The actual state and fish capacity of Sasyk reservoir (the comparison 1986-1987 and 2008-2009)

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1 Introduction

Until the end of the 1970s, the salty Sasyk estuary in the Black Sea was one of the most productive reservoirs in the Ukrainian Danube region (Bragynskyi, 1990; Mironov, 1990). According to projects on the large-scale diversion of Danube water to the Dnieper, a dam was erected separating the Sasyk estuary from the sea, and a canal was dug to fill the Sasyk reservoir with Danube water. From the 1980s, the Sasyk reservoir was used for water management purposes, initially, for irrigation. However, due to faulty design, the planned water quality parameters have never been attained. With the collapse of the Soviet Union, the pumping stations stopped working, irrigation was terminated, and the quality of water deteriorated. During 1983-1987, the fish capacity of the reservoir was rather high (about 100 kg per hectare) (Bragynskyi, 1990), but, bioproductivity has been reduced because of the lack of scientific management of the fishery and fish stocking programs. Recently, the public organizations as well as the scientific community addressed the matter of restoring the original state of the reservoir, namely connecting it with the sea to increase salinity.

The aim of the research was to characterize the up-to-date state of Sasyk reservoir and to document changes from the 1980s. The patterns of macrozoobenthos and the trophic relations were taken into account.

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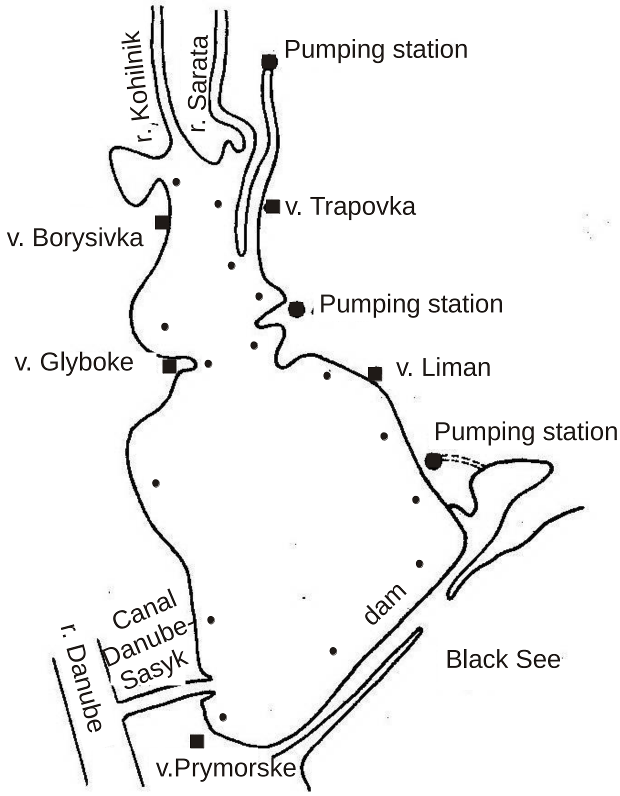

Figure 1. *Scheme of Sasyk reservoir (• - sample stations)*

2 Materials and methods

The samples were taken in 2008-2009 using the traditional network of stations (Braginskyi, 1990, Fig. 1). Several hydrochemical parameters were measured such as pH, oxygen content, and salinity according to standard methods (Romanenko, 2006). Water quality was assessed by macrozoobenthos indicator species by using the indices of Pantle & Buck (1955) and Woodiwiss (1964). The production of dominant macrozoobenthos groups was assessed for the vegetation period 2009 using the physiologic method (Alimov, 1989). The potential fish capacity was calculated from macrozoobenthos production using the corresponding coefficients (Polischuk & Bortkevich, 2006).

3 Results and discussion

Sasyk reservoir was and still is characterized by high alkalinity, reflected by maximum pH values (Table 1). By flushing with freshwater the salt concentration was decreased to the range of oligohaline – beta-mesohaline waters. The reduced salinity (0.7–1.6 mg/l) was confirmed by Smirnov & Tkachenko (2007). The oxygen patterns were rather variable, indicating periods of depletion and oversaturation.

We have recorded 64 species of macrozoobenthos. The insects were characterized by the largest species richness with Chironomidae larvae being represented by 20 species; further, we found 3 species of Odonata, 2 species of Ephemeroptera and 1 species each of Trichoptera and Chaoboridae. Among Annelida, Oligochaeta were represented by 11 species, Polychaeta by 2 species. Among Crustacea, the largest species richness was found in Gammaridae (9 species); we also found 3 species of Corophiidae 2 species of Cumacea and 1 species each of Misidacea and Decapoda. Mollusca, Gastropoda and Bivalvia were represented by three species each. One species each of Nematoda and Hydrozoa was also registered. Except of Gammaridae, in all major macrozoobenthos groups the species richness decreased slightly during the last 20 years. As a result, the total species number decreased 1.5-fold (Table 1).

