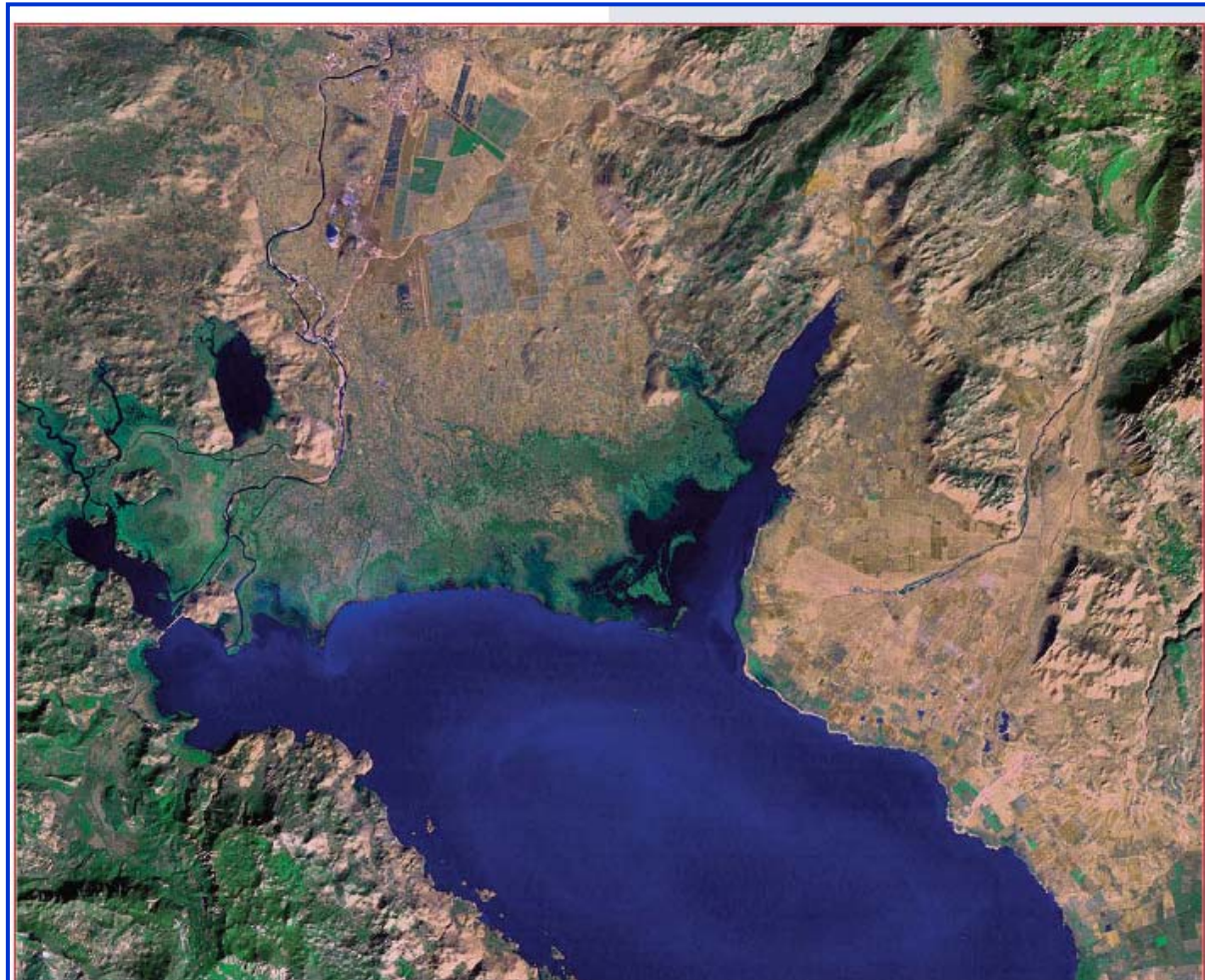


Interdisciplinary assessment of water resource management in two transboundary lakes in SEE



Andrej Perović
University of Montenegro
Department of Biology
E-mail: aperov@cg.yu

www.drimon.no

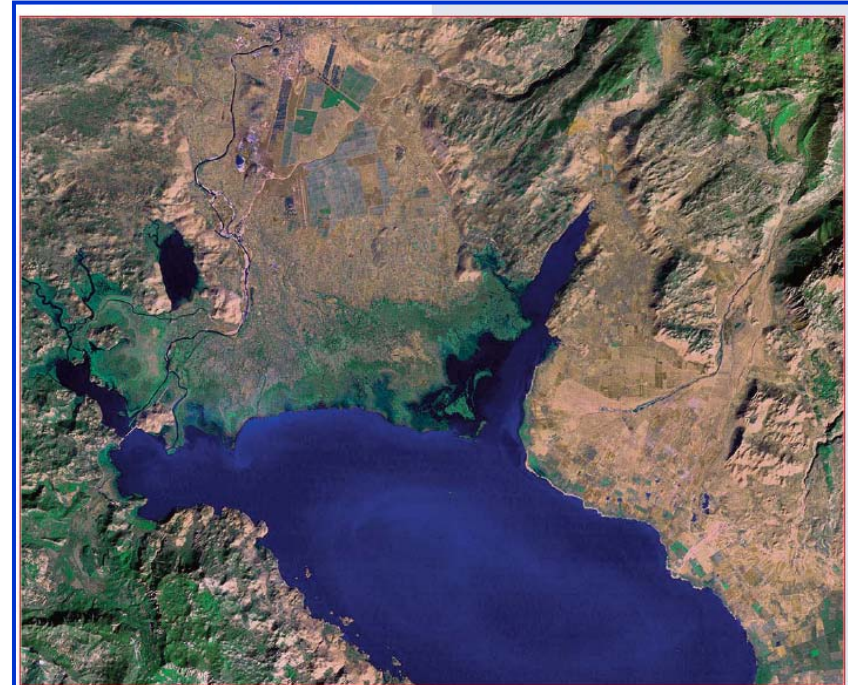


Bioforsk

Lake Skadar/Shkodra – environmental state and challenges

- ✓ Skadar Lake is situated in the Zeta-Skadar Valley. Its position is defined by the following coordinates: $19^{\circ} 03'$ and $19^{\circ} 30'$ eastern longitude and $42^{\circ} 03'$ and $42^{\circ} 21'$ northern latitude.
- ✓ The Bojana River links it with the Adriatic Sea. (This is the area of an old gulf which receded into the deepest part of the basin after the Taraboš Mountain surfaced and the Bojana River formed. It emerged as a lake from surging river waters).
- ✓ Skadar Lake is bordered by Zeta valley on the north and the mountains: Lovćen, Sutorman, Rumija and Taraboš, to the south.

Territorially, the Lake belongs to the municipalities of Podgorica (the capital Podgorica and town municipalities Tuzi and Golubovci), Bar and Cetinje (Montenegro) and Malesia, Madhe , and Skadar (Albania).
- ✓ Skadar Lake is the largest lake in the Balkans. The surface of the lake varies from **354 km²** when the water level is **4.71 meters** of altitude, to **505.8 km²** when the waters reach **10 mmm**. At the highest level, lake depth is over **12 meters**, while at the lowest, **8 meters**.



Environmental pollution

- ✓ **Most pollution of surface water, groundwater, soil and air in the basin originate from Podgorica, situated on the **Moraca River** terraces in the **Zeta Plain**. On Albanian side the main polluter is the City of **Shkodar** with its solid waste and wastewater. The main sources of pollution are:**

- ✓ **The biggest sources of pollution are:**
 - 1. The Aluminums Plant**
 - 2. Steelworks in Niksic**
 - 3. Wastewater from the cities and towns in the basin**
 - 4. Municipal wastes from the cities in the basin**
 - 5. Mineral waste oils in the Zeta Plan**

Past researches and data sources

- ✓ In the 1981 was done the first broad study overview of environmental data on Skadar Lake. This study serves today as the basis for evaluation and dynamic changes in lake status during the years.
- ✓ Comparison with newest data presented in this report show that during the past three decades the lake and its basin have experienced varying states of pollution. Water quality in the lake varies in space and time.
- ✓ Most pollutants are brought by the **Moraca and Crnojevica Rivers** that are common places of disposal for poorly treated wastewater and even solid waste.
- ✓ Significant research in ecology and eco-toxicology state of Skadar Lake were performed in 2001-2007 by Join cooperation of Uiversities of Montenegro, Skadar/Shkodra and Heidelberg. (**EULIMNOS project-founded by HRK**)
- ✓ Year monitoring of water quality done by CETI, Hydrometeorological Institute and Hygiene Institute.

