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New Approaches in Determining the Impacts of Chemical Pollution to Protect the Biodiversity of the Baltic Sea

Detect2Protect

Newsletter No. 2

THE MISSION

Detect2Protect (*New approaches in determining the impacts of chemical pollution to protect the biodiversity of the Baltic Sea*) examines the relationships between chemical pollution and biodiversity in the Baltic Sea. Apart from gaining important new knowledge on this linkage the objective is to develop integrated chemical-biological monitoring and assessment frameworks for the marine environment.

www.biodiversa.eu/2023/04/19/detect2protect/

PARTNERS OF THE PROJECT

- Marine and Freshwater Solutions, Finnish Environment Institute, Helsinki, Finland (Syke)
- Department of Marine Systems, Tallinn University of Technology, Tallinn, Estonia (TalTech)
- Laboratory of Ecotoxicology, Nature Research Centre, Vilnius, Lithuania (NRC)
- Institute of Oceanology, Polish Academy of Sciences, Sopot, Poland (IO PAN)
- Marine Monitoring, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University, Riga, Latvia (LHEI)
- Department of Biological and Environmental Sciences, University of Gothenburg, Gothenburg, Sweden (BIOENV)
- Environmental Science, Stockholm University, Stockholm, Sweden (SU)
- Department of Life and Environmental Sciences, Universita Politecnica Delle Marche, Ancona, Italy (UNIVPM) - subcontractor

Syke TAL TECH UNIVERSITÀ POLITECNICA DELLE MARCHE GAMTOS TYRIMŲ CENTRAS IBPAN LATVIJAS HIDROEKOLOĢIJAS INSTITŪTS UNIVERSITY OF GOTHENBURG UNIVERSITET STOCKHOLMS

DESCRIPTION AND KEY OUTPUTS OF WORK PACKAGES (WP)

WP 1
Project management

Syke is responsible for all operational management activities of the project, including the organising of meetings and workshops, monitoring and administration. Syke together with the WP leaders ensures that the work in all WPs is performed according to the agreed work plan and a timely production of project outputs.

WP 2
Data mining

Open source databases are used to collect data on (i) chemical contaminants in sediment and biota, (ii) biological effect parameters in target species, and (iii) species abundance in benthic communities aggregated into a structured data set.

- Impact map for sampling site selection
- Background data for integrated assessments

WP 3
Field studies and laboratory analyses

Target species were collected from six study regions to assess their contaminant levels and health status by using various biological effects methods. These data will be linked to eDNA metabarcoding for community diversity analysis and stable isotope mapping of the trophic niche.

- Review on the use of biological effects methods in the Baltic Sea
- Report on biomarker baseline variability in the study regions
- Report on the synthesis of biological effects and biodiversity in contaminated vs. reference sites
- A complete project dataset
- Scientific publications

WP 4
Data integration, multivariate analyses and modelling

The data obtained in WP2 and WP3 will be processed in WP4 to investigate relationships between the different contamination and biological effect patterns with biodiversity.

- Data integration procedures and new approaches
- Multivariate analysis on linkages between biodiversity and contamination
- Structure of the diagnostic model and first results from its application

WP 5
Dissemination of results and stakeholder involvement

Outreach activities, dissemination of results, and communication with stakeholders are channelled via WP5 in collaboration with WP1. The results will be systematically presented to researchers, policy makers and the general public.

