Combination of Biological Quality Elements towards a complete water body assessment

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Outline

- Issue: how to combine information at BQE level into an assessment at water body level?
  - Requirements of the WFD
  - Implementation of the requirements in EU countries
    - Example: Basque coutry
  - Demonstration of how classification outcome is effected by # BQEs, Combination rules, Uncertainty in BQEs, Sensitivity to pressures
    - Using simultated data
    - Using monitoring data from lakes
  - Some practical recommentations

- WISER work package 6.2:

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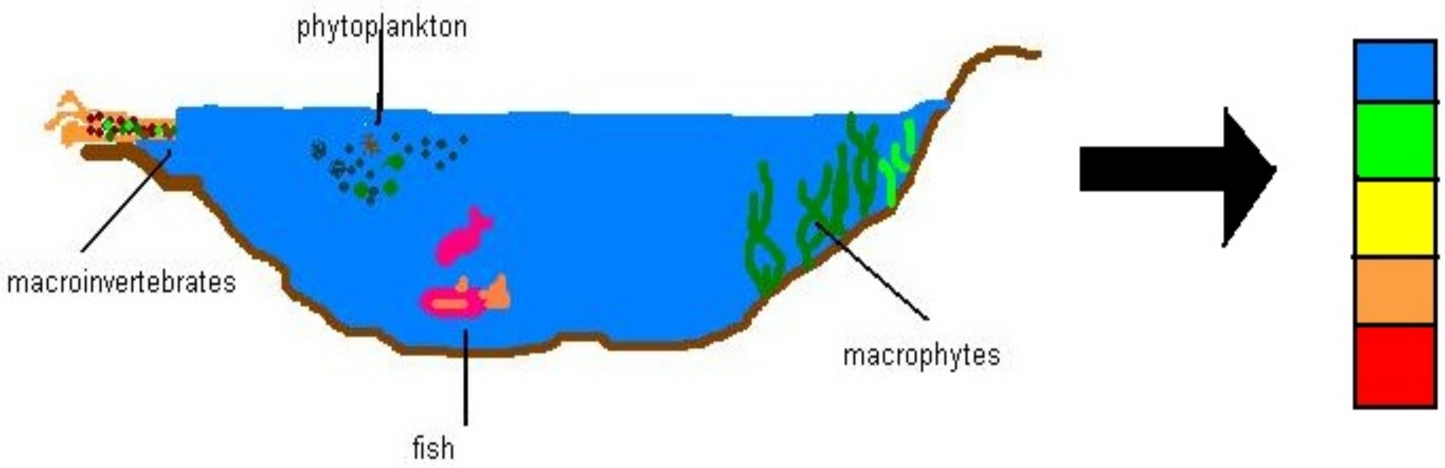
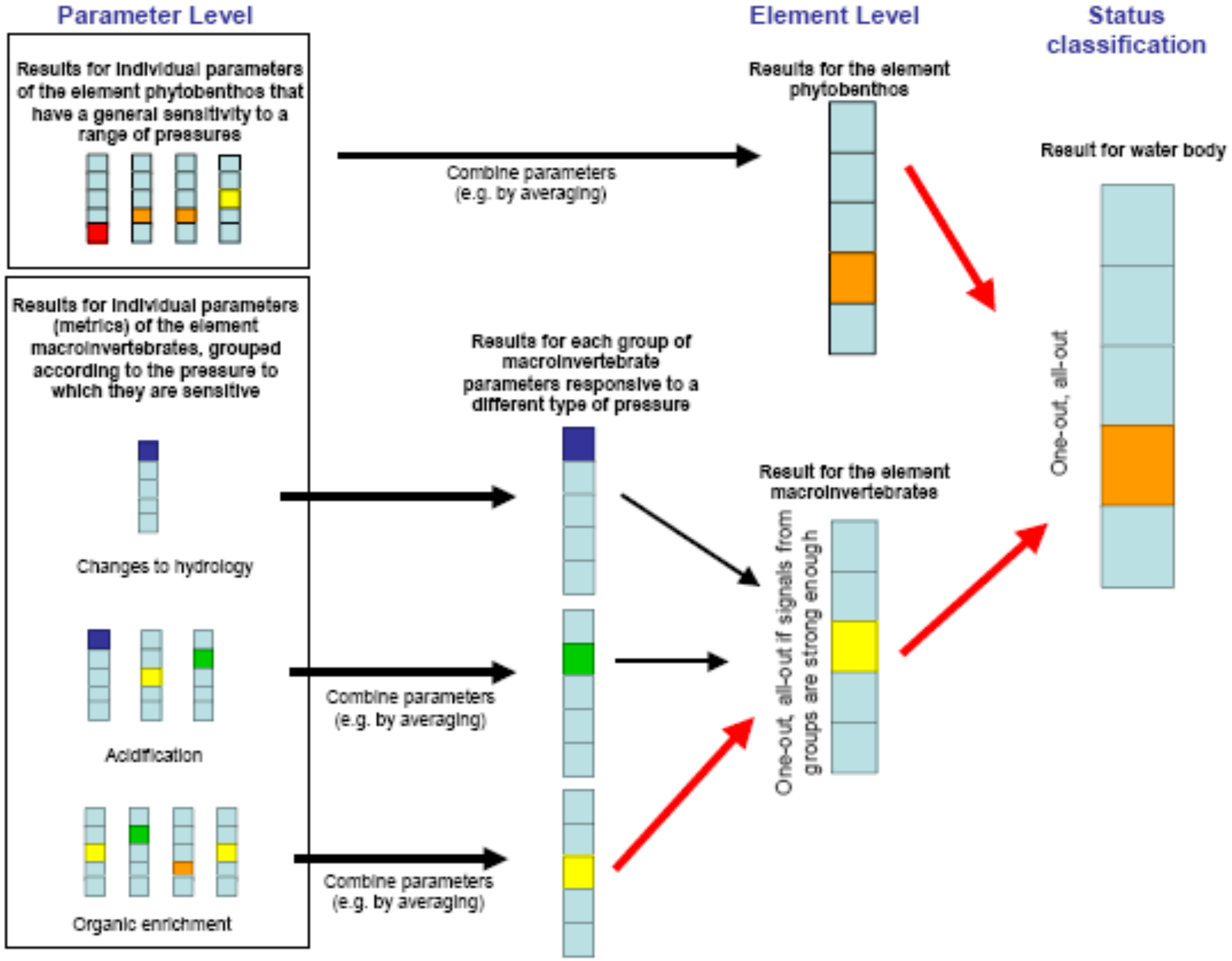


WFD Classification Guidance:

- Within BQEs: metrics can be combined as seen appropriate
- Between BQEs: ‘one out-all out principle-



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Water bodies in Europe: Integrative Systems to assess Ecological status and Recovery

DELIVERABLE

Deliverable D6.2-1: Review of approaches for combining BQEs in WFD assessment

Lead contractor: **Joint Research Centre**
Contributors: **Rossana Caroni, Wouter van de Bund**

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Main findings of the review

- Different combination rules applied in different countries:
  - One out – all out (e.g. PT, DE)
  - Alternative combination rules (e.g. ES, CZ)
  - Evidence-based approaches using expert judgement (e.g. SE, ES)
- Differences in number of BQEs used – even within countries

Example: Coastal/Transitional, Basque country

Elements	Water Categ.	Method (Publication)	Tested	Intercal. status	Reliability
Chemical	TW/CW	W/S/B -Borja *et al.*, 2004; Rodríguez *et al.*, 2006;Tueros *et al.*, 2008	Yes	No	
Physico-chemical	TW/CW	PCQI -Bald *et al.*, 2005	Yes	No	
Phytoplankton	TW	Basque -Borja *et al.*, 2004	Partial	No	
	CW	Spanish -Revilla *et al.*, 2009	Yes	Yes	
Macroalgae	TW	Basque -Borja *et al.*, 2004	No	No	
	CW	CFR -Juanes *et al.*, 2008	Yes	Yes	
Benthos	TW	M-AMBI -Borja *et al.*, 2004; Muxika *et al.*, 2007	Yes	No	
	CW	M-AMBI -Borja *et al.*, 2004; Muxika *et al.*, 2007	Yes	Yes	
Fishes	TW	AFI -Borja *et al.*, 2004; Uriarte & Borja, 2009	Yes	No	

Example: Coastal/Transitional, Basque country

-Does each BQE meet High or Good quality?

