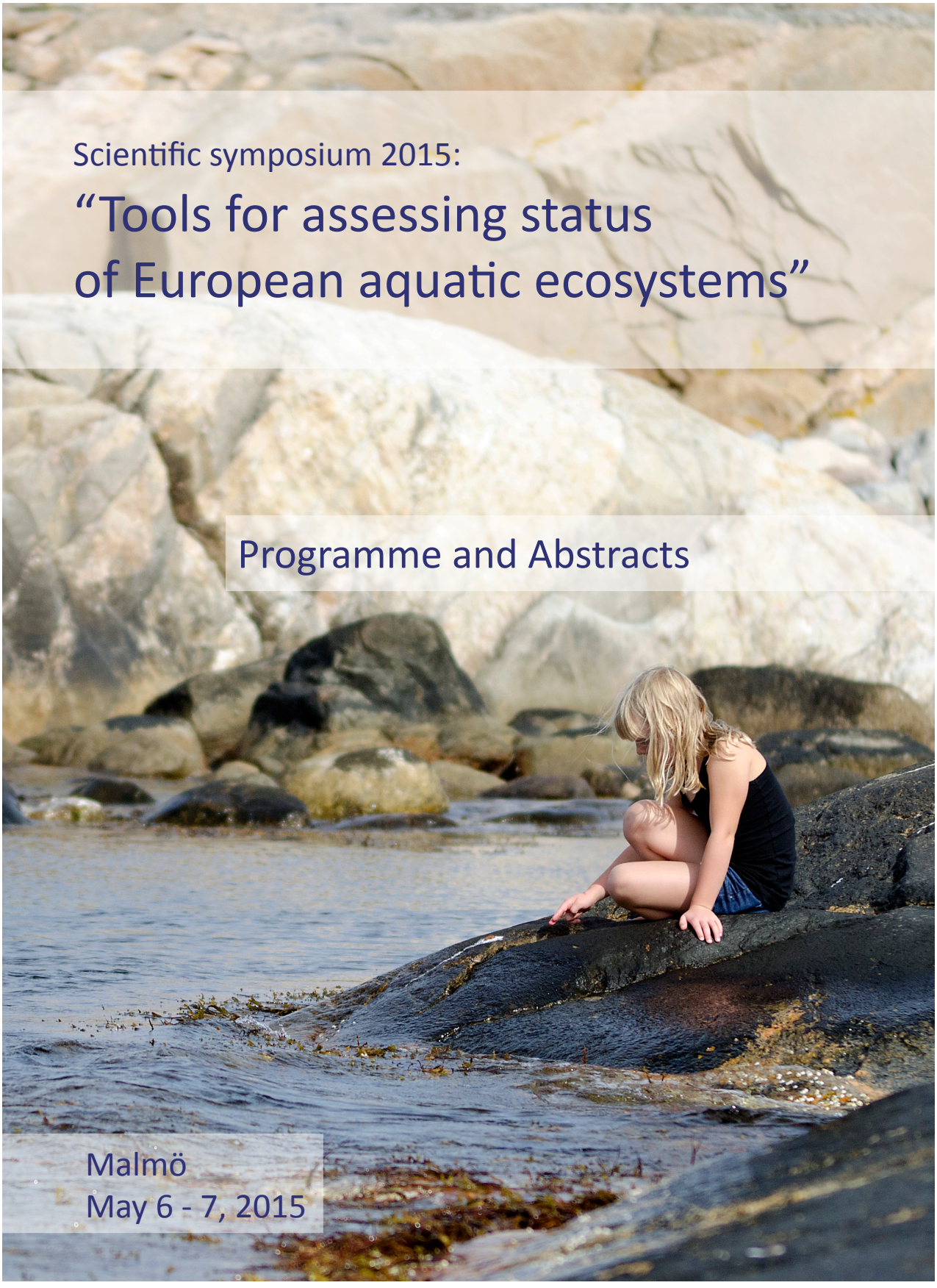
Scientific symposium 2015:

“Tools for assessing status of European aquatic ecosystems”



Programme and Abstracts

Malmö
May 6 - 7, 2015

WATERS

DEVOTES

MARS PROJECT
Managing Aquatic ecosystems and water Resources under multiple Stress

About the organizing projects

WATERS is a five-year research programme that started in spring 2011. It´s objective is to develop and improve the assessment criteria used to classify the status of Swedish coastal and inland waters in accordance with the EC Water Framework Directive (WFD). In focus are the biological quality elements used in WFD water quality assessments: i.e. macrophytes, benthic invertebrates, phytoplankton and fish; in streams, benthic diatoms are also considered. The research programme will also refine the criteria used for integrated assessments of ecological water status.
www.waters.gu.se

DEVOTES is a four-year project that started in 2012. The overall goal of DEVOTES is to better understand the relationships between pressures from human activities and climatic influences and their effects on marine ecosystems, including biological diversity. A major aim of DEVOTES is to test the indicators proposed by the EC for status classification of marine waters, and to develop new ones for assessment at species, habitat and ecosystem levels. The indicators will be integrated into a unified assessment of the biodiversity and cost efficiency. DEVOTES is funded by the 7th Framework Programme of the European Union.
http://www.devotes-project.eu/

MARS is a four-year research project investing how multiple stressors affect rivers, lakes and estuaries. MARS supports the EC Water Framework Directive (WFD) and the Blueprint to Safeguard Europe's Water Resources. Among the objectives are to understand how ecological status and ecosystem services are related – if at all. The project will advice river basin management how to restore multiply stressed rivers and lakes, and to advise the revision of the WFD on new indicators for ecological status and ecosystem services. In addition MARS intends to develop methods and software for the Programmes of Measures. MARS is funded by the 7th Framework Programme of the European Union.
http://www.mars-project.eu/

Tools for Assessing Status of European Aquatic Ecosystems #WDMSS2015

Mounting pressures and deterioration of marine and inland waters has led to a series of new policies and legislation in Europe. As a consequence there is an increased need for reliable methods and tools to assess and manage ecological status in aquatic environments. These developments represent great challenges for the scientific community and as a response several research initiatives have been formed.

WATERS is a research programme funded by the Swedish Environmental Protection Agency and Swedish Agency for Marine and Water Management, which is dedicated to the improvement of assessment criteria for the WFD. Despite its national focus, one important strategy for promoting high-quality research is to stimulate communication and to participate in the lively scientific discussion on the international scene. Prompted by suggestions from our international reference panel, WATERS took the initiative to an international scientific symposium. For a broader perspective we invited two major European projects, DEVOTES and MARS as co-hosts.

The symposium brings together scientists and environmental managers to present and discuss state-of-the-art indicator development and assessment methods for ecological/environmental status of freshwater and marine ecosystems. The main part of the symposium is devoted to in-depth presentations and discussions structured around particular types of indicators and integration. In addition, the invited keynote speakers will present important views on societal needs and future challenges.

It is my firm belief that the symposium can contribute greatly to the important task of improving future ”Tools for Assessing Status of European Aquatic Ecosystems”! I am convinced that we will have fruitful discussions, create links among researchers from Europe’s different corners and that we will all have fun while doing it!

Welcome to the conference!

Mats Lindegarth, coordinator of WATERS
and chairman of the WDMSS scientific committee

Scientific committee

Mats Lindegarth, University of Gothenburg, Sweden (chair) • Torsten Berg, Marilim, Germany • Wendy Bonne, JPI Ocean, Belgium • Angel Borja, AZTI, Spain • Jacob Carstensen, Aarhus University, Denmark • Anna-Stiina Heiskanen, SYKE, Finland • Seppo Hellsten, SYKE, Finland • Daniel Hering, University of Duisburg-Essen, Germany • Richard Johnson, Swedish Agricultural University, Sweden • Anne Lyche Solheim, NIVA, Norway

Programme

Tools for assessing status of European aquatic ecosystems

May 6 - 7, 2015

Hotel Elite Plaza, Malmö, Sweden

- **MAY 6**

Session 1 13.00 – 14.15 Room: Ribban/Pildammen

Societal needs, stakeholder perspectives on status assessment of aquatic ecosystems. Chair: Karl Norling, SwAM

13.00	Opening of the symposium. ***Jonas Svensson, SwAM***
13.10	European Freshwater Ecosystem Assessment: Cross-walk between the Water Framework Directive and Habitats Directive types, status and pressures. ***Anne-Lyche Solheim, EEA***
13.25	Presentation of OSPAR science agenda. ***William Turrell, OSPAR***
13.40	Developing a holistic assessment of ecosystem health in the Baltic Sea. ***Lena Bergström, HELCOM***
13.55	How can research address management needs? ***Panel discussion***

14.15 – 14.30 Short break

Session 2 14.30 – 15.50 Room: Ribban/Pildammen

Overviews of major research programmes in the field (DEVOTES, MARS, MARMONI and WATERS). Chair: Mats Lindegarth, University of Gothenburg

14.30	WATERS: Waterbody Assessment Tools for Ecological Reference conditions and status in Sweden. ***Mats Lindegarth, WATERS***
14.45	Development of innovative tools for understanding marine biodiversity and assessing good environmental status: the progress of the EU project DEVOTES. ***Angel Borja, DEVOTES***
15.00	Managing multiple stress for multiple benefits: Towards new scientific concepts, methods and tools in river basin management. ***Anne-Lyche Solheim, MARS***
15.15	The MARMONI indicator based assessment approach. ***Martin Isaeus, MARMONI***
15.30	Common developments, complementarity and synergies among projects. ***Panel discussion***

15.50 – 16.20 Coffee break

Session 3 16.20 – 18.20

	Room Gripen **Benthic Indicators** Chair: Rutger Rosenberg	Room Möllan **Plankton indicators** Chair: Anne Lyche Solheim	Room Ribban/Pildammen **Overall assessment** Chair: Richard Johnson
16.20	A B Josefson (1)	J Walve (7)	C Murray (13)
16.40	A Tengberg (2)	P Kauppila (8)	S Strāķe (14)
17.00	M Chuševė (3)	J Paczkowska (9)	M Søndergaard(15)
17.20	M Blomqvist (4)	B Karlson (10)	A Grimvall (16)
17.40	M Pantazi (5)	S Drakare (11)	J Aroviita (17)
18.00	A Borja (6)	J Carstensen (12)	

- **MAY 7**

Session 4 8.30 – 10.10

	Room Gripen **Pressures and ecosystem responses** Chair: Richard Johnson	Room Ribban **Plankton and microalgal indicators** Chair: Jacob Carstensen	Room Pildammen **Overall assessment** Chair: Angel Borja
08.30	H Gundersen (18)**	M Kahlert (23)	A Pavlidou (28)
08.50	B McKie (19)	S Drakare (24)	G Phillips (29)
09.10	A Truchy (20)	T Harvey (25)	J-A Pitt (30)
09.30	V Milun (21)	H Höglander (26)	S Olenin (31)
09.50	J Andersen (22)	J Walve (27)	

10.10-10.40 Coffee break

Session 5 10.40 – 12.20

	Room Gripen **Pressures and ecosystem responses** Chair: Richard Johnson	Room Ribban **Fish indicators** Chair: Mike Elliott	Room Pildammen **Vegetation indicators** Chair: Seppo Hellsten
10.40	K Kalpus (32)	L Bergström (37)	F Ecke (41)
11.00	C Wynne (33)	M Karlsson (38)	A Šiaulys (42)
11.20	C Almeida (34)	K Holmgren (39)	M Bucas (43)
11.40	R Johnson (35)	S Poikane (40)	D Krause-Jensen (44)
12.00	JW Hansen (36)		S Wikström (45)

12.20-13.20 Lunch

Session 6 13.20 – 14.40 Room: Ribban/Pildammen

General issues on integrated assessment. Chair: Mats Lindegarth, University of Gothenburg

13.20 Ecosystem status and indicators: the way it can, should and will work! ***Gert Van Hoey***
13.40 Imperfect information: Status classification in a world of uncertainty ***Jacob Carstensen***
14.00 Overcoming the challenges of indicator integration and arriving at a full-bodied classification of Good Environmental Status sensu the MSFD. ***Jesper Andersen***
14.20 Questions and discussion of assessment systems ***Panel discussion***

14.40 – 15.10 Coffee break

Session 7 15.10 – 16.30 Room: Ribban/Pildammen

Future challenges and closing of the meeting. Chair: Angel Borja

15.10 Management implications of global change impacts on stream ecosystems. ***Piet Verdonschot***
15.40 The consequences of global climate change for complying with MSFD Indicators. ***Mike Elliott***
16.10 Conclusions. ***Panel discussion.***
– 16.30

* Presenting author if not first author
** Benthic Indicators

Session 1 13.00 - 14.45 Room: Ribban/Pildammen

European Freshwater Ecosystem Assessment: Cross-walk between the Water Framework Directive and Habitats Directive types, status and pressures

Anne Lyche-Solheim[1], Jonas Persson[1], Kari Austnes[1], Jannicke Moe[1], Eleftheria Kampa[2], Ulf Stein[2], Janos Feher, Sandra Poikane[3], Peter Kristensen[4]

[1]Norwegian Institute for Water Research (NIVA), Gaustadalléen 21, 0349 Oslo, Norway, [2]Ecologic, Pfalzburger Strasse 43/44, 10717 Berlin, Germany, [3]European Commission, Joint Research Centre, Institute for Environment and Sustainability, via E. Fermi 2749, Ispra, VA I-21027 Italy, [4]European Environment Agency (EEA), Kongens Nytorv, Copenhagen, Denmark

