SCOPING STUDY TO DEVELOP A MEDITERRANEAN PILOT ON MEASURING THE SUSTAINABILITY OF THE MEDITERRANEAN BLUE ECONOMY

vol 1: Literature Review and Analysis of Currently Used Indicators

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Context

As a Regional Activity Center of the United Nations Environment Programme/Mediterranean Action Plan, Plan Bleu seeks to develop a comprehensive framework for assessing the sustainability of the Mediterranean Blue Economy. Supporting the transition towards sustainable economic activities and advancing the understanding of the interconnections between economic activities, social well-being, and ecological health in the Mediterranean region are among Plan Bleu's mandates.

Plan Bleu has developed the Mediterranean Observatory on Environment and Sustainable Development to support Contracting Parties of the Barcelona Convention and report on the implementation of the Mediterranean Strategy for Sustainable Development (MSSD), and as such plays a crucial role in monitoring the sustainability of the blue economy. However, available information related to blue economy sectors in the Mediterranean primarily describes economic activities using indicators such as value added (% of GDP), employment figures, quantification of other physical elements (number of berths in ports, passenger counts, tourist numbers, catch volumes, etc.), and occasionally qualitative descriptions of interactions with the environment and society. This is insufficient to determine whether an activity is « sustainable » or not. The existing approaches, while valuable, often provide a fragmented view of sustainability. As the Mediterranean Blue Economy continues to evolve quickly, a comprehensive framework that goes beyond the current indicators is needed to understand its sustainability. Plan Bleu aims to support the development of an integrated assessment framework which accounts for the interactions between economic activities, ecosystems, and communities and includes sector-specific indicators. The framework is planned to align with, and draw from, the Mediterranean Strategy for Sustainable Development 2016-2025 (MSSD 2016-2025), the Sustainable Development Goals (SDGs), the Kunming-Montreal Global Biodiversity Framework and the Regional Action Plan for Sustainable Consumption and Production.

A crucial step in the comprehensive framework development process is the initiation of a pilot study. A feasibility study is needed to frame the development of a holistic assessment of the sustainability of the Mediterranean Blue Economy. This includes: proposing a set of selected indicators that inform the environmental, social and economic sustainability of the Mediterranean Blue Economy, considering interdependencies between indicators, and providing a comprehensive understanding of the region's state and progress in transitioning towards a Sustainable Blue Economy.

A feasibility study has thus been produced in two volumes.

- **This first volume proposes a literature review and analysis of currently used indicators**. It provides indications about the extent to which currently available Blue Economy literature takes into account and/or measures the economic, social and environmental sustainability of the relevant Blue Economy activities, at the global level and in particular in the Mediterranean region.
- A second, follow-up volume, proposes an original framework/concept that aims at providing comprehensive information about the economic, social and environmental sustainability of the Blue Economy. This framework includes a set of proposed potential alternative sectoral and cross-cutting indicators to measure the sustainability of the Blue Economy and explores methodologies and feasibility of quantification. It also further investigates the geographical and thematic scope to apply the above-mentioned framework in the Mediterranean, and provides a provisional list of the specific stakeholders that shall ideally be involved (local communities or associations of local communities, government bodies, industry representatives, NGOs, academic institutions, regional and international organizations, etc).

Summary and Key Takeways

The document presents a comprehensive literature review and gap analysis of global and Mediterranean blue economy sustainability measurement frameworks. The analysis identifies limitations and gaps in existing frameworks, emphasizing the lack of holistic indicators and standardized data, particularly in assessing policies, emerging sectors, social equity, and ecosystem health. The study advocates for a multifaceted approach to address these gaps, emphasizing expanded sustainability indicators, strengthened data collection systems, increased disaggregation, incorporated effectiveness evaluations, and improved data standardization. Key Takeaways include the following :

- Current global, EU, and Mediterranean blue economy sustainability frameworks exhibit shortcomings in representing key sustainability dimensions comprehensively, including environmental, economic, social, and governance aspects.
- Inadequate breadth of indicators is compounded by major data gaps, lack of harmonized datasets, and over-reliance on modelled data. Critical areas, such as policy effectiveness, emerging sectors, social equity, and ecosystem health, suffer from insufficient indicators and localized primary data.
- Economic indicators predominantly focus on traditional sectors, neglecting new blue industries. Environmental indicators lack multi-dimensional ecosystem assessments, while social indicators are limited in evaluating human well-being and community impacts. Governance indicators are weak in assessing policy implementations.
- To bridge existing gaps, a multifaceted approach is recommended, involving expanded sustainability indicators, strengthened data collection systems, increased disaggregation, incorporated effectiveness evaluations, and improved data standardization.
- The call for a broader scope of sustainability indicators includes consideration of nuanced factors such as biodiversity loss, social equity, and resilience to environmental changes, ensuring a more holistic view.
- The document concludes with a proposal for a structured framework (presented in volume 2) aiming to integrate expanded indicators, strengthened data systems, disaggregation, effectiveness evaluations, and data standardization. The envisioned framework aims to provide a unified and globally applicable system for assessing and enhancing sustainability.

I. Introduction: Challenges in Monitoring the Mediterranean Blue Economy

The **Mediterranean region**, characterised by unique ecological, economic, and social features, is a significant area for examining the **Sustainable Blue Economy** (SBE). Given the growing global focus on sustainability, a thorough exploration of the Mediterranean Blue Economy is vital. This literature review aims to evaluate existing methodologies, literature, and reports that focus on measuring the **sustainability** of **blue economy sectors**.

Understanding the complex indicators of sustainability requires dual perspectives. One perspective should assess **marine environmental sustainability** in the Mediterranean while the other should explore the broader blue economy sectors. The overall goal is to pinpoint existing indicator gaps, assess the applicability of global and European Union (EU) standards to the Mediterranean region, and verify the importance of these indicators, particularly concerning emerging sectors of the blue economy.

In 2015, the United Nations initiative introduced several global monitoring indicators for **Sustainable Development Goal (SDG) 14** which aims to conserve and use ocean and marine resources sustainably. These indicators include, but are not limited to, the percentage of safeguarded coastal and marine areas and the proportion of fish tonnage landed within Maximum Sustainable Yield (MSY). However, they are not comprehensive in defining ocean sustainability. Presently, a total of ten indicators related to SDG 14 are consistently monitored globally, aligning with the 2030 Agenda for Sustainable Development.

In the context of the EU, monitoring SDG 14 includes evaluating trends in ocean health, marine conservation, and sustainable fisheries. As Figure 1 illustrates, the EU's approach to SDG 14 has been streamlined to six indicators, contrasting with the broader set of ten global indicators. This difference underscores the varied methodologies, data availability, and indicator relevance across regions.

Figure 1. Indicators measuring progress towards SDG 14 at EU level

Table 14.1: Indicators measuring progress towards SDG 14, EU

| Indicator	Period	Annual growth rate	Trend
Ocean health			
Global mean surface seawater acidity	2006–2021	− 0.02%	↘
	2016–2021	− 0.03%	↘
Marine waters affected by eutrophication	2007–2022	4.2% (¹)	↓
	2017–2022	19.5% (¹)	↓
Coastal bathing sites with excellent water quality	2011–2021	0.8%	↗
	2016–2021	0.1%	↗
Marine conservation			
Marine protected areas	Time series too short for long-term assessment		:
	2016–2021	Observed: 10.3% Required: 10.5%	↑
Sustainable fisheries			
Estimated trends in fish stock biomass	2005–2020	1.3%	↑
	2015–2020	2.6%	↑
Estimated trends in fishing pressure	2005–2020	− 3.1%	↑
	2015–2020	− 3.0%	↑

Source: EU

On a **regional scale**, the Mediterranean Strategy for Sustainable Development 2016-2025 (MSSD) outlines six main objectives that combine environmental and developmental concerns. Objectives related to "sea and coasts" and transitioning to a green and blue economy are especially relevant. The Mediterranean Observatory on Environment and Sustainable Development, led by Plan Bleu, is instrumental in monitoring these objectives. Moreover, based on the MSSD, this observatory plays a pivotal role in supporting sustainable development monitoring by providing a dataset of various indicator factsheets. These sheets depict different environmental and sustainable development challenges identified in the Mediterranean region.