- Does Benthos meet High quality and from the remainder 1 or 2 meet Moderate quality? (1)

- Do Benthos and another BQE meet Good quality and the remainder Moderate? (2)

- Coast: Does Benthos meet Good quality and other Moderate? (3)

-Does one BQE meet Moderate quality (except 1,2,3)

- Does Benthos meet High or Good quality and no one has Bad quality?

- Other combinations

- Does Benthos meet Poor quality?

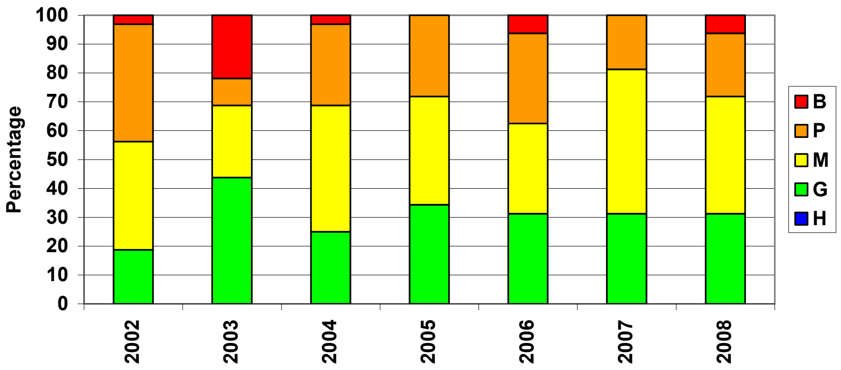
- Do all BQEs meet Bad quality?

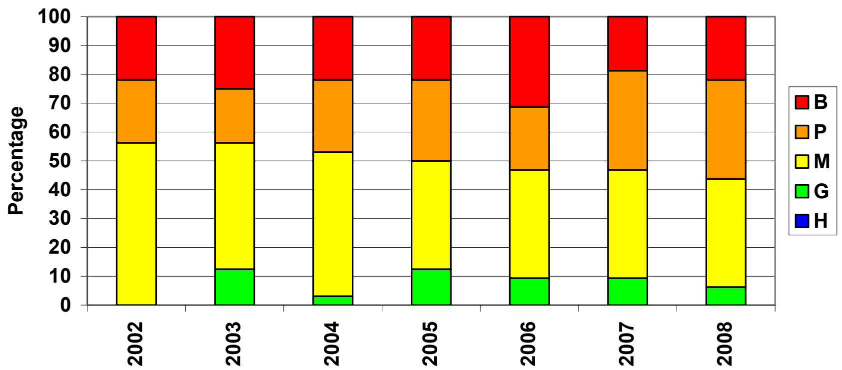
- Does Benthos meet Bad quality?

Final Ecological Status

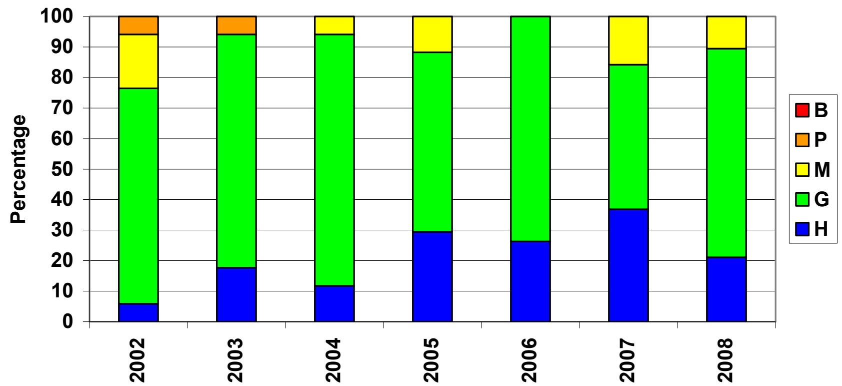
Integrative method | **One out, all out**

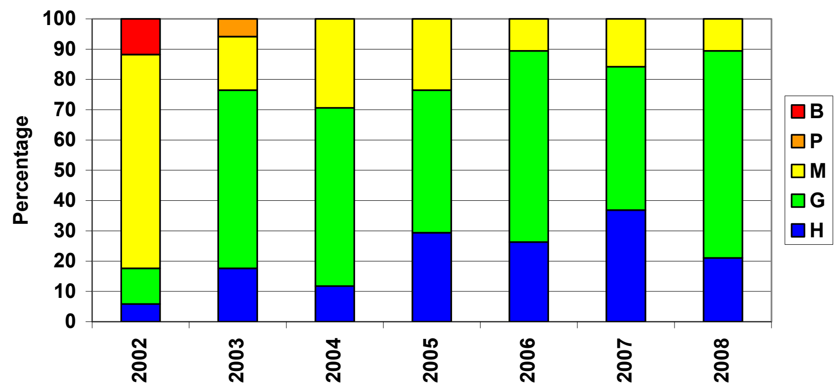
Transitional





Coastal waters





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Editorial

Problems associated with the 'one-out, all-out' principle, when using multiple ecosystem components in assessing the ecological status of marine waters

WISER publication Borja et al., 2010

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Simulated data

- Why?
  - Complete monitoring data covering all BQEs including EQR classes is surprisingly difficult to obtain
  - With simulated data it is possible to control all aspects of the data set (uncertainty, sensitivity to different pressures, etc.)
  - Simulated data allows to demonstrate the principles in a clear and unambiguous way

Simulated data - methodology

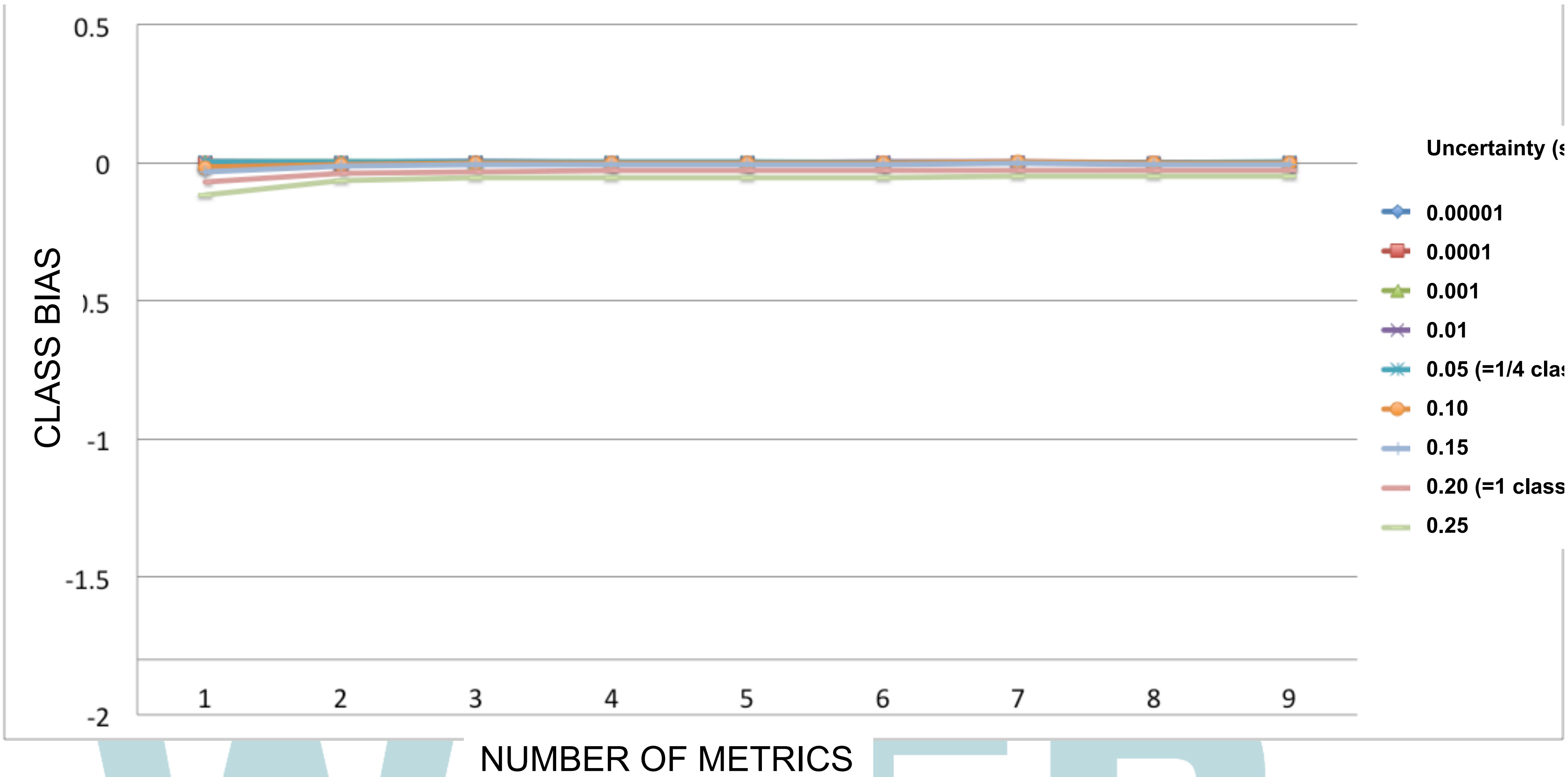
- 1000 water bodies
- Up to 3 independent pressures were randomly attributed to each water body (representing the „real status")
- 9 metrics were calculated for each water body
  - Sensitivity for each of the pressures and the level of uncertainty could be varied
- Metrics could be combined into BQEs (3 metrics for each BQE)
- End points: classification bias, class agreement

