DEPARTMENT OF INTERNATIONAL AND EUROPEAN ECONOMIC STUDIES

ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS

Blue Innovations Enablers in Support of the Sustainability Transition: A case from the Black Sea Blue Economy

Alice Guittard

Lydia Papadaki

Giota Koltsida

Eleni Toli

Ebun Akinsete

Phoebe Koundouri

Working Paper Series

25-55

September 2025

"Blue Innovations Enablers in Support of the Sustainability Transition: A case from the Black Sea Blue Economy"

Alice Guittard[1], Lydia Papadaki[1], Giota Koltsida[2], Eleni Toli[2], Ebun Akinsete[1], Phoebe Koundouri[3]

[1] Sustainable Development Unit, Athena RC; School of Economics and ReSEES Research Laboratory, Athens University of Economics and Business; UN SDSN Global Climate Hub
[2]Sustainable Development Unit, Athena RC;
[3]School of Economics and ReSEES Research Laboratory, Athens University of Economics and Business; Sustainable Development Unit, Athena RC; UN SDSN Global Climate Hub; UN SDSN Europe & Greece; World Council of Environmental and Resource Economists Associations, Alliance of Excellence for Research & Innovation on Aephoria (AE4RIA) and SDSN Global Climate Hub, SDSN Europe, Paris France

Key words: innovation, pathways, blue economy, sustainability transition, blue economy observatory, Black Sea

Introduction

Over the past decades human economic activities at sea have been designated interchangeably under the umbrella of the 'Ocean Economy,', the 'Marine Economy', 'Blue Growth,' and more recently the 'Blue Economy'; all those terms essentially referring to the exploitation of marine resources (Cisneros-Montemayor et al., 2019), despite the will to integrate more and more sustainable concepts, in line with the Sustainable Development Goals1 such as SDG 14, life below water. The Ocean Economy, or Marine Economy, refers to any and all market-value public and private activities related to ocean (Park & Kildo, 2014). Similarly, Blue Growth is the expansion of said term in a market economy with implicit conformance with sustainability (Brent, Barbesgaard & Pederson, 2018). While more recently the blue economy has been defined as the sustainable use of ocean resources for economic growth, improved livelihood and jobs, and ocean ecosystem health (World Bank 2017; Bennett et al., 2019; Cisneros-Montemayor et al., 2021). The blue economy concept emphasizes a shift from the management of a single sector to holistic, multisector-linked development, having the sustainable use of marine ecosystems as an essential component, acknowledging the fact that coastal and marine activities are intrinsically related to the good environmental status of marine ecosystems. Marine ecosystems deliver vital good and services that improve the well-being of all living and non-living components of the environment. These goods and services—such as regulatory, provisioning, cultural, and supporting services—represent the array of benefits known collectively as Ecosystem Services (ES) (Guerry et al., 2015; Koundouri et al., 2023a); therefor the blue economy integrates the necessity to apply an ecosystem-based management approach.

In line with the evolution of the theoretical concept and approach around the exploitation of the ocean, four years ago, the European Commission released a Communication "on a new approach

[1] https://sdgs.un.org/goals

for a sustainable blue economy in the EU - Transforming the EU's Blue Economy for a Sustainable Future" (European Commission, 2021), acting the transition from the concept of 'blue growth' to the concept of 'sustainable blue economy', strongly emphasizing the sustainability aspect when developing the blue sectors. This conceptual transition aimed to move away from primarily focusing on economic growth to fully support Europe's sustainability transition trajectory defined in the European Green Deal (EGD), as a strategy to achieve the Agenda 2030[2] (European Commission, 2019a). The blue economy offers great opportunities to support the EGD in terms of climate neutrality and renewable energies (i.e. the objective of 90% reduction in greenhouse gas emissions from all modes of transport) where offshore energies (i.e. offshore wind farm, tidal and wave energies) and decarbonisation of the maritime sector will greatly contribute. By depolluting port, fishing and aquaculture operations, the blue economy will support the achievement of the zero-pollution action plan (i.e. halve plastic litter at sea, nutrient loss into the sea and the use and risk from chemical pesticides by 2030). By implementing sustainable practices in the fishery and aquaculture sectors, it will generate a European sustainable food farming system as expressed in the EU vision for Agriculture and Food3 (i.e. objective: "A future-proof agri-food sector that is functioning within planetary boundaries, where farming and the food sector contribute together to the EU's climate objectives while preserving healthy soils, clean water and air, and protecting and restoring Europe's biodiversity" - European Commission 2025). The transition towards a sustainable blue economy has also the capacity to strongly support the EU biodiversity strategy for 2030 and SDG 14 by protecting 30% of EU sea waters.

