July 2015

Ecological State of Lake Durowskie during Restoration Measures Macroinvertebrates Report

Students: **Anna Kozlowska (AMU)**
Linda Staponites (CAU)
Niklas Lausen (CAU)

Supervisors: **MSc. Ing. Piotr Domek**

Christian-Albrechts-Universität zu Kiel

Index

List of Figures

1 Introduction

Research Site

Lakes are valuable ecosystems that can provide a wide range of environmental benefits and support human recreational activities. In order to enjoy the benefits provided by lakes, we must protect them (EPA (2015): Water: Lakes. Lakes Awareness Month and Outreach Materials). Lake Durowskie, located in Wagrowiec Poland, is an essential component to the city's well being. The activities of the lake account for approximately 25% of jobs and brings in many economic benefits such as tourism and local recreational use including boating, fishing and hiking.

Surface Area	143,7ha
Volume	11,322,900 m3
Maximum depth	14.6 m
Average depth	7.9 m
Catchment area	236,1 km2

Located in central Poland, Lake Durowskie was formed by activities of glaciers which created a chain of lakes connected by the tributary Struga Gołańska (Gołdyn et al., 2013). Now, the catchment area is surrounded by forest, urban areas and agricultural fields.

1.1 Problems

In 2008, Lake Durowskie experienced severe eutrophication due to cyanobacterial blooms (Gołdyn et al., 2013). The toxic algae blooms reduced the transparency of the water and created high pH, killing fish and other aquatic organisms. Due to this decrease in water quality, the beaches were closed and tourism declined. This problem of eutrophication was a consequence of increased human activity. Recreational activities, such as the use of motor boats, caused changes in the littoral zone, and agricultural runoff from surrounding areas also increased the nutrient load into the lake. Durowskie is situated in the bottom of a chain of lakes, connected by the Struga Gołaniecka River, therefore upstream lakes can easily transport additional pollutants into the waterbody. Lake Durowskie is a stratified lake, which also creates problems with oxygen depletion on the lower layers of the lake.

1.2 Restoration Measures

Restoration measures started in 2009, which utilize three methods simultaneously: importing small doses of chemical treatment of Iron sulfate 2-3 times a year to immobilize phosphorus, oxygen exchange of the hypolimnion layer via two aerators, and biomanipulation with the introduction of non native fish species (pike and pikeperch) added every spring. Every summer, the international summer school conducts a lake assessment which monitors physio-chemical parameters, algae, macrophytes, and micro-invertebrates communities. Through this data we are able to determine the current ecological state and its development over the past 7 years.

1.3 Macroinvertebrates for Indicating Water Quality

Macroinvertebrates are organisms without backbones that can be seen with the naked eye (EPA, 2012). The monitoring of macroinvertebrates is valuable for indicating freshwater health. Found in the substrate of an underwater environment, macroinvertebrates are easy to sample and identify. They are vital elements of the aquatic food chain; macroinvertebrates feed on algae and are a favorable food source for small fish which has influence on the species composition within lakes. The abundance of a community composition can indicate water quality due to the fact that particular species can tolerate specific levels of pollution. For example, species such as Molanna Sp. are indicators of good water quality because they cannot survive in polluted waters, while species such as Mosquito Larvae are indicators of poor water quality due to the fact that they can survive in extremely polluted conditions. In our 2015 monitoring, changes in composition of macroinvertebrate communities were investigated.

2 Methodology

2.1 Sampling Methods

Using a boat for transport, samples of benthic macroinvertebrates were collected at 14 different sites distributed all over the lake. Littoral samples were taken at stations 1, 2, 4, 6, 8, 12 and 13, while pelagiał samples were taken at stations 3, 5, 7, 9, 10, and 14 (Figure 1). Ten sediment samples were collected from each site using two separate samplers; the Czapla which collects samples under a 2 meter depth from the shallow littoral zones, and the Kajak which collects samples from the Pelagial zones. Sediment samples were then sieved and stored into separate plastic boxes filled with water. All the samples were collected between the 29th of June and 4th of July in 2015.

