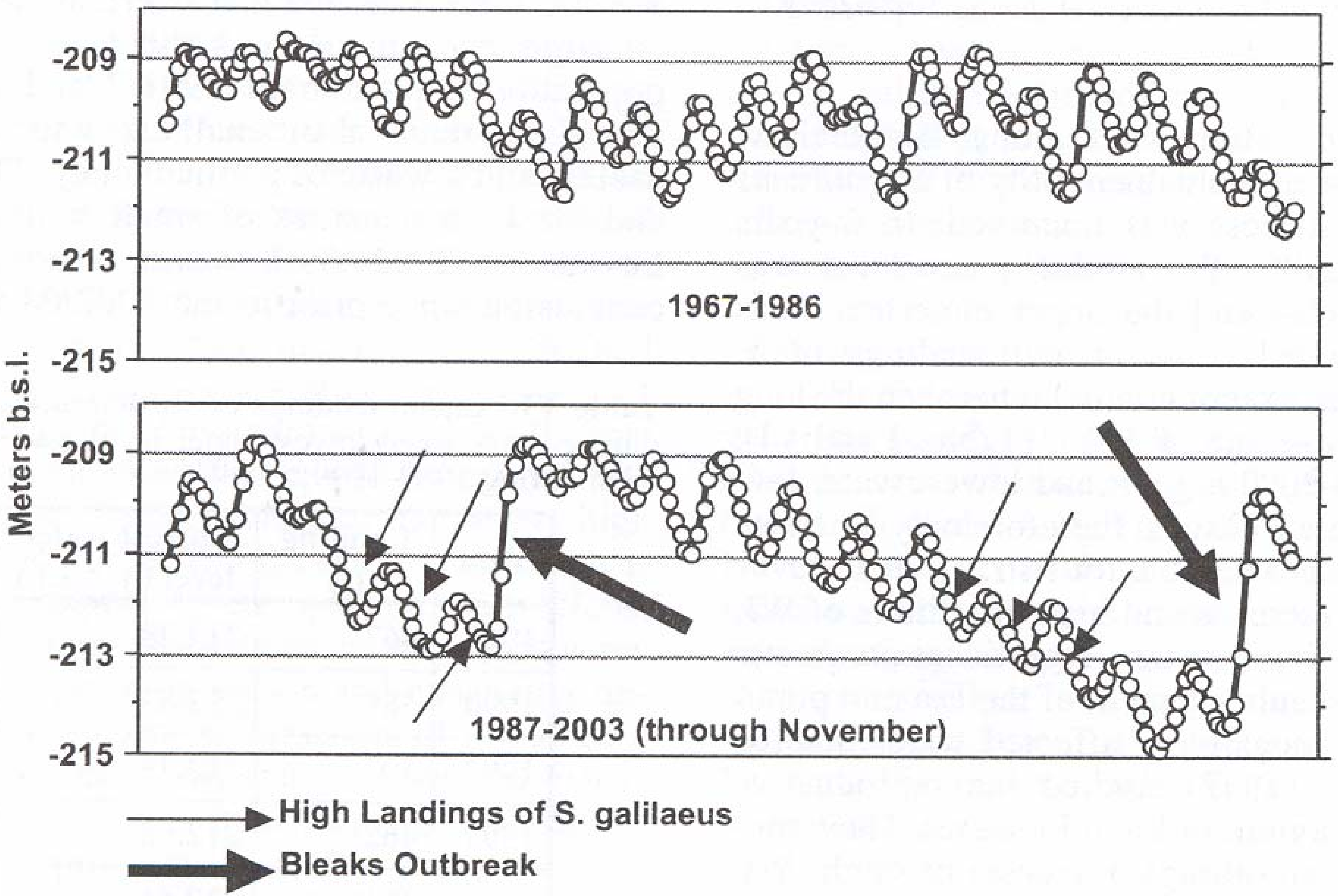
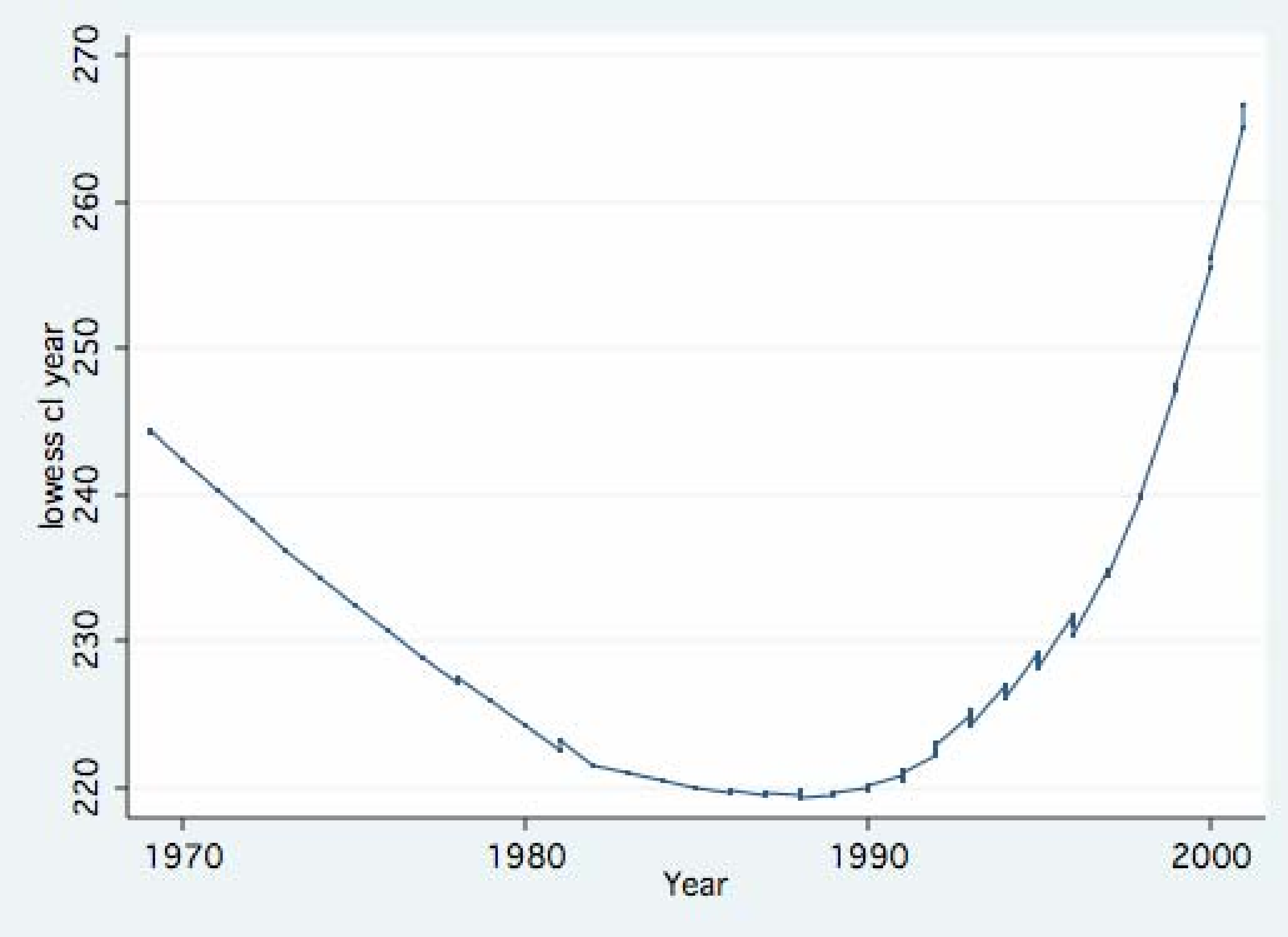
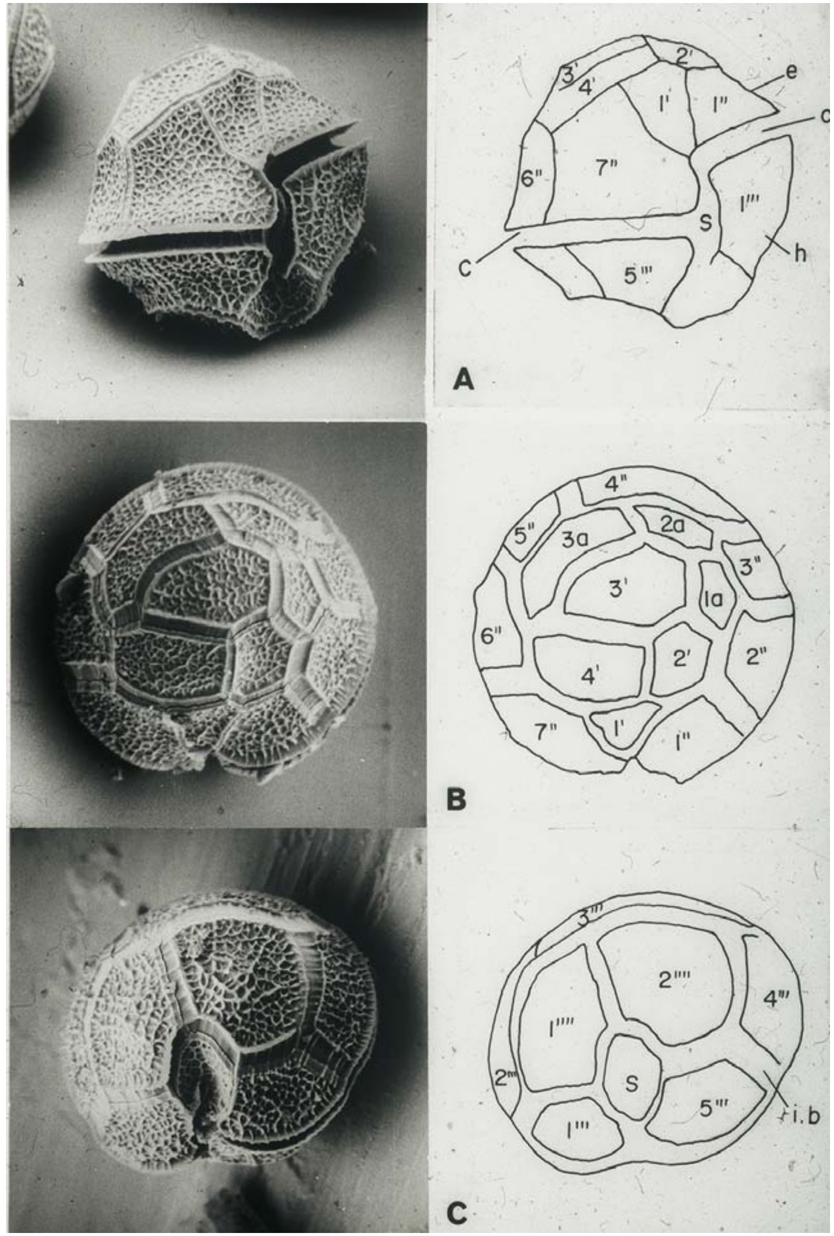