Table 1. *Patterns of macrozoobenthos and productivity of Sasyk reservoir.*

Characteristics	1986-1987[a]	2008-2009
Hydrochemistry characteristics		
pH	7.8-9.2	7.8-9.0
O_2, mg/l	7.0-15.4	6.6-13.5
Salinity, mg/l	0.7-2.5	0.7-1.6
Species richness		
Chironomidae	28	20
Oligochaeta	15	11
Cumacea	5	2
Gammaridae	7	9
Corophiidae	3	3
Total[d]	99	65
Ponto-Caspian fauna	27	19
Intruders	1	3
Biotic indices		
Shannon index, bit/ind	-	1.87−2.23
Saprobity index P&B	2.30-3.60[b]	1.90–3.48
Woodiwiss index	-	4-5
Catches fishes, t (%)[c]		
Benthos feeders	486.52 (66%)	357.83 (91%)
Plankton feeders	16.96 (2%)	20.20 (5%)
Predators	231.20 (31%)	6.06 (1%)
Others	8.56 (1%)	10.57 (3%)
Total	744.34 (100%)	395.47 (100%)

Characteristics	1986-1987[a]	2008-2009
Abundance, thousand ind/m^2		
Chironomidae	1.05-7.77	0.96-3.60
Oligochaeta	11.28-23.20	4.63-11.62
Cumacea	2.27-6.03	0.07-5.39
Gammaridae		0.21-0.35
Corophiidae		0.001-15.38
Total[4]	22.01-35.81	6.44−19.44
Biomass, g/m^2		
Chironomidae	28.30-31.90	1.25-1.72
Oligochaeta	13.30-31.60	2.78-11.80
Cumacea	2.10-4.10	0.001-14.26
Gammaridae		1.29-5.20
Corophiidae		0.001-0.03
Total[d]	174.20-210.26	13.98−113.94
Production, kJ/m^2 of the vegetation season		
Chironomidae	846.03	43.50
Oligochaeta	167.91	82.78
Dreissenidae	179.37	60.97
Cumacea	44.39	124.60
Gammaridae		27.74
Corophiidae		0.25
Total production	1237.70	339.84
Fish capacity, kJ/m^2 (kg/ha)	61.86 (148.02)	30.94 (74.01)

Note: [a] – by Bragynskyi (1990), [b] – by Lyashenko & Metelezkaja (1997), [c] – by Smirnov & Tkachenko (2007), [d] – including smaller macrozoobenthos groups not given in the table.

19 macrozoobenthos species belong to the relict Ponto-Caspian fauna (14 species of Crustacea, 3 species of Bivalvia, and 2 species of Polychaeta). Such species native to the Danube Delta may indicate whether the natural ecosystems are unimpaired (Mordukhai-Boltovskoi, 1978). Earlier, the Ponto-Caspian species in the benthos of Sasyk reservoir were more abundant (27 species, (Bragynskyi, 1990)). The following species have not been found in our recent samples: Hirudinea – *Caspiobdella fadejewi* (Epstein), Bivalvia – *Hypanis pontica* (Eichw), *H. yalpugensis* (Borcea), *H. laeviscula fragilis* (Milachavitch), Crustacea – *Pseudocuma graciloides* G.O.Sars, *P. cercaroides* G.O.Sars, *Schizorhynchus eudorelloides* (G.O.Sars), *Paramysis baeri bispinosa* Martynov, *P. kessleri sarsi* (Derjavin) and *P. lacustris* (Czerniavskyi).

The ability to resist the invasion of new species is one of the parameters characterizing the state of the ecosystems (Alimov & Bogutzkaia, 2004). Shortly after filling the reservoir with fresh water, *Rhithropanopeus harrisii tridentata* Maitland, which inhabited the Sasyk estuary before, was recorded as invasive species (Yenaki et al., 1973). In 2008/9, we have found two more invasive species. The North American Hydrozoa *Bougainvillia megas* Kinne, which intruded the Black Sea in 1932 (Paspalev, 1933), was present in various regions of Sasyk reservoir in benthos, in biofouling, and in the weed bed. Bivalvia *Dreissena bugensis* Andr., which has not inhabited the Delta until the beginning of the 21st century (Lyashenko et al., 2009; Micu & Telembici, 2004), recently became the abundant representative of macrozoobenthos in Sasyk reservoir.

The inter-seasonal variations of Shannon species diversity index (MacArthur, 1955) in macrozoobenthos were insignificant. Saprobity changed within β–α-mesosaprobic state, slightly decreasing from the 1980s. The maximum values of Woodiwiss index in recent times did not exceed 4–5 points corresponding to «poor» – «moderately polluted» grades (Afanasiev & Grodzinskyi, 2004).

The abundance and biomass of invertebrates changed significantly from 1986/7 to 2008/9 (Fig. 2). Oligochaeta showed maximum abundance (64%), while Bivalvia contributed maximum biomass (71%; predominantly *Dreissena*). The structure of macrozoobenthos changed significantly from the 1980s. The abundance and biomass of Oligochaeta and Chironomidae larvae decreased (15-fold for Chironomidae biomass). The amount of predatory Chironomidae diminished from 60% to <5%. However, the abundance and the biomass of Gammaridae, especially Cumacea, have increased substantially. Mollusca remain the dominant group with regard to biomass (Fig.2).