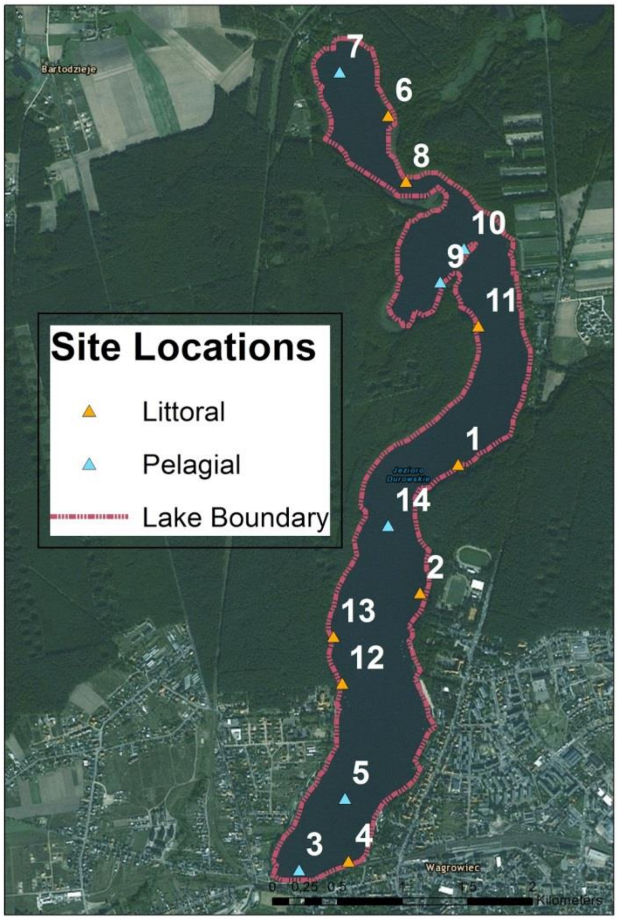

Figure 1: Overview site locations

2.2 Data Analysis

In the Laboratory, the samples were sought through and macroinvertebrates with a length greater than 2mm were separated by species, counted, dried then weighed. For preservation, each weighed organism was then placed in a test tube with alcohol. By means of microscopic analysis, the macroinvertebrates were classified by species and identified using a key (PAWLEY et al. (2011). Biomass and number of individuals per square meter was calculated. The number of individuals was multiplied by 26 (Kajak) or 39 (Czapla) in order to find the density per square meter, then the biomass was multiplied by 26 (Kajak) or 39 (Czapla) to find the total biomass of each species per square meter.

2.3 Indices

Two indices were used to interpret samples and compare data; the Biological Monitoring Working Party (BMWP) and the Shannon Weiner Index.

The Biological Monitoring Working Party (BMWP) is an index used for identifying species of macroinvertebrates into prescribed classifications of water quality. The individual family scores places species in a class from 1 to 5 (Hawks, 2012). The method is based on the principle that different aquatic invertebrates have different tolerances to pollutants.

The Shannon Weiner Index is a quantitative measures of diversity in categorical data. This index takes into account proportion of each species and how evenly the individuals are distributed within the community (Seagrant 2015). The index can increase by obtaining uncommon species, or possessing greater species evenness.

$$H = -\sum_{i=1}^{S} \rho_i \log_2 \rho_i$$

3 Results

The assessment of macroinvertebrates in Lake Durowskie during July 2015 supplies information about about the frequency of species, the number of Individuals/m² and the biomass of macroinvertebrates in [mg/m²]. To derive an overview about the state of zoobenthos at different positions in the lake, this information is also station based.

3.1 Frequency

The total number of species varies from 1 to 16 at each station. This year's assessment is the first time that at least one species was found on every station. The species richness is highest on station 7 which is located in the northern part of the lake but also on station 2, 4 and 12 which are located in the middle or southern part of the lake with quite a high number (10-13) of species present. Conspicuous is that all samples taken from the deeper parts of the lake are represented by only one species.