Fig.7. Monthly means of water level in Lake Kinneret during 1967-2003 (through November). Periods of high landings of *Sarotherodon galilaeus* and Lavnun outbreak are arrowed.

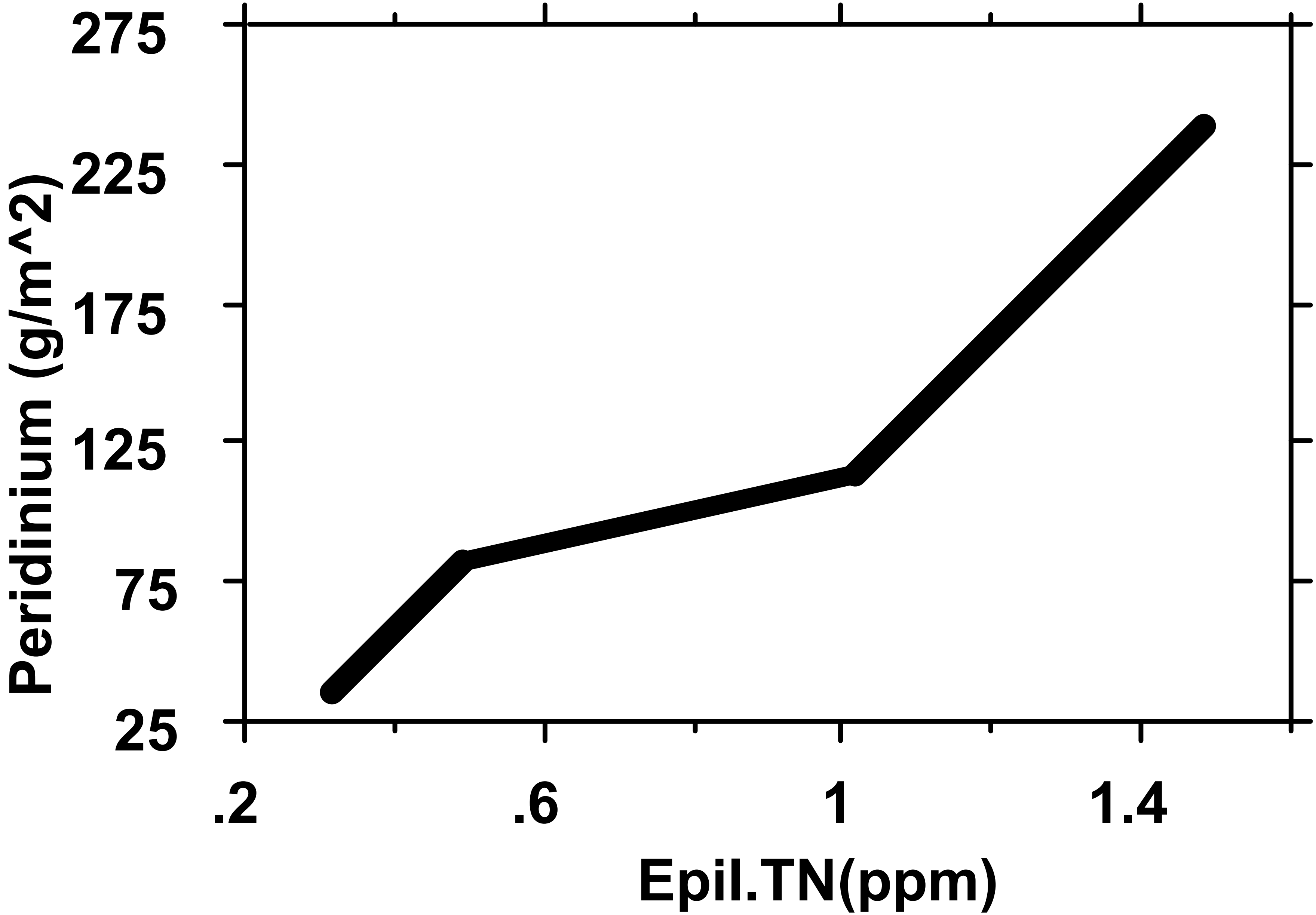

Stainless Steel
MADE IN JAPAN

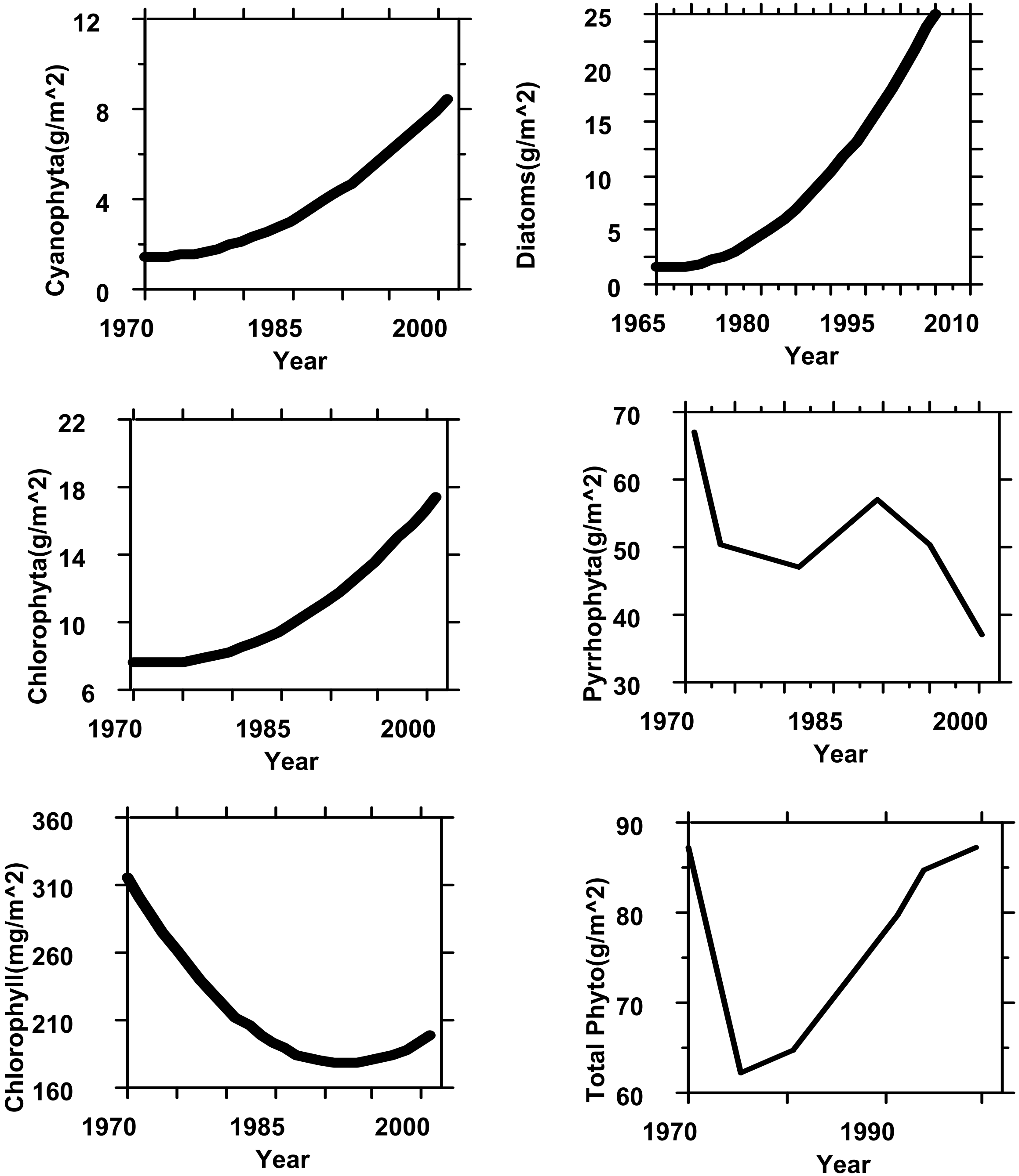


שינויי מליחות (לפי כלוריד) בכינרת: 36487 מדידות (1969-2001)



Peridinium spp


275
225
175
125
75
25
Peridinium (g/m^2)
.2
.6
1
1.4
Epil.TN(ppm)



Cyanophyta(g/m^2)
0
4
8
12
1970
1985
2000
Year
Diatoms(g/m^2)
0
5
10
15
20
25
1965
1980
1995
2010
Year
Chlorophyta(g/m^2)
6
10
14
18
22
1970
1985
2000
Year
Pyrrhophyta(g/m^2)
30
40
50
60
70
1970
1985
2000
Year
Chlorophyll(mg/m^2)
160
210
260
310
360
1970
1985
2000
Year
Total Phyto(g/m^2)
60
70
80
90
1970
1990
Year


