strateginen TUTKIMUS

Marine waterways as a sustainable source of wellbeing, security, and safety (WATERWAYS)

State of Play Report 2025

SUOMEN AKATEMIA

1. Summary

WATERWAYS addresses pressing societal challenges related to the sustainable and safe use of the Baltic Sea's waterways by developing tools, insights, and policy recommendations that support multi-sectoral marine operations in a rapidly changing risk and regulatory environment. The project improves understanding of how key maritime-related sectors - such as shipping, boating, fisheries, and offshore wind energy - interact with and depend on marine routes, both now and in uncertain future scenarios. By enhancing monitoring beyond AIS coverage, analyzing impacts on the UN Sustainable Development Goals, and applying optimization and foresight tools, WATERWAYS helps balance sectoral coexistence, environmental sustainability, and maritime safety.

Combining expertise from fields such as marine technology, environmental science, law, and computer science, the multidisciplinary consortium engages stakeholders across public, private, and civil sectors through an integrated societal interaction plan. Outputs include new data, models, and policy recommendations that inform governance and maritime spatial planning at national and international levels. Collaboration with other WaWe projects reinforces shared impact goals and ensures that WATERWAYS contributes effectively to more coherent maritime regulation, improved risk preparedness, and a more resilient and sustainable Baltic Sea.

2. Societal challenge

The WATERWAYS project tackles key societal challenges vital to the sustainable use of the Baltic Sea’s waterways. Its overarching aim is to develop tools and insights that support multi-sectoral waterway use in a constantly evolving operational environment shaped by shifting risk landscapes, changing regulations, and societal values.

A central challenge is the lack of comprehensive understanding of how marine sectors like shipping, boating, and fisheries currently interact with and depend on these waterways - let alone how this might evolve. This uncertainty hinders effective marine spatial planning and makes balancing economic interests with environmental sustainability difficult, yet essential for national welfare and the UN Sustainable Development Goals.

The maritime operational environment of the Baltic Sea is undergoing major transformation, driven by the green transition, geopolitical tensions, and climate change. These forces are reshaping the maritime risk landscape, affecting both navigational safety and environmental pressures. The growing presence of offshore wind farms further complicates this picture, requiring strategic planning to ensure their coexistence with maritime traffic. At the same time, fragmented regulatory frameworks impede coordinated and effective sustainability efforts.

WATERWAYS addresses these challenges by improving situational picture of multi-sectoral waterway use and applying advanced monitoring methods to track vessel activity beyond AIS coverage. It evaluates the sectoral impacts - both risks and opportunities - on the UN SDGs and develops tools and metrics to guide sustainable decision-making. The project also explores interactions between marine traffic and

emerging infrastructures such as offshore wind farms, using optimization tools to identify balanced solutions that support both access and sustainability.

Finally, by translating its findings into actionable, science-based policy recommendations, WATERWAYS aims to strengthen governance frameworks and support the development of coherent, future-resilient strategies for the sustainable management of the Baltic Sea's waterways.

Societal outcomes and impacts pursued by the WATERWAYS project

WATERWAYS aims to deliver four concrete societal impact outcomes that contribute directly to maritime sustainability, safety, and governance:

1. **Enhanced monitoring and environmental impact assessment capabilities:** By improving the tracking and analysis of both legal and illegal marine activities, the project strengthens maritime law compliance and reduces operational pollution, contributing to a safer and cleaner sea.
2. **Improved conditions for sustainable coexistence of maritime sectors**: The project develops solutions to align maritime activities, ensuring balanced resource use. Collaborative planning with stakeholders enhances shared understanding and capacity to take decisive, sustainability-driven action.
3. **Up-to-date risk awareness:** Through advanced modelling and analytics, WATERWAYS enhances understanding of the evolving maritime risk landscape in the Baltic Sea, supporting timely and future-oriented navigational risk management and preparedness to oil and chemical spill response.
4. **Readiness for more coherent maritime regulation:** The project assesses current maritime legislation in light of new findings and identifies regulatory obstacles to safe and sustainable use of maritime routes, aiming to provide recommendations for more integrated, future-oriented regulation.

These societal impact outcomes (SIO) align with the WaWe programme's broader impact goals: strengthening the societal knowledge base (SIO 1-4), supporting stakeholder capacity-building (SO 1-4), and informing decision-making to improve preparedness in water safety and responsibility (SIO 1-4). The WATERWAYS consortium ensures their realization through an integrated multi-channel Societal Interaction Plan (Section 5).

Collaboration with other WaWe projects supports these aims. In particular, WATERWAYS and the CoWup consortium - focusing on environmental risks in the Gulf of Finland - have identified shared interests in understanding maritime risks and infrastructure vulnerabilities. Their collaboration, especially around risk landscape analysis and stakeholder-engaged co-creation of sustainable solutions, reinforces all WATERWAYS impact goals, particularly those related to sectoral coexistence (SIO 2) and risk awareness (SIO 3).