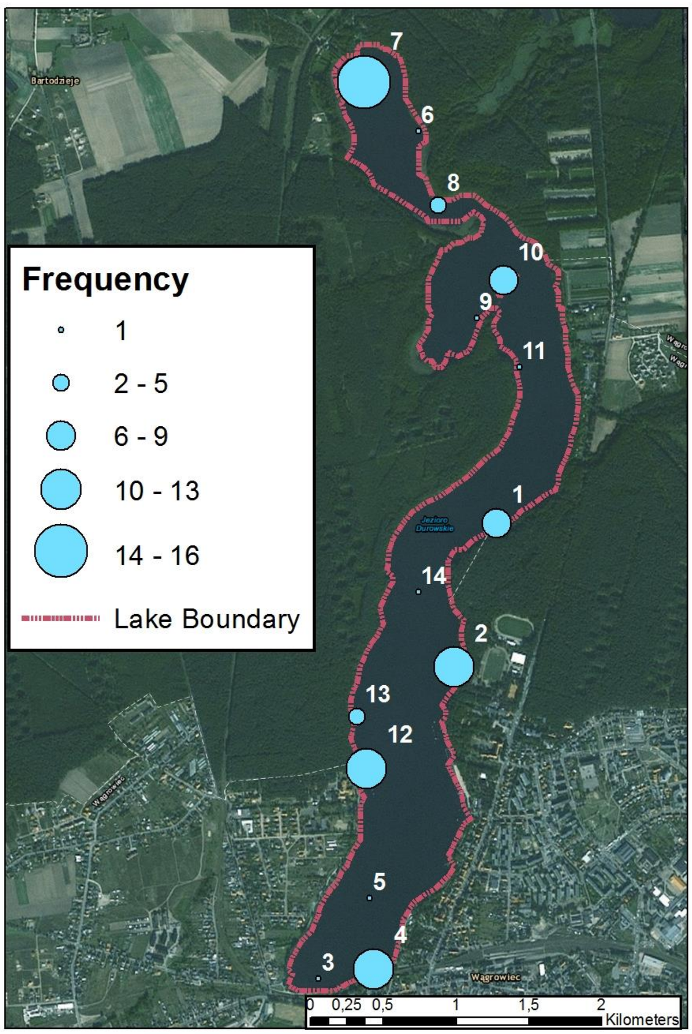

Figure 2: Frequency of species in 2015

3.2 Individuals

The number of individuals/m² varies from 78 to 7.839. The lowest values again are found at the stations that represent the pelagial zone such as 3, 5, 14, 11 and 9. The largest number of species were found at the stations 1, 2, 4, 7, 12 and 13. Stations with higher amounts of individuals occur evenly spread throughout the lake and are not concentrated to one single location. A general pattern is obscured.

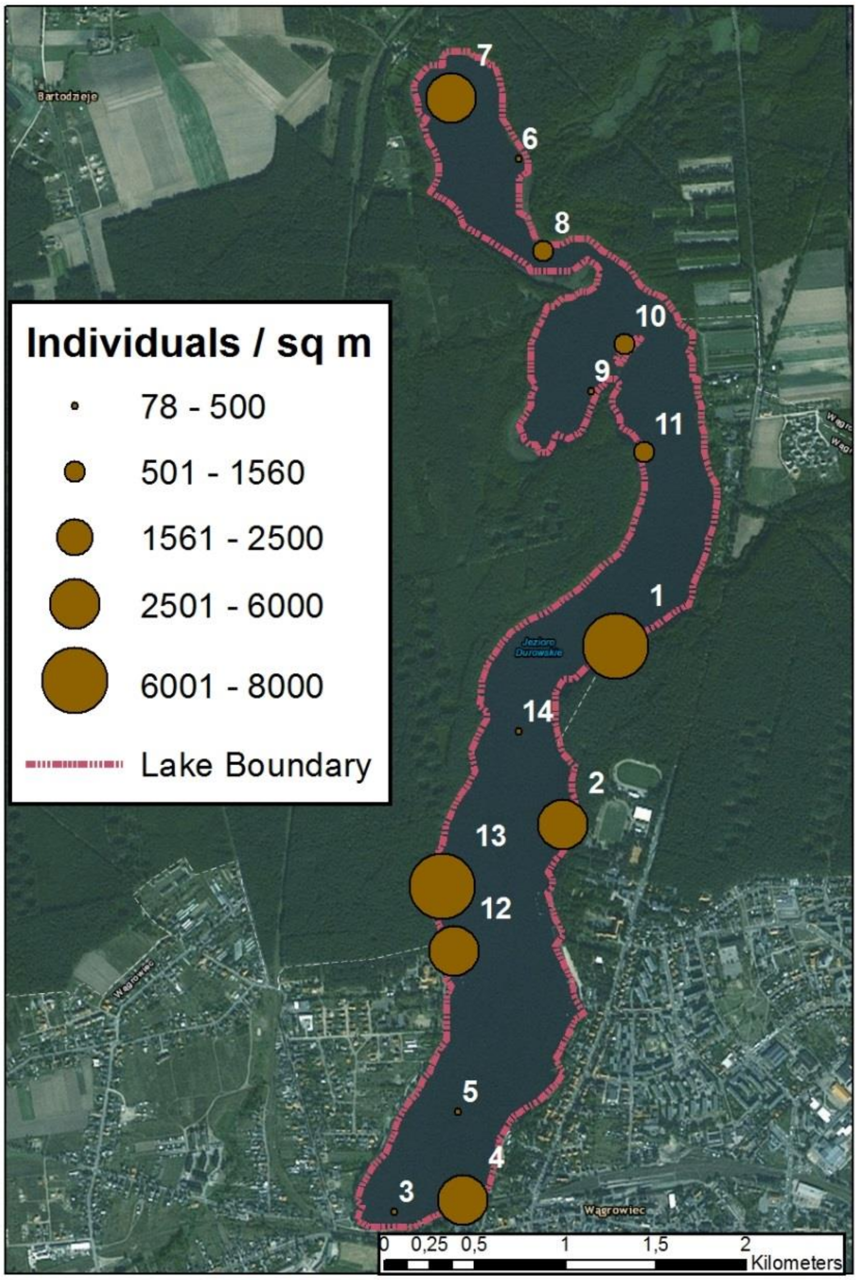

Figure 3: Number of Individuals/m² at each Sampling Site in 2015

3.3 Biomass

The biomass is weighed in [mg] and range from 286 to 1.310.283. Once again, the pelagial station 3, 5 and 14 in addition to littoral station 6 display the lowest values. There are large differences in values in the remaining sites. Site 1 represents the highest value for biomass/m² with more than 1,3 kg/m². Also the view on biomass does not show a general pattern about the distribution in the lake.