The Sustainable Blue Economy (SBE) encompasses sectors like oil and gas, fisheries, transport, and tourism. However, the blue economy sectors' sustainability monitoring has seen limited advancement.

The EC has published a **guideline for sustainability criteria** for the **blue economy sectors** ((European Commision 2021b). This guideline comprises 44 common indicators that are applicable across multiple sectors, along with 20 key common indicators and additional subsector-specific indicators. As shown in Figure 2, sustainability management embodies a multifaceted and multidimensional concept which requires a dynamic balance among the economic, social, environmental, and institutional/governance dimensions. However, as highlighted by Organisation for Economic Cooperation and Development (OECD 2023), the environmental and economic ocean data are immature compared to the terrestrial domain, and considerable **data collection and integration challenges** remain in order to comprehensively monitor progress towards a sustainable ocean economy. In particular, there is a need to fill data gaps related to measuring and monitoring the status of marine ecosystem services and to strengthen their valuation to identify priorities and address potential trade-offs.

Figure 2. Balance in sustainability dimensions for the blue economy sectors
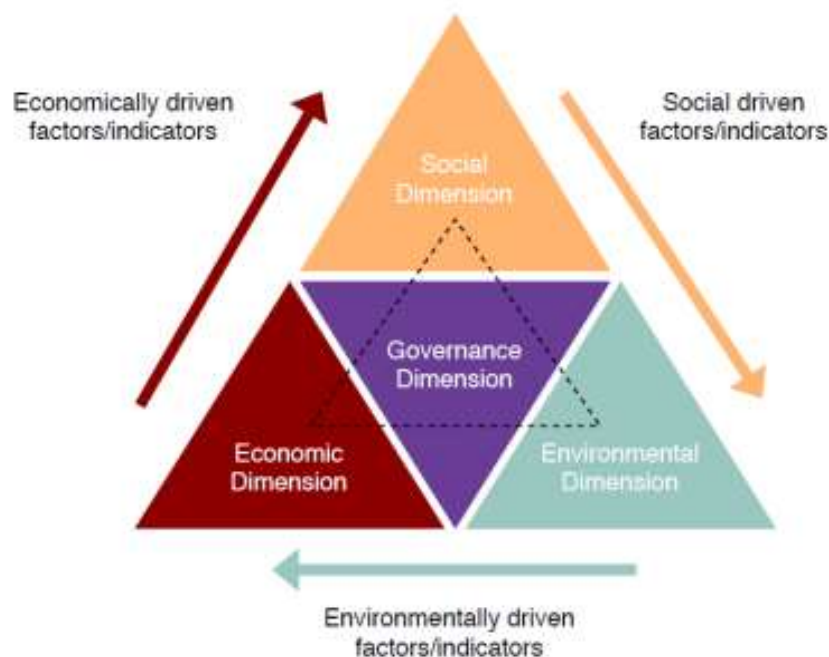
Source: EC, 2021

This literature review is underpinned by several primary justifications:

- Differences in **ocean sustainability** metrics across global, European, and regional frameworks.
- **Data challenges** exclusive to the **Mediterranean region**.
- The **dynamic** nature of **blue economy sectors** necessitating modern evaluation tools and indicators.
- A call for **concise** yet comprehensive **indicators**.

Subsequent sections will delve into the aforementioned topics by providing insights into the Mediterranean Blue Economy and stressing the need for progressive indicators. This review lays the groundwork for effective future monitoring, evaluation, and policy creation.

A. INTERPRETATIONS OF THE SUSTAINABLE BLUE ECONOMY (SBE)

In the Mediterranean, holistically understanding the Sustainable Blue Economy (SBE) is crucial. The term, SBE, is recurrent in academic publications, policy documents, and discussions within civil society. However, its definition varies among sources (European Commission (2020), COA (2019), World Bank and UN (2017), Patil et al. (2016), WWF (2015 & 2018), Economic Intelligence Unit (2015), the legal framework of the Changwon Declaration 2012 [Article 2], and the consolidated national definitions from Park and Kildow (2014)). One commonality is the economic focus, but vital components such as equity, social, and ecosystems are at times side-lined. For instance, Patil et al. (2016) accentuate the environmental and economic facets of the SBE and place less emphasis on social elements. Conversely, the World Wildlife Fund (WWF, 2018) definition incorporates social equity and terrestrial activities. The COA (2019), while not directly referencing equity, underscores the "equitable distribution of benefits." The urgent need for marine spatial planning to restore ocean health and properly utilize its resources prompts a call for a clear and universal "Blue Economy" definition that prioritizes ocean health, coexistence of activities, and community well-being to guide equitable decision-making and ensure a sustainable future (Ward-Paige et al. 2023).

Given the diversity in definitions and their implications on policy and research, it is pivotal to adopt a precise definition for the context of this review. For the scope of this study, the SBE definition provided by the SBE Visions and Pathways document (UNEP, UNEP-WCMC and the University of Portsmouth) will be used. According to this source, the SBE is defined as "**an approach to governing the ocean and coastal systems that facilitates the creation of equitably shared economic and social benefits, including across generations, from ocean and coastal resource use, while ensuring that the ecosystems upon which most ocean and coastal resources depend are not degraded and, where possible, are restored to a healthy functioning state**."

The Sustainable Blue Economy (SBE) encompasses sectors like oil and gas, fisheries, transport, and tourism. Some sectors, such as waste disposal and desalination, are less commonly considered. Notably, land-based sectors with oceanic ties, like agriculture, aren't mentioned. Definitions vary due to the inclusion of public sectors, non-ocean activities, and emerging industries. Several references often view oceans as natural capital, livelihood sources, business platforms, and innovation drivers (Park and Kildow, 2014; Voyer et al., 2018).

II. Methodological Framework for Literature Review

An exhaustive literature review was conducted to systematically analyse diverse sources including academic literature, technical reports, policy documentation, and indicator databases. This meticulous exploration aimed to elucidate methodologies employed in measuring blue economy sectors sustainability with a specific focus on the Mediterranean region due to its distinct ecological and economic attributes.

The investigative approach was anchored around critical inquiries:

- What are the inherent deficiencies or **gaps** in the **current indicators**?
- How do **global** and **European indicator frameworks** align or deviate when contextualized to the **Mediterranean environment**?
- To what extent are the current indicators **robust** and **adaptive** to gauge sustainability in both established and **nascent blue economy sectors**?

Outlined below are the primary references on a global, European, and Mediterranean scale, that substantiated our review:

A.   GLOBAL OVERVIEW

- The **United Nations (UN)** has been pivotal, especially regarding the inception of the Sustainable Development Goals (SDGs) in 2015. By 2023, they expanded their indicator framework to incorporate ten specific indicators pertinent to SDG 14: Life Below Water (UN, 2023).
- The **UN Environment Programme (UNEP)** released the "Measuring Progress" report in 2022 describing comprehensive ocean assessment methodologies and indicators congruent with the UN Ocean Decade's objectives (UNEP, 2022).
- The **United Nations Economic Commission for Africa (UNECA)** produced the Blue Economy Policy Handbook, a living document, the implementation of which will generate further lessons and good practices emerging from countries engaged in the Blue Economy process (UNECA, 2016). It includes freshwater resources in the concept of the blue economy, a growing trend especially in African countries.
- The **Organisation for Economic Cooperation and Development (OECD)** introduced a salient contribution via its report "The Ocean Economy in 2030," suggesting that indicators be categorized across various capital domains. Capital domains refer to the different forms of capital that provide value in the economy - natural capital (ocean resources), human capital (labor and knowledge), produced economic capital (ships, ports), social capital (institutions and relationships), etc. Concurrently, the OECD's Ocean Economy Database which encompasses multifaceted indicators was also scrutinized (OECD, 2016).
- **Selected scientific papers and reviews**: The scientific papers by Martínez-Vázquez et al. (2021) and Lu et al. (2019) play a crucial role in the global review of Blue Economy (BE) indicators. Martínez-Vázquez et al.'s analysis, conducted through bibliometric methods, explores the growth and trends in BE, Maritime Economy (MAE), Ocean Economy (OE), Marine Economy (ME), and Blue Growth (BG). The study delves into key themes such as sustainability, governance, economics, ecosystem protection, industrial development, and the growth of the ocean economy. Importantly, it identifies a potential link between BE and Circular Economy (CE) through BG, emphasizing the need for alliances to achieve sustainable BE. Lu et al.'s paper provides valuable insights into successful BE examples with an international perspective, showcasing practical applications and case studies. Together, these papers contribute to a comprehensive understanding of BE, offering data-driven analysis and case-based exploration, essential for informing global policy decisions and promoting the development of the blue economy.
- The **World Bank,** in its 2021 publication, underscored the blue economy's potential in Small Island Developing States (SIDS) and Coastal Least Developed Countries (CLDCs), advocating for a holistic monitoring framework (World Bank, 2021).

