



Ecological state of Lake Durowskie during restoration measures: Macroinvertebrate Analysis 2018

Supervisor: MSc. Ing Piotr Domek

Students: Alam Ferdous, Jessica Hodal,

Oscar Rojas & Agnieszka Szymańska



Contents

Introduction

Methodology

Results & Discussion

Conclusion

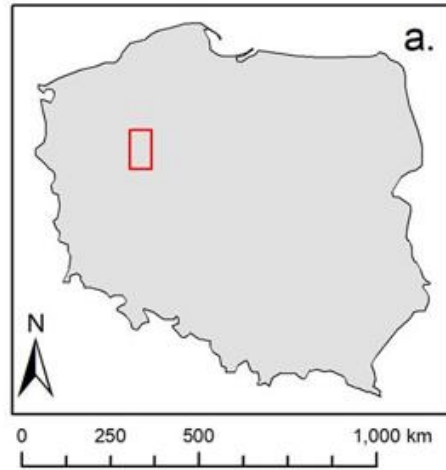
Recommendations

Questions

Parameter	Values
Surface	143.7 ha
Volume	11,322,900 m ³
Maximum Depth	14.6 m
Mean Depth	7.9 m
Total Catchment Area	23,610 ha
Land Use Form	Share of Direct Catchment Area in %
Urban	8.25
Agriculture	33.52
Forest	58.26



Wągrowiec Lake System and Lake Durowskie



Legend

Stations

● littoral

● pelagial

Landuse

■ agriculture

■ forest

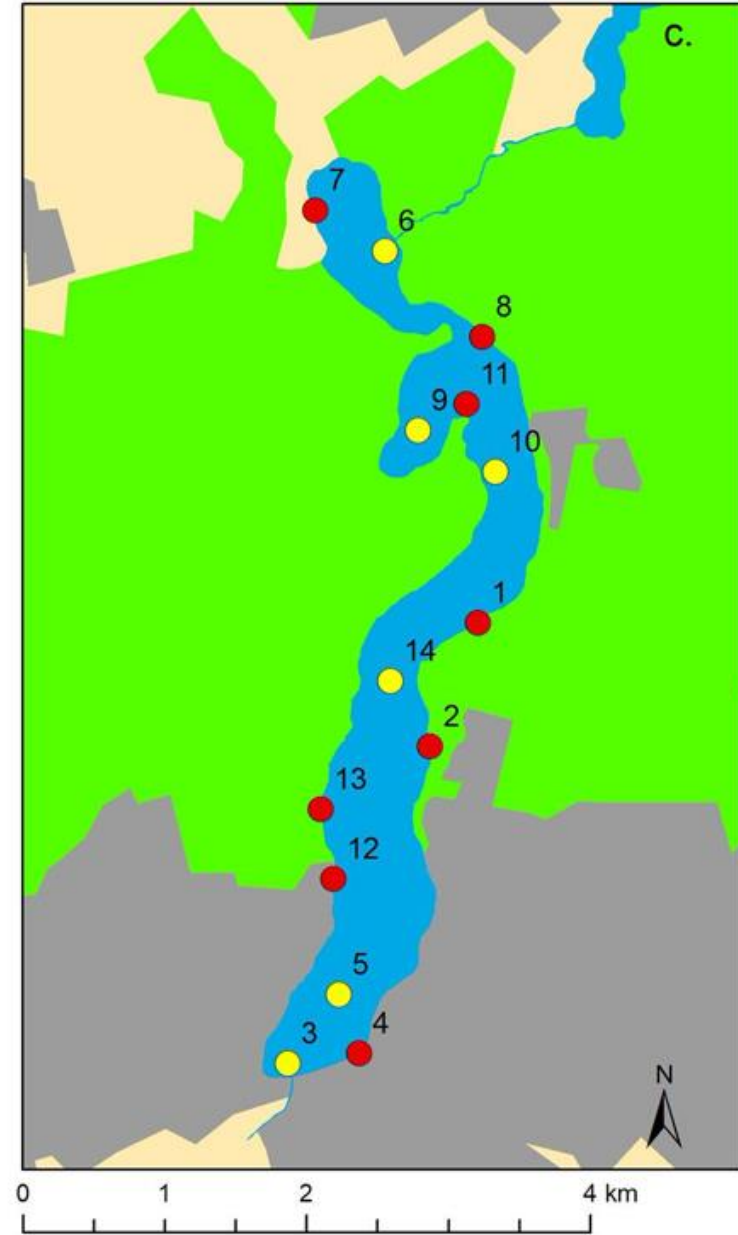
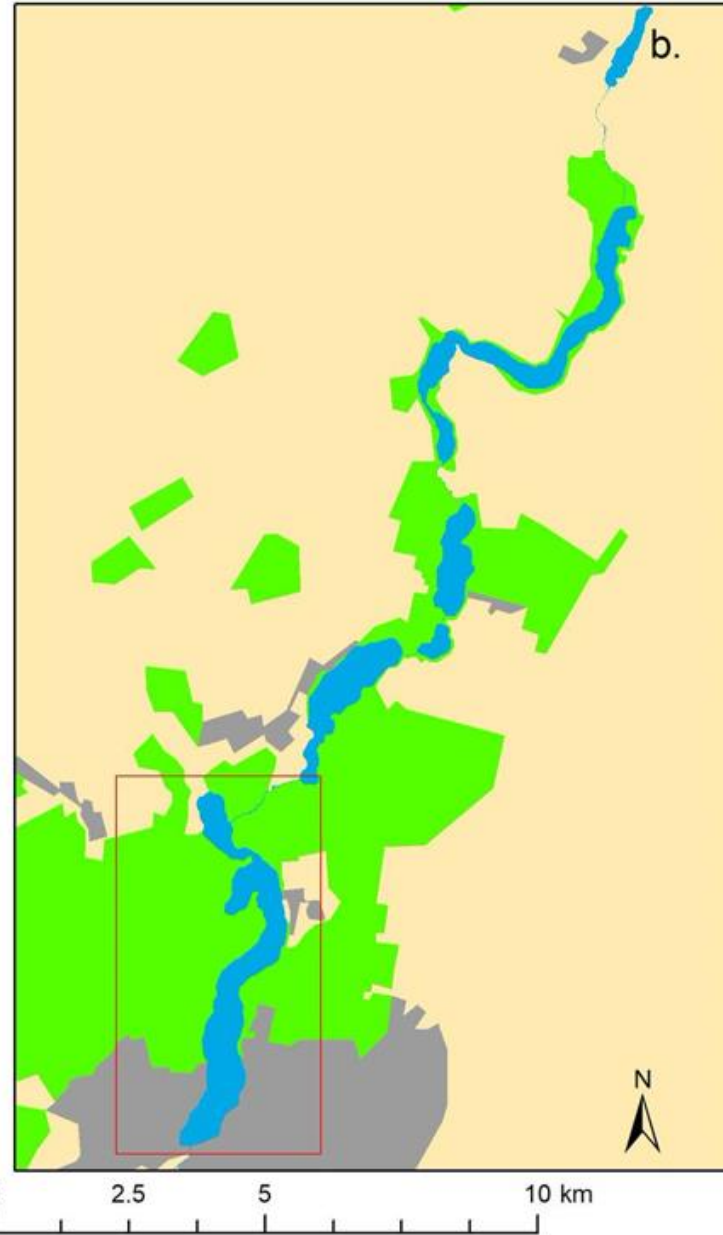
■ urban area

■ water

a. Map of Poland

b. Wągrowiec Lake System

c. Lake Durowskie



Background

- Problems
 - Anthropogenic Disturbance
 - Nutrient Loading
 - Cyanobacteria Blooms



(Berger et al., 2017)

Background

- Restoration Measures
 - Aeration
 - Chemical treatment
 - Biomanipulation



Macroinvertebrates

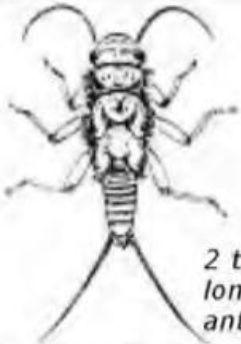
Macroinvertebrates, or zoobenthos are well-suited bioindicators of water quality:

- Diverse species with trophic variation
- Wide spectrum of tolerance levels
- Relatively easy & inexpensive sampling
- Short and long range of lifespans
- Extensive geographic distribution
- Fast recovery from sampling events



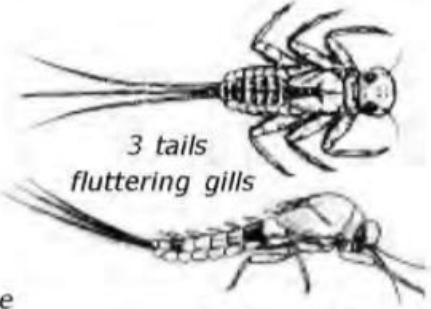
(WVDEP)

GROUP 1 – Very Intolerant of Pollution



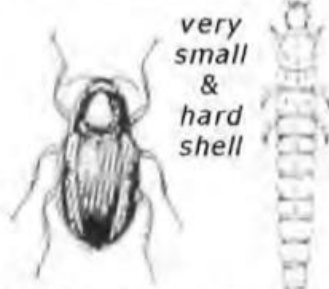
2 tails
long
antennae

Stonefly Nymph



3 tails
fluttering gills

Mayfly Nymph



very
small
&
hard
shell

**Riffle Beetle
Adult & Larva**



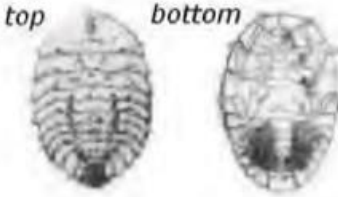
makes a case from
twigs, rocks, leaves

Caddisfly Larva



large head &
2 pinchers

**Dobsonfly
Larva**



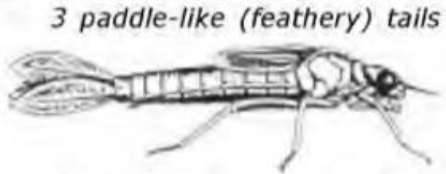
top bottom
looks
like a
suction
cup

Water Penny Larva



**Right-
Handed
Snail** must be
alive to
count

GROUP 2 – Moderately Intolerant of Pollution



3 paddle-like (feathery) tails

Damselfly Nymph



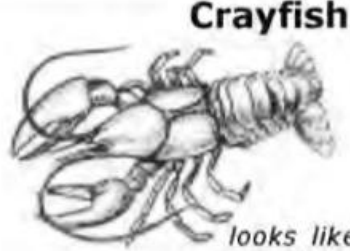
**Dragonfly
Nymph**

no tails
large eyes



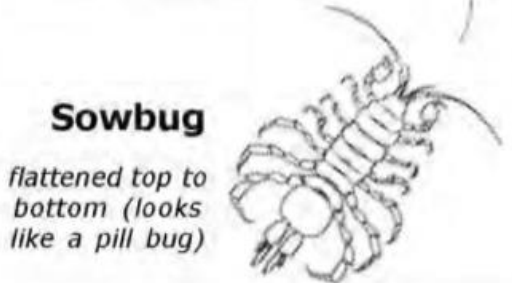
flattened
side-ways
& swims
on side

Scud



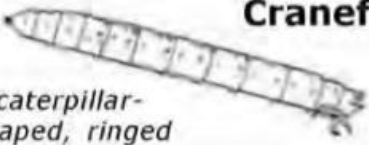
Crayfish

looks like
a mini-
lobster



flattened top to
bottom (looks
like a pill bug)

