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Increasing Eco-efficiency via Digitalisation in Maritime Industry in The Baltic Sea Region: Policy Support through Carrots or Sticks?

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Abstract

This article will give a brief look into the state of the Baltic Sea and its current policy framework regulating in particular maritime activities. It will also outline the most important findings arising from project titled ECOPRODIGI (2017-2021), an EU-funded endeavour which has brought together 21 organisations, businesses and foundations from five countries across the Baltic Sea region. Together with academic researchers, industry end-users, and experts from maritime field the project addresses the most significant bottlenecks i.e. eco-inefficiencies at three stages of shipping: while on sea, at the port and during assembly process at the shipyard.

The findings discovered during research period were focused on by the partners through developing various type of digital solutions to enhance the practices and processes which were felt impractical, slow and/or wasteful. The pilots carried out thereafter demonstrated concretely whether the solutions were indeed viable and most importantly, practical, or if further development was needed. Eventually, the project succeeded in producing digital tools which were both developed and tested by the end-users, which will - if not guarantee, at least very firmly suggest their usability thus possible wide applicability into similar processes across the maritime industry.

Several issues were raised during the project, mostly concerning the regulations or mainly the lack of them concerning e.g. waste, port stays and energy usage. These will eventually be elaborated in detail in individual policy briefings which are an essential part of the project's outcomes, together with a compilation of educational content and training packages which will support the implementation of the digital tools and processes.

Key words

Maritime industry, green transport, digitalisation, green shipping, Baltic Sea, international cooperation

Disclaimer: The opinions expressed in this report represent those of the author and do not represent the opinion of the Centrum Balticum Foundation, and thus, the Centrum Balticum Foundation does not bear any responsibility for the opinions expressed in the report.

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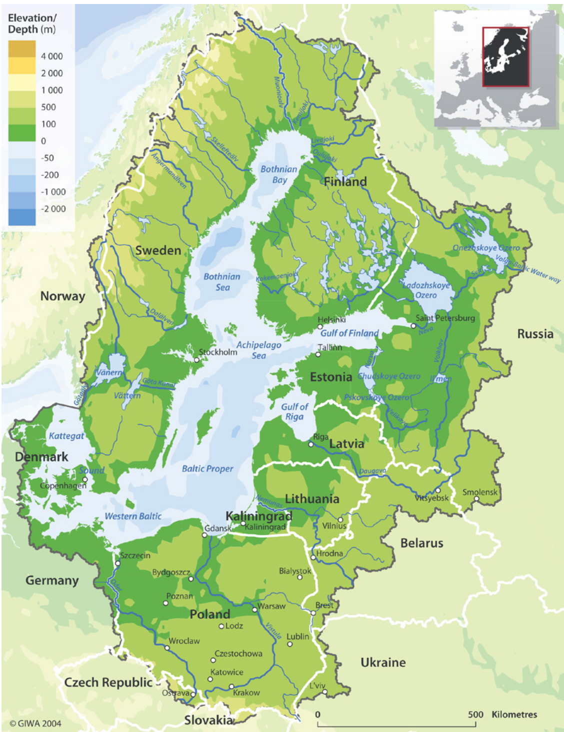
1 Introduction

"Sixty percent of the oceans lie beyond the borders of any national jurisdiction and are under a shared responsibility." -Friess and Grémaud-Colombier, 2020:6

Suffice to say, the world is currently in a middle of a vast change: this change is such in volume that it might very well be labelled as unprecedented in the modern time, despite the fact that at this stage we cannot even know the sheer impact of the current events. This change concerns every sector, society, and not the least the biosphere as a whole. This change does not refer to the current pandemic, even though its impact cannot be undermined either; this change, or revolution of sort, will fundamentally affect the way we carry on our everyday life even after the pandemic. This change is brought through with numbers: 1s and 0s of the binary system to be precise. The Fourth Industrial revolution weaves in together the Internet of Services, the Internet of Things (IoT) and cyber-physical systems thus is essentially digitalising industries, and it has already transformed many and is currently taking the maritime industry with a wave. It has already created many ripple effects on education, land transportation and policy making, to say the least.

Digitalisation will optimise maritime operations dramatically, potentially bringing in both economic and environmental gains. It has particularly been championed on the positive impact on the environment by making shipping less harmful. This has been welcomed among the Baltic Sea interest groups, who have been bringing in bad news for a few decades now: the Baltic Sea is known as one of the most polluted seas in the world (SIWI, 2018). It is a subject of pollution from multiple directions – from each of its littoral countries, and through direct and diffused pollution from various sources. Some of the major sources are agriculture, maritime traffic, wastewater treatment facilities, land transport and forestry (HELCOM, 2018b; Andersen et al., 2010). This multifaceted pollution is most drastically resulting as eutrophication, caused by excess nutrients in the water which ultimately leads into dead zones in the bottom of the sea, and also under water noise harmful for marine life, and chemical imbalances caused by a mixture of chemical being leaked from shipping (SHEBA, 2020). The Baltic Sea has a unique sea water composition of brackish water, indicating that it is not quite salty as typical sea, yet not fresh such as a lake – but something in the middle. This together with the fact that the water body changes very slowly (approximately between 30-50 years) and the shallowness of the Sea makes it all particularly sensitive to changes in the chemical composition caused by pollution (HELCOM, 2018b).

One of the most significant sources of diffuse and point source pollution currently is maritime activities (HELCOM, 2018b), namely sea traffic which has doubled in volume over the past 30 years, and further accelerated since 2010 (Baltic LINes, 2016). Indeed 80-90% of the trade in the region sails on the Sea, consisting of 2,000 vessels at any given time resulting as 1.1 Gt of CO2 emissions annually, together with 2.3Mt of sulphur dioxide and 3.2 Mt nitrogen oxides (Balcombe et al., 2019). These numbers are predicted to increase by 50-250% by the year 2050, and shipping is expected to be responsible of 17% of the global CO2 emissions (currently at 3%, or 3.7% of the total EU CO2 emissions), if no measures take place to prevent it (Gritsenko, 2017; Balcombe, 2019; EC, 2020). These facts and figures however have alarmed the policy makers to set down some ground rules through transnational regulation – a look into the most relevant policies set will be outlined in Section 2: Current Policy framework.