Example 1:

- OOAO vs. averaging: effect of number of metrics and level of uncertainty

- Single pressure situation

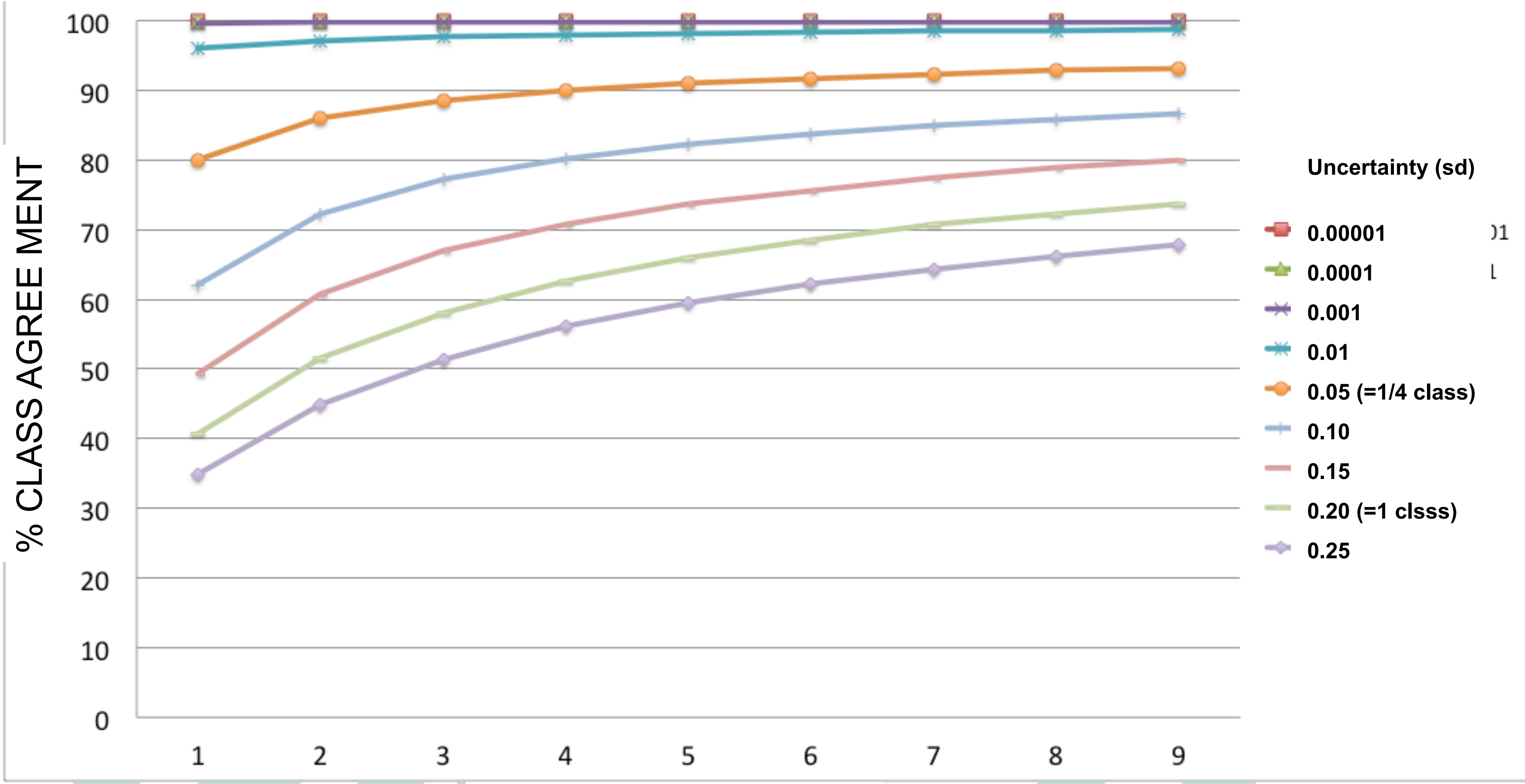
Averaging



AVERAGING METRICS:

- Averaging metrics does not create any classification bias
- Even at extremely high levels uncertainty the classification is unbiased