- Project website and periodic newsletters
- Stakeholder workshop
- Policy Brief

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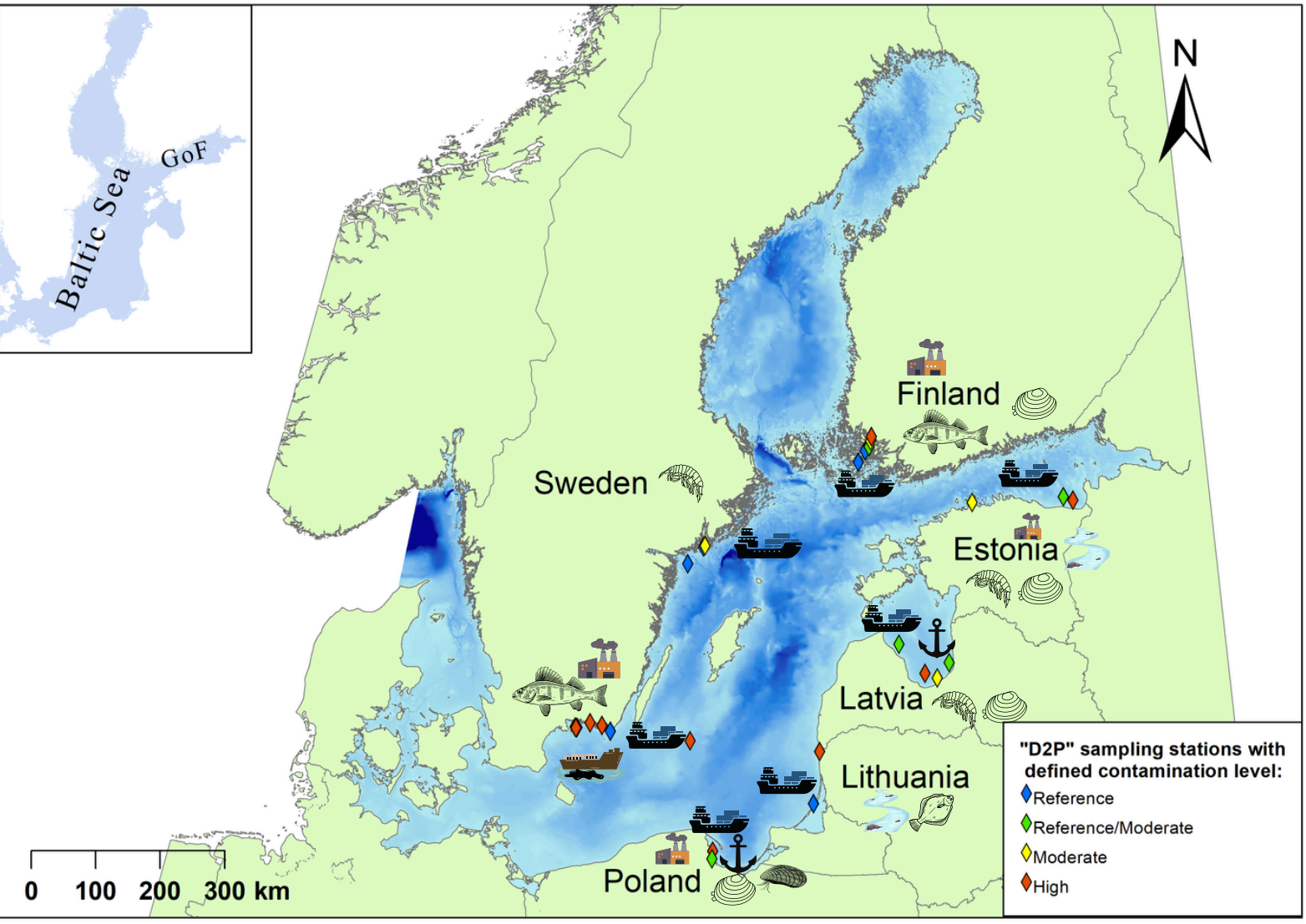
LOCATIONS OF SAMPLING SITES



source of pollution

industry | agricultural runoff | oil spills | shipping | port

target species

Perca fluviatilis | *Platichthys flesus* | *Macoma balthica* | *Mytilus trossulus* | *Monoporeia affinis*

Extensive chemical pollution originating from both terrestrial and marine sources affects the Baltic Sea. The majority of sources are land-based, including runoff from farms and industries, wastewater treatment facilities and atmospheric deposition of industrial pollutants. Shipping, fishing, and past marine dumpings such as World War II chemical munitions are examples of marine sources.

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TARGET SPECIES

In the selection of target species we considered several key features including ecological relevance, sensitivity to contaminants, response time to environmental stressors and the possibility to measure biological effects using biomarkers.