In addition, growing population, leading to increased economic activity is growing fast around the Sea: in 2018, 84 million people resided in the Baltic Sea catchment area, contributing directly or indirectly on the wastewater loads washing into the water bodies which eventually lead to the Sea (HELCOM, 2018a). This means, that the 84 million people in the 9 littoral states around the Sea and its catchment area will need to adjust the economic activities in the region in a way to ensure that we are not burning the candle from both ends, or more likely, setting the entire candle in fire. In order to prevent the wasteful use of resources, the concept of circular economy has been brought into rescue, and appears to be widely accepted in many countries – indeed Finland has set itself its own Circular Economy Roadmap which "plans to reform its economic model to ensure successful sustainability" (Sitra, 2020; para.1) In addition to the Finnish Circular Roadmap, the EU itself has set a new bar concerning sustainable development, by setting the "Green Deal" which aims to design transformative policies across the society – economy, industry, production and consumption. In their communication they particularly mention their will to "promote and invest in the necessary digital transformation and tools as these are essential enablers of the changes" (EC, 2019:4), and indeed set as one of their objectives to "mobilise industry for a clean and circular economy" (EC, 2019:7).

The application of circular economy thinking and being supported by the EU is crucial in many sense, and both will without a doubt contribute positively in blue economy in the region, which of course is directly dependent on the condition of the seas and life around them: it is estimated that the combined seas, coasts and maritime sectors in the EU come together as gross added value of just under EUR 500 billion per year, and 5.4 million jobs. (Friess and Gremaud-Colombier, 2020) In Finland alone, the maritime cluster provides close to 50,000 jobs and revenue of 14.3 billion for the Finnish economy (Haanpää et al., 2019; Itämeriportaali, 2020). Seeing that the value of the global ocean economy is expected to more than double by 2030 (OECD, 2017), a sustainable approach is essential.

The idea of circular economy is growing in popularity also in the maritime field, and indeed the industry in the Baltic Sea region shows great leadership in having formed business clusters such as the One Sea Ecosystem. Its objective is to create an environment suitable for autonomous shipping by 2025, one of its targets being decreasing the environmental footprint of marine traffic. (One Sea Ecosystem, 2020)

It could be argued, that sustainability policies are indeed part of every single maritime industry stakeholder these days, whether they have made a conscious decision to include it or not: the amount of environmental regulations that have been set over the past decades have made the Baltic Sea as one of the most regulated seas in the world (Ringbom, 2016). The next section will give an overview of some of the most relevant regulations in the area.

2 Current Policy Framework

The Baltic Sea region was famously the first one to implement an EU Macro-Regional Strategy (EUSBSR, 2020), and thus far the Strategy been has seen to have positive ripple effects on the regional economy and transnational cooperation. Strategy's transnational approach enables effective implementation in particularly as far as the Baltic Sea is concerned; after all, the sea's problems do not care about national borders thus are common to us all, and also often exploited by us all, therefore often considered as the victim of the 'Tragedy of the Commons' as described by Garrett Hardin (1968). The Tragedy itself implies to a situation where common resources, when not managed by an appointed entity, are depleted and degraded by the people's innate greed. This metaphor is common when e.g. describing the unsustainable fishery practices in certain parts of the global seas. The question for long was, how can this Tragedy be avoided?

This puzzle was addressed by Elinor Ostrom in her Nobel-prize winning work of "Governing the Commons" (1990), where she describes the design principle for Common Poll Resource (CPR) institution which, if applied with success, ensure the thriving of the commons and their ecologically and economically sustainable use. Ostrom argued against the central administration in the favour of polycentral approach, which in regard to the oceans for example could be seen as the only viable management plan, and is indeed now used at the heart of the European Commission's approach of establishing Marine Protected

Areas through Maritime Spatial Plan (MSP) Directive, adopted in 2014, in which each region would control their MSPs. The EU will be setting down legally-binding framework for the establishment of the MSPs by 2021, and its objective is to give tools to the local, public authorities to "organise human activities in marine areas so that various ecological, economic and social objectives can be achieved" (Friess and Gremaud-Colombier, 2020:2).

This approach is preceded by a line of policies with an objective to set some rules to protect the Baltic Sea and secure prosperity in the area: perhaps the first or at least the most known of its kind was the Convention on the Protection of the Marine Environment of the Baltic Sea Area, also known as the Helsinki Convention in 1974, which was signed by all the Baltic Sea coastal countries including Russia – then of course the Union of Soviet Socialist Republics (USSR) and was set to "address the increasing environmental challenges from industrialisation and other human activities and that were having a severe impact on the marine environment" (HELCOM, 2020, About us, para. 1.). The convention was updated in 1992 to reflect the changed geopolitical situation around the Sea, and has thereafter been amended when needed to acknowledge and adapt to the development and changes in the international environmental regulation and maritime laws (HELCOM, 2020).

In regard to marine environment and issues concerning its multifaceted concept, suffice to say that only transboundary cooperation can have any meaningful effect and/or results. For example, Janben et al. (2018) state transboundary interaction as a necessary step on the way to transboundary integration, and argue it in fact crucial particularly in terms of MSP. This type of interaction is seen to include all types of collaboration, cooperation and also communication and consultation. The EUSBSR does exactly this by strengthening cooperation between the EU Member States, without forgetting the neighbouring non-EU countries (EUSBSR, 2020). In addition the EU is setting ambitious guidelines to its member countries through the recently established "Green Deal" which aims to "transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use." (EC, 2019:2) The Deal addresses every strain of human activity, also announcing on the EU's objective to be "at the forefront of coordinating international efforts towards building a coherent financial system that supports sustainable solutions." (EC, 2019:2) It also acknowledges the fact that the issues travel across the borders, and EU's efforts alone cannot be the whole solution, but it is eager to lead.

A seminal regulation concerning the environmental impacts from shipping was set by the UN agency International Maritime Organisation (IMO) in 1997 and strengthened by 2005 through Maritime Agreement Regarding Oil Pollution better known as MARPOL. It has been updated through Annex VI to cover sulphur emissions / SOX (known as the sulphur cap, came into effect in January 2020), nitrogen (NOX) and GHG in addition to oil spills. MARPOL also drafted Emission Controlled Areas (ECA) which require ships to comply with stricter emission limits, e.g. around major cities and/or sensitive areas (Stevens et al., 2015; Balcombe et al., 2019).

The EU responded to the growing concerns of the marine and maritime issues with its Integrated Maritime Policy in 2012 (EC, 2020).

Table 1 in Annex I summarises the key conventions, strategies and directives concerning the governance of the Baltic Sea.

