BEDÖMNING AV EKOLOGISK STATUS I INLANDSVATTEN:
Förslag på förbättrade indikatorer, konsekvenser för miljöövervakning och vad som återstår att göra

Richard K Johnson, SLU
Inland WATERS

• **Phytoplankton** (Stina Drakare)
• **Benthic diatoms** (Maria Kahlert)
• **Macrophytes** (Frauke Ecke)
• **Benthic invertebrates** (Richard Johnson, Simon Hallstan)
• **Fish** (Kerstin Holmgren)
• **Gradient studies** (Brendan McKie, Amélie Truchy)
Outline

- Harmonized approaches
- Review of five BQEs
  - highlights
  - remaining challenges
- Gradient studies - indicator responses
Harmony

- Revision of reference filter
- **Standardised** field and laboratory protocols
- SLU quality-assured **species and environmental** data
- Workshops on identifying ecological thresholds and modelling
Phytoplankton in lakes - highlights

- Strong response to eutrophication
  - chlorophyll-a and PTI correlated with TP
  - PTI higher precision than TPI
- Cyanobacteria for assessing health risks
- Other pressures: mining and urbanisation
- Typology- vs site-specific reference values
- Data missing for most lakes
  - 16% of 806 lakes categorised IC typologies
  - 30–40% of 806 reference conditions using models
Phytoplankton in lakes – remaining challenges

- More background data to estimate reference conditions
  - lake mean depth, alkalinity, and water colour

- Natural gradients – reference conditions is challenging
  - chemical criteria for natural acidity and nutrients

- Indicators show promise – multimetric index
  - need additional data, tools for estimating reliable reference conditions and class boundaries
Benthic diatoms - highlights

- **Response to pH and nutrients**
  - strong correlations: ACID to pH and IPS to TP (latter H/G ≈ 20 µg TP L⁻¹)

- **Similarly response in lakes and streams**
  - use of the same indices in both systems

- **Metals and herbicides resulted cell deformities**

- **BenthoTorch**
  - ok for quantifying total algal biomass but caution is advised
Benthic diatoms – remaining challenges

- Diatom flora typical of stream types to be defined
  - more info on natural and human-induced variability

- Responses to different pressures
  - indices for metals, organic pollutants (herbicides)

- Harmonize traditional knowledge with DNA barcoding
Macrophytes - highlights

- Norwegian TIlc and ICM better than TMI
- Ecologically relevant class boundaries improved TMI
  - bryophytes: 13 of 39 species displayed sudden drops
- Potential of remote sensing
  - Accuracy > 80% in identifying vegetation stands
- Hydromorphological pressures
  - water-level drawdown indicator (WILc), ratio between sensitive and tolerant macrophyte species
Macrophytes - remaining challenges

- Potential indicators Tlc and ICM
  - assess indicators and typology
- Responses in rivers need study
  - new standards & indicators
- Remote sensing to be validated
- Multiple pressures merit study
- Additional data, reference conditions, class boundaries
Benthic Invertebrates - highlights

- ASPT responds to multiple pressures
- Eutrophication of lakes and streams
  - lake BQI and stream DJ index correlated to TP
  - marked changes <10 µg TP L−1, near the upper limit of oligotrophic conditions
- Revised indicators of acidity
  - excluding leptophlebid and adjusting threshold values
Benthic Invertebrates – remaining challenges

- Increase BQI taxa and standardise OTUs
- Responses to other pressures need study
  - forestry, altered hydrogeomorphology, urbanisation
- Establishing reference conditions
  - typology- and model-based approaches
- Assessments need to be harmonised
  - user-friendly software
Fish - highlights

- VIX passed, but EQR8 did not
  - EQR8 responds more to acidity
- Complementary methods
  - mobile hydroacoustics and methods for composition and age structure
- Indicators for large lakes
  - pelagic fishes, benthic planktivorous species, benthic cyprinids
- Refined index of morphological pressure
Fish - remaining challenges

- G/M boundaries needed
  - Swedish–Norwegian results suggest revision

- Data needed for indicator development
  - more data on deep and slow-moving river reaches

- Rigorous tests of RIX and VIXMORF with hydrological and morphological data for streams
Stream gradients

- c. 40 streams

- Unregulated to dammed with strong flow regulation
- Undisturbed to clearcut and ditched
- Forested to agriculture
Impacts of multiple stressors along a hydromorphological gradient on stream ecosystem structure and functioning
Hydropower dam gradient

Physico-chemical data
pH, alkalinity, conductivity
[nutrient], [O2]
channelization
water depth & flow

Functional data
litter decomposition
algal growth

Taxonomic data
macroinvertebrates
macrophytes
fish
(diatoms)
- 60% of electricity production
- ≥ 5300 dams in Sweden
  - 96% are small dams

Water final conference, 11 October 2016

http://vattenwebb.smhi.se/svarwebb/
Hydropower dam gradient

- 10 sites: unimpacted to heavily impacted by hydropower

*Increasing stream regulation*

10 sites
Community responses

• Macrophyte community:

Bryophyte frequency vs. Hydromorphological gradient (PC1)

- $R^2 = 0.4463$
- $p = 0.03475$
Community responses

• Fish community:

Trout densities (number of individuals/100 m²)

Hydromorphological gradient (PC1)

Trout densities are naturally low but are the highest at intermediate level of perturbation!

