The development of integrated assessment tools – from HEAT over NEAT to WATERS

Jacob Carstensen

NIVA-DK 10 years anniversary

27 September 2024

AARHUS UNIVERSITY
DEPARTMENT OF ECOSCIENCE

NIVA Danmark

UNIVERSITY OF GOTHENBURG

Cumulative effects on marine ecosystems

- Eutrophication
- Harmful substances
- Food-web alteration
- Physical disturbance
- Habitat destruction
- Invasive species
- Climate change
- ……

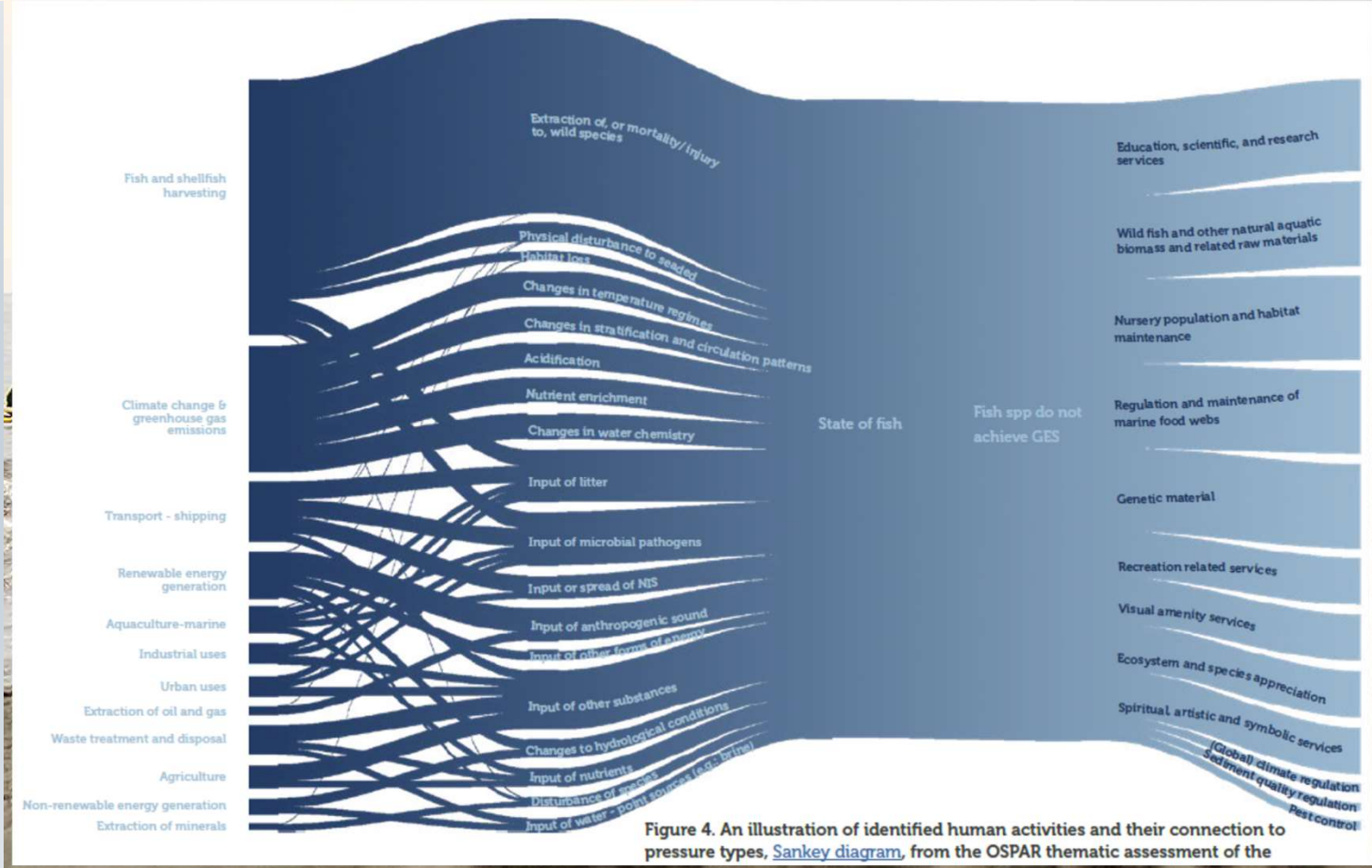
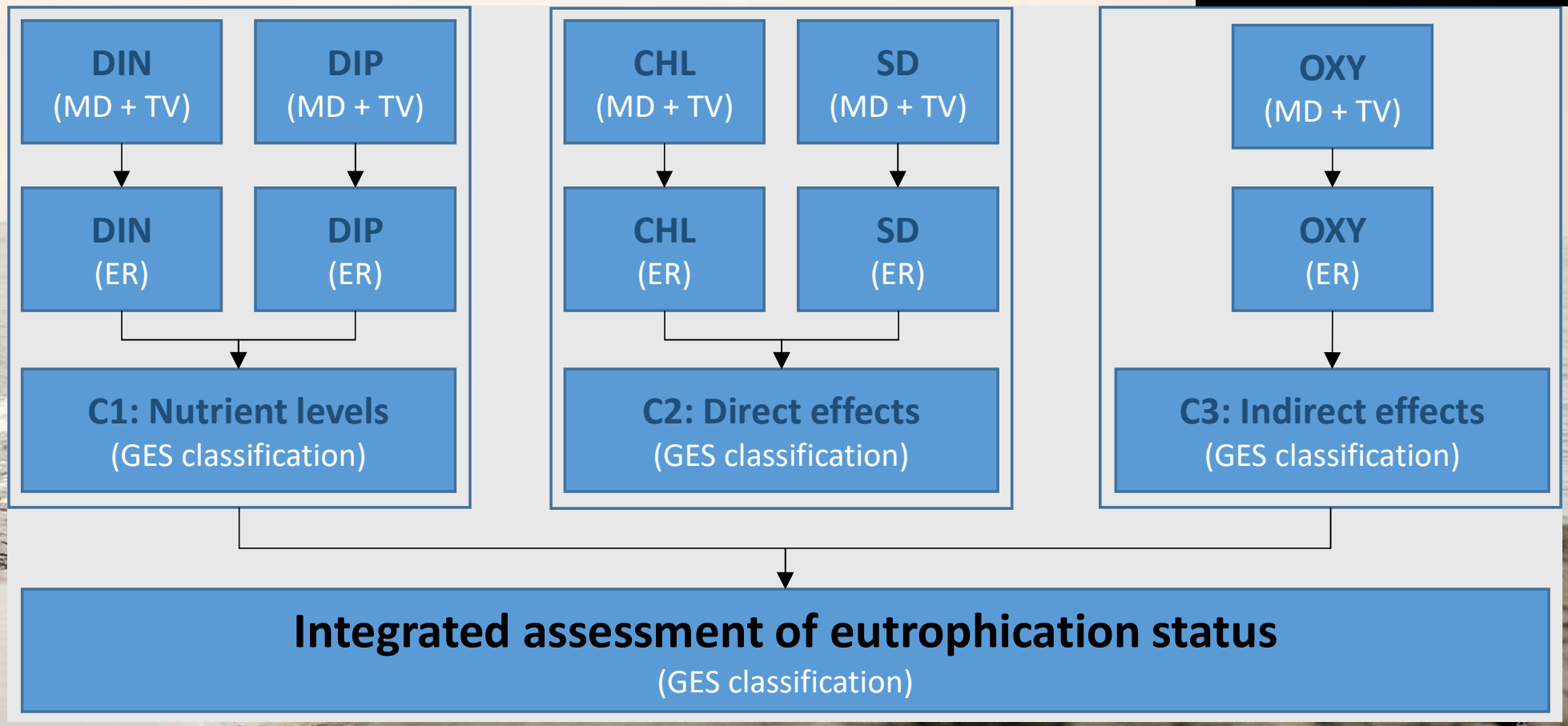


Figure 4. An illustration of identified human activities and their connection to pressure types, Sankey diagram, from the OSPAR thematic assessment of the