- Nutrient inputs is directly relates to discharge: higher discharge – higher inputs. The major impact on water quality improvement when WL is low emerge from lower discharges, and nutrient inputs. Epilimnion loads directly affected by external inputs.
- Chlorinity is affected by salts inputs which is directly related to underground water influx: higher precipitation cause higher salt inputs. During droughts the major factor of salt concentration increase is due to water balance, especially in summer: if inputs are lower than evaporation salt concentrations is increasing.
- WL factor by itself has no impact on salt concentrations
- Changes in zooplankton populations is due mainly to fishery management
-

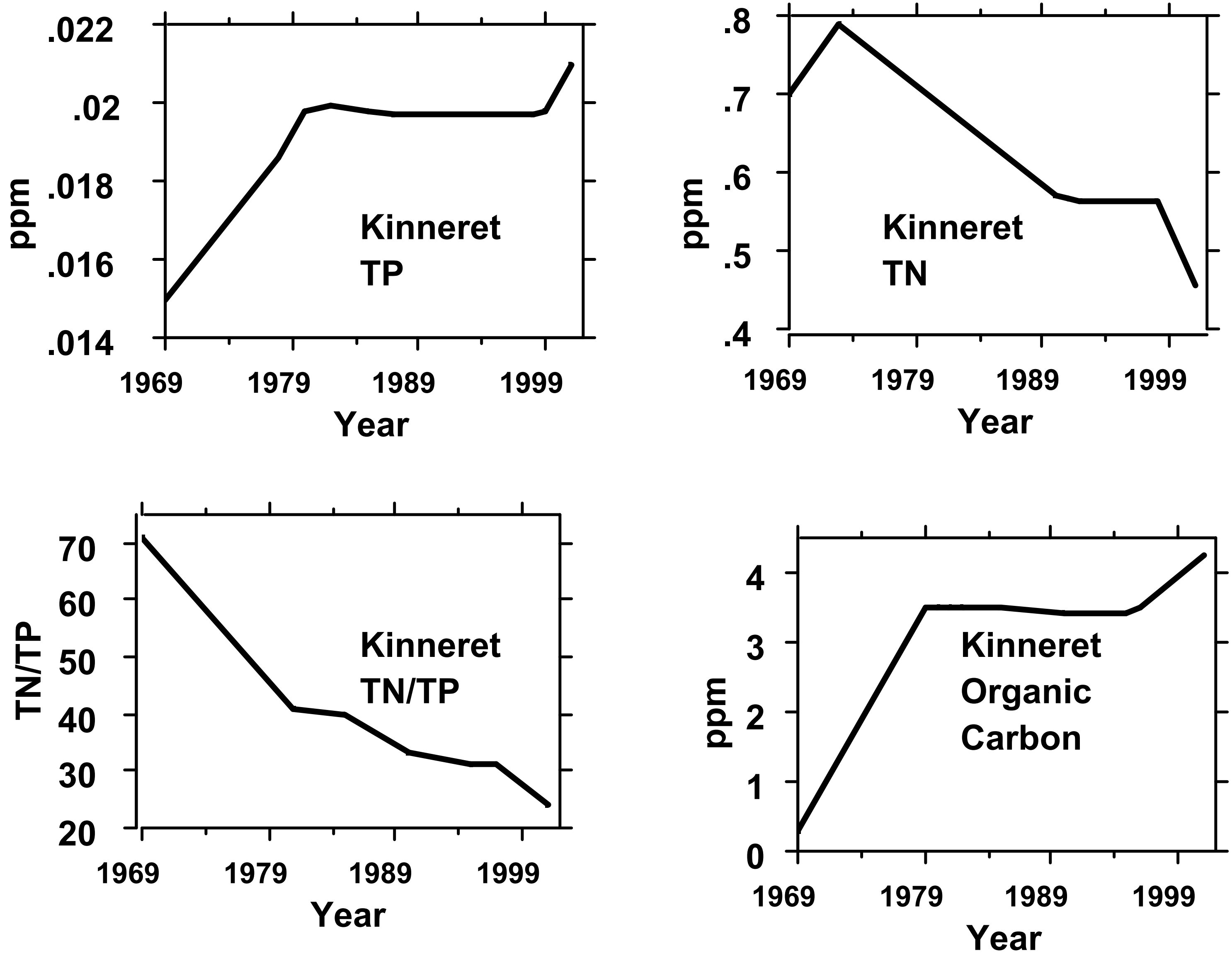
Discharge & WL impacts on the WQ of Lake Kinneret Epilimnion (1969 – 2008)