PROJECTS 2001-2006

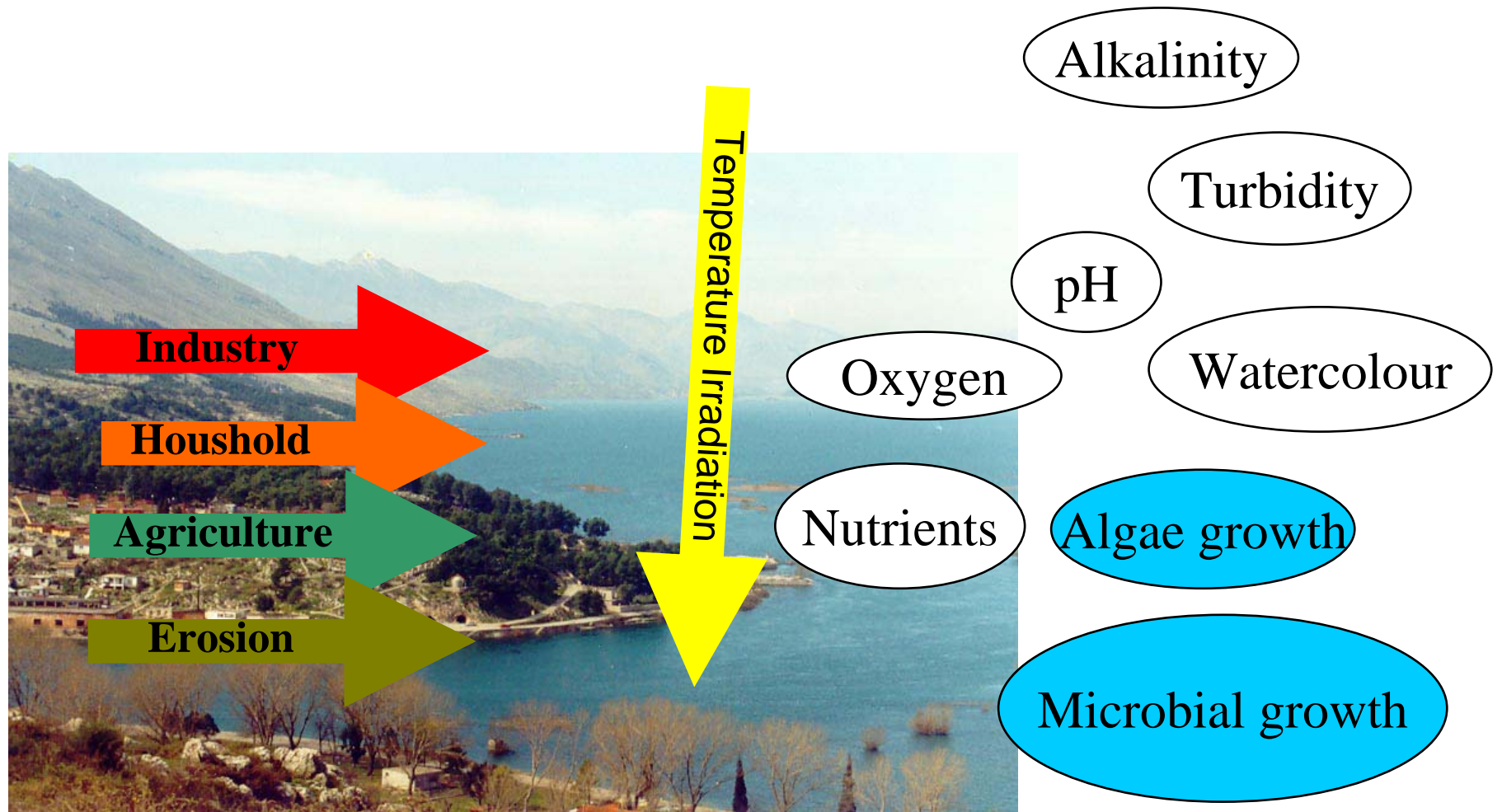
- ✓ Umbrella Project
Monitoring of several sampling sites on both sides of the lake for basic chemical and microbiological Parameters.

- ✓ Biological monitoring of Fauna and Flora
Taxonomic studies on biodiversity of algae, macrophyts, fish, and other species.

- ✓ SPMD Project
Development and application of innovative sampling methods for bioavailable compounds.

- ✓ Triad Project
Integrative assessment of water and sediment quality at selected sites on the lake.

Lake monitoring DRIMON



Eutrophication process

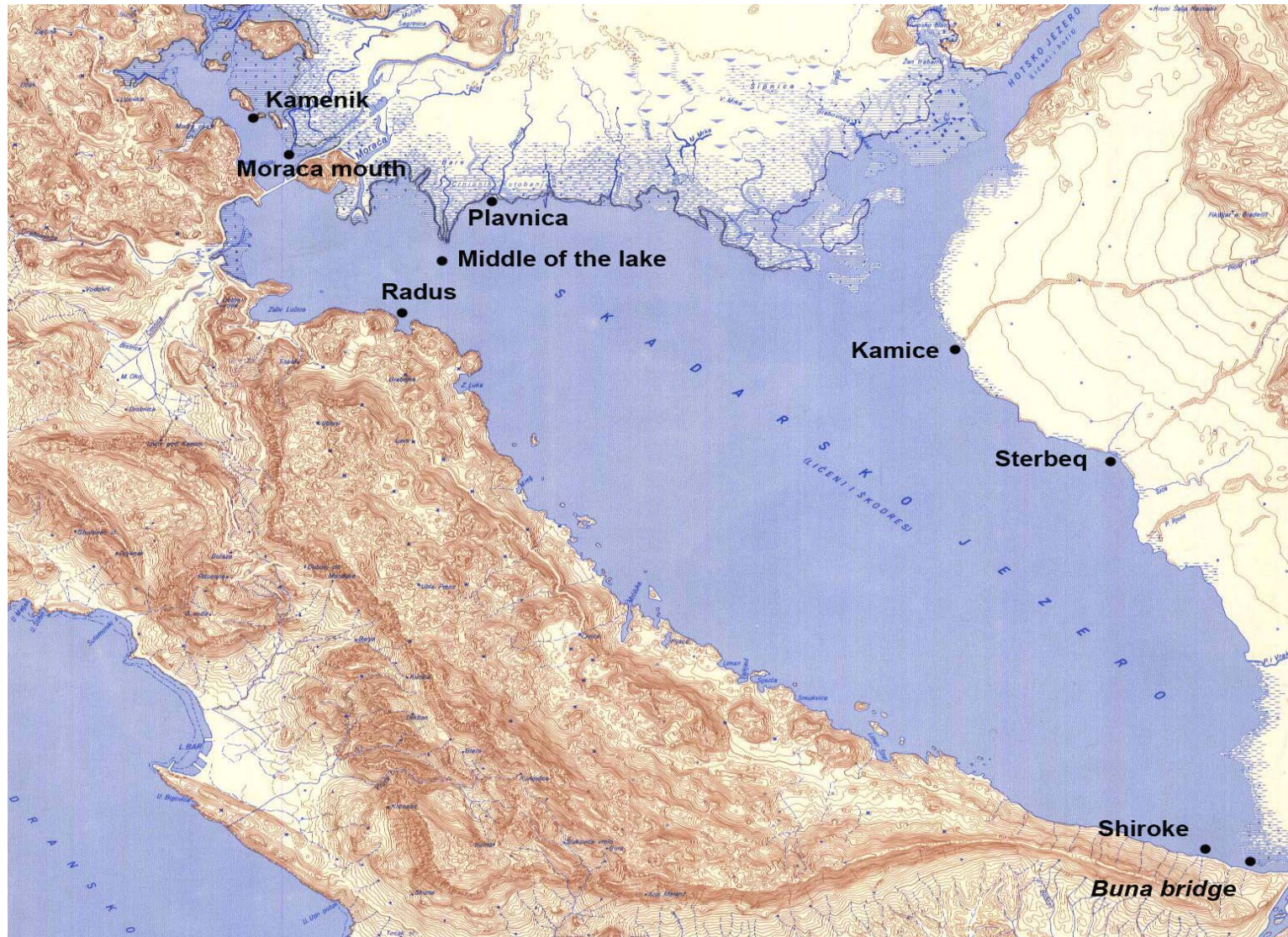
Eutrophication is the process by which lakes are enriched with nutrients, increasing the production of rooted aquatic plants and algae.

The extent to which this process has occurred is reflected in a lake's trophic classification or state:

- ✓ **oligotrophic** - nutrient poor and low productivity; high transparency (deep secchi depth), low chlorophyll-a, low phosphorus
- ✓ **mesotrophic** - moderately productive; intermediate clarity, chlorophyll and phosphorus concentration
- ✓ **eutrophic** - very productive and fertile; low clarity/shallow secchi; high chlorophyll and phosphorus concentrations.
- ✓ **hypereutrophic** - extremely productive with noxious surface scums of algae