- **Non-Mediterranean Countries Overview:** Australia developed the AIMS Index of Marine Industry, emphasizing economic metrics but lacking sustainability indicators (AIMS, 2017). India adopted a National Marine Policy in 2021, focusing on sustainable development without a defined set of sustainability indicators. China established a Marine Economic Statistical System, primarily concentrating on economic indicators with minimal emphasis on environmental sustainability. Canada developed an Ocean Accounts Framework, measuring economic importance without substantial inclusion of environmental sustainability indicators. Small Island Developing States, guided by the World Bank, proposed a comprehensive conceptual model emphasizing sustainability and resilience, addressing livelihoods, ecosystems, and the enabling environment. Challenges persist, including a lack of harmonized data and the need for more localized community-based initiatives.

B.   EUROPEAN CONTEXT

- The **European Commission (EC)** has significantly influenced the discourse by promoting guidelines in 2021 that define sustainability criteria for the blue economy and sector-specific indicator frameworks. The EC's annual Blue Economy Report (EC, 2023) and a 2020 focused study on marine-relevant SDG indicators in Europe provided substantial analytical insight (EC, 2020 & EC, 2021).
- **Selected scientific papers and reviews**: The paper by Rickels et al. (2019) plays a pivotal role in the European Blue Economy indicators review. This study evaluates the progress of EU coastal states against Sustainable Development Goal 14, utilizing a set of 18 indicators. Contrary to assumptions, the findings question the comprehensive achievement of blue growth in the EU. The research underscores the need to distinguish between weak and strong sustainability, revealing variations among countries. Specific challenges, such as increasing fishing mortality and a reduced willingness to align with scientific advice, are identified as contributors to unsustainable development. This detailed analysis provides essential insights for assessing the sustainability and challenges of blue growth in the European context.

C.   MEDITERRANEAN FOCUS

- The **Mediterranean Action Plan (UNEP/MAP)** in 2016 propagated the Mediterranean Strategy for Sustainable Development (MSSD), charting strategic trajectories for blue economy and marine sustainability within the Mediterranean region (UNEP/MAP, 2016). Progress monitoring mechanisms are facilitated through the Plan Bleu Mediterranean Observatory's indicator database (Plan Bleu, 2022) and supplemented by UNEP/MAP's periodic environmental and developmental assessment reports for the Mediterranean domain (UNEP/MAP, 2022).
- **Selected scientific papers and reviews**: In a comprehensive examination of the Blue Economy, Nourhan Hamdy and Carmelina Bevilacqua (2023) focus on the role of Blue Growth industries in Calabria, Southern Italy. Their study delves into the characteristics, size, and specialization of Blue Growth industries in the region, employing cluster-based analysis to uncover interconnections between sectors. Meanwhile, Cappelletto et al. (2021) present a Mediterranean perspective in their paper, "The Mediterranean Sea we want." This work critically assesses the implementation challenges of the UN Decade of Ocean Science for Sustainable Development (2021-2030) in the Mediterranean region. Addressing gaps and proposing recommendations based on regional consultations, the paper emphasizes the urgent need for a sustainable blue economy, considering climate change vulnerabilities and escalating human-induced pressures. Together, these papers contribute valuable insights into both regional and broader aspects of the Blue Economy, offering a nuanced understanding of challenges and opportunities in different coastal areas.

Table 1 on the next page shows an example of the indicators associated with specific actions under Objectives 1 and 5 which are strictly related to the development of blue economy in the Mediterranean. An exhaustive analysis of all the indicators is undertaken in the following sections.

Table 1. Example of indicators associated with the different strategic directions of the MSSD

Objective	Strategic direction	Actions	Indicators
Objective 1: Ensuring sustainable development in marine and coastal areas	1.1: Strengthen implementation of and compliance with the Protocols of the Barcelona Convention and other regional policy instruments and initiatives supplemented by national approaches	1.1.4. Support national coastal conservation initiatives and strengthen or develop specific national laws for conservation of coastal areas, building on concepts such as public trusteeships	• Number of initiatives and legal instruments addressing specifically coastal conservation
Objective 1: Ensuring sustainable development in marine and coastal areas	1.2: Establish and enforce regulatory mechanisms, including Maritime Spatial Planning, to prevent and control unsustainable open ocean resource exploitation	1.2.1. Promote and support the blue economy concept through strong partnerships between maritime sectors and public authorities regarding the sustainable and equitable use of marine areas and resources	• Percentage of contribution of maritime-related activities to the gross national product • Coastal livelihoods and economies
Objective 5: Transition towards a green and blue economy	5.1: Create green/blue and decent jobs for all, particularly youth and women, to eradicate poverty and enhance social inclusion	5.1.1. Undertake a skills assessment and gap analysis, monitor and forecast demand for green/blue jobs to strengthen the role of green jobs in eradicating poverty and enhancing social inclusion	• Number of countries undertaking skills assessments and gap analyses on green/blue jobs • Number of countries with administrative processes in place for monitoring and forecasting green/blue job demand
Objective 5: Transition towards a green and blue economy	5.4: Encourage environmentally-friendly and social innovation	5.4.5. Create and promote a Mediterranean business award for environmental innovation	• Business award established

Source: UNEP/MAP, 2016

These numerous sources are slated for in-depth analytical processing in the following sections, further refining our comprehension of marine ecosystem sustainability, particularly in alignment with SDG 14.

D.   OTHER RELEVANT FRAMEWORKS AND METHODOLOGIES APPLIED WORLDWIDE

In the realm of global environmental governance, regional conventions and frameworks play a crucial role in addressing diverse challenges for a sustainable future. Regional pillars such as HELCOM, OSPAR, and the Barcelona Convention focus on preventing marine pollution in European seas, employing indicators like spills and discharges per ship mile to quantify the impact on ecosystems. Initiatives like the IMO Ballast Water Management Convention, World Bank Logistics Performance Index, ILO Maritime Labour Convention, and FAO Code of Conduct for Responsible Fisheries use indicators to navigate issues from invasive species to logistics efficiency and fair working conditions. Globally, the UN FAO Blue Growth Initiative, NOAA Aquaculture Policy, IRENA Renewable Energy Costing methodology, and circular economy indicators from Ellen MacArthur Foundation and World Economic Forum contribute to sustainable practices in aquaculture, renewable energy, and circular economy. Specific national policies, like the UK Offshore Wind Sector Deal and EU Aquaculture Sustainability Framework, employ indicators for monitoring offshore wind growth and ensuring environmental responsibilities. Frameworks such as the Global Sustainable Tourism Council Criteria, the Ellen MacArthur Foundation Circular Economy Indicators, and the European Commission's Product Policy Roadmap establish benchmarks for sustainable tourism, circular economy, and product lifespan, respectively. The OECD Sustainable Manufacturing Indicators contribute to embedding circularity in manufacturing. Together, these frameworks and conventions, each with its unique set of indicators, represent a collective effort toward a sustainable global future.

On a different note, industry cluster analysis, rooted in Porter's concept, serves as a valuable methodology for understanding innovation flows, performance factors, and competitiveness within regional economic systems. Utilizing the European Observatory for Clusters and Industrial Change (EOCIC) methodology, key indicators such as employment, establishments, and Location Quotient measure the size and specialization of industries over time. Additional calculations like Plant Quotient, Size Quotient, Beta Size, and Beta Plant reveal industry structures, highlighting the dominance of large firms versus SMEs. By employing robust cluster-based techniques, this approach provides a comprehensive understanding of Blue Economy sectors, revealing gaps, potentials, and the region's transition needs for sustainable development.