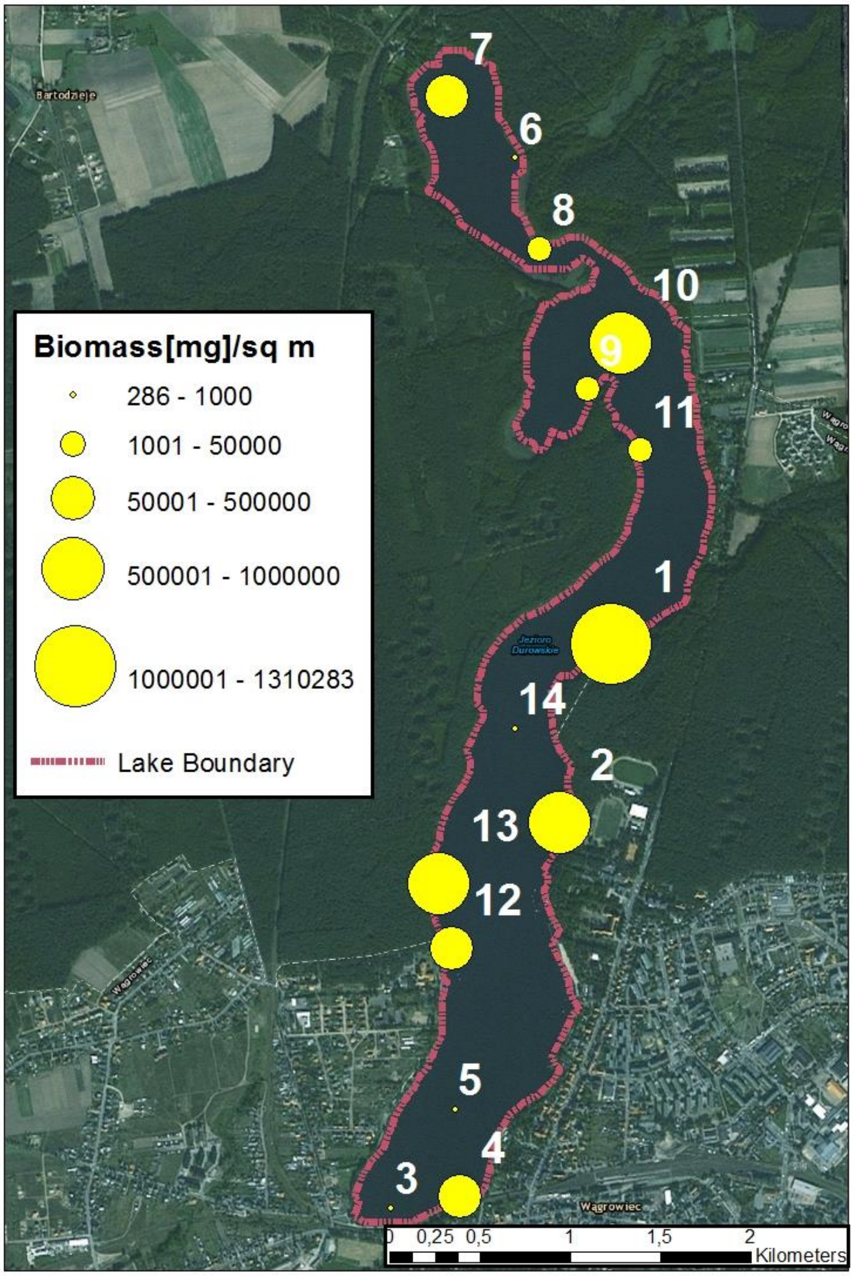

Figure 4: Biomass of Macroinvertebrates in mg/m² at each Sampling Site in 2015

3.4 Development over the years

To decipher whether the previous measurements have improved the water quality, it is useful to have an overview of the development of macroinvertebrates over the past 6 years. Therefore the mean of frequency, individual/m² and biomass/m² was calculated. As figure 5 shows, there is a general increase of the frequency of species. However compared to the year 2014 a slight decrease can be observed.