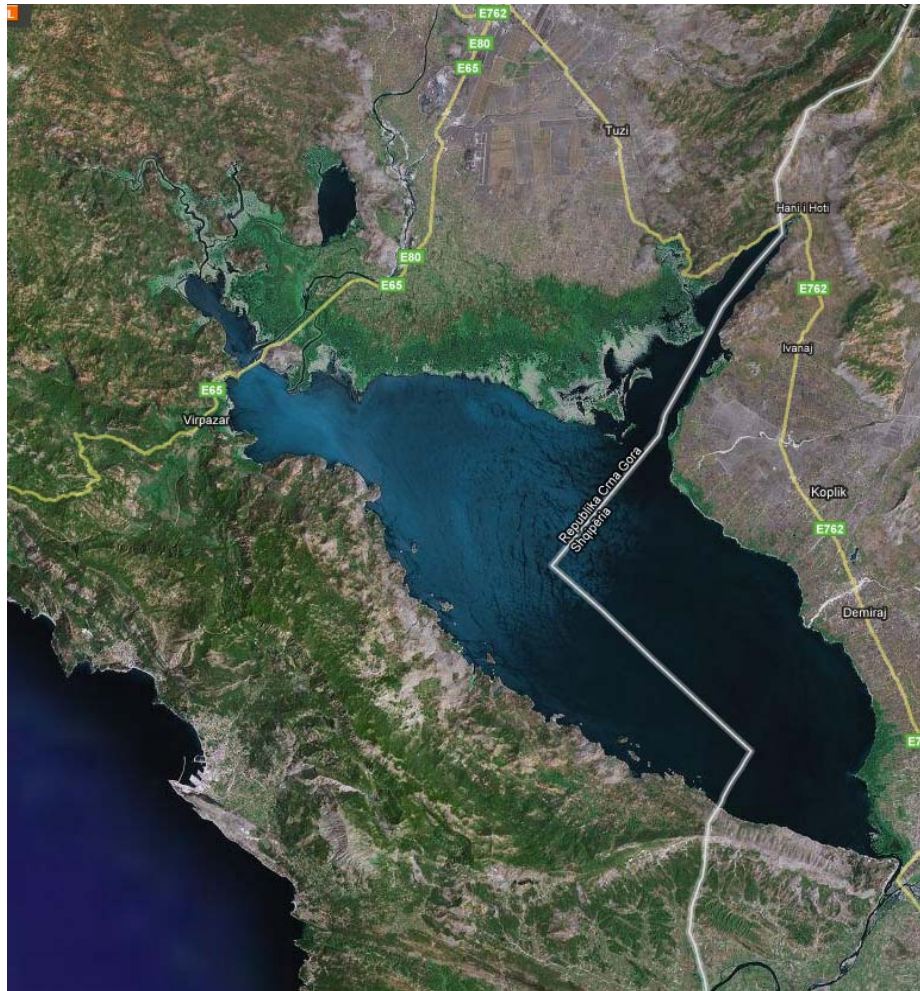
DRIMON LAKE DATE 2007-2008



www.drimon.no



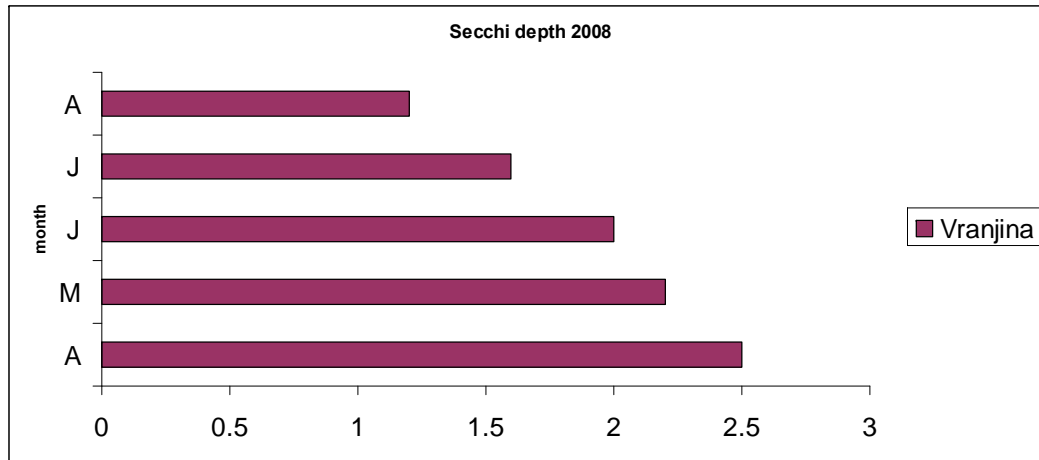
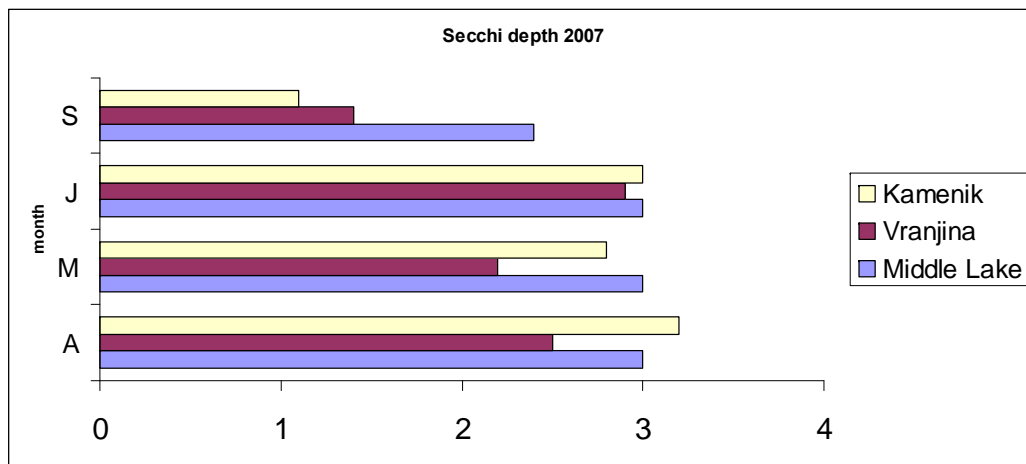
Eutrophication process from 2007-2008



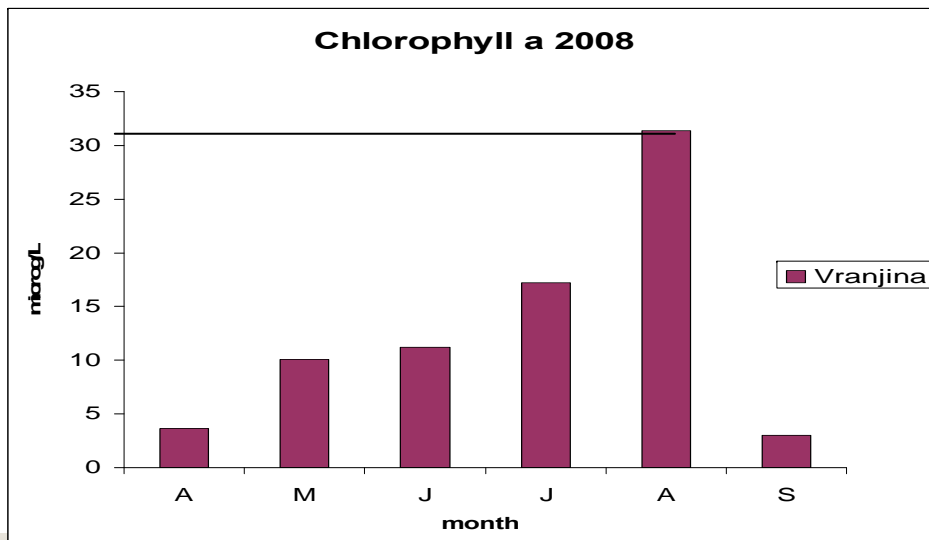
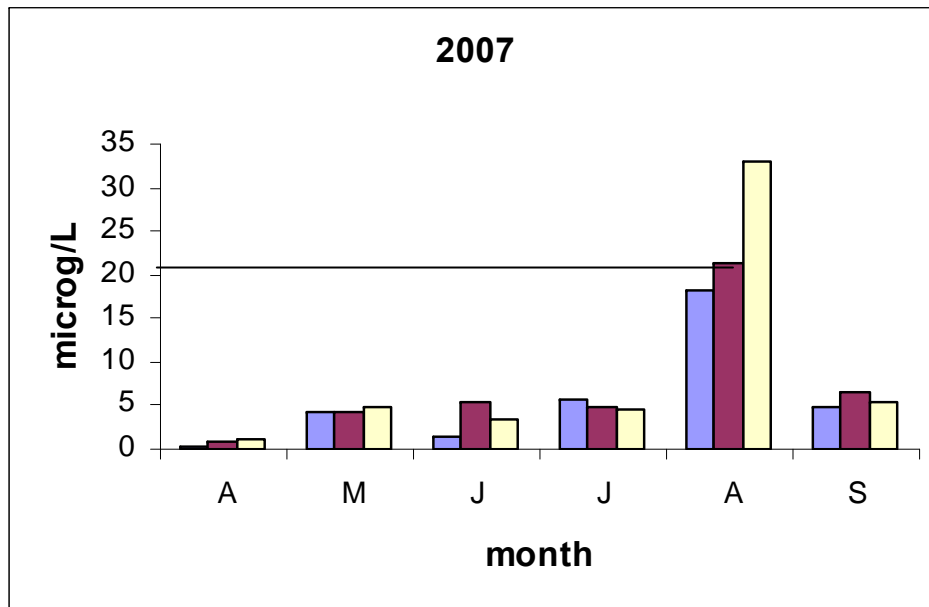
Monitoring

- ✓ Secchi depth
- ✓ Chlorophyll a
- ✓ Algae growth
- ✓ Suspended Matter
- ✓ Nutrients: Total P and Total N
- ✓ Trophic State Index (TSI)
- ✓ Lake grades (Temp., Ph, O₂)

Secchi depth 2007-2008

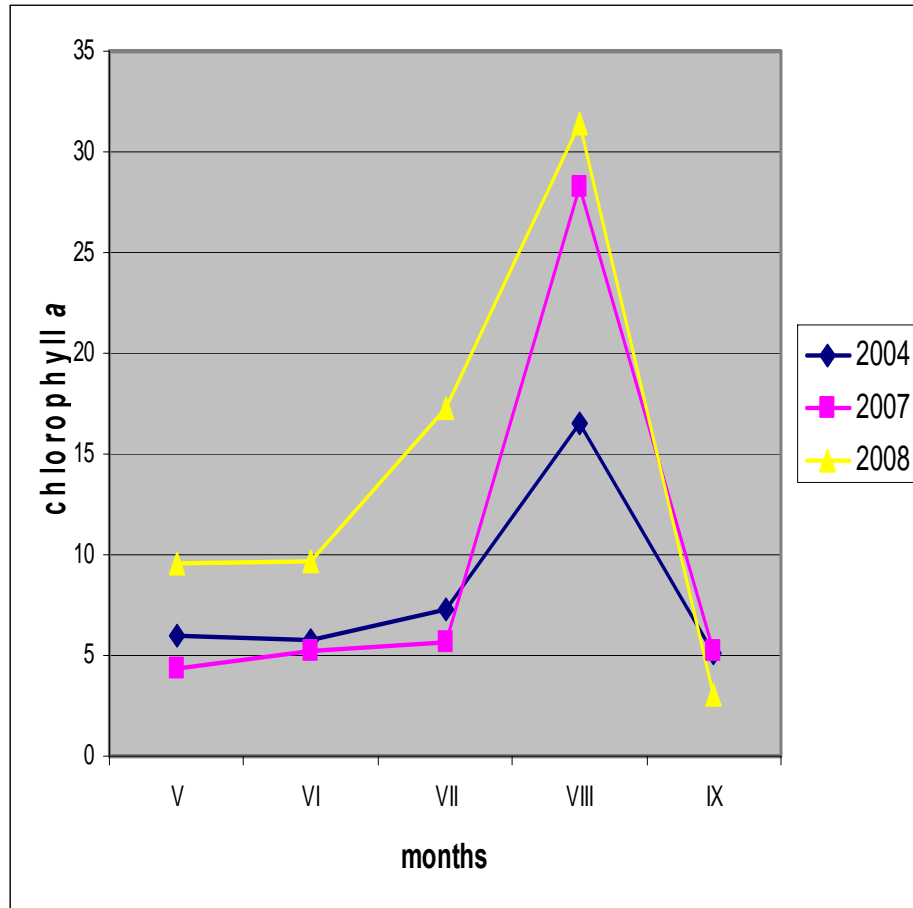


Chlorophyll a 2007-2008



- **Chlorophyll a** concentration during warm period of year (May-September) was between 3.1 and 33.1 $\mu\text{g/l}$, with average (for that period) of $8.5 \mu\text{g/l}$ and with highest values in August (monthly average for August 24.1 $\mu\text{g/l}$). Average chlorophyll a concentration (for investigated period) of $8.5 \mu\text{g/l}$ show that during warm period of year 2007. Skadar lake was on eutrophic level.
- But if we consider monthly chlorophyll a concentrations separately, recorded values indicated **mesotrophic** conditions for all months, except in August – **eutrophic** conditions (OECD, 1982).
- Values were between 3.02 and 31.37 $\mu\text{g/l}$, with average concentration 14.64 $\mu\text{g/l}$ and highest concentration was recorded in August 31.37 $\mu\text{g/l}$. These results show that during whole warm period of year 2008. Skadar lake was on **eutrophic level**.