Sowbug



caterpillar-
shaped, ringed

Crane fly



Clam/Mussel

must be
alive to
count

GROUP 3 – Fairly Tolerant of Pollution



Midge Larva

*small, but visible head
intense wiggler*



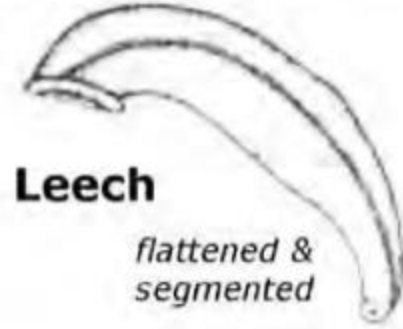
Planaria

*2 eye spots
& very small*



one end is swollen

Black Fly Larva



Leech

*flattened &
segmented*

GROUP 4 – Very Tolerant of Pollution



*segmented
"earthwormy"*

Aquatic Worms

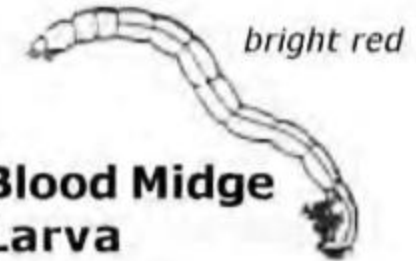
*must be
alive to
count*



**Left-
Handed
Snail**



**Rat-tailed
Maggot**



bright red

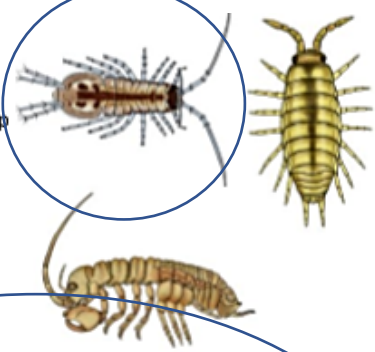
**Blood Midge
Larva**

Isopoda (Freshwater slater)

Very Tolerant

Description: Flattened from top to bottom with no body carapace. Slow movement. Up to 7mm.

Habitat: Wetlands and river edges.

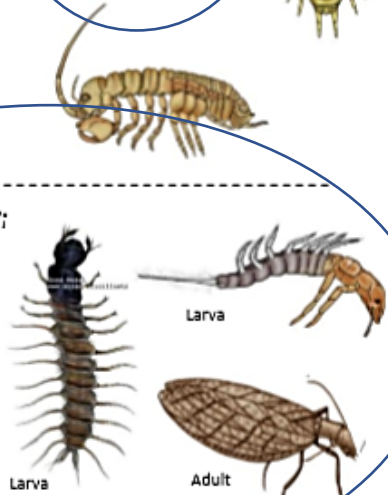


Megaloptera (Dobson fly; Alder fly; Toebiters)

Very Sensitive

Description: Slow deliberate crawl. Dark brown microspines. Up to 35mm.

Habitat: Fast flowing stony rivers.



Nematoda (Roundworms)

Moderately tolerant

Description: Thin elongated worms without segments. Can be transparent. Thrashing coiling/uncoiling movement. Can be confused with Gordian worms. Up to 12mm.

Habitat: Burrow into the substrate.



Nematomorpha (Gordian worms)

Sensitive

Description: Long thin parasitic worm up to 1 metre long.

Habitat: Adults are free living in aquatic environments.

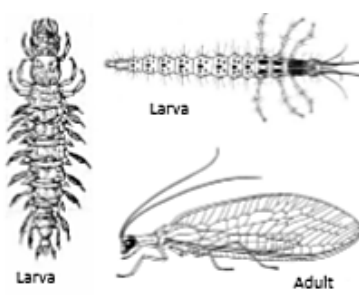


Neuroptera (Lacewings)

Sensitive

Description: Distinct neck and jaw with very fast or very slow movement. Confused with beetle larvae. Up to 20mm.

Habitat: Fast flowing streams

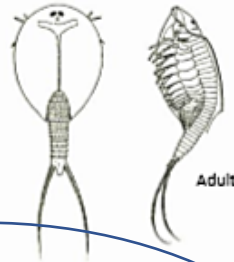


Notostraca (Tadpole shrimp; Shield shrimp)

Very Tolerant

Description: Shell-shaped dorsal shield that covers elongated body. Up to 35mm.

Habitat: Burrow into soft substrate.

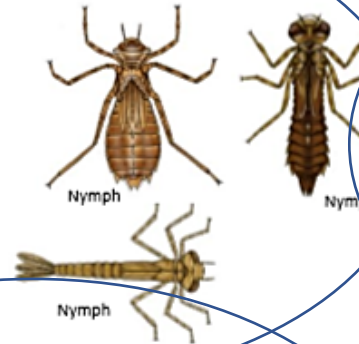


Odonata (Dragonfly nymph)

Moderately tolerant

Description: Stout bodies, no external gills and extendable mouth parts. Between 12-50mm.

Habitat: Found within the substrate and vegetation of rivers and streams.



Oligochaeta (Freshwater worm)

Very Tolerant

Description: Segmented worm with rounded ends, no suckers or legs and usually red or flesh coloured. Up to 30mm.

Habitat: Found in soft sediment rich in organic matter.

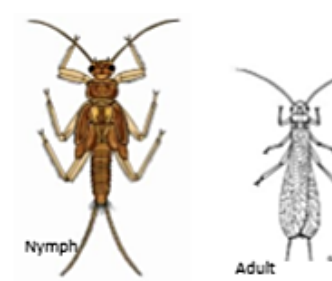


Plecoptera (Stonefly nymph)

Very Sensitive

Description: Two thin tails and gills extending from their abdomen. Shimmy from side to side. Between 7-12mm

Habitat: Found among stones or plants in fast moving waters.

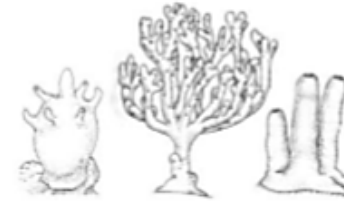


Porifera (Freshwater sponge)

Moderately tolerant

Description: Bodies filled with holes or pores for water circulation. Colour is grey, brownish or yellowish. Individuals are 5-10mm that form large colonies.

Habitat: Form a mat-like colony on underside or edges of submerged rocks or wood.



Trichoptera (Caddisfly Larva)

Very Sensitive

Description: Often enclosed within a case of twigs, plant material or silk. Rocks head back and forth to move. Up to 20mm.

Habitat: Found among sediment and rocks in streams and ponds.



Turbellaria (Flatworms)

Very Tolerant

Description: Primitive body plan. Flat with ribbon or leaf-like body. Slow moving. Between 6-20mm.

Habitat: Prefer the dark. Found in submerged leaf litter or under rocks.



Water Bug Detective Guide

Common Water Bugs

Acarina (Water mite)

Sensitive

Description: Simple round body with eight legs. Can be confused with Ostracods. Up to 5mm.

Habitat: Plants or stones on stream bed in standing or slow moving water.



Amphipoda (Side-swimmers, scuds)

Moderately tolerant

Description: Rests on its side and swims in swift bursts. Up to 15mm.

Habitat: Wetlands and edges of slow moving water.



Coleoptera (Beetles; eg. Riffle beetles, Whirligigs)

Moderately tolerant

Description: Small head, rounded back, smooth swimming action. Between 5-40mm.

Habitat: Flowing waters, found on detritus, river edge.



Beetle Larvae



Diving Beetle Adult



Larva



Whirligig Beetle Adult



Larva



Riffle Beetle Adult



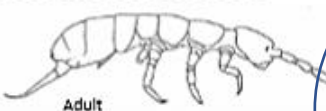
Larva

Collembola (Springtails)

Very Tolerant

Description: Either compact or elongated body shape. Sudden jumping action. Up to 10mm.

Habitat: Surface of still waters and on terrestrial vegetation.



Adult



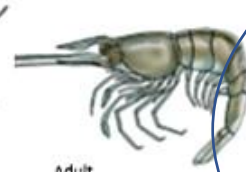
Adult

Decapoda (Yabbies, shrimp, crayfish)

Moderately tolerant

Description: Walk with sudden movement when disturbed. Hard shell, fan tail. Up to 30cm.

Habitat: Between plants and rocks in pools and rivers.



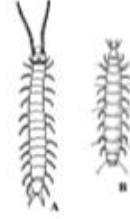
Adult

Diplopoda (Aquatic millipedes)

Moderately tolerant

Description: Worm-like with two pairs of legs per body segment.

Habitat: avoids light; hides under debris on waters edge.



A

B



C

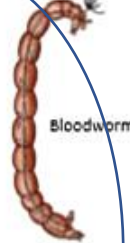
D

Diptera (Fly larva; eg. mosquito larvae and bloodworm)

Moderately tolerant

Description: Elongated body with no true legs. Worm-like and C-shaped. Bend and unbend, sometimes thrashing to move. Between 20-50mm.

Habitat: Still shallow water amongst mud and detritus.



Bloodworm



Pupa

Larva



Larva



Pupa



Larva



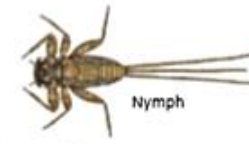
Pupa

Ephemeroptera (Mayflies)

Very Sensitive

Description: Three long thin tails. Movement like a rocking horse. Up to 15mm.

Habitat: Cool flowing upland streams.



Nymph



Nymph



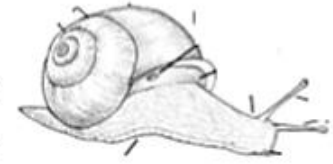
Adult

Gastropoda (Freshwater snails)

Very Tolerant

Description: Soft bodied animals enclosed in hard, protective, coiled shell. Up to 25mm.

Habitat: Found on plants and rocks in slow flowing or standing water.

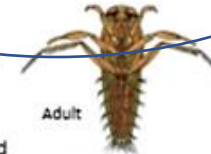


Hemiptera (True Bugs; eg. Back swimmers, water boatman, needle bug)

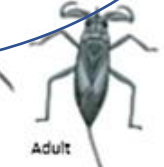
Very Tolerant

Description: Flat backs, head as wide as body. Jerky swimming action. No wings when young. Up to 10mm.

Habitat: Wetlands and river edges.



Adult



Adult



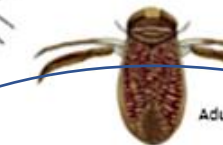
Adult



Nymph



Adult



Adult



Adult

Hirudinea (Leech)

Very Tolerant

Description: Flattened soft bodied annelid with suckers for creeping. 10-20mm.

Habitat: Standing or slow moving water and moist edge areas.



Hydrozoa (freshwater jellyfish)

Very Tolerant

Description: simple sack-like body with a mouth encircled by tentacles. Up to 30mm.

Habitat: Attached to rocks, plants or twigs in fast flowing water.

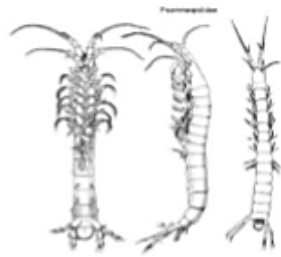


Anaspidacea (Cave shrimp)

Sensitive

Description: True carapace and compound eyes. Not strong swimmers.