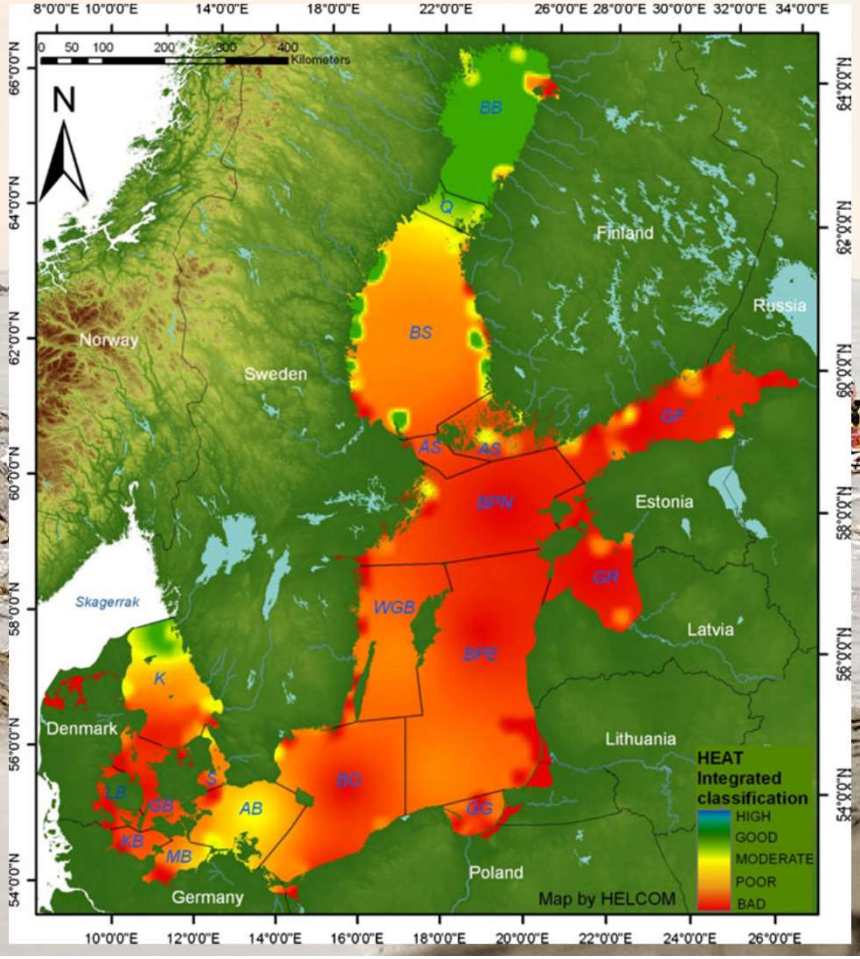
GES4 SEAS

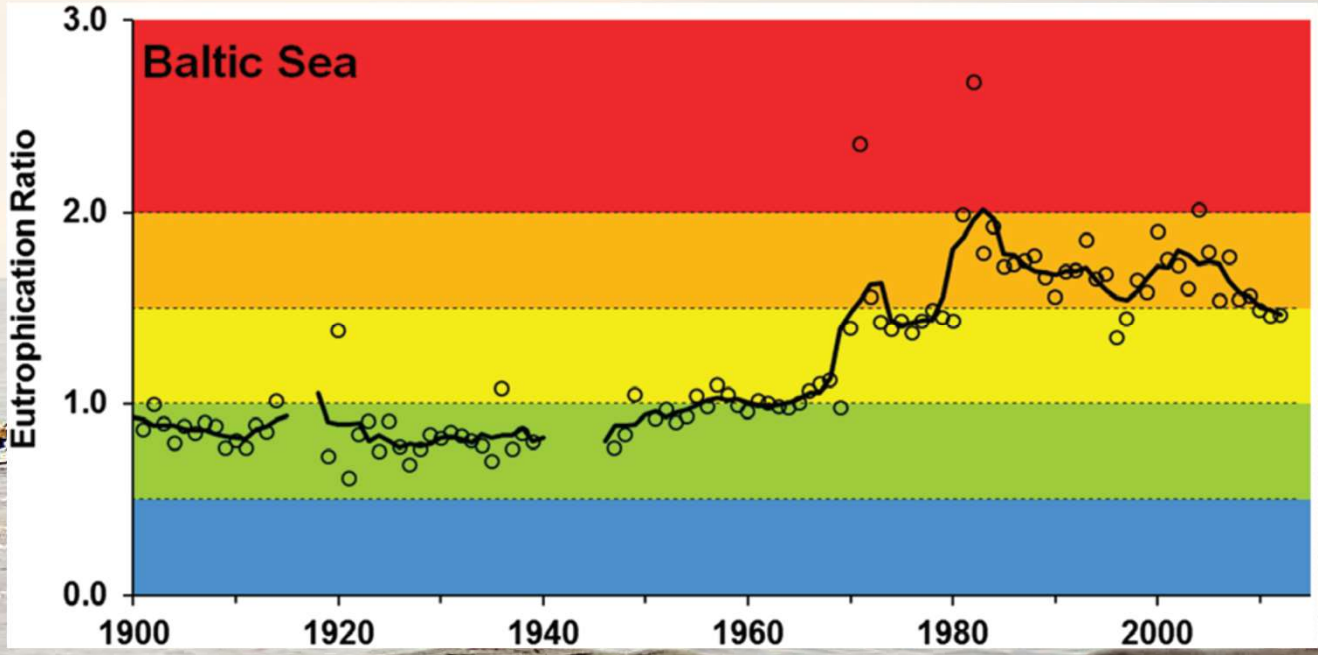
Assessing the status of eutrophication

The HEAT tool



Eutrophication status assessment in the Baltic Sea



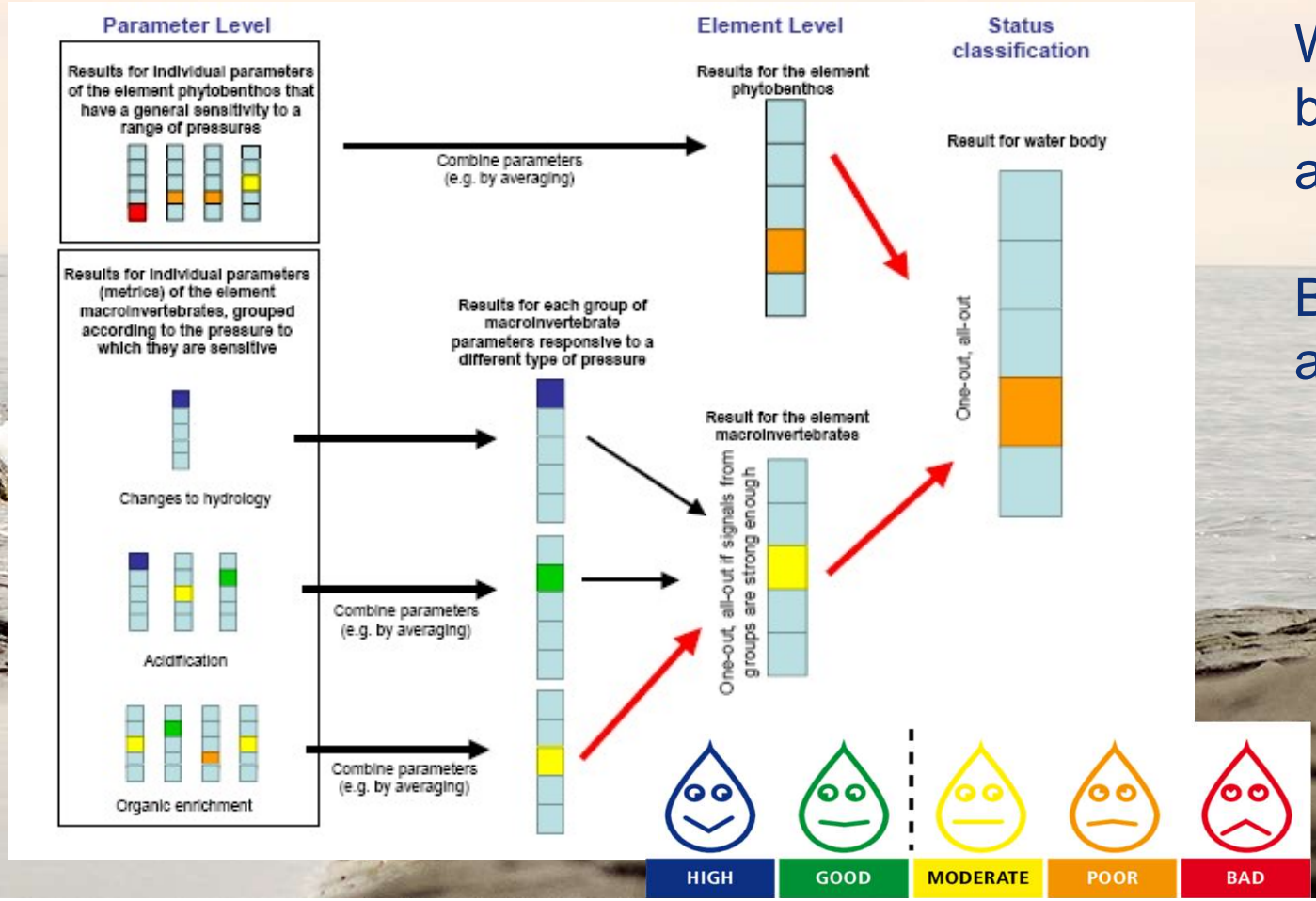


References:

Andersen *et al.* (2011) *Biogeochemistry* 106:137-156

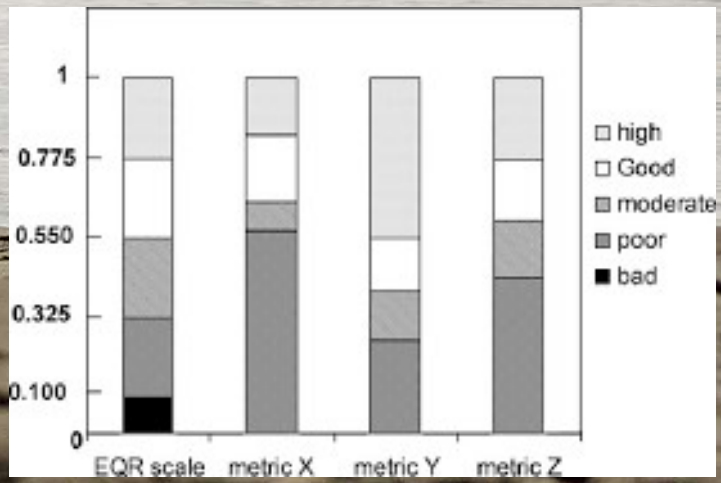
Andersen *et al.* (2017) *Biol. Rev.* 92:135-149.