In addition to those listed in the table, the IMO through MARPOL set an Energy Efficiency Design Index (EEDI), which acts as a benchmark for new vessels' energy efficiency targets. It will ensure that ships that are built after 2025, will be consuming at least 30% less fuel, and the older ships will have to be retrofitted with applications reducing the amount of CO2 emissions (Stevens et al., 2015; Ang et al., 2017; Balcombe et al., 2019). This type of regulation is used as an example of aiming to foster innovation for rapid technological development in ship design and technology.

EEDI is complemented by the Ship Energy Efficiency Management Plan (SEEMP) which addresses both old and new ships but aims to improve fuel efficiency through operational improvements such as planning, implementation, monitoring and self-evaluation (Stevens et al., 2015). It does not have numerary objectives as such (Balcombe et al., 2019).

The most recent, and also arguably the most significant strategy set by the IMO concerns the GHG emissions: the target for the international shipping industry is to reduce their CO2 emissions by at least 50% from the 2008 baseline by 2050 (IMO, 2018). IMO states that they are "committed to working to combat climate change, in line with the United Nations Sustainable Development goal (SDG) 13 on climate action" (IMO, 2019, para. 2.) A more concrete strategy is expected to be introduced in 2023 (Balcombe et al., 2019).

While the more concrete plan is being drafted, several policy instruments have been suggested from which the next section will consider a few.

3 Policy Instruments

By default, the policy instruments should aim to:

- achieve environmental improvements
- cause the lowest possible cost for economic actors
- avoid negative, and create positive impacts in other areas of society.
  (Common and Stagl, 2005)

Policy measures can be divided into two categories based on their intended effect time-wise: 1) short-term measures and 2) mid- and long-term measures. In addition to these two categories, they can be put into categories based on their method of impact: a) economic incentives or more commonly known as Market Based Mechanisms (MBMs), which aim to ignite technological or other development towards a known goal – such as eco-efficient maritime industry – and can be thought of as the 'carrot', and b) "command and control" instruments or emission price control/regulations which can be thought of as the 'stick'. (Nikolakaki, 2013; Balcombe et al., 2019; Johensen, Kari and Kanto, 2020).

a) MBMs include: environmentally differentiated operational fees and taxes, national and EU co-funding for investments in technology and practice, emission charges, product charges, subsidies, deposit-refund systems and tradable permits.
b) Command and control approach includes: taxes, uniform reduction percentages across pollution sources, input restrictions, product requirements and technology-specific prescriptions and/or

"require specified economic actors to change their behaviour for the sake of achieving specified environmental goals, such as emission standards" (Common and Stagl, 2015:405).

The following table demonstrates on where the mentioned factors fit under the time line:

Table 2. Short, mid- and long-term factors affecting policy instruments

Short term ("push" factors)	Mid- and long-term ("pull" factors)
• EU, national and private R&D funding • EU co-funding • National state aid • European Green Deal • EIB loans initiatives • National export credit • National ship credit • Sustainability requirements of private banks	• Environmentally differentiated operational fees (e.g. port fees and fairway dues) • Modal shift support (land to sea) • Market demand: green transport labels, vetting • Taxes on: emissions, tonnage, fuel/energy • Emission trading scheme

Source: Adapted from Johensen, Kari and Kanto, 2020

4 Resolution: Eco-efficiency Through Digitalisation

The term eco-efficiency is not new; in fact the World Business Council for Sustainable Development has claimed to have come up with the term in 1991 with their attempt to capsulate the business perspective in sustainable development (WBCSD, 2020). This indeed captured the essence in a form, since the prefix "eco" refers to both ECOnomic and ECOlogical efficiency – therefore a conceptual win-win situation to any business longing to streamline their operations to match with the current needs and wants of their customers, whether they represent B2B format or B2C. The initial perception of the term was to create more with less, or as the WBCSD defined in 2006: "Eco-efficiency is a management philosophy that encourages business to search for environmental improvements that yield parallel economic benefits. It focuses on business opportunities and allows companies to become more environmentally responsible and more profitable." (WBCSD, 2006:3)

The mentioned 'parallel economic benefits' can come in many forms - often through actual monetary savings, but also as grown positive brand for the company which further promotes sales. As an example, the Sustainable Brand Index™, is an independent study constructed annually through 58,000 consumers in eight countries, which evaluates over 1,400 brands in more than 35 industries on sustainability and by ranking creates value to the most sustainable brands (SBI, 2020). It can be said that eco-efficiency gives a boost to business in many forms, which is also why it is a key strategy for the majority of industries – and maritime industry has taken giant leaps over the past years to get on board to sail with green sails.

The status quo in terms of digitalisation in maritime industry is in fact currently in a much better state than merely few years ago, never mind a decade; the development has been rapid ever since the industry realised that it will have to adopt the new ways that had already taken over other industries (e.g. automotive and aviation) and pushed them into an unparalleled flow of rapid development. It could be argued that the development per se with the other industries has not exactly advanced in the most sustainable way; in fact the term of sustainable development as defined by Brundtland Commission in 1991, as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" has to great extent failed where powered by fossil fuels (Dresner, 2011:70). Therefore the development powered by digitalisation has now revolutionised many industries.

Maritime industry has traditionally been stated as a one last in line in regard to transitioning into the digital age. It can be argued that it has been lagging behind at Industry 2.0, identified with mass production, assembly lines and electrical energy, and is now quickly been forced into adopting into not only Industry 3.0 - automation, computers and electronics, but the first steps of 4.0 characteristic of cyber-physical systems, IoT and data-based environment (Schwab, 2016). This requires a great deal, not only from the infrastructure and the vessels themselves, but even more from the current staff and crew both off-, and on-board. Digitalisation offers tools which are revolutionising the industry in such speed that requires for unprecedented capabilities from the people involved, and who in many cases have years and years of experience of the 'old school way' of operating vessels and shipyards. Therefore the challenge lies not only in the digital technology and having it implemented across the vessel life-cycle; the main challenge might be in the acceptance of the staff and motivating them to embrace the change.

An excellent method of how this transformation can be made as smoothly as possible, is to include both, blue and white collars around the table to come up with the solutions and co-create them. This is what has taken place in ECOPRODIGI, an EU-funded project which will be introduced next.

5 ECOPRODIGI

ECOPRODIGI project's ultimate goal is to increase eco-efficiency in maritime industry processes with digital solutions. In order to achieve this goal, it has gathered 21 partners together, each unique with expertise, field and focus from five countries surrounding the Baltic Sea. The particular strength and remarkability of the project lies in the fact that half of the project partners are businesses, i.e. representing the end-users for the solutions being developed. This has ensured that the relevance, usability and user experience have been at the very core from the beginning, potentially also ensuring the adoptability and acceptance of the users in the maritime industry.