Increase:

- **Nanoplankton Biomass & compositional %**

Decrease:

- **Chlorophyll concentration**
- **Pyrrhophyta Biomass**
- **Total Phytoplankton Biomass**
- **The following nutrient loads: DON, TDN, Particulate-N, TIN, TN, TDP, TP, Kijldhal total & Dissolved**



.022
.02
.018
.016
.014
ppm
Kinneret
TP
1969
1979
1989
1999
Year
.8
.7
.6
.5
.4
ppm
Kinneret
TN
1969
1979
1989
1999
Year
70
60
50
40
30
20
TN/TP
Kinneret
TN/TP
1969
1979
1989
1999
Year
4
3
2
1
0
ppm
Kinneret
Organic
Carbon
1969
1979
1989
1999
Year

Fig.4

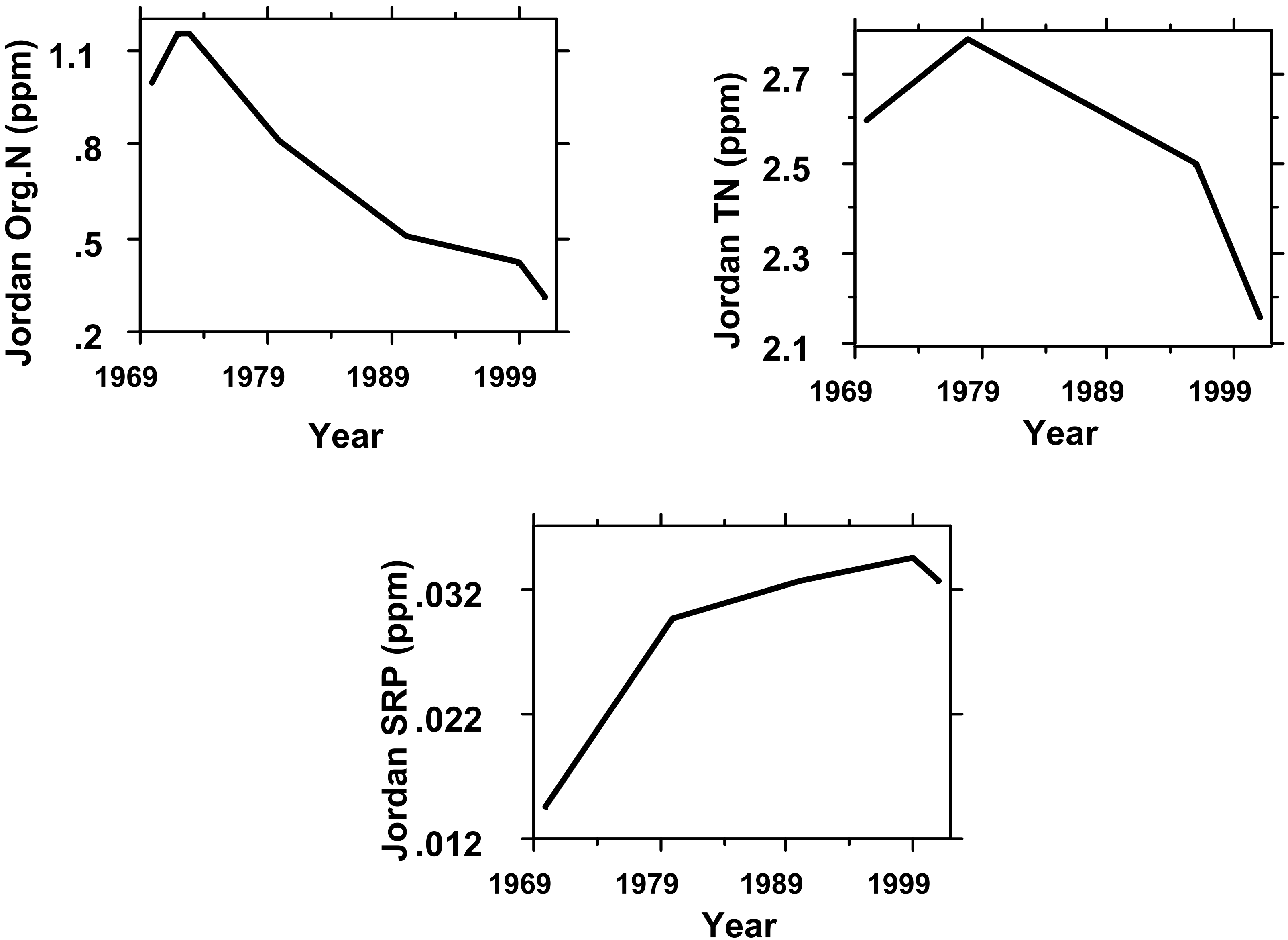

Jordan Org.N (ppm)
1.1
.8
.5
.2
1969
1979
1989
1999
Year
Jordan TN (ppm)
2.7
2.5
2.3
2.1
1969
1979
1989
1999
Year
Jordan SRP (ppm)
.032
.022
.012
1969
1979
1989
1999
Year

Fig.3

Lake Sivan

1923 – Sevan Institute of Hydroecology & Ichthyology

High Altitude lake : 1898 MABSL

Utilization:

Irrigation (Ararat Valley), hydroelectric power, drinking water.