The objective of this study, requested by EEA, has been to explore the possibilities of linking the Water Framework Directive (WFD) and Habitats Directive (HD) information on types of water bodies and freshwater habitats, and their status, pressures and measures. The data sources have been WFD data reported by EU Members States and HD information on habitat types, conservation status and threats. Although the aims of the two directives are closely related, their types and status assessments are not directly comparable. The first step to explore these links was therefore to develop a set of broad types as a common denominator for the WFD national types, common intercalibration types and the HD and EUNIS freshwater types. The key result was that many of the 2300 reported national WFD types have high similarity and could be aggregated into 20 broad river types and 15 broad lake types based on altitude, size and geology (and mean depth for lakes). These broad types include ca. 75% of all river and lake water bodies in Europe. For lakes, we found a good match between these WFD broad types, the WFD common intercalibration types and most of the HD standing water habitat types, as well as the EUNIS types. For rivers, the match was best for Alpine and Mediterranean types and less good for other types, probably due to two very wide HD river habitats: the HD type 3260 rivers from plain to montane levels, and 3210 Fennoscandian rivers. WFD data on ecological status and pressures aggregated into these broad types show that the status is best in highland and mid-altitude areas with siliceous geology and worst in lowland areas with calcareous geology, consistent with the different pressure intensities. These differences are further supported by aggregating WFD water bodies into HD biogeographic regions, showing that water bodies in the Alpine and Boreal areas of Europe are in better status and have less pressures than those in other parts of Europe.
We also compared WFD ecological status in water bodies connected to the HD Natura2000 sites with the status of all water bodies, and found the status to be generally better in water bodies associated with Natura 2000 sites than for all water bodies.
HD Conservation status was also found to roughly correspond to WFD ecological status for comparable types/habitats in selected countries. WFD pressures were also corresponding reasonably well with the HD threats. Multiple benefit measures for water management and nature protection include removal of fish
migration barriers and restoration of floodplains and riparian zones. In conclusion, the assessments of freshwater status and pressures reported under the WFD are mostly consistent with assessments of conservation status and threats reported under the Habitats Directive. Inconsistencies and mismatches are due to non-co parable types/habitats and/or to non-comparable assessment systems.
The results are used as input to the EEA Freshwater Ecosystem Assessment in 2015, and also for future European assessments of specific objectives, status and trends for various types of rivers and lakes after the reporting of the WFD 2nd RBMPs and the next HD article 17 reporting. The outcome may also be used to discuss the potential for WFD and HD synergies in terms of monitoring, assessment and measures to improve status.

The OSPAR Science Agenda

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The OSPAR Convention 1992 recognises that the work of the OSPAR Commission needs to be science-based, and the OSPAR Commission recognises that this science-base needs to be sourced from both within the OSPAR Contracting Parties and from wider international sources. The Quality Status Report (QSR) process repeatedly run by OSPAR regularly identifies knowledge gaps, but coordinated action to actively address these gaps has been lacking. Since 2012, the OSPAR Science Agenda (OSA) Task Group aims to provide the science base OSPAR needs to carry out its future work, and to fill the identified knowledge gaps in a coordinated way, involving all Committees and working groups under OSPAR. The OSA lists the principle current knowledge gaps under the themes of the OSPAR Joint Assessment and Monitoring Programme (JAMP), i.e. A. Ecosystem approach and cross-cutting issues; B. Biodiversity and ecosystems; E.

Eutrophication; H. Hazardous substances; O. Oil and gas industry and R. Radioactive substances. Current knowledge gaps constantly change through time, and hence the OSA is a "living document" and is regularly updated. Although structured around the themes of the JAMP, the OSA has received increased focus from a consideration of the science needed to deliver the European Union Marine Strategy Framework Directive.

The OSA is used to help OSPAR communicate with science providers as well as science funders. It has helped establish a framework for continuing and strengthening the partnership that OSPAR has with organisations such as ICES. It is hoped that the OSA can provide a basis for the coordination of national and international research programmes.
Although the OSA was published in 2014, it has yet to generate the cross-cutting internationally coordinated projects that the OSPAR OSA Task Group hoped would be stimulated by the OSA. The EU funded "Joint Monitoring Programme for the North Sea / Celtic Sea" was possibly the first such international programme informed by the OSA. Funding agencies, multi-national bidding consortia, and national research programmes are asked to consider the OSA when formulating future projects so that the science needs of OSPAR can be addressed alongside other associated requirements.

Developing a holistic assessment of ecosystem health in the Baltic Sea

Lena Bergström and Ulla Li Zweifel*

HELCOM (Baltic Sea Environment Protection Commission), Katajanokanlaituri 6B, FI-00160 Helsinki, Finland

The HELCOM project for the second holistic assessment of ecosystem health in the Baltic Sea started in late 2014 and will continue until June 2018. The assessment will give an update of the overall environmental status of the Baltic Sea and evaluate progress in relation to the goals of the Baltic Sea Action Plan. It will be developed so that it can also be used in the reporting under the EU Marine Strategy Framework Directive. This is achieved by development of joint HELCOM tools and concepts. The assessment will be focusing on the regional scale, but performed in such a way that the results can also be used in national assessments of marine and coastal areas.
The work of the project is guided by a core team with representation from the Contracting Parties to the Helsinki Convention i.e. the nine countries bordering the Baltic Sea and the European Union. The planned assessment is structured around the DPSIR framework. The assessment is set to cover all aspects within this cycle, with a focus on assessing pressures, status, and social and economic impacts. The main pressures addressed are related to inputs of nutrient loading and hazardous substances, fisheries and maritime activities. Marine litter, underwater noise and non-indigenous species are also considered. Status of the environment is based on key elements of biodiversity, focusing on marine mammals, fish, birds, the seafloor, and the pelagic habitat. The assessment of impacts is carried out by environmental economic analyses to assess the cost of degradation, and addresses ways of optimizing the probability of success for different management measures to improve environmental status. The assessments will build on a regional set of indicators, developed jointly by HELCOM, and by ICES for commercial fish stocks. The methods and tools applied will be developed during the course of the project.

Session 2 14.30 - 15.50 Room: Ribban/Pildammen

Waterbody Assessment Tools for Ecological Reference conditions and status in Sweden (WATERS): challenges, aims and achievements

Mats Lindegarth

Swedish Institute for the Marine Environment, University of Gothenburg

The Water Framework Directive (WFD) is the fundament for achieving good ecological status and prevent deterioration of European inland and coastal waters. Monitoring and assessment of biological quality elements (BQEs) are primary components for determining ecological status according to the directive. During the Swedish implementation of the WFD, a number of problems were encountered. This spawned ideas about a national research programme targeting specific insufficiencies in overall assessment routines and for individual BQEs.
WATERS is a five-year research programme that started in spring 2011. It is funded by the Swedish Environmental Protection Agency (SEPA) and Swedish Agency for Marine and Water Management (SwAM) and involves ten partners from Sweden and Denmark. Its overall aims are to develop and improve the assessment criteria that are used to classify the status of Swedish coastal and inland waters in accordance with the WFD. Specific objectives are to achieve (1) more reliable and sensitive indicators, (2) improved and more harmonised strategies for defining reference conditions, class boundaries and assessment of uncertainty and (3) a coherent framework for whole-system assessment. WATERS is organised into three scientific focus areas dealing with integrated assessment , coastal waters and inland waters.
The over-arching work on general integrated assessment suggests that definitions and incorporation of pressure criteria and the use of typologies are strongly divergent between coastal and inland waters, but that modelling is and

can be used successfully to remove variability due to natural processes within waterbody types. A coherent framework for quantifying and reducing uncertainty in estimation and classification has been developed and tested. The framework is based on partitioning of variance into spatial, temporal, methodological and interactive components and can be used in combination with fixed factors that can remove predictable variability.
A general strategy in coastal and inland WATERS has been to perform synoptic studies of all BQEs in defined pressure gradients in coastal areas, lakes and streams. This has allowed quantification and validation of dose-response relationships and comparison of responses among indicators in natural environments. Additionally coastal waters has reviewed and selected candidates for new indicators, quantified responses to natural and anthropogenic pressure gradients using monitoring data, and modified existing indicators to increase sensitivity and reduce uncertainty. Inland WATERS has refined the pressure-filter approach, developed extensive databases on all BQEs and evaluated sampling methods for various BQEs.
WATERS involves extensive end-user contacts with regular meetings and workshops with authorities responsible for implementing and using national assessment criteria for the WFD, monitoring and (e.g. SwAM, SEPA and River Basin District Authorities). In order to maximise the benefits of the programme, WATERS and its individual partners are also working towards harmonisation with other important policy developments nationally and internationally.

Development of innovative tools for understanding marine biodiversity and assessing good environmental status: the progress of the EU project DEVOTES

Ángel Borja
AZTI; Marine Research Division, Herrera Kaia, Portualdea s/n, 20100 Pasaia, Spain

The Marine Strategy Framework Directive (MSFD) was The Marine Strategy Framework Directive (MSFD) was issued for "establishing a framework for community action in the field of marine environmental policy". The MSFD requires Member States to take the necessary measures to achieve or maintain Good Environmental Status (GES) in the marine environment, by the year 2020 at the latest.
To assess GES, the MSFD requires the study of 11 descriptors, of which biological diversity is the first. GES is defined as regarding the structure, functioning and processes of marine ecosystems, together with natural physiographic, geographic and climatic factors, and physical and chemical conditions including those derived from human activities. However, it is recognised that the dynamic interactions of human activities within ecosystems, which also are undergoing climate-driven changes, still are only partly understood. Biodiversity is one of the key factors which support ecosystem resilience and the sustainable provisioning of goods and services, which in turn contribute to the performance of economic systems and human well-being. Many indicators of biodiversity exist, most are mutually complementary, and representing different aspects of the multidimensional concept of biodiversity. However, to be informative at a societal level, biodiversity indicators need to be combined within integrated monitoring, modeling and decision making frameworks. Indicators of biodiversity should be used to translate biodiversity loss and degradation directly into policy responses.
The overall goal of DEVOTES is to better understand the relationships between pressures from human activities and climatic influences and their effects on marine ecosystems, including biological diversity, in order to support the ecosystem based management and fully achieve GES of marine waters. Hence, the following five key objectives for DEVOTES have been established, in a harmonized way for the 4 Regional Seas:
(i) Improve our understanding of the impact of human activities (cumulative, synergistic, antagonistic) and climate change on marine biodiversity, using long-term biodiversity and human pressures data, both in pelagic and benthic environments. This will identify the barriers and bottlenecks (socioeconomic and legislative) that prevent GES from being achieved.
(ii) Test the relevant indicators listed by EC, and develop new, innovative ones to assess biodiversity at several ecological scales (species, habitats, ecosystems), including functional diversity, metagenomic and metagenetic analyses and approaches; test the relevant level of integration of the indicators to produce a holistic assessment of biodiversity.
(iii) Develop, test and validate innovative integrative modelling (e.g. statistical, conceptual) and monitoring tools to further improve our understanding of ecosystem and biodiversity changes in space and time, applying both traditional sampling and autonomous data acquisition devices. We will propose and demonstrate the pros and cons of innovative monitoring systems capable of efficiently and effectively providing data for many biodiversity parameters, to be used as indicators of GES, and, finally, for integration into a unique and holistic assessment.
(iv) Implement cost-effective indicators, monitoring and assessment strategies, which will serve as operational tools for managers and policy makers, with a view to reduce pressures through actions.
(v) Propose and disseminate strategies and measures for ecosystems' adaptive management. These strategies will include the active role of industry and relevant stakeholders and an economic assessment of the consequences of the management practices proposed by DEVOTES.
This contribution will present the progress made by DEVOTES project.

Managing multiple stress for multiple benefits: Towards new scientific concepts, methods and tools in river basin management

Anne Lyche-Solheim[1], Sebastian Birk[2], Daniel Hering[2]
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[2]*Department of Aquatic Ecology, University of Duisburg-Essen, Essen, Germany*

Water resources globally are affected by a complex mixture of stressors resulting from a range of drivers, including urban and agricultural land use, hydropower generation and climate change. Understanding how stressors interfere and impact upon ecological status and ecosystem services is essential for developing effective River Basin Management Plans and shaping future environmental policy. This contribution details the nature of these problems for Europe's water resources and the need to find solutions at a range of spatial scales. In terms of the latter, we describe the aims and approaches of the EU-funded project MARS (Managing Aquatic ecosystems and water Resources under multiple Stress) and the conceptual and analytical framework that it is adopting to provide this knowledge, understanding and tools needed to address multiple stressors. MARS is operating at three scales: At the water body scale, the mechanistic understanding of stressor interactions and their impact upon water resources, ecological status and ecosystem services is examined through multi-factorial experiments and the analysis of long time-series. At the river basin scale, modelling and empirical approaches is adopted to characterise relationships between multiple stressors and ecological responses, functions, services and water resources. The effects of future land use and mitigation scenarios in 16 European river basins is assessed. At the European scale, large-scale spatial analysis is carried out to identify the relationships among stress intensity, ecological status and service provision, with a special focus on large transboundary rivers, lakes and fish. The project supports managers and policy makers in the practical implementation of the Water Framework Directive (WFD), of related legislation and of the Blueprint to Safeguard Europe's Water Resources by advising the 3rd River Basin Management Planning cycle, the revision of the WFD and by developing new tools for diagnosing and predicting multiple stressors.