Averaging

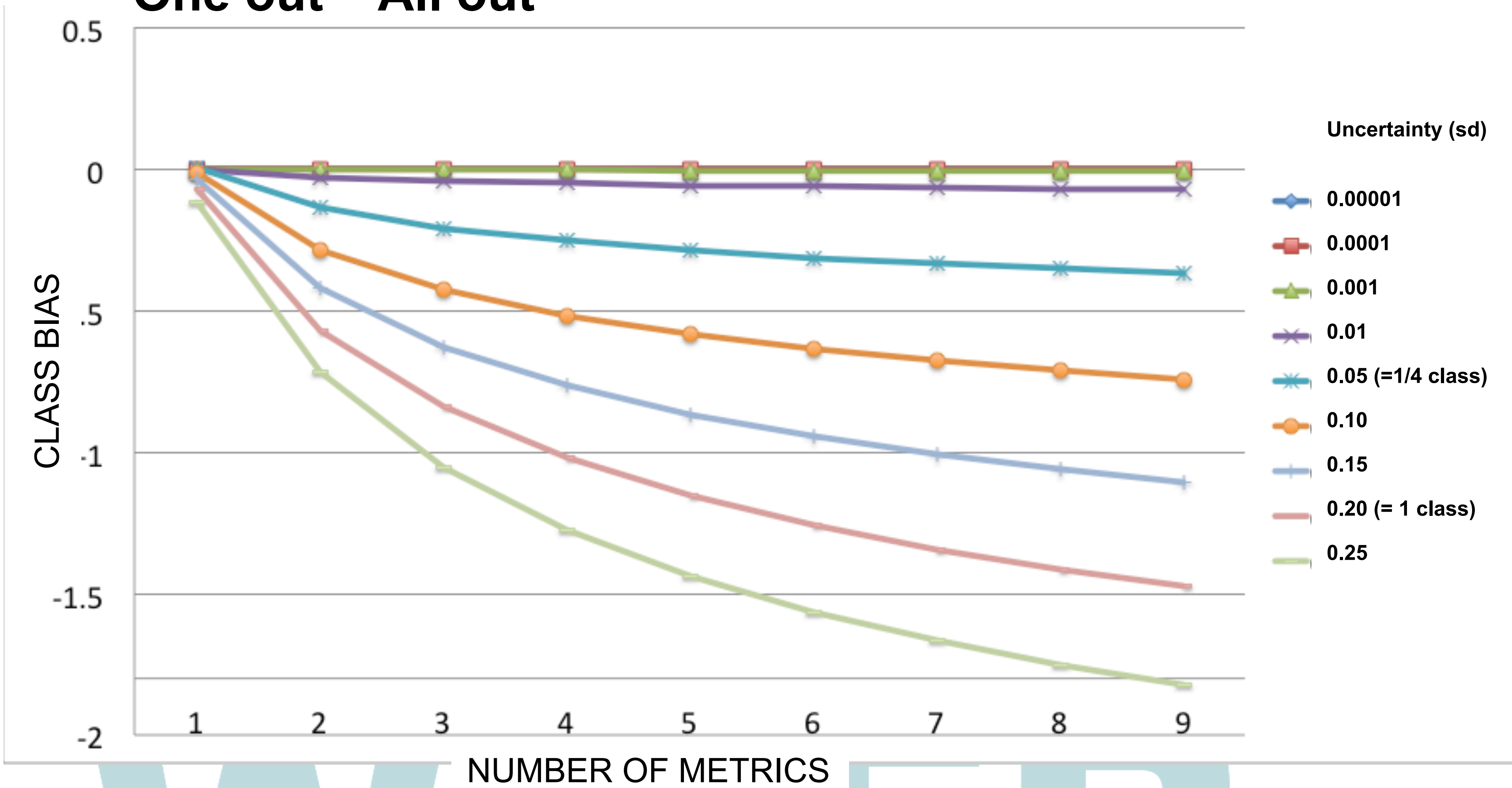


NUMBER OF METRICS

AVERAGING METRICS:

- class agreement improves with higher # metrics
- even at high levels of uncertainty class agreement can be quite high

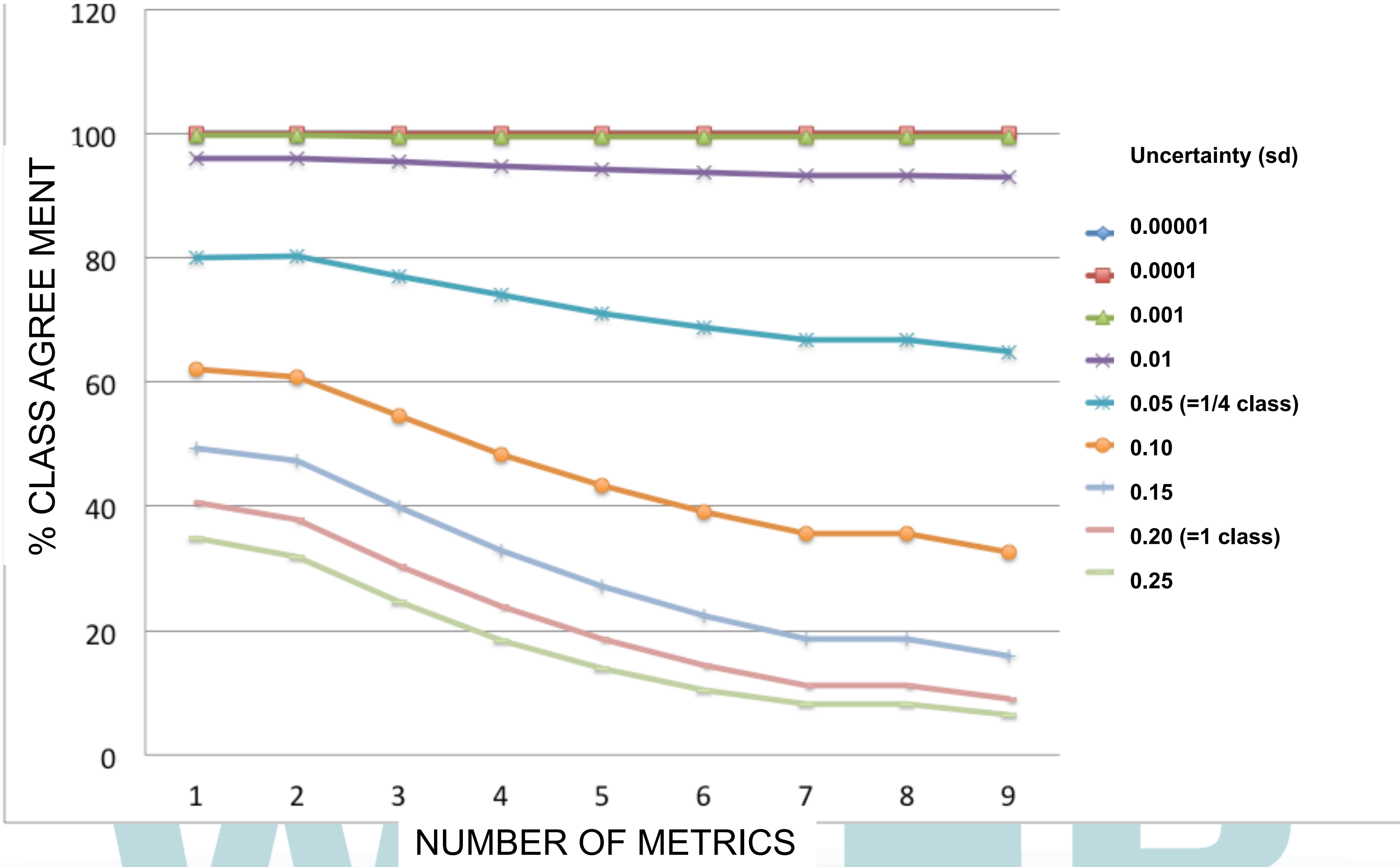
One out – All out



ONE OUT – ALL OUT:

- underestimation of class with higher number of metrics
- except in cases where the uncertainty is extremely low

One out – All out



ONE OUT ALL OUT:

- class agreement gets very low with high metric uncertainty
- class agreement decreases with higher number of metrics
- this is already a problem at not-too-high uncertainty levels

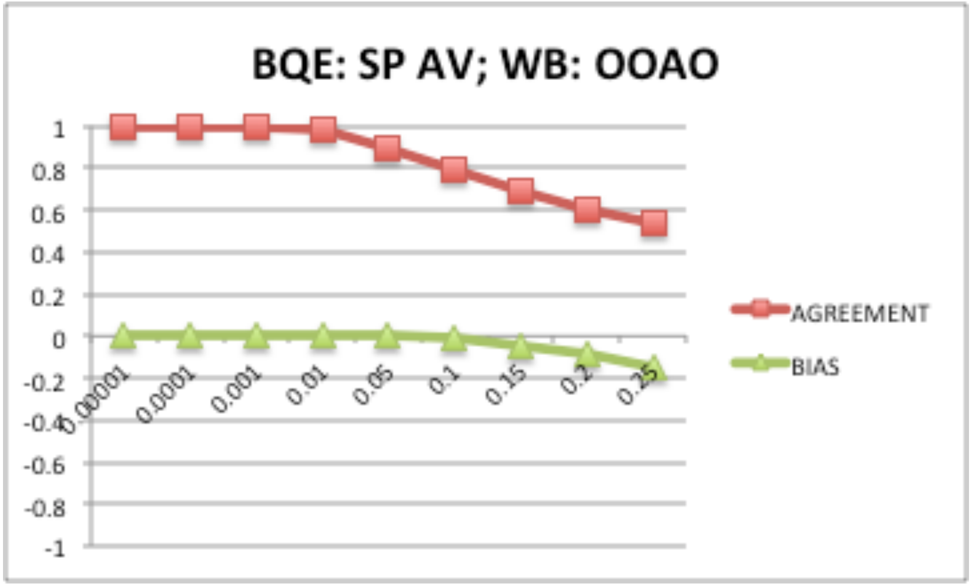
Recommendations for combining metrics addressing a single pressure

- Only include metrics that have a low level of uncertainty
- Including high-uncertainty metrics “because they are required by the WFD” is not recommended
- Combine metrics by averaging, not OOAO

Example 2:

Sensitivity of BQEs for different pressures: pressure-specific BQEs vs. pressure redundancy

Single-pressure BQEs (each BQE responds to a different pressure)