However, to live up to the expectation the blue economy must move away from business-as-usual and transition towards sustainability (Koundouri et al., 2023b). Over the past twenty years, the exploitation of the seas has been growing exponentially to harvest food and materials but also as a space to develop further activities such as deep-sea mining, aquaculture, offshore renewable energies (Jouffray et al. 2020), sometimes resulting in conflict across sectors, communities and countries. Today the European seas are considered overexploited, with marine habitats and biodiversity placed under multiple pressures and cumulative impacts from human activities: fish stocks are depleted, ecosystems are degraded, and marine waters are increasingly polluted with plastics, nutrients and chemicals (EEA, 2019), while suffering from acidification and increased temperature essentially due to climate change. Those increased pressures are threatening the good functioning of the very ecosystem services most of the blue economy sectors depend on. Thus, the sustainability transition with the blue sectors (i.e. fishery and aquaculture; ports and shipping; coastal and maritime tourism; mineral exploitation) is becoming increasingly pressing. In this context, innovation is set to play a crucial role in the transition towards sustainability by addressing environmental and social challenges, and enable the transformation of current unsustainable blue socio-technical systems (Schot and Steinmueller, 2018), through the development of clean technologies, alternative business models and governance arrangements, to

[2] https://sdgs.un.org/2030agenda

[3] https://agriculture.ec.europa.eu/overview-vision-agriculture-food/vision-agriculture-and-food_en

ultimately create the necessary conditions for coastal communities to meet the ambitious objectives of the EGD and the Sustainable Development Goals. Sustainability is seen as achievable through innovative sustainable ocean solutions (Pace et al., 2022; Elston et al., 2024), capable of reducing and mitigating anthropogenic impacts on the marine environment (e.g. developing sustainable fishery practices; reducing maritime transport noise pollution) on one side, offering new sustainable business opportunities (e.g. in blue biotechnology or ocean energies) on the other side. Social innovation, as a "reconfiguration of social practices in response to societal challenges, which seeks to enhance outcomes on societal well-being and necessarily includes the engagement of civil society actors" (Polman et al., 2017) is also expected to contribute to systemic transformation towards sustainability (Wittmayer et al., 2019) by preserving marine ecosystem services and the well-being of coastal communities through new social relationships/collaborations, new institutional environments and arrangements related actors' interactions, change in communities value and norms (Akinsete et al., 2022), having social equity and environmental justice as key principles (Bennett et al, 2019; Cisneros-Montemayor et al., 2019).

This chapter looks at how different tools can be mobilized to boost innovations for a sustainability transition within the blue economy, taking the example of the Black Sea region. The chapter starts with an overview of the Black Sea characteristics from a geographic, environmental, economic and policy perspective. It then explores two tools as 'enablers' for achieving a truly sustainable blue economy. First, the co-development of sustainability pathways such as blue transformative pathways or innovation pathways with stakeholders provides a roadmap of actions for long term sustainability while tackling practitioner challenges and answering communities' needs. Second, it is looking at the implementation of a Blue Economy Observatory, as a digital innovation, to monitor the sustainability of blue economy sectors, highlighting opportunities and remaining gaps, emphasizing the need to measure and track the development of blue sectors to be sustainably managed. **6.1 The Black Sea context**

Located in southeastern Europe, the Black Sea is an inland sea covering an area of 436,400 km², bordered by Bulgaria, Georgia, Romania, Russia, Türkiye, and Ukraine. Positioned on the outer limits of the European Union, the Black Sea region is often regarded as a strategic bridge, serving as an essential economic, geopolitical, and trade corridor. It connects the Mediterranean Sea via the Marmara and Aegean Seas and links Europe with Asia, the Caspian Sea, Central Asia, and the Middle East. The region is highly dynamic and diverse, characterized by strong economic potential and close interconnections among its countries. However, it also faces complex challenges, including diverging national interests and an ongoing war greatly impacting the regional geopolitical stability, the economic dynamics but also the marine environment (European Commission, 2022). The Black Sea Blue Economy encompasses key sectors such as aquaculture, tourism, shipping, and fisheries, all of which offer significant opportunities for economic growth, job creation, and innovation. However, these industries depend on maintaining a healthy marine environment, including clean waters and thriving natural ecosystems.

Sustainable marine resource management is essential for providing critical ecosystem services such as food supply, coastal protection, and recreational opportunities. Nevertheless, the region faces considerable political, socio-economic, and environmental challenges aggravated by the Russo-Ukrainian war, shifting borders, economic crises, rapid urbanization, pollution, habitat degradation, and overfishing. These threats not only endanger the region's economic stability and potential but also put its biodiversity at risk. Regional initiatives and policies are increasingly addressing these concerns, aligning with broader European objectives such as the European Green Deal to support the transition to a sustainable Blue Economy.

Despite its vast potential, the Blue Economy in the Black Sea remains largely underdeveloped (European Commission, 2022). However, the region's economic importance has been formally recognized by key stakeholders in the Burgas Vision Paper (European Commission, 2019b) and the Common Maritime Agenda (European Commission, 2019c). While the Black Sea is rich in resources, it also exemplifies the environmental degradation affecting European seas. It is considered one of the most polluted seas globally, containing twice as much marine debris as the Mediterranean. Additionally, it suffers from severe eutrophication, with elevated levels of phosphorus, nitrogen, and other pollutants. Poor water quality has led to significant declines in fish populations and biodiversity, exacerbated by deoxygenation, climate change, and the introduction of invasive species. As the largest anoxic-sulfidic water body on Earth, the Black Sea's deteriorating ecological state has severe socio-economic consequences, affecting employment, food security, tourism, and public health. These challenges underscore the urgent need for a sustainable development trajectory.