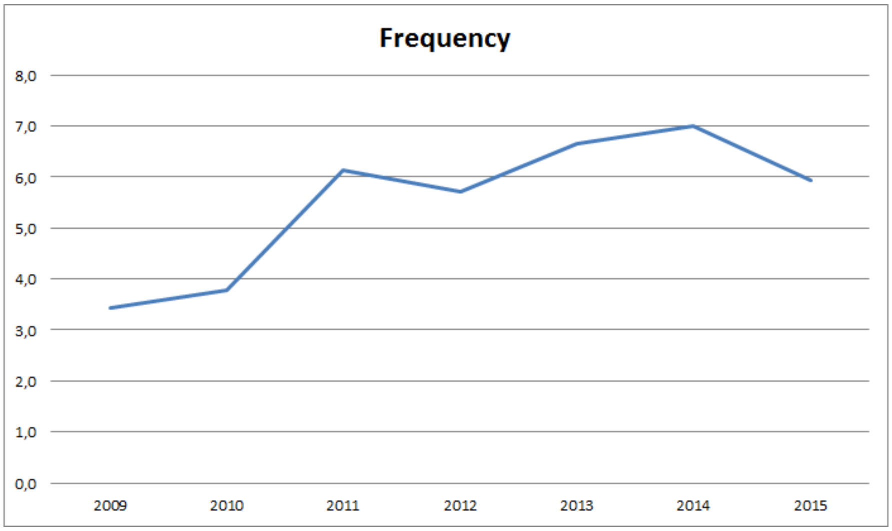

Figure 5: Development of Frequency from 2009 - 2015

A general increase is also displayed for the individuals/m². As shown in figure 6, the number of individuals increases from 2010 up to 2015. Only in the recent year a decrease of individuals can be detected.

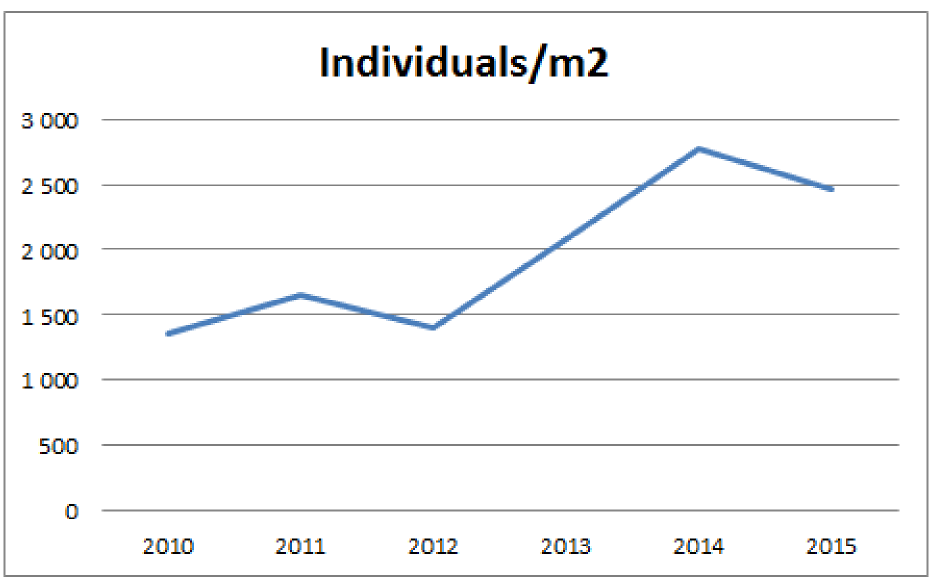

Figure 6: Development of the Number of Individuals from 2010 - 2015

In comparison, the development of biomass/m² experiences a general increase of over the recent five years, but especially the very last year needs to be considered: The amount of biomass/m² doubled in this time.

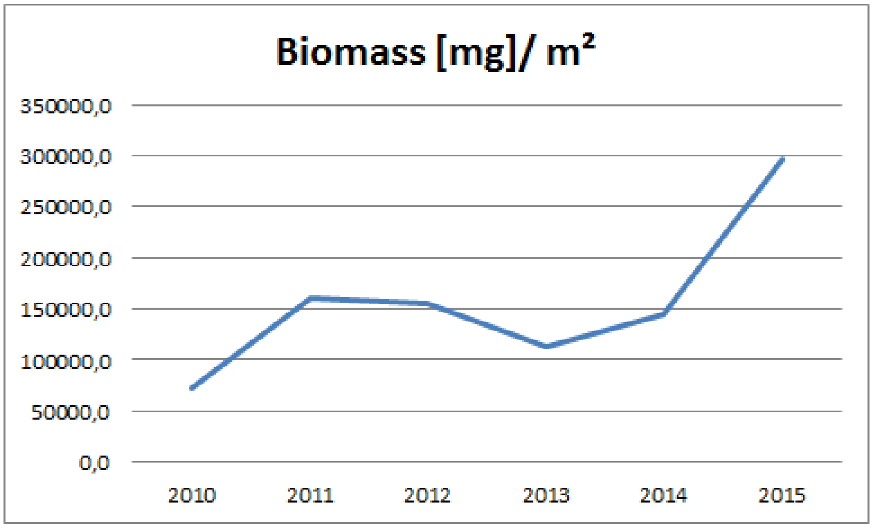

Figure 7: Development of Biomass [mg/m²] from 2010 - 2015

3.5 Shannon-Wiener-Index

The Shannon-Wiener-Index was determined to estimate the diversity of macroinvertebrates in Lake Durwoskie. To achieve representative data the mean of all sampling sites were calculated and compared with the results from the previous years. The overall trend of the mean Shannon-Wiener-Index is increasing. However, variations have occurred such as the one peak in 2011 that was followed by a strong decrease.