3. State of the art of the research

The WATERWAYS project addresses pressing challenges in maritime safety, sustainability, and governance by combining advanced data analytics, legal research, and participatory foresight. Internationally, the use of big data, AI, and process mining in maritime traffic analysis is growing, but cross-sectoral, human-centered approaches remain limited. WATERWAYS advances the field by integrating visual process models, satellite data, and risk analysis tools to better understand vessel operations and maritime anomalies.

In maritime surveillance, the project enhances current methods by combining AIS data with satellite observations to detect activities not otherwise visible. Current environmental impact assessments for the waterborne traffic mostly rely on vessel activity sent by transponders. Those vessels which do not use the transponder are not included in the assessment. WATERWAYS aims to apply AI tools and satellite observations to solve this issue. Satellite tracking of ships is implemented widely already, but so far the component has not been untilized in emission reporting. Further, boating is not considered in inventory reporting at all, at least not on the scale needed.

On the legal front, WATERWAYS explores how national and regional regulations can complement international maritime law, particularly in emerging contexts such as offshore wind energy, hybrid threats, and environmental risks.

The project also applies novel decision-support tools - like dynamic Bayesian Networks and value-of-control analysis - to address long-term uncertainties in maritime planning. These tools help develop flexible, adaptive strategies for risk mitigation and sustainability, accounting for societal values and environmental impacts.

By tackling fragmented risk management and siloed sustainability efforts, the project introduces optimization methods that reflect multisectoral needs and stakeholder input. This system-level, human-informed approach positions WATERWAYS at the forefront of maritime research in the Baltic Sea region and beyond.

4. Multidisciplinary cooperation

WATERWAYS brings together theoretical approaches and methodological toolkits from multiple disciplines - including computer science, marine technology, environmental science, environmental social science, environmental economics, environmental engineering, and maritime law. The consortium includes research teams from Aalto University, the Finnish Meteorological Institute, Kotka Maritime Research Association (Merikotka), the University of Helsinki, and Åbo Akademi University.

Through participatory research and stakeholder engagement (see Section 5), the project aims to foster dialogue across diverse sectors that rely on the marine waterways and sea space of the Northern Baltic Sea. These include commercial shipping, recreational boating, fisheries, and offshore wind energy. In addition, the

project engages stakeholders involved in marine environmental protection, national security of supply, and overall maritime safety and security.

Stakeholders represent a range of perspectives and organizational levels - from ministries and authorities to operational agencies, businesses, and NGOs. A key partner in reaching this wide audience is Finland's national coordination body for maritime spatial planning, operating under the Regional Council of Southwest Finland.

The scenarios, risk assessments, and policy analyses produced by WATERWAYS will also benefit other projects within the WaWe programme. The consortium actively seeks to share knowledge and identify opportunities for collaboration throughout the research and interaction process. By combining perspectives from different scientific fields, the projects can address common research questions more comprehensively. For example, the CoWup consortium brings added value with expertise in environmental policy and sociology, while WATERWAYS contributes strengths in marine technology and legal sciences. Joint researcher meetings are planned to support continuous interaction across the consortia.

5. Societal interaction and the promotion of impact

To achieve its targeted societal impact outcomes (see Section 2), WATERWAYS implements a multi-channel, interactive stakeholder engagement strategy centered on co-creation and mutual learning. The project actively collaborates with stakeholders from public authorities, the private sector, civil society, academia, and media to ensure the relevance, uptake, and long-term impact of its results.

A key interaction platform is the Advisory Stakeholder Group, which facilitates regular dialogue and feedback. The project also organizes thematic workshops and discussions, culminating in a co-created roadmap for the sustainable cross-sectoral use of marine waterways. Project partners additionally contribute to stakeholder-organized events and serve as expert advisors in national and international policy processes, such as maritime spatial planning and regulatory forums.

Based on its findings, the consortium will formulate clear, actionable policy recommendations to support national and international strategies, action plans, and agreements. Societal engagement and dissemination efforts are supported by targeted communications through the project website https://waterways.projectsites.aalto.fi , newsletters, LinkedIn, and media outreach. Planned collaboration with the Finnish Maritime Museum also provides an opportunity to communicate key results to the wider public.

Scientific outputs will include peer-reviewed publications and open data, ensuring that research is both accessible and impactful. This integrated approach ensures that the project's outcomes are timely, actionable, and support improved maritime sustainability, safety, and governance.

All WaWe programme projects share common stakeholders, particularly at the ministerial level, with whom engagement is coordinated. WATERWAYS and CoWup, in particular, have a significant overlap in stakeholders - ranging from maritime safety

actors to those concerned with environmental impacts. The consortia have agreed to coordinate activities, participate in each other's events where relevant, and explore opportunities for joint stakeholder **e**ngagement, aligned with the goals and needs of both projects.