Ecological status assessment according to the European Water Framework Directive

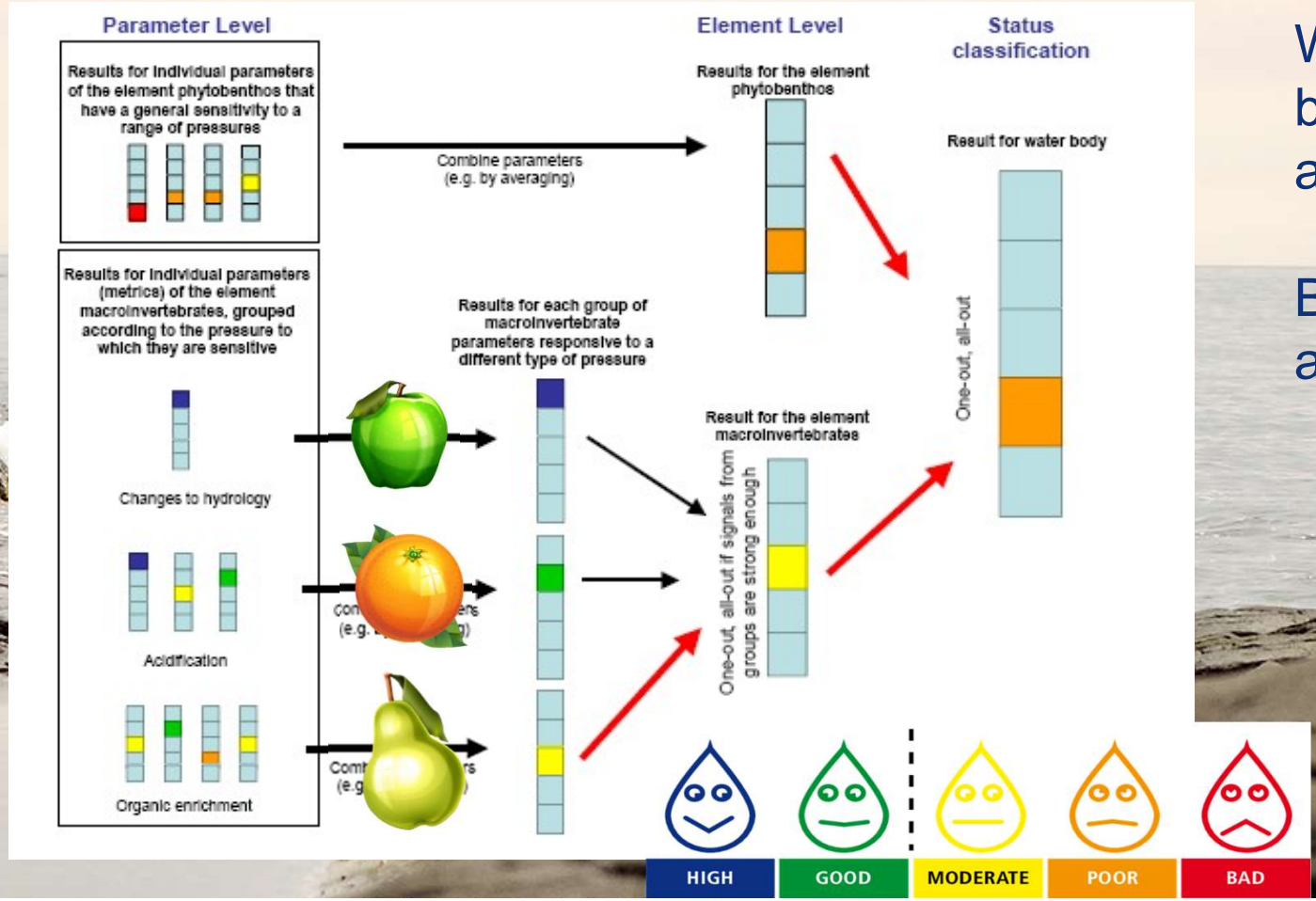


Within BQEs: metrics can be combined as seen appropriate

Between BQEs: ‘one out-all out’ principle

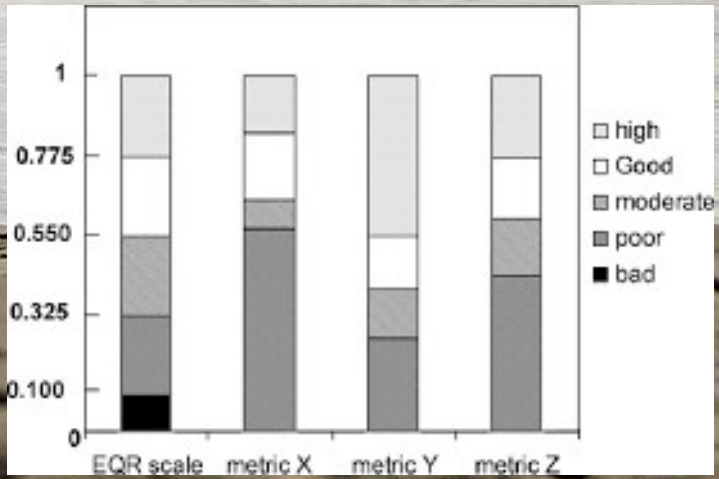


Ecological status assessment according to the European Water Framework Directive

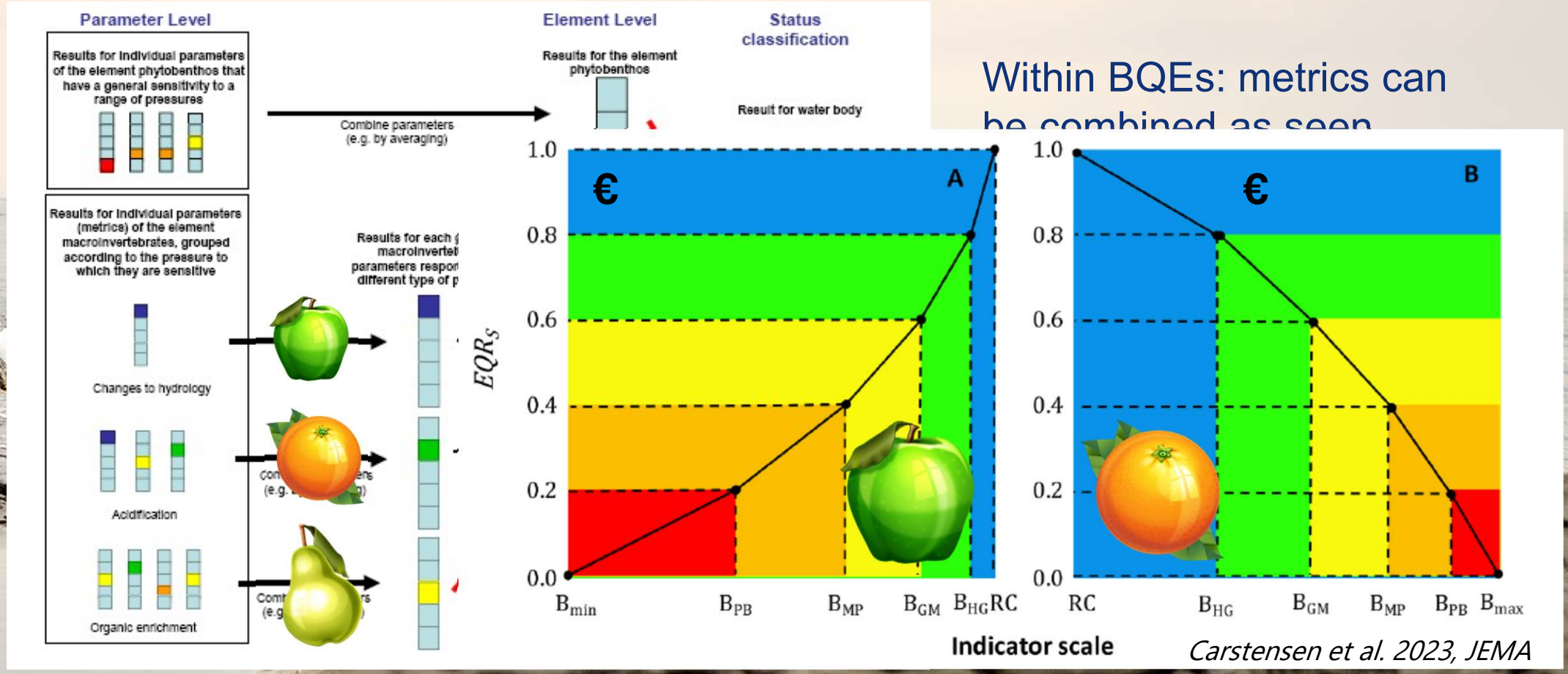


Within BQEs: metrics can be combined as seen appropriate

Between BQEs: ‘one out-all out’ principle



Ecological status assessment according to the European Water Framework Directive



Within BQEs: metrics can be combined as seen

Carstensen et al. 2023, JEMA

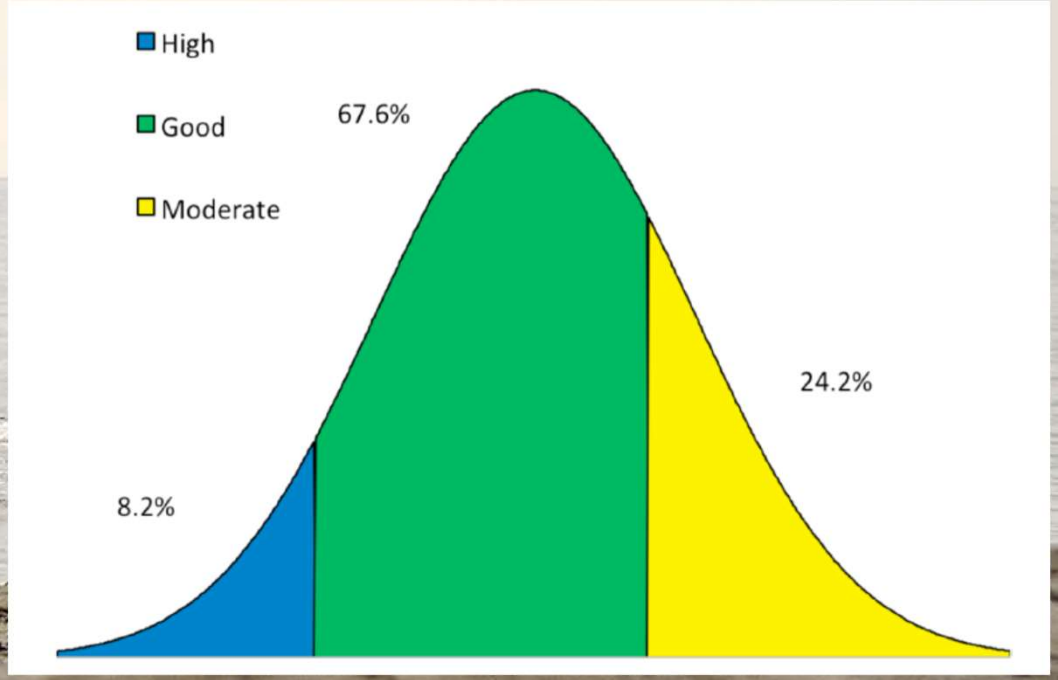
Uncertainty and confidence

Confidence in ecological status assessment

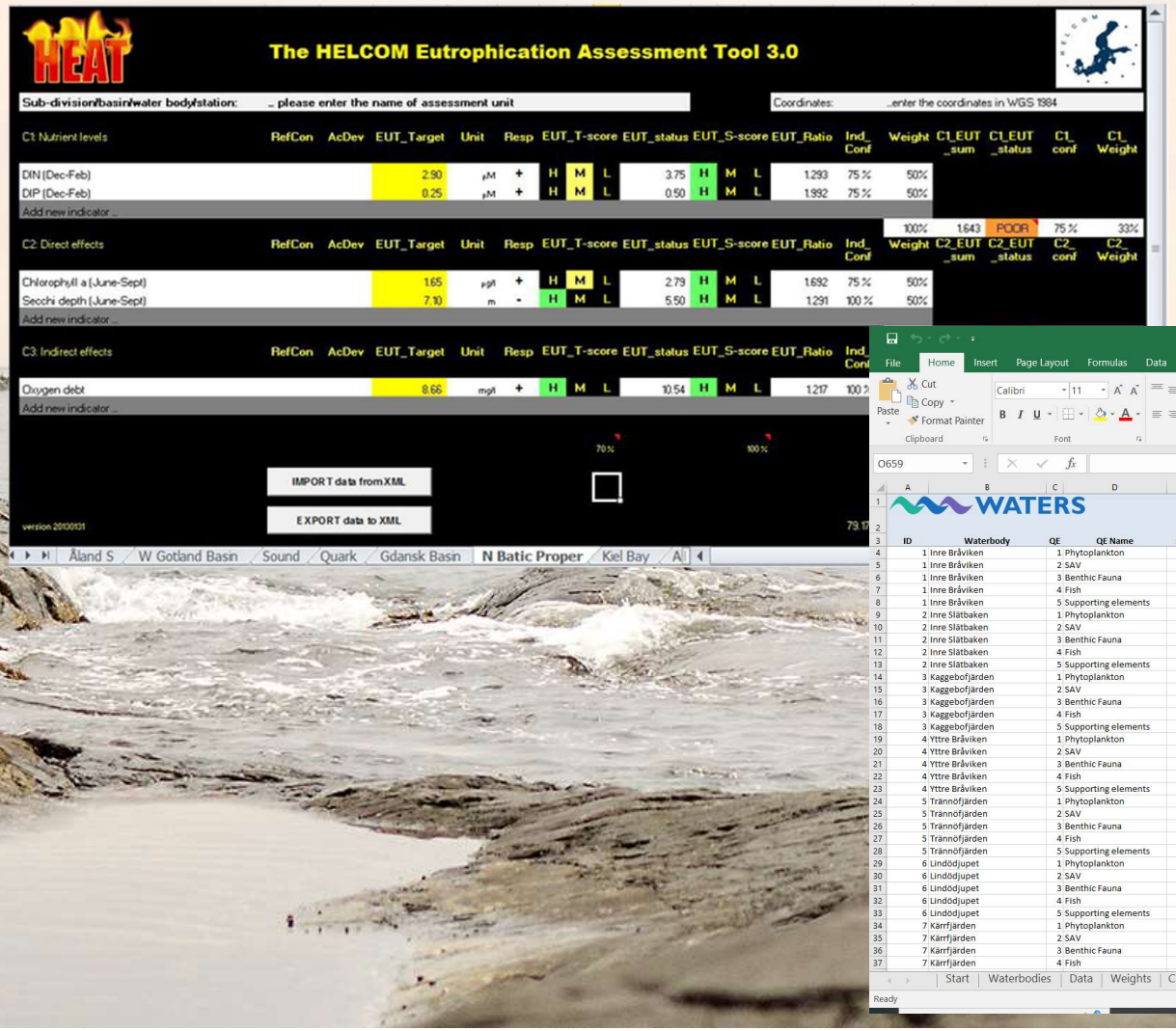
Heuristic approaches → Approach founded in probabilistic theory

Table 1
Scoring matrix. A score of 3 indicates the best possible classification where a "High" quality rating has been assigned to RefCon, AcDev and to AcStat. A score of 9 indicates the worst possible classification, where all scores are rated "Low". The indicator scores from 3 to 9 are converted to an indicator confidence rating ranging from 0 to 100%. The worst possible result is assigned a confidence score of 0% and the best possible score is equivalent to a confidence score of 100%. The confidence score for other combinations is arrived at by interpolating linearly.

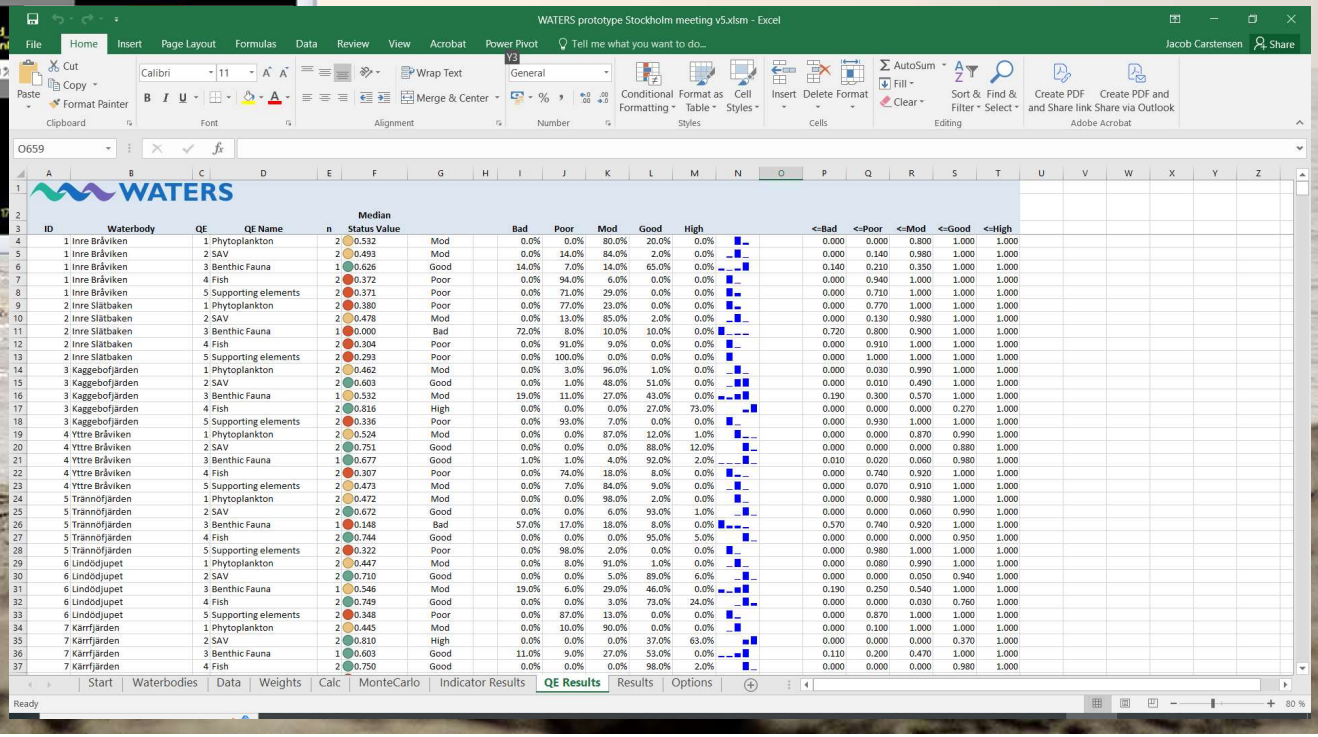
Scores			∑	Ind_conf
RefCon	AcDev	AcStat		
1	1	1	3	100%
1	1	2	4	83%
1	2	2	5	67%
2	2	2	6	50%
2	2	3	7	33%
2	3	3	8	17%
3	3	3	9	0%



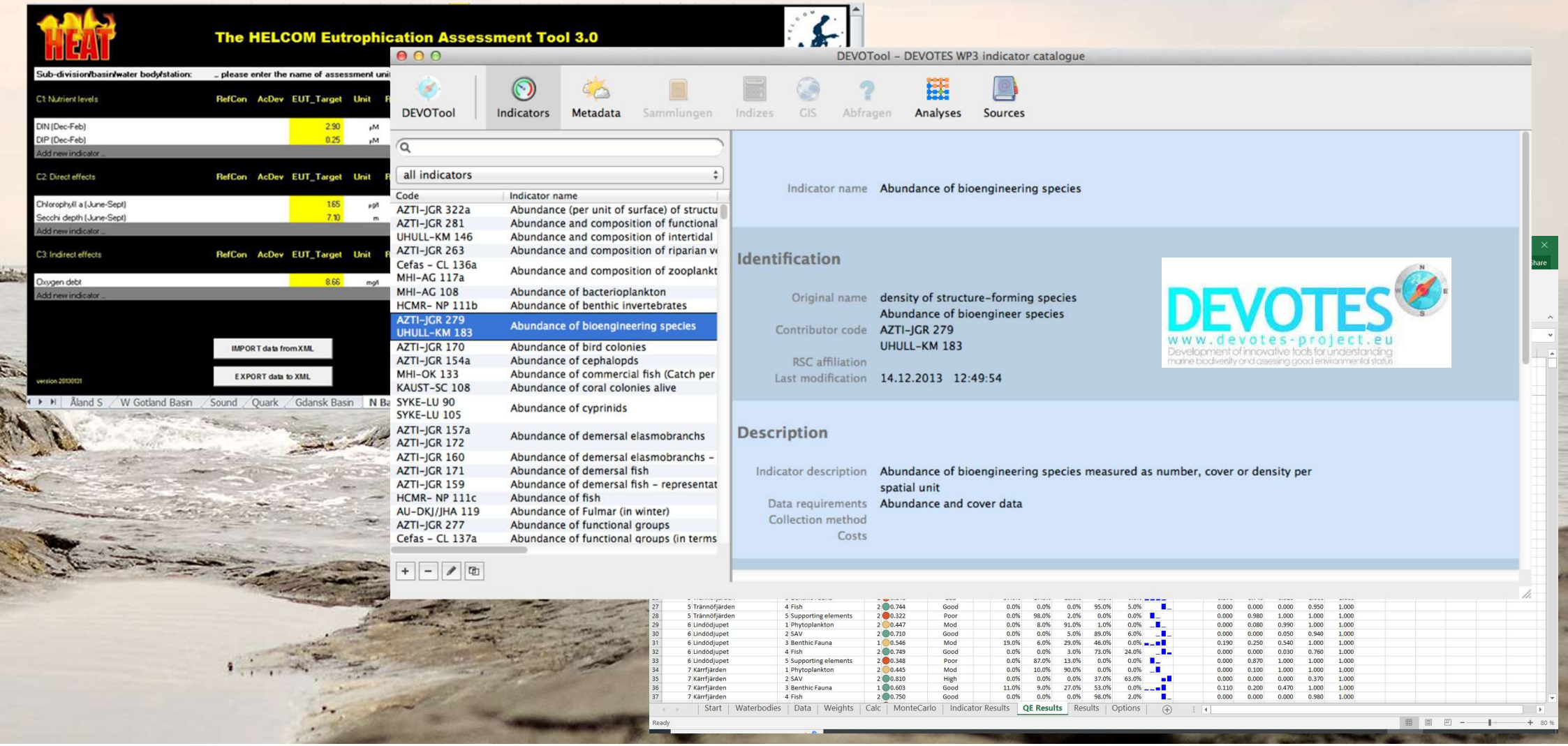
The transition from Excel to web-based tools