The MARMONI indicator based assessment approach

Martin Isaeus
AquaBiota, Swedish coordinator of MARMONI

In the project Innovative approaches for marine biodiversity monitoring and assessment of conservation status of nature values in the Baltic Sea (MARMONI) we have developed a large number of indicators on marine biodiversity. The indicators are tested in the field and useful for the MSFD. A tool for indicator-based assessment biodiversity status was produced. The tool follows the hierarchical approach of MSFD, and is accessible for anyone to use. As a test and demonstration biodiversity status assessment was performed in each of the four pilot areas. As a comparison an assessment of favorable conservation status was also performed for each area.

Session 3 16.20-18.20 Rooms: Gripen, Möllan, Ribban/Pildammen

Gripen

Long term trends in alpha diversity of benthic macro-invertebrates in the Kattegat are influenced by differences in reproductive traits

Alf B Josefson[1] and Mats Blomqvist[2]
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Differences in reproductive traits may be a key factor influencing dispersal and consequently spatial and temporal dynamics of community assembly in natural ecological communities at several spatial scales. One measure of assembly often used in assessments of environmental quality in marine benthic communities is species richness (alpha diversity) at the sample scale. While some spatial studies inmarine environments have indicated great importance of differences in reproductive traits, translated into differences in dispersivity, in coastal environments, there are few, if any, that have investigated eventual effects of dispersive trait differences on long term trends in alpha diversity. In this study we examine importance of reproductive trait identity for long-term (15-40 years) dynamics of alpha diversity and abundance on the sample scale, based on Swedish and Danish surveillance data from some 40 sites scattered over the Kattegat, a sea area covering ca 20 000 km2. We demonstrate clear, large scale, trends in alpha diversity over the past 15 – 40 years. These trends differ between the reproductive traits planktotrophic development, direct benthic development and a trait group dominated by species with some pelagic stage and lecithotrophic larvae development. Spatially, there were also different trends above and below 25 m depth. In the deeper parts there was an overall decrease in alpha diversity and

abundance since the 1990s and a major part of this decrease was due to a dramatic decrease of species with direct benthic development, a decrease > 80% of both alpha and abundance over the last 15 years. In contrast, planktotrophic species showed only a 20 % decrease of alpha and no change at all in abundance over the same time period. In the shallower stratum the decreases, although also mostly significant, were less pronounced. The observation that the long-term decreases were directional and gradual and occurred on a large scale could indicate importance of changes in climate factors and/or productivity. However, several different hypotheses are discussed including recent oligotrophication and impacts of fishery activities.

Oeresund marine environment in change: are major ecosystem changes reflected in the Benthic Quality Index?

*Peter Göransson[1], Olle Nordell[2], Anders Tengberg[3]**

[1]*Municipality of Helsingborg,* [2]*Municipality of Landskrona,*[3]*University of Gothenburg* 2

Since about 20 years an elaborate marine monitoring program has been in operation in the Oeresund straight (between Sweden and Denmark). It includes: bottom fauna sampling (two times per year), sediment chemistry including pollutants, persistent toxins in mussels and run-off from land. Starting in 2005 multi-parameter instruments have been installed to measure hydrographic changes at hourly intervals. In general results from the project shows that eutrophication and persistent toxic substances have decreased in the environment while benthic fauna has been impoverished. The program has also been successful in finding and stopping polluting point sources. Results will be presented and discussed with focus on the recent disappearance of haploops from the area and how this is reflected in the Benthic Quality Index.

Validation of benthic quality index and setting boundaries of quality classes for the open coastal waters of the eastern Baltic

Romualda Chuševė[1], Henrik Nygård, Diana Vaičiūtė, Darius Daunys, Anastasija Zaiko

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Benthic Quality Index (BQI) is a multimetric index based on benthic macrofauna species richness, species abundance and species sensitivities, and used for status assessment of marine waters (Rosenberg et al. 2004; Fleischer and Zettler, 2009; Leonardson et al. 2009). Although its suitability for different environments fundamentally depends on reliability of species sensitivity values (Zettler et al. 2007), validation against pressures and availability of well justified quality class boundaries are crucial for its application.

In this study, a long-term (1984-2012) benthic macrofauna dataset covering Lithuanian coastal monitoring sites (depths from 7 to 20 m, sampled and samples processed according to the standard HELCOM recommendations) was used for calculation of species sensitivity values (ES50-0.05) following Leonardsson et al. (2009). Quality class boundaries were identified using distribution of relative abundance of four species sensitivity groups along the gradient of BQI values. Index values were validated using surface water chlorophyll-a concentrations (2005-2011) retrieved from MEdium Resolution Imaging Spectrometer (MERIS) for macrofauna sampling sites s and applying one year lag relationships. The regression analysis revealed statistical significant correlation between BQI values and chl-a concentrations ($r=-0.86$; $R2=74\%$, $p< 0.05$).

Signal Detection Theory (SDT) was applied to evaluate the specificity and sensitivity of the BQI, its response to the total nitrogen, total phosphorus and chlorophyll-a concentrations at at the boundary of good environmental status (GES). The BQI showed acceptable response to all three eutrophication parameters and results suggested suitability of SDT for setting GES thresholds in a standardized way.

Reducing uncertainty in benthic assessment with the Benthic Quality Index, BQI

Kjell Leonardsson[1], Mats Blomqvist[2], Marina Magnusson[3] and Rutger Rosenberg[3, 4]*

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The Benthic Quality Index, BQI, is widely used (Rosenberg et al. 2004, cited 306 times up to February 2015) for benthic quality assessment. In this presentation we suggest improvements for the use of BQI as presented earlier by Rosenberg et al. 2004 and Leonardsson et al. 2009. Here with the Swedish west coast as an example.

First, we have evaluated the species sensitivity values used in the BQI and suggest replacing the former ES50-value with richness in order to reduce misclassifications due to occasional strong dominance of some recruiting species in single samples. Further we have evaluated the effect of uncertainty and accuracy in the sensitivity values on the final BQI values.

Secondly, we have statistically evaluated the effects of

salinity, sediment structure and depth on the uncertainty of BQI using regression approaches based on data from "unimpacted" stations. All variables had an influence on the uncertainty of BQI but were also correlated with each other. The regression model with depth as the only independent variable showed the best fit. The residuals from this model showed no meaningful relationship to salinity or sediment structure and accordingly these factors were excluded in the regression model.
We suggest using the residuals from the regression model as the indicator. Instead of having different boundary values for different depth ranges, or rather salinity regimes, it is now possible to use one common boundary value for all depths. Since the residuals from the unimpacted stations were homogenous and normally distributed we suggest using the 0.05 quantile as the boundary between good and moderate status according to the EU Water Framework Directive. This choice is based on the management perspective that the unimpacted stations represent conditions where measures to improve the benthic environmental conditions were unnecessary.

Evaluation of four existing benthic indices in Spain & Greece using Signal Detection Theory

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Benthic indices have long been used due to their ability to evaluate the ecosystems' biological integrity, by representing the macro-benthic community structure (Díaz et al., 2004). The fluctuations of an index's performance, when it is used in a different geographic area other than where it was developed, can be proved helpful for environmental managers by assisting them to decide about a rational threshold between good and not good status, guided by probabilities. Signal Detection Theory (SDT) is a rigorous method based on which the performance of different ecological indices can be evaluated (Murtaugh, 1996).
In the present study four community-based benthic indices (AMBI, Bentix, M-AMBI and multimetric Bentix) were selected in order to evaluate their performance in two different study areas and Regional Seas (Mompás-Pasaia Coastal Water Body in Spain- Bay of Biscay –Atlantic Ocean) and Saronikos gulf in Greece –Mediterranean Sea) under urban wastewater discharge pressure. The performance was determined as change in the state of sediment redox potential and organic matter content, in the Bay of Biscay, and total organic carbon in Saronikos Gulf (these are considered as 'gold standards'). These indices are considered to be ecosystem relevant since they are used to measure the evolution of the ecological status of a particular region and therefore detect the impact of anthropogenic pressures in these environments, thus constituting them a solid management tool. This study was carried out in order to assess the performance of benthic indicators for the Marine Strategy Framework Directive implementation.
SDT was implemented in order to calculate the sensitivity and specificity (Hale and Heltshe, 2008) of each of the indices in the two study areas. ROC (Receiver Operating Characteristic) curves were plotted and the area under the curve (AUC) was calculated for each of the indices, in order to assess their discriminating ability in respect to the haphazard discrimination. Positive predictive values (PPV), and negative predictive values (NPV), were calculated, and plotted against a range of prevalence of the response, in order to assess the accuracy of the indices in areas with a different proportion of impacted and non-impacted samples.
By modifying the original boundaries of these indices, between good and not good status, we have maximized their responses and obtained a higher sensitivity and specificity, improving the average performance of all indices for the full gradient of prevalence.
In its first application SDT was seen as a very useful tool and as a next step, further tests could be carried out with larger datasets and stations with comparable prevalence.

Is there a possibility of ranking benthic quality assessment indices to select the most responsive to different human pressures?

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A plethora of marine benthic indices exist, but there is not an agreement regarding what index or indices should be used to establish benthic quality, giving advice to managers. The objective of this investigation was to rank 35 benthic quality assessment indices, used in different countries to evaluate the impacts produced by 15 different human pressures (including multipressure, aquaculture, sewage discharges, eutrophication, physical alteration, chemical pollution, climate change, oil and gas extraction, etc.). The ranking was determined taking into account coverage (local, regional, global), number of citations testing a pressure; and number of citations with significant correlation with pressure. We analysed 363 references, from which 169 showed quantitative data. Over a potential total score of

1500 (100 scores * 15 pressures), the highest values were obtained by: (i) AZTI's Marine Biotic Index (AMBI), which scored 914, tested using 14 pressures, showing in 93.2% of the tested cases significant correlation with pressure; (ii) multivariate-AMBI (M-AMBI) scored 765, tested with 12 pressures, showing 93.7% of significant correlations; (iii) BENTIX scored 356, tested with 8 pressures, showing 80% of significant correlations; and (iv) Benthic Opportunistic Polychaetes Amphipods (BOPA) index scored 314, tested with 8 pressures, showing 63.6% of significant correlations. The remainder indices scored <200.

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Möllan

Uncertainty of the phytoplankton indicator chlorophyll a in coastal waters of the Baltic Sea - Effect of sampling frequency simulated from high-frequency data

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A long-term chlorophyll data set from the north-western coastal Baltic Proper (stations B1 and H4) with high sampling-frequency (weekly in spring, biweekly in summer), was used to simulate the effect of monthly sampling on the uncertainty of different seasonal means. There was a distinct spring bloom peak each year, resulting in large within-month variability in March and April, and occasionally, also in May. Simulation of monthly sampling was done by retrieving data for a certain sampling day each month from the interpolated data set, e.g. either the 5th, 14th, or 23rd each month, or some other arbitrarily chosen day. From the retrieved monthly data sets, seasonal means were computed for spring (March-May), summer (June-August) and the full growth period (March-October). Seasonal means were aggregated into 6-year means, corresponding to the current assessment cycle of the EU Water Framework Directive. In the 1980´s to early 1990´s the spring period was characterized by large inter-annual variability but from the late 1990´s and onwards, the monthly data showed a relatively small inter-annual variability. However, in this later period the results were very sensitive to the arbitrary choice of sampling date. Sampling in the early part of the month often coincided with the spring bloom peak in early April. The results show that with a monthly sampling there is a risk of biased assessment due to changes in the timing of the spring bloom. In order to include the spring bloom in the assessment period, sampling much more frequently than monthly is recommended.

Inclusion of Earth Observations and ferrybox data improves status assessments in the Gulf of Finland

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EU directives require its member states to assess reliably and comprehensively eutrophication status of surface waters. This requirement cannot be fulfilled using the analysis results from traditional monitoring alone but compel to develop and implement more sophisticated methods and approaches, especially in case of marine environments. The inclusion of Earth Observation (EO) methods and Alg@line ferrybox data improves the areal and temporal representativeness in the data originated from monitoring stations. Moreover, the high-frequency monitoring of EO and Alg@line data enable the development of various kinds of phytoplankton products not only for summer but also for springtime to be applied in status assessments.
This study focuses on the multi-faced Gulf of Finland (GOF). The data consisted of chlorophyll results derived from three sources and covering the period since the early 2000s. (i) The traditional monitoring data originated from the databases of Finnish Environment Institute and the HELCOM COMBINE database hosted by ICES. (ii) The satellite instruments included MERIS (MEdium Resolution Imaging Spectrometer), which provide the best functionality for the estimation of parameters related to parameters such as chlorophyll a. The advantage of MERIS is based both on their spatial resolution of 300m and band combinations. (iii) The Alg@line ferrybox system provides real-time information on the water quality with high-frequency automated sampling onboard five merchant ships on the GOF. Alg@line devices measure chlorophyll together with other water quality parameters. The depth of the inlet is ca. 5 m below the surface with a spatial resolution of 200 m. The system includes a sequence water sampler storing 24 water samples along the route.
In this study we compare and evaluate chlorophyll results produced through EO, Alg@line and the traditional water quality monitoring methods in the GOF. The comparisons were carried out by analyzing areal distributions, time series and histograms in different water bodies. We also tested the ability of different measures of central tendency in EO and traditionally monitoring data to describe eutrophication status in the open GOF as a whole. Using chlorophyll data from different sources, we can yield spatially and temporally representative assessment of the eutrophication status for the GOF in the 2000s. The studied approach is directly applicable for the forthcoming assessments.