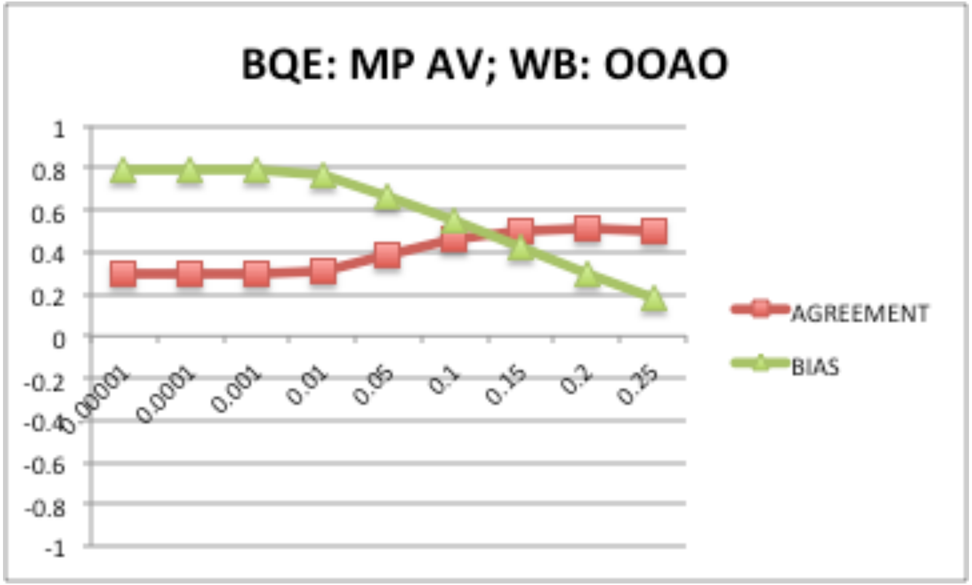


Averaging of metrics at BQE level and OOAO between BQEs

- No or very slight bias
- High level of class agreement, even at higher levels of metric uncertainty

→ Recommended approach

Multi-pressure BQEs (each BQE consist of 3 metrics responding to the same 3 pressures)



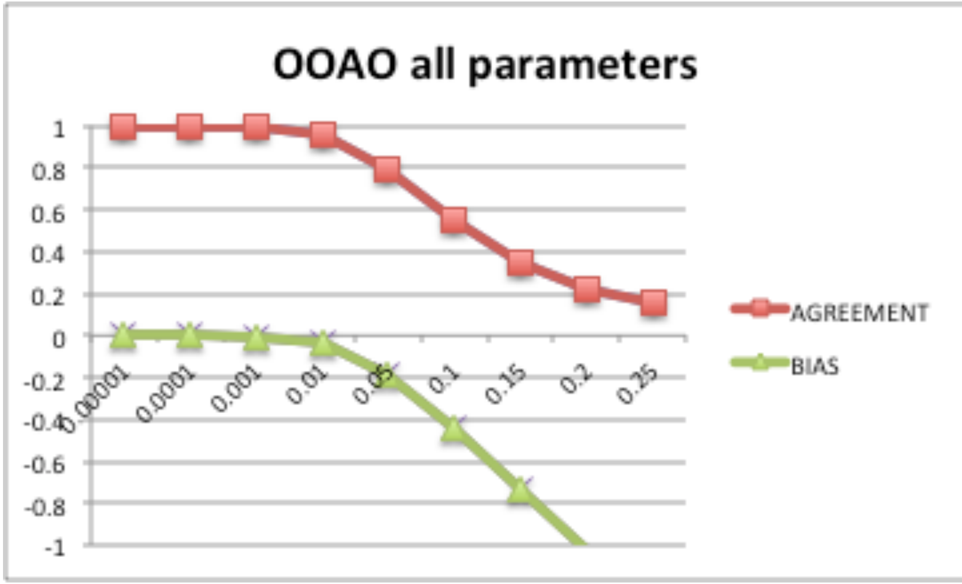
Averaging of metrics at BQE level and OOAO between BQEs

-Biased results because metrics sensitive for different pressures are combined by averaging

-Low levels of class agreement

-→ Not a recommended approach

Multi-pressure BQEs (each BQE consist of 3 metrics responding to the same 3 pressures)

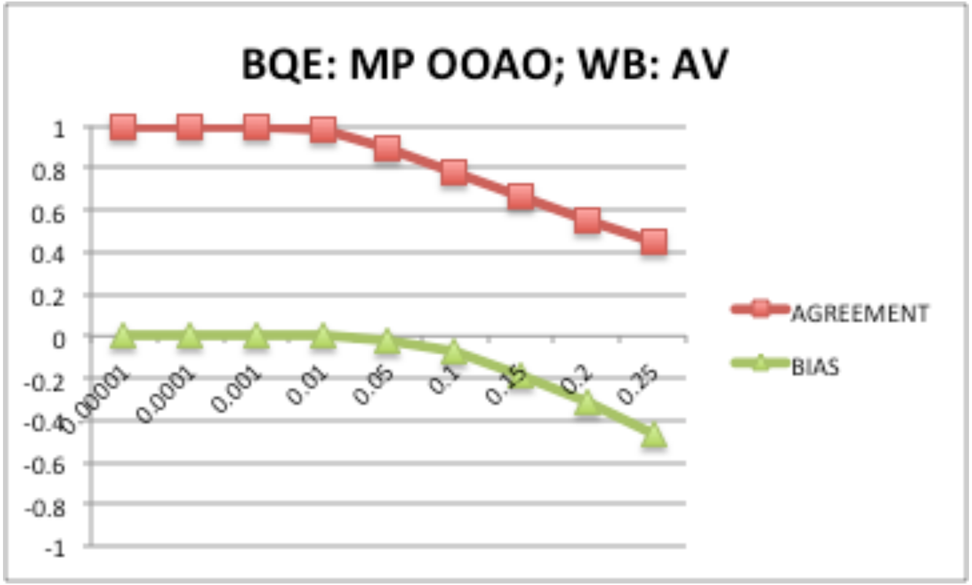


OOAO of metrics at BQE level and OOAO between BQEs

-Unbiased results and good class agreement
-Very sensitive for metrics with high uncertainty

→ To be applied with care

Multi-pressure BQEs (each BQE consist of 3 metrics responding to the same 3 pressures)



OOAO of metrics at BQE level and averaging between BQEs

- Better results in cases with metrics with high uncertainty

→ This approach givers more robust results – but not in accordance with guidance..

Conclusions..

- Pressure-specific BQEs give the most robust results
  - Averaging of metrics within the BQE
  - OOAO between BQEs
- BQEs sensitive for multiple pressures…
  - Use OOAO within the BQE
  - OOAO between BQEs can be dangerous if BQEs respond to the same combinations of pressure
  - Avoid metrics with high uncertainty

Analysis of existing lake monitoring data

Data and methods

- Monitoring data from 86 Swedish lakes (SLU), 4 BQEs, estimates of uncertainty and class boundaries for each metric
- Metric values have been transformed into normalized EQR according to lake typologies and reference values (Intercalibration Guidance, 2010):
- Integration of uncertainty for multiple BQEs was done using WISERBUGS (WISER Bioassessment Uncertainty Guidance Software, Clarke 2010) (http://www.wiser.eu)

WISERBUGS

WISER
Bioassessment
Uncertainty
Guidance
Software

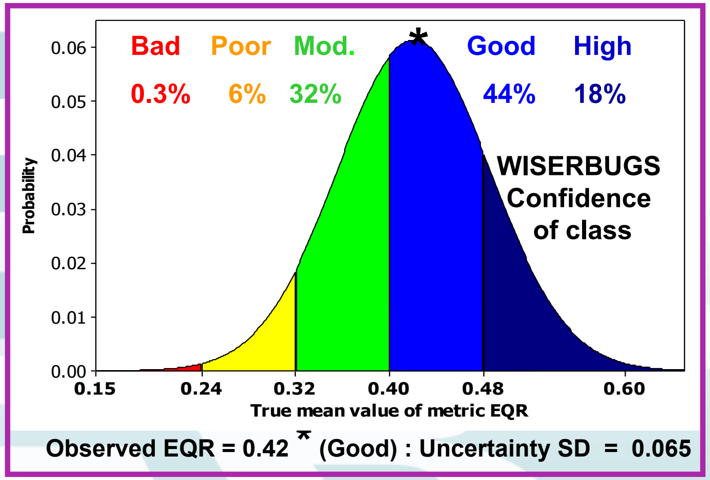
SOFTWARE product for assessing and simulating the effects of sampling variation and other errors on the UNCERTAINTY and CONFIDENCE of water body WFD ecological STATUS CLASS based on Ecological Quality Ratios (EQR) for either single metrics or multiple metrics or multi-metric indices, derived from sampling/surveying one or more Biological Quality Elements (BQE)