To enhance sustainability, governance, and regional cooperation, two flagship strategies were introduced in 2019: the Common Maritime Agenda[4] (CMA) for the Black Sea and the Black Sea Strategic Research and Innovation Agenda[5] (SRIA) (European Union Horizon 2020 Black Sea Connect (Grant A. No. 860055), 2023). The CMA focuses on three main objectives: (i) ensuring healthy marine and coastal ecosystems, (ii) fostering a competitive, innovative, and sustainable Blue Economy, and (iii) promoting investment in sustainable maritime sectors. Meanwhile, the SRIA, as the scientific pillar of the CMA, aims to address fundamental research challenges, develop innovative solutions and clusters, establish critical support systems and research infrastructures, and enhance education and capacity-building efforts (Salihoglu et al., 2024). In 2023, the Black Sea SRIA implementation plan was officially launched, while the CMA has been actively implemented since its adoption, with annual stakeholder conferences and meetings driving its objectives forward.

As the region navigates its economic and environmental challenges, the effective implementation of these initiatives will be crucial in unlocking the full potential of the Black Sea's Blue Economy, ensuring long-term sustainability, and fostering regional stability and prosperity.

[4] https://black-sea-maritime-agenda.ec.europa.eu/
[5] http://connect2blacksea.org/the-sria/

6.2 Co-design of pathways to support sustainability transitions

Methodological background

'Sustainability transitions' refers to the processes of change through the shift from one socio-technical system (i.e. energy, food or mobility system) to another involving technological discontinuity and transformation of culture perceptions and symbols, user preferences and practices, market structures, industry strategies, business models, policies, and regulations (F. W. Geels, 2024). They are multi-actor, long-term and goal-oriented processes where innovation plays a key role through, for instance, the concept of 'niche', a space that supports radical innovation able to drive systems changes for transitioning towards sustainability (i.e. solar and wind energy, social media; electric vehicles; multi-trophic aquaculture) (Davis and Schutz, 2023).

Figure 1: Geography of Black Sea Blue economy stakeholders' engagement

As part of the EU H2020 BRIDGE-BS[6] ("Advancing Black Sea Research and Innovation to Co-Develop Blue Growth within Resilient Ecosystems'') and DOORS[7] ("Developing Optimal and Open Research Support for the Black Sea") projects, stakeholders representing key sectors of the Black Sea blue economy were engaged in a system innovation approach (*detailed in chapter 5*)

[6] https://bridgeblacksea.org/
[7] https://www.doorsblacksea.eu/

to co-design pathways supporting the achievement of a sustainable blue economy in the Black Sea, targeting specific sectors prioritized by stakeholders representing public and private sectors, academia and civil society (Figure 1). The approach followed within the BRIDGE-BS and DOORS projects aimed at co-developing sustainability-driven pathways in the Black Sea countries at local and national levels respectively, using local living labs for the former and national multi-actor labs for the latter. Pathways are understood here as a portfolio of short, mid, and long-term innovations and sustainable solutions (Matti et al., 2020), aiming at improving environmental performance and coastal communities' well-being while enhancing economic performance of blue economy sectors.

In the BRIDGE-BS project, blue transformative pathways were co-designed with local representatives of key blue economy sectors through a series of participatory workshops. Local stakeholders first mapped the challenges and opportunities related to marine ecosystems services and the blue economy to reach a common and holistic understanding of the marine system in each Black Sea country (besides Russia) (problem scoping workshop held in winter 2022). Local stakeholders were then invited to co-develop a cross-sectoral sustainable vision of their region by 2050 where the main challenges would be solved, using guiding principles derived from the 2030 SDGs[8] targets (envisioning workshop held in winter 2023). Through the vision, key sustainability targets, which all stakeholders agreed upon, could be extracted, which provided sectoral goals for the pathways co-designed with the stakeholders (pathway co-design workshop winter 2024). When co-designing the pathways, stakeholders identified a set of intermediary milestones and actions including technological, social and institutional innovations perceived as necessary to support the transition towards those sustainability goals described in a 2050 vision (Guittard et al., 2025). In the DOORS project the forums united national stakeholders to help scientists prioritise Black Sea issues (Akinsete et al., 2025a). The focus was on blue economy policies. The first round of workshops, held between November 2022 and February 2023, aimed at prioritising the blue economy sectors with the greatest value for each of the BS countries, as well as revealing the challenges associated with these sectors, using the PESTLE framework (Seyhan et al., 2025). The second round of forum was held between February and April 2024. The goals included downscaling generic innovation pathways produced between workshops, reviewing the working vision for the Black Sea derived from the SRIA, identifying milestones for achieving the vision in each relevant sector, and mapping relevant innovations onto these milestones.

The sectors considered in the pathways by the stakeholders were: shipping & port, fisheries, aquaculture, coastal and maritime tourism, ocean observation and environmental protection, and blue renewable energies. Additionally, the blue biotechnology sector was also considered a priority at national level while at local level stakeholders identified governance and planning as another key area of intervention to reach sustainability goals by 2050.

