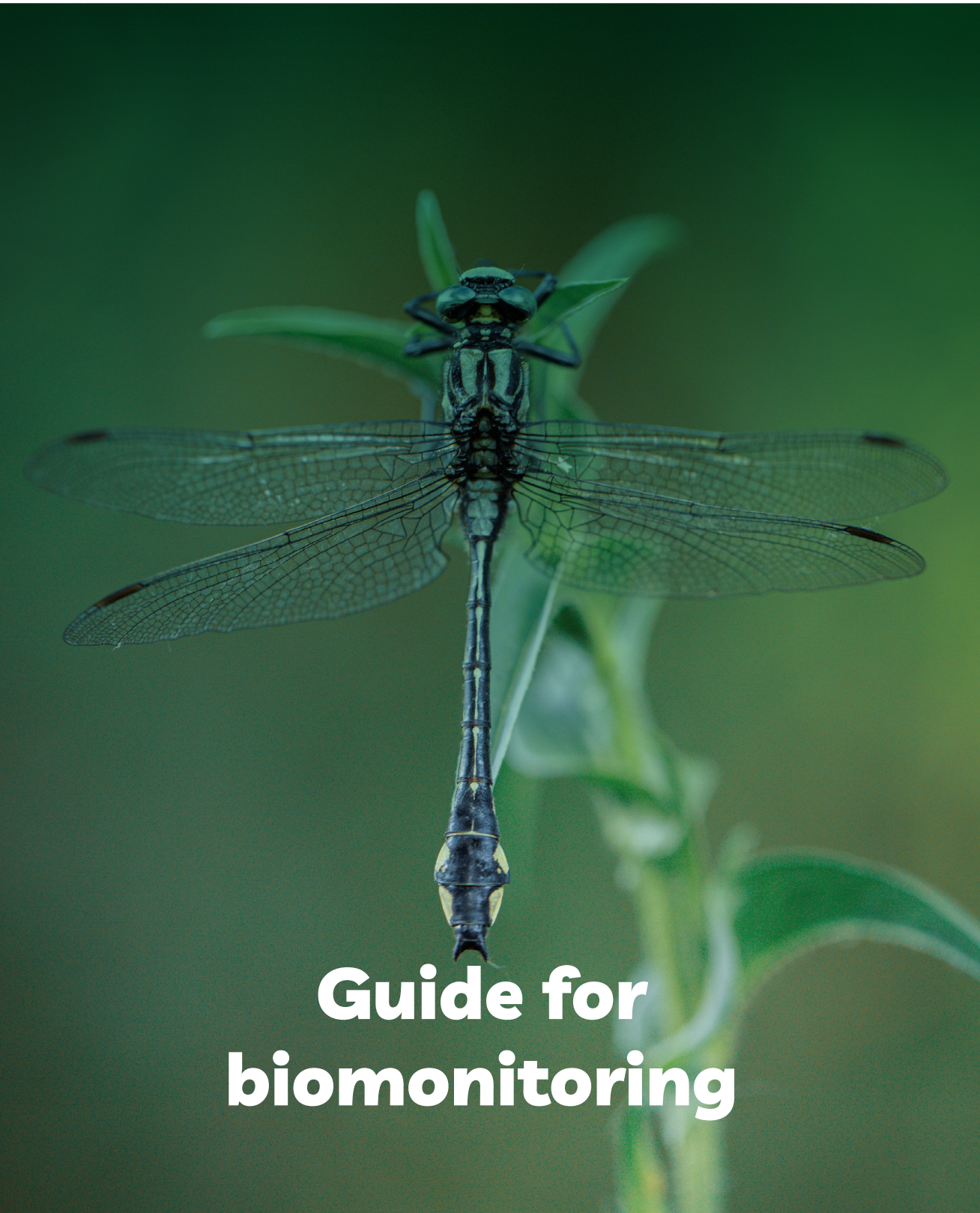
BIOMONITORING
RIJEKA ZETA

ENVPRO

The Nature Conservancy

USDA FOREST SERVICE



Guide for biomonitoring

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Balkans Water: bio indicators, education and tourism – management through cooperation