The project is comprised of three technological cases, which will be described in detail: 1) Digital Performance Monitoring, 2) Cargo Stowage Optimisation, and 3) Process Optimisation at Shipyards. In addition to the digital solutions that are developed, piloted and eventually also implemented in these cases, the project also addresses the human aspect: education and policy outreach. Indeed it has been shown time and again that technological development and processes simply fail if the actual user, the person in the centre is forgotten. In addition, in order to ensure the support that is needed from the policy level – both national and EU, the project has organised several seminars which have invited policy specialists to learn about new innovations and solutions which are being developed and come across in maritime industry. A major part of the policy outreach is also the production of short policy briefings which will be focusing on some the individual challenges that have arisen from the research, and also the practical application of the solutions – such as slow steaming, emission reductions through fuel, material and time savings. They will be discussed in detail in the forthcoming briefings based on the final results of the project, which will be reap for picking in autumn 2020.

5.1 ECOPRODIGI Partnership

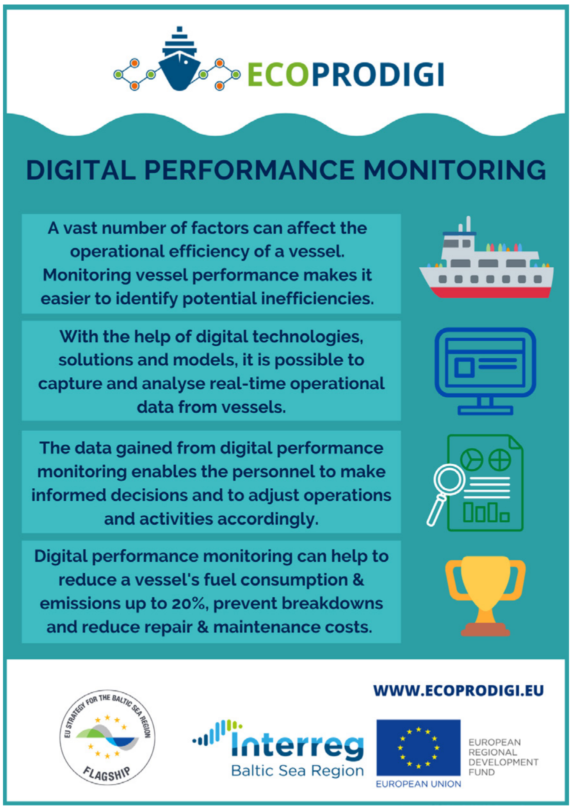
Table 3 List of ECOPRODIGI Project Partners

Partner No	Partner Name	Country of origin	Organisation type
1	University of Turku	FI	Higher education / research institution
2	Aalborg University Copenhagen	DK	Higher education / research institution
3	Chalmers University of Technology	SE	Higher education / research institution
4	University of South-Eastern Norway	NO	Higher education / research institution
5	University of Southern Denmark	DK	Higher education / research institution
6	Carina Solutions Oy	FI	Small/Medium Enterprise
7	Centrum Balticum Foundation	FI	Interest Group
8	Danish Maritime	DK	Business support organisation
9	DFDS A/S	DK	Large Enterprise
10	Island Ferry Secretariat	DK	Sectoral agency
11	Klaipeda Science and Technology Park	LT	Business support organisation
12	Machine Technology Center Turku Ltd	FI	Business support organisation
13	Meyer Turku Ltd	FI	Large Enterprise
14	OSK-ShipTech A/S	DK	Small/Medium Enterprise
15	Kockum Sonics AB	SE	Small/Medium Enterprise
16	Logimatic Solutions A/S	DK	Small/Medium Enterprise
17	Sininen Polku Oy	FI	Small/Medium Enterprise
18	RISE Research Institutes of Sweden	SE	Higher education / research institution
19	JSC "Western Baltic Engineering"	LT	Large Enterprise
20	Vessel Performance Solutions Aps	DK	Small/Medium Enterprise
21	J. Lauritzen	DK	Large Enterprise

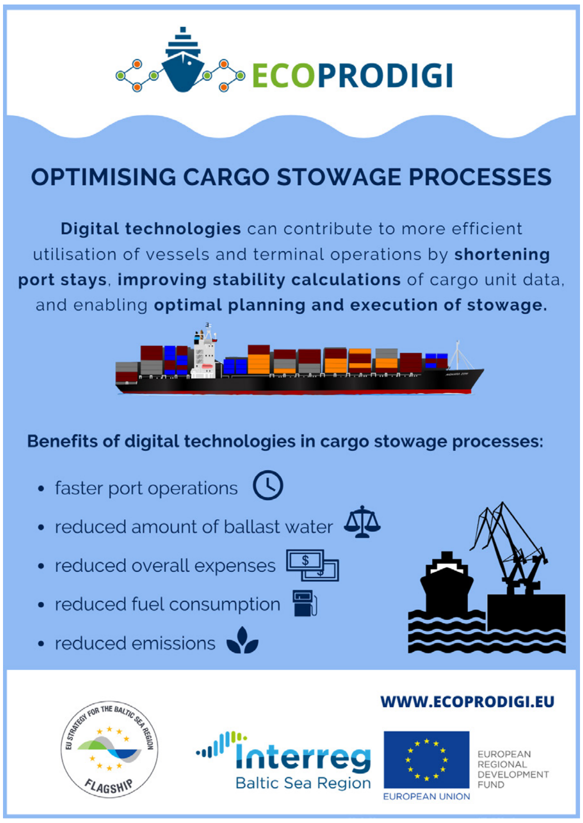
The project's implementation begun in October 2017 and it was due to finish by the end of 2020, but has now been prolonged until Spring 2021 due to delays imposed by COVID-19 pandemic. It has budget of apprx. 4.2M euros and is co-funded by Interreg Baltic Sea Region.

5.2 ECOPRODIGI Cases

Work in ECOPRODIGI's Case 1: Digital Performance Monitoring focuses on the processes taking place during voyages on-board the vessel; more specifically, the on-board operations and how they can be improved by applying digital technology, for example, censors and algorithms to estimate the most cost-beneficial and ecological thus eco-efficient route for every particular sailing conditions, and to predict maintenance cycles to prevent costly breakages during voyages. The case was divided in two sub-cases: Case 1a/ Island Ferries which carried out the research and pilotings on Small Island Ferries of the inland waters of Denmark, and Case 1b/J. Lauritzen concentrated on digitalising data capture enabling performance monitoring and decision support on large gas carrier vessels owned by a Danish shipping company J. Lauritzen. The research on both sub-cases was led by Aalborg University (from now on AAU), whose researches carried out invaluable work in cooperation with the crew on- and off-board.