[8] Sustainable Development Goals - https://sdgs.un.org/goals

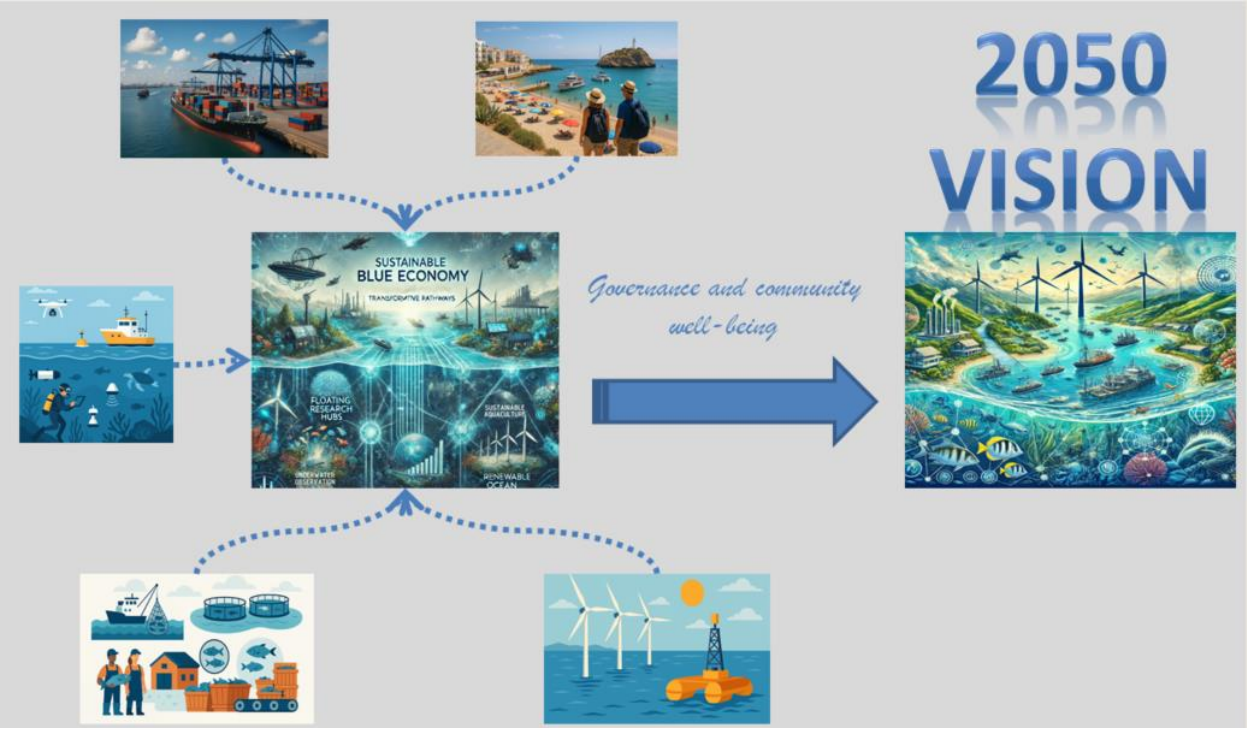

Figure 2: Blue economy sustainability-oriented pathways – *Images generated by AI- Chatgpt*

Innovation needs in key Black Sea blue economy sectors

Aquaculture

Achieving the transition towards sustainability in the aquaculture sector will require building a skilled workforce, developing infrastructures, adopting innovative technologies, and ensuring a diverse range of products. To this end, multiple innovative technologies are being prioritized such as smart disease control, smart underwater monitoring systems, and multi-trophic aquaculture systems; alongside specialized education and training programs, awareness-raising campaigns, and innovative financial incentive schemes.

Coastal and maritime tourism

By 2050, the coastal and maritime sector is envisioned as eco-friendly and sustainable which can be achieved by:

- establishing education programs targeting children, the workforce, and the general public.
- implementing energy-efficient systems and smart eco-friendly infrastructure, with a particular focus on waste management and transport. Romanian stakeholders have even proposed achieving a fully circular tourism sector by 2045.
- developing alternative and sustainable tourism offerings to diversify the sector beyond the traditional seasonal sea-sun-sand model such as underwater cultural heritage or the establishment of a maritime museum and marine mammal observation activities as specific milestones by 2027.

The adoption of innovative technologies, centered on digital tools, such as virtual and augmented reality, is expected to enhance the tourist experience, promote cultural heritage and reduce the environmental impact of the sector on marine ecosystems.

Blue renewable energy

By 2050, Black Sea coastal regions aim at achieving carbon neutrality, primarily through offshore (wind) energy. Therefore, the installation of offshore wind farms supported by the development of the necessary legal frameworks and investment plans is the key priority. Stakeholders have highlighted the innovation needs in this sector to enhance the efficiency of offshore installations and storage while minimizing environmental impacts. Additional measures include fostering partnerships between the state and industry, involving local communities in offshore development projects, and building a skilled local workforce.

Ocean observation and protection

Stakeholders have envisioned a restored, well-functioning, and well-protected Black Sea marine biodiversity by 2050. To achieve such ambitious goal actions, focus primarily on:

- strengthening and expanding a network of marine protected areas (MPAs) through legislative measures, ecosystem-based management, and a participatory stakeholder approach.
- developing advanced underwater monitoring systems by implementing innovative technologies such as automated vehicles, acoustic methods, smart forecasting and monitoring systems, and a digital twin of the ocean. More specifically the construction and maintenance of cloud infrastructures for ocean data, the establishment of national sea observation systems, and improving maritime and coastal surveillance via new AI and machine learning application have been identified as key steps

Additionally, citizen science initiatives and public awareness campaigns have been identified as key actions to foster greater commitment to marine environmental protection.

Innovations are also expected to play an incremental role in addressing waste pollution from both land- and sea-based sources.

