Workshop Output WS 2.3.C

Title of workshop: Lakes in Mountain regions as integrative landscape elements: ecosystem services and threats

Prepared by

Moderators	**Rainer Kurmayer, Karin Koinig, Josef Wanzenböck**
Participants*	**Veronika Fontana, Christoph Matulla, Martin Dokulil, Quenta Herrera and the most valuable audience**

* Workshop participants that have submitted contributions to the workshop

General questions to please be answered in the workshop reporting

1) What was the focus of the workshop? Methodological issues and advancements or thematic issues (systems knowledge, transformation knowledge, target knowledge). Please check and fill in the matrix in the output section.

Methodological issues and advancements	**Thematic issues**		
	System knowledge	Transformation knowledge	Target Knowledge
	x	x	

1) Which key points were discussed in the workshop as a whole? (This should be more a synthesis and not simply a summary of the key points in each presentation)

1) Evaluating Ecosystem services (ES) (of lakes), comparing different tools to evaluate ecosystem services (Veronika Fontana, Uta Schirpke, Karin Koinig)

ES evaluation is clearly a concept with limitations but the best tool currently available. The limitations include e.g. monetary value forced on an ecosystem or the weakness that some stakeholder positions must have a legal support (i.e. ownership) while other have less (i.e. nature conservation). Biodiversity as such is not directly reflected in the ES concept but rather indirectly, i.e. through ecological functioning or nature conservation. Another limitation is that the ES concept and results are potentially biased by the respective participants deciding on relevant ES.

The aim of the ES concept is to take a multitude of aspects into account as well as different stakeholders. It is important to state that the ES concept is not limited to monetary techniques and should be seen as assisting a potential required decision basis. Indeed monetary techniques have been criticised because of the human centred vision producing unrealistic vales. Instead, participatory and deliberative approaches combining monetary and non-monetary techniques may be a more sustainable compromise in ES evaluation. When applying participatory approaches stakeholder selection (and participation) will be most crucial and requires a careful selection (including scientists from relevant disciplines).

2) Lake ecosystem services, translating limnological measurements to indicate ES (Martin Dokulil, Rainer Kurmayer)

Usually the relevant ES will help to decide the appropriate limnological measurement and which parameters are required. One example is given by using the term “organic matter” in Andean peatlands which is used to translate this understanding into the provision of food sources. One caveat mentioned is that as a consequence of simplification this approach might result in a ecosystem monitoring which is drawn apart from the basic concept of ecological functioning (which is also the basis for the current water frame work directive, WFD).

It is further recommended to translate “biodiversity” to parameters that are better understood by stakeholders. Although the term “biodiversity” is standard among nature conservationists, it is difficult to translate on the political level. One example could be the term “soil stability” that is influenced by biodiversity and influencing terrestrial surface runoff and which can be translated easier.

When using limnological terms such as “organic matter” nevertheless care must be taken that this terms are used in a sustainable ecological way. Eg more organic matter is not the necessarily “better” in ecological terms or for all aquatic ecosystems.

3) Indication of ecological quality, making use of the so-called metabarcoding technique (Rainer Kurmayer, Josef Wanzenböck)

Basically, metabarcoding is a rather recent approach taking advantage of deep-amplicon sequencing of taxonomic marker gene regions which have been amplified from aquatic environmental samples. By this technique, taxa inventories can be obtained for various biological quality elements (BQE) currently addressed in the WFD (water frame work directive) in a semi-automatic manner. Potential improvement by this technique include a more time and cost efficient acquisition of taxa inventories, a more rapid or even on time results provision, less dependence on microscopic and subjective species keys, and less invasive (and destructive) sampling (avoiding the sacrificing of specimen in fish).

On question is related to the overall perception and application of this technique. It can be stated that some countries like in the UK several BQE (phytobenthos) relevant for the WFD are already only recorded by the metabarcoding technique. Also in other countries this technique is applied already more widely when compared to other countries, eg Austria or Germany. It should be added that one of the early questions from the political side was how metabarcoding can complement the WFD implementation rather than to replace it. Nevertheless metabarcoding as a complementary technique might have an influence on the foreseen political evalution of the WFD implementation in the course of the WFD implementation cycles (2021, 2027).

From a practical point of view metabarcoding is unlikely to replace BQE monitoring in the near future. Currently only qualitative estimates are provided, e.g. taxa inventories which could be used semi-quantitatively if protocols could be installed in a strict standardized manner. Because of the mandatory PCR amplification step such strictly standardized protocols might be indeed impossible for biological reasons. However, direct single molecule sequencing techniques not requiring PCR amplification of marker genes might provide even quantitative results in the near future. Furthermore metabarcoding results cannot inform on demographic parameters, e.g. discriminate

juvenile stages from adult stages or age classes. While this limitation is less relevant for microbiota it is very much limiting for BQE fish and macrozoobenthos.

4) Lake climatology, merging lake surface temperature modelling with "real" temperature measurements (Christoph Matulla, Martin Dokulil, Karin Koinig)

In general lake surface temperature (LST) modelling can be seen as alternative approach to temperature recording and extrapolation. While extrapolation of long-term series has served important conclusion on lake temperature forecasts in the Alps, LST can hopefully be used to answer more questions.

One important field is to use LST modelling on physical, chemical and biological consequences in both temporal and spatial resolution.