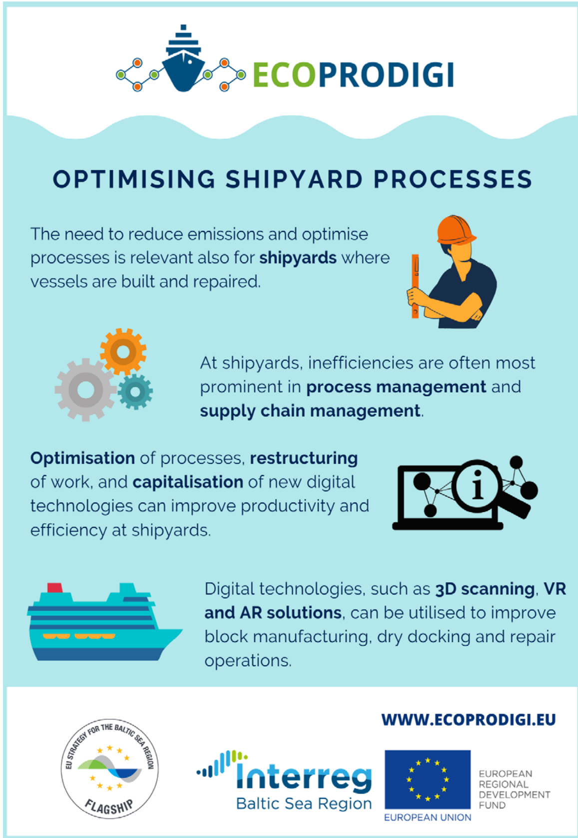


Case 2: Cargo Stowage Optimisation looks at the daily port operations, where the cargo stowage process was known to be the source of multiple eco-inefficiencies (hence processes not good for neither the environment nor the wallet) resulting as excess pollution being emitted into the air and water. Through research carried out in the first year of the project, the partnership led by AAU focused on the ro-ro operations and mapped out 13 stages during the process in which the most costly bottlenecks occurred during the stowage loading and off-loading process. From the recognised eco-inefficiencies the enterprise partner, DFDS developed a "Vision 2025" in which they have ideally solved each and every one of the issues on the list by 2025. Recognising that ECOPRODIGI project could only address some of them, the partners including researchers form AAU, Southern University of Denmark (SDU), University of South-Eastern Norway (USN), DFDS and two technology providers Kockum Sonics and Logimatic set aside the key issues which fitted under the schedule and budget. These will be described in detail in the Results-section.



Case 3: Process Optimisation at Shipyards concentrates on the shipyard environment in two locations: in Turku, Finland and in Klaipeda, Lithuania. The intention was to apply digital tools for project management and harness

3D technology in order to increase eco-efficiency in both, shipyard's internal and external processes. The two shipyards involved, Meyer Turku and Western Baltic Engineering (WBE, also part of the Western Shipyard Group) were particularly meaningful since in addition to their own activities, WBE acts as a supplier of vessel blocks for Meyer Turku. The project was used to map out how that collaboration and business operations could also be enhanced.



During research process, the involved partners identified the core issues which they decided to concentrate on: in Finland at the Meyer shipyard, Carina Solutions (from now on: Carinafour) whose expertise focuses on developing and optimising production systems and processes in the supply chain, and Sininen Polku who specialises on the quality management, supply chain management and IT systems. They both interviewed and observed the current operations at the shipyard, and with the help of Chalmers University of Technology analysed the needed changes. In Lithuania, WBE purchased a 3D scanner and with the help and support of Chalmers University of Technology and OSK-ShipTech, whose expertise is in marine consultation and vessel design, planned new ways to carry out retrofitting and maintenance work. The workshops around the development work were organised and facilitated by Klaipeda Science and Technology Park.

5.3 Education and Policy Outreach

In addition to the Case work, as mentioned, ECOPRODIGI was designed to also address the human dimension: as indicated in the Golden Triangle –theory popularised by Bruce Scheneier in late 90s, it is of utmost importance that each corner in "Process, People and Technology" is considered when a significant change is attempted to address any of the objects in the Triangle. Therefore the project is also considering the need to equip the crew, staff and any other stakeholders involved with educational content and training packages (where appropriate) to ensure that the new technology applied will be indeed correctly implemented and more importantly, adopted by the end-users. These deliverables also provide a base for further work and development, which can be updated as the technology develops and changes – as it tends to do and quite rapidly so. Machine Technology Centre Turku has been following the work carefully at both shipyards in Finland and Lithuania, and the material they produce will be answering directly to the needs of the local industry end-users, but also making sure that the packages can be modified to any environment in need of eco-efficiency education. In Denmark and Norway, the USN has developed simulation games which educate the current staff and crew on dual-cycling process which has been found most beneficial for the cargo stowage operation. In addition, they have developed content for a Masters course which will demonstrate the challenges and opportunities of using digitalisation of multiple business processes to reduce environmental impact, both in ship and terminal activities.

The educational material, where appropriate, will be provided to the project partners to be used alongside the new solutions, and it will also be made available for any interested stakeholder via the project's communication channels.

In addition to the educational content, the project partnership led by Danish Maritime is producing digitalisation Roadmaps for the three vessel life-cycle stages addressed in the project: the vessel, the port, and the shipyard. The Roadmaps are developed by the academic partners and validated by the end-users themselves to ensure relevance and realistic expectations. These Roadmaps will also be made available for the maritime industry communities, who are then able to use them as guidelines which will allow them to plan their own technological development accordingly. Lastly but definitely not least, these roadmaps will raise awareness among the policy makers in terms of where regulation currently lies in relation to the technology. The project also includes a concrete goal to arrange policy seminars to communicate the bottlenecks and other issues brought up during research and development (R&D), and finally formulate a policy agenda (by the University of Turku) which will comprise of policy briefings concentrating on each of the Cases and concretely answer the questions of the current status of the issue, outlook for future development, current actions on policy and industry level, and most importantly: what should be done about it, by whom, how and when?

This policy briefing prepared for the Centrum Balticum Foundation will be providing a more holistic view over the whole project and its context, analysing the current framework in regard to the national vs. EU-wide regulation and also pondering the different policy instruments which could be used when setting the regulations in the near future.

