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BONUS

SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

briefing

BEAST

Biological effects of human induced chemical stress: tools for the assessment of ecosystem health



BEAST has made marked progress on developing integrated measures of chemical pollution and tools contributing to holistic ecosystem health assessments in the Baltic Sea. Quality assured data and information of biological effects of contaminants in different sea areas of the Baltic Sea have been collected to facilitate the implementation of this component into the Baltic Sea monitoring programme with regard to the requirements of HELCOM Baltic Sea Action Plan and EU Marine Strategy Framework Directive.

OVERVIEW

Marine and coastal ecosystems are impacted by multiple human induced activities including a severe load of hazardous substances. Effects of hazardous substances can be observed at all different levels of biological organisation, starting from the genome and going through cell, tissue/organ and organism up to populations and communities. Moreover, many chemicals present in the environment act together and during a long time span. Consequently, the impacts must be strongly considered when assessing the health status of marine ecosystems. To ensure validity of risk assessments, there is a need to bridge the gap between the measured concentrations of chemicals and their biological effects in the real world. This becomes of a critical importance especially when considering that most typically the risks are assessed and their threshold levels

identified under laboratory conditions by the use of selected test organisms while the ensuing management measures are based on the chemical monitoring of the levels of individual substances in the environment.

Monitoring of biological effects of contaminants is, to a large extent, lacking in the Baltic Sea region. The outcomes of BEAST facilitate the implementation of these methodologies currently in use in marine areas elsewhere (e.g., the North Sea, the Mediterranean). The major aims of the project have been to

- develop a comprehensive and integrated multi-level toolbox for the detection and evaluation of biological effects of contaminants
- contribute to the establishment of the baseline and target values on a sub-basin level
- provide scientifically-based instruments for an integrated chemical-biological effects monitoring and thus ecosystem health assessment in the Baltic Sea, harmonized with similar activities in other European sea areas
- arrange workshops and training activities encompassing methodological aspects.

BEAST is a true pan-Baltic effort with 16 partner institutions from all nine Baltic Sea countries participating in the project. This is of crucial importance in regard to the success of implementing the approach and methodologies. BEAST has also been nominated as a Flagship project in the EU Strategy for the Baltic Sea Region (EUSBSR) Priority Area 3.

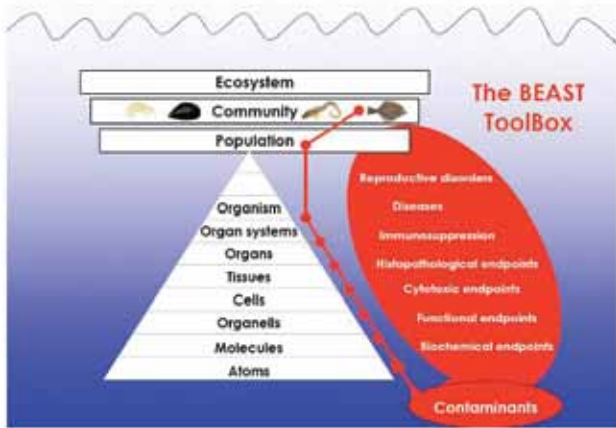


Figure 1. Hierarchical structure presenting targets of biological effects of contaminants and their respective measurable endpoints.

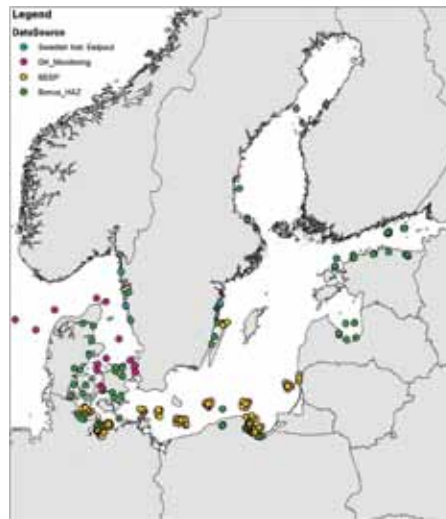


Figure 2. BonusHAZ database: sampling sites (as up to August 2011)