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Author:
dr Bogić Gligorović – Teacher researcher, expert on EnvPro Project

Project team:
mr Ana Katnić – Executive director of EnvPro
dr Snežana Dragićević – scientist and coordinator of EnvPro Project
mr Marija Popović – communication and visibility of EnvPro
Milan Mijajlović – cooperation with local community and promotion, NGO I love Danilovgrad

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1 office@envpro.me, www.envpro.me

Balkans Water Project: bioindicators, education and tourism – management through cooperation, is implemented by EnvPro in cooperation with partner global organization for nature protection *The Nature Conservancy* (TNC), with the support of the *United States Forest Service* (USFS).

The Guide is primarily intended to teachers in implementation of the school curriculum that also includes field activities, but can also be used by other stakeholders.

In support of the implementation, the web application has also been developed that, together with the educational guide for biomonitoring, will still be considered for formal integration into the educational curriculum tools of elementary schools.

In case of elementary education, biomonitoring is implemented by pupils, supervised by their teachers. The collected data are entered in the monitoring application.

In implementation of monitoring it is necessary to take care about the security and health protection. During the field activities it is necessary to use appropriate clothes and shoes and move carefully.

Educational guide for biomonitoring is conceptualised in a manner that it can apply to biomonitoring of other areas and of other species.

Additional instructions,maps and updates are available in application for collecting data with integrated key. Please start the use via link: **www.biomonitoring.me** or by scanning the QR code.

Biomonitoring

Biomonitoring constitutes the system of long-term monitoring of changes in the status of biodiversity on the basis of bioindicator species and parametres of habitat/environment.

Bioindicators are organisms used for monitoring the status and establishing environmental changes, registering of negative impacts and establishing effects of pollution on eco-system. Monitoring of indicator species and collecting their data enables establishment of changes within the eco-system on the basis of the trends in their populations.

For biomonitoring in the area of Zeta river we have selected significant groups of benthic macroivertebrates (large invertebrates living in the water), ten-clawed freshwater crayfish, dragonflies and freshwater mussels representing the most significant bioindicator organisms.

Selected bioindicator species are:
- White-clawed crayfish - *Austropotamobius pallipes;*
- Balkan goldenring - *Cordulegaster heros;*
- Sombre Goldenring - *Cordulegaster bidentata;*
- Green-eyed hawker - *Aeshna isoceles;*
- The smallest Aeshnidae - *Caliaeschna microstigma;*
- Turkish clubtail - *Gomphus schneiderii.*

Organizing of the field work

Preparations for going to the field will be implemented as follows:

- Preview of the Guide for monitoring.
- Planning of the field activities date on the basis of the attached monitoring preview for individual species (see in chapters of this document). Details are found in the Field Guide for Biomonitoring (PDF document), and in the video tutorials, available through the application (**www.biomonitoring.me**).
- Selection of the site on which biomonitoring will be implemented.
- If possible, plan implementtaion of field activities on recommended sites presented on the map (Figure 1).
- Preparation of field and other equipment (nets, traps, measuring devices), preview in more details is provided in this document below.
- Preview of application and introduction to the method of its use through reading of given instructions.
- Giving instructions to children on rules of the field work, safety, appropriate clothes and footware.

- Implementation of monitoring to be adjusted to the age of children the field work is planned with in accordance with cognitive levels and school curriculum.