III. Global Indicators

A. AT THE GLOBAL LEVEL (UNITED NATIONS, SDGS 2015 & 2023):

The UN SDGs, adopted in 2015, identified two key indicators pertaining to ocean sustainability under Goal 14: "Life Below Water". These indicators were **14.1.1 (coverage of protected areas in relation to marine areas)** and **14.2.1 (proportion of national Exclusive Economic Zones managed using ecosystem-based approaches)**. The 14.1.1 indicator offers spatial extent measurement but does not convey if these areas are being effectively managed or producing desired biodiversity outcomes. Conversely, the 14.2.1 indicator only monitors policy adoption without tracking actual implementation.

By 2023, the UN expanded the SDG indicator framework to include ten additional indicators for directly gauging progress towards various Goal 14 targets. These indicators aim to Minimize marine pollution, Safeguard marine ecosystems, Address ocean acidification, Regulate fishing activities, Expand protected marine areas, Eliminate detrimental fisheries subsidies, Boost economic benefits for small island states from marine resources, Promote marine research and technological advancements, Ensure small-scale fishers can access marine resources and Enforce the international law of the sea.

The newly proposed indicators help monitor progress in these domains. However, challenges persist such as inconsistent methodologies across nations, technical capacity gaps, representativeness issues with sampled data, lack of effectiveness measures, and heavy reliance on self-reported data (UN, 2023).

B. SPECIFIC INDICATORS AND THEIR LIMITATIONS:

- **Indicator 81 & 14.5.1 - Coverage of Protected Marine Areas**
  Limitations: Merely assessing the percentage of protected areas does not provide insights about their effective management or actual biodiversity outcomes. Also, this indicator does not assess the efficiency of these protected zones in minimizing biodiversity loss. Several initiatives are addressing this shortcoming.
- **Indicator 82 & 14.2.1 - Percentage of Fish Tonnage within Maximum Sustainable Yield (MSY)**
  Limitations: MSY typically calculates for a single species and ignores impacts on or from other species. A more comprehensive approach such as the Optimum Sustainable Yield (OSY) considers economic, social, and ecological aspects. However, there is no universally accepted OSY definition.
- **14.1.1(a) - Index of Coastal Eutrophication & (b) Plastic Debris Density**
  Limitations: The data generation methods are intricate and need training over time. Existing assumptions are that countries use this data for policy-making, but the marine pollution transboundary nature complicates decisions.
- **14.2.1 - Ecosystem-Based Approaches to Marine Area Management**
  Limitations: This indicator evaluates policy formulation but neglects its actual execution.
- **14.3.1 - Average Marine Acidity (pH)**
  Limitations: Given its complexity, obtaining precise measurements of marine acidity is challenging. Metadata addition to the methodology is vital for data traceability and transparency.
- **14.4.1 - Proportion of Sustainable Fish Stocks**
  Limitations: This indicator requires catch data, fishing effort data, and other biological inputs along with expert knowledge. The Food and Agriculture Organization of the United Nations (FAO), using a 1980s methodology, estimates the global level. Even with regular updates, regional discrepancies might occur.

C. ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT (OECD) NATURAL CAPITAL INDICATORS

The OECD indicators focus on **threatened marine species** status and trends, **coastal zone population pressures**, and the **biological well-being of fish stocks**. For example, tracking fish stocks within biologically sustainable limits helps nations assess fishing pressure on vital commercial species and set informed catch limits. From 1974 to 2015, the percentage of such fish stocks dropped from 90% to 66.9%, highlighting overfishing as a persistent concern. The OECD framework also includes indicators like the ocean health index, coastal eutrophication, plastic waste levels, and marine protected area coverage policies — all crucial for marine biodiversity conservation and sustainable ocean management (OECD, 2023, table 2).

Table 2. Series of indicators of sustainable ocean economy

Indicator group	Indicator
Natural capital of the ocean	• Threatened marine fish species • Urbanisation in coastal areas • Biological status of fish stocks
Environmental and resource productivity	• International marine bunker CO2 emissions
Economic opportunities from pursuing ocean sustainability	• Ocean-related renewable energy public R&D budget • Innovation in selected ocean-related technologies
Policy responses directed at ocean sustainability	• Update of policies and practices against illegal, unreported, and unregulated fishing • Share of marine area designated protected • Extend of marine protected area coverage • Number of ocean sustainability-related policy instruments • Ocean sustainability-related tax revenue • Ocean-related fossil-fuel support measures
Socio-economic context	• Marine landings volume • Aquaculture production volume • Employment in fishing and aquaculture • Fishing fleet • Trade in fisheries products • Marine freight transport • Trade in ocean-related tourism services • Coastal population

Source: OECD, 2023

World Bank Framework

The World Bank's proposed framework suggests indices for **blue economy sustainability** and resilience, covering livelihoods, ecosystems, and supportive environments. The indicators span income, jobs, coastal risks, ecosystem services, and governance.

The World Bank has proposed a framework with various indices and indicators to measure the sustainability and resilience of blue economies. The framework covers three broad dimensions:

Livelihoods and Jobs

- Income per capita from key ocean-based industries like fisheries, aquaculture, tourism, transport, and oil and gas.
- Number of ocean-related jobs created or supported.
- Ocean Gross Value Added (GVA) as a percentage of national GVA.

Ecosystems

- Coastal protection levels based on presence of mangroves, reefs, seagrass.
- Water quality as measured by pollutant concentrations.
- Health of fish stocks based on catch data and stock assessments.
- Protected ocean area coverage.

Supportive Governance and Institutions

- Ratification and compliance status for key international agreements like UNCLOS.
- Existence of integrated ocean policies and blue economy development plans.
- Investment in ocean health and sustainability.

- Access to ocean-related financial services.

The World Bank emphasizes that global or regional models may not fully capture local contexts. Additional location-specific data collection could supplement the framework to tailor it for specific countries or communities' blue economies. But overall, the indices aim to provide standardized metrics for assessing progress towards sustainable, resilient ocean economies worldwide.

A significant reliance on global or regional modelling might result in data lacking local specificity (World Bank, 2021).

D. EXAMPLES FROM NON-MEDITERRANEAN COUNTRIES

Australia

Australia has developed the AIMS Index of Marine Industry to quantify the economic contribution of marine industries to the national economy. This index provides a standardized methodology for calculating key economic metrics like gross value added, exports, imports, and employment for major marine sectors including offshore oil and gas, shipbuilding, ports, tourism, and others (AIMS, 2017). However, the AIMS index focuses predominantly on economic indicators and does not incorporate sustainability metrics. Some studies have analyzed the environmental impacts of Australian marine industries, but an integrated sustainability measurement framework is still lacking (Voyer et al., 2018).

India

India adopted a National Marine Policy in 2021 that aims to promote the sustainable development of the country's blue economy across priority sectors like fisheries, coastal tourism, maritime transport, and offshore energy (Ministry of Earth Sciences, 2021). The policy emphasizes the need to enhance environmental monitoring and data collection capabilities to assess the performance and impacts of these marine industries. However, India has not yet established a defined set of indicators tailored to measuring the sustainability of its blue economy sectors. The focus has been more on supporting the economic growth of these industries currently.

China

China has established a Marine Economic Statistical System to assess the scale and economic contributions of its marine sectors like maritime shipping, offshore oil and gas, shipbuilding, and others (OECD, 2016). The system compiles total output value, business revenue, profit and other economic indicators for these industries. However, environmental sustainability measurement is minimal within this framework beyond some basic metrics like wastewater discharge volumes and oil spill numbers. Broader ecosystem impacts and sustainability have not been a priority in China's blue economy assessment.

Canada

Canada has developed an Ocean Accounts Framework to measure the economic importance of its ocean-based industries through indicators like ocean GDP, employment, wages, and capital investment (Government of Canada, 2021). The framework draws on national economic statistics to quantify the financial flows and economic contributions of Canada's ocean sectors. However, the current scope is limited to economic metrics without substantially incorporating environmental sustainability indicators.

Small Island Developing States

The World Bank has developed a comprehensive conceptual model for measuring the blue economy in SIDS that emphasizes sustainability and resilience (World Bank, 2021). This recognizes the heavy dependence and vulnerability of small island nations to marine resources and advocates a holistic approach to monitoring across multiple dimensions:

Livelihoods: Indicators proposed cover income, employment, poverty, food security, health, education, gender equity and social inclusion. These aim to capture the dependence of island communities on marine resources for subsistence, livelihoods and economic welfare. However, limitations persist in availability of localized household and individual-level data (World Bank, 2021).