WATERS



The transition from Excel to web-based tools

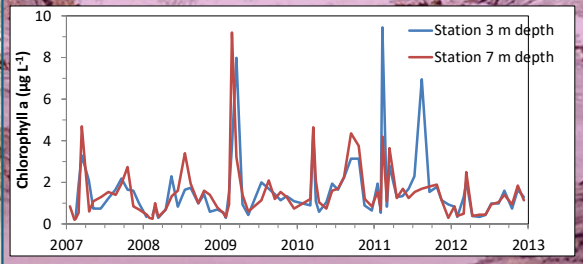


The transition from Excel to web-based tools

Övervaknings-databas

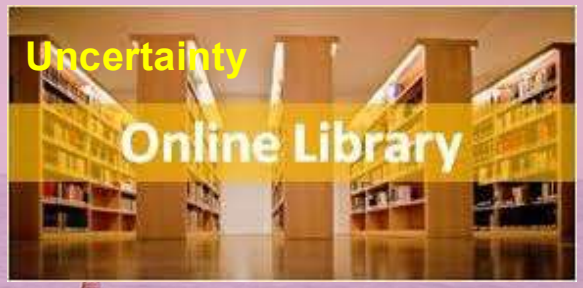
SLU DB

SMHI SharkWeb

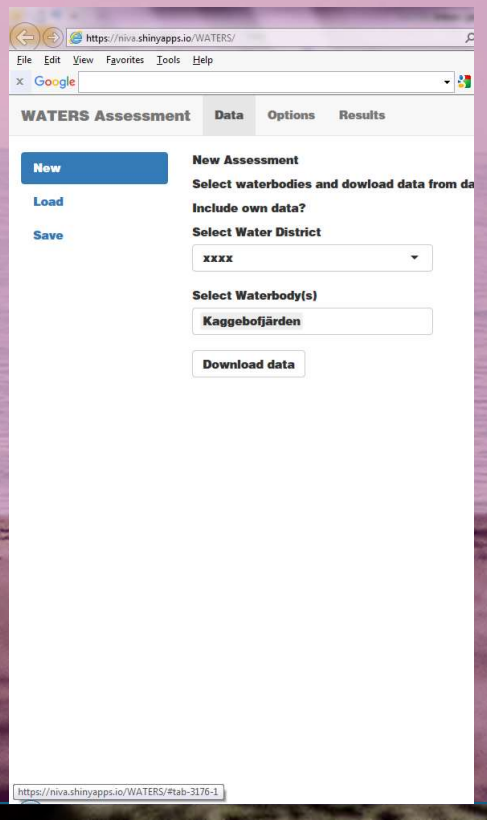


VISS

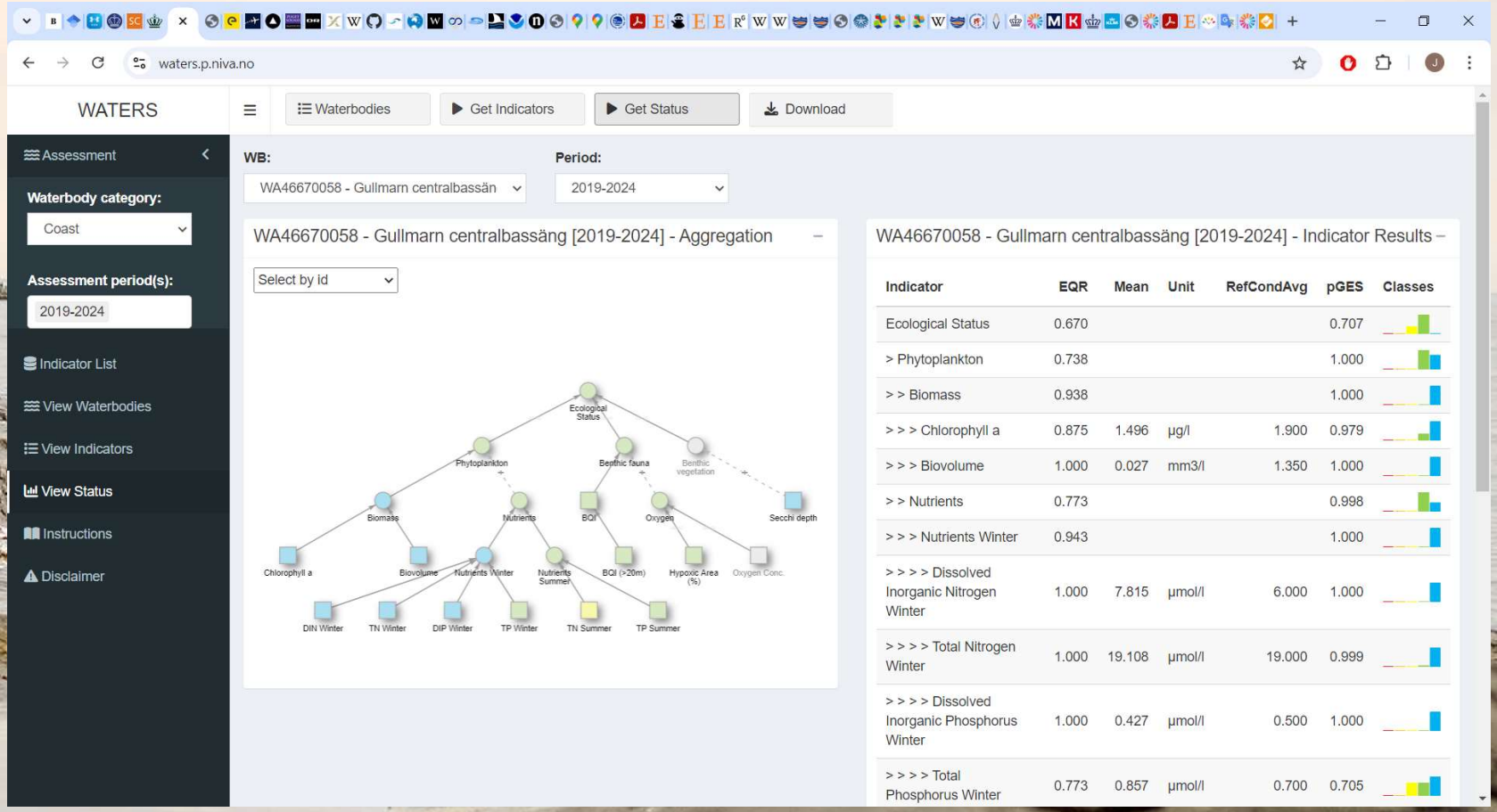
R-package för indikatorberäkning



Sammanväg-ningsverktyg



An online tool for the user making the WFD status assessment

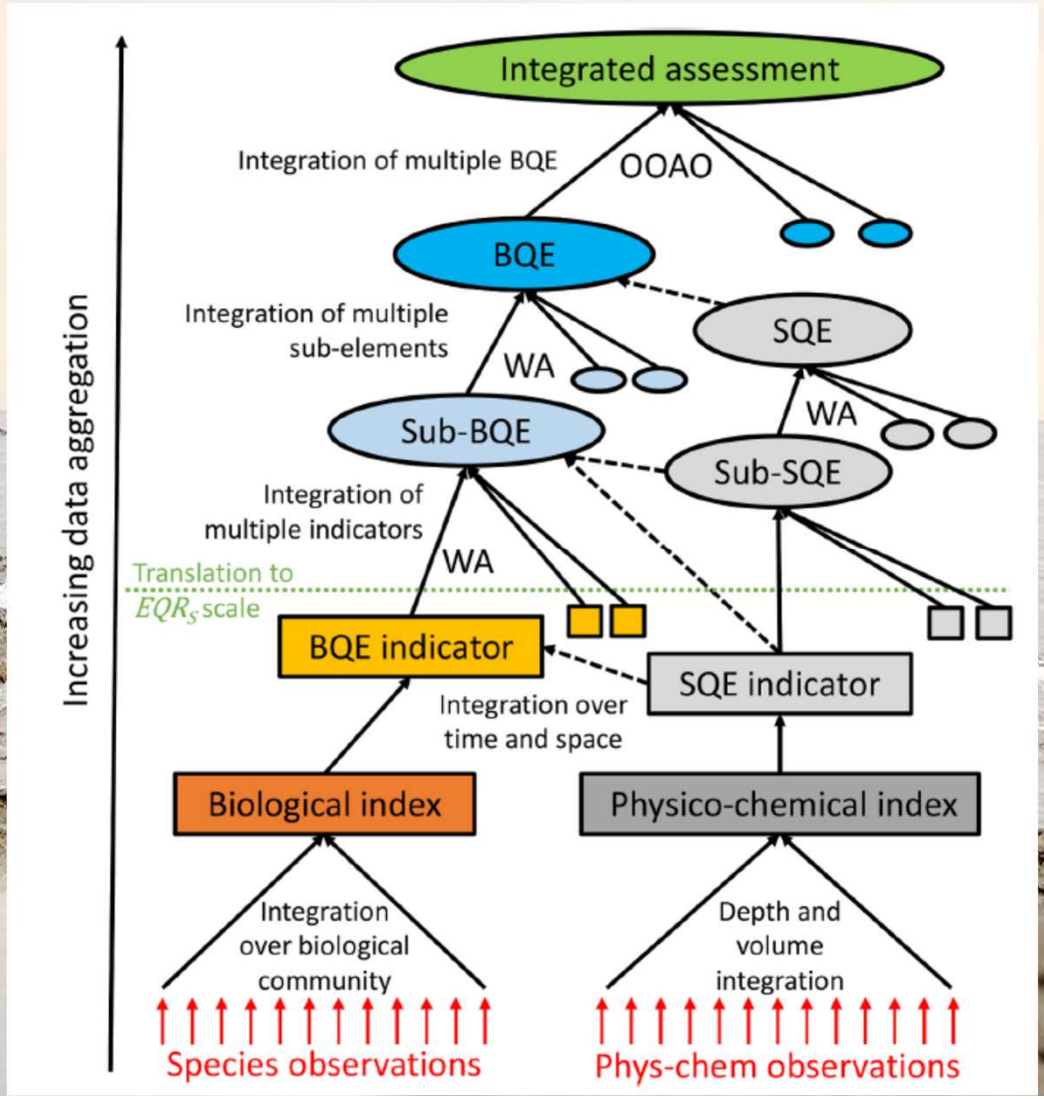


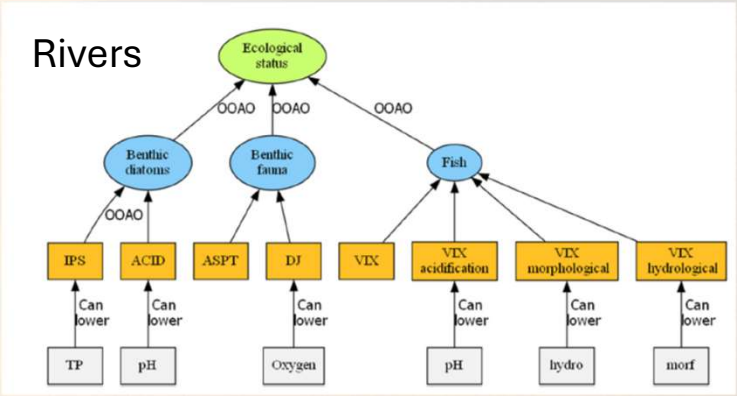
Indicator	EQR	Mean	Unit	RefCondAvg	pGES	Classes
Ecological Status	0.670				0.707	
> Phytoplankton	0.738				1.000	
> > Biomass	0.938				1.000	
> > > Chlorophyll a	0.875	1.496	µg/l	1.900	0.979	
> > > Biovolume	1.000	0.027	mm3/l	1.350	1.000	
> > Nutrients	0.773				0.998	
> > > Nutrients Winter	0.943				1.000	
> > > > Dissolved Inorganic Nitrogen Winter	1.000	7.815	µmol/l	6.000	1.000	
> > > > Total Nitrogen Winter	1.000	19.108	µmol/l	19.000	0.999	
> > > > Dissolved Inorganic Phosphorus Winter	1.000	0.427	µmol/l	0.500	1.000	
> > > > Total Phosphorus Winter	0.773	0.857	µmol/l	0.700	0.705	