Trend chlorophyll a monitoring

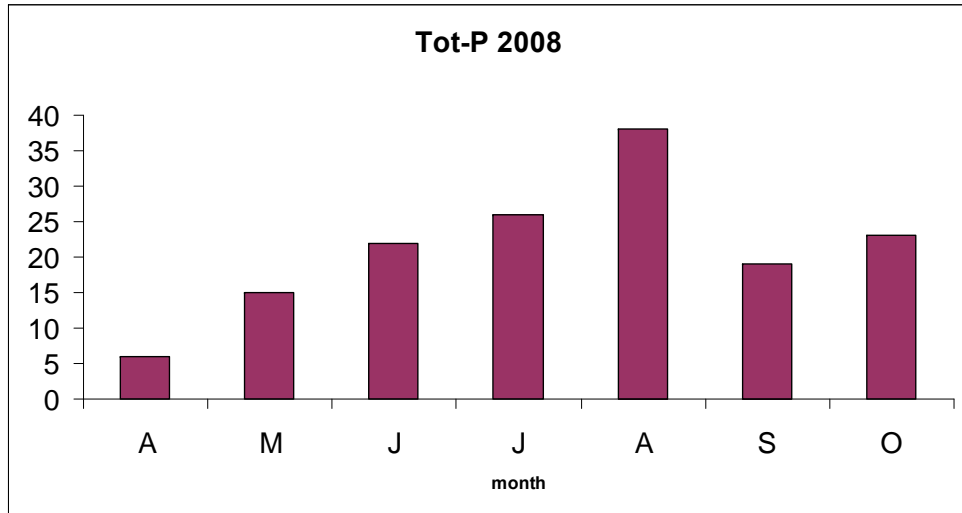


Chlorophyll a concentration ($\mu\text{g/l}$) in Skadar lake during warm period of year (May-September) in different years: 2004, 2007 and 2008.

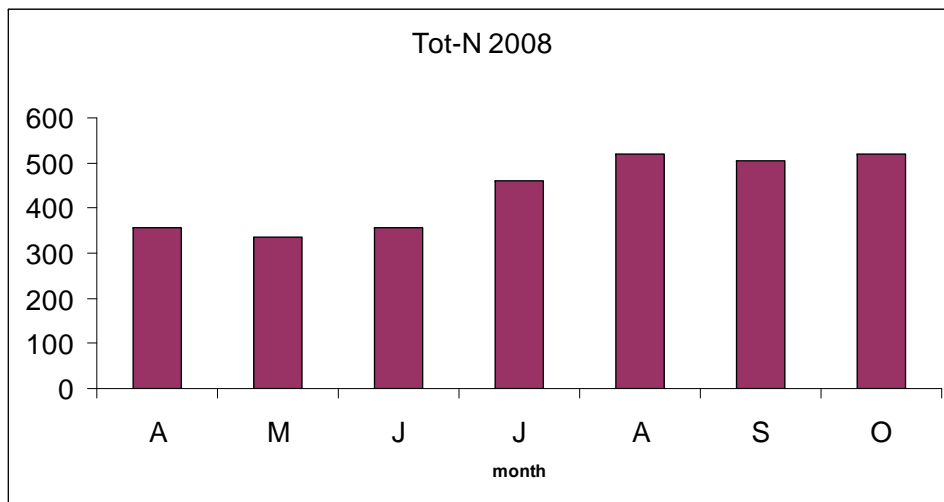
If we summarize results from 2004, 2007 and 2008 there can be made some general conclusions:

- Chlorophyll a concentration was in range: **0.15 - 39.78 $\mu\text{g/l}$**
- Generally, open part of Skadar Lake (Middle lake) had lower chlorophyll concentration than shallower more or less littoral parts. I was domination of small diatoms in phytoplankton community during whole period of investigation.
- Average concentration of chlorophyll a ($8 \mu\text{g/l}$) ranks Skadar lake as **meso-eutrophic** (OECD, 1982).
- Trophic level of Skadar lake changes depending on season
- Warm period of year (April – September) had average chlorophyll concentration of $10 \mu\text{g/l}$, with highest concentration in August (August monthly average **23.98 $\mu\text{g/l}$**), which indicates that generally during warm period of year Skadar lake is on eutrophic level
- If we compare chlorophyll a concentrations of investigated years (2004, 2007 and 2008), we can conclude that concentration increased, especially during 2008

Nutrients Tot-P and Tot-N

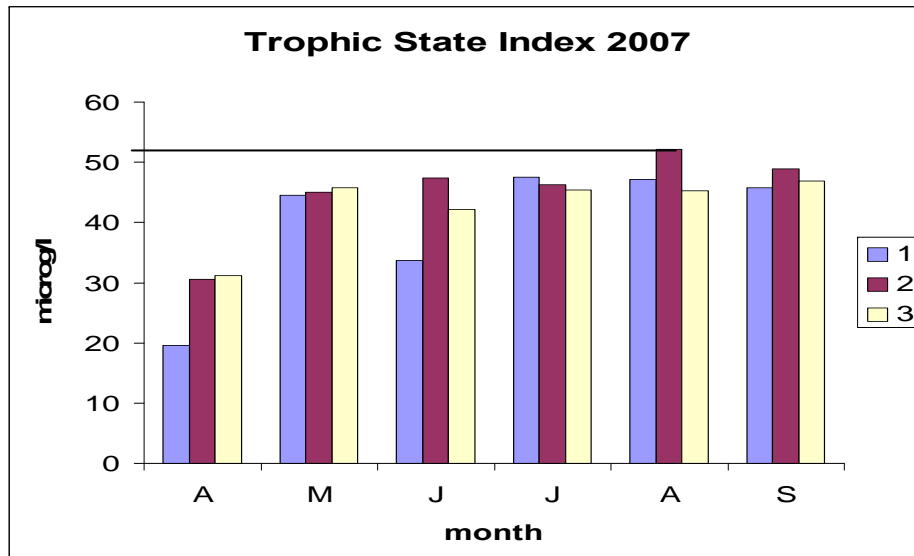


The concentration of total phosphorus was less than **50** micro g/l P, in all measurement points. The maximum we measured in August (38 mg/l).

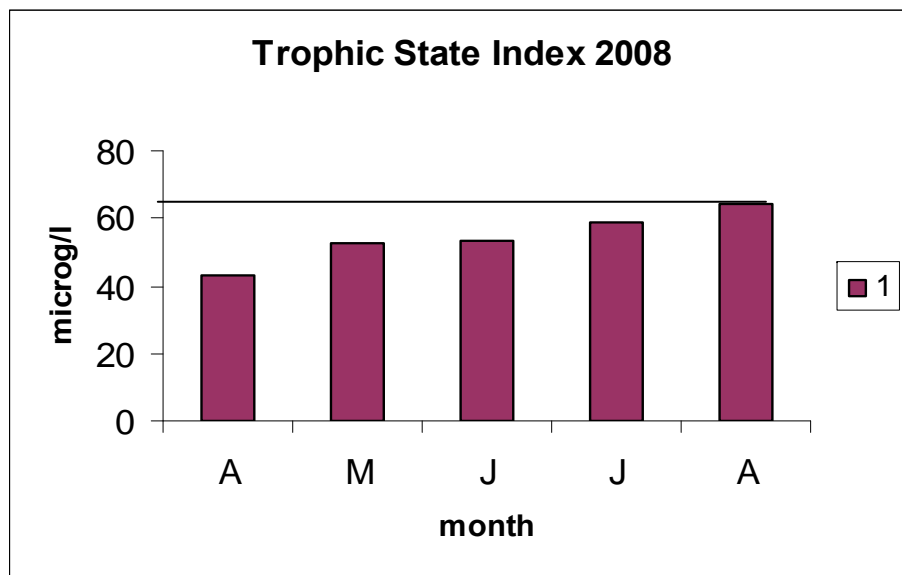


The concentration of Tot-N was ranged from 300-600 mg/l. The maximum we measured in August (520 mg/l).

Trophic State Index (TSI)

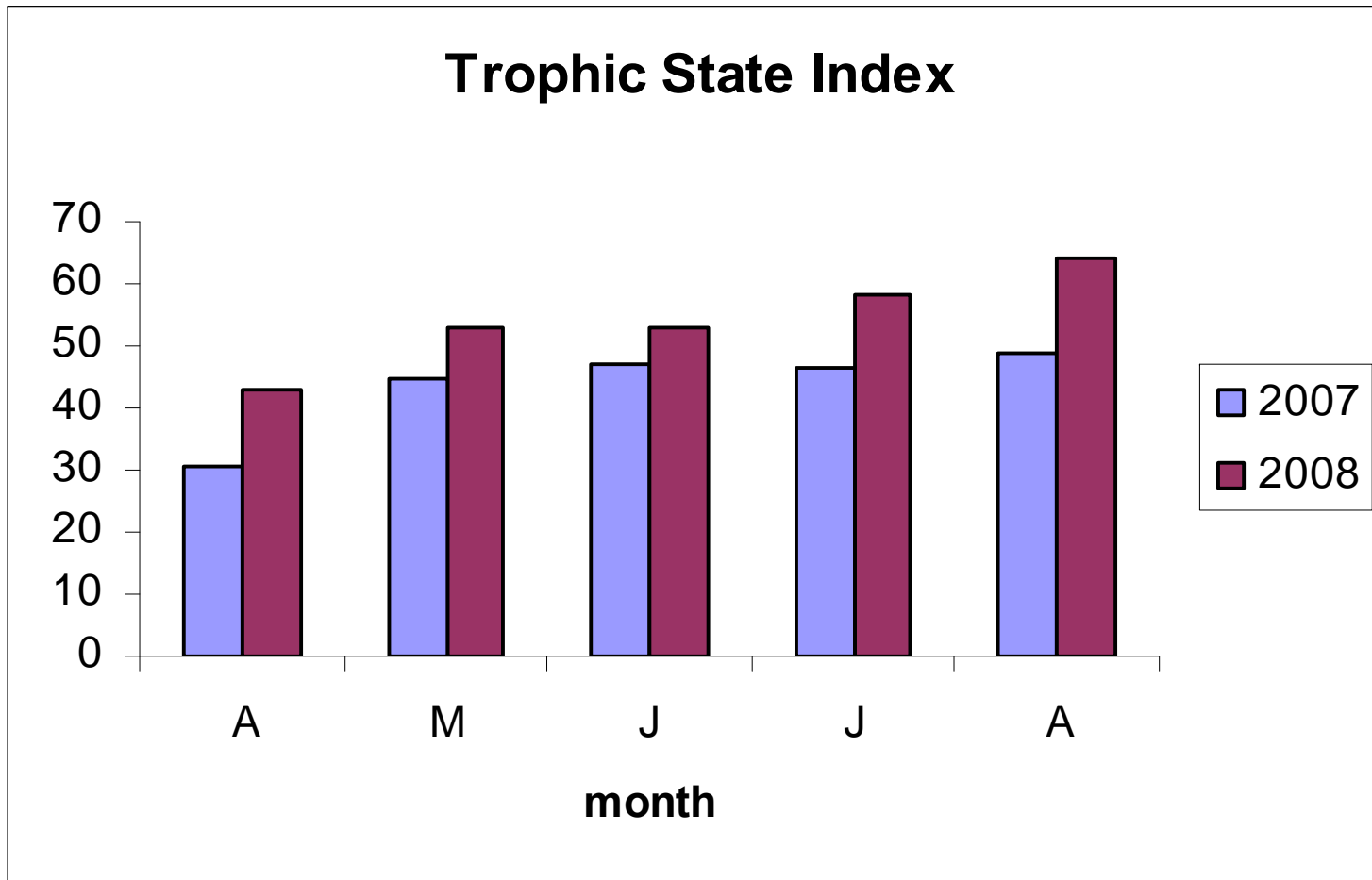


- The same conclusion about trophic level in 2007 can be made following calculated values of trophic state index (TSI), which were between 40 and 50 in all months (**mesotrophy**), except in August (TSI over 50) – **eutrophy**.