WISER Deliverable D6.1.3
Obtainable from :
www.wiser.eu/highlights

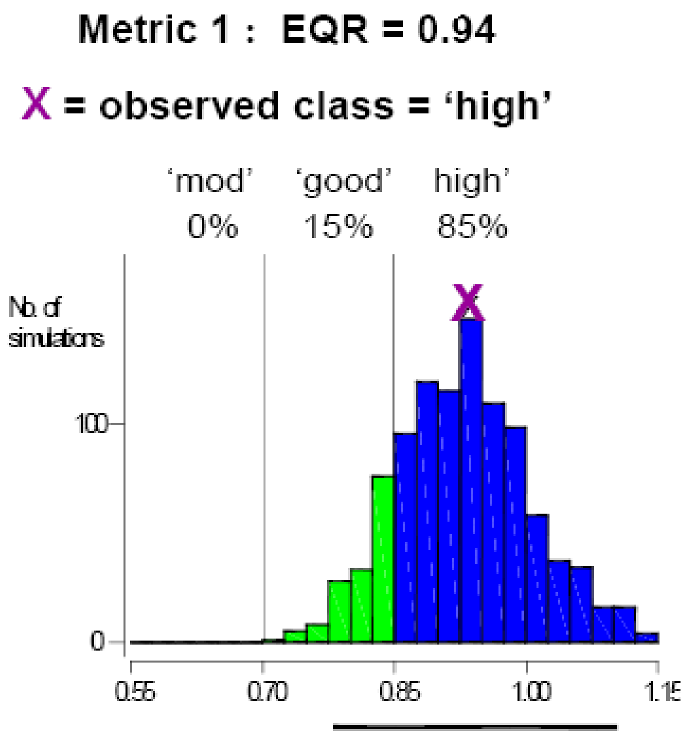
produced by Ralp

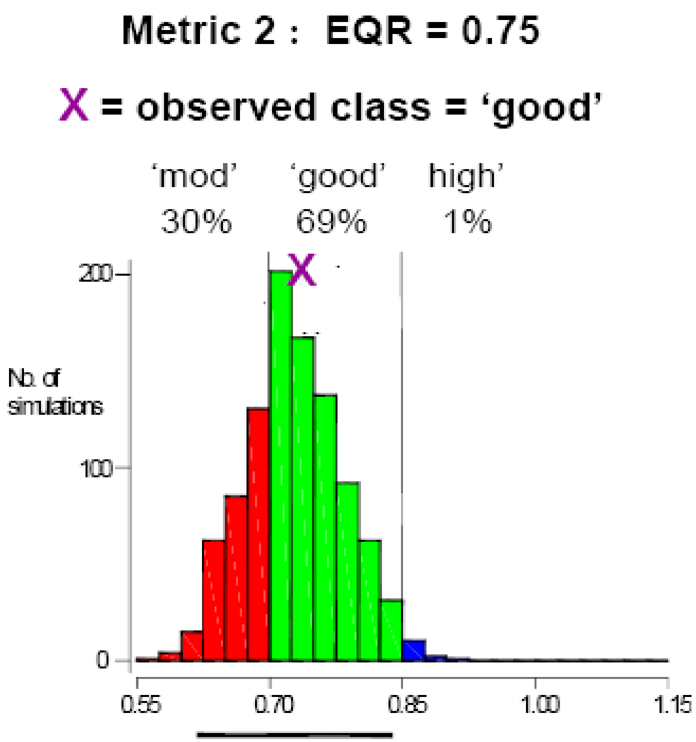
Clarke

Bournemouth University



WISERBUGS Uncertainty Simulation Model





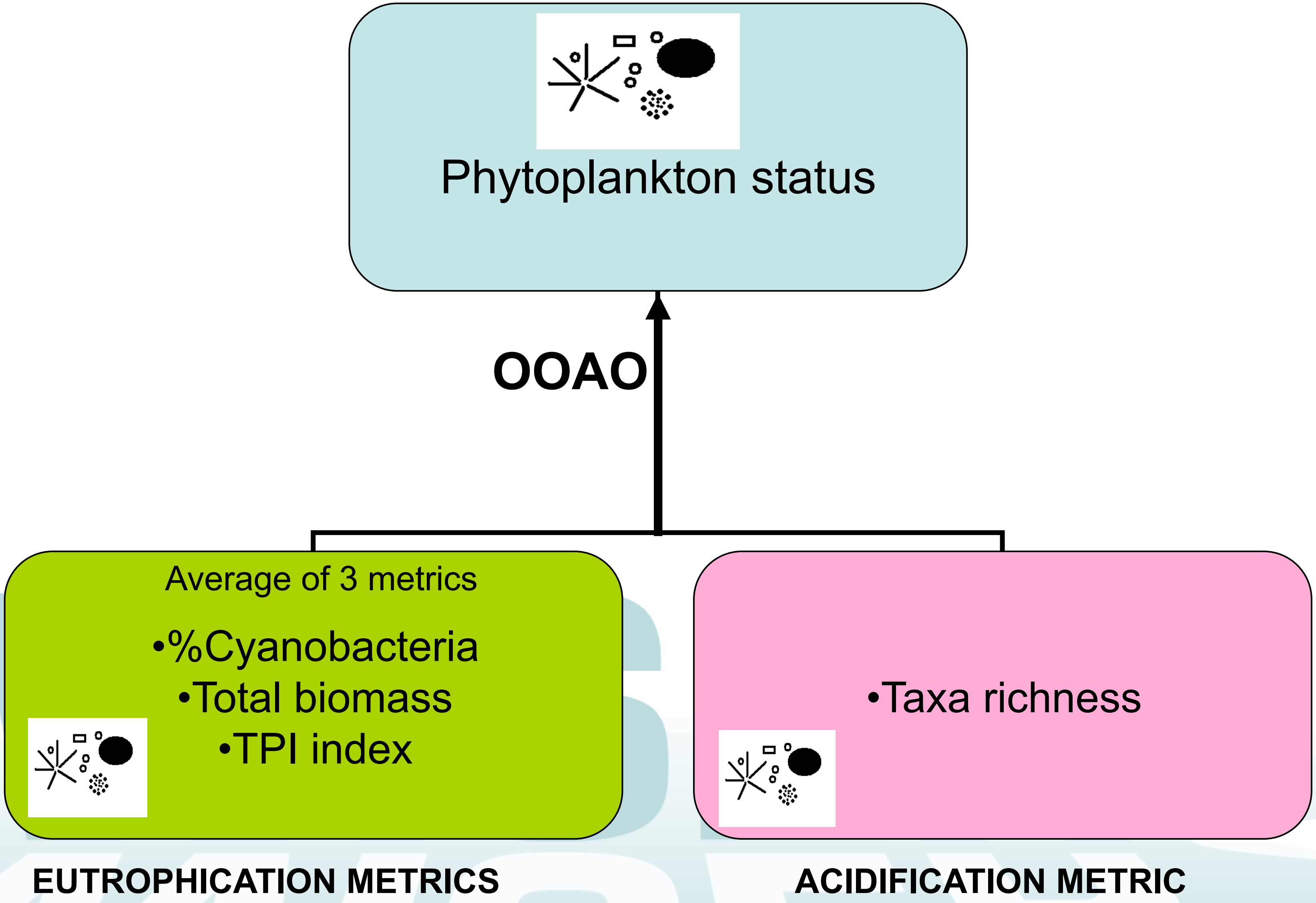
based on n = 1000 simulations

(WISERBUGS hands-on session Wednesday afternoon)