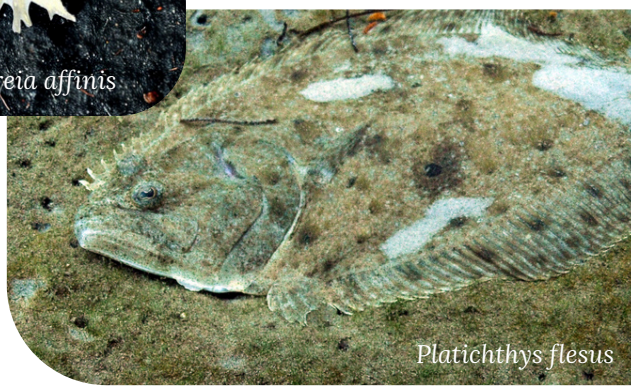
Due to its low biodiversity the Baltic Sea offers a limited number of potential target species suitable for biological effect monitoring. The newly updated recommendations of the ICES/OSPAR/HELCOM Study Group SGEFF include several fish, bivalve, amphipod and gastropod species. In Detect2Protect, the following were chosen: the European perch *Perca fluviatilis* and European flounder *Platichthys flesus* for fish, the Baltic clam *Macoma balthica* and the mussel *Mytilus trossulus* for bivalves, and *Monoporeia affinis* for crustaceans. However, not all of them could be studied at all the study regions.