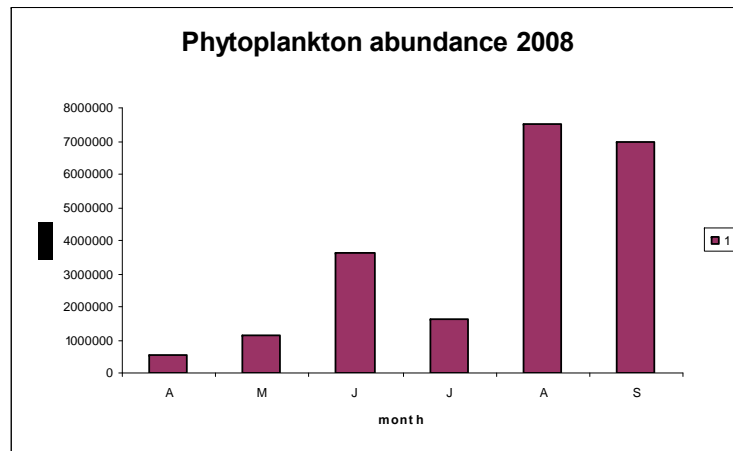
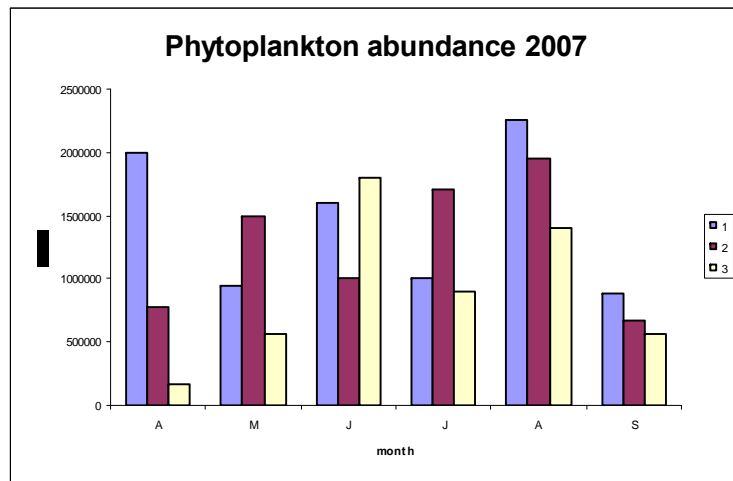


- Following calculated values of trophic state index (TSI) in 2008, which were over 50 during whole investigated period, Skadar Lake belongs to category **eutrophy I**, except in August, when calculated TSI values higher than 60 indicated higher eutrophic level **eutrophy II**.

Trophic State Index (TSI)



Trend phytoplankton monitoring for evaluating water quality from 2007-2008



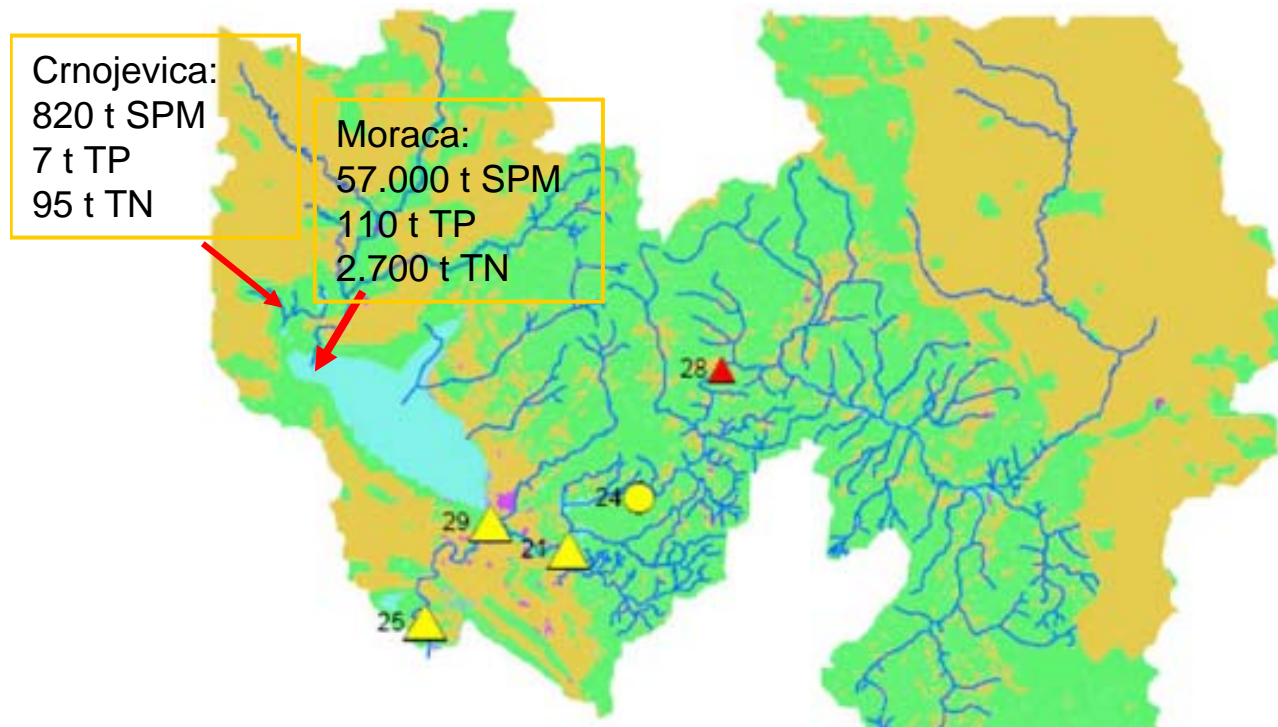
- highest total phytoplankton abundance was recorded at point D1 (open water) in April: 2×10^6 ind/l, but considering all 3 localities, maximal phytoplankton abundance was in Jun.
- In spring (April) and beginning of autumn (September) total phytoplankton abundance was **highest in the open part of the lake (point D1)**, thanks to high density of small euplanktonic diatom species *Cyclotella ocelata* and *C. glomerata*, which dominated in both periods at all 3 localities.
- During beginning and middle summer, diatoms kept domination in term of abundance in May and July on all localities. But during Jun, they dominated only in open water (point D1), but in shallower western part (point D2) greens had highest abundance (with dominance of filamentous species *Planktonema lauterbornii*) and in north-western part (point D3) blue-greens had highest density, with dominance of filamentous species *Anabaena affinis*.

Trend phytoplankton monitoring for evaluating water quality from 2007-2008

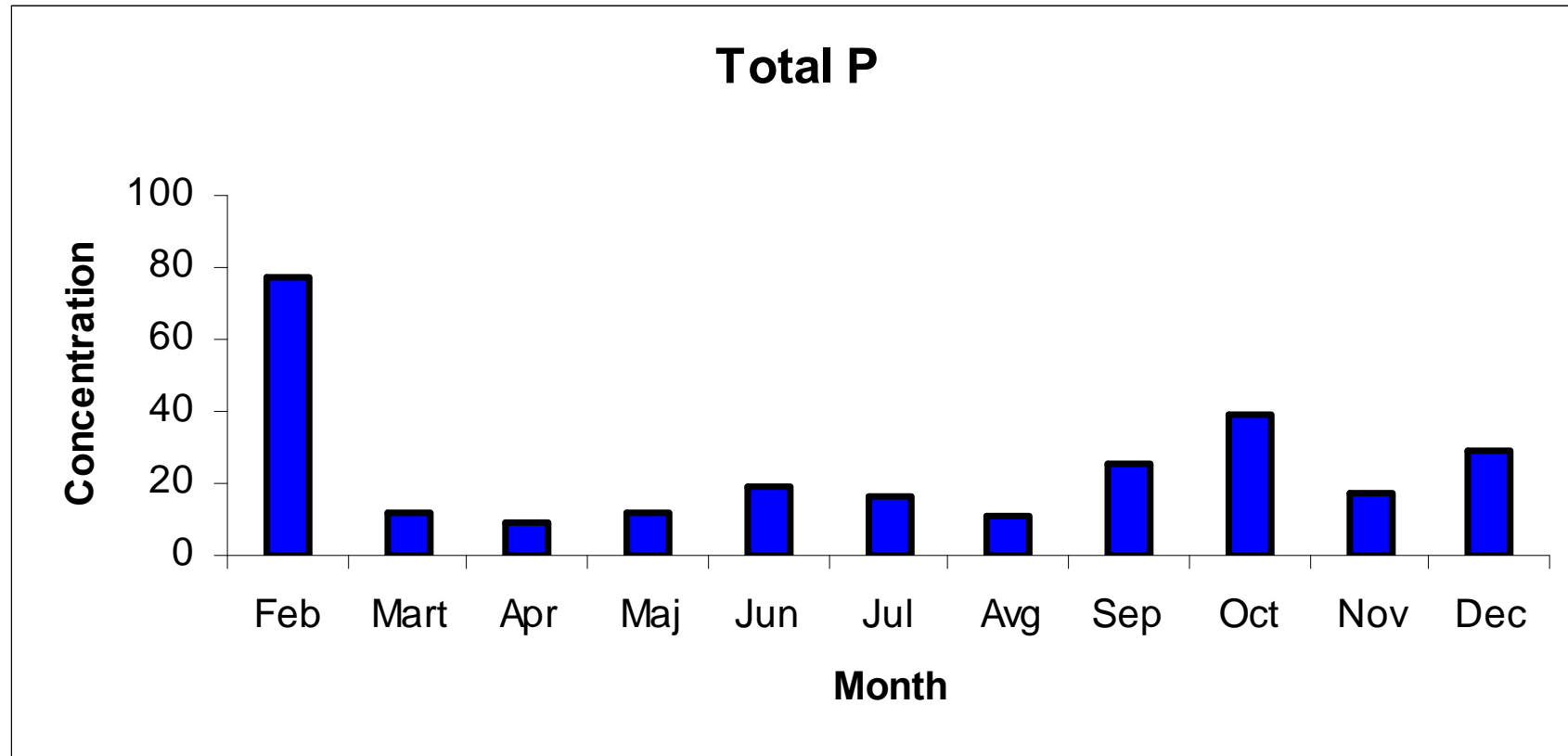
From this study, the following conclusions can be drawn:

- The total number of 95 phytoplankton taxa was recorded, with a qualitative dominance of Chlorophyceae.
- Quantitatively, the most important taxonomic group was *Bacillariophyceae* with a relatively high abundance during the whole investigated year.
- Only two typical perennial species were recorded: *Cyclotella glomerata* Bach. and *Cyclotella ocellata* Pant, which were mostly responsible for a high abundance of Bacillariophyceae.
- According to the mean chlorophyll *a* concentration, Lake Skadar can be classified as being mesotrophic.