5.4 Project Results

In the first phase of the project, "Evaluating maritime industry processes and technology outlook" the work started off with a mapping of the status quo and the perceived barriers for eco-efficiency. Due to the multi-faceted focus of the project activities, the investigation was spread over the vessel life-cycle therefore gaining a comprehensive look into the maritime industry processes.

The research was carried out by the academic partners – namely Aalborg University, University of Southern Denmark, Chalmers University of Technology, University of South-Eastern Norway, and University of Turku, supported by Danish Maritime and Klaipeda Science and Technology Park. However the business partners, involved in the day-to-day operations, have been heavily involved from the beginning, and have been showing the lead to the researchers in all the cases. This has ensured that the eco-inefficiencies have indeed been concrete bottlenecks in operations for which the men and women in the field have been calling for a better solution.

In Case 1a, Vessel Performance Monitoring with Small Island Ferries, it was seen that the major eco-inefficiency, i.e. fuel consumption can be to great extent tackled by simply operating the ferries in a different manner. The research and test pilots showed that e.g. by sailing a slightly longer route on deeper waters can reduce fuel consumption by 5% even with increased speed which will ensure the set transit time. In addition, sea trials suggested that fuel consumption can be reduced by up to 15% by operating the ship with an optimal push/pull distribution of workload on board. Adding it all together, the research concluded that there is a potential to reduce fuel consumption and emissions by between 10-20% per ferry route compared to the baseline, and also prevent business- and safety-critical engine breakages during voyages with an estimated value of +2,000 EUR / day. (ECOPRODIGI, 2020)

Results from Case 1b, Vessel Performance Monitoring with J.Lauritzen showed that the performance monitoring of the on-board equipment can potentially reduce fuel consumption between 2-4%, result as 1-3% emission reductions, 4-6% of reduction on maintenance costs and prevent costly engine breakdowns if digital data capturing is enabled through Artificial Intelligence (AI) models and crew is equipped with decision support tools together with e-learning applications.

Case 2, Cargo Stowage Optimisation revealed several steps at the process that could be streamlined, digitised and enhanced. As mentioned, it led to DFDS' "Vision 2025" which has six phases consisting of several discreet events. The solutions that were chosen for piloting under ECOPRODIGI concentrated on a "Smart Gate" technology, e.g. accurate and digital information about cargo which will enable a more precise stability calculations when the vessel is being loaded, which will ultimately result as less ballast water been used, and less fuel being consumed.

Additionally, by digitalising the terminal operations and integrating applications will enable the terminal planners and vessel cargo officers to manage their work more efficiently, which has a potential of shortening vessel's port stays significantly, and allowing the ships to sail slower and save fuel. (ECOPRODIGI, 2020)

Finally Case 3 Process Optimisation at Shipyards showed potential at many stages: the Finland case, concentrating on the internal processes at the everyday working environment and supply chain management, found that the processes were at length still often managed to great extent by pen and paper, and/or based on memory. A current state analysis revealed waste, both in material and time that were the subject of the process development. At the same time in Lithuania, the shipyard looked into the 3D laser scanning and project development enabled by the technology. End-user involvement since the beginning of the process has allowed a quick analysis of the eco-inefficiencies and in some cases this troubleshooting phase has materialised quickly as brainstorming-sessions for solutions.

In Finland, Carinafour and Sininen Polku looked into the supply chain management and on the process of few specific work stages at the outfitting process at Meyer Turku. Shortly after the initial pilotings of digital project management tools and applications on the outfitting process it was evident that such tools are able to save time and materials through more efficient resource (both human and material) allocation. As for the supply chain, it was shown how crucial it is to pay attention to the complete value chain thus overall supplier network including second- and third-level suppliers. More visibility is needed over the whole supply chain, and efforts to develop a solution are on their way.

Work in Lithuania revolved around the possibilities enabled by the 3D scanning technology. In short, it was found revolutionising in regard to retrofitting and maintenance work on old vessels. The team at WBE started working with the 3D scanner for the first time, and were eager to share their lessons learned and this process was documented by Chalmers University of Technology (from now on CHA). In addition to the applications found in collaboration with CHA, WBE and Meyer Turku also discovered new ways to improve their mutual collaboration in the block delivery process: currently, WBE supplies Meyer Turku with blocks used in the large cruise ships that are built at the Turku shipyard. As they arrive from Lithuania to the assembly point in Finland, blocks are rarely ever 1:1 of the blueprint, due to the behaviour of the material, temperature etc. It often takes hours to analyse the needed corrections which are then welded before the block is attached to the rest of the ship. Now the 3D technology enables a process in which the block is scanned prior to the departure from Lithuania and the data is sent to Finland; while the physical block is being transported to Finland, the engineers can already plan the welding process thus save a substantial amount of time and other resources. Guidelines on how this process can be carried out will be one of the deliverables of Case 3. It has been shown that 3D scanning technology can provide more accuracy into the processes thus eliminate material and time waste, leading thereby into cost savings.

In addition to the saved resources, 3D scans and reports can increase transparency in processes and enhance reporting practices: e.g. the customer could potentially 'review' the digital ship before delivery, or the classification societies could monitor development via 3D images. These could save physical visits from taking place, which at least in the current COVID-19 situation can be a "new normal" in the future were health and safety practices and measures are being re-written.

6 Implications

The described results retrieved from ECOPRODIGI project show great potential in gaining eco-efficiency benefits across the industry, which of course is also great news for the ship owners, operators, builders and other stakeholders balancing between the needs of business and regulations from authorities.

These results also raise questions on what this rapid development and application of technology means for the policy makers, and whether they are on the same page with the industry – or two steps ahead, as would be ideal.

First question is what: each of the solutions being developed in ECOPRODIGI relies on a common factor - data. Some of the barriers for increasing eco-efficiency in data-driven operations is the availability, format and shareability of data: there is currently a lack of standards for e.g. storage, operational data capture, and also performance monitoring (ECOPRODIGI, 2020). Availability and transparency of data is also of concern when looking at supply chains, since not all suppliers provide their sustainability records automatically, and if the requirement is not in the company policy, it is not asked. Therefore there should be universal database where the companies could check where the supplier stands in terms of social and environmental responsibility, set by a directive or similar.