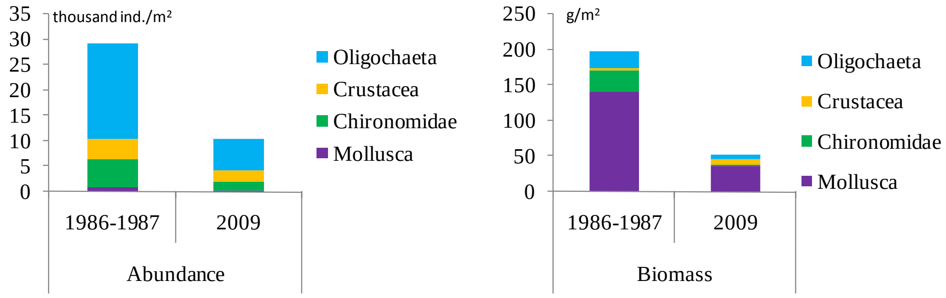

Figure 2. *Macrozoobenthos patters of Sasyk reservoir: abundance and biomass of main groups of invertebrate*

Macrozoobenthos production in the vegetation period of 2009 amounted to 339.84 kJ/m^2 (3.7 times less than in the 1980s, Table 1). The largest contribution to the overall production is recorded for Cumacea (Cructacea). The production of Oligochaeta and Dreissenidae is also high. Nevertheless, earlier Chironomidae larvae contributed most of all in terms of the production. Now the contribution of Chironomidae larvae has been reduced from 68% to 13% (Fig. 3). In contrast, the proportion of Crustacea has increased from 4% to 45%.

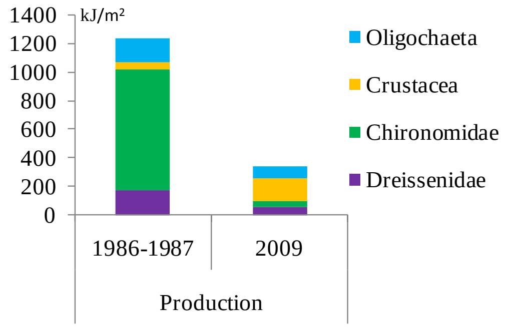

Figure 3. *Production of dominant groups of macrozoobenthos in various periods*

The fish capacity calculated according to macrozoo-benthos production in 1986–1987 amounted to 61.68 kJ/m^2 or 148.02 kg/ha (Bragynskyi, 1990) which is twice as much as nowadays (30.94 kJ/m^2 or 74.01 kg/ha, respectively). In fact, the official fish yields were substantially less: 25.5 kg/ha in 1981–1985 (Smirnov & Tkachenko 2007) and 43.9 kg/ha in 1986–1987 (Braginskyi, 1990). In the first half of the 1990s, the value decreased further to 22.5 kg/ha. The minimum fish catches were recorded late in the 1990s, namely, 17.9 kg/ha, with slight increase in the following years to 19.8 kg/ha (Smirnov & Tkachenko, 2007). Benthophagous fish have increased from 66% in 1986–1990 to 91% in 2000–2001 (Smirnov & Tkachenko, 2007). Earlier, the bream *Abramis brama* Linnaeus (36%) (benthos feeder), the pike-perch *Sander lucioperca* Linnaeus (24%) (predator), and the carp *Cyprinus carpio carpio* Linnaeus (benthos feeder) (20%) dominated in the catch. Now, the crucian carp *Carassius auratus gibelio* Bloch (benthos feeder), is the dominant species (80%). The overall fish catch now has been reduced 1.88-fold as compared to the mid 1980s. While the relative contribution of benthophages increased the catch decreased 1.36-fold (Table 1).

4 Conclusion

The study has demonstrated certain shifts in the Sasyk reservoir ecosystem. The water salinity has been stabilized, pH and oxygenation state have remained the same, and the saprobity has slightly improved. At the same time, the patterns of macrozoobenthos have changed significantly. Within the first ten years after water diversion, Sasyk reservoir was at the "chironomidae" high-productive stage because with Danube's freshwater were provided additional energy (Bragynskyi, 1990; Kharchenko, 1991, 1998). Later on, when the pumping stations stopped working, species richness and productivity diminished substantially with the changes in the dominating species. Macroozoobenthos now is dominated by Crustacea. The top-down control of predator fish has decreased sharply, with the crucian carp (benthos feeder) being the dominant species now. Overall, we observed the transition from a high-productive pulse-stabilized mode (Bragynskyi, 1990; Kharchenko, 1991, 1998) to a more stable but less productive lake-type reservoir. In principle, there are several ways for increasing productivity, including the reversion to the initial succession stage of the salty estuary. Or else, the connection with the Danube should be restored by resuming the operation of the pumping stations. In any way, such water managment measures will require a lot of money. If no measures are taken, the natural succession from aquatic to terrestrial ecosystems including rampant weeds and marsh formation will continue.

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