Fishery

Fishing activities have been identified as significant sources of pressure due to unsustainable and illegal practices around the sea basin. The sector's future remains uncertain given the continuous decline of fish stocks and the deteriorating marine ecosystem. Therefore, a transformation in practices and business models is essential. A mix of social and technological innovations along with management measures, have been identified for:

- enhancing knowledge and monitoring of fish stocks for sustainable management.
- strengthening collaboration between scientists and fishermen.
- promoting the use of sustainable fishing techniques.
- implementing up-skilling and reskilling programs to adapt the workforce to new standards and facilitate the adoption of innovative fishing techniques and technologies.
- increasing international cooperation and strengthening law enforcement.

Innovative solutions include developing educational programs and awareness campaigns for fishermen and local communities on sustainable fisheries management; introducing eco-labels, certifications, and reward systems; advancing fishing selectivity techniques and zero-emission vessels, with dedicated training for fishermen; implementing automated fisheries monitoring and management systems to track

and regulate fishing activities; and integrating block-chain technologies to improve traceability within the seafood supply chain, launching 'Fishing for Litter' initiatives to tackle marine plastic pollution generated by the sector.

Shipping and ports

The shipping and ports sector is a key sector with ambitious international zero-net emission goals. Innovation will be needed to integrate low-emission and renewable energy sources in ports' operations and logistics, as well as improving the management of solid and liquid waste at sea and in port facilities. Actions to promote greener ports and vessels include:

- developing and implementing low-emission technologies for vessels and port operations to reduce air pollution and fuel consumption.
- digitalizing port operations and logistics through the use of Artificial intelligence, Internet-of-Things, and drones.
- automating monitoring systems for pollution control and enhancing incident response.
- ensuring the implementation of international regulations in Black Sea ports.

Governance community well-being

This cross-cutting theme focuses on improving horizontal and vertical policy integration, implementing sustainable environmental action plans for coastal and natural resource management, and advancing marine spatial planning through the implementation of specific social innovation such as:

- establishing a Ministry of the Sea and general directorates, and creating an independent nature conservation management unit
- formulating international joint strategies on renewable energy under the ministry's leadership,
- fostering investment partnerships between the technology, private, and public sectors
- establishing clean sea and environmental training centers
- promoting conscious consumer behavior
- developing community centers and sustainable certification schemes

Additionally tailor-made digital tools for awareness campaigns, incorporating virtual reality technologies into training programs, implementing a digital visitor management plan are innovative socio-technological solutions with the capacity to transform the blue economy socio-technological systems towards sustainability.

6. 3 The Black Sea Blue Economy Observatory

An example of regional digital innovation

An economic observatory is a platform for collecting, analysing, and disseminating economic data to provide actionable insights for policymakers, researchers, and businesses. It is a tool to address the complexities of interconnected global economies by tracking key socio-economic indicators such as GVA, and employment rates. Integrating sustainability metrics like resource uses and social equity indicators helps align economic strategies with environmental and social

goals, such as those outlined in the UN's Sustainable Development Goals (SDGs). A Blue Economy Observatory (BEO) focuses on marine and coastal economic activities to promote their sustainable development. It aims to integrate environmental, economic, and social metrics, to help policy makers and citizens identify trends, evaluating policy impacts, promoting on blue economy assets, and inform strategies to address challenges like fishery overexploitation, climate change adaptation and marine pollution. A BEO can be considered as much as an innovation enabler by providing market readability as a digital innovation itself in a context where no other technology can provide those specific services.

Today socio-economic data monitoring the activity of the Black Sea blue economy sectors are scattered across different databases and producers, often sector-specific, with no common framework for collecting, analysing, visualizing, and making accessible to policymakers, businesses, research and the wider public. A coordinated management of the Black Sea across riparian countries must rely on a common set data for a common knowledge and understanding.

In the framework of the EU H2020 BRIDGE-BS project a Black Sea BEO (BS BEO) is being developed as a first attempt to create such a tool dedicated to the Black Sea region (Guittard et al., 2025c). The BS BEO aims at providing Black Sea stakeholders with a one- point stop for collecting, visualizing socio-economic data from all blue economy sectors in all Black Sea countries, in a user-friendly way, and providing insights on sector present development status and future opportunities. Additionally, through the building work of the observatory, the project aims at identifying gaps in blue economy data collection and monitoring at country level and fostering data harmonization across the Black Sea region, in terms of indicators used, the format of the data collected, and data accessibility. Therefore, it will minimize the problem of blue economy data dispersion across different databases, repositories and formats. The BS BEO follows the framework of the European Blue Economy Observatory[9] (EU BEO) in a more simplistic structure, with four dedicated sections: i) a visualization dashboard to monitor the blue economy sectors per country, providing interactive visualizations on a set of sustainability indictors aiming at capturing the economic, environmental and social aspects of development in the region; ii) a sectors section, that provides detailed information on the current development of the Black Sea blue economy sectors; iii) a scenarios and roadmap section where blue economy scenarios will be displayed in a user-friendly way, exploring potential future blue economy development paths to give policy-makers future insights of present strategic development decision making; iv) a maritime policies and finance section providing information and links on the main regional and national policy frameworks, as well as funding opportunities in the region.