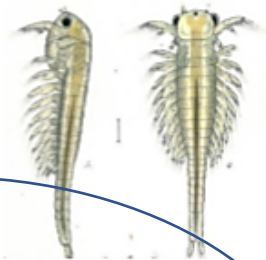
Habitat: Found in crayfish burrows; or mats of algae on the bottom.



Anostraca (Brine shrimps; Fairy shrimps)

Very Tolerant

Description: Pale colour with constant pulsing rows of legs. **Habitat:** Can live in fresh or salty waters.



Bivalvia (Freshwater mussels; Clams)

Moderately tolerant

Description: Paired hard shells with fleshy body between them. Up to 150mm.

Habitat: Found on sandy or muddy stream beds.

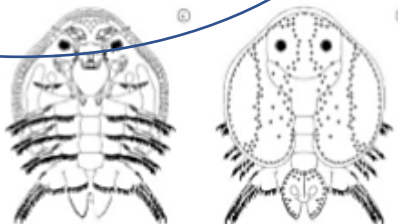


Branchiura (Fish lice)

Very Tolerant

Description: Flat oval body covered by carapace with prominent eyes. Fast swimmer. Between 5-10mm.

Habitat: Spend most of their time on a host except when moving between hosts or laying eggs.

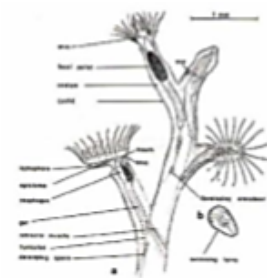


Bryozoa (Pipe mosses)

Moderately tolerant

Description: Form large colonies of several square meters that look like moss. Filter feeders with tentacles. Colouring brownish or opaque.

Habitat: Shaded littoral areas on the underside of rocks, logs or submerged debris.

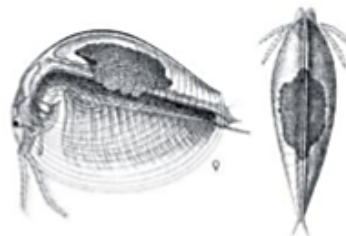


Conchostraca (Clam Shrimp)

Very Tolerant

Description: Bivalved carapace, enclosing whole animal. Slow swimmers. Up to 25mm.

Habitat: Turbid freshwater systems.



Lepidoptera (Moth Larvae)

Very Tolerant

Description: Caterpillar with soft segmented body, short legs and hair-like projections. Length 10-20mm.

Habitat: Pupate attach to vegetation and are found in moist soil and litter.



Larvae

Mecoptera (Scorpion flies)

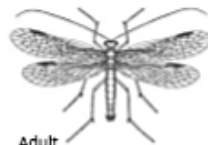
Very Sensitive

Description: Larvae are smooth and look like caterpillars with short clawed true legs and suction hook at the end of the abdomen. Length 10mm.

Habitat: Larvae live in leaf litter and moist soil.



Larvae



Adult

Nemertea (Proboscis worms)

Moderately tolerant

Description: Unsegmented thin body with no differentiated head. Less than 20cm.

Habitat: Brackish waters in and around rocks and substrate.



Polychaeta (Bristle worms)

Very Tolerant

Description: Segmented worm with bristles on their many leg-like parapodia. Slow movement. Max size 4cm.

Habitat: Marine systems in mud and sand habitats.



Water Bug Detective Guide

Uncommon Water Bugs

Methodology: Sampling

“Don’t Forget Vacuum!!”



A Team Action Boat

Kajak Sampler
Diameter 6.0cm
Pelagic samples
> 3m depth

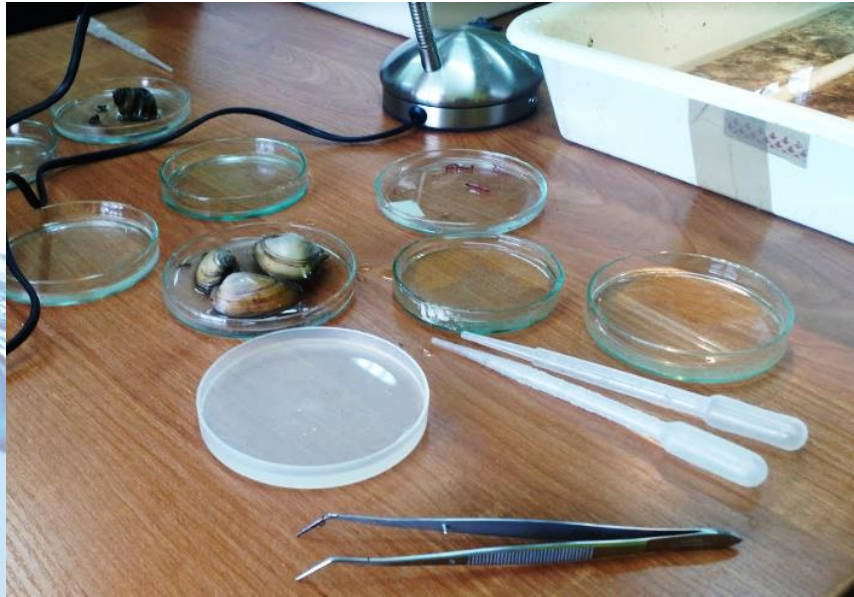


Czapla Sampler
Diameter 5.6cm
Littoral samples
< 3m depth

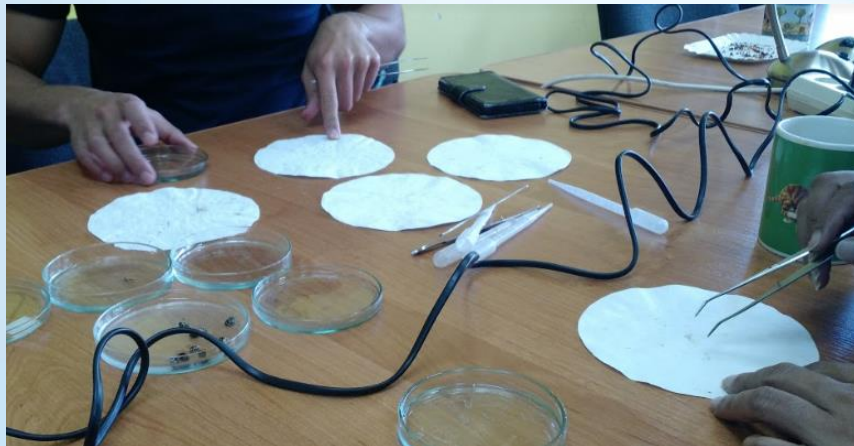


Sieve (Mesh = 004µm)

Methodology: Pre-Laboratory Analysis



Extracting and sorting macroinvertebrates from sediment samples



Drying and weighing (mg)



Coffee & Cake



Intoxicating (killing) organisms and preparing samples for transport to laboratory

Methodology: Laboratory Identification



Microscope

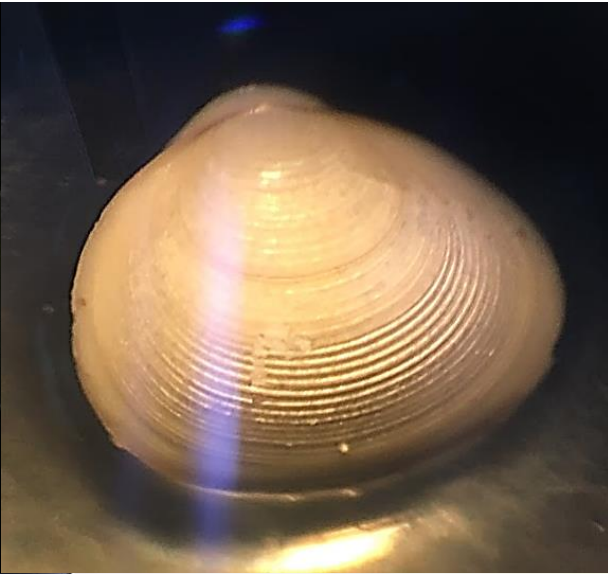
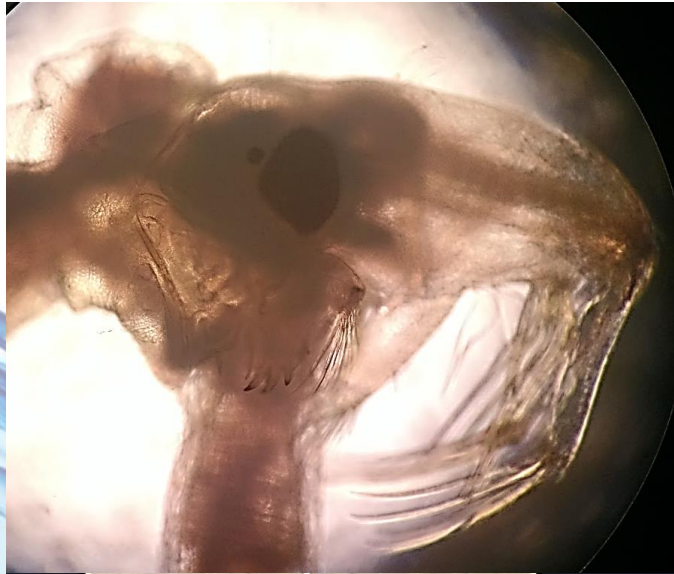