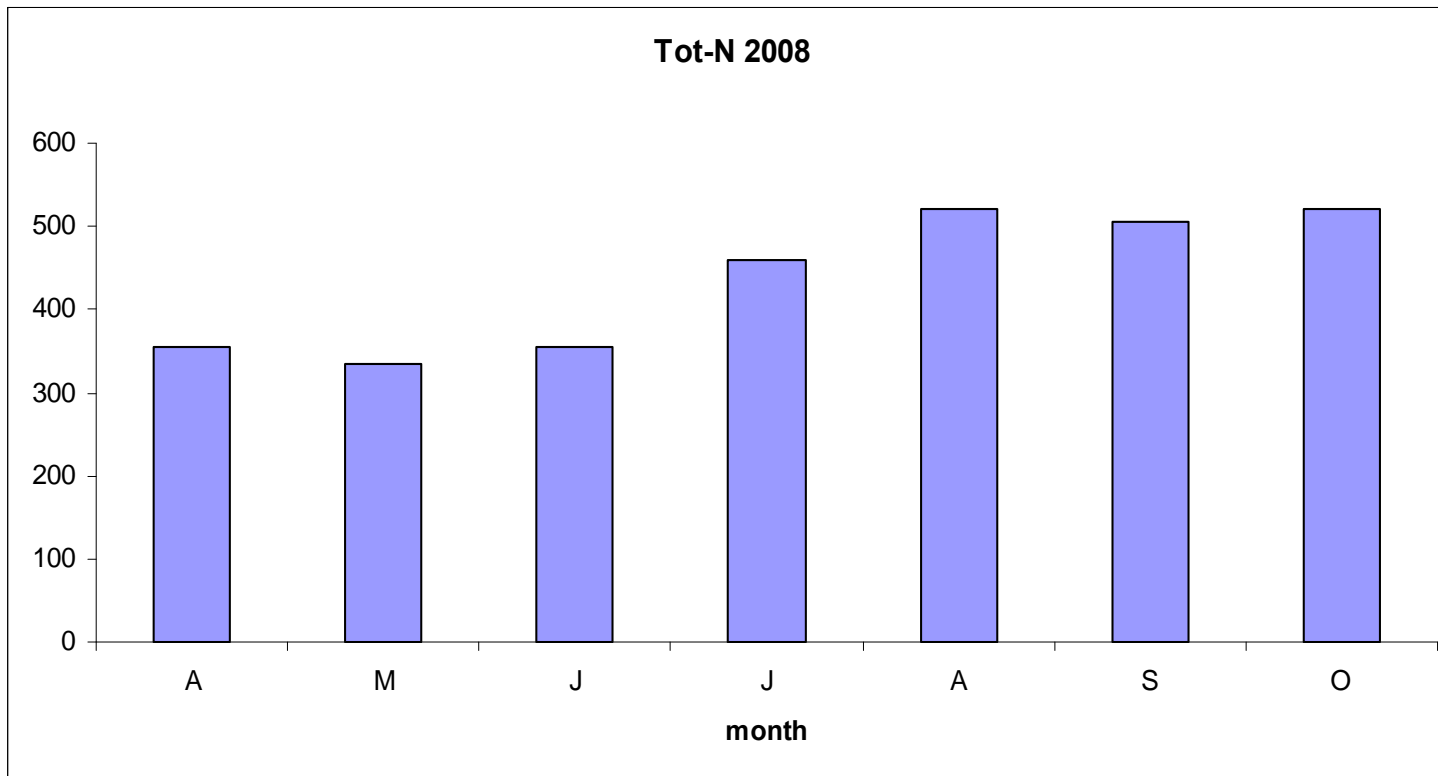
High inputs of SPM, TP and TN



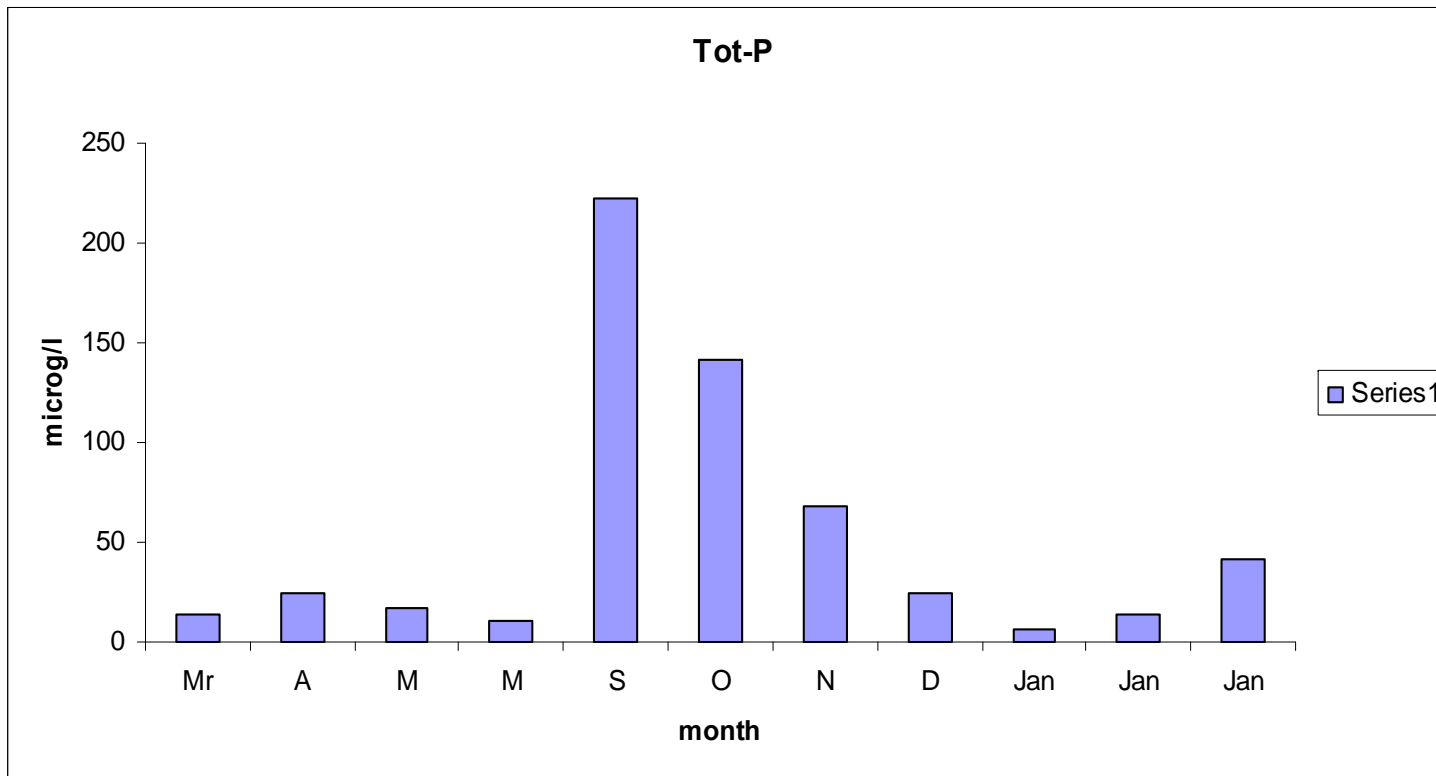
Total-P in 2008 in River Moraca



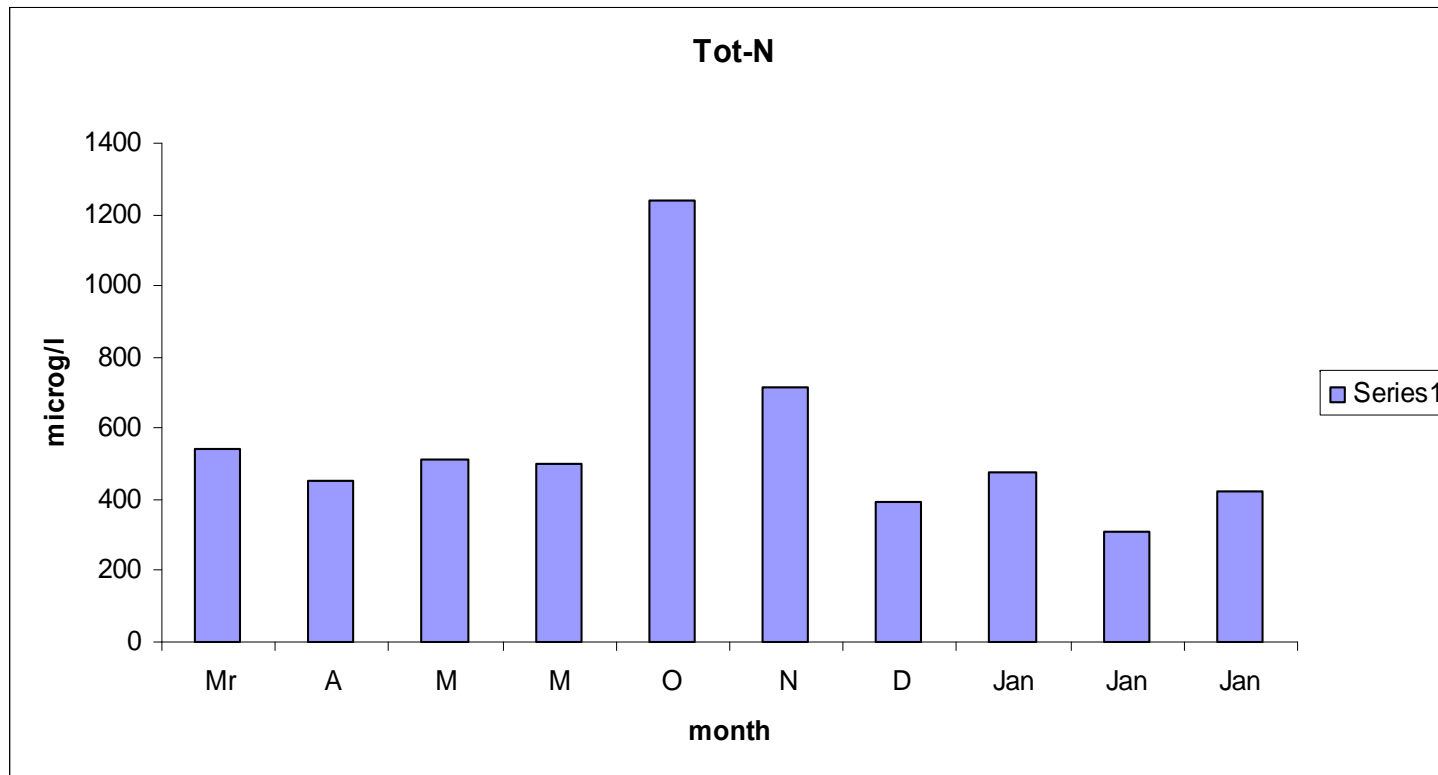
Total-N in 2008 in River Moraca



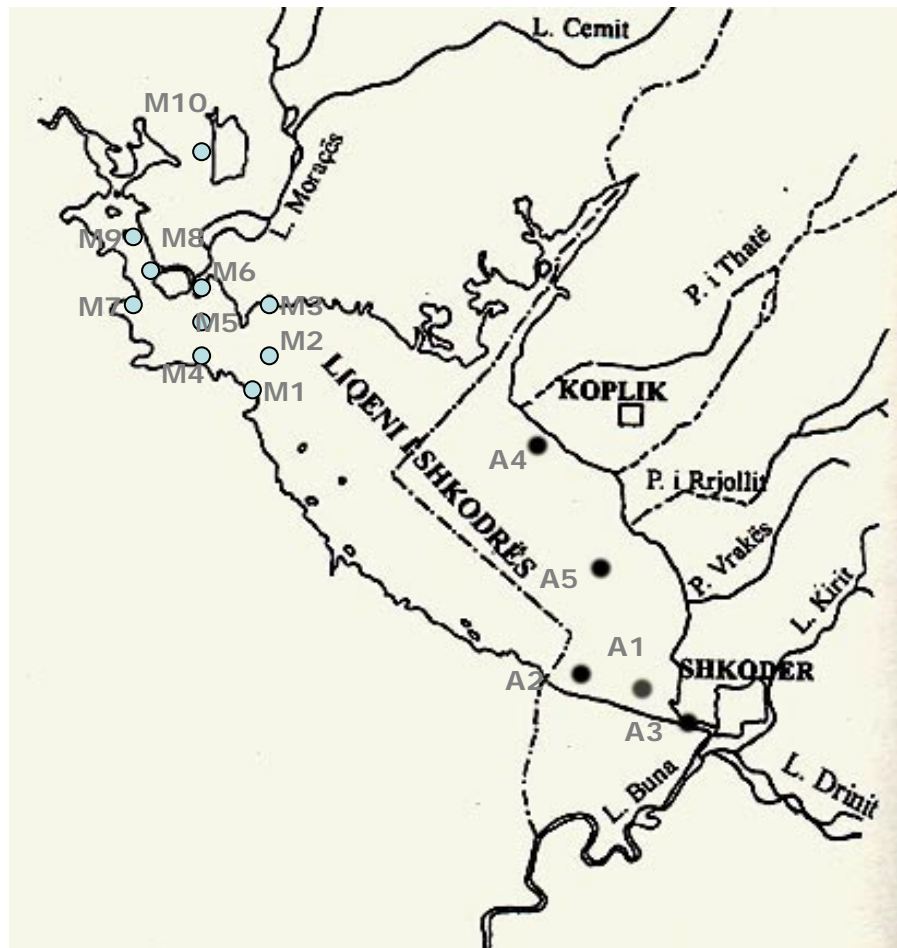
Total-P in River Crnojevica