OUTLINE OF KEY RESULTS

FIELD STUDIES AND EXPERIMENTS

Field research providing an extensive database that enables assessments of biological effects in different regions of the Baltic Sea has been carried out throughout the life-time of the BEAST project. The usefulness of various new and already established biomarkers of contaminant effects have been identified. Also, new biomarker methods have been developed. Differences among various species of animals regarding their sensitivity to contaminant exposure have been shown in different sub-regions of the Baltic.

GUIDELINES AND INTERCALIBRATION OF METHODS

BEAST has generated recommendations of methodologies, data integration and environmental assessment criteria based on new and previously acquired data covering all main regions of the Baltic Sea. In addition, a marked effort has been made in dissemination of the methodological know-how by arranging a number of workshops on various biological effects across the Baltic Sea region, forming a practical basis for the implementation process.

The technical guidelines for monitoring biological effects of contaminants in the Baltic Sea will be finalised and made publicly available as an output of the project. Recommendations for the design of future integrated monitoring of contaminants and their biological effects in the Baltic Sea are being developed. A number of training/intercalibration activities have taken place, e.g. regarding sampling for biomarker measurements, the measurement of polycyclic aromatic hydrocarbon (PAH) metabolites in fish bile, infectious and non-infectious fish diseases, pathology in liver tissue, reproductive disorders in eelpout, enzymatic biomarkers in bivalves, chemical biomarkers in fish tissue, and reproduction and developmental disorders in amphipod crustaceans.

DATA TREATMENT, INTEGRATION AND ADVICE

The BonusHAZ database, created jointly with the BONUS+ BALCOFISH project, is developing into the most comprehensive database for the Baltic Sea in regard to bioeffects of contaminants on a range of key species. Presently, datasets consist of up to 60 different parameters for approximately 600 single specimens of different fish species (e.g. eelpout, flounder, herring), bivalves or crustaceans.

In addition, all data collected different Baltic Sea parts by the previous EC-funded project BEEP (2001-2004) are part of the BonusHAZ database. Moreover, relevant monitoring data from Denmark and Sweden for eelpout, amphipods and mussels have been included as well. Data integration exercises have shown the value of biological effects methods in detecting and assessing pollution in the Baltic Sea.

In relation to the HELCOM CORESET project¹ BEAST has provided recommendations for a set of bioeffect core indicators to be proposed to HELCOM contracting parties and included into the future Baltic Sea environment monitoring and assessment programme. The recommended methods ("Core Indicators") are the following:

- General stress caused by a range of contaminants ("early warning"): *lysosomal membrane stability (LMS) in fish, bivalves or amphipods*
- Effects caused by genotoxic contaminants ("early warning"): *induction of micronuclei (MN) in fish, bivalves or amphipods*
- Reproductive success impairments caused by a range of contaminants: *embryo aberrations in fish (eelpout) or amphipods*
- General health status: *Fish Disease Index based on externally visible fish diseases, macroscopic liver neoplasms and liver histopathology.*

In addition, two contaminant-specific biological effects indicators, *imposex in marine snails* and *PAH metabolites in fish*, have been included as part of the Core Indicators for TBT and PAH compounds, respectively.

Throughout the BEAST work, close collaboration with key inter-governmental organizations such as HELCOM and ICES has been instrumental. Supported by findings of the BEAST project and the previous EC-funded project BEEP, the ICES Study Group for the Development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea (SGEH) was able to develop the Baltic-specific assessment criteria and finalize corresponding background documents for a range of potential bioeffect core indicators. These documents are already available at the ICES website www.ices.dk.

1. CORESET is a HELCOM project aiming at developing the core sets of indicators of biological diversity and hazardous substances for the Baltic Sea.