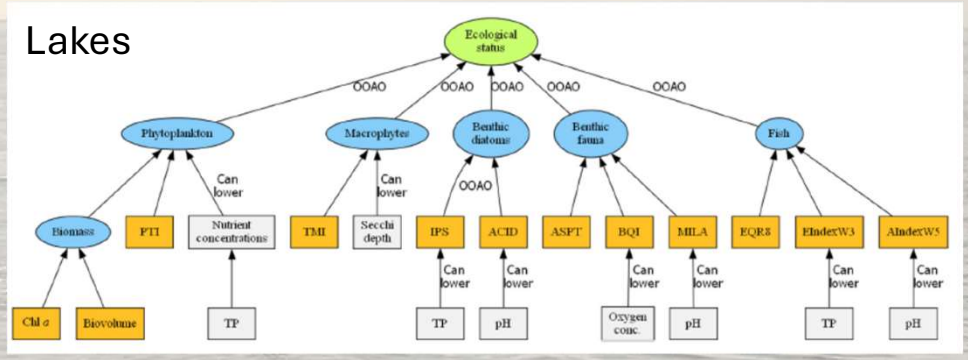
- Downloading data from national hosts (SLU, SMHI)
- Configuration files for boundaries, uncertainty library, water bodies, default indicators, other parameters
- Interactive selection of indicators