The first and most crucial step in building such an observatory is the selection of the indicators to be visualized and the harvesting of the relevant datasets for each country in the Black Sea. This proved to be a challenging task due to lack of available data in some countries, the use of different databases / repositories, and of diverse data formats and / or structures and different licenses. The development of the observatory has followed a 4 steps process:

[9] https://blue-economy-observatory.ec.europa.eu/index_en

1. Search, identify and validate the selection of important socio-economic indicators for the selected area.
2. Define a process for collaborative collection of the needed datasets for each country of the Black Sea.
3. Setup a data import / update workflow for importing the source datasets into the observatory and generating the required aggregated datasets to generate a dataset for each indicator including the information from each country. This step also provides the required process for periodically updating the source datasets.
4. Define the visualization descriptors for each indicator.

This process ensured the harmonization of the different datasets, originating from different sources, the visualization of them by using the most effective type and the seamless update of the information with the most up-to-date datasets, making the observatory sustainable in the long term.

Defining a blue economy sustainability dashboard

The selection of blue economy sustainability indicators was based on a methodology adapted from Foley et al. (2014) following 4 key criteria:

- *Comparability across sectors and regions*: the data should be consistent across all countries
- *Comparability across time*: the data should be sufficiently consistent over time so that changes can be observed and measured accurately
- *Theoretical and accounting consistency*: double counting of economic activity should not occur; all measures can be summed across industries and geographies
- *Replicability*: the collection of data should use a methodology that can be replicated by all administrative bodies from all countries

The methodology for selecting the indicators to be used in the dashboard to monitor the sustainable development of blue economy sectors followed an inventory of the most commonly used socio economic indicators as the BS BEO does not aim at developing a new set of metrics but rather, in a first stage, review and collect existing Black Sea blue socio-economic data while identifying the potential gap. Nevertheless, the BS BEO ambitions to be a tool for effectively measuring the sustainable development of the blue economy in its three dimensions (economic, social, and environmental), which implies going beyond the conventional economic indicators (i.e. GVA, turn-over, employment). However, as highlighted in the Plan Bleu recent study on indicators, despite notable advancements, several gaps remain, even at the EU level, for monitoring all blue economy sustainability components.

The blue economy is characterised by the absence of holistic indicators that fully encompass sustainability; therefor there are serious constraints in terms of data availability, which results in

a lack of unified –blue economy-wide datasets. More specifically, as pointed out by Plan Bleu (2023), the blue economy frameworks critically lack metrics for measuring ecosystem health and services. Therefore, the BS BEO tried to propose a set of indicators capable of measuring the long-term sustainability of blue economy activities in terms of economic viability, social equity, and environmental responsibility. Nonetheless, the choice of indicators to be integrated into the BS BEO, in its initial stage, had to consider data availability as a major constraint. Indeed, not all Black Sea countries have information, observation and indicator calculation systems with the same level of performance and ambition. The final selection of the BS BEO metric was performed through a data assessment analysis which enabled to highlight of current gaps in the Black Sea country data collection and monitoring systems dedicated to the blue economy.

The BS-BEO Observatory as innovation enablers

This data-driven approach enables the visualisation of the most important and up to date socio-economic indicators in the Black Sea region, aggregating distinct datasets and visualising them using a uniform way. This systematic gathering, analysis and visualisation of data, supports Black Sea stakeholders in multiple ways. First of all, it places the Black Sea region on the "EU innovation map" and acts as a benchmark to identify shortcomings and gaps but also innovations and best practices in the Black Sea countries when compared to each other, or to other EU countries through existing available observatories and data repositories.

Black Sea policy makers, businesses and communities are supported in informed decision-making and can deploy evidence-based policy and business development. Data observatories can also increase resource efficiency in the Black Sea, being a region with well-defined geographical boarders and stakeholders active in the area. Data collection and presentation through an observatory can strengthen the exchange among all actors, help identify sustainability challenges, plan actions in the area, track progress, and ultimately contribute to development and optimization of strategies for long-term impact.

The above can be further accelerated through the application of Open Science (OS) principles. Open science by design promotes transparency, accessibility, and collaboration and can therefore play a crucial role in enhancing data-driven sustainability transitions. By making not only research data, but also methodologies and research findings openly available, OS fosters knowledge-sharing across disciplines and sectors, reduces barriers to knowledge exchange, shares and accelerates technological advancements. For the Black Sea policymakers, businesses, and communities this ensures access to the latest scientific insights and allows the co-development of sustainability solutions that are scalable, inclusive, and adaptive to emerging challenges.

Conclusion

This chapter presented different tools, as innovation enablers for the deployment of a sustainable blue economy in the Black Sea, tested within the frame of the BRIDGE-BS project, capable of tackling the multiple social, environmental and economic challenges characterizing the region.

Sustainability-oriented pathways targeting specific blue sectors (aquaculture, blue biotechnology, blue renewable energies, coastal and maritime tourism, fisheries, governance and communities' well-being, ocean observation and protection, shipping & port), and co-designed with stakeholders, are providing a portfolio of short, mid and long terms innovation needs (technological, social, and institutional). The pathways can be used as strategic planning document for long term innovation investment to support the blue sustainability transition. However, innovation in the Black Sea remains hindered by fragmented networks, limited funding, and unequal innovation capacities among countries, which slow the transposition of research into market-ready solutions. Strengthening accelerators like the Black Sea accelerator (Akinsete et al.,2025b), alongside targeted support for entrepreneurship, partnerships, and skills development, is essential to overcome these barriers and unlock the region's full potential for a sustainable blue economy.