Allochthonous matter and nutrients shape phytoplankton communities

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The nutrient availability is a well-known factor shaping the phytoplankton communities in marine systems, but in coastal systems the occurrence of allochthonous matter may also be of central importance. We performed a study on factors governing the composition, size-structure and pigment content of the phytoplankton community in the Baltic Sea. Samples were collected at fourteen stations, from southerly Kattegat to the northerly Bothnian Bay during a summer and a winter–spring cruise 2011-2012. In summer the proportion of autotrophs decreased gradually from south to north, while the opposite trend was observed for mixotrophs. Picoplankton was the dominant size class in the Baltic Proper and Bothnian Sea (~70%), while their importance decreased gradually towards the north. Mixotrophic nanoplankton was most abundant in the Bothnian Bay, which is characterized by high concentration of humic substances and low concentration of phosphorus. During the nutrient rich winter-spring period, no noticeable trend was observed with respect to autotrophs, mixotrophs, and microplankton (> 20 µm) was dominated size group at all stations. The chlorophyll content of the phytoplankton increased from north to south, indicating adaption to darker humic rich water in the north during summer. The photoprotective pigments were 10-fold higher in the summer than in the winter, and during the summer the photoprotective index was higher in the southern Baltic Sea, indicating adaption to high light-climate in this area. The results show that not only nutrients but also humic substances are important for the size-structure and composition of the phytoplankton community.

How do we best estimate phytoplankton biomass?

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In the EU Water Framework Directive the biological quality elements for classification of the ecological status of coastal waters include phytoplankton composition, abundance, frequency and intensity of blooms and biomass. Biomass can be estimated in different ways. In the Swedish assessment system the biovolume of phytoplankton and the concentration of chlorophyll a, a proxy for phytoplankton biomass, are presently used to express the biomass of phytoplankton. The biovolume of phytoplankton is based on microscope analysis of autotrophic and mixotrophic phytoplankton (> 2µm) from water samples. Organisms are identified and counted and standard geometric shapes of the different taxa (according to HELCOM COMBINE manual) is used to calculate cell volumes which, together with the abundance of individual taxa, is used to calculate total biovolume per taxa. Biomass can also be expressed as carbon content (where the biovolume is converted to carbon according to a standard formula). Using data from national and regional monitoring in Sweden the different methods are compared. The results show a non-linear correlation between microscope-based biomass and chlorophyll a. Another result is that biovolume overestimate the biomass of the algal group diatoms compared to if chlorophyll a or t if carbon content is used as biomass measure. The contribution of autotrophic picoplankton to total phytoplankton biomass was also investigated. The picoplankton, e.g. cyanobacteria of Synechococcus type with a cell size less than 2 µm, are not included in traditional microscope-based phytoplankton monitoring. Picoplankton may contribute up to 85% of total biomass in summer. Other proposed methods for estimating phytoplankton biomass, such as in situ chlorophyll fluorescence, measured using oceanographic buoys and Ferrybox-system, and measurements of ocean colour using sensors on satellites will also be discussed. The implications for updated monitoring programs will be discussed.

How to assess lakes with high biomass of Gonyostomum

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Species within the genus of the raphidophyte Gonyostomum often form mass development in lakes and it is unclear if such algal blooms are related to anthropogenic pressures. During the WFD intercalibration process lakes with such algal blooms (> 50% of total biomass) were excluded from the analysis as they were major outliers in the ordinations (N=29). In Sweden it is however a need to assess also lakes with high biomass of Gonyostomum. Currently it is suggested to remove the biomass of Gonyostomum from the total biomass of phytoplankton when assessing the impact of anthropogenic nutrient sources. Different solutions for assessing lake ecological status with phytoplankton in lakes with Gonyostomum will be discussed based on a dataset where 158 of a total of 824 lakes were found to have a biomass of Gonyostomum exceeding 50 % of the total phytoplankton biomass.

Can we develop operational indicators for coastal phytoplankton composition?

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The Water Framework Directive requires that ecological status of phytoplankton taxonomical composition should be assessed. The phytoplankton community consists of several thousand different species, each having their own optimal life strategy, selected through evolution. At the same time, the dynamics of physical and human-induced perturbations in coastal ecosystems constantly alter the environmental conditions and as a consequence, the phytoplankton community changes to adapt to these dynamic conditions. In addition, biological interactions, most prominent in the form of grazing by both filter feeders and zooplankton as well as phytoplankton phenology, further add to this complexity of factors governing the phytoplankton community. I propose the following ranking of factors controlling the phytoplankton community structure: 1) phytoplankton phenology, 2) physical forcing, 3) nutrient ratios, and 4) nutrient concentrations. The implication of this ranking is that the response of the phytoplankton community to changing nutrient levels is relatively weak and often masked by other variations that are difficult to describe quantitatively. Therefore, the uncertainty surrounding relationships between nutrient pressure and phytoplankton composition is large, rendering the development of operational indicators for phytoplankton composition difficult. Although the phytoplankton community responds to changing nutrient levels, composition indicators are too insensitive to provide operational indicators useful for discriminating between good and moderate status.

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Ribban/Pildammen

Two prototype tools for assessing good environmental/ecological status (GES) in aquatic ecosystems – DEVOTES and WATERS

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We present two prototype tools for assessment of GES (good ecological status and good environmental status) in aquatic ecosystems: the DEVOTES biodiversity assessment tool (for the MSFD) and the WATERS ecological status assessment tool (for the WFD). Both tools are multi-metric indicator-based tools, which classify ecological/environmental status in two classes (good or not good) and five classes (High, Good, Moderate, Poor or Bad) by comparing observed indicator values with specified status classification boundaries. Assessments are made for geographical entities ("sectors" in DEVOTES / "waterbodies" in WATERS) resulting in both an overall status for the geographical entity as well as classifications within indicator groups.
Both tools are Excel-based and share many similarities. Whilst the WATERS tool performs assessments for a simple "flat" set of waterbodies, the DEVOTES tools allows for sub-division of sectors and habitat types into hierarchical structures. The DEVOTES tool weights indicator results from different sectors according to their geographical extent and/or assigned quantitative value scores.
The DEVOTES tool allows the assessment to be targeted to a particular ecosystem descriptor by limiting selection of indicators included in the assessment to those from indicator groups matching a user-selected descriptor. Similarly, the WATERS tool can select for indicators specific to a given pressure or combination of pressures.
A key feature in both WATERS and DEVOTES assessment tools is the inclusion of an uncertainty assessment. Monte Carlo simulations of observed indicator values using a normally distributed random variable are performed to obtain the probability distribution of the different biodiversity status classifications. In this way the tools can be used to examine the propagation of uncertainty from indicators to overall assessment.

Ecological quality assessment of coastal and transitional waters based on phytoplankton, phytobenthos, benthic invertebrates and fish indicators in the Gulf of Riga (Baltic Sea) – implementation of the European Water Framework Directive

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Phytoplankton, macrovegetation, benthic invertebrate and fish constitute the biological quality elements proposed in the Water Framework Directive (WFD) to be used for the classification of the ecological status of coastal and transitional waters. A number of biotic indices have been designed to establish the ecological quality of European coastal waters based on the response of biological quality elements to natural and man-induced changes in environmental conditions. In the present work following indicators have been developed for the ecological statuss classification of the Gulf of Riga coastal waters: phytoplankton biomass, chlorophyll a, Phytobenthos Ecological Quality Index (PEQI) which is based on two metrics: depth distribution of phytobenthos and depth distribution of Fucus vesiculosus, Benthic Quality Index (BQI) and for the ecological statuss classification of the Gulf of Riga transitional waters: phytoplankton biomass, chlorophyll a and adapted Transitional Fish Classification Index (TFCI). In results we will show the development of each indicator and their relation to the pressures. This research is supported by Administration of Latvian Environmental Protection Fund project „EU Water Framework Directive 2000/60/EC implementation in the Latvian coastal and transitional waters (Baltic Sea): biological quality elements intercalibration (phytoplankton, macrophytes, benthic invertebrates) and testing (fish)"

ECOLOGICAL CLASSIFICATION OF DANISH LAKES

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About 850 Danish lakes larger than 5 ha and some between 1 and 5 ha are included in the Danish River Basin Management Plans. The lakes are grouped into 11 different lake types of which the shallow, calcareous, freshwater and non-humic lake type makes up about 40% of all Danish lakes. Chlorophyll a concentrations still constitute the core of how the lakes are being classified, but intercalibrated indices of the biological quality elements of submerged macrophytes,

phytoplankton and fish (not yet intercalibrated) have now also been included in the ecological assessment of lakes. This assessment calculates an Ecological Quality Ratio (EQR) between 0 and 1 where the boundary between the good and moderate ecological state is 0.6. The macrophyte index is based on the presence of species indicating nutrient-poor conditions, the maximum growing depth of submerged macrophytes (in deep lakes) and the coverage of submerged macrophytes (in shallow lakes). The phytoplankton index is based on chlorophyll a concentrations, the presence of species (nutrient-poor–nutrient-rich), the relative biomass of cyanobacteria and the relative biomass of chrysophytes. The indices have been validated as indicators of eutrophication by relating them to the concentration of total phosphorus (TP) and total nitrogen. Overall, there is a strong correlation with TP, but also extensive variability occurs because the indices depend on a number of other chemical and biological factors and the interactions between these than on TP alone. In this presentation, we will illustrate how the indices can be used in different lake types and how they relate to nutrient concentrations. Based on 25-year long data series we will also illustrate the year-to-year variability in phytoplankton and macrophyte indicators and show how this impacts the uncertainty of the ecological classification. For example, we demonstrate that if the ecological classification is based on the phytoplankton index and just one year's data, then EQR needs to be above 0.74 to classify with a high certainty the lake into at least a good ecological state. If the ecological assessment can be based on four years' data then EQR just needs to be above 0.67. Predicting the uncertainty in the classification and the likelihood of a given ecological class can be used by managers and policy makers to decide on how to monitor most efficiently and to decide on how much to reduce the external loading of nutrients.

Status assessments based on multiple sources of monitoring data

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Monitoring of aquatic environments can have several different objectives and be ordered and performed by a multitude of organisations. Here, we discuss how such circumstances can influence status assessments of aquatic environments according to prevailing EU directives. Furthermore, we propose a protocol for assessing the quality of measured physico-chemical and biological data. A comprehensive study of measured data from coastal and off-shore waters surrounding Sweden demonstrated that the use of monitoring data from programmes other than the Swedish national environmental monitoring had a significant impact on which water bodies, water types and sea areas that were deemed to have good status. This was primarily due to differences in the spatial distribution of data collected in different programmes. However, also the handling of deviations from national sampling guidelines was found to have a considerable impact on the outcome of status assessments. Moreover, our study revealed the occurrence of systematic measurement errors that can lead to spurious trends in the collected data and be a source of uncertainty of status assessments. Nevertheless, our study provided clear evidence that status assessments of coastal and off-shore waters can benefit from using measured data from a wide range of monitoring programmes, including both national and more local programmes.

Exploring the potential of predictive models to estimate biological status of unsampled water bodies

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Modern assessment of biological status should be consistent and extensive across large geographic regions. The task is challenging for water managers who need to estimate biological status also of water bodies that are not sampled for the biota. For the purpose to estimate Observed to Expected ratio (O/E, or Ecological Quality Ratio, EQR) of unsampled water bodies, I explored potential utility of modified RIVPACS-type models to predict both 1) expected reference biota at non-altered conditions and 2) observed biota at current altered environmental conditions. I used monitoring data of benthic invertebrate assemblages and associated environment (e.g. GIS, water chemistry) from streams across Finland. Specifically, I first developed traditional RIVPACS-type models to predict the macroinvertebrate assemblages expected in reference conditions based on variables insensitive to human actions. Then, I combined the output from these models and biological and environmental data from altered sites to explore potential to predict impaired assemblages that would expected under the current altered conditions. I evaluated the performance of the approach using a fully independent data set covering reference and altered conditions. If successful, the approach could help water managers in areas with dense stream network such as in Finland where 70420 stream kilometres have >10 km2 catchment area: all cannot be sampled, but all need to be assessed to plan river basin management.

Session 4 8.30-10.10 Rooms: Gripen, Ribban, Pildammen

Gripen

Acknowledging natural variation in reference conditions for marine soft-bottoms**

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There is an increasing need to assess the ecological quality of coastal waters. This requires a comparison with reference conditions, i.e. areas with no or minor disturbance from human activities. A lot of attention has been given to the development of benthic indices, but less to developing methods for setting reference conditions taking natural variation into account. In order to fulfil the requirements from the EU Water Framework Directive we need knowledge of the variability in reference conditions, as this will influence how and where action for improvement will be taken. This means moving from using one reference value for all areas to a method that differentiates between e.g. inner, sheltered bays/fjords and the outer, exposed coast. In our study we explore the relationships between 10 benthic macroinvertebrate indices along geophysical gradients (wave exposure and different measures of bathymetry) for 1237 soft sediment "benchmark reference" samples at the Norwegian Skagerrak coast. Statistical models were fitted using Generalized Additive Mixed Models (GAMMs), using Akaike Information Criteria (AIC) for model selection. The Indicator Species Index (ISI) performed best of all the tested indices (explaining 50% of the deviance), and was determined by depth, slope, coarse-scaled terrain curvature, finer-scaled pit depth and wave exposure. Using spatial modelling, we suggest areas for which reduced reference conditions should be considered; which is a first step towards differentiating reference conditions along environmental gradients.