Mytilus trossulus

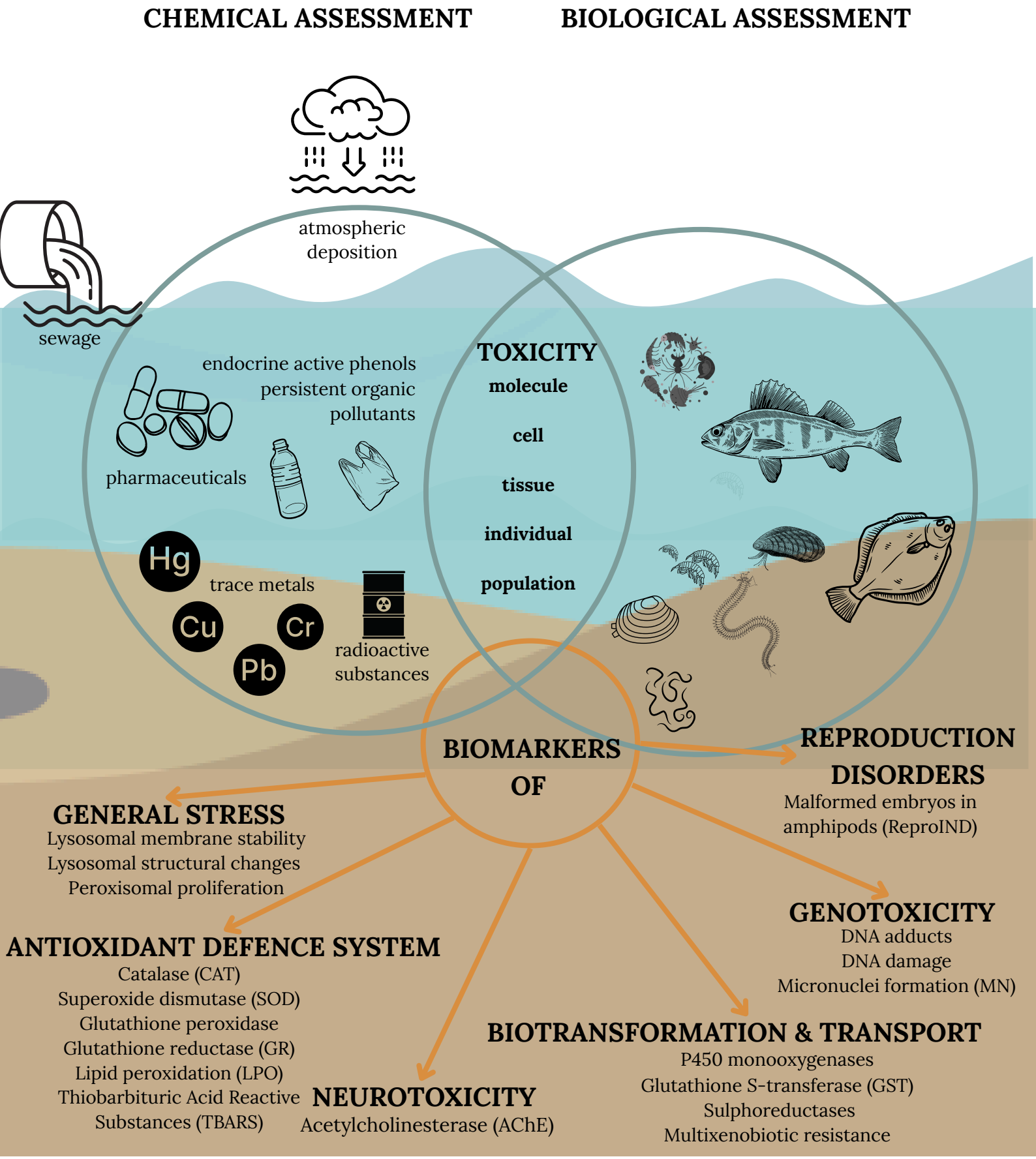

Macoma balthica


Monoporeia affinis


Perca fluviatilis


Platichthys flesus

GENERAL APPROACH

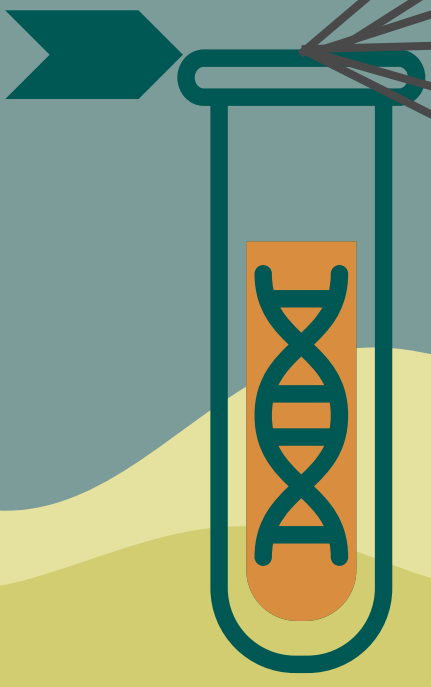


SELECTED METHODS

Metabarcoding using environmental DNA (eDNA) is a promising tool for biodiversity assessment. Sequencing of DNA from environmental samples is used to determine the presence of species and to assess overall biodiversity. To study the impacts of pollution on biodiversity we combined the eDNA approach with biological effects methods (biomarkers) and chemical data to integrate responses across the different levels of biological organisation.

COLLECTION OF SEDIMENT SAMPLES

eDNA METABARCODING



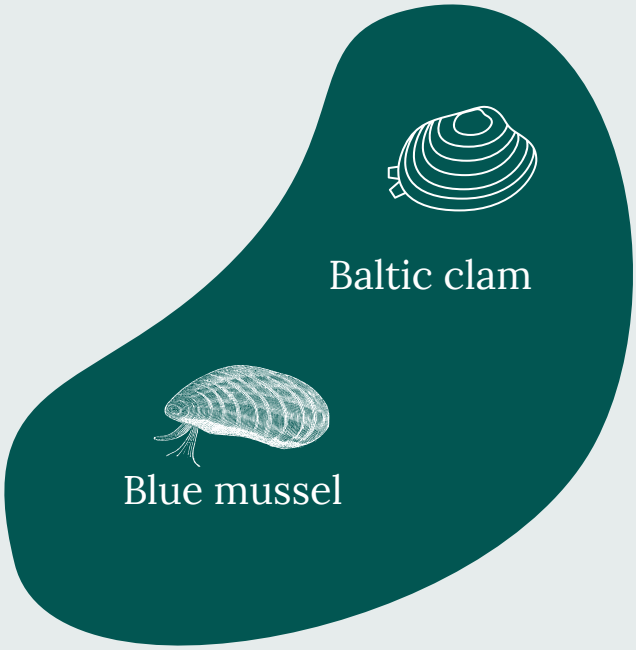
INFORMATION ON LOCAL BIODIVERSITY

SELECTED METHODS

The chosen biological effect methods focus on some key types of chemical toxicity with potential impacts at population, community and ecosystem levels.