Stereoscope

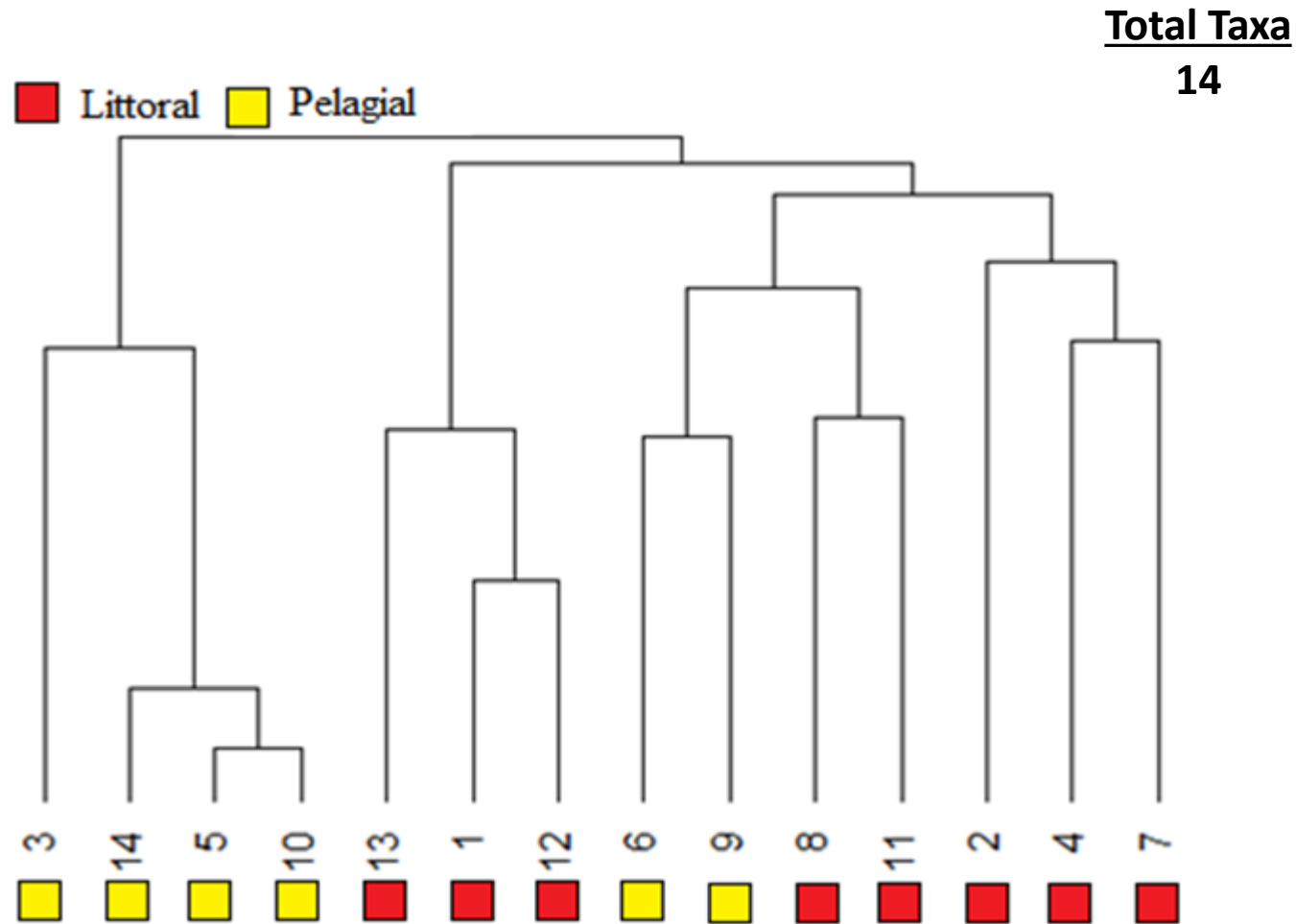
HIRUDINEA - Helobdella stagnalis (L.) - $1 \times 49 = 49$ indiv./m²
OLIGOCHAETA - $8 \times 49 = 392$ indiv./m²
 $21 \times 49 = 1029$ indiv./m²
BIVALVIA - Dreissena polymorpha (Pall.) - $1 \times 49 = 49$ indiv./m²
GASTROPODA - Theodoxus fluviatilis (L.) - $3 \times 49 = 147$ indiv./m²
 $20 \times 49 = 980$ indiv./m²
 $253 \times 49 = 12397$ indiv./m²
 $162 \times 49 = 7938$ indiv./m²

Calculations

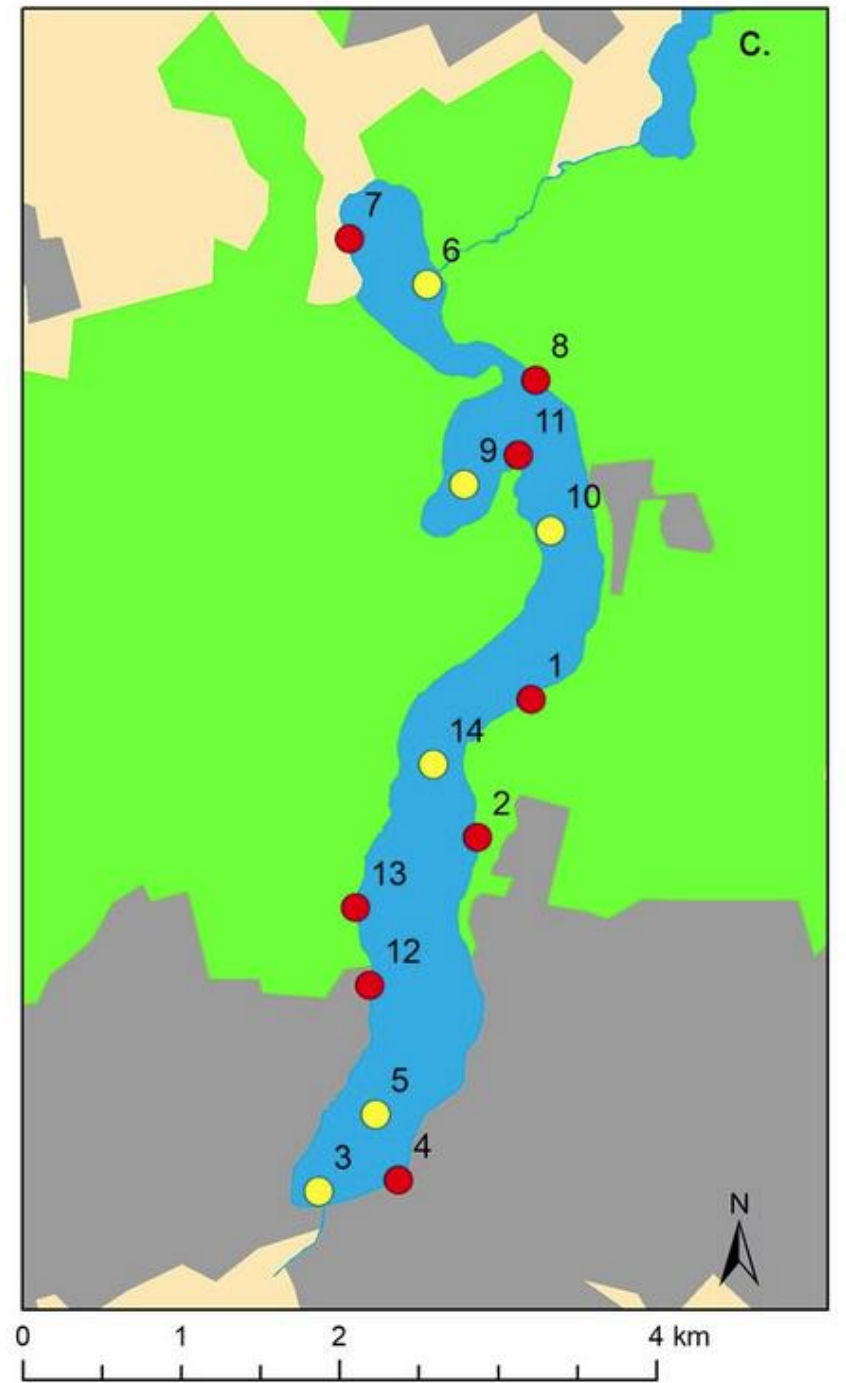
Methodology: Laboratory Identification



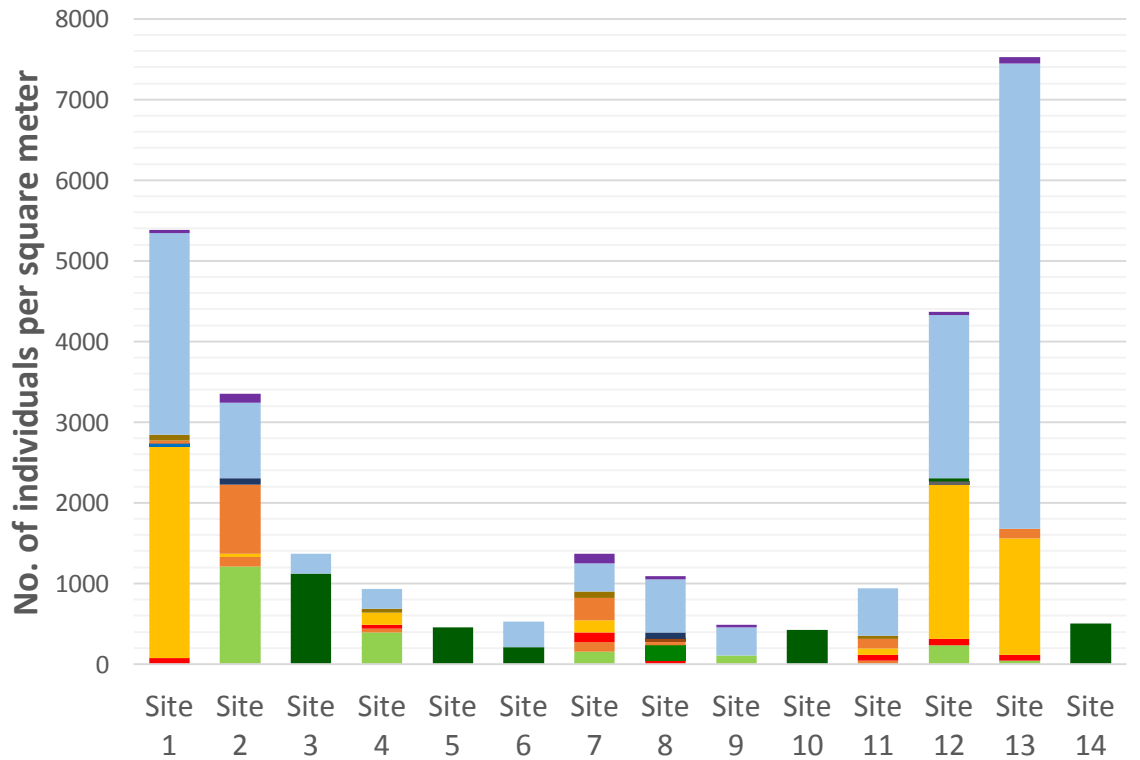
Jaccard Index



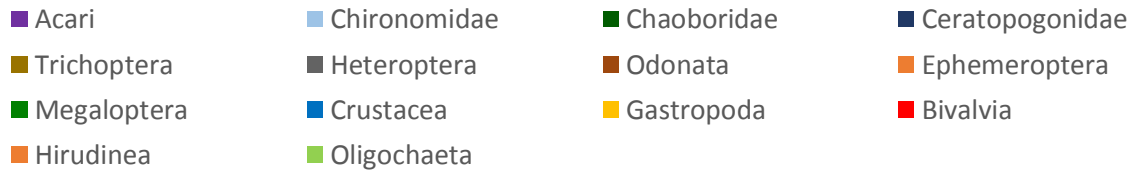
1	2	3	4	5	6	7	8	9	10	11	12	13	14
<2	<2	11	<2	15	5	<2	<2	5	11	<2	<2	<2	13