Impacts of three contrasting disturbance gradients on stream ecosystem structure and function part I: Responses of taxonomic groups

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Bioassessment of streams and rivers within the Water Framework Directive primarily centers on four taxonomic groups: benthic macroinvertebrates, diatoms, macrophytes and fish. However, while our understanding of the responses of these groups to two major classes of anthropogenic disturbances – eutrophication and acidification – is relatively advanced, research on their responses to other pervasive anthropogenic disturbances is often severely limited. To address these deficiencies, we are studying three well-defined human disturbance gradients, and assessing simultaneous variations in physico-chemical, community and functional responses. The first gradient comprised 10 streams from Southern Sweden representing an agricultural gradient, ranging from pristine streams in nature reserves to very agricultural streams impacted by heavy nutrient runoff. The second and the third gradients represent less-well studied anthropogenic disturbances: (i) a forestry gradient, comprising 16 streams from Northern Sweden with varying intensity of forest management in their catchments, and (ii) a hydromorphological gradient, consisting of 10 streams from Western Sweden ranging from unregulated to strongly regulated for hydropower. All three gradients have been thoroughly characterised based on land use, water chemistry, riparian and hydrogeomorphological data, along with other relevant information (including clear-cutting history for the forestry gradient, and the extent of ditching). We found that diversity metrics for most groups generally declined with increasing agricultural impact, and somewhat surprisingly peaked at intermediate levels of forest management, whilst there was little consistency among the taxonomic groups for the hydromorphological gradient. These results are discussed also with reference to shifts in community composition.

Impacts of three contrasting disturbance gradients on stream ecosystem structure and function part II: Key ecosystem processes

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Direct measurement of ecosystem process rates, such as litter decomposition, can provide an additional dimension in the bioassessment of human impacts on aquatic ecosystems. Such processes underpin key ecosystem services delivered from freshwater environments, including provision of food and clean water, and the mitigation of pollutants and

toxins. However, the use of process-rate based measures in bioassessment is hindered by the limited understanding of (i) variation in the sensitivity of different ecosystem processes to contrasting anthropogenic pressure gradients, (ii) variation in different ecosystem processes along pressure gradients in relation to changes in community structure and diversity, and abiotic parameters and (iii) calibration of process-rate based metrics, including categorization of the reference vs impacted state. To address these deficiencies, we are studying three well-defined human disturbance gradients, and assessing simultaneous variations in physico-chemical, community and functional responses. Community structural variables include the responses of four taxonomic groups (diatoms, invertebrates, macrophytes, fish), while functional responses include litter decomposition, algal productivity, biofilm respiration and an aquatic phytometer. The first gradient comprised 10 streams from Southern Sweden representing an agricultural gradient. The second and the third gradients represented a forestry gradient (16 streams from Northern Sweden) and a hydromorphological gradient (10 streams from Western Sweden). Initial analyses indicate stronger responses overall to the agricultural and hydropower gradients, while functional responses along the forestry gradient were more subtle. Together, these results indicate that simple functional indices can be used to track changes in functioning along human impact gradients, but that the responses vary according to the main impact being assessed.

Environmental status of the Croatian part of the coastal Adriatic Sea

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The recent European legislation for the protection of the marine environment, in particular the Marine Strategy Framework Directive (2008/56/EC), demands each member State to develop marine strategies for its marine waters. With regard to the Republic of Croatia, the sea and marine environment is of strategic importance. Its protection, preservation and restoration of natural features aim for the conservation of biodiversity and marine ecosystems in order to facilitate and ensure the sustainable use of marine resources for the benefit of present and future generations.

As EU member, Croatia has transposed MSFD into Croatian legislation (OG 136/11) establishing a framework for action of the Republic of Croatia in the field of marine environmental protection, that sets the basis for the development, implementation and monitoring of the national marine strategy according to MSFD requirements. At the regional level, as a Party to the Barcelona Convention on the Protection of the Marine Environment and the Coastal Region of the Mediterranean, Croatia participates in all activities of the Mediterranean Action Plan Environment Programme of the UNEP.

Initial assessment of the situation and the load on the marine environment of the Croatian part of the Adriatic Sea was the first step in the preparation of the program of measures for achieving and maintaining good status of the marine environment. It was based on monitoring activities in the Adriatic coastal waters carried throughout national projects and in the frame of the MED POL monitoring program in the last decades. Outcomes of this activities represent a good background to define qualitative descriptors according to the MSFD and establish monitoring and observation system for ongoing assessment of the Croatian waters.

With regard to Descriptor 8, hazardous substances data obtained for sediment and mussels Mytilus galloprovincialis from coastal areas, during period 2002-2011 and new monitoring activities in 2013 year, were used to assess the "on-going chemical status" and to ensure that concentrations of contaminants are at levels not giving rise to pollution effects. Contamination by target hazardous substances were observed in areas in the vicinity of large towns, identified as hot spots. Major contamination problems include untreated or partially treated urban and industrial wastewaters and to a lesser extent agricultural activities in the past. Environmental concentrations of organochlorine pesticides (HCB, lindane, aldrin, dieldrin, p,p'-DDTs), showing in general low levels of contamination, have declined due to ban of their production and use. Contrary, there is much more widespread contamination by PCBs as a result of their historical use, exhibiting a slight decrease of concentrations. Evidently, PCBs are still present in the environment probably reflecting an inefficient management of the existing regulations concerning their use and stocking.

In order to define the environmental status in the Croatian waters, obtained contaminant concentrations were interpreted against assessment criteria defined by OSPAR, due to the lack of EQS and national target levels for sediment and biota. Examination of pesticides in mussels indicated that HCB and lindane levels were less than BAC, and moreover, at the majority of stations close to zero, while p,p'-DDE concentrations were above BAC at all stations suggesting a good status for pesticides. The assessment of ICES 7 PCBs, presented with PCB 153 and PCB 118, indicated that concentrations of the most abundant congener PCB 153 were less than EAC at all stations, indicating good status for non-dioxin like PCBs. However, PCB 118 levels were above EAC at the majority of stations, suggesting an unacceptable status for dioxin like PCBs. At coastal stations far from anthropogenic activities, concentrations of PCB 118 were close to zero. Similar assessment of pesticides and PCBs levels was observed for sediment. The reliability of monitoring data was checked through participation in quality assurance programme undertaken by IAEA for UNEP/MAP-MEDPOL.

Biodiversity status in the Baltic Sea correlates to cumulative pressures: implications for ecosystem-based management

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Many studies have tried to explain spatial and temporal variations in biodiversity status of marine areas from a single-issue perspective, such as fishing pressure or coastal pollution, yet most continental seas experience a wide range of human pressures. Cumulative impact assessments have been developed to capture the consequences of multiple stressors for biodiversity, but the ability of these assessments to accurately predict biodiversity status has never been tested or ground-truthed. This relationship has similarly been assumed for the Baltic Sea, especially in areas with impaired status, but has also never been documented.

Here we provide the first robust evidence that cumulative human impacts strongly relate to ecosystem condition, i.e. the biodiversity status in the Baltic Sea, and that threshold values of cumulative pressure and impact may exist. Thus, cumulative impact assessments offer a powerful and efficient tool for ecosystem-based management and may prove useful for setting priorities as well as caps to maximum allowable human impacts. Examples of setting of both priorities and maximum allowable human impacts in the open parts of the Baltic Sea will be given.

Session 4 8.30-10.10 Rooms: Gripen, Ribban, Pildammen
Ribban

Development of diatom indicators for assessing inland waters within the WATERS project

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Traditionally in Sweden, benthic diatoms have been used to assess the ecological status of streams. The current assessment criteria using benthic diatoms are based on two indices and two additional metrics: The "indice de polluo-sensibilité spécifique" (IPS) indicates eutrophication and organic pollution. Two additional metrics are used to confirm the assessment, i.e., the percentage of pollution-tolerant valves (%PT) indicating organic pollution and the trophic diatom index (TDI) indicating eutrophication. The acidity index for diatoms (ACID) indicates acidity in streams. The acidity index value does not influence the ecological status class; rather, it is used to assess stream pH regimes in which low pH can be natural.
In the WATERS project, we aimed at minimizing error in the ecological assessment of stream status using benthic diatoms, include the assessment of lake status, and use information on the entire benthic algal community in the assessment. We found that the stream diatom method can be applied in lakes as well despite some differences in diatom assemblage composition, and that the assessed chemical background is the same as for streams. We also found that benthic diatoms reflected lake water chemistry at least equally good as plankton. Still there are unsolved problems regarding the impact of toxins, which are currently not reflected by the indices used today. We found however that the amount of malformated diatom valves can be used as an indicator of the impact of heavy metals and propose to include this as additional metric. The WATERS project also included a study of the reference diatom assemblages, and we used two different approaches to assess those. We found that regional differences in assemblage composition were rather low, and that diatoms are mainly steered by water chemistry. Last but not least, we tested the possibility to use a new instrument for a fast assessment of other benthic algal groups than only diatoms, but it turned out that only biomass can be assessed, not algal groups.

Comparison of the Swedish (TPI) and European (PTI) indices for phytoplankton community composition for 800 Swedish lakes

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During the WFD intercalibration process a plankton trophic index (PTI) was developed to compare national classification systems in Northern and Central Europe. This metric uses genus level of about two hundred phytoplankton taxa based

on data from 1795 lakes in 20 countries and it is sensitive to total phosphorus concentration, alkalinity, lake size and climatic variables. The Swedish trophic plankton index (TPI) is similar but consists of fewer taxa which sometimes make assessment with TPI impossible or uncertain if too few taxa with indicator values are found in a lake. This study is an extended test of the two metrics after the intercalibration adding 700 more Swedish lakes into the comparison, with the aim to improve the Swedish ecological status assessment based on phytoplankton community composition.

Is Secchi depth an adequate indicator for eutrophication in optically complex waters?

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Successful management of coastal marine environments requires good and reliable monitoring methods and indicators. An increasing awareness of eutrophication has led to several national and international agreements and directives on how to reduce the adverse effects on ecosystems. Secchi depth (SD) and chlorophyll-a (chl-a) concentration are regularly monitored and used as indicators for the assessment of eutrophication, both within the European Commission's Water Framework and Marine Strategy Directives and the Helsinki commission. Chl-a is a proxy for phytoplankton biomass and SD is used as a proxy for chl-a. In optically complex waters SD is also influenced by other factors, not strongly correlated to eutrophication, such as coloured dissolved organic matter (CDOM) and suspended particulate matter (SPM). In this study we evaluate how much chl-a, CDOM and SPM (both organic and inorganic fraction) each contribute to the SD. We collected in situ data from different coastal gradients in the Bothnian Sea, the Baltic Proper and the Skagerrak over four years. The correlations between SD and the optical parameters (log transformed) varied between areas with a range of r=0.21 to 0.69 for chl-a, r=-0.35 to -0.8 for CDOM, r=-0.21 to -0.83 for SPM, r= -0.10 to -0.80 for inorganic SPM and r=- 0.28 to -0.78 for organic SPM. Linear multiple regression models for each area, with chl-a, CDOM and inorganic SPM as predictors, explained SD well (R2adj=0.78, p< 0.0001 for Bothnian Sea, R2adj=0.840, p< 0.001 for the Baltic Proper, R2adj=0.48, p< 0.0001 for the Skagerrak (slope for inorganic SPM n.s.). The follow-up analysis of the multiple regressions and the commonality analyses showed differences between the areas of the contributions of the optical parameters to the variance of the coefficient of determination (R2) of the predicted SD. In the Bothnian Sea the unique contributions were low (12, 8 and 3 % for CDOM, inorganic SPM and chl-a), but the combination of CDOM and inorganic SPM explained nearly all remaining variance in R2 (77 %). In the Baltic Proper, the general model was mainly governed by inorganic SPM (16%) and less by chl-a (3%) and CDOM (2%). All predictors combined, explained 79% of the remaining variance in R2, but chl-a the least. In the Skagerrak both chl-a and CDOM were important to the prediction of SD (36% and 41%, respectively). The remaining 22% of the variance in R2 was nearly fully explained commonly by CDOM and chl-a, hence the inorganic SPM had very low contribution. Differences in natural processes (factors affecting the optical components determining the SD), such as; land and river run-off, resuspension, bottom substrate hydrography, and salinity may explain the differences seen between the areas. The results imply that in optically-complex waters SD is not a sufficient indicator for eutrophication as a response to increased chl-a concentrations. For example, changes in CDOM loads in the Bothnian Sea or the Baltic Proper will affect the SD more. Moreover, the natural coastal gradients in SD will influence the determination of reference conditions for other eutrophication indicators, such as the depth distribution of macro algae. Hence, setting targets for SD based on reducing the chl-a concentrations might in some cases have no or very limited effect on the SD.

Development of phytoplankton taxonomic composition indicators of Baltic coastal waters – the WATERS gradient studies 2012 and 2013 as a model to illustrate important constraints

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At present only biomass, measured as chlorophyll a and biovolume of autotrophic and mixotrophic phytoplankton, is used in phytoplankton assessment for the EU Water Framework directive in Sweden for coastal and transitional waters. Total biomass is however not providing any information about the composition of the phytoplankton community. It could be a mono-culture, composed of toxic species or a very diverse community but all having the same biomass. A gradient study was conducted within the WATERS project in the Baltic Sea on the Swedish East coast (the county of Östergötland). Phytoplankton samples (0-10 m hose samples) were collected once in every summer month (June, July and August) in 2012 and 2013 at seven stations. The stations where distributed in three parallel gradients. Environmental parameters (salinity, temperature, inorganic nutrients and total nitrogen and total phosphorus) were measured. This gradient study, although limited in temporal and spatial resolution, is here used as the model to point out some of the important constraints that must be taken in consideration when developing indicators for phytoplankton taxonomic

composition.
• Stations with similar salinities have similar taxonomical composition. If both the salinity and nutrient availability changes along a gradient, it can be very difficult to separate what is an effect of the nutrients or what is the salinity effect. Preferably, an index using phytoplankton composition information should be developed for different salinity intervals.
• The relative nitrogen and phosphorus availability change along the gradients, with the highest phosphate concentrations at the outer stations. The occurrence of N2-fixing cyanobacteria is usually not a sign of local eutrophication in such gradients.
• Some species cannot consistently be identified to species level in ordinary light-microscope. Higher taxonomic levels should be used when comparing datasets if species identification is uncertain.
• The phytoplankton composition within stations often differs strongly between months and years. Low amount of data, both in temporal and spatial resolution, sets constraints for both the development of taxonomic phytoplankton indicators and for their use in assessment.