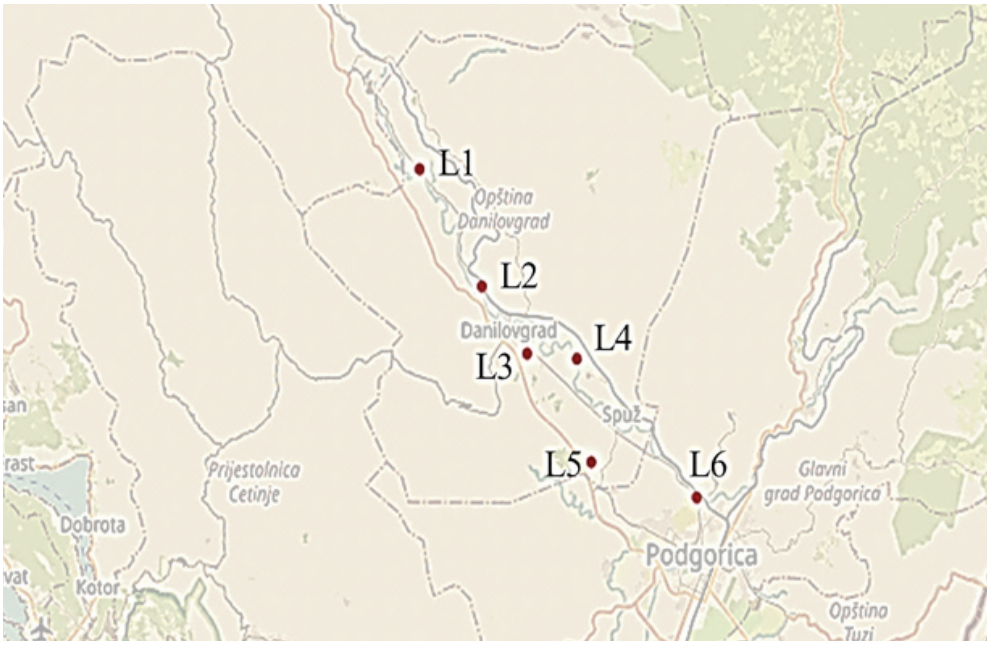

Figure 1. Map of the sites suitable for monitoring in the area of Zeta River

SITE	DESIGNATION	COORDINATES
Bogićevići	L1	42°34'21.01"S 19°04'59.93"I
Dobro polje	L2	42°37'49.07"S 19°01'57.51"I
Ćurilac	L3	42°32'21.42"S 19°07'12.23"I
Šabov krug – Martinići	L4	42°32'12.15"S 19°09'38.13"I
Kraljičino oko	L5	42°29'80.52"S 19°10'20.26"I
Vranjske njive	L6	42°28'50.56"S 19°15'29.03"I

Materials and methods

Collecting and observing bioindicator species is conducted by different methods. The field research requires the use of following equipment: nets, traps, biomonitoring application, camera (mobile phone) and a measuring device for determining physical-chemical parametres of water (Figure 2).

White-clawed crayfish can be collected by bare hands, traps and nets (Figure 3). Adult dragon flies are collected by entomological nets (Figure 4). Larvae of dragon flies are sampled by plankton nets (Figure 5).
Freshwater mussel is collected by hand.

Figure 2. Instrument for measuring physical-chemical parametres
Photo: Marko Nikolić

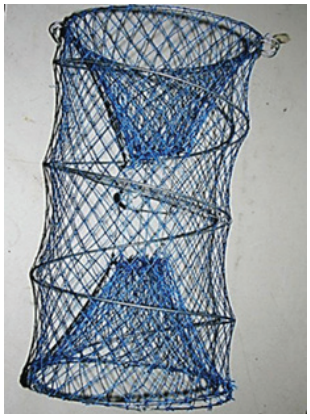

Figure 3. Trap – crayfish trap
Source: http://www.trapperarne.com

Figure 4. Entomological net
Photo: Bogić Gligorović

Figure 5. Plankton „kick net" net
Photo: Bogić Gligorović

Instruction for bioindicator species

Monitoring of white-clawed crayfish

Austropotamobius pallipes (Lereboullet, 1858)

Habitats of white-clawed crayfish are rivers and streams, with present roots of coastal plants, rocks and water plants. Monitoring of this species is done from June to November.

During the field research the white-clawed crayfish may be collected by hand, by nets and traps (nets with openings). The traps are placed in the vicinity of river banks and streams, under the rocks and/or roots of coastal vegetation and left in the water overnight, and checked early in the morning. Crayfish activity is the greatest in the autumn when they are getting ready for mating, or in the spring when they eat more after the reduced activity lasting during the winter. Transect in which collection is done is 100m long and 2m wide. For each researched site, subject to the researcher's/observer's qualifications, the data are entered in the application.

