Securing the Baltic Sea's built seascapes: Balancing innovation, security, and sustainability

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Karina Barquet, Hans Liwång, and Torsten Linders explore how the Baltic Sea is evolving into a 'built seascape.' They highlight the necessity for cooperation and security strategies, alongside renewable energy and improved digital connectivity developments, to harmonize innovation with environmental protection

The Baltic Sea is transforming. Once defined by natural marine ecosystems and traditional maritime activities, it is now evolving into a 'built seascape' – a marine environment increasingly shaped by human infrastructure. Offshore wind farms, subsea cables, and digital monitoring systems are expanding rapidly, driven by the need for renewable energy, improved digital connectivity, and enhanced security (Paolo et al. 2024). These changes bring significant opportunities and present complex challenges that demand new governance, cooperation, and security approaches.

A paradox lies at the heart of this transformation; while offshore infrastructure is essential for economic growth and sustainability, it is also highly vulnerable. Recent incidents of sabotage, cyberattacks, and geopolitical tensions have highlighted the risks of critical

offshore systems. Additionally, the technologies shaping these built seascapes often serve dual purposes, used by both civilian and defense actors. The question is how to balance innovation, security, and environmental protection while ensuring that governance keeps pace with rapid technological advancements.

Built seascapes:

The promise and the risk Human activity in marine environments has always existed, but today's built seascapes represent a fundamental shift. Temporary interactions such as fishing or shipping can impact aquatic ecosystems and even disturb the seabed. Still, offshore wind farms and undersea infrastructure represent human presence at sea by adding (semi) permanent constructions to the marine environment. This requires a different form of long-term planning, maintenance, and protection. In the EU, this transformation is particularly evident as countries invest in offshore energy production to strengthen energy security and meet climate goals, which aligns with the RePower EU. However, this growing reliance on offshore systems also introduces new risks.

One of the most pressing concerns is the vulnerability of critical infrastructure. The damage to subsea gas pipelines and communication cables in recent years has exposed the fragility of these networks. The Baltic Sea, surrounded by multiple nations, some with competing interests, is a region where infrastructure security is increasingly under scrutiny. While offshore wind farms could contribute to clean energy production, they raise concerns over data security, navigation safety, and geopolitical tensions. Addressing these risks requires approaches that integrate security measures without hindering innovation.

The role of data and technology

Data and technology are at the core of ensuring resilient seascapes. Offshore wind farms, undersea cables, and digital sensors generate vast amounts of data, which can be used for energy management, environmental monitoring, and maritime safety. For instance, real-time ocean monitoring can optimize shipping routes, track climate change impacts, and detect potential security threats. However,
the benefits of this data depend on how effectively it is shared and managed.

Much of the data collected from offshore infrastructure remains siloed within specific industries or government agencies. While energy companies monitor turbine performance and subsea cables, defense agencies track underwater movements, and environmental researchers study marine biodiversity, these datasets are rarely integrated. A more collaborative approach where stakeholders share critical insights while maintaining necessary security restrictions could enhance economic efficiency and regional security.

However, this integration is not without challenges. Many technologies used in built seascapes have dual-use capabilities, meaning they can serve both civilian and military purposes (Vaynman & Volpe, 2023). For example, surveillance systems designed for offshore energy operations could also be used to track naval activity, raising concerns about data access and national security. Finding the right balance between open data exchange and necessary restrictions will be crucial for future governance.

Governing a complex and shared space

Governance is at the center of the built seascape debate. As a semi-enclosed and highly geopolitical space, the Baltic Sea presents unique governance challenges. International agreements such as the United Nations Convention on the Law of the Sea (UNCLOS) provide a legal framework, but they do not fully address the complexities of offshore digital infrastructure, cybersecurity, and the integration of civilian and defense technologies.

A key challenge is ensuring that governance keeps pace with technological change, particularly as the expansion of offshore infrastructure brings both opportunities and vulnerabilities. For instance, the rise of offshore wind farms in the Baltic Sea presents an energy security advantage. However, their integration with undersea communication cables and surveillance networks raises concerns about cybersecurity threats and geopolitical risks (Bueger & Liebetrau, 2021). Similarly, the dual-use nature of maritime technologies, such as autonomous underwater drones used for both environmental monitoring and naval reconnaissance, complicates regulatory oversight (Vaynman & Volpe, 2023).

Policymakers, industry leaders, and researchers must work together to develop regulations that encourage innovation while safeguarding critical infrastructure. Regional cooperation among Baltic Sea nations will be essential to address these challenges, as demonstrated by Sweden and Finland’s long-standing collaboration on icebreaker operations and digital navigation safety (Boström & Österman, 2017). Additionally,

NATO's increasing focus on hybrid threats in the region underscores the need for standardized security protocols and coordinated response strategies (Liebetrau & Bueger, 2024). By establishing shared frameworks for data governance, risk mitigation, and cross-sectoral collaboration, states can enhance both economic resilience and national security in this rapidly evolving seascape.

Public-private partnerships can also play a crucial role in strengthening the resilience of built seascapes. Energy companies, maritime industries, and research institutions are already investing in advanced monitoring systems and AI-driven analytics to enhance infrastructure security.

For example, offshore wind operators have tested the integration of surveillance sensors into wind turbine networks, allowing them to detect vessel movements and underwater disturbances, thereby contributing to both energy security and maritime situational awareness (OX2 2024). Similarly, NATO's Maritime Command (MARCOM) has explored collaborations with civilian actors to improve undersea infrastructure monitoring, leveraging data from commercial sensor networks and AI-driven threat detection tools (Willet, 2025). The use of federated data-sharing models, where environmental and security data can be accessed selectively without compromising sensitive information, represents another promising area of cooperation (Trice et al., 2021). By working together, these stakeholders can create more resilient systems that benefit economic development and environmental sustainability, ensuring that offshore infrastructure remains secure and operational in an increasingly complex geopolitical landscape.

The Swedish research program Mistra Co-Creating Better Blue (C2B2) (Wehn et al., 2023) experiments with LivingLabs to let stakeholders find effective governance solutions in the increasingly crowded and contested marine space. The participants in the C2B2 LivingLab for Baltic Proper especially have to deal with rapidly evolving security realities.

Towards a resilient future for the Baltic Sea

The transformation of the Baltic Sea into a built seascape presents significant opportunities and new risks. Offshore energy production, digital connectivity, and advanced monitoring systems are essential for economic growth and sustainability, but they also introduce security vulnerabilities that cannot be ignored. Effective governance, enhanced cooperation, and strategic use of data will be key to ensuring that these built environments remain resilient and sustainable. Moving forward, policymakers, industries, and researchers must adopt a more integrated approach to managing built seascapes.

By strengthening cross-sectoral collaboration and improving data governance, we can navigate the challenges of this new maritime era – ensuring that the Baltic Sea remains a secure, thriving, and sustainable ocean space for generations to come. Looking at past and present global experiences of civilian-military and cross-sectorial collaborations could help navigate the current geopolitical landscape.

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