Finally, a blue economy observatory can be used as an innovation enabling tool while being fully part of a digital transformation sustainability process. It allows the implementation of a unified sustainability monitoring framework for the blue economy, highlighting the remaining gaps the Black Sea region is currently facing, preventing the effective implementation of a regional blue sustainability strategy to achieve the objectives of the EU Green Deal and Agenda 2030

Acknowledgements

This paper is an output of the science project BRIDGE-BS. BRDIGE-BS has received funding from the from the European Union's Horizon 2020 Framework Programme for Research and Innovation under grant agreement No 101000240. DOORS BS has received funding from the from the European Union's Horizon 2020 Framework Programme for Research and Innovation under grant agreement No 101037424.

References

Akinsete E., Vassilopoulos A., Secco L., Pisani E., Nijnik M., Marini Govigli V., Koundouri P., Kafetzis A., (2022). Social innovation for developing sustainable solutions in a fisheries sector. Environmental Policy and Governance, 1 16. https://doi.org/10.1002/eet.2022

Akinsete, E., Papadaki, L., & Koundouri, P. (2025a). **Black Sea Blue Transitions: Multi-actor Forums to Promote a Sustainable Blue Economy.** In M. Amer, M. El Kaftangui, I. El-Sayed Maarouf, N. Khalid, & S. S. B. Dol (Eds.), *Territorial Landscapes Solutions for*

Sustainable Energy and Food Security (pp. 43–51). ***Springer, Cham.*** https://doi.org/10.1007/978-3-031-82419-7_6

Akinsete E., Flerianou A., Herpers F.,Manousiadi E., Papadaki L., Katris I. Koundouri P., (2025b). "Accelerating Sustainability: Innovation Pathways and Entrepreneurial Ecosystems in the Black Sea Blue Economy," DEOS Working Papers 2537, Athens University of Economics and Business. https://ideas.repec.org/p/aue/wpaper/2537.html

Bennett, N. J., Cisneros-Montemayor, A. M., Blythe, J., Silver, J. J., Singh, G., Andrews, N., Calò, A., Christie, P., di Franco, A., Finkbeiner, E. M., Gelcich, S., Guidetti, P., Harper, S., Hotte, N., Kittinger, J. N., le Billon, P., Lister, J., López de la Lama, R., McKinley, E., … Sumaila, U. R. (2019). Towards a sustainable and equitable blue economy. Nature Sustainability, 2(11), 991–993. https://doi.org/10.1038/S41893-019-0404-1

Brent, Z., Barbesgaard, M., & C. Pedersen (Carsten). (2018). The Blue Fix: Unmasking the politics behind the promise of blue growth. Retrieved from http://hdl.handle.net/1765/113242

Cisneros-Montemayor, A. M., Moreno-Báez, M., Reygondeau, G., Cheung, W. W. L., Crosman, K. M., González-Espinosa, P. C., Lam, V. W. Y., Oyinlola, M. A., Singh, G. G., Swartz, W., Zheng, C. wei, & Ota, Y. (2021). Enabling conditions for an equitable and sustainable blue economy. Nature, 591(7850), 396–401. https://doi.org/10.1038/S41586-021-03327-3

Davies, J., & Schultz, W. (2023). NGFS Climate Scenarios Expansion. https://doi.org/10.6084/m9.figshare.24190755

Elston, J., Pinto, H., & Nogueira, C. (2024). Tides of Change for a Sustainable Blue Economy: A Systematic Literature Review of Innovation in Maritime Activities. Sustainability, 16(24), 11141. https://doi.org/10.3390/su162411141

European Commission (2025), COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A Vision for Agriculture and Food Shaping together an attractive farming and agri-food sector for future generations; COM/2025/75 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0075

European Commission. (2022). The EU blue economy report 2022. Publications Office of the EU. https://op.europa.eu/en/publication-detail/-/publication/156eecbd-d7eb-11ec-a95f-01aa75ed71a1/language-en

European Commission (2021), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on a new approach for a sustainable blue economy in the EU: transforming the EU's blue economy for a sustainable future. 17.5.2021 COM 240 final. Brussels: Publications Office of the European Union.

European Commission (2019c). Common Maritime Agenda for the Black Sea. Available online at: https://black-sea-maritime-agenda.ec.europa.eu/key-documents?page=1 (Accessed February 24, 2025).

European Commission (2019b). Bucharest Declaration on the Black Sea Research and Innovation Agenda. Available online at: https://black-sea-maritime-agenda.ec.europa.eu/key-documents?page=1 (Accessed February 24, 2025).

European Commission (2019a), COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS The European Green Deal
COM/2019/640 final. Brussels: Publications Office of the European Union, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640

European Environment Agency (2019), Marine messages II: Navigating the course towards clean, healthy and productive seas through implementation of an ecosystem-based approach, EEA Report , No 17/2019

European Union Horizon 2020 Black Sea Connect (Grant A. No. 860055) (2023). Black Sea Strategic Research and Innovation Agenda. Available online at: http://connect2blacksea.org/wp-content/uploads/2024/01/Black-Sea-SRIA_2023.pdf (Accessed August 23, 2024).