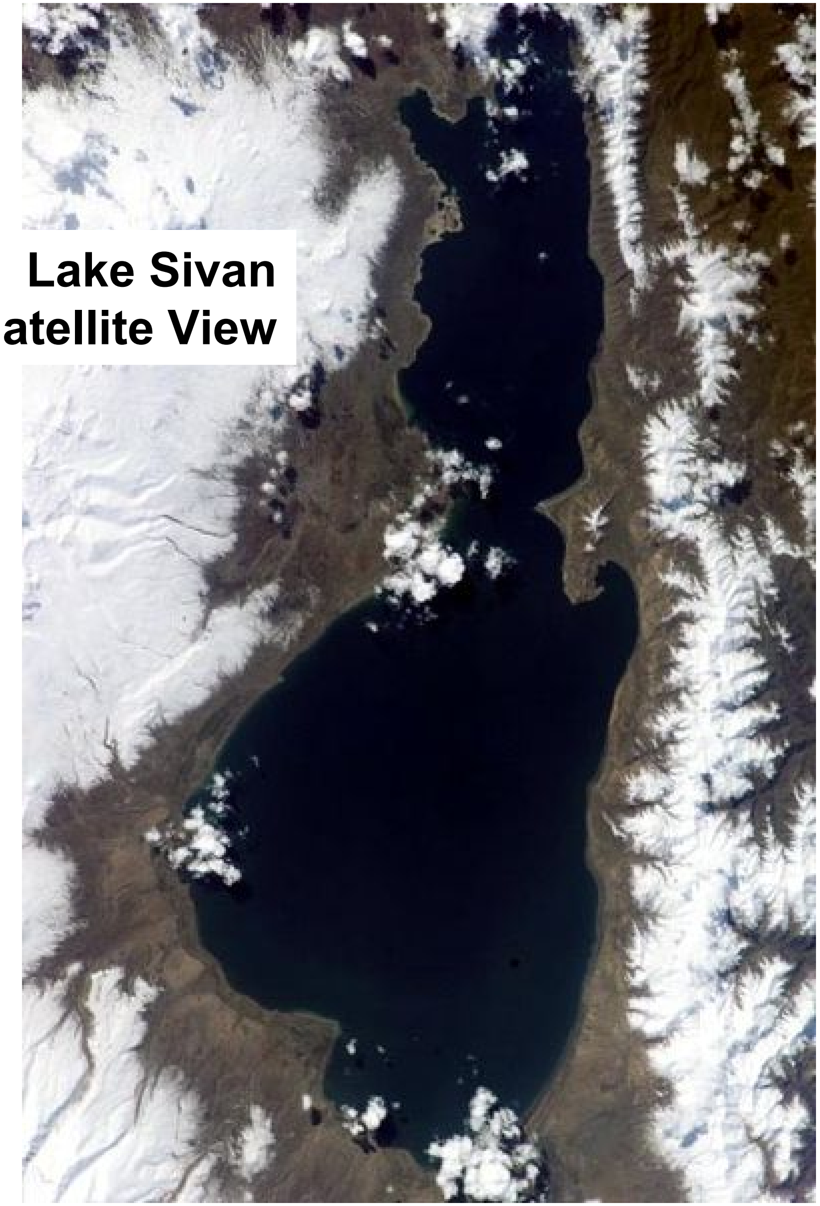
Changes during 1949 – 2006:

	1949	2006
Water surface(km^2)	1416	1236
Volume (km^3)	58.5	32.9
WL altitude (MABSL)	2018	1898
Maximum Depth (M)	100	80
Mean Depth (M)	41	27

Drainage Basin 3600 km^2 (3 times the lake surface)

Lake Kinneret: Drainage basin – 2730 km^2, lake surface – 169 km^2; 16.5 times)

1910 – Plan of 50 m WL decline(S. Manasserian)



Lake Sivan Satellite View

1933 – 1949: water diversion for agriculture and lowering surface to reduce evaporation
1m/y WL decline
Surface reduce by 200 km2
WL decline= 20% of maximum depth
In Lake Kinneret=11% (5m decline, 44m max.depth)
1956 as a result of the Aral disaster new policy: pumping and diversion stop, water quality changed, eutrophication signals.1958 – New program, WL increase.
1978 – National park and monitoring center.
Diversion of river waters into Sivan new to the lake.
2003 – Parlament decision of 1903m surface altitude. Practically implemented within 15 years.
Pollution by agricultural fertilyzers and sewage

Changes of fish populations:

4 species of Salmo
6000t/y in early 1950's
A few hundreds t in 1976
Fishing prohibition, than,
1982 – 16000 t/y than decline
and massive fish kill in 1984
Accidently introduction of
Carassius carassius

Water Balance

Evaporation – 90% 0f outputs
Direct precipitation – 360 mm/y
Outflow – 2m/s (3.6% of total output)
Seepage – 6.4% of total outflow
Retention time – 50 years (Lake Kinneret – 5-10 years)
Soft Water – 700 mg/L
WL decline – Hypolimnion reduction :31km^3 to 12km
Decomposition of organic matter sharply declined.
Reduction of littoral flora and fauna (Gammarus).
Enhancement of Oligochaets in bottom sediment.

Ecological consequences of the 20m WL decline

1950-1970-Macrophyte biomasses reduction
1964 – Anabaena flos aquae first record
1970's Maximum Nitrogen and PP level
1970 – 1973- First record of bottom Anoxia, Methane and H_2S.
1970 – Decline of Salmo ischchan fishing

Cyanophytes replaced Diatoms
When WL declined
Secchi depths became
shallower: 12.5 – 2.7m.(1986)
Presently 4.5 m

1976 – Prohibition of S. ischchan fishing
1982 – Maximum catch of introduce exotic Sig (coregonid)
1983 –Mssive fish kill (mostly Sig)
1988 – Earthquake, decline of Sig fishing
1996 – Sig fishing require licence.

TDP decreased dramatically during 1970 – 1980's while nutrient loadings were increased. As a result of the "whitings episode" of precipitation of P – CaCO3 complexes.

Legovich et al. (1973) reported:

WL decline of 17m was accompanied by:

