monitoring a newly re-born patient:
water quality and cyanotoxin
occurrence in a reconstructed shallow Mediterranean lake

Lake Karla

ancient lake

Homer (8th century BC)

And with him there followed forty black ships. And they that dwelt in Pherae beside the Lake Boebeïs, and in Boebe, and Glaphyrae, and well-built Iolcus, these were led by the dear son of Admetus with eleven ships, even by Eumelus, whom Alcestis, queenly among women... [Iliad, II.715]
Lake Karla

before 1950

- level fluctuations
- flooding in the area
- reduced catches
- need to control malaria
- need for more farmland

“measurements”

max depth 5.5m

180 km²

40 km²
Lake Karla

completely dried by 1962

- rapid decline of the aquifer
- penetration of the seafront in the aquifer area of Karla
- pollution and impacts on the nearby closed Pagasitikos bay
- cracks and buildings’ destructions in neighboring areas
- impact on fauna and flora
- changes in the area’s microclimate
- city water supply weakness
Lake Karla [newly reborn]

decision to re-habilitate the lake

- series of works to collect water from adjacent river, stormwaters etc
- flood protection of lowland regions
- works to promote the lake functions as a wetland
- creation of plant ecosystems around the lake
Lake Karla

unique example – at European scale:
• shallow lake ecosystem dried in 1960s
• currently undergoing re-construction
  phase for establishing a ‘new’ ecosystem
Lake Karla [newly reborn]

• considered a vital aquatic ecosystem, in terms of biodiversity

• listed in the network of the Greek protected areas

Natura site GR1420004
Ramsar site
Special Protected Area site for birds
Lake Karla [patient]

heavy agricultural and industrial land uses

sink of fertilizers and agricultural effluents
Lake Karla [patient]

extensive water blooms
[Oikonomou et al. 2012, Scientific World J]

fish mortalities
[Papadimitriou et al. 2013, Sci Tot Environ]

cyanotoxins
[Gkelis and Zoutsos 2014, Toxicon]
monitoring programme

✓ Implement a system for scientific monitoring to assess the state of Lake Karla
✓ Water-quality parameters database
✓ Assessment of the effects and risks of pressures on degradation of water quality
✓ Suggestions for rational water resources management at catchment level
✓ Reference values of selected monitoring parameters taking into consideration the WFD
monitoring programme

- hydrogeology
- physico-chemical parameters
- phytoplankton
- cyanotoxins [MCs-CYNs-STXs]
- benthic macro-invertebrates
- fish

[July 2013-July 2015]
sampling plan

seasonal sampling: 6 samples per year [July 2013-July 2015]

4 sampling stations
Kalamaki Reservoir

0.5-0.8 m

Lake Karla

0.8-1.4 m
physicochemical parameters
phytoplankters [biomass]

cyanobacteria dominance

Biomass (%)

- Cyanobacteria
- Eukaryotic algae

2013
2014
2015
phytoplankters

Nostocales dominance

- Nostocales
- Synechococcales
- Oscillatoriales
- Chroococcales
- eukaryotic algae

Biomass (%)

DIN/SPR ratio

Nostocales dominance over time:
- July 2013: 100%
- September 2013: 80%
- November 2013: 60%
- February 2014: 40%
- May 2014: 20%
- July 2014: 0%

Eukaryotic algae also show a decrease in dominance during the same period.
phytoplankters

[Biomass]

**Anabaenopsis elenkinii**
**C. raciborskii**
**Dolichospermum spp.**
**Sphaerospermopsis**

**Microcystis aeruginosa**
**Planktothrix agardhii**
**Aphanizomenon sp.**

Biomass (mg L⁻¹)
phytoplankters

[biomass]

Sphaerospermopsis

Anabaenopsis elenkinii
C. raciborskii
Dolichospermum cf. smithii
Planktothrix agardhii
Microcystis aeruginosa
Lyngbya sp.
Nitzschia sp.

Aphanizomenon sp.
Dolichospermum spp.
Dolichospermum cf. smithii
Anabaenopsis elenkinii
Cylindrospermopsis raciborskii
Limnothrix redekei
Lyngbya sp.
Microcystis aeruginosa
Microcystis flos-aquae
Monoraphidium sp.
Nitzschia sp.
Planktothrix cf. agardhii
Pseudanabaena limnetica
Scenedesmus sp.
Sphaerospermopsis aphanizomenoides
Tetrastrum sp.
cyanotoxins

[cell bound-ELISA]

MC

CYN

STX

CHARTS:
- MC (mg L⁻¹) from 2013 to 2015
- CYN (mg L⁻¹) from 2013 to 2015
- STX (mg L⁻¹) from 2013 to 2015

LOCATION:
- KK
- KL2
- KL1
- KL3

DATA:
- July, August, September, November, February, May, July
cyanotoxins
cylindrosperrmopsins

*Sphaerospermopsis aphanizomenoides*?
cyanotoxins

saxitoxins

Aphanizomenon sp.

Biomass (mg L$^{-1}$)

STX (μg L$^{-1}$)

July 2013
Sep 2013
Nov 2013
Feb 2014
May 2014
Jul 2014

Jul 2013
Sep 2013
Nov 2013
Feb 2014
May 2014
Jul 2014
future work: strains

Strains isolated

- *Limnothrix redekei*
- *Planktothrix agardhii*
- *Pseudanabaena*
- *Synechococcus*
- *Microcystis*
- *Radiocystis*
- *Anabaena/Dolichospermum*
- *Anabaenopsis elenkinii*
- *Sphaerospermopsis aphanizomenoides*
- *Cylindrospermopsis raciborskii*
conclusions

✓ Lake Karla is exposed to pollution sources leading to a progressive eutrophication
✓ cyanobacteria dominate Lake Karla throughout the year
  N₂ fixing- N:P ratio
✓ cyanotoxins co-occur
✓ *Aphanizomenon* species potential STX and/or CYN producers
✓ water quality related problems expected
acknowledgments

Management Body of Lake Karla

Omicron Ltd

Manthos Panou
Nikos Zaoutsos