When we take crayfish (Figure 6), we catch carapace (anterior part of the body behind the pincers) with thumb and forefinger, and when returning it to the water we do it slowly, with belly part turned upward, which provides the air absorbed under carapace (in gill area) to come out. We do not take and do not raise from the water females carrying eggs on their belly legs.

Figure 6. *Austropotamobius pallipes*, habitat in the Zeta River
Photo: Mihailo Jovićević

Monitoring of dragon-flies
Odonata

For monitoring in the area of Zeta River we have selected 5 species of dragon-flies living in different habitats.

- *Cordulegaster heros Theischinger*, 1979 (Figure 7) – Balkan goldenring, inhabits large springs and streams and small rivers with dense overgrowth of coastal vegetation;

- *Caliaeschna microstigma Schneider*, 1845 (Figure 8) – The smallest Aeshnidae, inhabits large springs and streams and small rivers whose bottom is overgrown with moss and water vegetation;

- *Aeshna isoceles* (Müller, 1767) (Figure 9) – Green eyed hawker, inhabits paddles and marshes overgrown with vegetation;

- *Cordulegaster bidentata Selys*, 1843 (Figure 10) – Sombre goldenring, inhabits small springs and streams;

- *Gomphus schneiderii Selys*, 1840 (Figure 11) – Turkish clubtail, inhabits rivers.

Monitoring of dragonflies is carried out from June to September. The individuals are counted along transect, subject to the length of the course or width of the water body, maximum up to 100 m. Transect is divided to sections of 20-25 m. The width of transect is taken subject to the species and habitat. For Balkan goldenring and Turkish clubtail it is 5 m in inland part and 2m above the water. For Sombre goldenring and the smallest aeshnidae the width of transect is 5 m in inland part, and from 0,2 to 2 m in water part, depending on the width of spring or stream. For green-eyed hawker the width of transect is 5 m in inland part and 10 m above the water. Counting along the transect is carried out twice on the same route, where the 20 minute break is made at the ultimate point of the transect, so that disturbed individuals calm down. Collection of adult individuals for the determination of presence of species is made by entomological net. After determination, the individuals are released. Depending on the observer's/researcher's qualifications, the data are entered in the application. Total number of individuals is obtained by adding up the avarage number of individuals per repetition in all sections of the transect.

Figure 7. *Cordulegaster heros*
Photo: Mihailo Jovićević

Figure 8. *Caliaeschna microstigma*
Photo: Mihailo Jovićević

Figure 9. *Aeshna isoceles*
Photo: Bogić Gligorović

Figure 10. *Cordulegaster bidentata*
Photo: Mihailo Jovićević

Figure 11. *Gomphus schneiderii*
Photo: Mihailo Jovićević

Monitoring of the freshwater mussel
Unio mancus Lamarck 1819

Freshwater mussel inhabits slower parts of the river with sandy bottom, overgrown by water vegetation (Figure 12). Monitoring of freshwater mussels may be carried out throughout the year when the water level in the river is low. Individuals are collected manually in order to determine their species. When the species is determined, the mussls, if visible, are counted from the water surface. Collection or counting are done along the transect up to 30 m, on three training grounds in the distance of 5m, whose length is 5 m, and width 2 m. If the size of appropriate habitat is smaller, the length of transect and dimensions of the training ground are reduced. Research is mainly conducted in summer months. Since the species is identified on the basis of specific characteristics (size, color, age, damage and other characteristics), the individual is returned to the sand. While samples are collected it is necessary to take care that the sand bottom is damaged to the smallest extent. In addition to alive individuals, empty shells on the same training grounds are also counted.