Ecosystems: The natural capital contributed by coral reefs, mangroves, seagrass and other coastal ecosystems is a priority for monitoring. Proposed indicators include habitat extent and condition, water quality, fish diversity and abundance. Constraints include lack of scientific monitoring capabilities in some SIDS (Fiji, 2019).

Enabling Environment: This focuses on governance indicators related to institutions, management capacity, infrastructure, disaster resilience, and mechanisms for stakeholder engagement. Small islands often lack technical and human resources for comprehensive monitoring. Various studies have contributed insights into potential blue economy indicators for SIDS:

- Blue capital indicators spanning natural, social, human, physical and financial assets (Patil et al., 2016).
- Ocean Health Index adapted for Pacific Islands to measure clean waters, biodiversity, habitats, carbon storage, coastal livelihoods (Halpern et al., 2019).
- Framework for monitoring livelihood benefits, food security, poverty reduction from Pacific coastal fisheries (Gillett, 2016).

However, the lack of harmonized data remains a systemic challenge for SIDS (UN, 2016; Cisneros-Montemayor et al., 2021). Efforts to collate localized community-based data through initiatives like the Local Ocean Trust in Fiji are a step forward for small islands (Veitayaki et al., 2020). But significant gaps persist in tailoring global blue economy models into tangible, measurable indicators for enhancing sustainability policy and monitoring capacities in SIDS.

E.   REVIEW OF KEY PAPERS

Martínez-Vázquez et al. (2021) and Lu et al. (2019) offer crucial insights into the evolving landscape of Blue Economy (BE) indicators. Martínez-Vázquez et al.'s analysis explores BE trends, emphasizing sustainability, governance, and the potential link with Circular Economy (CE) through Blue Growth (BG). The paper highlights a significant increase in scholarly articles and calls for alliances between BG sectors and CE principles to achieve a sustainable BE globally. Lu et al. 2019 work focuses on practical aspects, stressing the importance of careful definitions and case studies for BE development. Their paper acknowledges the Blue Economy's multifaceted nature and advocates for consensus on management, data access, and international collaboration. Despite promising explorations, it signals the need for ongoing research and collective efforts to fully comprehend the Blue Economy's scope and depth.

F.   CONCLUSION

In conclusion, the global indicators landscape reflects ongoing efforts to balance economic development with sustainable practices, with opportunities for improved methodologies, data quality, and a more nuanced understanding of the interplay between economic growth and environmental preservation.

IV. European Union Blue Economy Sustainability Indicators

The European Union (EU) has been at the forefront in monitoring and assessing the blue economy's sustainability through various indicators, reports, and guidelines. A comprehensive overview is detailed below:

A. EU'S MONITORING OF SDG 14 ON LIFE BELOW WATER

The EU outlines six headline indicators under SDG 14 (Life Below Water), aligned with the United Nations methodology:

1. **Surface area of protected marine sites** (DG ENV; EEA) (sdg_14_10; EC, 2023)
2. **Estimated trends in fish stock biomass in the North East Atlantic and Mediterranean Sea** (JRC-STECF) (sdg_14_21; EC, 2023)
3. **Estimated trends in fishing pressure in the North East Atlantic and Mediterranean Sea** (JRC-STECF) (sdg_14_30; EC, 2023)
4. **Coastal bathing sites with excellent water quality** (AEE) (sdg_14_40; EC, 2023)
5. **Global average acidity of surface seawater** (CMEMS) (sdg_14_50; EC, 2023)
6. **Marine waters affected by eutrophication** (CMEMS) (sdg_14_60; EC, 2023)

These indicators, however, represent a more restricted set than the expanded list of ten indicators under the global UN SDG framework. Specifically, there is an absence of indicators capturing essential dimensions such as ecosystem services, economic sustainability, livelihoods, and social aspects including equity and inclusion, which are paramount for a comprehensive evaluation and progress measurement (EC, 2023, table 3).

Table 3. Overview of the sustainability criteria grouped by environmental economic and social / governance dimensions

Environmental dimension	Economic dimension	Social and governance dimension
• Chemical use • Emissions to air • Emissions to water • Energy efficiency • Farm management • Fishery management • Flood safety • Harvesting Management • Impact on environment • Impact on ecosystems • Infrastructure capacity • Introduction of invasive species • Level of energy consumption • Level of water consumption • Mitigation • Oil spill response • Status of stock • Supply chain • Level of fuel consumption • Use of shore power • Waste/wastewater management • Water quality	• Concentration of businesses • Costs • Durability of structure • Economic benefits • Economic viability • Employment • Feed management • Financial viability • Flood safety • Funding • Infrastructure capacity • Processing conditions	• Employment conditions • Health and safety management • Inclusiveness • Level of acceptance by stakeholders • Social balance • Fairness in renumeration • Certification and labelling • Climate change • Development control • Education on sustainability • Fishery management • Harvesting management • Impact assessment • Innovation • Level of stakeholder engagement • Nature-Based Solutions • Permits • Risk management • Strategy and vision • Supply chain • Sustainable infrastructure • Hazardous waste management

Source: EC, 2021

B. EU BLUE ECONOMY REPORT

The annual EU Blue Economy Report by the European Commission primarily presents economic indicators on established sectors, emphasizing employment, gross value added, personnel costs, and the number of enterprises at both EU and Member State levels using data from Eurostat's maritime economic statistics (EC, 2023). Key economic data include the gross value added (GVA) of established maritime sectors which amounted to €129 billion in 2020, a 30% fall compared to 2019, but a performance which needs to be nuanced in light of the impacts of the COVID-19 pandemic. Nevertheless, this report does not delve into environmental sustainability or social indicators.

2021 EU Guidelines on Blue Economy Sustainability Criteria

A notable development is the 2021 EU guidelines on sustainability criteria for the blue economy which introduced 44 common horizontal indicators spanning environmental, economic, social, and governance aspects. Out of these, 20 have been pinpointed as "key indicators," establishing a mandatory and essential set of criteria for evaluating the sustainability of particular activities. Here are a few highlights from these indicators:

- **Environmental**: Focus on mitigation efforts, biodiversity protection, and energy use. Examples include C.EN.1 (mitigation investment) and C.EN.4 (threatened species).
- **Economic**: Emphasizing benefits for the local economy, sector viability, and job creation. Notable indicators are C.EC.2 (local economic benefits) and C.EC.4 (economic viability).
- **Social**: Centred on fair labour practices and inclusion of marginalized groups with C.SO.2 (labour unions) and C.SO.7 (vulnerable group employment) being significant.
- **Governance**: Addressing responsible management practices like C.GO.1 (permitting) and C.GO.11 (stakeholder engagement).

These guidelines also introduce sector-specific indicators for tourism, marine living and non-living resources, shipbuilding, marine renewable energy, and blue biotechnology. They advocate tailoring these to diverse geographical scales using the Driver-Pressure-State-Impact-Response framework. However, the guidelines acknowledge the **scarcity of coherent and harmonized datasets at the EU level for a full representation of the proposed indicators** (EC, 2021).

Despite the advancements, some gaps persist at the EU level including:

- **A lack of holistic indicators** covering all sustainability dimensions.
- **Data availability constraints** and the absence of unified EU datasets.
- **Insufficient measurement** of ecosystem health and services.
- **A need for refined indicators** for emerging blue economy sectors, such as blue bioeconomy, blue-tech innovation and robotics, and ocean energy technologies.
- A vacuum in assessing **blue economy policy implementation** and its effectiveness.

By addressing these, the EU can bolster its commitment to ensuring the sustainable development of its blue economy sectors.

C. OUTCOME OF SELECTED SCIENTIFIC PAPERS:

Wilfried Rickels et al.'s (2019) scientific paper critically evaluates the progress of EU coastal states against Sustainable Development Goal 14, utilizing a comprehensive set of 18 indicators. The study challenges the assumption of the EU's comprehensive achievement of blue growth by revealing variations in sustainability among countries. This analysis underscores the necessity of distinguishing between weak and strong sustainability, shedding light on specific challenges contributing to unsustainable development. Notably, increasing fishing mortality and a reduced willingness to align with scientific advice emerge as significant contributors to unsustainable practices. The study provides essential insights into the sustainability landscape of blue growth in the European context. By questioning assumptions and identifying challenges, it contributes to a nuanced understanding of the interplay between economic development and environmental preservation. The findings emphasize the need for tailored strategies and policies that consider the diverse sustainability profiles of EU coastal states, ensuring a more balanced and environmentally conscious approach to blue growth.