BEAST Sampling scheme for flounder (*P. flesus*)

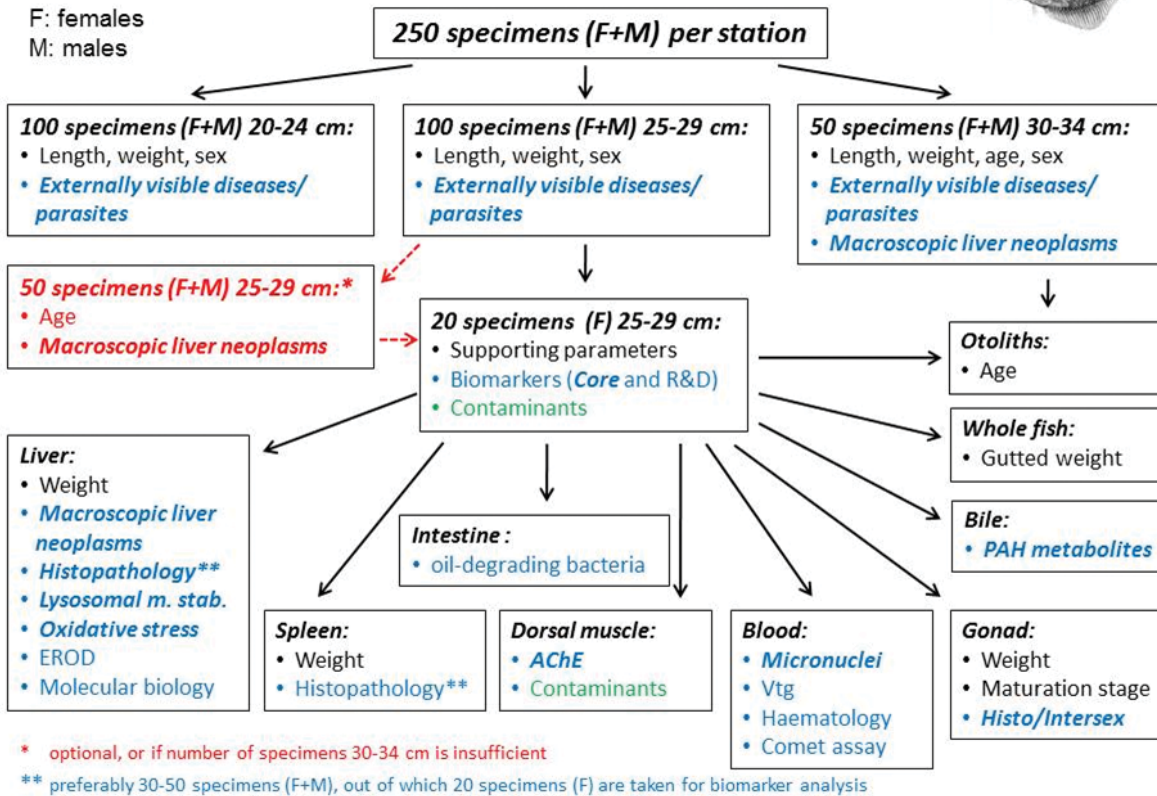


Figure 3. BEAST sampling scheme for flounder.

The science-based recommendations and compilation of sub-regional monitoring and assessment practices and methodologies will provide a major boost for managing of problems concerning chemical contamination and its potential ecological and socio-economic impacts in the Baltic Sea.

NEXT STEPS AND FUTURE PLANS

Whereas the aim of the BEAST project is to support the harmonised implementation of the HELCOM Baltic Sea Action Plan and EU Marine Strategy Framework Directive in relation to contaminants and pollution effects on marine wildlife in the Baltic Sea, the ultimate goal of practical implementation of an integrated chemical-biological monitoring methodology into national and international monitoring programmes must be reached by further activities now being planned.