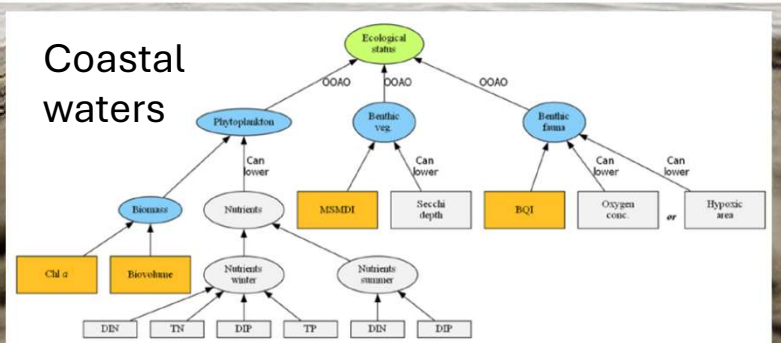
From observations to ecological status

Carstensen et al. 2023, JEMA



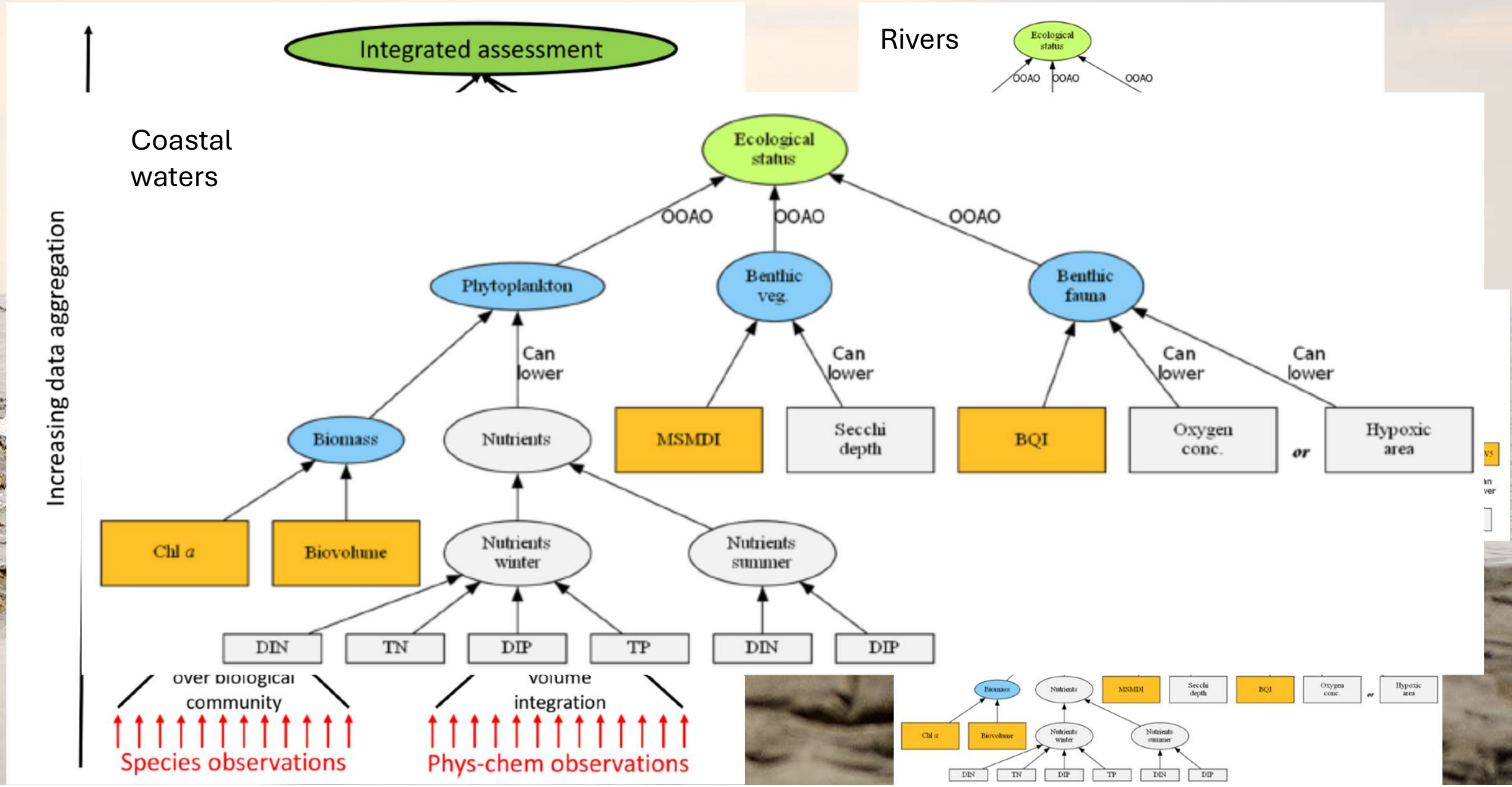




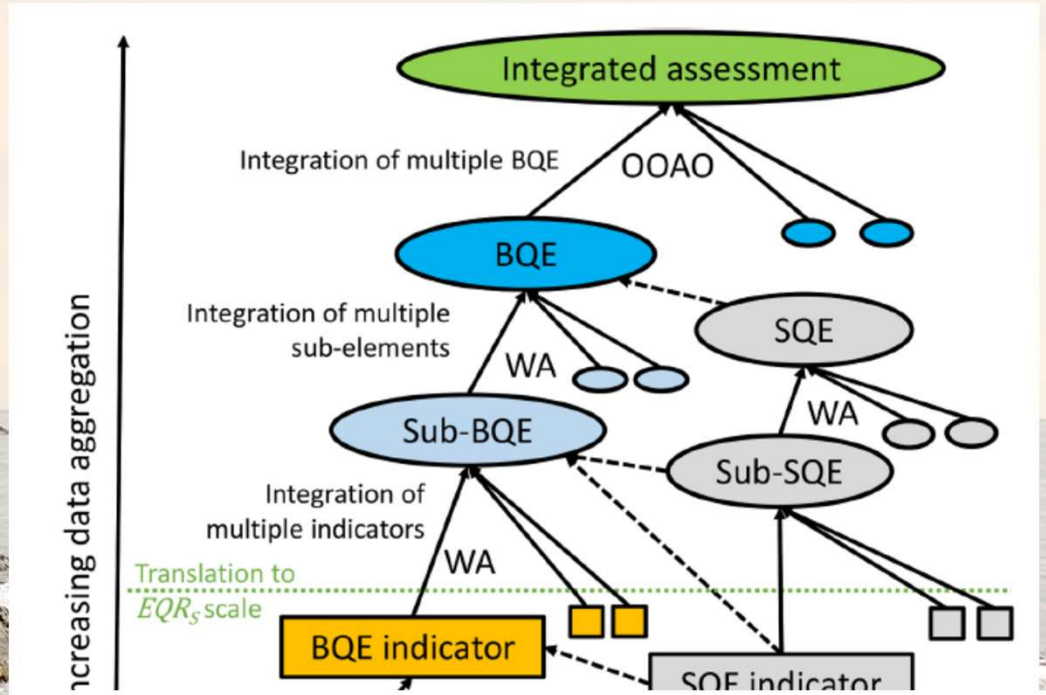


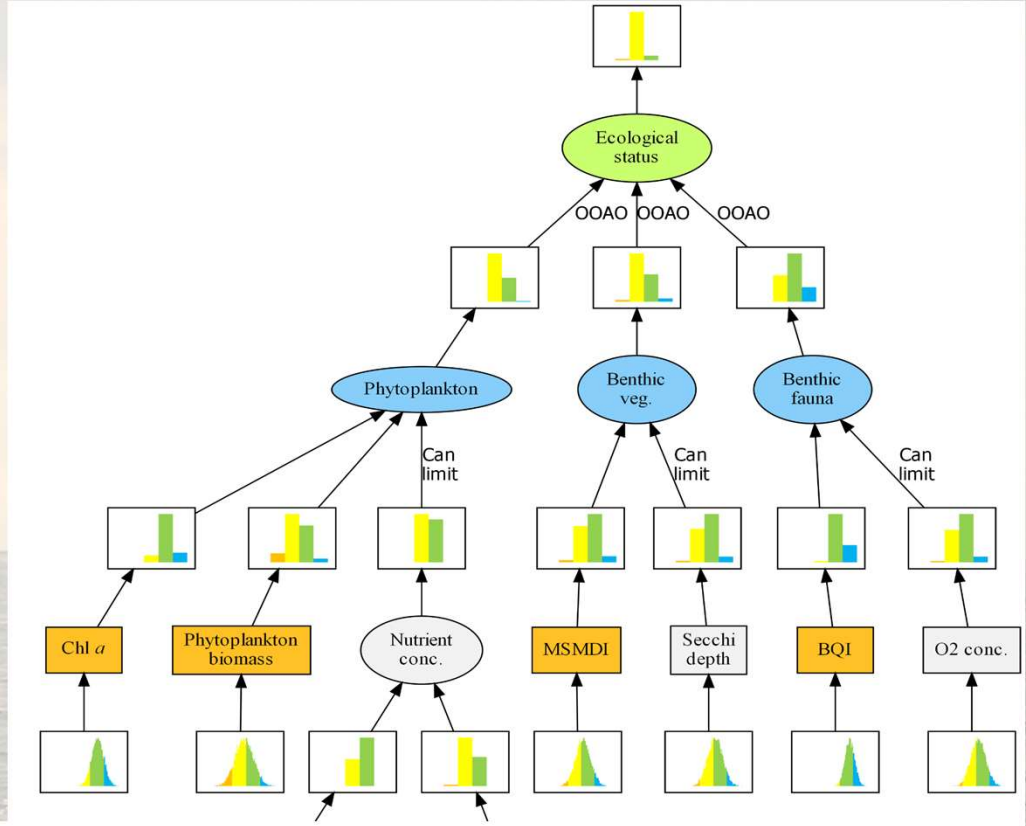
From observations to ecological status

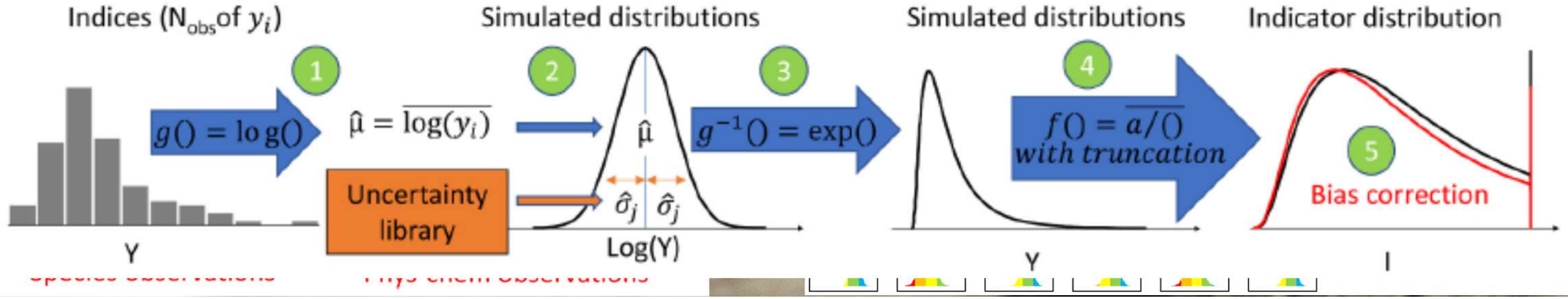
Carstensen et al. 2023, JEMA



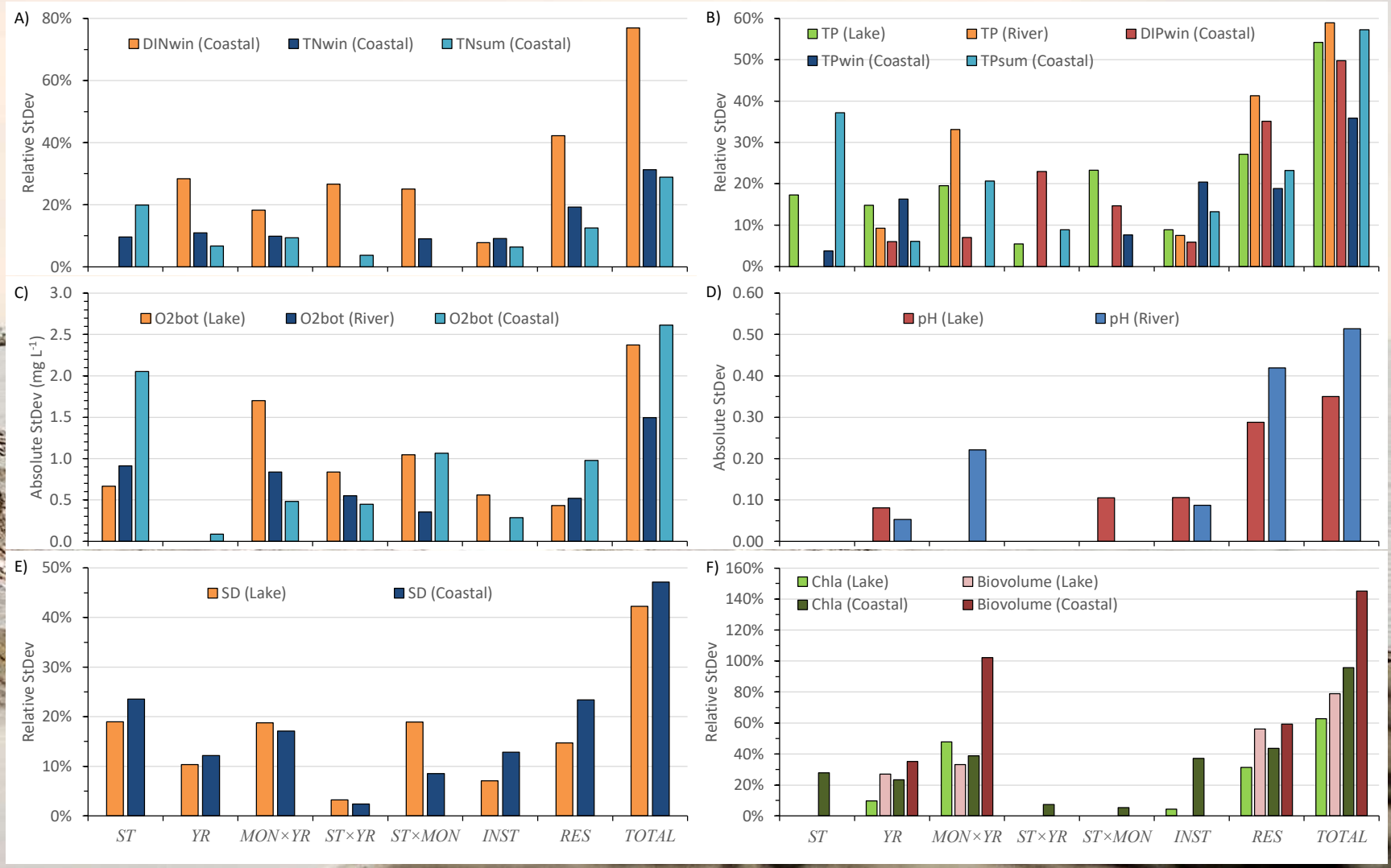
Confidence assessment







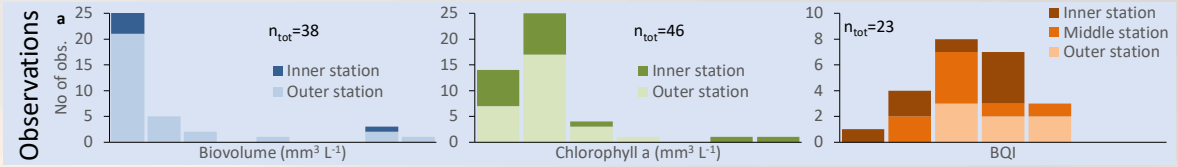
Getting the errors right: Uncertainty library

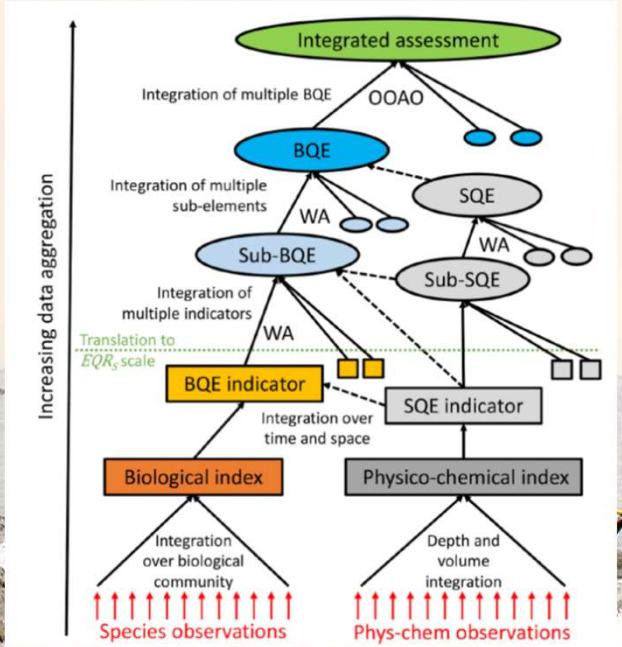


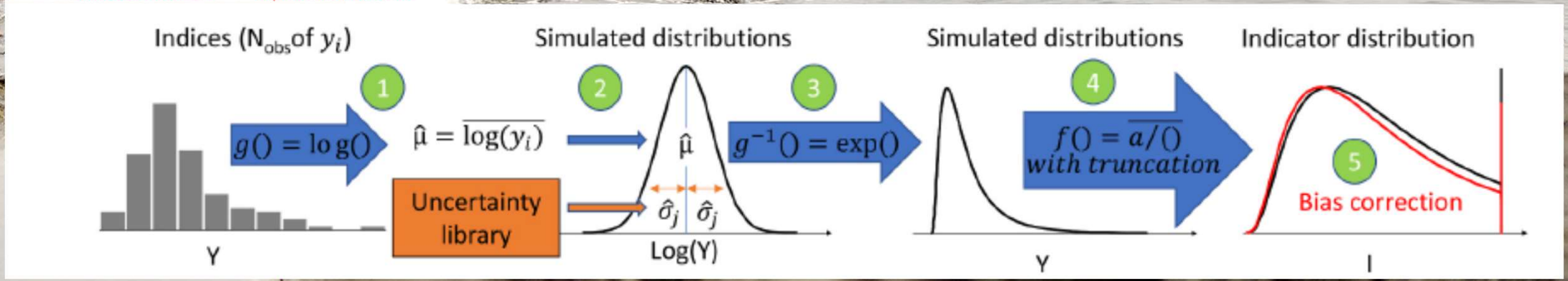
- Incorrect partitioning of error sources underestimates total uncertainty
- Sampling distribution in time, space and across institutions influence indicator uncertainty

Carstensen et al. (2024) Ecological Indicators

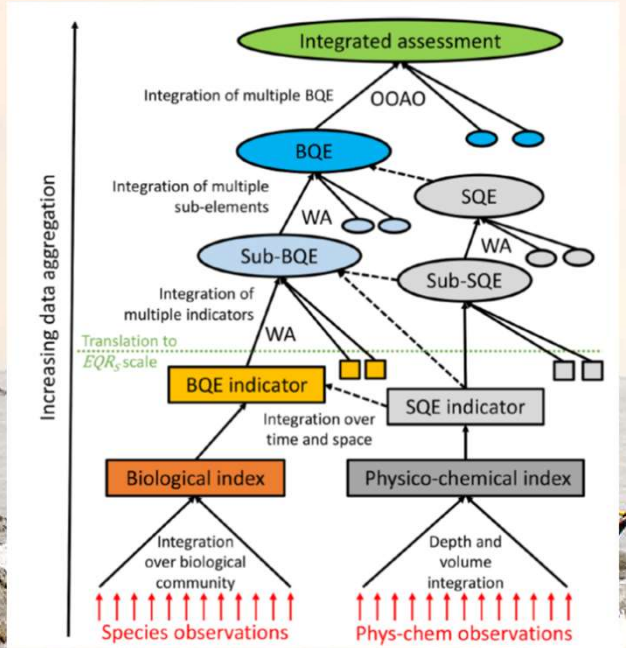
How does it work in practice?

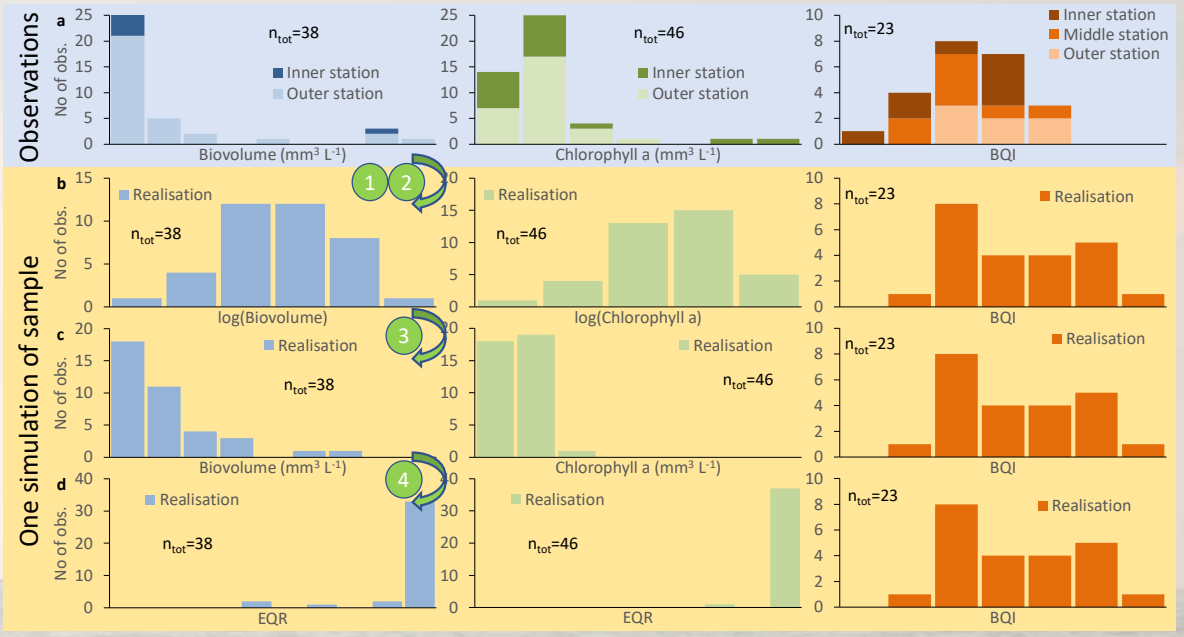


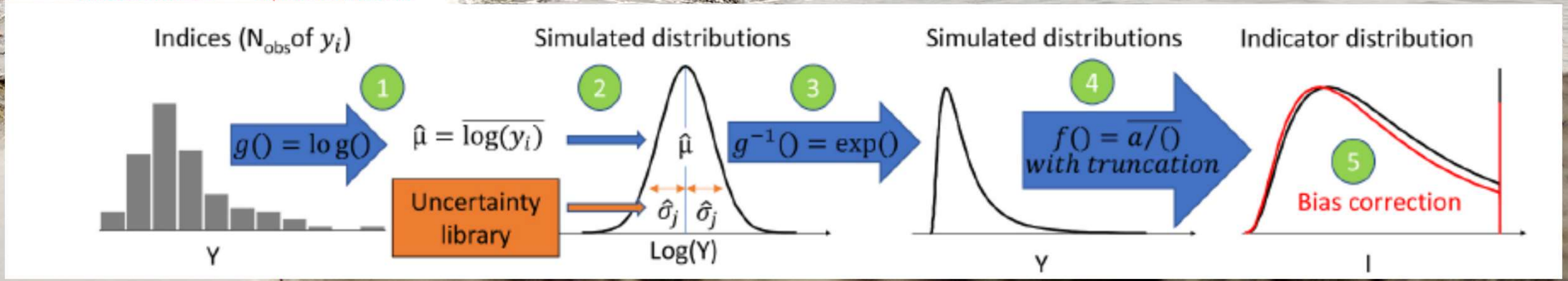




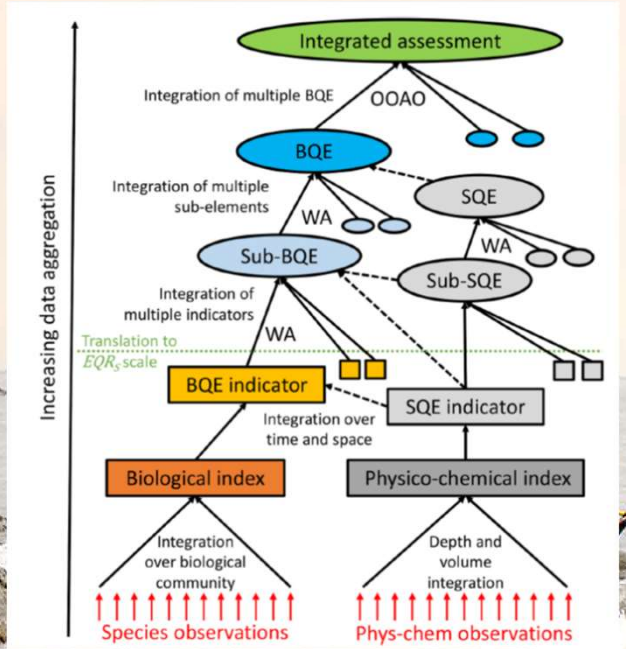
How does it work in practice?