Summer nutrient and chlorophyll gradients in Stockholm archipelago estuaries (Baltic Sea) – observations and predictions from river and point source nutrient loadings

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Eutrophication effects in coastal waters are often coupled to the anthropogenic loading of either nitrogen (N) or phosphorus (P), or both these elements. However, due to water exchange and nutrient turnover processes, such as losses to or inputs from sediments, the effects in a certain area are often difficult to predict. Thus, if historical data of natural conditions are missing, reference nutrient concentrations may be difficult to estimate. For Swedish coastal waters the N and P reference values, used in the assessment according to the EU Water Framework directive (WFD), are predicted from modeled background nutrient loading and a coastal surface water mixing model. In this model, the reference nutrient concentration in a certain coastal gradient is a linear function of salinity. For some areas, empirical relationships are used to also estimate reference chlorophyll from the reference nutrient concentration.
In this study we evaluate summer surface water nutrient and chlorophyll data of 8 coastal gradients (July-August 2001- 2012, in total 17 occasions), located in the Stockholm archipelago area of the NW Baltic proper, in relation to the loading of nutrients to these gradients, in order to: 1. Test the WFD model, both for N and P, 2. Estimate the nutrient contribution from point sources and potential gain of reducing these point source loadings, 3. To validate the phytoplankton chlorophyll a (chl-a) indicator against the nutrient loading pressure and to use the chl-a to nutrient relationships to predict potential improvements from reduced nutrient loading.
Total N (TN) concentrations were linearly correlated to salinity in most of the coastal gradients. Moreover, TN concentrations generally were well predicted from the salinity and the weighted TN loading concentration preceding the sampling, if this time period was relevant to the water turnover rate of the area. Thus, TN loss or gain processes were either insignificant or balanced. In some areas with low water turnover rate, some net TN gain processes appear to contribute, such as N inputs from sediments or N2-fixation, whereas in one area loss processes dominate. Point sources were important contributors to the observed TN in several of the gradients. As for TN, total P (TP) was also mainly linearly correlated to salinity, but the correlation was weaker and, for most gradients, the weighted TP loading did not fully explain the observed TP concentration, i.e. other P sources have to be invoked. Partly, P transport from the outer coastal area into the coastal gradients may be underestimated, but P inputs from sediments must also be an important P source. In only one of the gradients, point sources were an important contributor to the observed TP concentrations.
The results show that the simple WFD mixing model worked fairly well for predicting summer TN, although it may be difficult to adapt to complex gradients with loading from several different sources to different sub-areas. However, the model consistently underestimates the actual summer TP concentration, implying that also natural (WFD reference) TP concentrations are underestimated. Chl-a was well correlated to both TN and TP concentrations. Since the anthropogenic contribution is larger for N than for P, reduction of N loading has the greatest potential to improve conditions in the coastal gradients.

Session 4 8.30-10.10 Rooms: Gripen, Ribban, Pildammen
Pildammen

ASSESSMENT OF THE PHYSICOCHEMICAL STATUS OF GREEK COASTAL WATERS USING INDICATORS UNDER THE EU WATER POLICY DIRECTIVES

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The physicochemical conditions of the Greek coastal waters were assessed by using various classification methods among which the factorial method of Bald et al. (2005) and the Eutrophication index (E.I.) of Primpas et al. (2011). In the factorial analysis method all the physicochemical parameters meeting the needs of the WFD were taken into account: transparency (measured as Secchi disc depth of disappearance-SD); percentage of oxygen saturation and nutrients (ammonium, nitrate and phosphate). The E.I. method takes into account chlorophyll-a biomass and nutrient concentrations (ammonium, nitrate, nitrite, phosphate). The physicochemical status assessed was used in the decision tree of combining biological and physico-chemical status into integrative ecological and environmental status (Simboura et al., 2015). Results of both methods were evaluated in relation to the integrative ecological status assessed.
The results of the factorial analysis indicated as a primary factor the nutrient concentrations and the percentage of oxygen saturation and as a secondary factor the SD; the class assessment was compared to the respective assessment by E.I. and the agreement was found low, the FA method significantly upgrading the status in relation to E.I. and the biological status assessment. When the percentage of oxygen saturation indicator was not considered in the assessment of the physic-chemical status, the analysis showed as the primary factor the SD and as the secondary the nutrient concentration. In that case however, the class agreement with E.I. was largely improved. It seems that the percentage of oxygen saturation in the well oxygenated coastal waters of Greece probably overestimates the trophic status of the Greek coastal areas. The Good Environmental status (GEnS) threshold for SD was also estimated by a variance analysis of the SD values plotted over the integrative status. However, results should be further tested taking into account the frequency of occurrence of the assessed physicochemical status using longer series of data.
It is noted that the E.I. index has been used as a surrogate for the physicochemical status within the decision tree method for the assessment of the integrative ecological status of Greek water bodies under the EU Water Framework Directive and the EU Marine Strategy Framework Directive.

Phosphorus as a supporting element for the Water Framework Directive – how do we establish appropriate boundaries that effectively underpin water quality management?

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Eutrophication remains a key pressure influencing European freshwaters. If ecological improvements are to be made significant further investment will be required to reduce nutrient concentrations, particularly phosphorus. The Water Framework Directive provides a mechanism to achieve this through the river basin planning process.
Member States are required to establish nutrient concentration boundary values which will support good ecological status. Recent work has demonstrated that during the first river basin planning cycle the majority of Member States established such boundaries for phosphorus, although the values used cover a significant range of concentrations. This must partly be a result of the variety of water body types found across Europe. However, it may also be a reflection of the methods used to establish the boundary values. In this paper we show the approach used to establish a relationship between phosphorus and the nutrient sensitive biological quality element of macrophytes and phytobenthos for UK rivers, and how this was used to revise the WFD boundaries for phosphorus for the second river basin planning cycle.
The relationship was developed from a large matched chemical and biological data set collected to support work for the WFD. We used an approach that compared the change in biological status from reference conditions (EQRs) with changes in current phosphorus concentration from reference values (P EQR). We quantified the uncertainty in these relationships and used this information when establishing boundary values.
There is a high level of uncertainty in these relationships and we suggest how this could be taken into account when using the standards for water quality management.

Improving certainty of eutrophication impact – a structured weight of evidence approach for lakes and rivers

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The Water Framework Directive (WFD) has driven a new approach to the assessment of ecological status in freshwaters, and in England and Wales has confirmed the importance of eutrophication as a stressor. The 'one out all out' rule for classification determines the status class of a water body, but may not provide catchment managers with sufficient certainty of real ecological impact to prioritise large scale investment in water quality improvements. The WFD monitoring programme generates water body level data relating to eutrophication pressure and impacts, but our experience is that tools sensitive to eutrophication may give contradictory classification results for different biological elements, and for the primary supporting element (phosphorus). This may be due to uncertainty in the data, confounding effects of other pressures, or site-specific factors influencing the pressure-response relationship. Further assessment of the certainty that eutrophication impacts are occurring within a water body is required, taking account of the wider evidence available in addition to the formal classification of status using WFD methods.
To address this need we have developed a structured approach to assessing the "weight of evidence" in fresh waters, using an excel spreadsheet tool with supporting documentation to guide non-expert users. A weighted scoring system has been developed, with scores based on expert judgement, enabling the combination of data from different sources, for example WFD classification data for elements relevant to eutrophication impact, older data from the same water body, catchment-wide data and anecdotal information.
The WFD classification data and statistical confidence of class are first combined using a set of rules to determine a level of certainty that eutrophication impact is occurring. A range of additional information can then be included, in a constrained manner, to adjust this certainty. For example where the weighted scores from this additional evidence are high we can increase the certainty (e.g. from "quite certain" to "very certain") or for low scores we may decrease the certainty. The use of this weight of evidence approach provides a user-friendly, consistent and transparent framework aiding decision making at a local, water body level. It also provides a mechanism for combining WFD classifications, our understanding of uncertainty and locally held information, enabling a more robust national assessment of eutrophication impact.

ASSESSING UNCERTAINTY OF INDICATORS: AQUATIC INVASIVE SPECIES AND ENVIRONMENTAL STATUS OF WATERBODIES

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The environmental status of waterbodies traditionally have been assessed by measuring the effects of chemical pollution, eutrophication, habitat destruction and overfishing, without taking into account the adverse effects of invasive alien species (IAS), i.e. biological pollution. The latter is defined as IAS impacts at a level that disturbs environmental quality by effects on: an individual (contamination by parasites or pathogens), a population (by genetic change), a community (by structural shift), a habitat (by modification of living conditions) or an ecosystem (by alteration of energy flow and organic material cycling). A novel aspect of the European Marine Strategy Framework Directive (MSFD) is that it specifically addresses the problem of biological invasion in marine environment defined by the Good Environmental Status Descriptor 2 (D2): "Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems". A set of indicators was proposed in the EC Decision (2010/477/EU) to assess the status of marine waters in initial assessments. However, one aspect of IAS impacts is still neglected: biological invasions may cause changes in the aquatic ecosystems, which, depending on the context, may be regarded as either negative or positive. Such IAS effects may increase uncertainty of various indicator systems used to establish the progress towards achieving the environmental targets set by MSFD. The paper gives an overview of various aspects of changes caused by IAS in transitional, coastal and offshore waters. This study is a contribution to the EU FP7 Project DEVOTES (DEVel-opment Of innovative Tools for understanding marine bio-diversity and assessing Good Environmental Status. Grant Agreement No.308392).

Links between ecosystem services (ES) and indicators of state and pressure of Lake Võrtsjärv (VJ)

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The ecosystem of the large (270 km2) shallow (mean depth 2.8 m; max 6 m) eutrophic (long term average for TP 49.1 µg L-1 and TN 1.38 mg L-1) and unregulated (annual average water level fluctuation 1.4 m) VJ is significantly influenced by its catchment as the drainage ratio is 11.5. Annually, VJ is covered by ice on an average of 131 days. The retention time of water in VJ is around one year. From earlier studies it is known that the fluctuation of water level and eutrophication have marked pressure on the ecosystem of VJ. We hypothesized that the hydrology and eutrophication govern also the ES of VJ. We applied Spearman Rank Correlation Analysis and Principle Component Analysis (PCA) to link ES to the indicators of the ecological status and pressure of VJ. Available data for the recent eight years (2006-2013) were used in the analyses. The first two principle components explained 41.03 % and 27.81 % of the changes in VJ, respectively. The first component was mainly related to the hydrological and physico-chemical characteristics (water discharge into lake, transparency (Secchi depth), depth, electric conductivity, concentration of dissolved oxygen). The second component was associated with the indicators of eutrophication (TN, Chl a, BOD, TP, pH). The studied ES were (1) provisional: fish catches (eel, pike perch, pike, bream, burbot, perch, and total) and the annual net proceeds of OÜ Järveroog engaged in manufacturing reed; (2) regulating: self-purification of VJ (retention of DIC, DOC, TN, TP, DSi in/by the lake); (3) cultural: number of visitors of the Lake Museum and the Visiting Centre and the annual net proceeds of two larger guest houses near the lake. Of the provisional services, the catch of eels and the total fish catch were positively correlated with eutrophication indices (Chl a, TN, TP, BOD, Secchi depth). PCA showed negative relationship between catch of pike and water discharge into the lake. The catches of perch were higher in the years when the discharge from the lake was larger. Reed manufacturing was more successful in the years of deeper water (during the eight years annual mean depth fluctuated less than one m, 2.06-3.00 m). Self-purification took place all the time. Correlation analysis indicated that the lake retained more DIC, DOC, and TN in the years when the oxygen concentration was higher. The retention of DSi was negatively correlated with Secchi depth. PCA showed that the retention of TP increased with prolonged ice-cover period and with higher concentration of TP. The cultural ES were difficult to relate to the state and pressure of the lake as comparable data characterising these ES were not available. However, correlation analysis revealed that in the years of lower trophy there were more visitors of the Lake Museum and Visiting Centre. It can be concluded that the provisional and regulating ES were more closely related to the state and pressure of the lake compared to the cultural ES.

Predicting ecological status of unmonitored lakes based on hydrogeomorphology and land use

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EU Water Framework Directive monitoring programmes may be structured such that the operational and surveillance monitoring sites must provide data not only for the water bodies of interest, but also for unmonitored water bodies of similar typology. Generalising relationships between water body condition in monitored lakes and landscape scale descriptors of anthropogenic activities to make predictions for unmonitored water bodies can be complex. Part of this complexity is due to collinearity between anthropogenic activities and hydrological, geological and morphological settings.
We provide a characterisation of hydrogeomorphological setting of Irish lakes within which we further characterise the pressures on systems. The outputs of this hierarchically arranged analysis are groups of lakes with similar settings and pressures. To assign status to unmonitored lakes within the low alkalinity type (<20 mg L-1 CaCO3) we propose a donor lake approach, by which monitored lakes confer status on similar unmonitored lakes within a group. Status was determinedbymacrophytes as these were monitored across the highest number of lakes and have relatively low uncertainty associated with their measurement of ecological status.
We found that overall pressures were lower in low alkalinity lakes than in the other alkalinity categories. Of the 365 lakes to which status was assigned, 250 were assigned to High status by their donor lake, 75 to Good and 35 to Moderate. Across all settings, lakes assigned as Moderate Status tended to have higher percentages of coniferous forestry and those given Good Status tended to have higher catchment sheep densities. The majority of lakes predicted as High Status class had low overall pressures. However, a number of these lakes had high percentage of coniferous forestry plantations

within their catchments. These lakes may be at risk in the future if the forestry within the catchment is to be felled. Within settings, it was difficult to discern patterns between pressures and status classes as not all status classes were represented within all of the settings. This study provides a framework within which the hydrogeomorphological setting of a water body can be incorporated into prediction of ecological status, without conflating the relationship between setting and pressure. This framework also provides a characterisation of Irish lake catchments and their pressures that can be used to assess setting specific thresholds for land use in the context of water quality management.