Foley, N. S., Corless, R., Escapa, M.,Fahy, F., Fernandez-Macho, J., Gabriel, S., Gonzalez, P., Hynes, S., Kalaydjian, R., Moreira, S., Moylan, K., Murillas, A., O' Brien, M., Simpson, K., and Tinch, D. 2014. “Developing a Comparative Marine Socio-Economic Framework for the European Atlantic Area.” Journal of Ocean and Coastal Economics: Vol. 2014: Iss. 1, Article 3. DOI: https://doi.org/10.15351/2373-8456.1007

Geels F. W., (2024), Sustainability transitions, Elgar advance introduction, 181pp, ISBN 978 1 035329700, Northampton, MA, USA

Guerry A.D. , S. Polasky, J. Lubchenco, R. Chaplin Kramer, Daily G.C. , Griffin R. , Ruckelshaus M. , Bateman I.J. , Duraiappah A. , Elmqvist T., Feldman M.W. , Folke C. , Hoekstra J. , Kareiva P.M. , Keeler B.L. , Li S. , McKenzie E. , Ouyang Z. , Reyers B. , Vira B. , (2015), Natural capital and ecosystem services informing decisions: from promise to practice, Proceedings of the National Academy of Sciences of the United States of America, 112 , pp. 7348-7355, 10.1073/pnas.1503751112

Guittard A., et al. (2025), Deliverable D6.4: Living Lab report, H2020 BRIDGE-BS project Grant Agreement 101000240, European Commission, 299 pp

Guittard A., Chatzigiannakou M., Koltsida K., Stefou T., Toli E., Koundouri P., (2025c), Deliverable 1.5: Black Sea Blue Economy Observatory (part 1), H2020 BRIDGE-BS project Grant Agreement 101000240, European Commission, 29 pp

Jouffray, J. B., Blasiak, R., Norström, A. v., Österblom, H., & Nyström, M. (2020). The Blue Acceleration: The Trajectory of Human Expansion into the Ocean. *One Earth*, *2*(1), 43–54. https://doi.org/10.1016/J.ONEEAR.2019.12.016

Koundouri, P., Halkos, G., Landis, C. F. M., & Alamanos, A. (2023a). Ecosystem services valuation for supporting sustainable life below water. *Sustainable Earth Reviews*, *6*(1). https://doi.org/10.1186/s42055-023-00068-1

Koundouri, P., & Plataniotis A. (2023b). Editorial: Towards a Sustainable Future – Insights from Marine and Coastal Research. ***Frontiers in Environmental Economics***, *Sec. Economics of Climate Change Volume 2*. doi: 10.3389/frevc.2023.1354990

Matti, C., Martín Corvillo, JM, Vivas Lalinde, I., Juan Agulló, B., Stamate, E., Avella, G., and Bauer A. (2020). Challenge-led system mapping. A knowledge management approach. Transitions Hub series. EIT Climate-KIC, Brussels, ISBN 978-2-9601874-3-4

Pace, L. A., Saritas, O., & Deidun, A. (2022). Exploring future research and innovation directions for a sustainable blue economy. https://doi.org/10.1016/j.marpol.2022.105433

Park, Dr. Kwang Seo and Kildow, Dr. Judith T. (2014) "Rebuilding the Classification System of the Ocean Economy, "*Journal of Ocean and Coastal Economics*: Vol. 2014: Iss. 1, Article 4. DOI: https://doi.org/10.15351/2373-8456.1001

Plan Bleu (2023), "Scoping Study to Develop a Mediterranean Pilot on Measuring the Sustainability of the Mediterranean Blue Economy, volume 2: Developing a Framework for Blue Economy Sustainability in the Mediterranean", December.

Salihoglu, B., Yücel, M., Uygurer, P., Yücel, E. Ş., Papathanassiou, E., Tezcan, D., Stanica, A., Stanciu, I., Moncheva, S. P., Dzhembekova, N., Blagovestova Stefanova, K., Komorin, V., Castravet, T., Bilashvili, K., Melikidze, V., Gvilava, M., & Kobaidze, S. (2024). Implementing regional blue economy research and innovation strategies: a case study for the Black Sea. *Frontiers in Marine Science*, *11*, 1409689. https://doi.org/10.3389/FMARS.2024.1409689/BIBTEX

Schot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, *47*(9), 1554–1567. https://doi.org/10.1016/J.RESPOL.2018.08.011

Seyhan, K., Dürrani, Ö., Papadaki, L., Akinsete, E., Atasaral, ebnem, Özs, K., Akpınar, H., Kurtulus, E., Evren Mazlum, an, Koundouri, P., Stanica, A., Angela Ciliberti, S., Liubartseva, S., CMCC Centro Euro-Mediterraneo sui Cambiamenti Climatici, F., George Zodiatis, I., & Ö, D. (2025). Bridging the gaps for a thriving Black Sea Blue Economy: insights from a multi-sectoral forum of Turkish stakeholders OPEN ACCESS EDITED BY. doi: 10.3389/fmars.2025.1491983

Wittmayer, J. M., Backhaus, J., Avelino, F., Pel, B., Strasser, T., Kunze, I., & Zuijderwijk, L. (2019). Narratives of change: How social innovation initiatives construct societal transformation. *Futures*, *112*. https://doi.org/10.1016/j.futures.2019.06.005

World Bank, (2017), The potential of the Blue Economy: Increasing long-term benefits of the sustainable use of marine resources for small island developing states and coastal least developed countries. World Bank, Washington DC.