Figure 12. *Unio mancus*
Photo: Mihailo Jovićević

Attachment 1:

Integration of biomonitoring program into the educational system

Program objectives and outcomes to be achieved by anticipated biomonitoring activities entirely correlate with:

1. Educational-pedagogical outcomes within the subject Biology for primary school.
2. Strategy for development and support of gifted pupils, and are implemenetd through competitions, projects, fairs and other types of organized activities intended for promotion of science and ensuring enrichment of the curriculum.
3. Inter-subject program „Education for sustainable development", and is implemented through educational-pedagogical outcomes including fields of environmental protection and biodiversity.
4. Montenegrin framework program of key competences: Mathematic competence and competence in science, technology, engineering through outcomes for ISCED 2.
5. Activities envisaged by the project, which are significant for the application of biology knowledge and development of digital skills within the educational system on improvement of the results of PISA testing.

Objectives of the biomonitoring program

Objectives of this program are harmonized with the learning outcomes envisaged by the Subject program for Biology in primary school:

Getting to know the nature and life in compliance with it;

Development of ecological awareness;

Development of intellectual skills;

Development of self-confidence;

Development of independence;

Development of moral and esthetic values;

Development of social-emotional skills (empathy, tolerance, respecting differences);

Development of skills for using information-communication technologies;

Improvement of STEM competences;

Practical application of the learned;

Quality organization of free time;

Adoption of functional knowledge;

Improving school achievement;

Development of skills for using digital keys for identifying species;

Familiarizing with biomonitoring methods and understanding its significance;

Fostering volunteerism;

Familiarizing with invertebrate species in the vicinity of school they are attending;

Familiarizing with protected organism species;

Adoption of positions on the significance of nature protection;

Familiarizing with mechanisms for the protection of Zeta River.

Expected program outcomes

Defined outcomes entirely correlate with educational-pedagogical, as well as with learning outcomes envisaged by the subject program Biology for primary school:

VI grade

- Educational-pedagogical outcome 1 - At the end of learning the pupil will be able to explain the concept, division, studying methods and significance of Biology.

VII grade

- Educational-pedagogical outcome 5 - At the end of learning the pupil will be able to explain characteristics of invertebrate with secondary body cavity.

IX grade

- Educational-pedagogical outcome1 - At the end of learning the pupil will be able to explain the subject of study and division of ecology, division of ecological factors and characteristics of different levels of ecological organization.

- Educational-pedagogical outcome2 - At the end of learning the pupil will be able to explain characteristics of different eco systems, with special reference to eco systems in Montenegro.

- Educational-pedagogical outcome 3 - At the end of learning the pupil will be able to explain the environmental pollution, significance of environmental

protection and principles of sustainable development.

- Educational-pedagogical outcome 4 - At the end of learning the pupil will be able to describe biodiversity and significance of its conservation with the referrence to biodiversity of Montenegro.

Outcomes defined by biomonitoring program are:

Pupils will be able to :

- apply elementary research methods in biology (observing, tracking, describing, experiment, research);
- process the collected data and present results of research (tabula, textually, verbally);
- use laboratory accessories, material and instruments;
- describe and determine bioindicator species and their habitats;
- analyse ecological factors that affect the habitats of bioindicator species;
- analyse population dynamics;
- use application with digital key;
- explain the plan of construction of individual species of molluscs and arachnids;
- explain reproduction and development of insects;
- explain the role of arachnids in the nature and their significance for humans;
- conduct research and explain with arguments the results of research;
- recognize members of individual groups of molluscs, segmented worms, arachnids and echinoderms;
- cooperate and work as a team on terms of reference;
- compare impacts of ecological factors;
- design experiment on the topic of ecologic factors;
- conduct research on different topics;
- abide to the operating rules within the group during research;
- describe characteristics of eco system in Montenegro (inland, water);
-enumerate characteristic species inhabiting some types of ecosystems;
- descibe adaptation of species;
- prepare collections of photos and characteristic species;
-explain ecosystem degradation;
- compare different types of pollution;
- describe consequences of environmental pollution;

- explain the significance of environmental pollution;
- explain the concept and division of biodiversity;
- indicate the significance of biodiversity conservation;
- describe human impact on biodiversity;
-explain the concept of Red List and Red Book;
- differ individual protected species in Montenegro;
- explain objectives of conservation biology;
- appoint conventions on biodiversity protection;
- indicate division and advantages of protected areas.


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