Modelling as a tool to diagnose relations between stressors and indicators in a regulated and strongly modified catchment

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Spatial and temporal scales are an important issue when considering aquatic ecosystem quality assessment, especially in catchments where artificial reservoirs modify water budgets, and loads. Ecosystems status is measured at a local scale using indicators assumingly correlated to stressors also measured locally. This stressors however are proxies of the pressures acting at the catchment level (e.g. Urban WWTP) or on a diffusive way, such as farming, or even acting off the catchment as is the case of atmospheric loads responsible for regional scale atmospheric deposition of nitrogen. Artificial reservoirs modify the hydrological regime in the catchment and the behavior of such drivers, making the correlation between pressures in the catchment and ecosystem stressors even more difficult. However WFD goals require prediction of stressor effects when delineating the programs of measures needed for river recovery.
This paper addresses the Sorraia catchment in Portugal where flow regime and agriculture activity depend on two artificial reservoirs built in 1957/58. The Sorraia is one of the main irrigated areas in Portugal, with large industrialized and innovative farming exploitations. These reservoirs reduced the frequency and magnitude of flash floods, modify land use and land cover, alter groundwater quantity and properties. Nevertheless, reservoir lakes are considered different water bodies in the river continuum, and their effect downstream encompassed under the broad designation of "heavily modified water bodies", and not distinguishing between different riverine consequences.
In this presentation a methodology based on fully distributed catchment modelling and 3D reservoir modelling (MOHID) will be showed. The catchment is divided into 3 parts, one above each reservoir and the downstream part. Upstream, the sub-catchment models compute loads to reservoirs as a function of land use/land cover and of irrigation water availability. Reservoir models compute biogeochemical processes in the reservoirs, assessing the relation between their trophic status and upstream loads. Loads discharged by reservoirs are computed as a function of each reservoir discharge and of the abstraction depth and are added as loads to the downstream catchment model, while flow regime is modelled, at a daily basis. Based on this modelling system, local stressors are computed along the whole river system and used to assess ecological status using empirical correlations obtained from site data. Calibration uses an independent set of empirical data, thus enabling to explain ecosystem's status at a large scale, and to bring evidence of the impact of changing land management.

DISENTANGLING MULTIPLE STRESSOR EFFECTS ON INVERTEBRATE ASSEMBLAGES OF BOREAL STREAMS

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Catchment land use and other human activities interact to affect the biodiversity of stream ecosystems. Understanding how different stressors individually or in concert affect aquatic communities is needed for river basin management. The North Baltic water district, the most populated area in Sweden (ca 2.9 million inhabitants), was selected as a model system to study the cumulative effects of different stressors on benthic assemblages of streams. A total of 88 streams sampled for benthic invertebrates and water chemistry, and classified according to land use and hydrogeomorphological variables, were included in the study. Agricultural land use was the main pressure, resulting in elevated nutrient levels (mean 48 ± 43 µg TP/L, max 205; mean 428 ± 431 µg NO3-N/L, max 2332), loss of connectivity (61% or 54 sites classified as poor or bad) and alterations in morphology (44% or 39 sites).The response of benthic invertebrate diversity and selected species traits along increasing gradients of exposure to single and combined stressors will be discussed.

INDICATOR RESPONSES TO OLIGOTROPHIATION IN DANISH COASTAL ECOSYSTEMS

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Danish coastal waters suffer from eutrophication. In the 1980s the situation was so bad with fish kill etc. that a public pressure for political response was established. Since the mid-1980s several mitigation measures have been adopted to reduce the nutrient input from land – a process stimulated by the objective of good environmental status as describe in the Water Framework Directive and Marine Strategy Framework Directive. Based on data from 25 years of monitoring this presentation will describe indicator responses to oligotrophication.

Nutrient inputs from land were reduced by almost 50% for nitrogen and just over 50% for phosphorus since 1990. These reductions resulted in significant declines in nutrient concentrations, and initiated a shift in the dominance of primary producers towards less phytoplankton and more macroalgae. In the last five years eelgrass has also expanded in response to increased water clarity. The reduction in phytoplankton caused a decrease in the biomass benthic macrofauna composed of a drastic decline of filter feeders paralleled by an increase of deposit feeders. This shift was most likely induced by increased stratification reducing the access of filter feeders to plankton in surface water. Reduced benthic filtration probably kept more particles in suspension, which together with increased resuspension due to reduced sediment stability can explain why improvements in water clarity were modest. Further, bottom water oxygen conditions have not improved, presumably because more frequent stratification and higher water temperatures have counteracted the expected positive effects of reduced nutrient inputs. Overall, several ecosystem components demonstrated clear signs of improvement, suggesting that at least partial recovery is attainable with different time lag of the indicators. On this basis we propose a conceptual scheme for recovery of shallow coastal ecosystems following oligotrophication.

Session 5 10.40 -12.20 Rooms: Gripen, Ribban, Pildammen

Ribban

Coastal fish abundance in relation to environmental gradients - variability at different scales

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Insights on how species assemblages change along environmental gradients, and on the relative impact of different pressures (anthropogenic and natural), are needed in order to guide management priorities. In the Baltic Sea, coastal fish assemblages (less than 20 m depth) are dominated by relatively stationary species, which may respond to environmental pressures originating from local as well as larger geographical scale. However, due to the lack of coherent data, these aspects are rarely addressed together quantitatively. We studied the abundance of coastal fish along a large latitudinal gradient in the Baltic Sea, across areas of various level of anthropogenic disturbance. Focusing on the main species groups in the fish assemblage, we compare the relative importance of inter-annual and geographical variation and describe the effect of small-scale natural environmental factors on local patterns in abundance. We use this information to further explore the importance of natural environmental variables (temperature and salinity) and anthropogenic pressures (related to eutrophication and fishing) on variation in fish abundance. Spatial variation dominated and local variation was partly explained by differences in depth, temperature at fishing and wave exposure. At the broader spatial scale the abundance of Cyprinids increased towards areas with lower water transparency, as seen in eutrophic areas. The abundance of perch decreased with mean seasonal temperature and salinity. Our results suggest that the abundance of Cyprinids is a useful indicator for assessing ecological status in relation to eutrophication in coastal waters.

Fish community responses along eutrophication gradients in coastal waters, Sweden

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Fish communities are essential elements for an environmental status assessment of coastal environments. Fish is a valuable resource for commercial and recreational fisheries, but are also crucial for maintaining the ecological function of food-webs. Although coastal fish do not have an established role in assessments under the Water Framework Directive, the development of indicators for coastal fish status has been motivated in recent years by biological reasons, and by their relevance for assessment under the Marine Strategy Framework Directive. One critical aspect for a useful indicator is that its response to environmental pressures is known. Within the WATERS program, field studies were conducted during 2012 and 2013 in areas of various levels of anthropogenic impact, focusing on eutrophication. The purpose of the studies was to evaluate how different indicators of state respond to natural and anthropogenic environmental gradients. The studies were conducted in two areas, one in the Skagerrak on the Swedish west coast and one in the Baltic Sea, and provided a coordinated data collection campaign for several biological elements, from phytoplankton to fish. The following presentation gives example of some coastal fish status indicators under development and shows how they performed in the studied gradients, comparing pressure-state relationships between the low salinity areas of the Baltic Sea with the more saline areas of the Skagerrak.

Age structure in fish status assessment, with focus on low diversity inland waters

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Along with species composition and abundance, age structure of fish communities is important in the normative definitions of high, good and moderate status of the fish fauna in lakes and rivers, according to the Water Framework Directive (2000/60/EC). In practice it is challenging to conclude whether age structures of type-specific species show signs of disturbance attributable to anthropogenic impacts, and whether failure in reproduction and development of particular species are indicated. Challenges occur already in sampling and analysis of age structures, especially in fish communities with high abundance and/or high species richness. Therefore it has often been assumed that body-size structure is a relevant approximation of age structure, but the assumption has seldom been tested and validated. Recent studies indicate geographical and climatic patterns in size structure of lake fish assemblages at the European scale, but also that temperature is a more powerful predictor of size structure in within colder compared to warmer regions. Colder regions are found in much of the Scandinavian peninsula, where the fish fauna is also characterized by lower species richness than in many other European regions. Whenever only one or a few fish species contribute to the entire fish community within lakes or streams, metrics of fish age and size structure might be expected to respond faster than species composition to environmental change. In many low diversity Scandinavian lakes and streams, the major environmental pressures are acidification and hydromorphological changes, rather than eutrophication. More or less regular incidences of recruitment failure of dominant species are expected responses to the major Scandinavian pressures. Age and size structure metrics therefore need serious consideration in current development of common Swedish-Norwegian indicators for fish in lakes.

Fish in lake ecological assessment in Europe: Construction of multiple pressure indices

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It is well established that fish are sensitive indicators of environmental degradation and offer the major advantage of integrating both the direct and indirect effects of stress over large scales of space and time. Nevertheless, the use of fish communities as indicators of environmental quality is highly challenging. Therefore, the fish community has been one of the less-developed aspects of lake ecological monitoring. For the development of assessment systems, the key element is well established relationships between human pressures and reaction of the metrics. In spite of the well-known impacts of certain pressures, significant correlations are not present in most pressure-impact-analyses for fish in lakes. The reasons are manifold: (1) Fish show a wide range of responses to different impacts; (2) Mostly, fish react to

the pressures indirectly; (3) Fish integrate time and space across the whole lake and therefore provide a more holistic response.
The construction of integrated indices for the total anthropogenic pressure intensity can provide a solution to this problem. Such indices provide a comparable measure for the pressure intensity throughout the whole ecoregion. This paper describes two cases of successful construction of multiple pressure indices in the Alpine region and Central Baltic region. In both cases, these indices were used to establish pressure-response relationships with the Member State fish assessment systems.
In the Alpine region, Pressure Index included eutrophication, water level fluctuation, shoreline modification, connectivity, fisheries, recreation and alien/translocate species. As the result, this simple and transparent index showed significant relationships with Austrian, Italian and German fish-based lake assessment systems.
In the Central Baltic region, this task was more complicated due to huge variety of human pressures and biogeographic conditions across the region, as well as different sampling strategies and fish assessment concepts employed by the Member states. The construction of Total Anthropogenic Pressure Intensity (TAPI) index included exploration of 19 pressure metrics of 5 pressure categories – eutrophication, pollution, morphological alteration, hydrological alterations and biological pressures. In total, 48 versions of TAPI were tested in order to find the TAPI version with the best relationships to the MS assessment systems.
This paper seeks to answer the following questions:
• What is the current state-of-the-art of the fish ecological assessment systems used across Europe?
• Which pressures are assessed by fish assessment systems and are the pressure-response relationships tested?
• What are the main lessons and challenges of the construction of multiple pressure indices ?

Session 5 10.40 -12.20 Rooms: Gripen, Ribban, Pildammen
Pildammen

Remote sensing-based bioassessment – potential and limitations exemplified by aquatic vegetation

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Field-based bioassessment is tedious, resource demanding and even impractically if water bodies are numerous or in remote areas. Here, we report on recent experiences of remote sensing-based bioassessment using aquatic vegetation (macrophytes) as target organisms. High-resolution images (ca. 5 cm ground resolution) enabled us to identify species composition of vegetation stands at lake and river sites with an overall accuracy of 95 % and 80 %, respectively. Such classifications including mapping has per se a high value to for example assess the successional state and recreational values of lakes. The high accuracies in the classification of species encouraged us to proceed and study if high resolution images even could be used to determine the ecological status of water bodies. Since submerged vegetation is not detectable with ordinary RGB (red-green-blue) high resolution images, we focused that study on emergent, floating and floating-leaved species in colored lakes. We compared the performance of a trophic metric score based on remotely-sensible species with that based on field data from all species along different environmental gradients. The analyses revealed a significant linkage between the two community fractions (remotely-sensible and non-sensible) and considerable assemblage concordance. The results suggest a notable potential of the use of remote sensing in lake macrophyte monitoring. Along a mining-impacted boreal river, we applied a combination of high resolution remote sensing and field sampling to quantify riparian vegetation biomass and the amounts of environmental contaminants (Cd, Cu, and Zn) stored in dominant plant species in the riparian zone. The method revealed great potential for accurately assessing nutrient and trace element cycling in the riparian zone and for planning potential phytoremediation measures in polluted areas. However, the above examples also highlight limitations and future challenges when using high resolution remote sensing for bioassessment. These limitations are mainly related to a) the automatic segmentation and classification of high resolution images, b) detection of submerged aquatic species and c) tree-cover in the riparian zone impeding the detectability of macrophytes. We outline how these limitations can be overcome by for example using the latest software for automatic segmentation and classification, new digital sensors and different types of drones (remotely piloted unmanned aircraft systems).