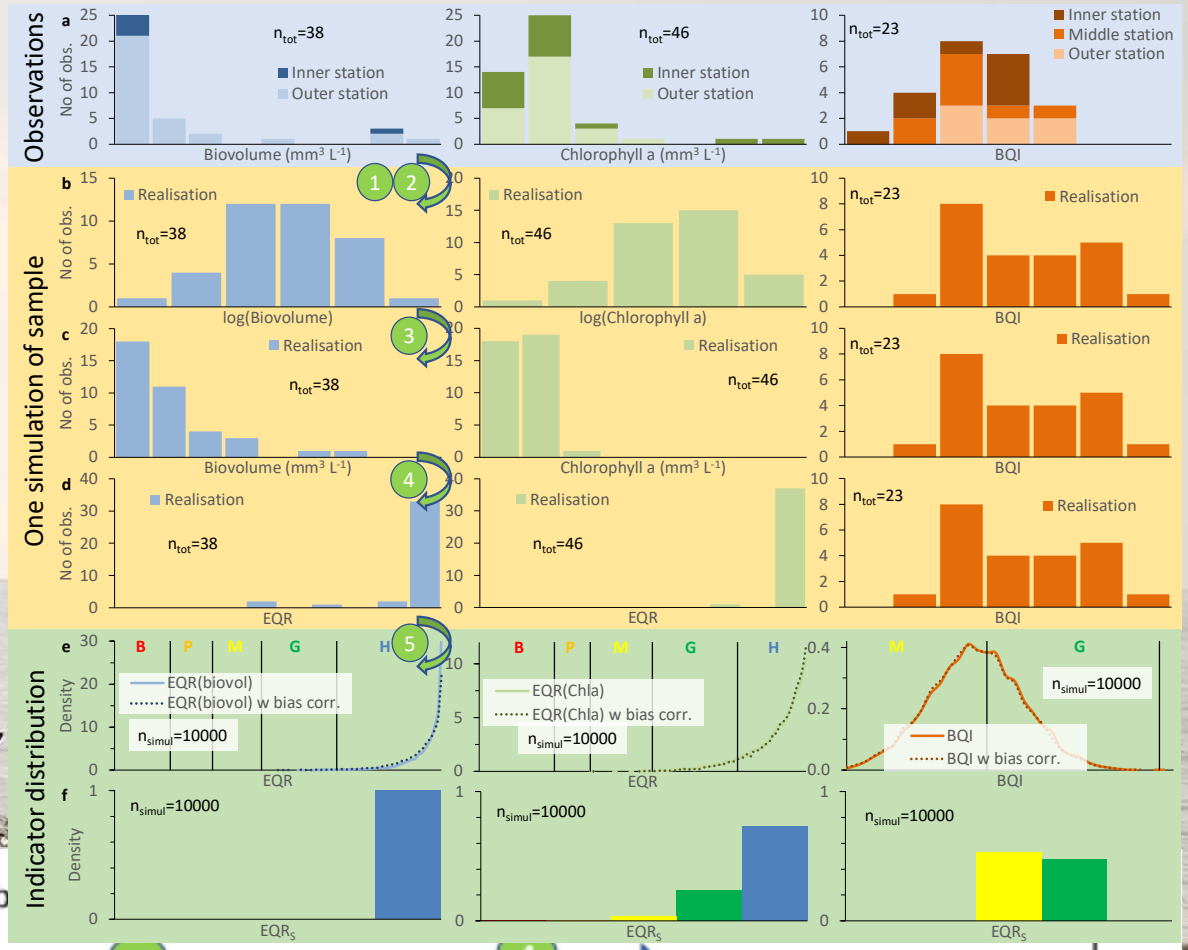


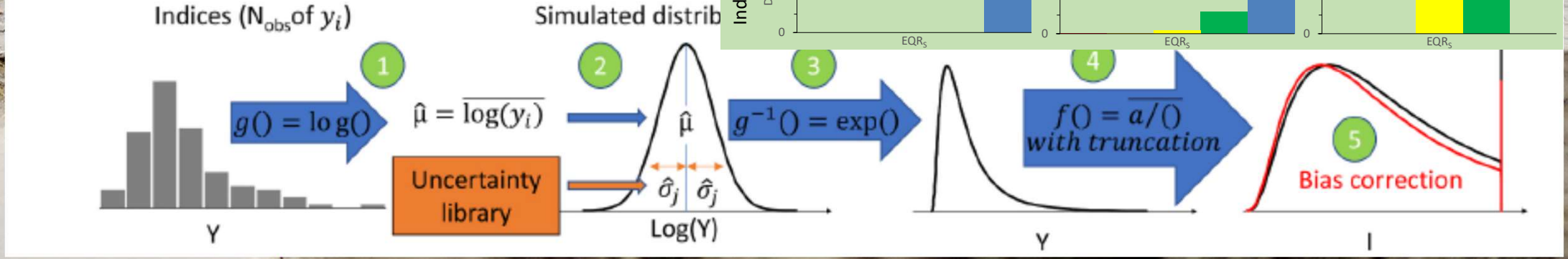




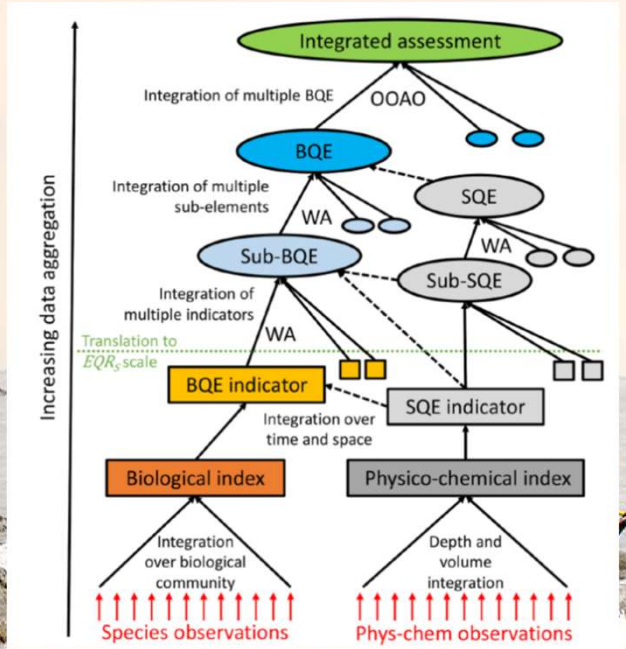
How does it work in practice?

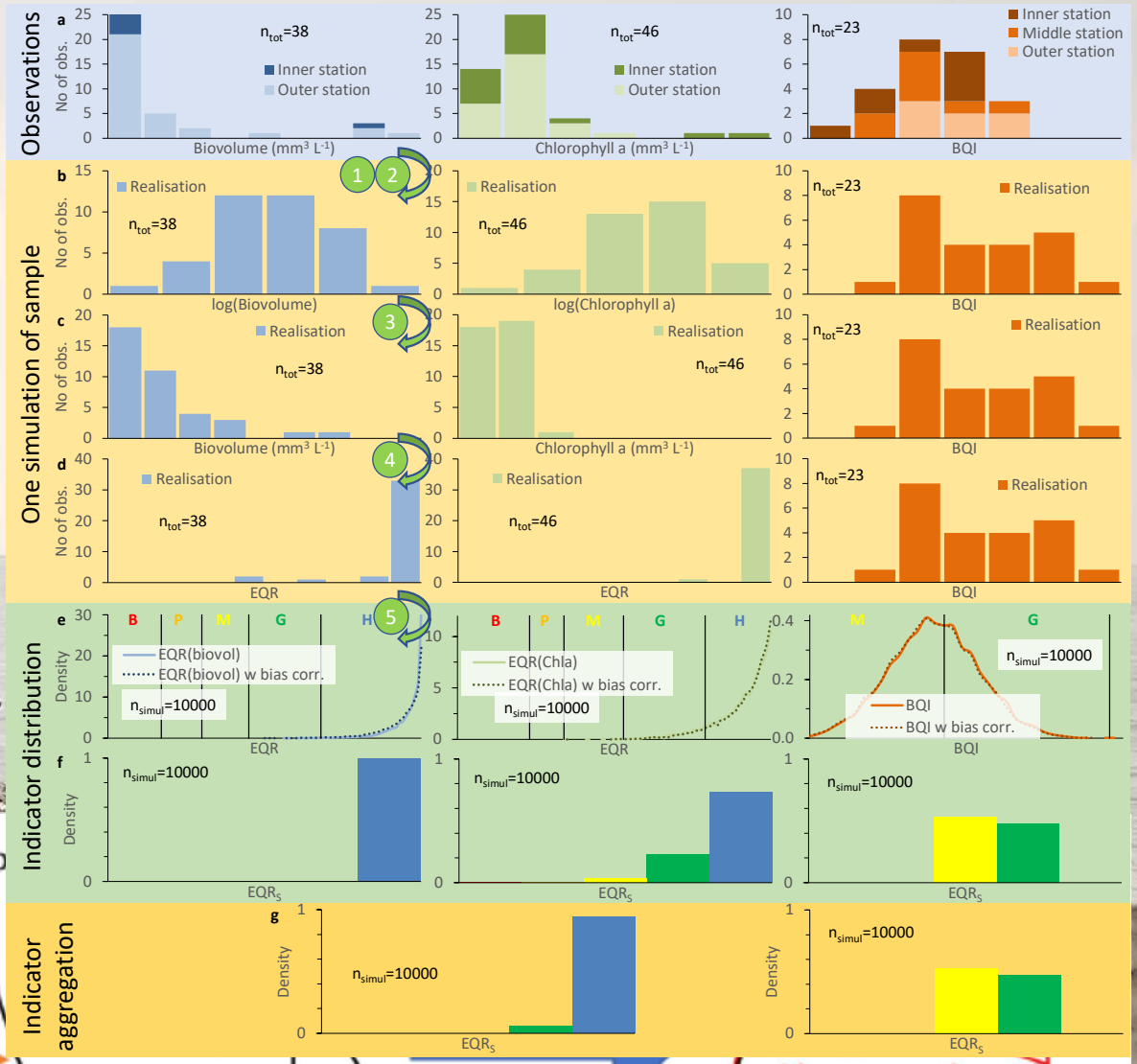


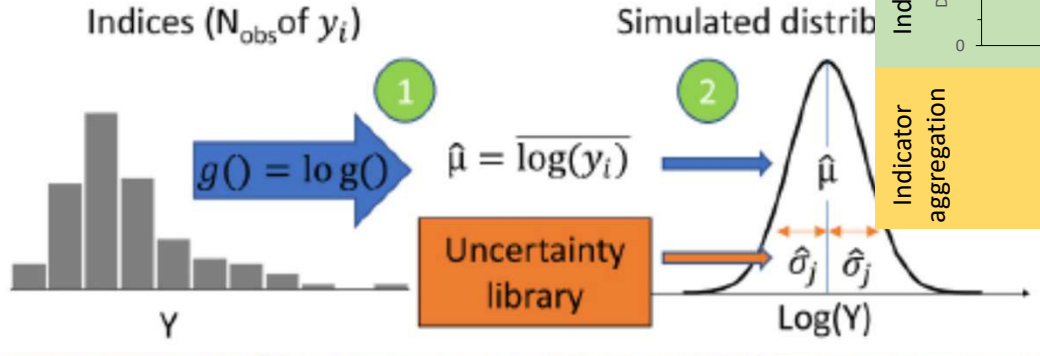


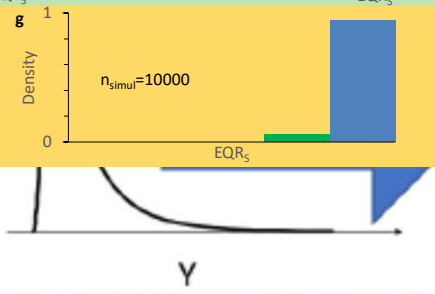


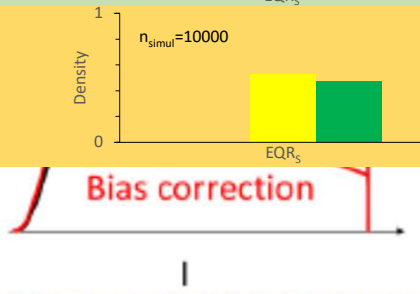
How does it work in practice?