Total-N in River Crnojevica



Trend bacteriological monitoring for evaluating water quality from 2001-2005



Routine Monitoring - *Bacteriology*

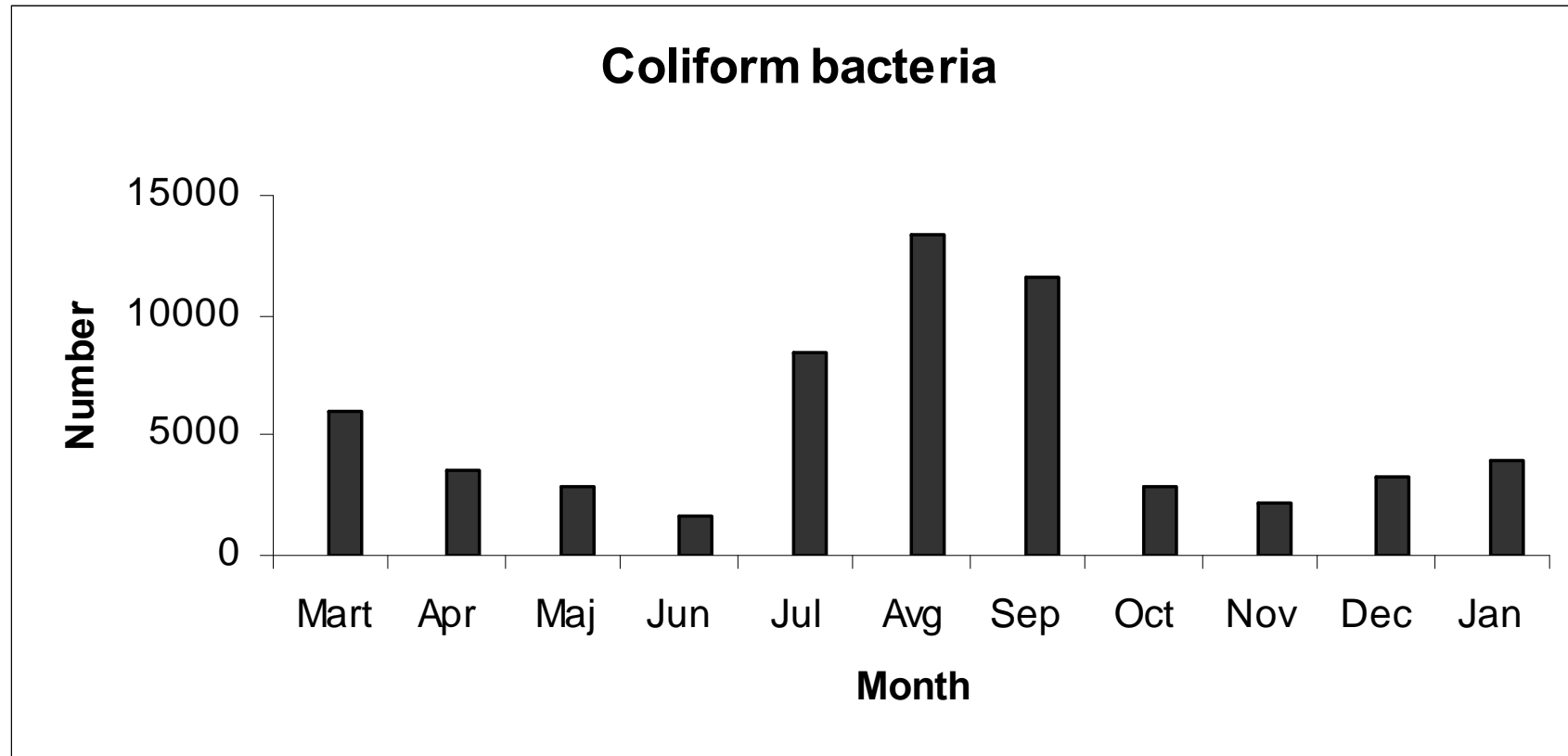
- ✓ Total coliform
- ✓ Fecal coliform bacteria
- ✓ Aerobic, mesophilic bacteria on 37C
- ✓ Classis of waters