D.   CONCLUSION:

The European Union's efforts to monitor its blue economy sustainability, while commendable, reveal notable gaps. While the environmental focus under SDG 14 is apparent, the absence of comprehensive indicators covering economic viability, livelihoods, and social aspects is evident. The annual EU Blue Economy Report provides economic insights but lacks a holistic approach. The 2021 EU guidelines introduce positive steps with 44 common indicators, yet challenges like data availability persist. Addressing these gaps is crucial for the EU to fulfill its commitment to sustainable blue economy development, necessitating a more inclusive and nuanced approach to balance economic prosperity with environmental well-being.

V. Mediterranean Region Indicators

A systematic review was conducted of strategic reports, indicator databases, and academic literature from institutions including **UNEP/MAP**, **Plan Bleu**, and the **Union for the Mediterranean** to analyse blue economy sustainability indicators applied in the Mediterranean region.

The Mediterranean Strategy for Sustainable Development (MSSD) adopted in 2016 by UNEP/MAP identifies strategic directions and recommended actions related to blue economy, especially under Strategic Objectives 1 and 5 on sustainable development of marine and coastal areas and the transition to a green and blue economy (UNEP/MAP, 2016), respectively. However, the MSSD does not contain or propose concrete measurable indicators specifically tailored to monitoring the sustainability of different blue economy sectors.

Here are some examples of strategic directions and recommended actions related to the blue economy, particularly under Strategic Objectives 1 and 5:

1. **Promotion of Sustainable Fisheries**: The MSSD emphasizes the need to promote sustainable fishing practices, reduce overfishing, and protect marine biodiversity. This can be achieved through measures such as implementing catch limits, promoting responsible fishing practices, and creating marine protected areas to conserve fish stocks.
2. **Marine and Coastal Tourism:** The MSSD encourages the development of sustainable tourism along the Mediterranean coast. This can include promoting ecotourism, supporting local communities in developing tourism infrastructure, and ensuring that tourism activities do not harm the marine and coastal ecosystems.
3. **Blue Innovation and Technology**: To transition to a green and blue economy, the strategy recommends fostering innovation in areas such as marine renewable energy, desalination technologies, and sustainable aquaculture. This can involve supporting research and development initiatives and creating incentives for businesses to invest in environmentally friendly technologies.
4. **Coastal Zone Management**: The MSSD advocates for integrated coastal zone management which involves planning and regulating land and water uses in coastal areas to minimize environmental impacts. This includes measures to prevent coastal erosion, protect wetlands, and promote sustainable development practices in coastal regions.
5. **Marine Pollution Reduction**: To achieve sustainable development of marine and coastal areas, the MSSD emphasizes the importance of reducing marine pollution. This can involve implementing stricter regulations on discharges from industries and shipping, promoting waste management and recycling, and raising awareness about the impact of marine pollution.
6. **Marine Conservation and Biodiversity**: Protecting marine ecosystems and biodiversity is a key aspect of the MSSD. This includes creating and expanding marine protected areas, conserving critical habitats, and implementing measures to combat invasive species that threaten native biodiversity.
7. **Capacity Building and Education**: The strategy recommends capacity building and education initiatives to empower local communities, governments, and stakeholders in understanding the importance of sustainable practices in the blue economy. This includes providing training, raising awareness, and building the skills needed to manage and conserve marine and coastal resources.
8. **Public-Private Partnerships**: Encouraging collaboration between the public and private sectors is crucial for implementing blue economy initiatives. This can involve partnerships for sustainable aquaculture, renewable energy projects, and responsible tourism development.

The **Mediterranean Observatory on Environment and Sustainable Development** maintained by Plan Bleu collects regional indicator data across various themes including seas and coasts, green economy, and governance. It contains relevant indicator factsheets on issues such as marine protection, fisheries sustainability, pollution, and economic indicators. However, the dataset does not yet provide comprehensive coverage of all aspects and dimensions of sustainability measurement for the blue economy. Gaps persist around economic, social, and environmental indicator data. Another key limitation is data availability predominantly at the national level rather than disaggregated by sector (Plan Bleu, 2022. Table 4).

Meanwhile, a relevant list of sustainability indicators specific for cruising and recreational boating can also be found in Plan Bleu's 2022 report on "Guidelines for the sustainability of cruises and recreational boating in the Mediterranean region". Indicators such as "Share of renewable sources in respect to total energy consumption", "% of recycled or

renewable materials per ship" and "Number of companies/marinas/ports with an environmental policy/plan/strategy" clearly encapsulate the environmental dimension.

Table 4. Indicators according to the Mediterranean Observatory on Environment and Sustainable Development

Type of Indicator	Indicator
General Indicators	• Ecological footprint • Human development index • Annual average growth rate per capita • Youth literacy rate • Girl/boy primary, secondary and tertiary school registration ratio
Sea and Coast	• Number of ratifications and level of compliance as reported by Barcelona Convention Contracting Parties • Coverage of protected areas in relation to marine territorial waters (SGD Indicator 14.5.1) • Proportion of fish stocks within biologically sustainable levels (SDG Indicator 14.4.1)
Green and Blue Economy	• Domestic material consumption per capita and per GDP (SDG Indicator 12.2.2)
Governance	• Number of National Strategies for Sustainable Development adopted or updated • Proportion of bank credit allocated to the private sector – Existence of alternative financing systems using bank credit • Research and development expenditure as a proportion of GDP (SDG Indicator 9.5.1) • Number of countries that have clear mechanisms in place for ensuring public participation and guaranteeing public access to environmental information • Number of countries that have National Strategies/Action Plans on Education for Sustainable Development in place

The **2022 State of Environment and Development Report** for the Mediterranean region led by UNEP/MAP employs a pressure-state response framework with indicators categorized across pollution and waste, biodiversity, coast, tourism, fisheries and aquaculture, and maritime transport themes. It compiles data from a variety of sources including UNEP/MAP components, UN agencies, and academic literature. However, there remain significant limitations in availability, comparability, and standardization of data across Mediterranean countries (UNEP/MAP, 2022).

This framework serves as a vital tool for assessing the various environmental and developmental aspects within the Mediterranean region. It categorizes indicators across several key themes, each of which plays a crucial role in understanding the region's challenges and opportunities.

- **Pollution and Waste**: This theme encompasses various indicators aimed at understanding the levels of pollution and waste management in the Mediterranean region. The "Coastal Water Quality Index" provides insights into the state of the Mediterranean's coastal waters, reflecting the presence of pollutants and their impact on marine ecosystems. The "Air Quality Index" helps assess air pollution, a growing concern in the region due to increased urbanization and industrial activities. Other indicators like "Marine Litter Density" and "Hazardous Waste Generation" offer crucial data to understand the extent of pollution in the marine environment and the generation of potentially harmful waste materials. Additionally, "Wastewater Treatment Coverage" provides insight into efforts to manage and treat sewage and industrial wastewater, a significant factor in preserving water quality.

- **Biodiversity**: The Mediterranean region is known for its rich biodiversity making it essential to track and protect the unique flora and fauna. Indicators in this category include data on "Endangered species population trends" and "Habitat loss and fragmentation" which inform us about the conservation status of various species and the health of their habitats. Monitoring "Invasive species presence" helps evaluate the impacts of non-native species on local ecosystems. Furthermore, "Protected area coverage" and "Ecosystem health assessments" provide information about the efforts in place to safeguard and restore biodiversity.

- **Coast**: With many Mediterranean cities and tourism centres located along the coastline, the health of coastal areas is a critical concern. "Coastal erosion rates" and "Land use changes in coastal zones" are indicators that reflect the effects of climate change and human development on coastlines. The "Infrastructure development in

coastal areas" indicator is significant for understanding the extent of construction and its impact on ecosystems. "Beach nourishment activities" are tracked to assess the steps taken to mitigate erosion and maintain the appeal of the region's beaches. Additionally, monitoring "Sea level rise impacts" provides insights into the challenges posed by rising sea levels and the need for adaptation measures.