Enhancement of algal biomass,

Appearance of blue greens,

Increase of rotifer biomass,

productivity of cladocerans and copepods was increased

Eutrophication trend in Sevan

whilst the opposite in Lake Kinneret

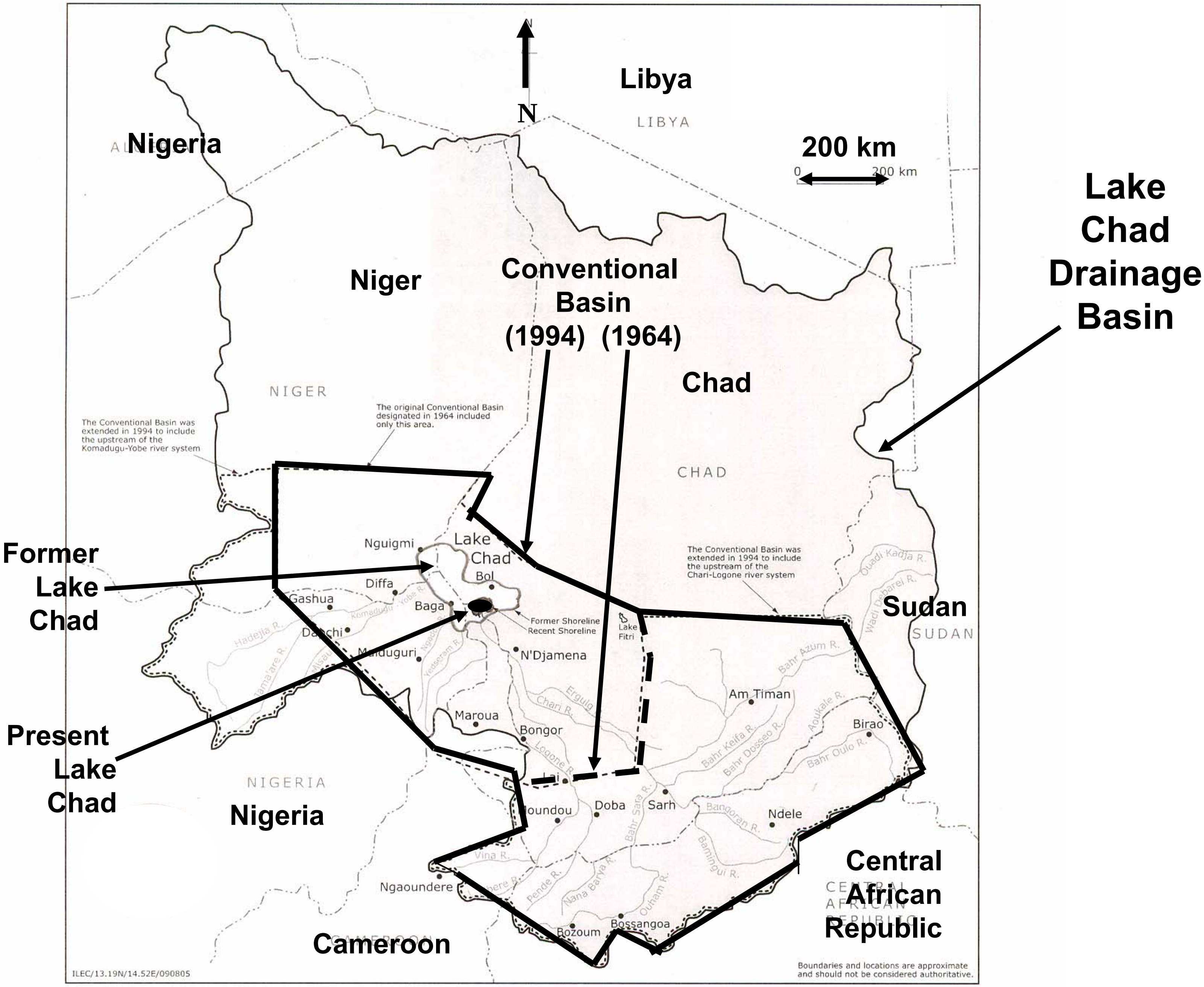


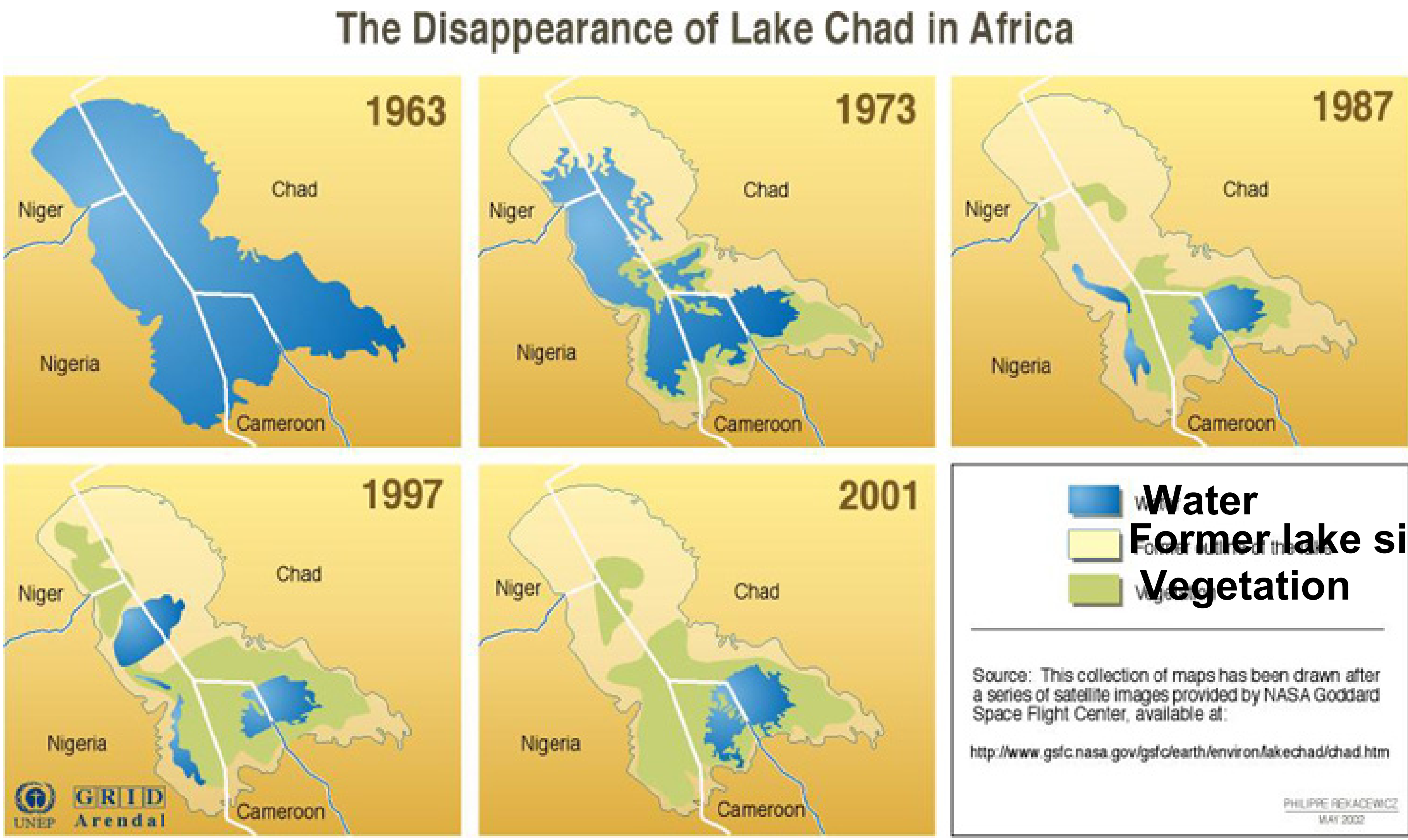
Figure 1. The Lake Chad Drainage and "Conventional" Basins.

Limnological parameters of Lake Chad WL was 281.5 m altitude (1972)

Basin	Water Surface (km2)	Depth (m)	Secchi Depth(m)	Conductivity(mS)	Volume ($10^9 m^3$)	Annual Renewal(%)
Northern	8299	4-8	0.4-0.8	0.2-1.5	47	40
Southern	8476	2-4	0.1-0.35	0.05-0.65	25	85

Deepest point was 10.5 m.
Present mean depth – 1.5m.
No outlet
Surface altitude 280 MASL.
The lake was nearly dried in 1908 and 1984.

Lake Chad was one of the largest lakes in the world (Survey started 1823)
Water over utilization
Damming and irrigation
Over-garzing, accompanied by desertification and vegetation decline
Climate change (rainfall decline)



1960 – 26000 km2, 2000 – 1500 km2, Prediction of Disappearance within 21 years. Proposals to divert waters from adjacent rivers.

Lake Chad in 1930

Two lake Chad sizes were observed:

Size	Mean depth	Surface(km^2)	Period
Big	4m	20-25000	1850-1900
Little	1.5m	12000	1908-1915
			1972-1977

Drainage Basin $2.5\ 10^6\ km^2$

Air temperature 29-320C

warm season

$22\text{-}24^0$C cool period

High Evaporation 2050-2250 mm/y

Rainfall season July-September:

500 mm/y –southern part and

250mm-northern part

Topographically flat area therefore

minor climatic change cause

significant change of water surface

Inlets: Chari-Logon, $40km^3/y$ and

El Beid river 1.4 km^3/y

Direct rainfall 2.7 – 8.7 km3/y

Total inputs: 23 – 61.4km3/y

87%-rivers, 13% - rainfall

No outlet

92% of output-evaporaqtion, 8% -infiltration

Daily changes of thermal stratification

1974-75 reduced WL and surface

vertical homogeneity only in winter

with zero DO and in summer

anoxic hypolimnion.

Lake Chad October 1968 (Apolo 7)

Droughts followed by declined WL
In early 1970's divided the lake
into three shallow water bodies
Followed by massive fish killing
Due to sediment re-suspension
And lack of DO.
After the 1974' s floods
vast area of vegetation
was inundated
and organic matter decomposition
consumed DO causing disastrous
massive fish killing.