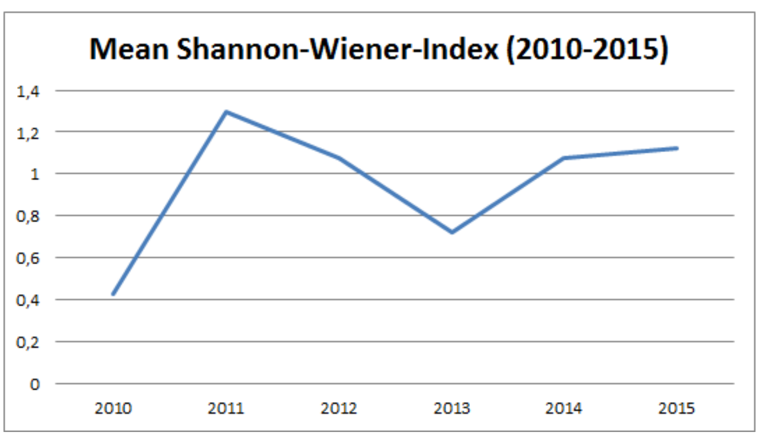

Figure 8: Development of Shannon-Wiener-Index from 2010 - 2015

3.6 Biological Monitoring Working Party (BMWP)

The estimation of BMWP-PL scores can be used to assume the water quality class to each sampling site. In figure 8, water quality classes are represented at each station of the lake from north to south. Based on this assessment, the water quality is best at station 7 in the very north of the lake with a classification of 3. The sites within the pelagial zone were all ranked in class 5, which is the lowest class. The remaining locations were ranked in class 4 indicating a poor water quality.

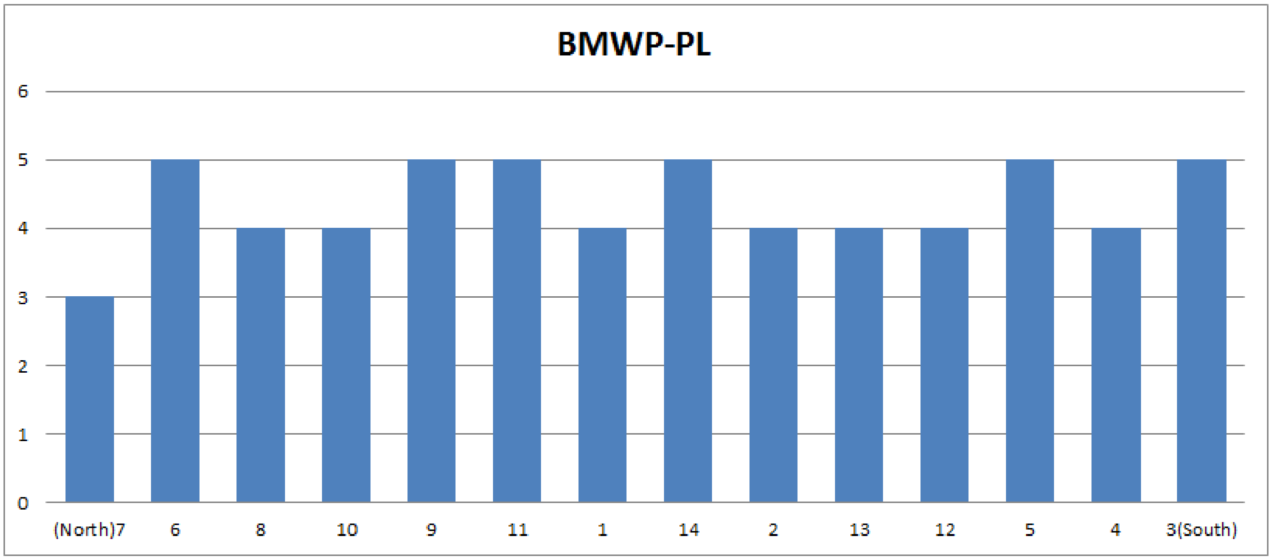

Figure 9: Water quality class at each station referring to BMWP-PL in 2015

4 Conclusion

During the monitoring in 2015, at least one species was found at each of the 14 stations. This happening occurred for the first time since monitoring began in 2009, indicating good development. Specifically, all of the pelagial stations of the lake had tolerable conditions for species to survive, which is an improvement from the previous years. At the same time, a decrease in species frequency and individuals/m² was detected since 2014. A possible explanation for this could be the short and abnormally warm winter period from 2014-2015. If the water in the lake heats up earlier in the year, the insect larvas reach the pupal stage quicker and moves to the surface earlier too. Since the sampling takes place every year in the first week of July, there is a high probability that a large amount of species and individuals have been absent in the 2015 assessment. Although the frequency and number of individuals showed a slight decrease over the past year, there is an overall increasing trend since the year 2009 representing consistent improvement of water quality.