Micronucleus test and other nuclear abnormalities; enzyme activities of CAT, SOD and GST; blood glucose

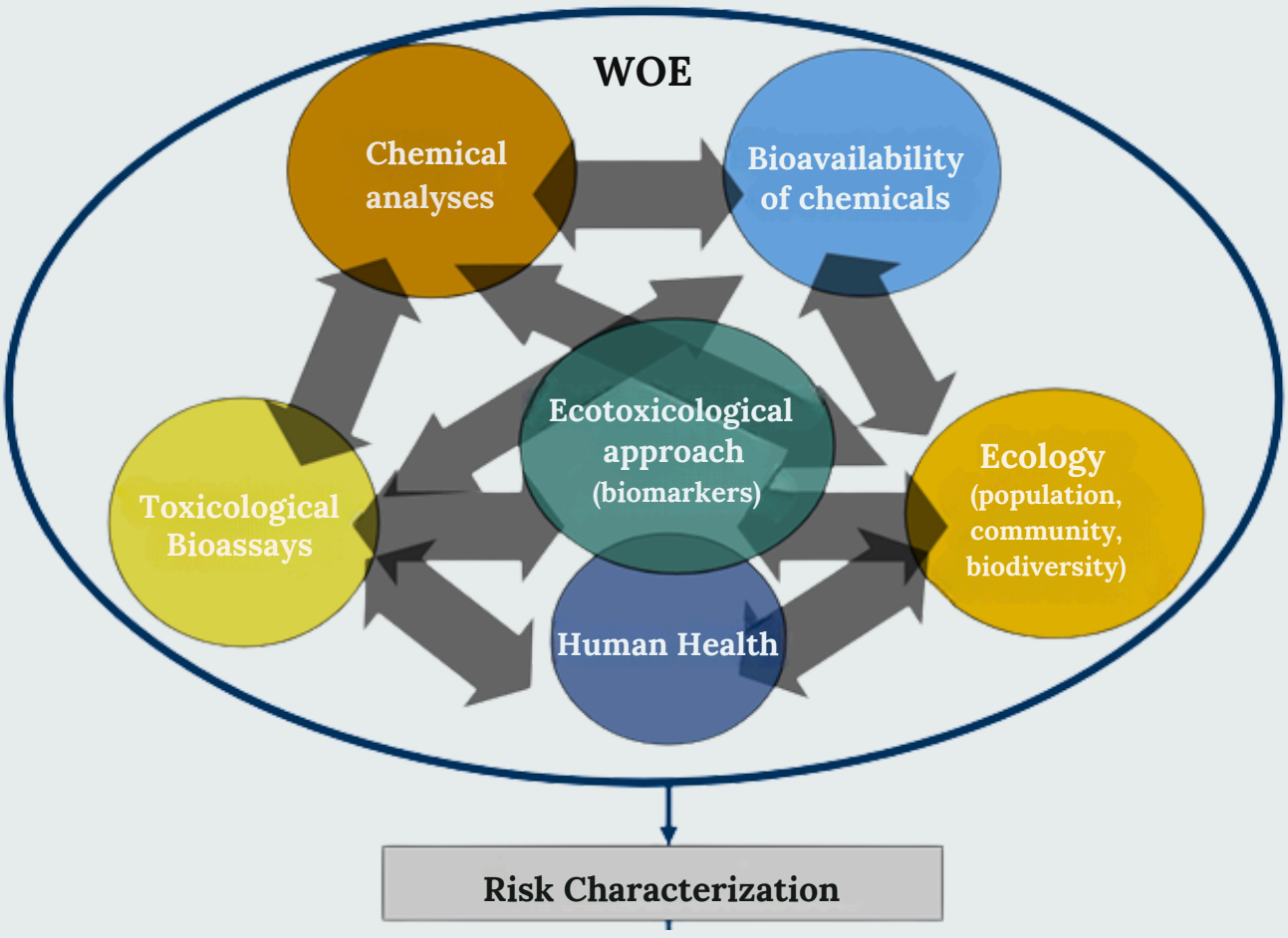
AChE, CAT, GR, GST, TBARS, ReproIND



AChE, TBARS, CAT, GST, GR

DATA INTEGRATION

The obtained data will be processed in WP4 to investiagte relationships between the different contamination and biological effect patterns as well as their relationships with the observed biodiversity at the polluted and unpolluted study sites in each region. Several approaches will be used, including integrative biomarker index calculation methods and the weight-of-evidence approach (WoE) consisting of the integration of different typologies of environmental parameters.



LATEST ACTIVITIES

We actively participated in the Baltic Sea Science Congress 2025, showcasing our recent work via several oral presentations and posters. Furthermore, the use of biomarkers in the monitoring of the Baltic Sea environment was addressed in the side event "*Monitoring of Chemical Pollution in the Baltic Sea: Why and How Biological Effects Measurements Fit in*?", co-organised by the project.

https://www.bssc2025.pl


Suomen ympäristökeskus
Finlands miljöcentral
Finnish Environment Institute
syke.fi | ymparisto.fi

Impacts of chemical pollution on biodiversity and biological responses in the Archipelago Sea (Baltic Sea)

Raisa Turja, Anna Reunamo, Ivan Kuprianov, Milda Stankevičiūtė, Janina Pažusienė, Ksenia Pazdro, Marcelina Zlotkowska, Riikka Puntila-Dodd, Joachim Sturve, Heidi Herlevi, Rahel El Daira, Ossi Tonteria, Kari K. Lehtonena

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The clam *Macoma balthica* is a useful biomonitoring species forchemicalpollution.
Pollution was associated with biomarker responses and lower biodiversity.
Biomarker profiles can differentiate between acute (heatwave) andchronic(pollution)stress responses.
Heatwaves induce stress and disturb the benthic macrofauna communitystructure.
Tolerantspeciesandlowspeciesrichnessatpollutedsites.