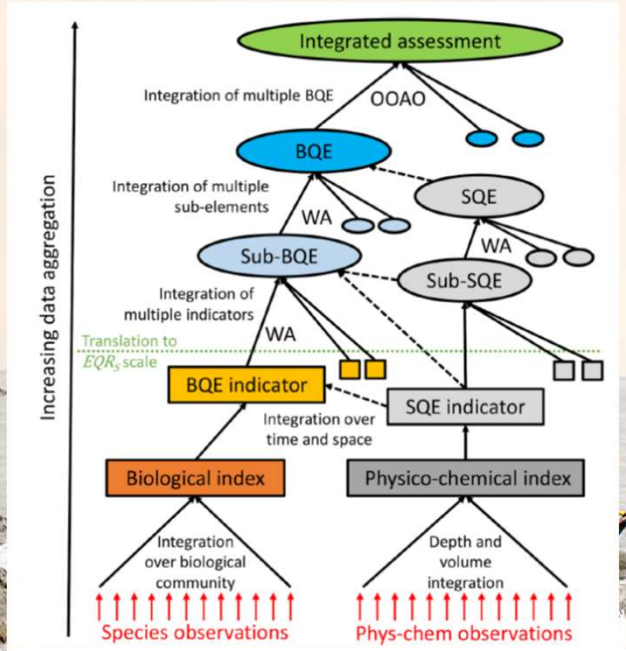


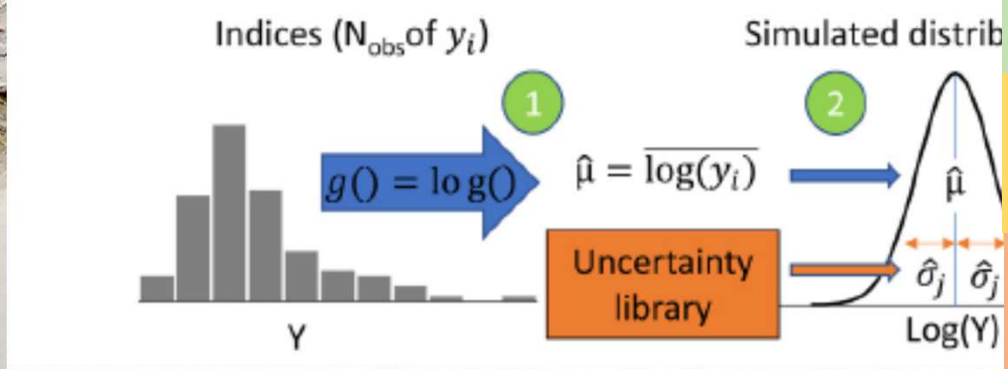


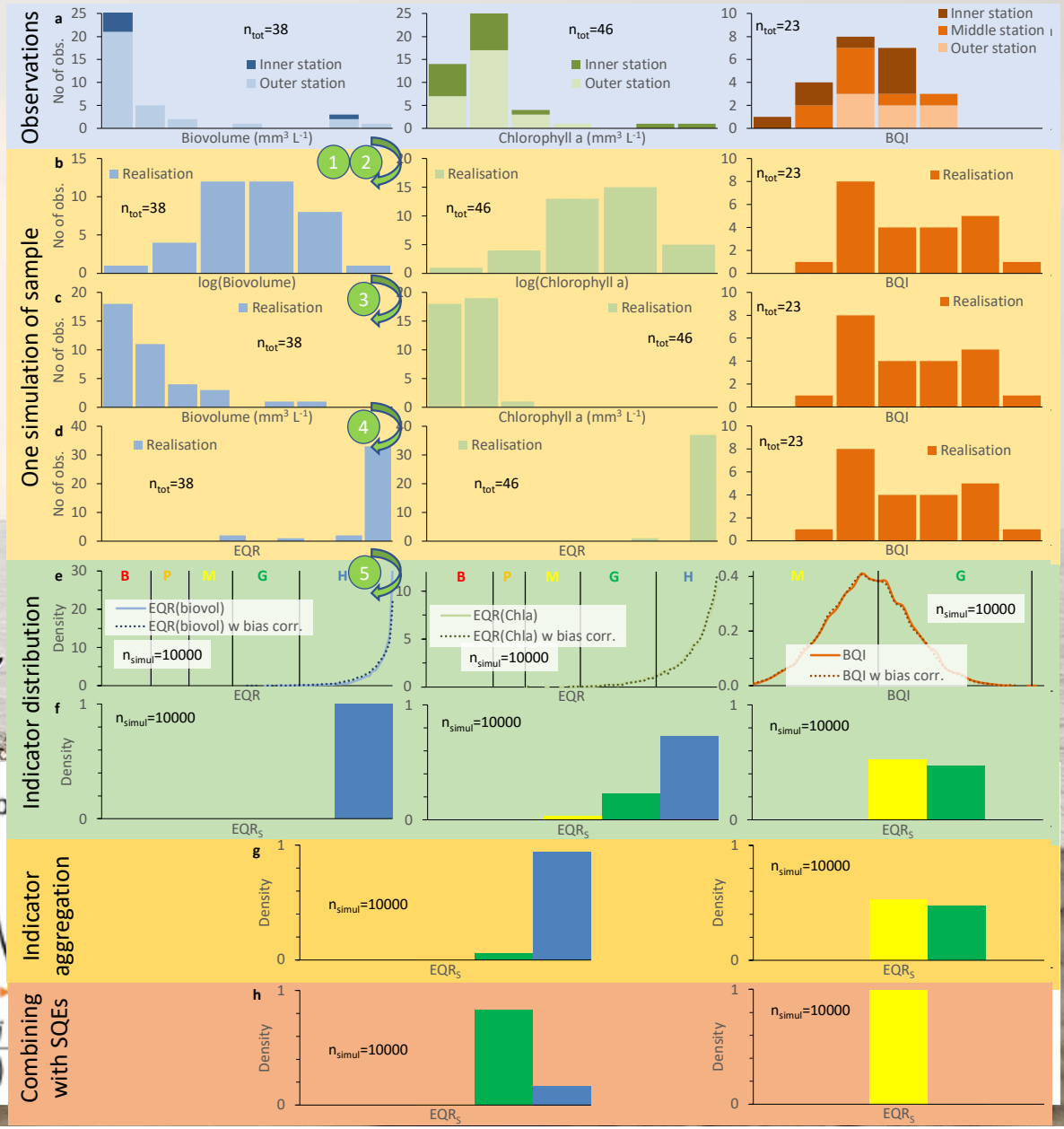




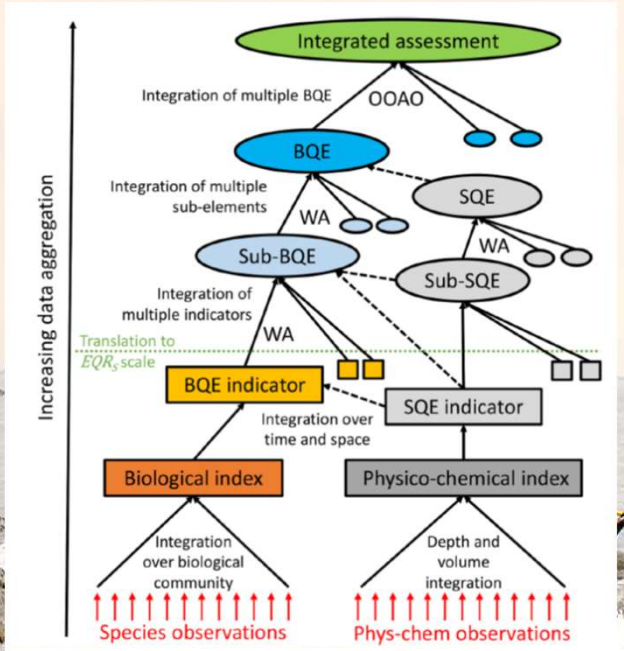
How does it work in practice?

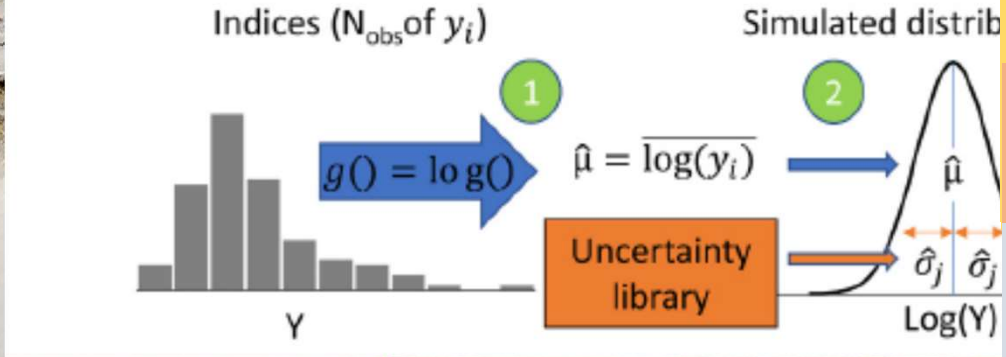


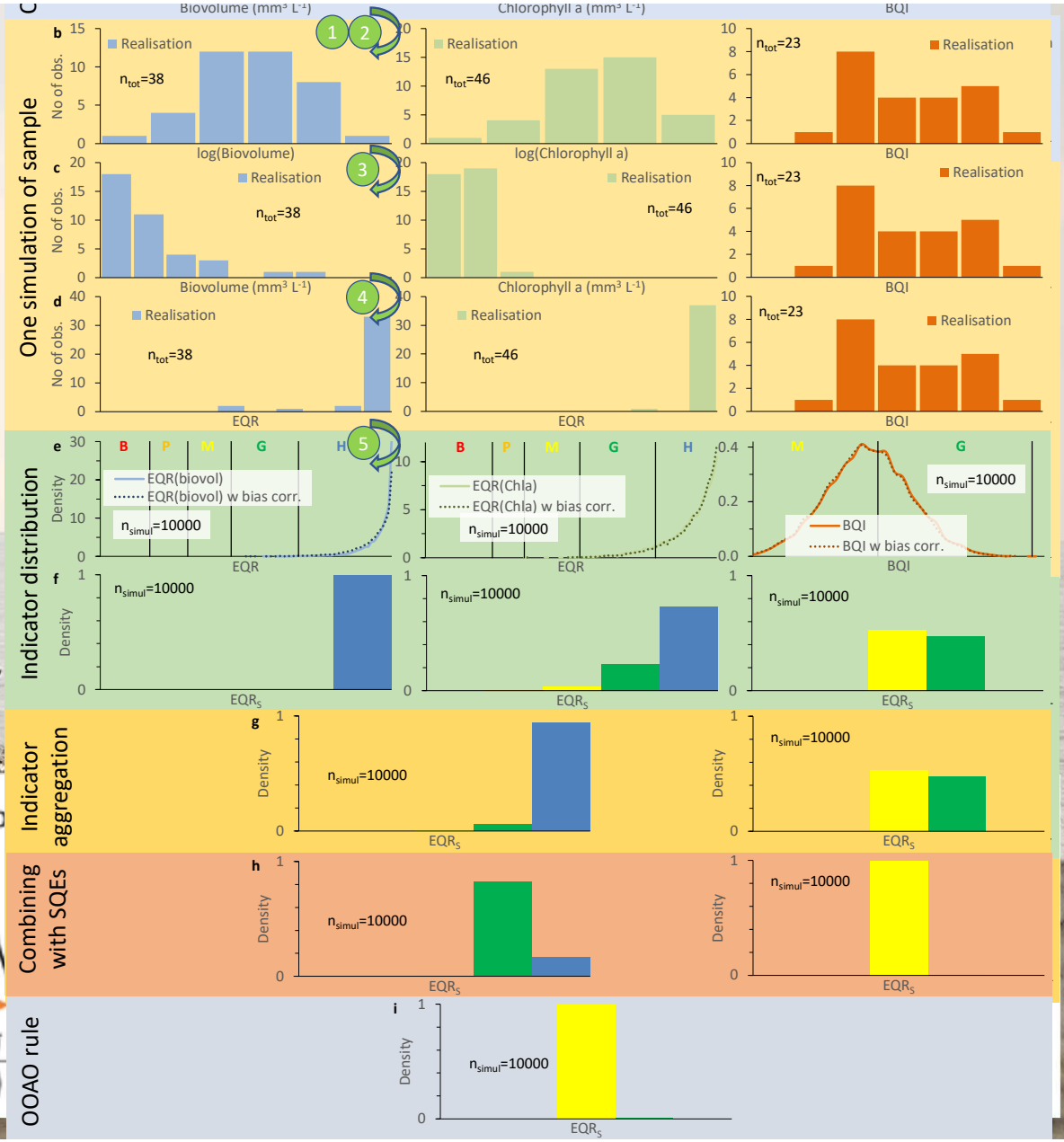




How does it work in practice?







Conclusions

- Integrated assessment systems have developed over time
  - Better integration of metrics
  - Incorporation of a probabilistic uncertainty framework
- Combining diverse indicators can be done through a standardized EQR-transformation
- Integrated assessment should consider indicator distributions (and not just values) to be able to assess the confidence
- Confidence and uncertainty assessment can be parameters through a general uncertainty framework and library
- This framework can handle all possible aggregation schemes through Monte Carlo simulations
- Such frameworks should be developed as web-applications for the user

Ecological Indicators 67 (2016) 306–317

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Confidence in ecological indicators: A framework for quantifying uncertainty components from monitoring data

Jacob Carstensen [a,*], Mats Lindegarth [b]

[a] Department of Bioscience, Aarhus University, Frederiksborgvej 399, DK-4000 Roskilde, Denmark
[b] Department of Biology and Environmental Science, Gothenburg University, SE-45296 Strömstad, Sweden

Ecological Indicators 167 (2024) 112637

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Original Articles

Getting the errors right: The importance of partitioning sources of uncertainty for ecological indicators

Jacob Carstensen [a,*], Ciarán J. Murray [b], Mats Lindegarth [c]

[a] Dept. of Ecoscience, Aarhus University, Frederiksborgvej 399, 4000 Roskilde, Denmark
[b] NIVA-Denmark, Njalsgade 76, 2300 Copenhagen S, Denmark
[c] Dept. of Biology and Environmental Science, Gothenburg University, SE-45296 Strömstad, Sweden

Journal of Environmental Management 344 (2023) 118625

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Mixing apples and oranges: Assessing ecological status and its confidence from multiple and diverse indicators

Jacob Carstensen [a,*], Ciaran Murray [b], Mats Lindegarth [c,d]

[a] Aarhus University, Department of Ecoscience, Frederiksborgvej 399, DK-4000, Roskilde, Denmark
[b] NIVA-Denmark, Njalsgade 76, 2300 København S, Denmark
[c] Gothenburg University, Department of Marine Sciences, Tjärnö Marine Laboratory, S-45296, Strömstad, Sweden
[d] Swedish Institute for the Marine Environment, Box 260, S-40530, Göteborg, Sweden