The second question is who: another common factor to all the solutions is the fact that they will be used by, or at least monitored by, a human being. This means that those involved should be educated, encouraged and monitored throughout the whole implementation phase. In addition the gained results should be regularly recorded and reflected to earlier ones. A key notion is also to acknowledge that the decisions, whether on investments or operational ones will be made by the same humans; therefore it is essential that the education and information is shared widely across the organisations and the industry.

The third question, and the one on which the following discussion will be focused on, is how: should the newly-formed policies and regulations based on latest research be implemented on regional, national or global scale? Which approach serves the industry, the market, the environment best? And finally will they be best to be implemented via MBMs, ‘command and control’ measures or something else? Or a combination of them all?

Seeing that even the final question on “how” cannot be comprehensively addressed even within this longer-than-average-policy briefing, the following will provide some suggestions from current research.

7 Policy Recommendations & Choosing the Policy Instrument(s)

Friess and Gremaud-Colombier (2020) argue that the key for a sustainable blue economy, which the maritime industry of course is integrally part of, is to develop a common vision for the region. By setting the goals of 1) Save the Sea, 2) Increase Prosperity, and 3) Connect the Region, EUSBSR has exactly done this. The Strategy itself is implemented through joint projects and processes, which ECOPRODIGI is indeed proudly part of as a Flagship project. In addition to the vision, of course more is needed: what factors need to be present in order to achieve meaningful results in the maritime sector?

Lindstad et al. (2015) note that regionally based regulations can provide a more realistic chance for the local shipping operators to respond to the restrictions, since the abatement opportunities vary greatly across the regions, and operational conditions are heavily influenced by the location: e.g. the MARPOL assumes engine performance baseline on medium to high loads and on calm water, which is rarely the occasion across the globe. The high variation between operating conditions and also between vessels has also been evident in ECOPRODIGI, where the partners include big shipping companies operating across the global seas, but also small ferries sailing in the inland waters of Denmark. It is clear that what is relatively easy to implement in large companies, can be a great challenge for the smaller operators, for multiple reasons varying from economic challenges to environmental conditions. Therefore when the restrictions and/or regulations make sense from the operator’s point of view, they are better followed.

The transboundary nature of any meaningful piece of regulation or legislation was mentioned; indeed Friess and Grémaud-Colombier (2020) also argue that the transnational approach which EU legislation demonstrates, is a key for successful implementation of sustainable blue economy. They also state that instead of country-specific MSP, a region-specific approach is more viable, which is also currently the method applied by the EU MSP legislation. Therefore they also support the notion that it is essential to hold the vision across the region, but concentrate the regulation at a local level, and if possible adapt it to the local circumstances; in that way it becomes meaningful to those who it impacts most, and who to great extent will be the ones carrying out the implementation. A demonstrably successful way of doing this, is through co-funding schemes where partners can in cooperation develop e.g. solutions which work in the area, and share the ideas and lessons learned with a wider community through the partnership. This was also shown in the Johensen, Kari and Kanto’s (2020) research, where EU co-funding schemes were shown successful.

Nevertheless, transnational governance does not come without challenges: as Lister, Poulsen and Ponte

(2015) point out, it needs to be carefully orchestrated in order to be carried out successfully – that is, engage and facilitate a wide variety of stakeholders. Their view of transnational environmental governance (TEG) is a "fragmented and multi-layered field where inter-governmental organisations and treaties operate alongside, and in interaction with, market-based instruments and different kinds of partnerships" (Lister, Poulsen and Ponte, 2015:186). Even conventions set by the IMO do not guarantee compliance: in order for its rulings to be implemented, its contracting governments (also known as flag states) push them through in their national legislation. It is not unheard of that states have hindered the ratification process, which at their best can still last for a decade. Therefore one is inclined to think that instead of trusting the legislation to push change through, it would be more beneficial to promote investment in green shipping through incentives and other MBMs. As for the attitudes of the shipowners themselves, literature suggests a critical attitude towards new regulation which adds costs and complexity to ship operations and at its worst reduces the competitiveness of maritime transport to other transport modes (Lister, Poulsen and Ponte, 2015).

Fears of the unfair competition challenging the industry in the region have also been brought up during ECOPRODIGI. Even though the stakeholders well acknowledge the benefits of digitalisation of processes and saving resources, they consider it crucial that any compromises they might make for the environment's benefit, will not affect their ability to compete with the rising Asian markets. However as noted earlier – the concept of eco-efficiency is built on the principle of considering the both ends of the stick – the economical and the ecological aspects are weaved tightly together. Indeed the EU's Green Deal also notes that particular attention will be paid in cases where there are perceived trade-offs between social, environmental and economic objectives (EC, 2019).

Another factor affecting the maritime sector's decisions that should be mentioned is the demand coming from the customers (Lister, Polsen and Ponte, 2015). The wants and needs in the bottom of the funnel are central, and since the growing awareness of climate change and environmental degradation concerning the Baltic Sea is without a doubt having an impact to the consumers and their decision making. Therefore factors such as the earlier-mentioned Sustainability Index cannot be underestimated among the maritime industry.

Through the recently introduced EU Green Deal, it is evident that the international community's focus is on investing in digital transformation which is regarded crucial in terms of reaching the goals of the Green Deal. One of the key steps in the Roadmap is to cut down emission from all transport by 90% by 2050, but also to move a substantial amount of inland freight on rails and water – increasing the load on inland waterways and short-sea shipping, further increasing the need for carbon-neutral maritime industry. The EU has announced that it will present a Sustainable Europe Investment Plan to help meet all the goals in the member countries, and without a doubt also bring through more MBMs to help in the transition to carbon neutral society. They also call for a 'socially just transition', which should be also reflected in policies at both, EU and national level.

The first note concerns the age-old question on whether to use the 'carrot' or the 'stick' – i.e. incentives or fines. Does regulation encourage innovation? Halff, Younes and Boersma (2019) claim that the new IMO standards might in fact hinder the transition from traditional bunker fuels to more ecological options. They identify factors, already briefly discussed earlier which they found discouraging positive response to new policies: 1) financial burden of premature compliance, 2) financial risks stemming from market uncertainty, and 3) regulatory uncertainty. These findings suggest that the policy instruments should be designed in a way that they respond to all the uncertainties, which also requires the instrument to be coherently written into the policies of both private and public sphere: a common interest and strategy for all actors is essential. This was also acknowledged in ECOPRODIGI's policy seminar where the project partners were joined by the Finnish governmental authorities and business representatives. One of the outcomes was the notion of the importance of the cooperation between the private and public sector, which was seen as the perfect marriage in creating the best possible methods to support and steer development toward sustainable shipping.