When the lake was very shallow
The bottom was colonized by
molluscs
Further lowering of WL (1968-
1972)
caused diminishing of the
molluscs bottom population

Main Inlets: Chari-Logon, 40km^3/y
and El Beid river 1.4 km^3/y
Direct rainfall 2.7 – 8.7 km^3/y
Total inputs: 23 – 61.4km^3/y
87%-rivers, 13% - rainfall

Lake Chad

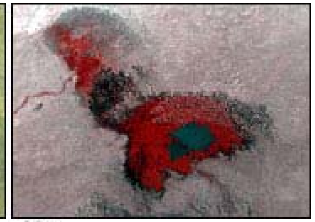
1973

1973

1987

1987

1997



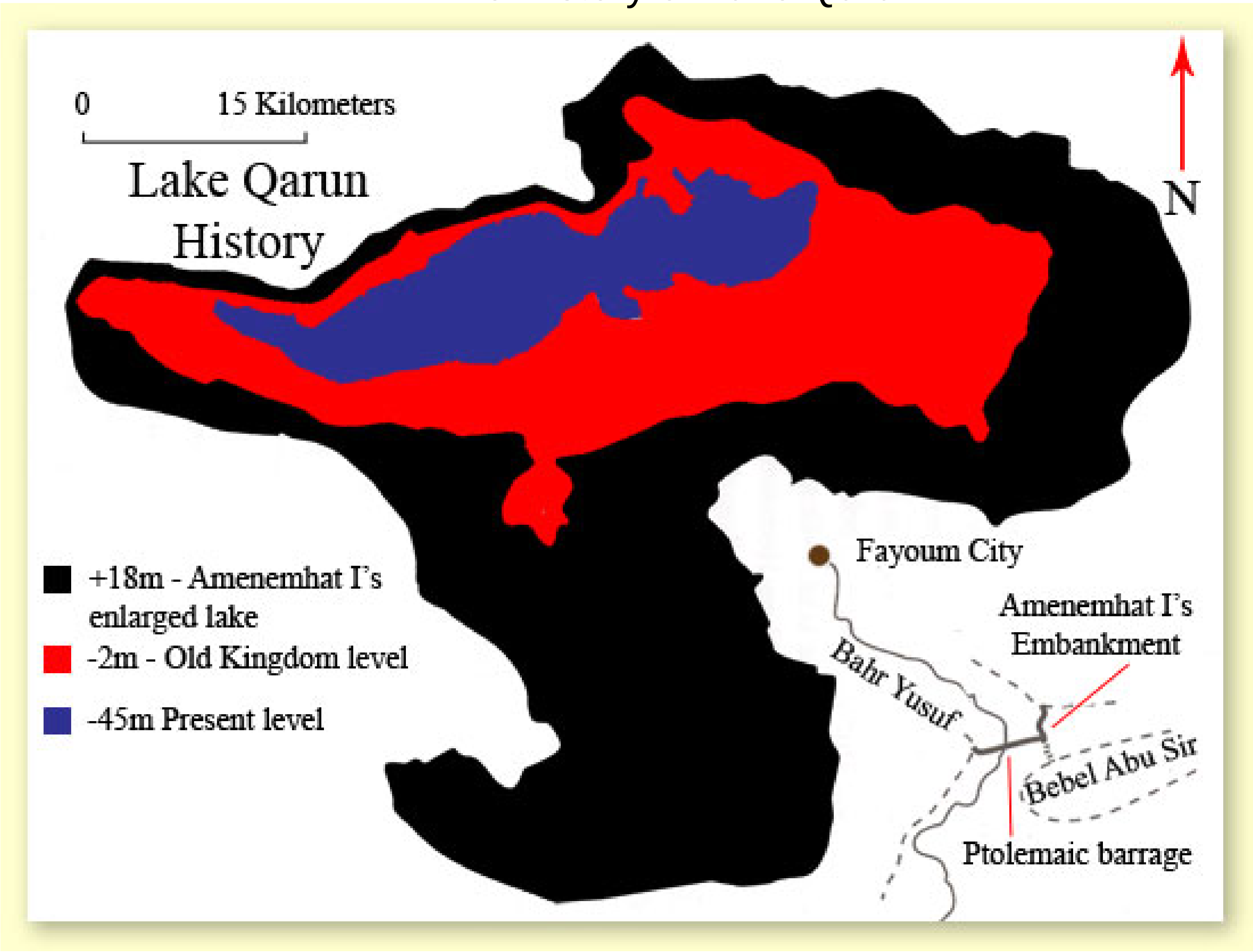
1997

2001

2001

No outlet
92% of output-evaporation,
8% of output -infiltration
Daily changes of
thermal stratification
1974-75 reduced WL and surface
vertical homogeneity
only in winter
with zero DO and
in summer
anoxic hypolimnion.

The History of Lake Qarun



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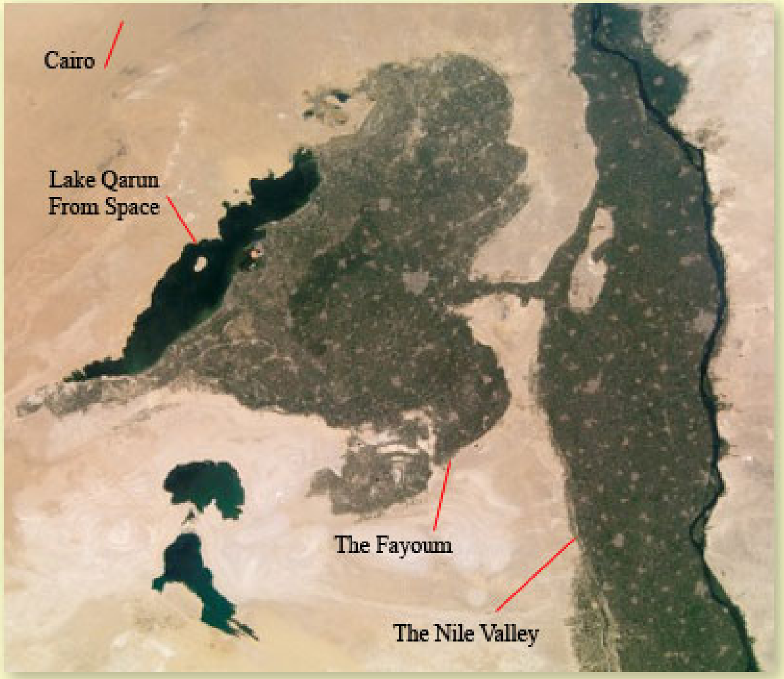
Lake Qarun and Fayum Depression from Space



The only lake in Egypt
Located in a depression
in the Lybian Desert
Separated from the Nile Valley by a ridge
Connection to the Nile by Hawara canal
Vestige of the larger Lake Moreis
Surface area 200 km^2
Two basins: Eastern, shallow, 1-5 m deep
Western 2-8.5 m deep
Water inputs from agricultural drainage:
350 mcm/y carrying 430000 tons of salts
And unknown volume of
underground income
Evaporation 455 mcm/y
Surface temperature 10-32^{0}C
Negligible Rainfall
Not stratified

Lake Qarun

Salt concentration increase:

1901-13.4 ppt
1919 – 1923- 18 ppt
1934 – 23.4 ppt
1953-1955- 30.6 ppt
1974-76-30.9-34.5 ppt

Alkalinity($CaCO_3$) 200 ppm
High DO concentration from surface to bottom
High NO_3 and P-PO_4Benthic fauna-molluscs

Lake Qarun

The lake was part of human culture history during about 8000 years
Presently utilized for food production and tourism


太湖周围
The Vicinity of Taihu Lake
无锡
Wuxi
Yu Shan
Changshu
Yangjian
Xishan
Qinbo's Tomb
Liyuan
Heqiao
Yifeng
104
312
204
虎丘
Huqiu
Weitang
Yixing
Shanjuan Cave
苏州
Suzhou
Weiting
Linggu Cave
Muli Cave
Taihua Shan
Lake
Tai Hu
Wujiang
Chuihong Bridge
Pingwang
Taipu
He
Changxing
湖州
Huzhou
318
Zhenze

Lake Tai Hu: Limno-Ecological-Socio-Economical Deterioration in the Tropical Dry Climate

In spite of ten years of treatment costing billions of yuan, the pollution in Taihu Lake continues to worsen. The 33.5 million people living around Taihu will probably have to wait another decade to drink clean water from the country's third-largest freshwater lake.