In contrast to frequency and number of individuals, the biomass doubled since last year. This sudden increase is due to the abundant number of mussels and snails that were found in this year's assessment. Mussels as well as snails nourish from algae and filter water which makes their existence a stabilizing effect for water quality in general. The highest concentration of biomass was found at station 1, which is located next to the forest. Stations 2 and 13 located close to beaches also had a high biomass concentration despite human disturbances.

The outcome of species frequency as an indicator is dependent on what species is present. This year, for instance, a new snail species *Planorbis planorbis (L.)* was found. This species was found at station 2 which is located close to a small beach. The *Planorbis planorbis* is an indicator for poor water quality which may be due to the anthropogenic influence from the beach area. Contrarily, approximately 1.3kg of the species *Bilvalvia* was found at station 1, indicating very good water quality. Although station 1 and 2 are located in close proximity to one another, station 1 is surrounded by forest and has less of an anthropogenic influence than station 2, verifying the negative influence of human disturbances. Additionally, the species *Viviparus Viviparus (L.)* was found at both stations 4 and 7, indicating very good water quality near the inflow and the outflow of the lake. Station 12 also had the indication of very good water quality through the species *Molana Sp.* which was found in the middle of the lake.

While the various data collection demonstrates a steady improvement in water quality since 2009, the BMWP index shows that six of the fourteen stations in the lake are still classified in the lowest class of water quality. With only one of the fourteen stations classified as moderate water quality, there is still a need for further management and restoration measures to achieve a healthy ecological state in Lake Durowskie.

References

EPA (2012): Water: Monitoring & Assessment. Chapter 4 Macroinvertebrates and Habitat. URL: http://water.epa.gov/type/rsl/monitoring/vms40.cfm (state: 11.07.2015).

EPA (2015): Water: Lakes. Lakes Awareness Month and Outreach Materials. URL: http://water.epa.gov/type/lakes/month_index.cfm (state: 11.07.2015).

GOŁDYN R. et al. (2013): The response of lake Durowskie ecosystem to restoration measures. Carpathian Journal of Earth and Environmental Sciences, August 2013, Vol. 8, No. 3, p. 43 – 48.

PAWLEY et al. (2011) Guide to British Freshwater Macroinvertebrates for Biotic Assessment. The Freshwater Biological Association, Ambleside. October 2011.

Hawkes, H. A. (1998): Origin and development of the biological monitoring working party score system. In: Water Research 32(3), p. 964–968.

SEAGRANT MARYLAND (2015): How To Calculate Biodiversity? URL: http://ww2.mdsg.umd.edu/interactive_lessons/biofilm/diverse.htm (state: 11.07.2015).

WALSH, C.J. (2005): Biological indicators of stream health using macroinvertebrate assemblage composition: a comparison of sensitivity to an urban gradient. In: Marine & Freshwater Research 57(1), p. 37-47.

Appendix

Frequency 2015

Frequency of macroinvertebrates collected from the sampling stations in Lake Durowskie (1m²)															
	Taxon Sta	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
HIRUDINEA															
1	*Erpobdella octooculata (L.)*							+							
2	Glossiphonia complanata (L.)		+												
3	Helobdella stagnalis (L.)				+			+			+		+	+	
4	Hemiclepsis marginata (O. F. Müller)		+					+							
5	Piscicola geometra (L.)							+							
OLIGOCHAETA			+		+			+					+		
BIVALVIA															
7	Anodonta anatina (L.)				+										
8	Anadonta cygnea (L.)	+						+							
9	Unio tumidus Philip.	+	+					+			+		+	+	
10	*Pisidium sp.*												+		
11	*Sphaeriidae sp.*							+			+				
GASTROPODA															
12	*Bithynia tentaculata (L.)*		+		+			+			+		+		
13	Lymnaea peregra (O. F. Müller)		+												
14	Potamopyrgus antipodarum (E.A. Smit	+						+					+	+	
15	*Planorbis planorbis (L.)*		+												
16	Theodoxus fluvitatilis (L.)	+	+		+			+			+		+		
17	Viviparus viviparus (L.)				+			+							
ISOPODA															
18	Asselus aquaticus L.				+						+				
MEGALOPTERA															
19	Sialis fuliginosa Pictet				+										
COLEOPTERA															
20	*Hydroporus sp.*	+													
EPHEMEROPTERA															
21	*Caenidae*	+			+			+					+		
TRICHOPTERA															
24	*Apatania sp.*				+										
26	*Molana sp.*												+		
25	*Trichoptera sp.*		+					+	+		+		+		
DIPTERA															
Chaoboridae															
27	Chaoborus flavicans (Meig.)			+		+	+					+			+
28	Chaoborus - pupae		+												
Ceratopogonidae			+		+			+	+						
Chironomidae															
29	*larvae*	+	+		+			+	+	+	+		+	+	
30	*pupae*		+		+				+						
ACARI															
31	*Hydrachna sp.*								+						
32	*Hydracarina sp.*												+		
	Summary	7	13	1	13	1	1	16	5	1	7	1	12	4	1