According to a very recent study by TRAFICOM, the Finnish Transport and Communications Agency, it has been shown that economic incentives seem to be promoting investments into eco-efficient solutions to improve the vessels' performance. The types of instruments mentioned were national state aid, EU co-funding and financing tools in particular. Indeed in regard to environmental impact, they were found significantly influential with both old and new vessels. As regards to the "Command and Control" category, environmental taxation showed as having more influence on the industry than others (Johensen, Kanto and Kari, 2020).

On the contrary, it was found that investments on eco-efficiency were not significantly influenced by environmentally differentiated operational fees. It was found that these types of incentives brought too low economic benefit compared to the magnitude of the initial investment. (Johensen, Kanto and Kari, 2020)

During ECOPRODIGI research, it was stated that the industry market is heavily influenced by the regulatory requirements imposed by the EU and IMO. However it was also estimated that the "ownership structures and commercial models of the industry might however still act as a hindrance for further investments in digitalisation or might imply a slower adoption of eco-efficient execution of vessel operations" (ECOPRODIGI, 2020:22) therefore in those cases the incentives need to be stronger to attract sufficient investments in technology, or then subsidised.

The EU Green Deal mentions particularly the Emission Trade Scheme for the maritime sector as a measure to increase transparency on the transport's impact on the environment and health. They underline the act to coordinate the ETS at global level due to the nature of the sector. It was pointed out by Koesler, Achtnicht and Köhler (2015) that there is no reason why a cap-and-trade system would not work in the maritime industry, and find in fact market based mechanisms most suitable in the international shipping industry. They note however that the industry representatives seem to be happy to be following any suggested method to gain environmental benefits, as long as the approach is explained to them. During a few of ECOPRODIGI events a similar remark was made by a ship-owner, who also commented on the necessity of engaging particularly the older crew into the discussions of the benefits of any new technology, which seems to be making their operations more complex. The "goodwill" exists, but education goes beyond.

Finally, any instrument or regulation will be much better perceived and adopted, if it shows coherence across the industry, is a long-term solution, and the results of its usage can be predicted (Koesler, Achtnicht and Köhler, 2015; ECOPRODIGI, 2020).

8 Conclusion

Particularly when environmental policies are discussed, the importance of global, unified and comprehensive policies being adopted in all metaphorical corners of the world is absolutely crucial – particularly as reminded by the quote that opened up this article, 60% of the world's oceans are a 'no-man's-land' therefore need special protection.

Different policy instrument's impacts on the maritime sector are surprisingly little researched, and even more rarely studied: the TRAFICOM research by Johensen, Kanto and Kari (2020) is one of the first publications to give clear implications on what works in that area, and what does not. In any case, from the research that was carried out for this article one could conclude with the following:

- Maritime sector requires global, at least transnational coherent regulation which sets the playing field level for each actor imposed by e.g. IMO;
- The global regulation needs to be flexible enough to be adjusted to meet regional conditions adjusted by e.g. the EU – and it should be legally binding;
- The regulation has to be implemented by the local/national authorities.
- Out of all mentioned policy instruments, MBMs are better perceived by the stakeholders of maritime industry than command-and-control -measures. Particularly ETS is seen sensible. The scheme is not implemented yet.
- Each required change in any operations carried out by a human being should be equipped with education/ sufficient information on the reasons why the certain change is being implemented. Therefore investment in education is imperative.

The issues concerning the Baltic Sea are even at their simplest complex: there is no doubt about the fact that the ecosystem is degrading, and climate change will not make the situation any easier. The amount of population is increasing, and economy will require more energy and the biosphere is more fragile than ever. It is in many ways overwhelming and no sector can address it all - it helps to break the issues down, to scale down to human-size issues in order to make change happen in a way that benefits us all. This briefing's focus is on maritime industry and eco-efficiency, which together form a companion which will – if not completely save the Sea, at least contribute to its condition in a positive way and equip the future generations with tools to develop them further to ensure a region which will prosper in every sense.

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ANNEX I

Table 1: Key Conventions, Strategies and Directives at the Baltic Sea

Adopted and updated from Janben et al., 2018 p. 202

Type	Name	Established	What?
Convention	**Helsinki Convention**	1974 / 1992	Aims to prevent and eliminate pollution in order to promote the ecological restoration of the Baltic Sea area and the preservation of its ecological balance. Covers the entire Baltic Sea including the seafloor and coastal zones, as well as its drainage area (reduction of land-based pollution).
Convention	**Espoo Convention** – Convention on Environmental Impact Assessment in a Transboundary Context,	1991	Sets out obligation to assess the environmental impact of certain activities at an early stage of planning (environmental impact assessment – EIA). States have to notify and consult each other on projects with likely significant adverse environmental impact across boundaries.
EC/EU Directives	**Water Framework Directive**	2000	Established a new system of river basin-based water management with a "good status" by 2027
Protocol	**Wismar Declaration on Transnational Spatial Planning and Development Policies**	2001	Addresses spatial planning and development in the framework of VASAB (Vision and Strategies around the Baltic Sea).
EC/EU Directives	**SEA Directive**	2001	Obliges EU Member States to carry out a Strategic Environmental Assessment (SEA) for official plans/programs that are likely to have significant environmental effects.
Protocol	**Kyiv Protocol** – Protocol on Strategic Environmental Assessment	2003	Sets out an obligation to assess the potential environmental impacts of plans and programmes.
EC/EU Policy	**Integrated Maritime Policy**	2007	The integrated maritime policy seeks to provide a more coherent approach to maritime issues, with increased coordination between different policy areas. It focuses on: • issues that do not fall under a single sector-based policy e.g. "blue growth" (economic growth based on different maritime sectors) • issues that require the coordination of different sectors and actors e.g. marine knowledge
EC/EU Directives	**Marine Strategy Framework Directive**	2008	Directive establishing a framework for community action in the field of marine environmental policy: aims to achieve a Good Environmental Status of marine waters by 2020.
Declaration	**Vilnius Declaration Towards Better Territorial Integration of the Baltic Sea Region**	2009	A common Baltic MSP approach.
EC/ EU Strategy	**Blue Growth Strategy**	2012	A long term strategy to support sustainable growth in the marine and maritime sectors as a whole.
EC/EU Directives	**Maritime Spatial Planning Directive**	2014	Directive establishing a framework for maritime spatial planning: helps EU Member States to reach GES, obliges Member States to establish coherent maritime spatial plans by 2021

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