Summary of the pilot study "Analysis of biodiversity trends based on NAWA data, considering the bioindicators diatoms, macrophytes, macrozoobenthos and fishes"

Commissioned by the VSA Platform Water Quality and FOEN to Hintermann & Weber (Tobias Roth and Nicolas Martinez)

1. Introduction and aims of the study

The National Surface Water Quality Monitoring Program (NAWA) collects biological data on four species groups every four years: Diatoms, macrophytes, macrozoobenthos and fish. These data are used to assess the ecological state of streams in Switzerland over time, applying defined indicators described in the Modular Stepwise Procedure (MSK). However, documenting aquatic biodiversity has not yet been the focus of the evaluations in the frame of NAWA.

Therefore, the aim of this study was to:

1) Analyze the NAWA data with a focus on biodiversity. The following biodiversity indicators, also used in the Swiss Biodiversity Monitoring (BDM), were calculated from the NAWA data:

- Number of species (alpha diversity)
- Diversity of species communities (beta diversity)based in presence/absence data
- Total number of species recorded across all sites (gamma diversity)
- Trends of individual taxa or specific taxa groups

2) Discuss a) the diversity patterns of the different taxonomic groups, and b) whether these indicators can be applied to the NAWA data, which aspects should be considered and which methodological adjustments would be useful.

3) Test the representativeness of the recorded species: i.e. test exemplary with macroinvertebrate data whether the proportion of detected taxa of the MSK macrozoobenthos method is sufficient to adequately represent the occurring species.

2. Calculation of the biodiversity indicators and discussion on the relevance of biodiversity indicators for NAWA data

2.1 Results of the calculation of the biodiversity indicators using NAWA Data

Using the diatom, macrophyte, macrozoobenthos and fish NAWA data from 2012, 2015, and 2019, trends in alpha, beta, and gamma diversity were calculated for each species group (Figure 1). In addition, the trends of the common taxa and the abundance distribution taxa were also calculated.

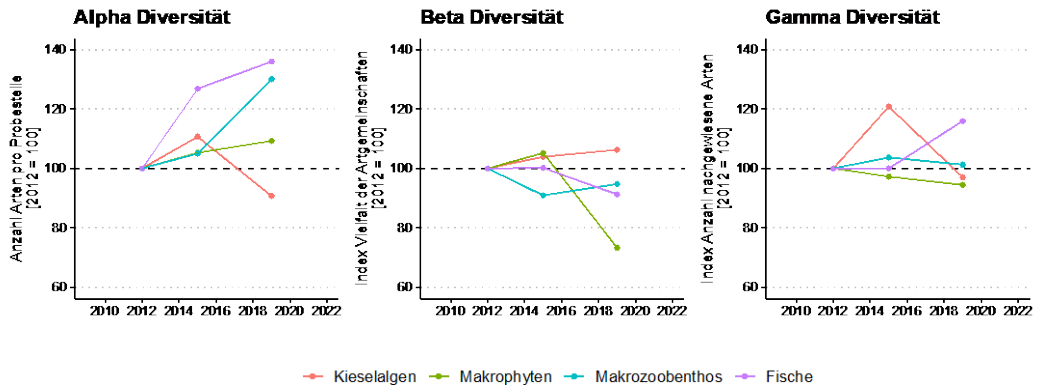

Figure 1 : Indexed indicator trends of the four species groups. The indicators were first calculated separately for the species groups and then indexed. For indexing, the calculated values were divided by the 2012 value and multiplied by 100.

2.2 Discussion on the diversity patterns of the different taxonomic groups

- The alpha and beta diversity show an opposite pattern: increasing alpha diversity and decreasing beta diversity (or vice versa). This is also observed in terrestrial species groups in the BDM. This reflects changes in species communities that are currently underway in Switzerland: Some rather common species seem to benefit from climate change, but also from other influences - leading to an increase in alpha diversity and a unification of species communities (decrease in beta diversity).
- The diatoms show a clearly different pattern than the other three species groups. One possible explanation is due to the method. Determination is restricted to 500 shells per sample. Therefore, if the dominance of a species increases, more of the 500 determined shells will belong to this species, and the number of remaining determined species decreases. Thus, an increase in the dominance of individual species leads to a decrease in alpha diversity in diatoms.

2.3 Relevance of calculating biodiversity indicators with NAWA data

The alpha, beta and gamma diversity indicators used in the BDM are also suitable for analyzing the four NAWA species groups. However the following aspects should be considered:

- Gamma diversity is more difficult to interpret and seem not to provide significantly additional information compared to alpha and beta diversity.
- Single species evaluations are only possible for the more common species. Providing information on trends for individual rare species is not possible with NAWA data. Special programs, such as the Red List programs, are necessary to determine trends for rare and endangered species.

3. Representativeness of the recorded species using MSK sampling methods

The test of representativeness of the recorded species was made using an additional macroinvertebrate dataset from a project of Pascal Stucki from the Jura. Usually the kicknet samples collected with the IBCH method at eight different sampling sites per survey area are pooled together prior to determination. For the Jura project, however, the eight kicknet samples were determined separately and offer the possibility to estimate the total species diversity using rarefaction curves and occupancy models.

The degree of detection was defined as the proportion of detected species compared to all occurring species. Three different methods were used to estimate the number of actually occurring species:

- Rarefaction Curves and probability of interspecific encounter (PIE) calculation
- Occupancy models

- Duplicate surveys

On average, the method used (MSK Macroinvertebrate method IBCH) captured about 2/3 of the IBCH macroinvertebrate taxa present at a site. This is consistent with what is known about the terrestrial species groups of the BDM. Therefore, the recorded taxon diversity with the MSK Macroinvertebrate method is a good, but not perfect, indicator of local diversity. It can be used as an unbiased indicator of local macroinvertebrate taxa richness.

Comments for the other species groups:

Fish: For the fish, two or three electrofishing runs per survey are carried out since 2015. The comparison of the calculations of the biodiversity indicators using only the first and all runs showed few differences. This is an indication that the degree of detection is high and that the data allow robust conclusions to be drawn about the calculated indicators.

Macrophytes: In the BDM, the degree of detection for terrestrial vascular plants is 0.84 ± 0.12 (mean ± standard deviation). It is assumed that the degree of detection for macrophytes is at least as high as for terrestrial vascular plants. The main reason for this assumption is that the number of species in terrestrial vascular plants is significantly higher than in aquatic vascular plants.

Diatoms: There seems to be no information on the degree of detection for diatoms. An investigation on the detection of this species group could be useful but the method is established and offers little opportunity for methodological changes.

4. Perspectives (proposals ordered by suggested degree of priority)

1a) Incorporation of the data of the NAWA 2023 campaign in the biodiversity indicators calculations and b) Publication of results of the project (e.g. article in Aqua & Gas)

2) Investigation of a) the causes of differences between diatoms and other species groups: Is the reason methodological as suspected? How could this methodological influence be taken into account in the evaluation and interpretation? and b) the use of abundance class data to calculate biodiversity indices (e.g. macroinvertebrate data).

3) Calculation/development additional indicators:

- Use of diversity indicators with consideration of species abundance, allowing also to measure how evenly individuals are distributed between the species (evenness).
- Development of a rare species indicator that examines the development of rare species as a whole (as a group of species).
- Trait-based evaluations. Currently applied indices such as SPEAR and IBCH already use taxa characteristics such as sensitivity to water quality and/or pesticides.
- Temporal turnover indicator, calculated similarly to beta diversity in order to compare temporal turnover per site.