Number of Individuals/m²

Number of macroinvertebrates collected from the sampling stations in Lake Durowskie (1m²)														
Taxon St	1	2	3	4	5	6	7	8	9	10	11	12	13	14
HIRUDINEA														
Erpobdella octooculata (L.)							39							
Glossiphonia complanata (L.)		78												
Helobdella stagnalis (L.)				78			195			117		78	39	
Hemiclepsis marginata (O. F. Müller)		39					39							
Piscicola geometra (L.)							39							
OLIGOCHAETA		897		468			195					312		
BIVALVIA														
Anodonta anatina (L.)				39										
Anadonta cygnea (L.)	39						156							
Unio tumidus Philip.	39	39					39			39		39	78	
Pisidium sp.												39		
Sphaeriidae sp.							78			39				
GASTROPODA														
Bithynia tentaculata (L.)		78		39			195			39		108		
Lymnaea peregra (O. F. Müller)		39												
Potamopyrgus antipodarum (E.A. Smi	975						39					1 326	195	
Planorbis planorbis (L.)		39												
Theodoxus fluvitatilis (L.)	78	39		78			234			78		312		
Viviparus viviparus (L.)				39			39							
ISOPODA														
Asselus aquaticus L.				741										
MEGALOPTERA														
Sialis fuliginosa Pictet				39										
COLEOPTERA														
Hydroporus sp.	39													
EPHEMEROPTERA														
Caenidae	624			117			117	117				78		
TRICHOPTERA														
Apatania sp.				39										
Molana sp.												156		
Trichoptera sp.		78					117	156		117		234		
DIPTERA														
Chaoboridae														
Chaoborus flavicans (Meig.)			78		78	130					572			130
Chaoborus - pupae		39												
Ceratopogonidae	39	117		39			39							
Chironomidae								234						
larvae	6 006	1482		3 861			1 131	975	104	780		2 418	5 967	
pupae		39		78				39						
ACARI														
Hydrachna sp.								39						
Hydracarina sp.												39		
Total	7839	3003	78	5655	78	130	2691	1560	104	1209	572	5139	6279	130

Biomass [mg/m²]

Biomass of macroinvertebrates collected from the sampling stations in Lake Durowskie (1m²)														
Taxon **Station**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
HIRUDINEA														
Erpobdella octooculata (L.)							117							
Glossiphonia complanata (L.)		390												
Helobdella stagnalis (L.)				429			780			507		468	468	
Hemiclepsis marginata (O. F. Müller)		117					78							
Piscicola geometra (L.)							468							
OLIGOCHAETA		2 106		702			312					1 677		
BIVALVIA														
Anodonta anatina (L.)				29 055										
Anadonta cygnea (L.)	510 120						9 750							
Unio tumidus Philip.	762 450	797 550					129 051			666 900		16 770	772 590	
Pisidium sp.												1 014		
Sphaeriidae sp.							2 964			5 889				
GASTROPODA														
Bithynia tentaculata (L.)		2 847		2 730			120 280			1 950		10 608		
Lymnaea peregra (O. F. Müller)		234												
Potamopyrgus antipodarum (E.A. Smith)	7 488						234					11 778	2 106	
Planorbis planorbis (L.)		312												
Theodoxus fluvitatilis (L.)	18 096	8 580		6 630			27 885			6 903		52 065		
Viviparus viviparus (L.)				2 240			10 764							
ISOPODA														
Asselus aquaticus L.				1 638										
MEGALOPTERA														
Sialis fuliginosa Pictet				312										
COLEOPTERA														
Hydroporus sp.	39													
EPHEMEROPTERA														
Caenidae	741			468			195	273				351		
TRICHOPTERA														
Apatania sp.				312										
Molana sp.												27 300		
Trichoptera sp.		234					5 811	312		858		20 514		
DIPTERA														
Chaoboridae														
Chaoborus flavicans (Meig.)			286		312	598					2 314			520
Chaoborus - pupae		234												
Ceratopogonidae	39	156		234			156	234						
Chironomidae														
larvae	11 310	2769		15 132			7 254	9 243	1 846	9 945		9 282	22 698	
pupae		234		468				39						
ACARI														
Hydrachna sp.								312						
Hydracarina sp.												39		
Total	**1310283**	**815763**	**286**	**60350**	**312**	**598**	**316099**	**10413**	**1846**	**692952**	**2314**	**151866**	**797862**	**520**