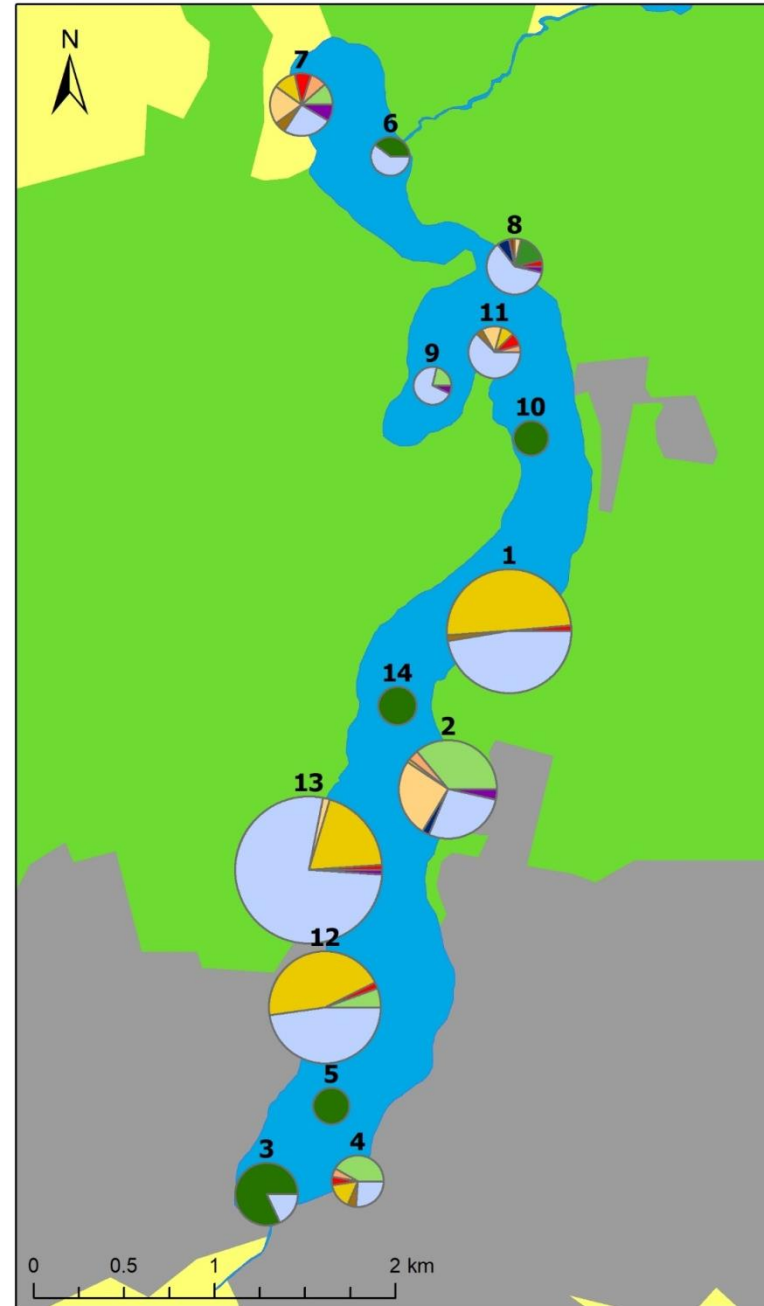
Number of individuals per m²



Site Number



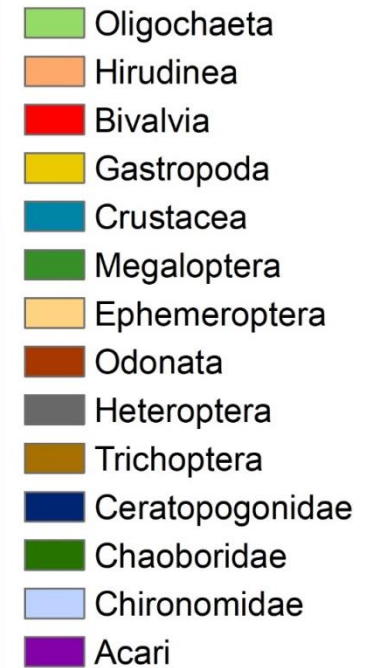
1	2	3	4	5	6	7	8	9	10	11	12	13	14
<2	<2	11	<2	15	5	<2	<2	5	11	<2	<2	<2	13



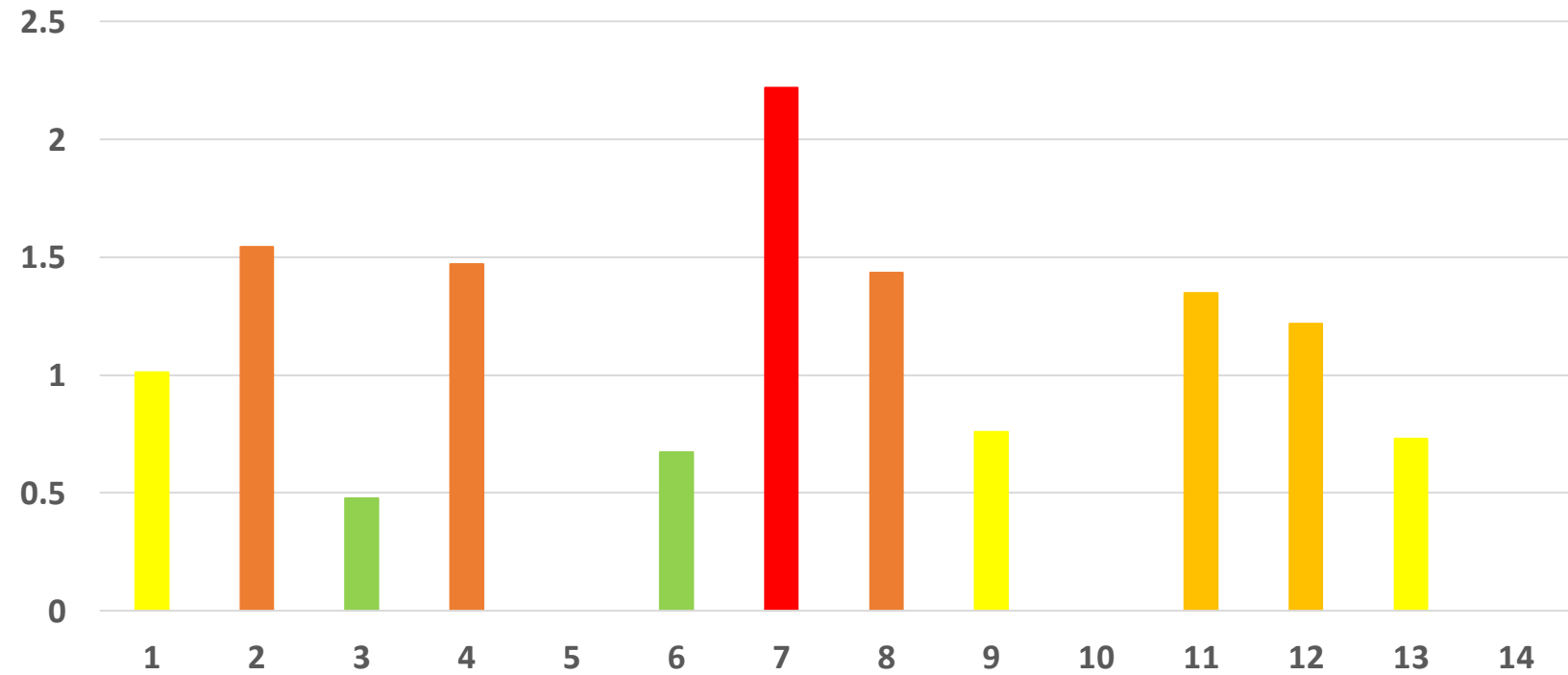
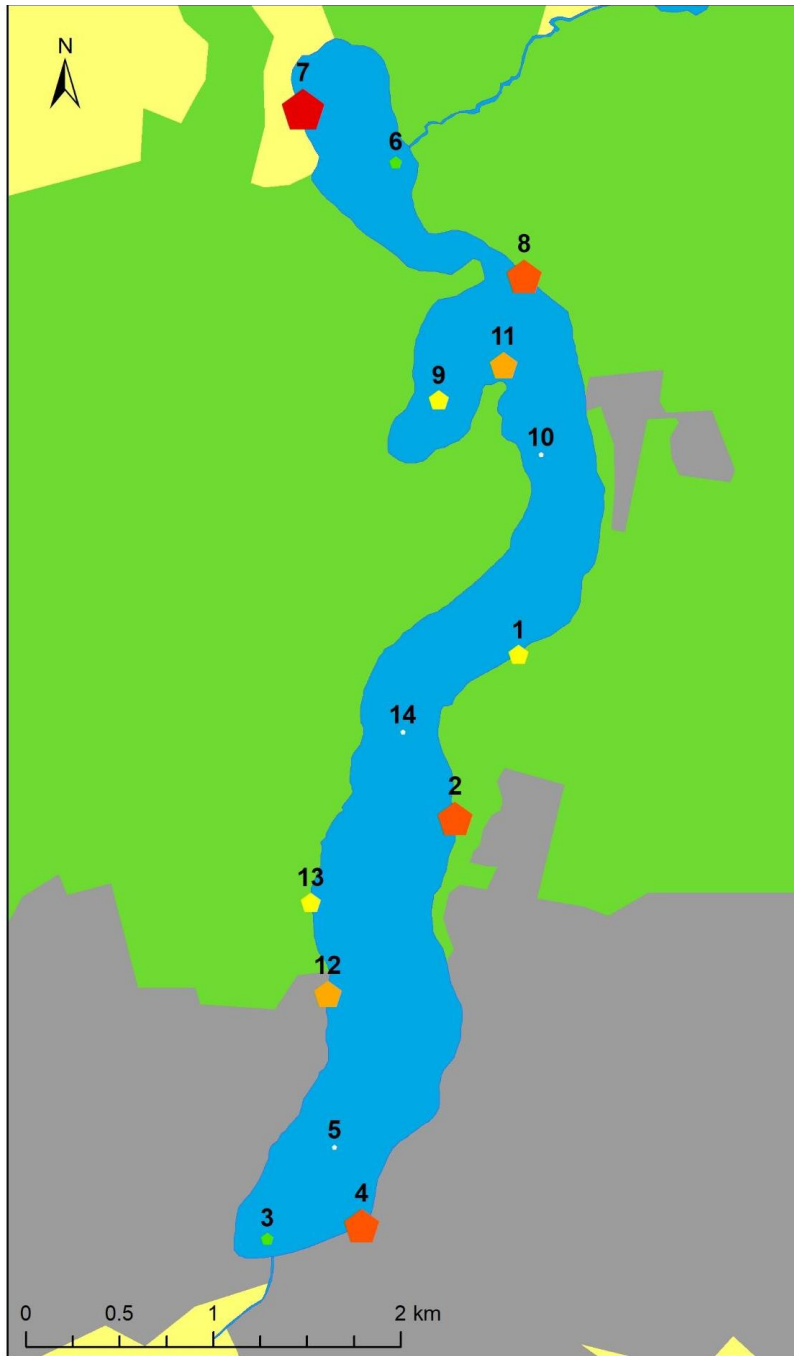
Total Amount
of Individuals
per 1 m²:

2,051

Taxa



Shannon-Wiener Index



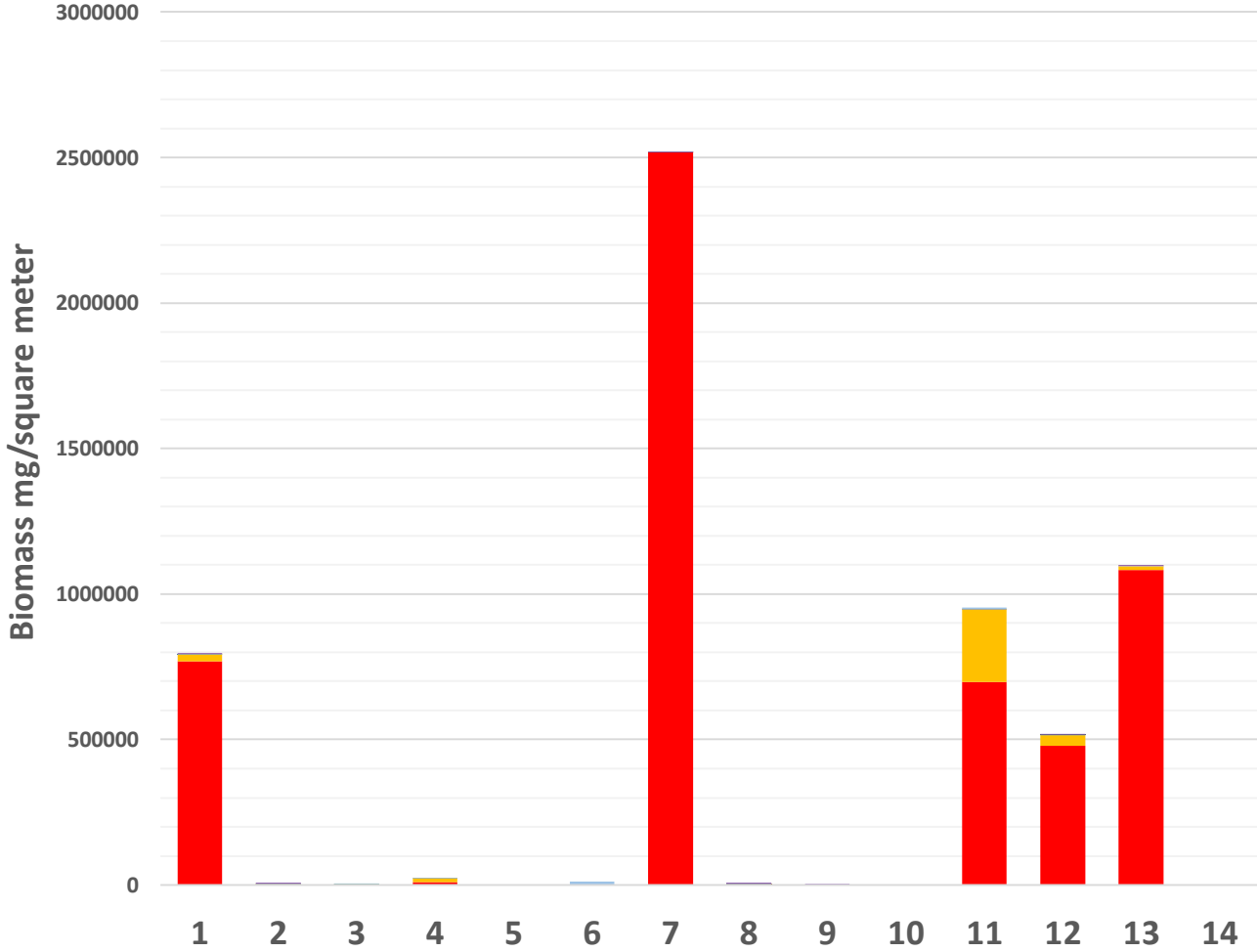
Shannon Index

- 0.000000
- 0.000001 - 0.686692
- 0.686693 - 1.049018
- 1.049019 - 1.424617
- 1.424618 - 1.813975
- 1.813976 - 2.217596

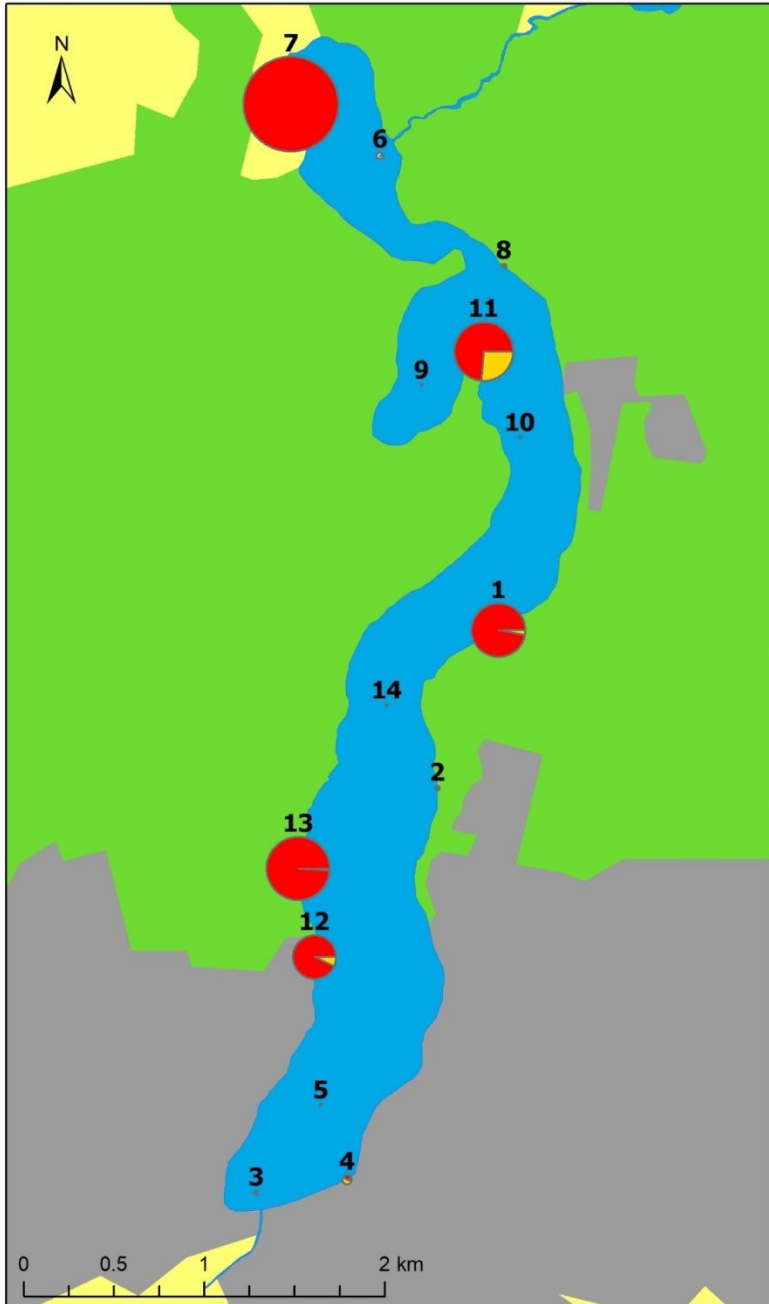
Average (2018) = 0.920453

1	2	3	4	5	6	7	8	9	10	11	12	13	14
<2	<2	11	<2	15	5	<2	<2	5	11	<2	<2	<2	13

Biomass in Lake Durowskie



- | | | | | |
|---------------|----------------|-----------------|-------------------|---------------|
| ■ Acari | ■ Chironomidae | ■ Chaoboridae | ■ Ceratopogonidae | ■ Trichoptera |
| ■ Heteroptera | ■ Odonata | ■ Ephemeroptera | ■ Megaloptera | ■ Crustacea |
| ■ Gastropoda | ■ Bivalvia | ■ Hirudinea | ■ Oligochaeta | |

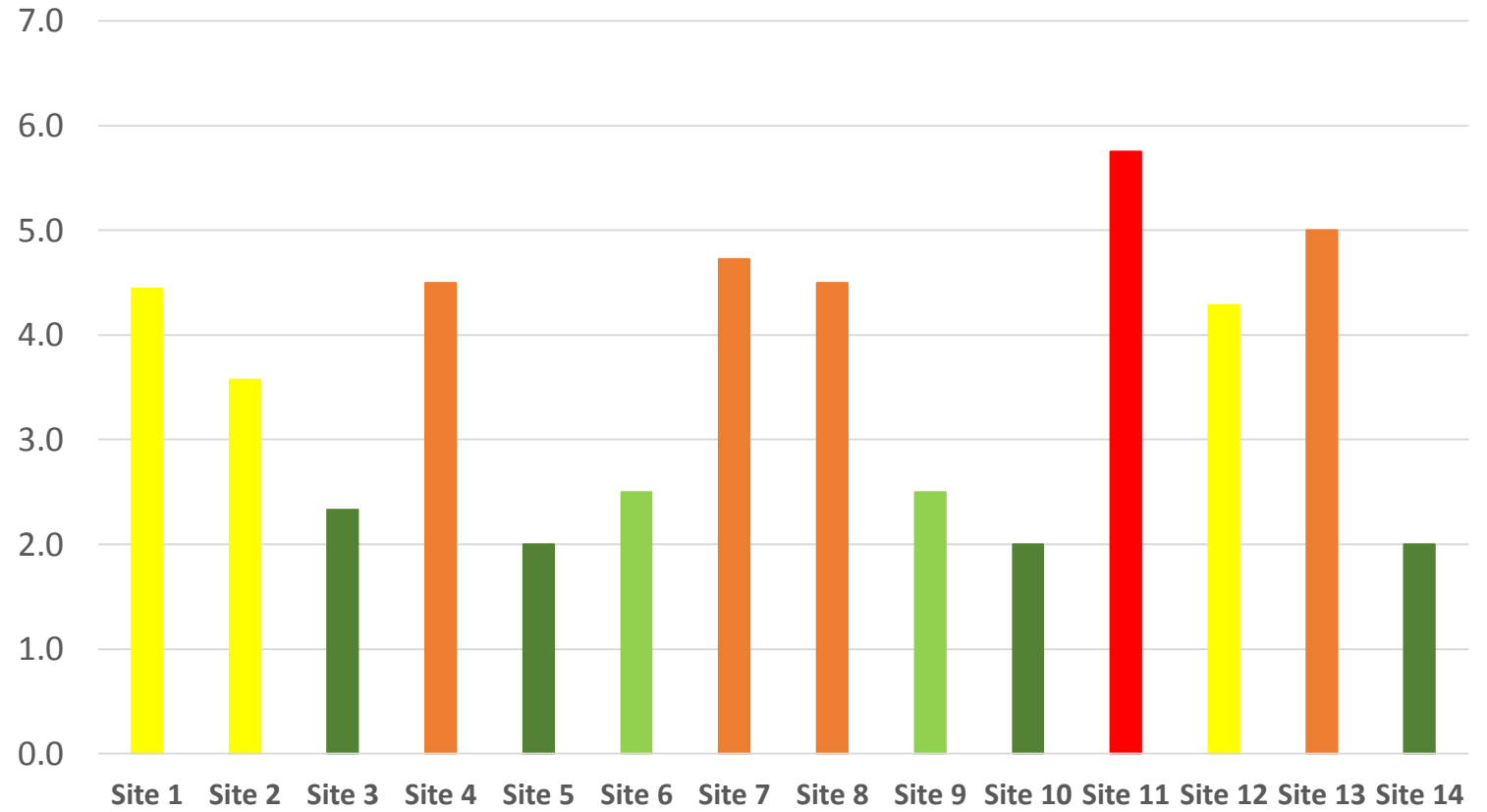
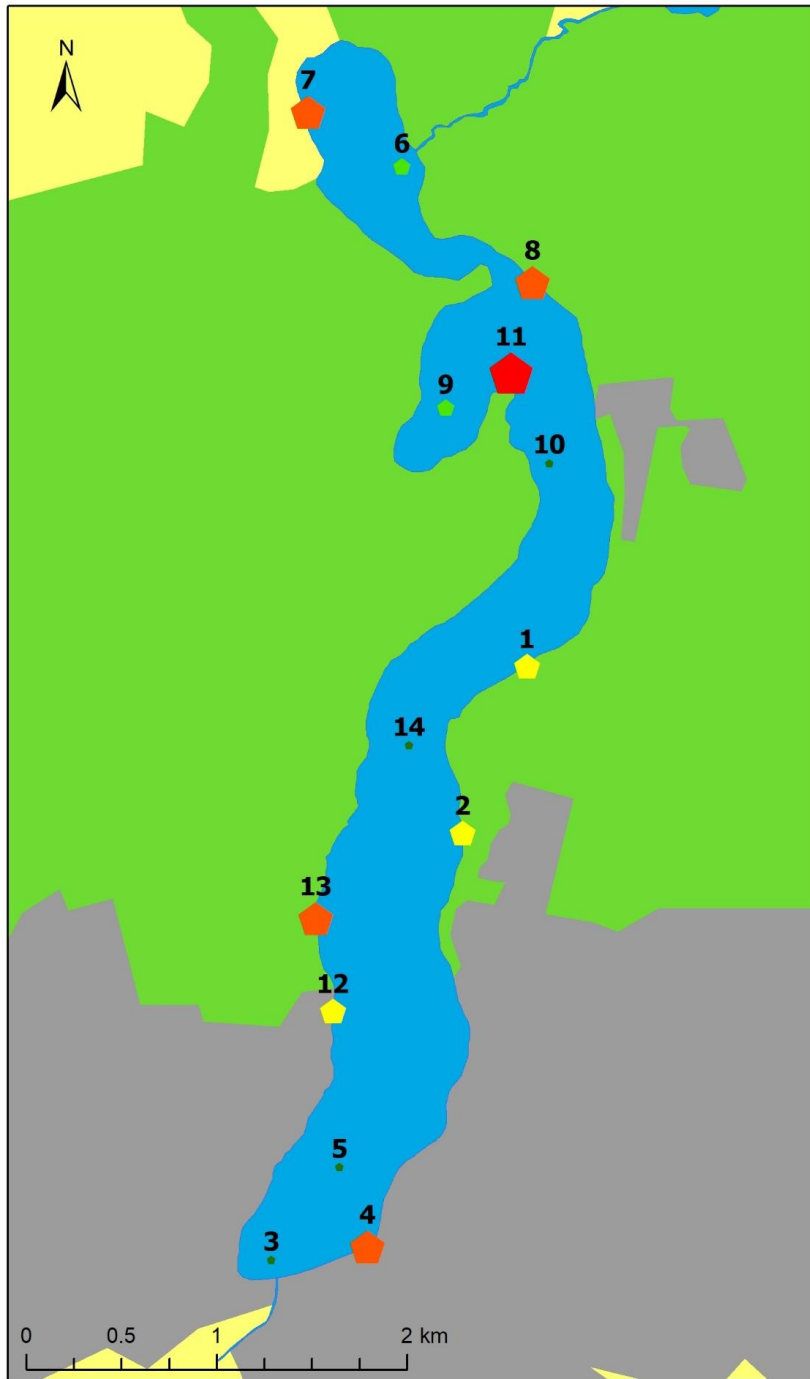