Bacteriological investigation

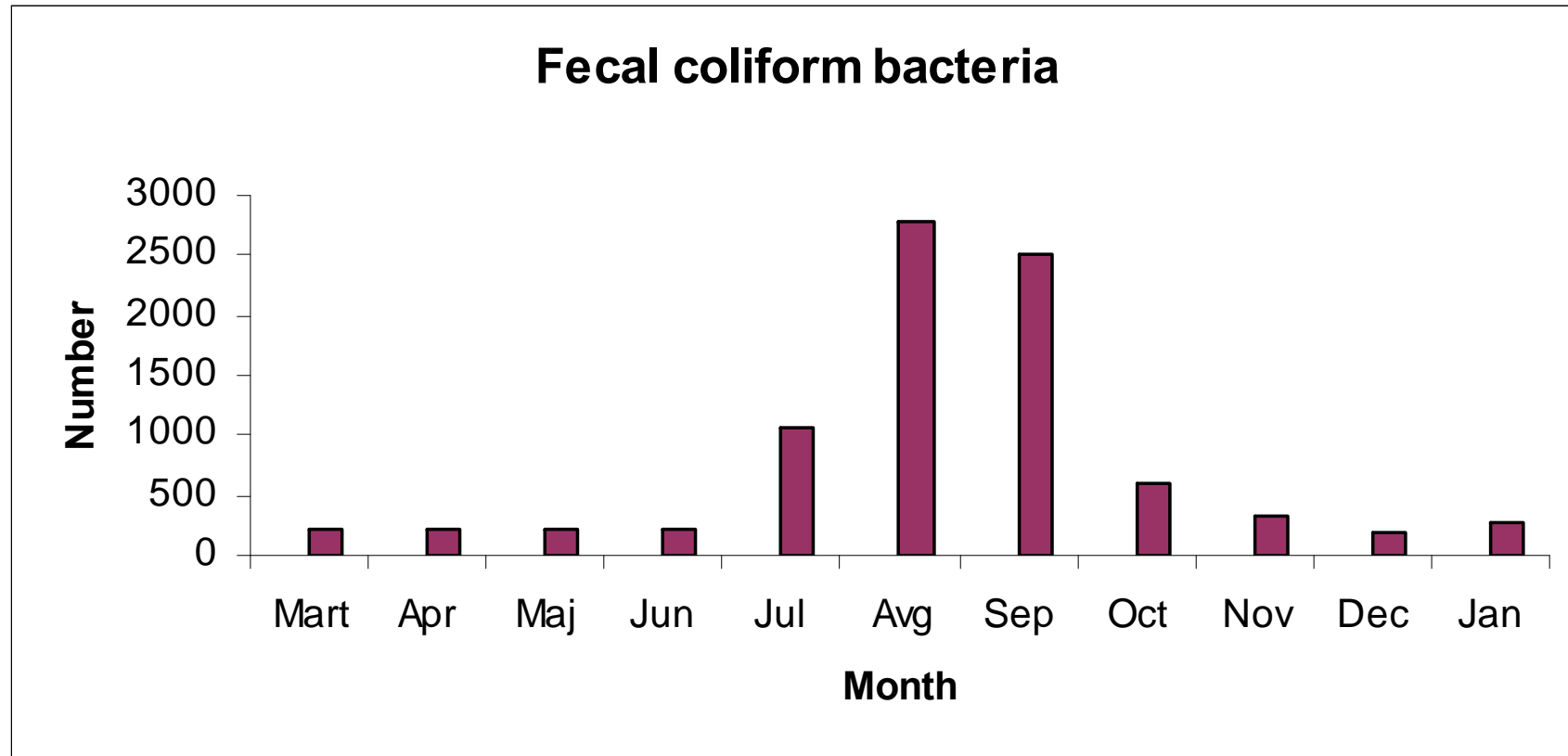
- One of the most important parameters of water quality is bacteria. Presence or absence of certain bacteria can be good indicator of the nature and level of water pollution.
- As the sanitary indicator used for assessing the probability of presence of pathogenic bacteria in water we use bacteria from guts of human and animals.

Coliform bacteria in 2008

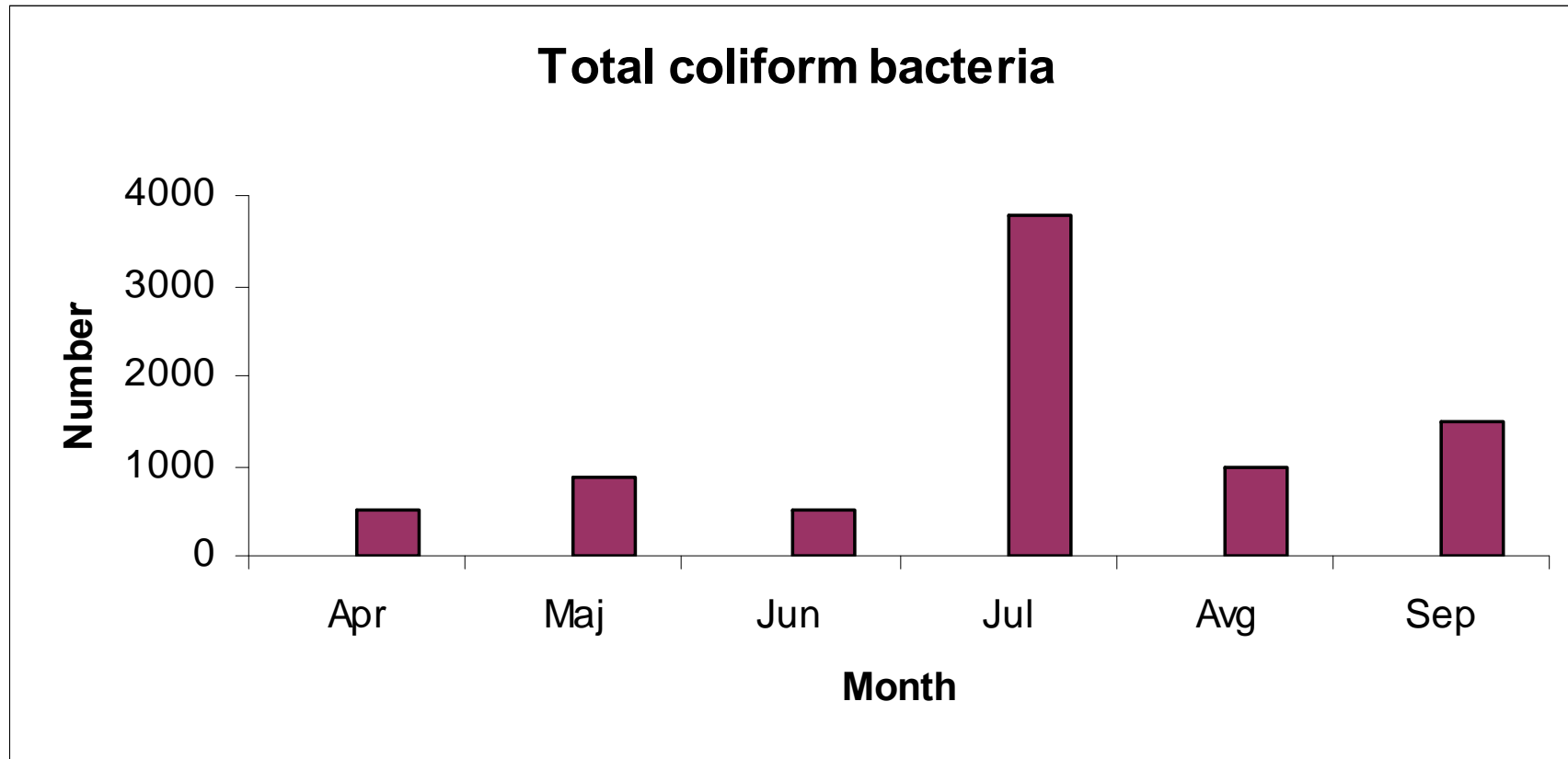
River Moraca



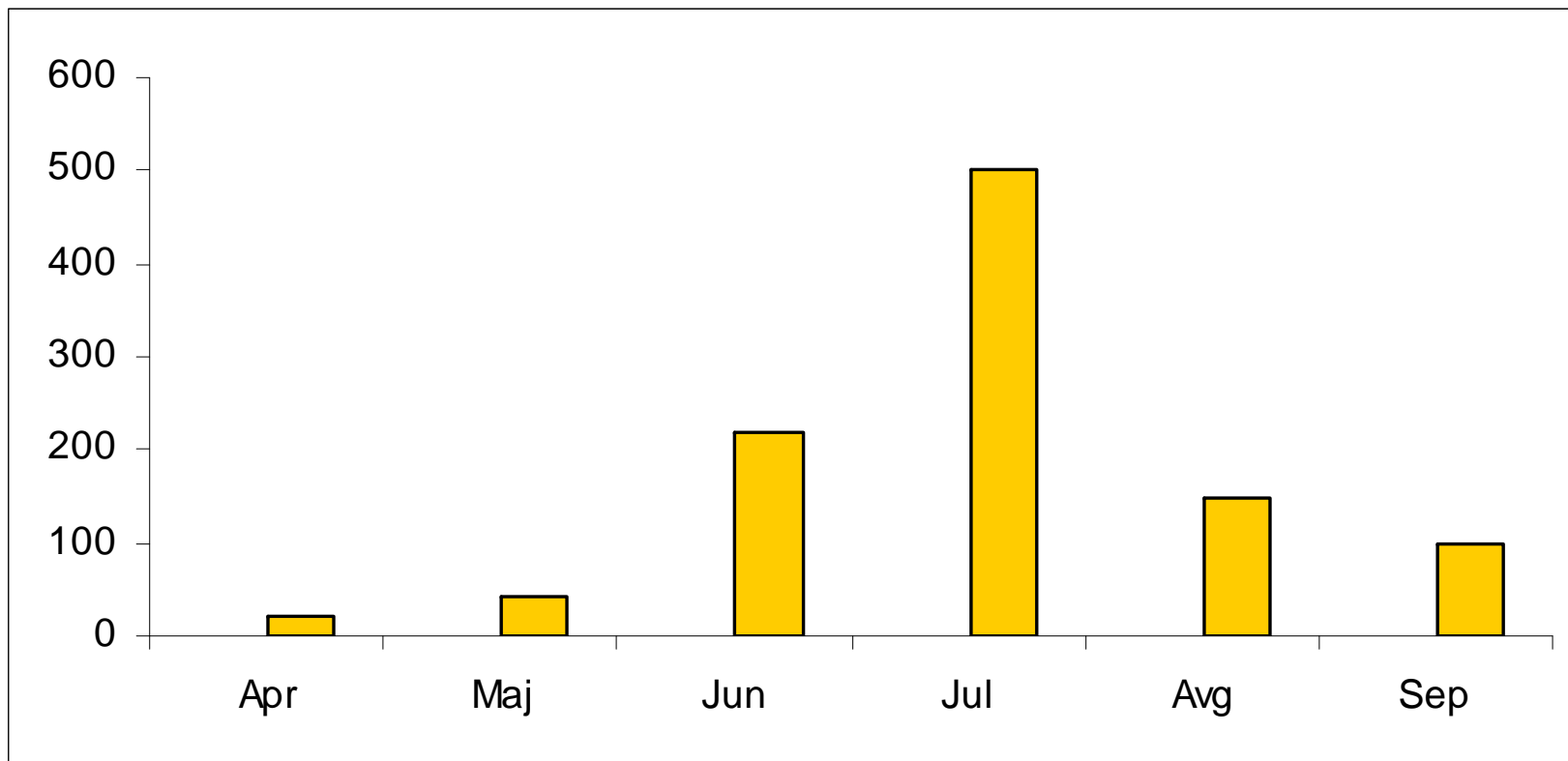
Fecal coliform bacteria River Moraca



Total coliform bacteria 2008 in Skadar Lake



Fecal coliform 2008 in Skadar Lake



- According to the received results for bacteria, the Lake water quality was in the frames of I-II class and III class in Jul.
- According to the received results for bacteria, the Moraca water quality was in the frames of II class and III class in Jul, Avg and Sep.