Chemical pollution is a major threat to marine ecosystems. This study combines biochemical biomarkers in the soft-bottom clam *Macoma balthica* with benthic community metrics to reveal how contaminants impact marine biodiversity. Biomarkers provide early warning signals of sublethal stress that may precede visible changes in community structure.

Results & Discussion

Site 1: Unpolluted, stable temperature, reference station
- Biomarkersshownoclearsignsofphysiologicalstressin***M. balthica***.
- Highestabundanceandspeciesrichnessofbenthicinfauna.
- Dominance of pollution-sensitive amphipods (***M. affinis***, ***P. femorata***) explainloweriversityandevennessdespitehighspeciesrichness.

Site 4: Polluted, stable temperature
- Biomarker responses indicate oxidative damage and weakened antioxidant defense; also low abundance of ***M. balthica*** was observed.
- Moderatediversityandevenness,butreducedspeciesrichness.
- Mix of pollution-sensitive (e.g., ***H. spinulosus***, ***M. affinis***) and tolerant species (e.g., ***Marenzelleria*** spp.), indicating a transitional community under moderate stress

→ **Low *M. balthica* performance and stress biomarkers, along with reduced richness and a mix of sensitive and tolerant species, indicate chronic pollution impact and a community in ecological transition.**

Site 3: Unpolluted, affected by a heatwave
- ***M. balthica*** showed high abundance and biomass, suggesting a healthy population undergoing active growth and reproduction.
- Cellular stress likely caused by the heatwave, resulting in increased membrane damage (elevated LPO) and DNA damage, as evidenced by an elevated genotoxic and cytotoxic response (increased MN frequency).
- Benthic macrofauna community showed high diversity and evenness, but low total abundance.

The heatwave likely triggered the observed biomarker effects in *M. balthica*. Despite the high diversity, the low overall species abundance may reflect heat-induced physiological stress across the whole benthic community.