Covering an area of 2,338 square kilometers in east China, Taihu Lake is a major source of drinking water for people living in Shanghai and east China's Jiangsu and Zhejiang provinces.

The Taihu Lake basin accounts for about 3% of the country's land area and 8% of its population. Historically a rich and fertile area, it has become one of the most populated and prosperous regions in the country.

But tremendous economic growth and the huge population of the area are putting the lake under increasing environmental pressure, resulting in deteriorating water quality.

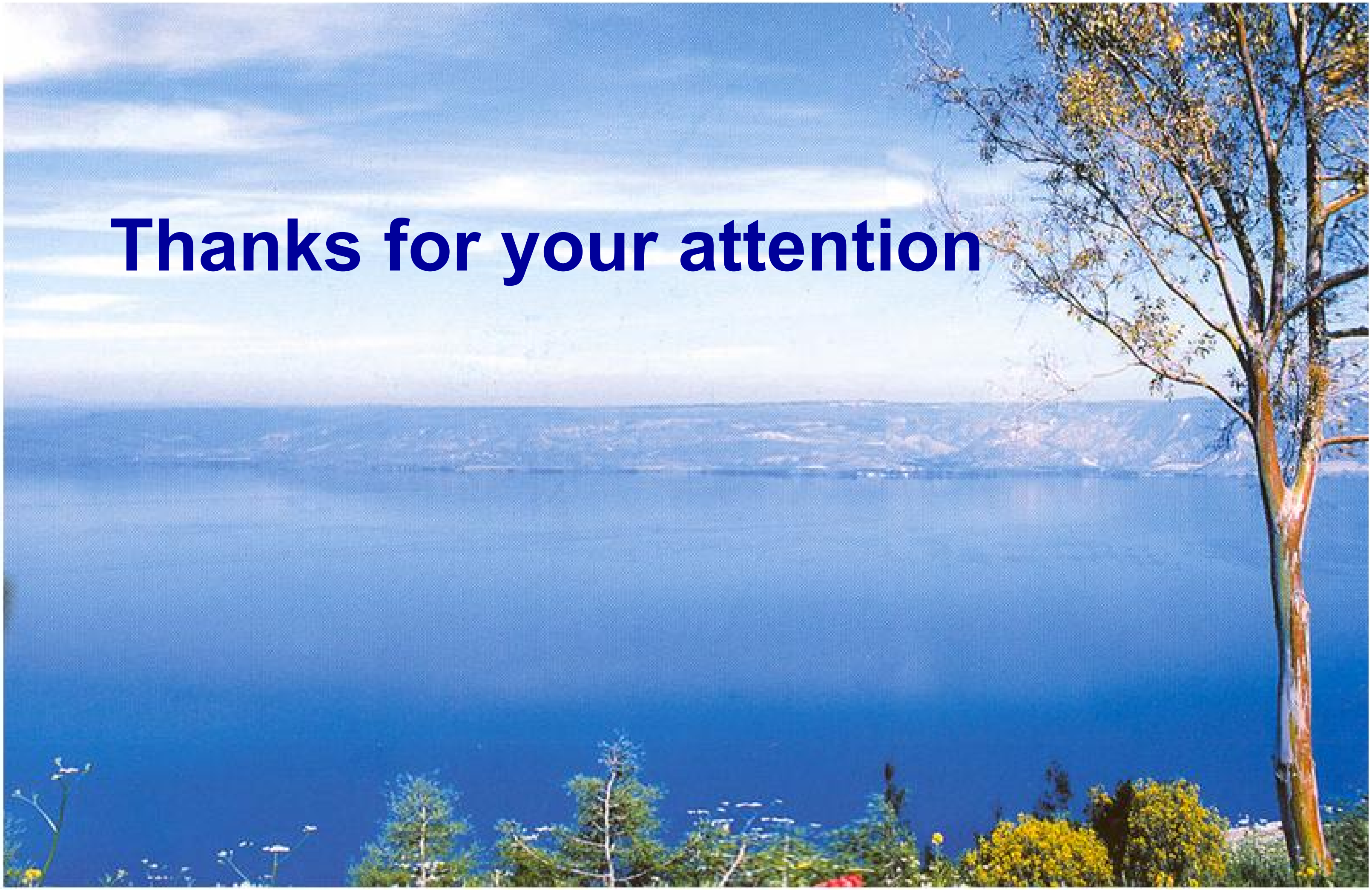
Limnological parameters of Lake Tai-Hu (China) and Lake Kinneret (Israel):

Parameter	Tai Hu	Kinneret
Surface Area (km^2)	2338	170
Depth(m): Max.	2.6	44.0
Mean	1.9	26.0
Volume (km^3)	4.3	4.0
Residence Time (month)	5	60
Secchi Depth (m)	0.15-1.0	0.2-7.1
Stratification	daily slight	9months stable
Temperature (0C)	2.9-29.9	14-28
Fishery and Aquaculture (Kg/ha)	56(fish,crustaceans)	108(Fish)
Watershed area (km2)	34207	2730
Population density (Ind./km^2)	1052	~75
Agricultural area (% of Watershed)	40	<10
Industry (factories)	~2800	~50(no metallurgy)
Blue-Green algae	Severe	Moderate
Trophic status	Hypertrophic	Meso-eutrophic
River inflows(km^3/y)	8.0	0.5
Direct Rain(km^3/y)	2.922	0.07
TP (ppm)	0.2- 0.8	0.08-0.01

Summary

Lake Management is dependant of the following:
1) Water supply demands (agriculture, domestic, drinking etc.)
2) Limnological characteristics of the lake
WL changes in lakes cause different outcomes.
Each lake response to WL fluctuations by its own typical conditions
The outcome of WL changes is not only a matter of dimensions and generalization of processes is incorrect.
Shallow lake responses to climate changes is more significant than those of deep lakes.
WL fluctuations are accompanied by higher amplitude of response ranges than those of deeper lakes.
A lake is not a simple water reservoir and when hydrology modified consequent changes of the limnological features are predicted.
Lakes are an eco-systems composed of many compartment, chemical, biological, microbiological and physical, all are affected and must be considered for a comprehensive analysis of WL decline.
Similar anthropological changes of initiate different response of lakes, therefore each one of the systems should be analyzed individually And overlap is uncommon.

Lake Kinneret was exposed to drought (natural climate change), and exceptional WL decline was operated to ensure domestic water supply Changes within the ecosystem did not deteriorate water quality.
Lake Sivan: High amplitude of anthropogenic changes were operated and water quality was deteriorated and water supply was interfered.
Lake Qarun is a desert body of water and all changes were anthropogenic Aimed successfully at fishery and tourism but un-controlled salinization process.
WL in Lake Tai Hu was not highly fluctuated but nutrient dynamics severely enhanced causing an extreme water quality deterioration. The Chinese lake supply drinking water therefore pollution is very significant
Similarly, drinking water supply from Lake Kinneret is crucial and lowered WL impact on quality was not significant.
This conference issue of the Aral Sea is the best presentation of negative impact of WL decline on the environment and human welfare scoped as real disaster .
Lake Kinneret and Lake Qarun exemplify the “welfare” concept.
Lake Chad and Aral Sea represent the “disaster”case.
Lake Tai Hu disaster is the outcome of anthropogenic pollution.


Thanks for your attention