R² = 0.6319
p = 0.03
Selecting robust indicators to detect change – key messages

- Phytoplankton and benthic diatoms are sensitive to agricultural pressure
- Turbidity primarily affected composition of diatoms in streams
- Macrophytes were affected the most by hydropower impact
- New specific indicators for hydropower and forestry need to be developed

Studies suggest that biological responses are context dependent.
Thanks

Swedish Environmental Protection Agency and Swedish Agency for Marine and Water Management for financial support, **AND** most of all those who contributed to making data available.
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## Phytoplankton in lakes - recommendations

<table>
<thead>
<tr>
<th>System</th>
<th>Indicator</th>
<th>Pressure</th>
<th>Suggested revisions and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake</td>
<td>Total Biomass</td>
<td>Nutrient load</td>
<td>Harmonize with new typology</td>
</tr>
<tr>
<td>Lake</td>
<td>Trophic Plankton Index</td>
<td>Nutrient load</td>
<td>Use new European Plankton Trophic Index (PTI) instead; harmonize with new typology</td>
</tr>
<tr>
<td>Lake</td>
<td>Proportion of cyanobacteria</td>
<td>Nutrient load</td>
<td>Use total biomass of cyanobacteria; develop class boundaries related to health risks</td>
</tr>
<tr>
<td>Lake</td>
<td>Number of taxa</td>
<td>Acidity</td>
<td>No revision recommended</td>
</tr>
<tr>
<td>Lake</td>
<td>Chlorophyll-a</td>
<td>Nutrient load</td>
<td>Harmonize with typology and start to use interchangeably with TotBio, averaging when both indicators are available</td>
</tr>
</tbody>
</table>
# Benthic diatoms - recommendations

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<tbody>
<tr>
<td>Streams</td>
<td>Indice de Polluosensibilité Specificque</td>
<td>Nutrient load and organic pollution</td>
<td>Use updated taxon list &amp; indicator values in assessment of both streams and lakes</td>
</tr>
<tr>
<td>Streams</td>
<td>Percent of pollutant-tolerant taxa</td>
<td>Organic pollution</td>
<td>- “ “ -</td>
</tr>
<tr>
<td>Streams</td>
<td>Trophic Diatom Index</td>
<td>Nutrient load</td>
<td>- “ “ -</td>
</tr>
<tr>
<td>Streams</td>
<td>Acidity index for Diatoms</td>
<td>Acidity</td>
<td>- “ “ -</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heavy metals and herbicides</td>
<td>Add this indicator as a new method of using diatoms to detect pollutants in routine environmental assessment</td>
</tr>
</tbody>
</table>
## Macrophytes - recommendations

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<tr>
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<th>Habitat, pressure</th>
<th>Suggested revisions and comments</th>
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<tbody>
<tr>
<td>Lake</td>
<td>Trophic Macrophyte Index</td>
<td>Whole lake, eutrophication</td>
<td>Set ecologically meaningful class boundaries; use quantitative macrophyte data; and further develop remote sensing-based assessment</td>
</tr>
<tr>
<td>Stream</td>
<td>—</td>
<td>—</td>
<td>Indicator needs to be developed</td>
</tr>
</tbody>
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# Benthic Invertebrates - recommendations

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</thead>
<tbody>
<tr>
<td>Lake</td>
<td>Average Score Per Taxon</td>
<td>Littoral, general degradation</td>
<td>Adjustments may be needed with revised estimates of reference condition.</td>
</tr>
<tr>
<td>Lake</td>
<td>Multimetric Index for Lake Acidity</td>
<td>Littoral, acidity</td>
<td>Exclusion of Leptophlebiidae and adjustment of threshold values for subindices. Further adjustments may be needed with revised estimates of reference condition.</td>
</tr>
<tr>
<td>Lake</td>
<td>Benthic Quality Index</td>
<td>Profundal, eutrophication</td>
<td>Adjustments may be needed with revised estimates of reference condition.</td>
</tr>
<tr>
<td>Stream</td>
<td>Average Score Per Taxon</td>
<td>Riffle, general degradation</td>
<td>- “ “ -</td>
</tr>
<tr>
<td>Stream</td>
<td>Multimetric Index for Stream Acidity</td>
<td>Riffle, acidity</td>
<td>Exclusion of Leptophlebiidae and adjustment of threshold values for subindices. Further adjustments may be needed with revised estimates of reference condition.</td>
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<tr>
<td>Stream</td>
<td>DJ index</td>
<td>Riffle, eutrophication</td>
<td>Adjustments may be needed with revised estimates of reference condition.</td>
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## Fish - recommendations

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<tbody>
<tr>
<td>Lake</td>
<td>Multimetric fish index for lakes</td>
<td>General degradation, acidity, and nutrients</td>
<td>Consider revision depending on the results of the project on common fish indices for Swedish and Norwegian lakes</td>
</tr>
<tr>
<td>Stream</td>
<td>Multimetric fish index for streams</td>
<td>General degradation and nutrients/organic load</td>
<td>No revision recommended</td>
</tr>
<tr>
<td>Stream</td>
<td>Hydrology side index to VIX</td>
<td>Hydrology impact</td>
<td>- “ -</td>
</tr>
<tr>
<td>Stream</td>
<td>Acidity or morphological side index to VIX</td>
<td>Acidity or morphological impact</td>
<td>- “ -</td>
</tr>
<tr>
<td>Stream</td>
<td>Morphological side index to VIX</td>
<td>Morphological alteration</td>
<td>New index suggested to complement the current one</td>
</tr>
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