Future work should focus on actions directed to support the implementation of the Baltic Sea Action Plan and EU Marine Strategy Framework Directive in the Baltic Sea region by active contacts with stakeholder organisations, industry and political decision makers. This is achieved by arranging seminars, meetings and other public events, where cost-efficient monitoring strategies in regard to chemical contamination are presented, discussed and evaluated. National and international workshops in regard to methodologies used; especially concerning biological effects measurements should be arranged. Effective communication with end-users of the data and knowledge in decision-making processes in regard to the management of contaminants in the Baltic Sea region is vital.

In addition to these goals, activities related to filling gaps in knowledge, e.g. testing of new potential methods to be used in monitoring should be initiated. Development of Ecological Risk Assessment involving biological effects should also be included in the new programme.

Enlarging of the BEAST network with the aim of bringing together all major actors in the field would facilitate the planning of projects specifically targeted at relevant research and application within the topic. BEAST has great potential to form the largest international network of expert institutions in the field of developing monitoring and assessment of chemical contaminants in the Baltic Sea region.

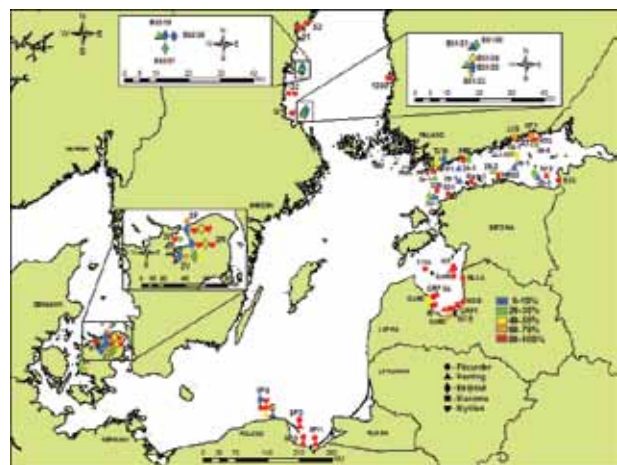


Figure 4. Micronucleus frequency (biomarker of genotoxicity) in various organisms from BEAST sampling sites in the Baltic Sea.

IN BRIEF

BEAST

Biological effects of human induced chemical stress: tools for the assessment of ecosystem health

BEAST is targeted at developing integrated chemical-biological monitoring of chemical contaminants and assessment of ecosystem health in the Baltic Sea with emphasis is on biological effects methods, so far very little applied in the area.

KEY RESULTS

- Guidance on the application of biological effects methods for the assessment of impacts of chemical contamination on ecosystem health of the Baltic Sea have been developed and actively disseminated through practical training of staff.
- A set of bioeffect "core indicators" for the Baltic Sea monitoring and assessment programme have been proposed: (1) general stress: lysosomal membrane stability (various species); (2) genotoxic effects: induction of micronuclei (various species); (3) reproductive impairments: embryo aberrations in fish (eelpout) and amphipods; (4) Fish Disease Index, based on externally visible diseases, macroscopic liver neoplasms and liver histopathology. In addition, two contaminant-specific indicators, imposex in marine snails and PAH metabolites in fish, are included as indicators of TBT and PAH contamination, respectively.
- The most comprehensive database to date on various biological effects of contaminants on Baltic Sea organisms has been created. This allows comparison of data from various species in different sub-basins of the Baltic and the establishment of assessment criteria for various parameters and species.

WHO NEEDS THE INFORMATION

The project results are directly applicable for all parties – national institutions/agencies, municipalities, industry, etc. – carrying out monitoring and assessment concerning contaminants and their effects in the Baltic Sea marine environment.



PROJECT PARTNERS AND COORDINATOR

Finland

Finnish Environment Institute (Coordinating partner)
Finnish Game and Fisheries Research Institute

Denmark

University of Aarhus, Department of Biosciences

Estonia

Estonian University of Life Sciences

Germany

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Lithuania

Nature Research Centre, Vilnius University

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Scientific Research Center for Ecological Safety RAS
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