LAKES – metrics and pressures

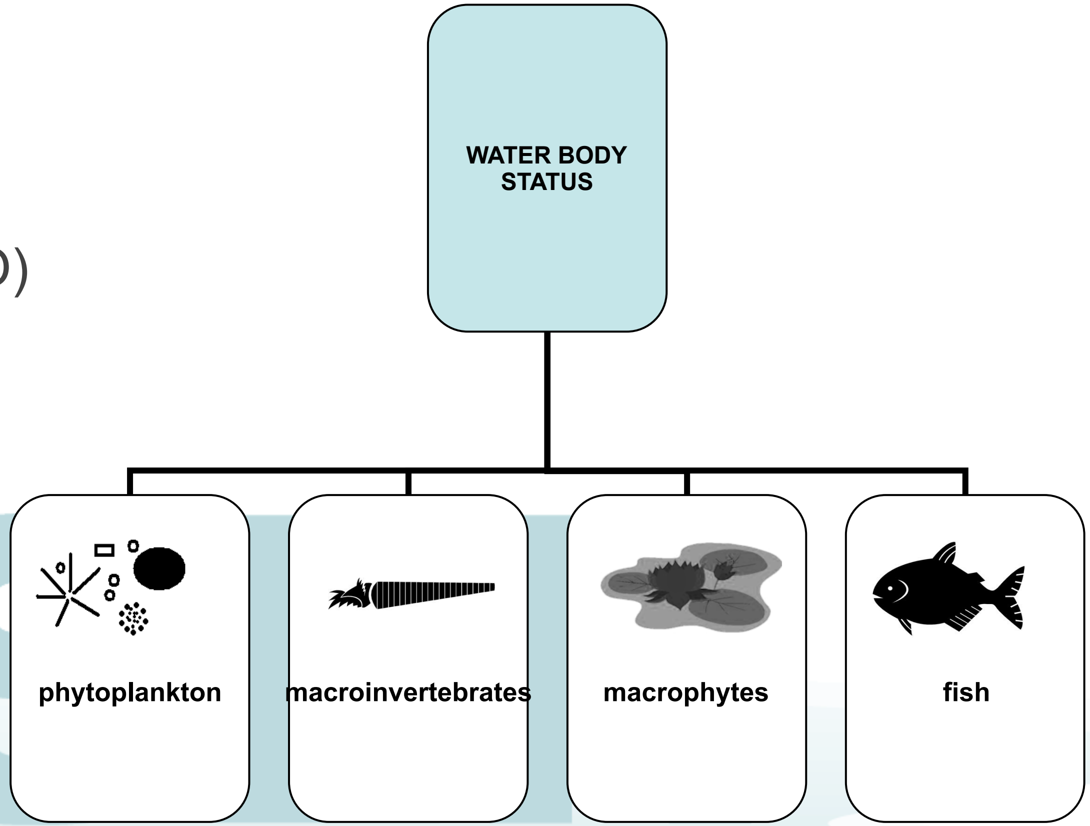
BQE	metric/index	detected pressure
	Total biomass	Eutrophication
Phytoplankton	%Cyanobacteria	Eutrophication
	TPI index	Eutrophication
	Taxa richness	Acidification
	ASPT	General degradation
Macroinvertebrates	MILA index	Acidification
Macrophytes	MTI index	Eutrophication
Fish	EQR 8 index	Acidification, eutrophication, general degradation

Grouping within BQE: OOAO across pressures

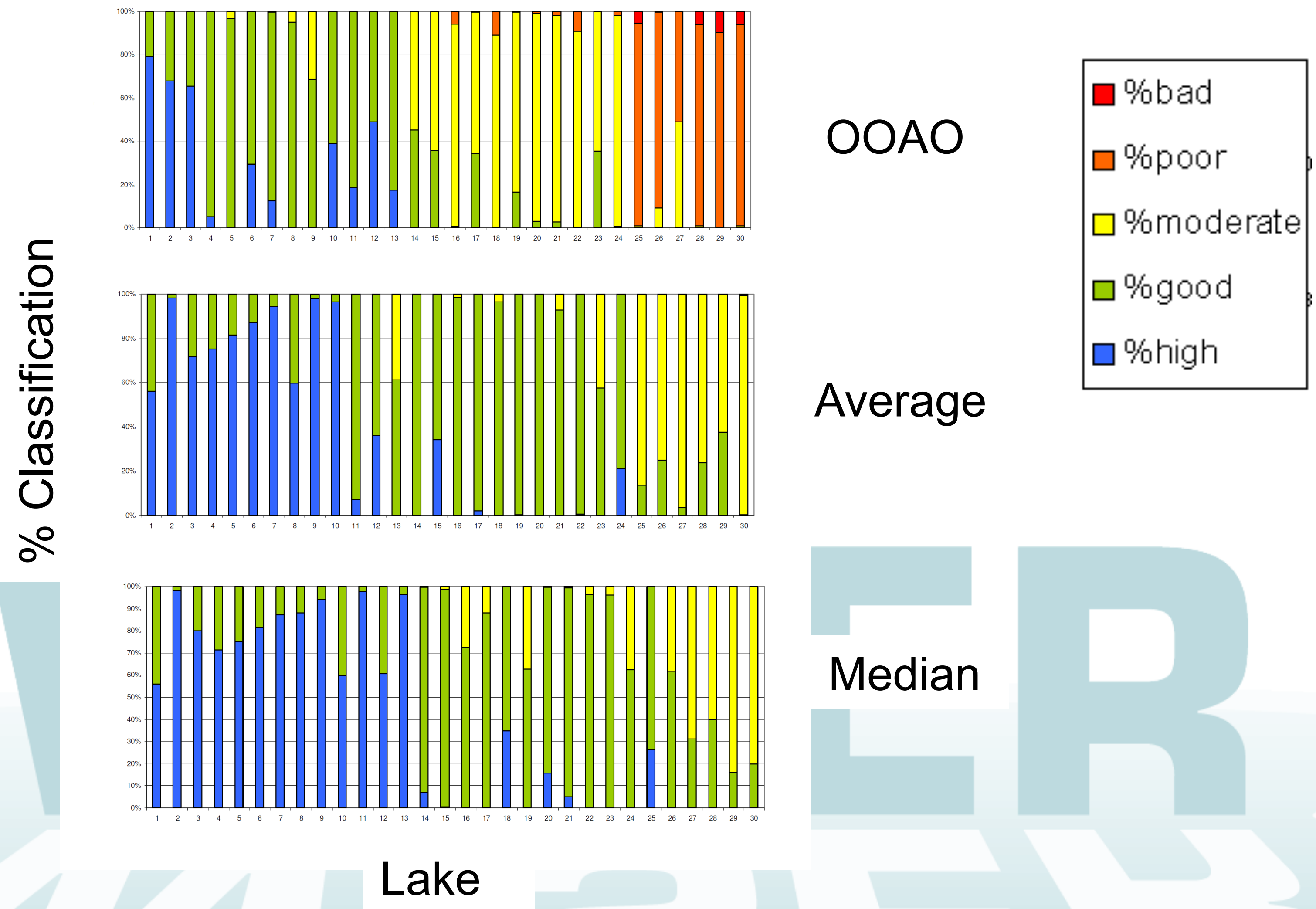


1. COMBINATION RULES ACROSS BQEs

- Different combination rules have been compared:
  - ‘One out-all out’ (OOAO)
  - Average
  - Weighted average
  - Median



Example of the effect of different combination rules across 3 lake BQEs (phytoplankton, macroinvertebrates and macrophytes) on lake ecological status



- Different combination rules across multiple BQEs change the outcome of lake ecological status
- probability of misclassification can help judgment