- **Tourism**: The Mediterranean is a popular tourist destination, and indicators related to tourism are crucial for sustainable development. "Tourist arrivals and trends" help in understanding the dynamics of the tourism sector. Data on "Tourism-related employment" and "Tourism's contribution to GDP" demonstrate the economic significance of tourism in the region. "Tourism infrastructure development" is essential for managing the growing influx of visitors, and "Sustainable tourism certification" reflects efforts to ensure that tourism remains environmentally-friendly and socially responsible.

- **Fisheries and Aquaculture**: The Mediterranean's fisheries are a valuable resource, but overfishing and unsustainable practices threaten their health. "Fish stocks status and trends" and "Overfishing indicators" provide insights into the state of fisheries. "Aquaculture production and practices" assess the sustainability of aquaculture activities. Monitoring "IUU fishing assessments" helps combat illegal fishing, and "Fishery management effectiveness" measures the success of regulations and conservation efforts.

- **Maritime Transport**: The Mediterranean is a key maritime trade route, and understanding its maritime transport is essential for managing environmental impacts. "Shipping traffic volume" and "Port infrastructure and capacity" data offer insights into the region's shipping activities and its preparedness for managing them. "Vessel emissions and fuel types" are vital in addressing air pollution and greenhouse gas emissions. Indicators such as "Accident and oil spill reports" and "Compliance with international maritime conventions" highlight the need for safety and environmental compliance in maritime transport.

In summary, some of the **key gaps identified** in indicators applied at the Mediterranean regional level include:

- **Absence of a systematic indicator framework** specifically focused on measuring blue economy sustainability
- Major data gaps and availability issues with lack of harmonized datasets
- Need for improved comprehensive **environmental**, economic, social, and governance indicators
- **Insufficient disaggregation by blue economy sectors**
- **Lack of effectiveness** measures **for policies, regulations, and interventions**

The 2022 Mediterranean Yearbook published by the European Institute of the Mediterranean (IEMed) includes a chapter reviewing the progress of blue economy initiatives in the region (IEMed, 2022). It notes that the BlueMed strategic research and innovation agenda adopted in 2019 provides a key framework for advancing the sustainable blue economy in the Mediterranean. Proposed indicators aligned with BlueMed objectives include:

- Water quality indicators such as nutrients (nitrates, phosphates), chlorophyll-a concentrations, and pollutant (hydrocarbon, heavy metal) levels to monitor coastal and marine ecosystem health.
- Underwater noise metrics such as continuous noise mapping and impulse event detection to assess impacts on marine mammals and other species.
- Fish stock health assessments using spawning stock biomass, fishing mortality rates, and recruitments levels for commercially targeted species.
- Tourism revenue and contribution to Mediterranean countries' GDP, as well as sustainability certification rates for hotels and marine tourism operators.
- Number of innovative marine-derived products and companies in blue biotechnology sectors including pharmaceuticals, cosmetics, nutritional supplements.

A 2021 report from the Institut de Recherche pour le Développement (IRD) emphasizes environmental sustainability indicators for the blue economy (IRD, 2021). Specific indicators suggested include:

- Marine Trophic Index to monitor changes in food web structure, with increases potentially indicating fishing pressure.
- Incidence, frequency, and extent of eutrophication and hypoxia events in coastal waters based on dissolved oxygen and chlorophyll measurements.
- Rates of plastic waste leakage into the marine environment from land-based sources, aquaculture, fisheries, and shipping.
- Stock status, fishing mortality rates, and biomass trends for commercially targeted fish stocks compared to maximum sustainable yield levels.

An analysis paper from the Euro-Mediterranean Academic Network (EMANES) reviews various blue economy indicator frameworks and identifies gaps (EMANES, 2021). It recommends a combined pressure-state-response indicator approach:

- **Pressures indicators**: Greenhouse gas emissions, pollution loads (nutrients, solid waste), habitat damage from human activities.
- **State indicators**: Water quality, biodiversity indices, extent of key coastal and marine habitats.
- **Response indicators**: Sustainability policies adopted, marine protected area coverage, fishing quotas and effort restrictions.

The Mediterranean Institute of Oceanography (MIO) proposed biological indicators of marine ecosystem function (MIO, 2022):

- Energy flows between predator and prey functional groups to monitor food web structure.
- Extent and condition of key nursery habitats (e.g. seagrass meadows, mangroves) which support fisheries.
- Population trends and conservation status for iconic Mediterranean species (e.g. groupers, marine turtles).

A.   OUTCOMES ON SELECTED SCIENTIFIC PAPERS

In their comprehensive exploration of Blue Growth industries in Calabria, Southern Italy, Nourhan Hamdy and Carmelina Bevilacqua (2023) employ cluster-based analysis to investigate the characteristics, size, and specialization of these industries. This study illuminates the interconnections between various sectors, providing valuable insights into the regional blue economy's dynamics. By identifying gaps and potentials within Blue Growth sectors, the research serves as an essential initial step in a series of comprehensive examinations aimed at informing sustainable development initiatives in the region. On a broader Mediterranean scale, Cappelletto et al.'s (2021) critical assessment focuses on the challenges associated with implementing the UN Decade of Ocean Science for Sustainable Development. Grounded in regional consultations, the paper underscores the urgency of transitioning to a sustainable blue economy, particularly considering climate change vulnerabilities and mounting human-induced pressures. Advocating for science-based measures, the authors address gaps in the implementation of sustainable practices and emphasize the need for concerted efforts to navigate the intricate socio-ecological system of the Mediterranean, promoting a future aligned with the principles of sustainable development.

B.   CONCLUSION

In summary, the examination of technical reports, policy papers, and scientific studies pertaining to the Mediterranean blue economy underscores persistent endeavors to formulate targeted sustainability indicators. While these proposals exhibit variations in their specific emphases, they consistently highlight crucial priority domains for indicator development, encompassing marine ecosystem health, biodiversity preservation, sustainable fisheries management, pollution mitigation, and innovation in blue biotechnology. Despite these advancements, the challenge remains to systematically integrate these diverse indicators into a unified framework applicable across the region. Efforts toward enhancing the availability and standardization of data collection are imperative for the effective implementation of proposed sustainability indicators in monitoring and evaluating the progress of blue economy sectors. An adaptive governance framework, facilitating periodic adjustments to indicators based on evolving knowledge, would further fortify management approaches. Looking ahead, fostering heightened coordination among the diverse Mediterranean entities engaged in blue economy sustainability indicators will prove pivotal in developing robust and collectively embraced measurement tools. The insights garnered from specific scientific papers, such as those by Nourhan Hamdy and Carmelina Bevilacqua (2023) on Blue Growth industries in Calabria and Cappelletto et al. (2021), contribute nuanced perspectives to this overarching endeavor, offering valuable considerations for the region's sustainable development initiatives.

VI. Gap analysis

A systematic review was conducted of academic literature, technical reports, policy documents and indicator databases relevant to measuring blue economy sustainability globally and in the Mediterranean region. Key sources were analysed to identify the main framework or methodology utilized, research questions examined, analysis undertaken, key results and conclusions, implications for future research and practice, and potential indicators covered. The insights from this analytical review are summarized in the literature review matrix presented in Annex 1. This matrix encapsulates the theoretical frameworks, research methodologies, primary findings and conclusions, limitations and gaps, and implications highlighted across the literature. It provides a synthesis of the current state of knowledge to inform efforts to develop improved indicator frameworks for monitoring progress towards blue economy sustainability. The matrix focuses on highlighting major indicators utilized or proposed across the sources to extract potential sets of indicators that could be further validated, refined, and applied in developing a blue economy sustainability monitoring framework.

The literature review revealed significant limitations and gaps across current global, EU, and Mediterranean blue economy sustainability indicator frameworks and underlying data availability.

There is an **insufficient breadth of indicators to holistically represent all key dimensions of sustainability including environmental, economic, social, and governance aspects**. Major data gaps and lack of harmonized, standardized datasets severely constrain measurement, monitoring, and comparison across countries and regions. Critical areas lacking indicators or data include effectiveness assessment of policies, regulations, and interventions, emerging blue economy sectors, social equity and inclusion, and comprehensive measurement of ecosystem health and services. Indicators frequently lack disaggregation by specific blue economy industries due to limited targeted analysis and monitoring. There is an over-reliance on modelled versus localized primary data in many cases.