TOWARDS MEASURING THE HABITAT EXTENT

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Under Marine Strategy Framework Directive (2008/56/EC) three criteria of good environmental status are established for the assessment of benthic habitats: distribution, extent and condition. The criteria 1.5 "habitat extent" refers to the area size of a habitat, but with relatively crude habitat maps and lack of spatial data with adequate sampling coverage in national monitoring programs to detect changes in habitat extent is really difficult if not impossible. In this study, we take a well-known and decently studied habitat in Lithuanian coastal area as a case study and try to select possible measures of its extent from the perspective that data is limited. Selected habitat is "Baltic photic mixed substrate dominated by perennial non-filamentous corticated red algae" (AA.M1C2 in HELCOM HUB classification). We discuss possible techniques for both mapping and monitoring of this habitat at different habitat classification levels, such as multi-beam and side-scan sonar for the third level of classification ("Baltic bottoms in the photic zone with more than 10 %, but less than 90 % coverage of both hard and soft substrata"), diver surveys, drop down cameras and ROV video surveys for the fourth ("perennial algae covers at least 10 % of the seabed") and fifth ("out of the perennial algae, perennial non-filamentous corticated red algae constitutes at least 50 % of the biovolume") level of classification. We also discuss the need to evaluate both criteria the habitat extent and condition, since the decrease in habitat quality eventually could lead in changes of habitat size.

VALIDATION OF THE RED MACROALGA FURCELLARIA LUMBRICALIS MAXIMUM DEPTH LIMIT AGAINST THE EUTROPHICATION PRESSURE IN THE SE BALTIC SEA

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The only habitat forming perennial macrophyte off the SE Baltic coastal zone is Furcellaria lumbricalis. The densely vegetated areas of this red alga are known as natural spawning substrates for the Baltic herring, as the secondary substrate for filamentous macroalgae and blue mussels, shelter of mobile crustaceans and feeding grounds for wintering birds. Generally perennial attached macroalgae integrate the effects of long-term exposure to nutrients or other pollutants, therefore macroalgae are considered as one of the best water quality indicators. Consequently there are proposed many water quality indicators based on macroalgae properties such as exent area, cover, maximum depth limit, proportion of annual vs. perennial species, etc. In this study we present applicability of the red macroalga Furcellaria lumbricalis maximum depth limit as indicator for eutrophication and biodiversity in the SE Baltic coastal zone. The sensitivity of indicator to eutrophication gradient (concentration of nutrients and Secchi depth) and biodiversity was assessed by correlation analysis. The obtained results are discussed, including proposed threshold values of criteria.

Cover of hard and soft bottom vegetation in coastal waters in relation to environmental variables

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Vegetation-covered belts composed of macroalgae and seagrasses/soft-bottom macrophytes are widespread along the Worlds' coastlines where light reaches the seafloor. The belts have important functional roles in primary production, habitat- and biodiversity, coastal protection, carbon- and nutrient cycling and storage which, in combination with their sensitivity to eutrophication, render them potential indicators of good environmental status. We hypothesized that vegetation cover increases along large-scale gradients of declining eutrophication pressure when variability in sampling and natural setting among sites are accounted for. We tested the hypothesis on the basis of a large data set covering the 11500 km long Swedish coastline from the high saline west coast to the brackish Bothnian Sea and Bothnian Bay on the Swedish east coast in the inner Baltic Sea. Macroalgal cover increased significantly along gradients of declining nutrient concentration and increasing water clarity when we had accounted for diver effects, spatio-temporal sampling variability and the strong gradients of salinity, exposure and latitude across the Baltic Sea. The developed empirical model explained ~80% of the variation in algal cover. On this basis we identified macroalgal cover as a promising indicator of ecological quality across the Baltic-wide study area. A parallel analysis of soft-bottom macrophytes identified significant increases in cover with decreasing concentrations of total nitrogen and increasing salinity and the resulting empirical model explained 52 % of the variation in cover. The model for soft-bottom vegetation was, hence, less robust than that for macroalgae as the data set did not allow as complete an understanding of the sources of variability. However, the study underlined that the largest cover of both macroalgae and soft bottom macrophytes occurred in the clearest and/or least nutrient rich sites along the coastline and tended to be higher in the most saline regions.

Biological traits of coastal soft-bottom vegetation – responses to natural and anthropogenic gradients

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The ability of organisms to occupy different niches along environmental gradients is to a large extent related to biological traits. Furthermore, as biological traits such as productivity reflect the ecological function of a species, grouping of species based on biological traits translates directly to ecosystem function. In this study we evaluated whether traits of soft-bottom macrophytes (vascular plants and charophytes) can be used to assess the effects of human impacts in coastal areas. We compiled a database of morphological and life-history traits for soft-bottom macrophytes present in monitoring data from Swedish marine and brackish waters and coupled the defined traits with abundance estimates of the species and with information on environmental gradients.
On the Swedish west coast and in wave exposed areas of the Baltic Proper the soft-bottom vegetation is strongly dominated by eelgrass (Zostera marina), the only true seagrass species that is found in the study area. With its marine origin, eelgrass possesses a unique combination of functional traits and ecology, highlighting that it plays a special role that cannot easily be replaced by any other species. Most of the other soft-bottom macrophytes in the study area are confined to areas with lower salinity and wave exposure. Thus, the largest variation in trait composition of the vegetation can be found in low-saline and sheltered areas of the Baltic Sea. Here we could show that some traits and trait combinations were correlated with a gradient in human pressures. Most prominently, there was a gradient from plant communities dominated by small, often rosette-forming species to communities dominated by large-growing species that coincided with a gradient in nutrient and chlorophyll concentrations. This supports the general notion that large size and possession of large seeds give a competitive advantage when resource availability is high. In aquatic systems, species that concentrate a large part of their biomass close to or at the surface are also less sensitive to reduced light availability due to phytoplankton blooms.
The results show that a trait-based indicator for soft bottom vegetation could only be developed for areas with low salinity and wave exposure, where the species pool is large enough to include a range of attributes and trait combinations. In the open, high-salinity parts of the Baltic Sea proper, as well as on the Swedish west coast, a more promising approach is to look specifically at the distribution and abundance of Zostera marina, and possibly the relative abundance of this species compared to the abundance of opportunistic macroalgal species.

Session 6 13.20 - 14.40 Room: Ribban/Pildammen

Ecosystem status and indicators: the way it can, should and will work!

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The main policy goals of the Water Framework Directive (WFD) & Marine Strategy Framework Directive (MSFD) are to reach a good status of the marine ecosystem, implying that human activities have to be performed in a sustainable way. Indicators are the scientific response to the governmental need for reliable and accurate information on the conditions or so-called 'status' of the ecosystem.
Due to the complexity of aquatic ecosystems, several indicators with complementary properties are needed to effectively support the decision-making process (Van Hoey et al., 2013). However, the delineation of an appropriate set of indicators still remains a major challenge. Both WFD and MSFD follow different strategies and EU member states are defining separate sets of indicators for either directive. Major discrepancies between directives and member states are related to: (1) differences in available research experience (and data availability) between member states, (2) lack of a common implementation strategy (several indicator types for the same ecosystem component and descriptor), (3) the degree of risk and uncertainty each authority is prepared to accept, and (4) the interpretation of the term 'good status'.
The WFD strategy allows each member state to define its own set of indicators, and adheres to multiple intercalibration exercises to evaluate the compatibility between the different indicators. Currently, the inter-calibration for the North East Atlantic (NEA) region is in its 3th phase (JPI oceans pilot action) and shows that, for example for the benthic ecosystem component in coastal waters an inter-calibration for the 10 existing and selected benthic indicators is feasible, be it a long-winded road to get there.
On the contrary, the MSFD strategy strives towards common indicators on a regional scale instead of inter-calibrating the existing or proposed ones. This development process is carried out by a variety of EC, OSPAR and ICES working groups, none of them with real 'political' power to take decisions on the implementation at EU (or regional) scale. This

has led to even more pronounced discrepancies compared to the WFD process. For example, a comparison of 45 benthic indicators for soft sediments in the NEA region proved to be chaotic, full of vague approaches, with only a weak link to the WFD indicators. Moreover, this whole comparison exercise is continuously struggling with the varying ambitions of the different authorities and member states.

There is still a long way to go, yet both WFD and MSFD processes already largely increased our knowledge on the application of indicators in marine management. The different processes show us how it can and should work, and slowly lead us in the right direction of a common assessment of the ecosystem status by means of a widely accepted and appropriate set of indicators.

Imperfect information: Status classification in a world of uncertainty

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Any ecological or environmental status classification is associated with uncertainty. Although uncertainty indeed is inconvenient in decision making, it cannot be neglected and probabilities of misclassification must be addressed together with the status classification. Uncertainty arises from multiple sources, including spatial and temporal properties of sampling as well as methodological errors, and these errors propagate from measurements to indicators to the final classification. In practice, all the possible uncertainty components cannot be quantified and it is therefore important to focus on the largest sources of random variation. In WATERS, we have developed an uncertainty framework with a gross list of uncertainty components that should be considered when calculating indicators from monitoring data to characterize an entire waterbody over an assessment period. We will demonstrate how this framework can be employed to quantify various sources of uncertainty for different indicators, and exemplify how these uncertainty components affect the overall assessment when integrating multiple indicators. Finally, we will discuss how uncertainty can be reduced by incorporating explanatory variables for the indicators and by designing monitoring programs aiming at establishing a more certain basis for status classification.

Overcoming the challenges of indicator integration and arriving at a full-bodied classification of Good Environmental Status sensu the Marine Strategy Framework Directive

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The Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) require assessments and classifications of 'status' based on an extensive range of indicators grouped according to WFD 'quality elements' or to MSFD 'criteria' and 'descriptors'. Guidance on integration principles and methods is, despite the 'one out - all out' principle, inadequate and therefore integration becomes a challenge with multiple dimensions. This presentation will present ways of overcoming these based on the development, testing, and application of both thematic assessment tools ('eutrophication status', 'chemical status', and 'biodiversity status') and an overarching tool for assessment of 'ecosystem health' (in practise equivalent to Good Environmental Status). Examples of various integration principles and methods will be given along with the results of the Baltic Sea 'ecosystem health' assessment.

Session 7 15.10 - 16.30 Room: Ribban/Pildammen

Management implications of global change impacts on stream ecosystems

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Changes in climate are occurring rapidly, far beyond the range of previous natural variability. I will deal with four major questions. 1) To what extend is climate changing compared to the management horizon? 2) What effects on aquatic ecosystems can be expected? 3) Do climate change effects matter in comparison to other human induced disturbances? 4) What are the consequences of climate change upon water quality assessment and water management?
Climate change forecasts indicate regional temperature increases and more variable precipitation patterns. Temperature increase directly affects aquatic ecosystems but also reduction in ice-cover and changes in phenology will pose

changes. More precipitation is predicted in winter for Northern Europe together with drier summers with incidental heavy thunder showers.
Parallel to this climate-induced change is the underlying effects that human-induced impacts, such land use (e.g. agriculture, urbanisation), are having on the biodiversity of aquatic ecosystems. The interaction of both can have both antagonistic as synergistic effects.
Until now, pressures related to anthropogenic land and water use and hydromorphological modification of water bodies have a much stronger impact on aquatic ecosystems than climate change. Changes in bed and bank structure and modification of water flow arising from human activities are the main threat for ecological status of streams in the EU. Despite improvements in some regions, nutrient loading from agriculture remains a major pressure on Europe's freshwaters, primarily as a result of eutrophication.
In the WFD water bodies are assessed using a methodology based on the use of reference conditions. Climate change will also change natural water bodies and thus the reference conditions. Shifting reference conditions imply more flexible approaches to WFD ecological water quality assessment. Managing water resources and aquatic ecosystems in the face of uncertain climate requires new approaches. Most of the adaptation strategies and measures are based on general ecological principles and are measures that managers are already using. To address climate change, managers will need to act over different spatial and temporal scales. The focus of management and restoration will need to (i) shift from (historic) references to potential future ecosystem services, and from reactive measures towards pro-active ones. Strategic adaptive management based on potential future climate impact scenarios will need to become a part of any action.

The consequences of global climate change for complying with MSFD Indicators

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Global climate change is regarded as an exogenic unmanaged pressure in which the local marine and estuarine management has to respond to the 8 sets of consequences of that change rather than address the causes of the change: (I) Altered temperature regime – species re-distribution; (II) Altered temperature regime – physiological repercussions; (III) Physiographic changes – increased relative sea-level rise; (IV) Coastal hydrodynamics – increased climate variability; (V) Land-based discharges and run-off – changes to NAO/rainfall run-off patterns; (VI) Estuarine hydrodynamics – increased relative sea-level rise; (VII) Seawater physico-chemical changes – ocean acidification, and (VIII) Global transport repercussions – loss of polar ice cover. Building on a recent study on the effects of these on Descriptors for attaining Good Environmental Status (GEnS) for the EU Marine Strategy Framework Directive, the analysis here cross-references these 8 topics against a set of 45 core indicators derived from OSPAR, HELCOM and MEDPOL agreed indicators. It is emphasised that complying with these indicators will be challenging and marine management difficult because of (i) 'shifting baselines' caused by climate change particularly during GEnS monitoring and assessment and (ii) 'unbounded boundaries' due to open marine systems given the migration and dispersal of highly-mobile species. It is suggested that climate change may prevent the indicators and hence GEnS being met, but Member States may rebut legal challenges by claiming that this is outside its control, force majeure or due to 'natural causes' (Article 14 of the MSFD). The analysis is relevant to management of other global seas.

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