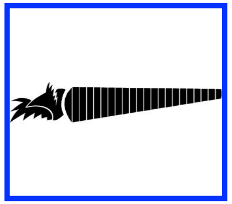
	OOAO			AVERAGE			MEDIAN		
LAKE CODE	STATUS	prob misclass	prob moderate or worse	STATUS	prob misclass	prob moderate or worse	STATUS	prob misclass	prob moderate or worse
ABI	good	5.1	0.1	high	44	0	high	44	0
BAEN	good	3.5	3.3	good	7.2	0.1	good	7.3	0.2
BAST	poor	6.2	100.1	mod	13.7	86.3	good	2	1.3
BRAN	high	20.9	0	high	1.9	0	high	1.9	0
DUNN	mod	45.2	54.8	good	36	0	high	19.9	0
FJAT	good	29.4	0	high	28.5	0	high	28.5	0
FYSI	poor	9.7	100	mod	25.2	74.8	good	27.5	27.5
GIPS	poor	48.8	100	good	38.6	38.7	mod	31.3	68.7
GOSJ	mod	35.9	64.1	good	0.1	0.1	good	11.9	11.9
HAVG	poor	7	100	mod	3.5	96.5	mod	39.8	60.2
HUMS	good	12.5	0.2	high	24.8	0	high	24.7	0
JUTS	good	5	4.8	high	34.3	0	good	34.9	0
KRANK	poor	10.1	99.9	mod	23.9	76.1	good	37	37.1
LOUWA	mod	6.4	99.4	good	1.7	1.6	good	16.1	0.2
OVERU	poor	7.2	100	mod	0.8	99.8	mod	20	80
PAHA	mod	34.3	65.9	good	2	0	good	5.9	0.6
ROTE	good	31.4	31.4	good	3.6	3.6	good	3.6	3.6
SANNE	good	17.6	0.1	high	40.2	0	high	40.2	0
SIGG	good	38.8	0	high	18.5	0	high	18.5	0
SKARS	good	18.8	0	high	12.9	0	high	12.9	0
SPJUT	mod	11.4	99.7	good	0.4	0.1	high	11.9	0
STENS	mod	16.6	83.6	good	0.3	0.2	good	4.3	3.9
STORAR	good	48.8	0	high	5.7	0	high	5.7	0
STORBA	mod	3.9	97	good	7.2	7.2	good	37.4	37.4
STORTJ	mod	4.5	97.3	good	0.5	0	good	26.7	0
TAFTE	high	32.1	0	high	2.2	0	high	2.2	0
TANGE	mod	2.5	99.4	mod	37.6	62.4	mod	16.1	83.9
TARNA	mod	35.4	64.6	good	21.1	0	high	39.4	0
TOME	mod	9.4	99.9	good	42.4	42.4	good	38.5	38.5
VALAS	high	34.7	0	high	3.5	0	high	3.5	0

- Lake Pahajärvi

ASPT= 99% high

MILA= 99% high

- **INVERTEBRATES= 99% high**



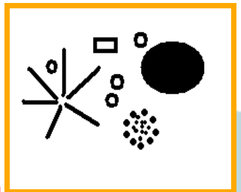
Taxa richness= 98% high

Total biomass= 86% moderate

%Cyanobacteria= 89% good

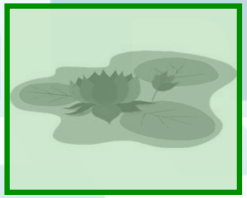
TPI index= 56 % moderate

- **PHYTOPLANKTON= 65% moderate – 35% good**



MTI= 94% good

- **MACROPHYTES= 94% good**

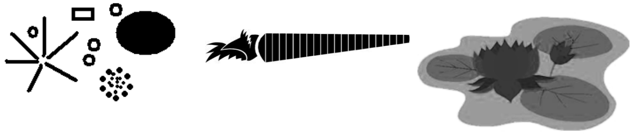


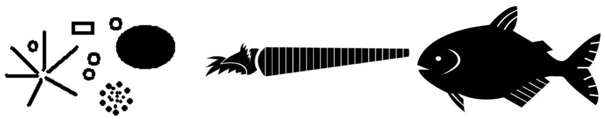
2. NUMBER OF BQEs IN THE ASSESSMENT

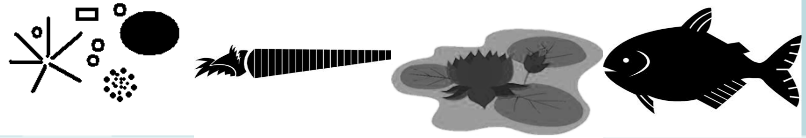
- In the same data set, it was investigated how the number of BQEs included in the assessment affects the classification outcome

- Monitoring data were available for 17 Swedish lakes with up to four BQEs –

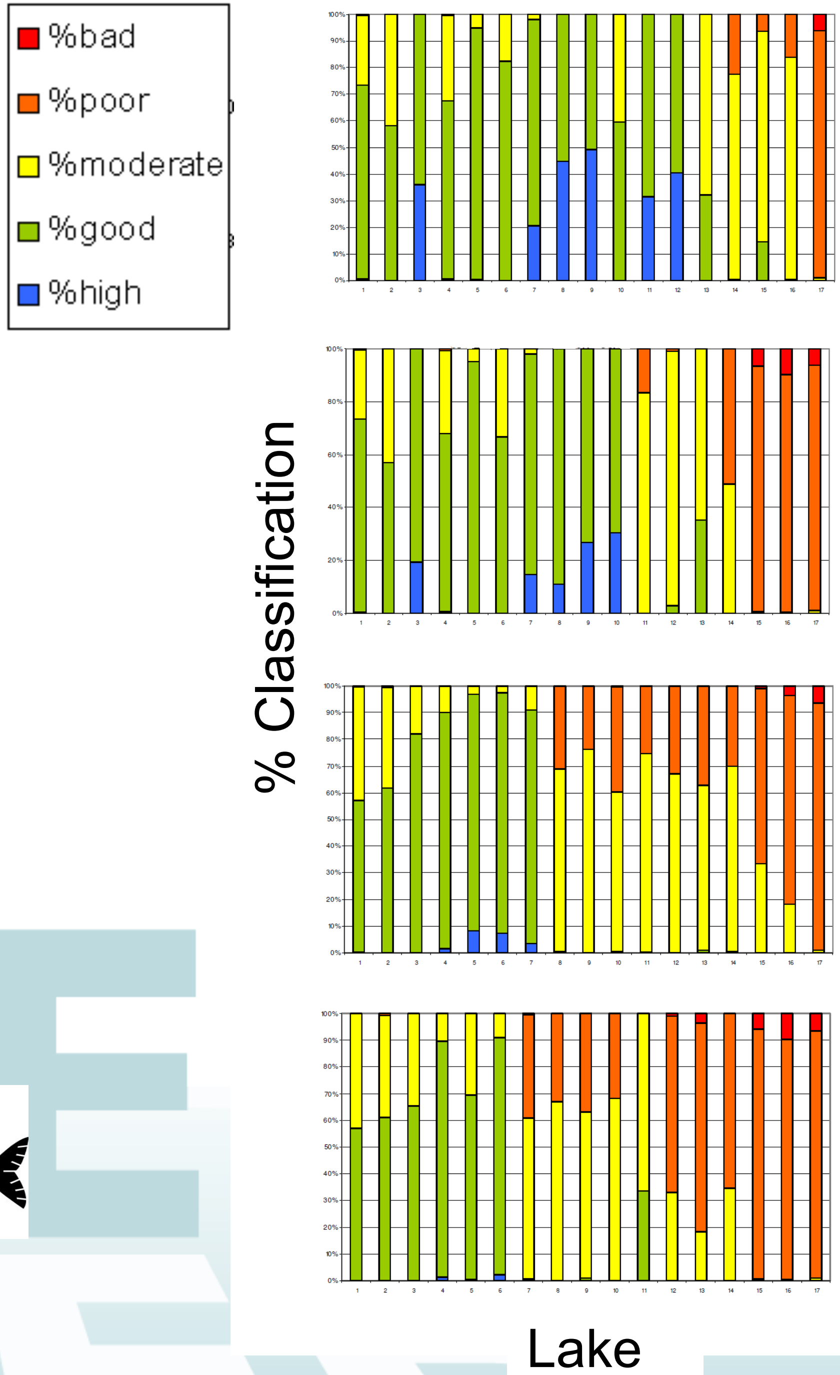
  phytoplankton, macroinvertebrates, macrophytes, fish







One out – all out to combine BQEs



Conclusions and recommendations

- There are considerable effects of combination rules on classification outcome
- Avoid redundancy between because it lowers classification outcome when using one out – all out
- Number of BQEs included in the assessment has a large effect – need for consistency to ensure comparability
- Intercalibration ensures comparability at BQE level – but not of the final classification
- Be careful to interpret ecological status data at EU level – BQEs give more comparable results because these have been intercalibrated
- Evidence based approaches to combine BQE information make sense where methods are not perfect…
- WISERBUGS information on classification accuracy of individual metrics provides useful information for diagnosing the situation in a water body