Majority of economic indicators focus on established traditional sectors and neglect new blue industries. Environmental indicators fall short of multi-dimensional ecosystem assessments and often utilize proxies rather than direct condition measurements. Social indicators are limited for assessing human wellbeing, livelihoods, and community impacts. Governance indicators are weak on evaluating policy and regulatory implementations.

To bridge the existing gaps and pave the way for more comprehensive sustainability assessments, it is essential to undertake a multifaceted approach. This approach should encompass various facets, including expanded sustainability indicators, strengthened data collection systems, increased national and sectoral disaggregation, incorporated effectiveness evaluations, and enhanced data standardization and comparability. Each of these components plays a pivotal role in creating a robust framework for addressing sustainability challenges.

1. **Expanded Sustainability Indicators:** The current set of sustainability indicators often falls short in capturing the full spectrum of environmental, social, and economic factors. To rectify this, it is imperative to broaden the scope of indicators used in sustainability assessments. These expanded indicators should not only encompass traditional metrics like greenhouse gas emissions and economic growth but also account for more nuanced aspects such as biodiversity loss, social equity, and resilience to environmental changes. By doing so, we can achieve a more holistic view of sustainability.

2. **Strengthened Data Collection Systems:** Without reliable and up-to-date data, sustainability assessments are inherently flawed. Therefore, there is an urgent need to invest in and strengthen data collection systems. This includes not only improving data quality but also expanding the geographical coverage of data collection efforts. Data should be collected consistently and regularly to ensure that decision-makers have access to the most accurate and current information.

3. **Increased National and Sectoral Disaggregation**: Sustainability challenges often vary significantly across different regions and sectors. Hence, it is essential to disaggregate data at the national and sectoral levels. This granularity is crucial for tailoring policies and strategies to address specific challenges in each context, rather than adopting a one-size-fits-all approach.

4. **Incorporated Effectiveness Evaluations:** Merely having data is not sufficient; it's also crucial to assess the effectiveness of sustainability initiatives and policies. Evaluations should be integrated into the sustainability framework to determine the impact of actions taken. This can help identify what works and what needs adjustment, leading to more informed decision-making.

5. **Improved Data Standardization and Comparability:** To enable meaningful comparisons between countries, regions, and sectors, there should be standardized data collection methods and reporting formats. Common data standards and measurement techniques will enhance comparability and facilitate the benchmarking of sustainability performance across various entities.

With consideration of these pivotal components, we shall now proceed to engage in a deliberation concerning the imperative development of a structured framework (volume 2). This framework, of paramount importance, is envisioned as a comprehensive and systematic methodology designed to facilitate the harmonious integration of the aforementioned expanded indicators, bolstered data collection systems, meticulous national and sectoral disaggregation, rigorous effectiveness evaluations, and enhanced data standardization. Its ultimate purpose is to engender a unified and globally applicable system for the assessment and augmentation of sustainability.

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Annex I: Literature Review Matrix

Author / Date	Theoretical / Conceptual Framework	Research Question(s) / Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice	Potential Indicators to be Included
European Commission (EC). (2021)	EU Blue Economy framework	What sustainability indicators can be used for EU blue economy sectors?	Review of academic, policy and technical sources	Proposed common and sector-specific indicators across economic, social, environmental dimensions	Data availability constraints across EU states	Improve availability of harmonized and coherent datasets	Provides a comprehensive proposed set of indicators to apply	Common and sector-specific indicators covering environment, social, economic, governance dimensions
European Commission (EC). (2023)	EU Blue Economy monitoring	What is the current status and trends in established EU blue economy sectors?	Collation of Eurostat maritime economic statistics	Report focuses on economic indicators e.g. employment, value added	Lacks indicators covering sustainability dimensions	Expand report indicators beyond just economic	Useful snapshot of EU blue economy but limited in scope	Economic indicators on employment, value added, enterprises, personnel costs
European Commission (EC). (2023)	EU SDG Indicator Framework	What progress has been made towards SDG 14 in the EU context?	Measurement and monitoring of SDG indicators	EU tracks 6 SDG 14 indicators aligned with UN methodology	Narrower set of indicators compared to global SDGs	Expand indicators to better cover sustainability dimensions	Provides high-level assessment against SDG targets	Marine protected area coverage, fish stock status, fishing pressure, water quality, ocean acidity, eutrophication
Organisation for Economic Cooperation and Development (OECD). (2016)	Framework categorizing indicators into natural capital,	What indicators can be used to monitor blue economy	Analysis of academic literature, technical reports and policy documents	Proposed indicators across 4 pillars but gaps	Significant gaps persist in holistic measurement	Further work needed to improve ecosystem	Provides a starting framework for monitoring	Natural capital, produced capital, human capital and

Author / Date	Theoretical / Conceptual Framework	Research Question(s) / Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice	Potential Indicators to be Included
	produced capital, human capital, ocean health	sustainability across economic, social and environmental dimensions?		remain in measurement of ecosystem services and data availability		service valuation and harmonize time-series datasets	across sustainability dimensions	ocean health indicators
UNEP/MAP (2016)	Mediterranean Strategy for Sustainable Development	What strategic directions can promote blue economy sustainability in the Mediterranean region?	Consultative process and review of regional challenges/priorities	Adopted strategy with recommended actions related to marine sustainability and blue economy	Does not put forward concrete measurable indicators	Specific indicators need to be developed to track strategy implementation	Provides high-level strategic directions only	Indicators to track actions under Strategic Objectives 1 and 5
United Nations (UN). (2015)	UN Sustainable Development Goals (SDGs)	What indicators should be used to measure progress towards SDG 14 Life Below Water?	Review of expert input and intergovernmental negotiations on SDG targets and indicators	Initial adoption of 2 indicators - 14.1.1 on marine protected areas and 14.2.1 on ecosystem-based management	Insufficient indicators proposed to cover all dimensions of ocean sustainability	Need to expand indicators to more comprehensively measure SDG 14	Adopted indicators provide high-level assessment but lack specificity to properly inform policies and interventions	14.1.1 Protected area coverage, 14.2.1 Ecosystem-based management adoption
United Nations (UN). 2022	UN SDG indicator framework	What progress has been made in expanding indicators to measure SDG 14 on Life Below Water?	Review of advances in indicator development and data availability	Expanded global SDG indicators to 10 for SDG 14 but limitations remain	Significant gaps persist in comprehensively measuring all dimensions	Further refinement of indicators and data collection needed	Provides more comprehensive measurement but issues remain	Expanded set of 10 global SDG 14 indicators

Author / Date	Theoretical / Conceptual Framework	Research Question(s) / Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice	Potential Indicators to be Included
United Nations Environment Programme (UNEP). (2022)	UN Environment Programme framework	What progress has UNEP made across focus areas including oceans?	Self-assessment review of program implementation	Assessed progress made towards expected outputs and outcomes	Gaps identified in fully achieving intended results	Improvements needed in monitoring, evaluation and reporting	Highlights achievements as well as areas for improvement	Indicators to track UNEP program/project outputs and outcomes
United Nations Environment Programme/Mediterranean Action Plan (UNEP/MAP). (2022)	Pressure-State-Response framework	What is the current state of the Mediterranean marine environment and blue economy?	Compilation of data from various sources	Assesses indicators across pollution, biodiversity, fisheries, transport themes	Data gaps and comparability issues between countries	Improve data availability, harmonization and standardization	Valuable integrated assessment but data could be expanded	Indicators across pollution, biodiversity, fisheries, transport
World Bank. (2021)	Blue Economy conceptual framework	What indicators can be used to measure blue economy sustainability and resilience in SIDS and CLDCs?	Modelling of datasets and indices	Proposed composite sustainability and resilience indices and indicators spanning livelihoods, ecosystems, governance	Relies heavily on modelled data which may lack local specificity	Need to improve accuracy through collection of localized primary data	Offers monitoring approach tailored to SIDS and CLDCs	Sustainability and resilience indicators covering livelihoods, ecosystems, governance