**Total Amount
of Biomass**

424,442 mg

- Taxa**
- Oligochaeta
 - Hirudinea
 - Bivalvia
 - Gastropoda
 - Crustacea
 - Megaloptera
 - Ephemeroptera
 - Odonata
 - Heteroptera
 - Trichoptera
 - Ceratopogonidae
 - Chaoboridae
 - Chironomidae
 - Acari

Biological Monitoring Working Party (BMWP) Score

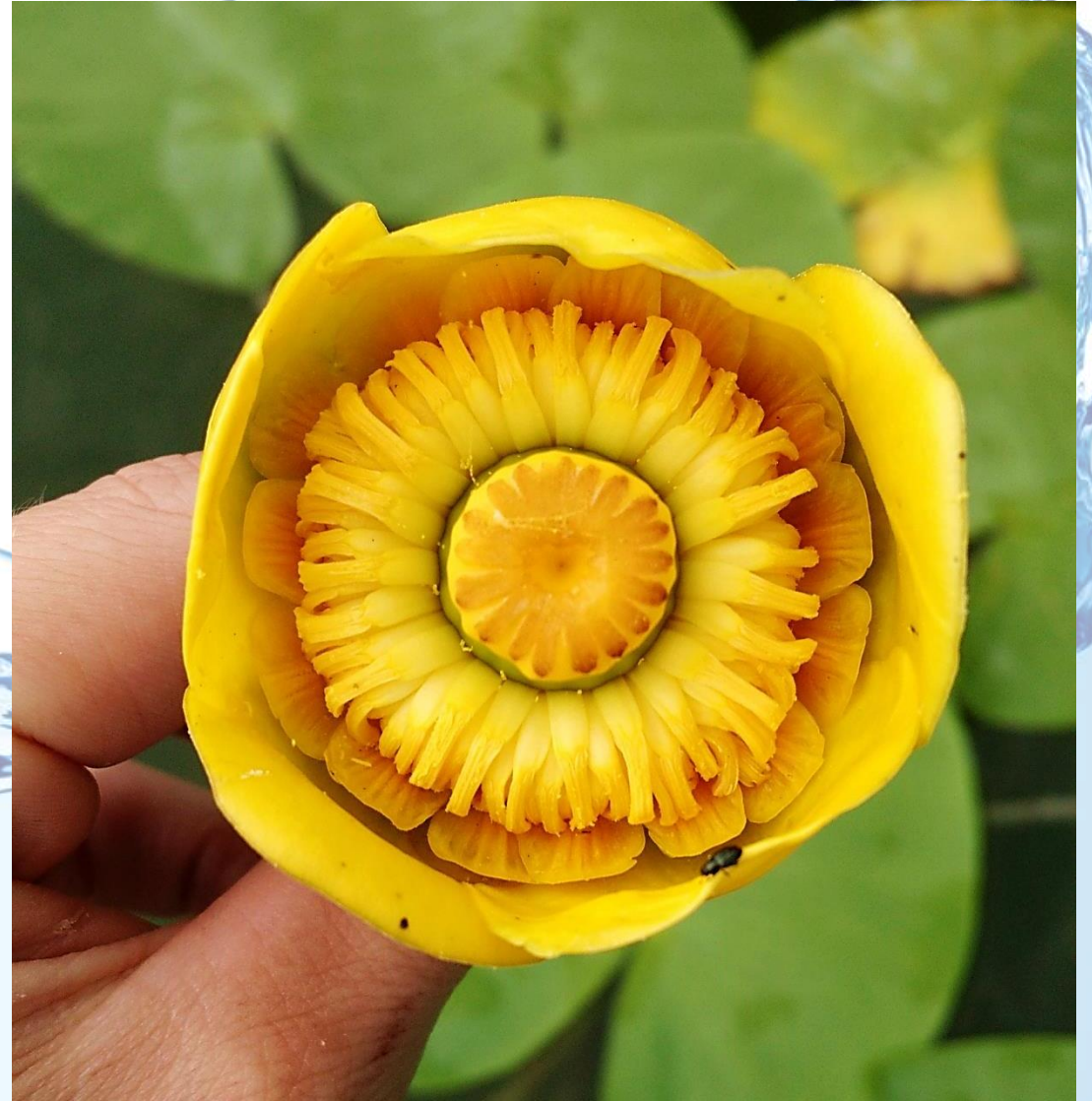


BMWP score

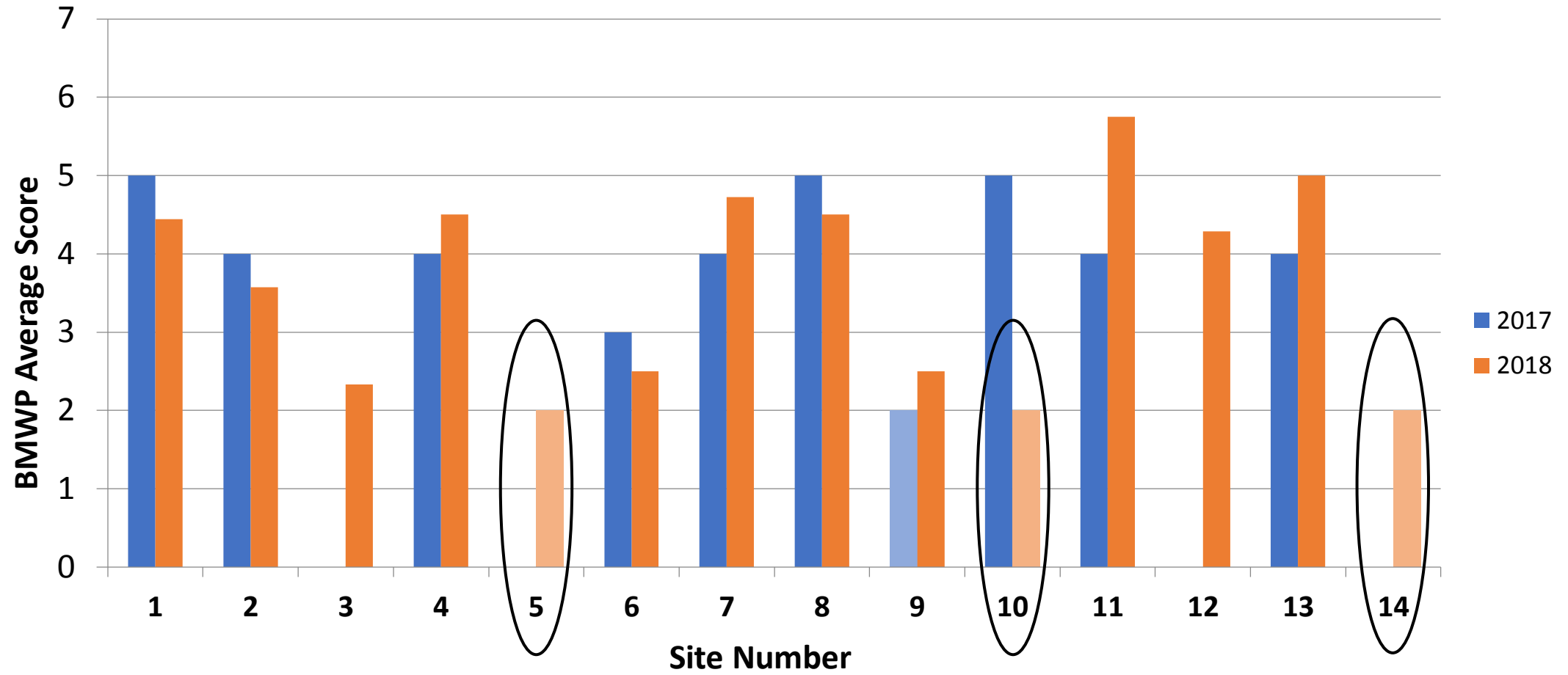


Restoration Success

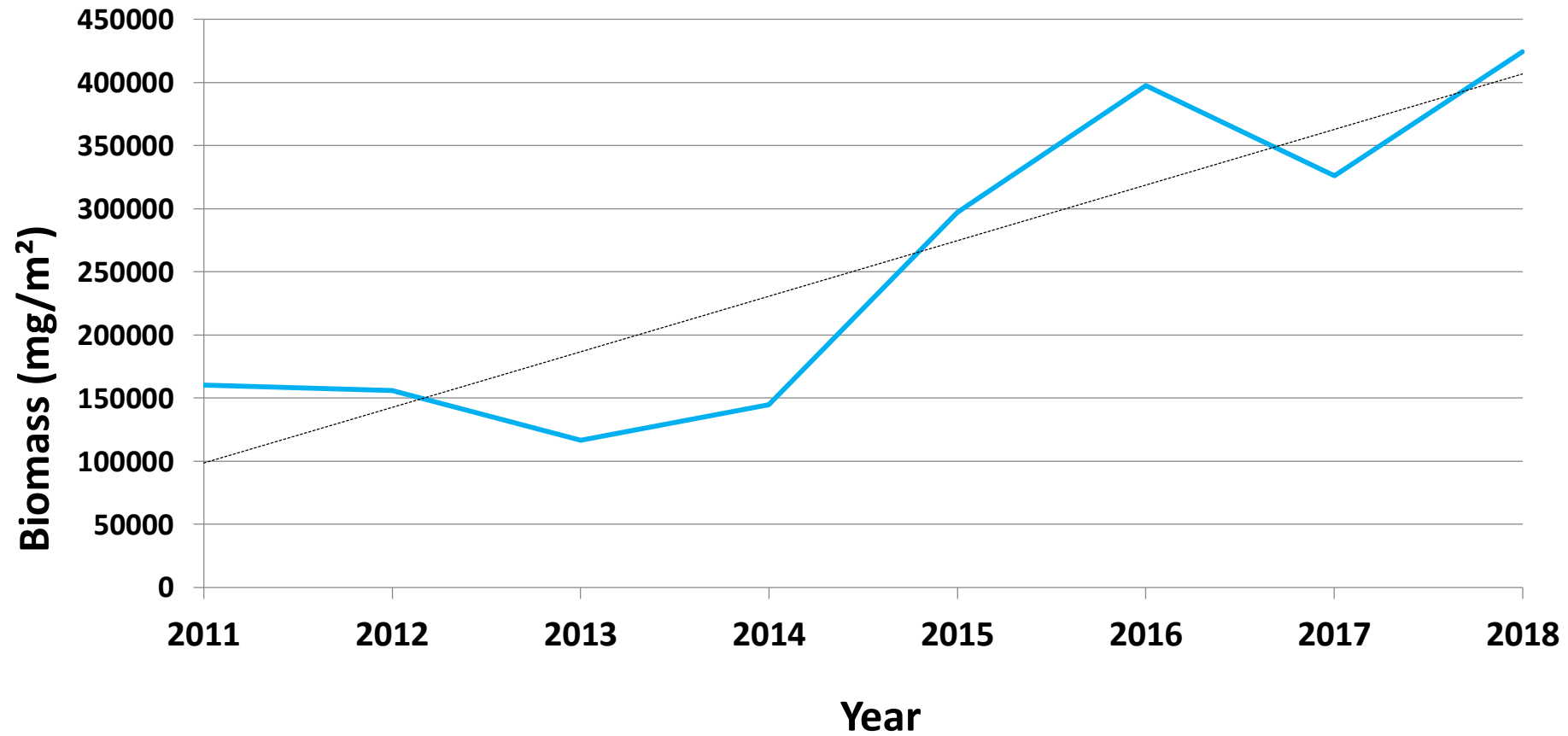
- Timespan of 10 years
- Temporal variations
- Overall improvement



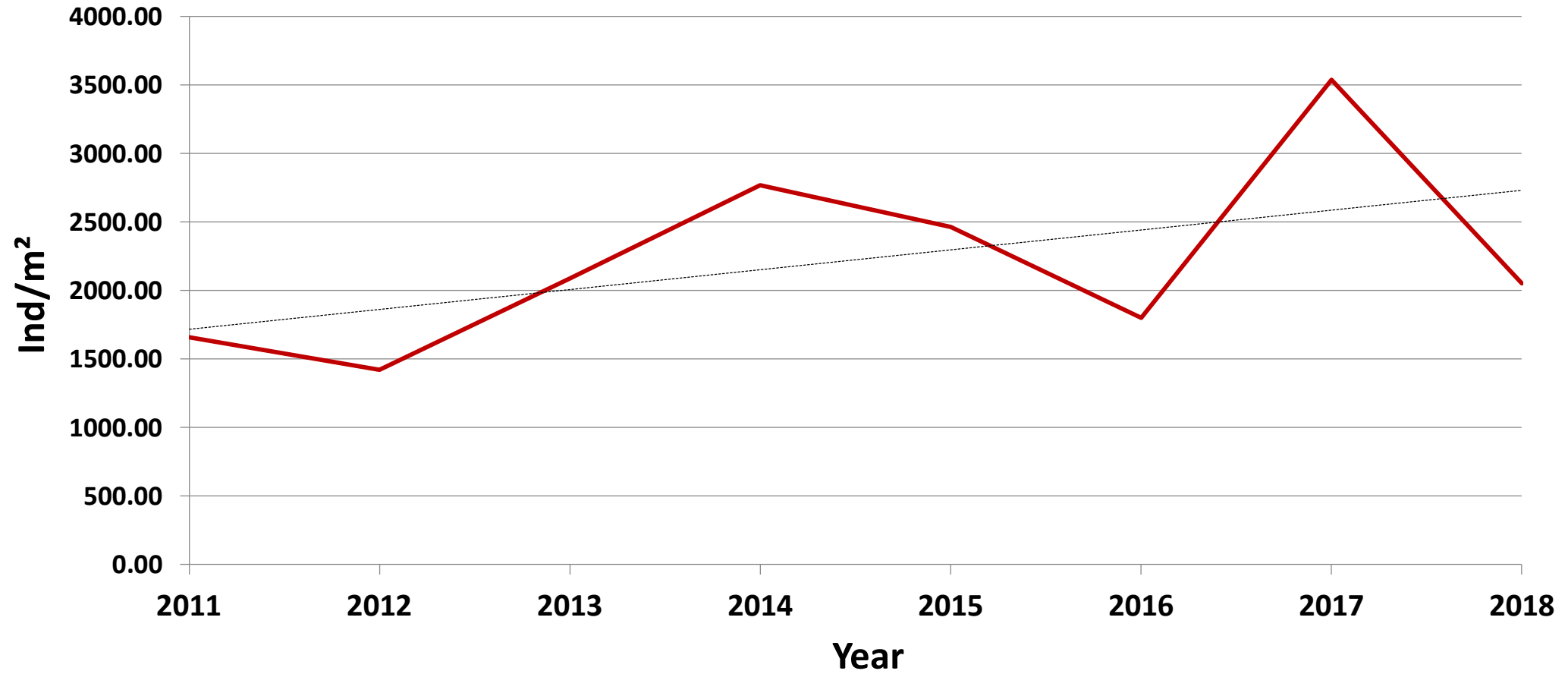
BMWP Comparison



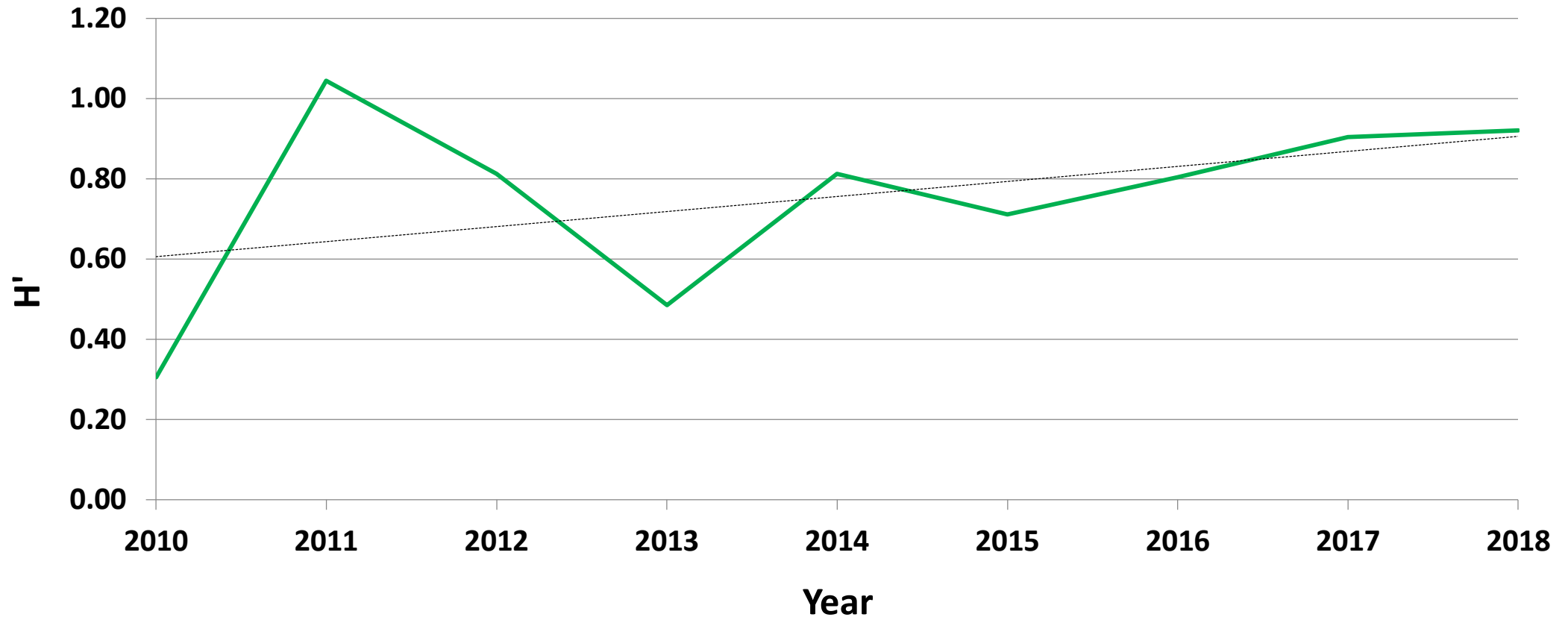
Changes in Biomass



Changes in Abundance



Changes in Biodiversity (Shannon-Wiener Index)



Conclusions

- Number of individuals decreased (possibly due to climatic conditions), but biomass has increased due to presence of bivalves
- Healthiest areas are in littoral zones, while anoxic conditions in pelagic zones affects diversity
- Trends for biomass, abundance, and biodiversity index are increasing which suggests good macroinvertebrate condition of lake



Recommendations

- Boost mussel populations in lake
 - High filtration capacity
 - Reduces algal blooms
- Install additional aerators
 - Improve O² levels in deeper parts of lake