Which seasonal periods are considered most relevant? From many observations it is probably the period after ice break up that has been highlighted and is most related to the increasing the length of the vegetation period. Besides autumn mixing and the date of ice on is considered relevant. In general, these time points are not estimated directly (by observation) but rather indirectly by the available methods, eg. direct temperature recording or remote methods (ortho photos).

In particular, the snow cover can substantially modulate this time periods. Late snow events are considered of increasing importance in modulating LST including ice on. Fortunately, snow as a parameter is included in the current LST model.

A higher resolution in time addressing short-term changes could be relevant to address the consequences of heat waves, i.e. for the physical stability of the watercolumn. In consequence to temperature effects changes on light and nutrients availability as well as plankton composition can be expected.

Larger lakes also require a higher spatial resolution, particularly if lake morphometry is resulting in different basins with variable water volumes.

5) Climate change and anthropogenic impact (incl. pollutants) as a threat to ecosystem service provision (Josef Wanzenböck, Karin Koinig, Christoph Matulla)

Generally, any pollution potentially threatens the ecological integrity and functioning of a lake. The anthropogenic driven input of nutrients, especially phosphorus but also nitrogen, are causing eutrophication and affect drinking water quality. Metal loads originating from smelting, mining or in some areas from rock glacier meltwater, deteriorate water quality and are elevated metal concentrations are toxic to several species.

More recently, the following synthetic pollutants increasingly threaten aquatic ecosystems:

1) nanoparticles, for example those processed into clothes to prevent soaking or to diminish transpiration like silver, Titaniumoxides, silicones (polysioxanes), or polytetrafluoroethylene (Gore-Tex).
2) Micro-plastics
3) particles that act as hormones (e.g. Bisphenol A in plastic bottles)
4) new synthetic particles of which impacts on aquatic ecosystems are still unknown

5) persistent organic pollutants

The impact of a specific pollutant might increase by bioaccumulation in the food chain and by cross-effects with other particles. For example, micro-plastic adsorbs pollutants thus potentially amplifying toxicity. It is thus necessary to assess pollutants not only individually with single test organisms but also on an ecosystem level.

In addition, the accelerated ongoing warming threatens lakes by changing lake properties such as species composition, chemical and physical properties, and most trivially lake temperature. Here, cold stenothermic species require cold refugia in order to survive. A species composition that includes a huge variety of taxa, i.e. also cold stenothermic taxa, is however more resilient versus environmental changes.

What do these threats mean in relation to ecosystem services? Clean drinking water is a prerequisite to ensure people's health. In consequence, one of the major ecosystem services in relation to water is to provide clean water, and drinking water. In case water is polluted, it has to be treated, e.g. by wastewater treatment plants or by special filters that capture synthetic particles. Warming enhances eutrophication that in some areas results in lakes not being suitable for swimming, fishing or recreation.

2) What is your opinion on the current state of knowledge concerning your topic(s) (focusing on mountain regions)? *Please check and fill in the matrix on the following page.*

Overall assessment of the state of:

What is your personal opinion on the current state of knowledge concerning the topic(s) addressed in your workshop. Please tick the appropriate field. Brief explanations are appreciated.

State of knowledge	Very good	Good	Poor	Very poor	Not appropriate	*Comments*
Global			x			
Regional			x			*Which region?*
Scattered case study-based knowledge			x			*Where?*
Knowledge about past states/trends		x				
Knowledge about current situation		x				
Knowledge about future states/trends/thresholds			x			*Will be worked on in two ongoing projects, 1) alpine space "Eco-Alps water" and 2) CLAIMES (climate resistance of alpine lakes and management consequences)*
Knowledge about the system			x			
Knowledge about shaping pathways to more sustainable development (transformation knowledge)				x		*As above*
Knowledge about envisaged goals (target knowledge)		x				*As above*

Ideas for questions to potentially be answered by the moderators after the workshop in the reporting (please delete what is not useful):

1) Were there any new insights and/or findings presented? If yes, which ones?

   +) Tools to evaluate ecosystem services in a non-monetary way (Multi criteria decision analysis)
   +) Temperature effects on planktonic microbiota in alpine lakes expressed in mathematical terms by appling metabolic theory
   +) Lake surface temperature modelling results for 12 lakes in the Alps which are in good correspondence to recent and historical on site recordings
   +) state of pollution of lakes in the Alps as a threat to ES provision (eg nanoparticles)

2) What was the main message/consensus of your workshop?

   +) though the risk of applying the ES concept to lake management is accepted, the ES concept is used because of the wide political acceptance

3) Were major uncertainty issues identified and discussed? If yes, which ones?

   +) as an emerging technique metabarcoding only can complement the estimation of ecological quality in lakes but not replace traditional methods

4) Was there any significant controversy (if so, what?) that requires new data (or further exploration of existing data) to resolve the issue? (explain)

   +) controversial discussion on the usefulness of the ES concept to gurantee ecological function in the longterm

5) Were new research questions raised? If yes, would working on these questions need to involve other disciplines (which ones)?

   +) LST modelling could offer several research question related to CC such as physical and biological changes

6) Did the workshop identify research topics (e.g. environmental drivers other than climate) that are, in your opinion, currently greatly underrepresented in mountain research, but should urgently be addressed?

   +) A couple of more relevant topics have been selected based on the expertise on the speakers. By no means all topics could be addressed.

Further Comments

The Workshop input and the participation of the audience in the discussion of the various topics was active and rewarding. The time of the individual topics was short, nevertheless the longer individual talks have been found useful to discuss the individual topics also with the audience.