Site 5: Polluted, affected by a heatwave
- ***M. balthica*** showed an elevated antioxidant defense system response via elevated SOD and a low CI, reflecting the high energetic cost of sustained physiological stress. Low abundance and biomass of ***M. balthica*** suggest
- possible demographic/genetic erosion or reproductive failure.
- The lowest biodiversity among the sites; community dominated by pollution-tolerant taxa, indicating a severely disturbed benthic ecosystem.

→ **Thecombined stressof chronicpollution and the heatwaveresultsin an ecologically degraded community.**

→ ***In M. balthica*, the depleted energy reserves (low CI) likely limit biomarker response capabilities, thus masking acute stress effects.**

Methods
- ***M. balthica*** and sediment were collected in the Archipelago Sea (SW Finland) in August 2024 along an assumed contamination gradient.
- Biomarkers mesured in ***M. balthica***: Micronuclei and nuclear buds (MN) for cytotoxicity and genotoxicity; lipid peroxidation (LPO), superoxide dismutase (SOD), catalase (CAT), glutathione *S*-transferase (GST), glutathione peroxidase (GPx) for oxidative stress; acetylcholinesterase (AChE) for neurotoxicityandconditionindex(CI) for generalhealth.
- The benthic macroinvertebrate community was analyzed for abundance and biomass. Biodiversity was assessed by using species richness, Shannon diversity(H'), andPielou'sevenness(J).

Fig. 1. Community composition of benthic Fig. 2. Benthic macrofauna community macrofauna taxa as total biomass proportions. diversity expressed as Shannon diversity. Total species abundance per site (mean ± SEM) Pielou's evenness and species richness is given on the right y-axis.(right y-axis)

Table 1. Summary of study site conditions, M. balthica abundance and biomass, biomarker responses, and the Integrated Biomarker Response (IBR) calculated from the individual biomarkers. Symbols: ↑ increased value, ↓ decreased value, = no notable change compared to reference (site 1).

Site	Temp	Depth	Contamination	Abundance	Biomass	CI	MN	LPO	SOD	CAT	GPx	AChE	IBR
ECP_1	6.5°C	95m	Low	High	High	=	=	=	=	=	=	↓	=
ECP_4	6.5°C	22m	High (city dump)	Low	High	=	=	↑	=	↓	↓	=	↑
ECP_5	18°C	16m	Low	High	High	=	↑	↑	=	=	=	↓	↑
ECP_5	18°C	8m	High (shipyard)	Low	Low	↓	=	=	↑	=	=	↓	↑

A regional Detect2Protect study on the biological effects of chemical pollution with linkages to biodiversity was presented at the Society of Environmental Toxicology and Chemistry Europe (SETAC) Annual Meeting in Vienna (Austria) in May 2025.

https://www.setac.org/discover-events/global-meetings/setac-europe-35th-annual-meeting.html

LATEST ACTIVITIES

The Final “Save The Baltic Sea” Expedition Event in Lithuania

At the concluding event, Detect2Protect partner NRC presented the project’s goals and practical research, capturing the attention of both the public and media. Attendees also enjoyed the stunning wildlife photography of Baltic Sea biodiversity, captured by Dr. Justas Dainys, a project team member.

https://gamtostyrimai.lt/en/save-the-baltic-sea-research-education-and-solutions-for-sustainable-future/

First meeting with the Advisory Board (AB)

On March 20, 2025, the Detect2Protect project partners had their first meeting with the representatives of the AB assigned to the project. During the meeting the project coordinator presented an overview of the project, outlining its main objectives, scope, and expected impact. The WP leaders then provided a structured update on the progress, challenges and the planned next steps in each WP. The next meeting with the AB will be held in autumn 2025.

LATEST ACTIVITIES

Project meeting in Sopot, Poland on 30-31 May 2025

Implementation and the current status of the project was discussed in a meeting hosted by IOPAN. WP leaders presented the future plans and gave a summary of the work completed thus far. Over 20 researchers attended the assembly on-site or on-line, representing all the Detect2Protect partner insitutions.

Welcome to the project new website!

https://www.syke.fi/en/projects/detect2protect#wp5-%E2%80%93-dissemination-of-results-and-stakeholder-involvement-

Syke

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