- Increase macrophytes around littoral zones of lake
 - Southern portion of lake is highly urbanized
- Cooperation between other municipalities
 - Restoration efforts for all five lakes within the system
 - Reduce sources of pollution entering lakes
 - BMPs for agriculture and wastewater treatment plants



Sources

Berger, E., Haase, P., Kuemmerlen, M., Leps, M., Schäfer, R. B., & Sundermann, A. (2017). Water quality variables and pollution sources shaping stream macroinvertebrate communities. *Science of The Total Environment*, 587-588, 1-10. doi:10.1016/j.scitotenv.2017.02.031

Indiana Department of Environmental Management (IDEM). (2017). Hoosier Riverwatch Volunteer Stream Monitoring Training Manual. Retrieved July 5, 2018, from https://www.in.gov/idem/riverwatch/files/volunteer_monitoring_manual.pdf

Water Bug Detective Guide [Diagram]. (2014, July 16). In *Australian Capital Territory Waterwatch*. Retrieved July 5, 2018, from [http://www.act.waterwatch.org.au/Files/Bugs/Macro Diagram Sheet 1.1.pdf](http://www.act.waterwatch.org.au/Files/Bugs/Macro%20Diagram%20Sheet%201.1.pdf)

West Virginia Department of Environmental Protection (WVDEP). (n.d.). Benthic Macroinvertebrates [Digital image]. Retrieved July 5, 2018, from <https://dep.wv.gov/WWE/getinvolved/sos/Pages/SOPcollect.aspx>



Questions?