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Blue Economy Business Case
Companies in alignment with SDG 14

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Executive Summary

The ocean is one of the world's most strategic natural assets, underpinning global trade, food security, climate regulation, biodiversity, and economic prosperity. At the same time, it is facing unprecedented pressures arising from climate change, pollution, biodiversity loss, overexploitation of marine resources, and increasing competition for ocean space. These challenges are particularly relevant for Portugal, whose economic, social, and cultural identity is deeply connected to the ocean.

Although the country has established an ambitious governance framework for the Blue Economy and recognized the ocean as a strategic priority through the National Ocean Strategy 2021–2030 (Direção-Geral de Política do Mar, 2021), progress towards SDG 14 remains uneven, with several targets still facing significant implementation challenges. This report therefore examines the current state of the Blue Economy, assesses Portugal's progress towards SDG 14, and identifies the principal structural challenges that continue to limit the sustainable development of ocean-based activities.

Building on this assessment, the report shifts the discussion from identifying problems to mobilizing business solutions. Drawing upon a systematic review of Portugal's blue economy ecosystem, stakeholder engagement and the consolidation of more than 800 identified challenges into 25 strategic challenges, it demonstrates that ocean sustainability should not be viewed solely as an environmental responsibility but as a source of innovation, competitiveness, and long-term value creation. By translating ~~a~~these final ~~number of 32~~25 challenges into different business cases (reducing costs, increasing prices, increasing market share and creating new business models) the report provides companies with a practical framework for integrating SDG 14 into corporate strategy, through 123 best practices around the world. The accompanying toolkit further supports organizations in identifying concrete opportunities to contribute to ocean regeneration while simultaneously strengthening their economic performance and resilience.

1. Blue Economy: Contextual Overview

The importance of the Ocean ecosystem

The ocean is a fundamental pillar of the global economy and is gaining increasing prominence on the international political agenda. Indeed, it represents roughly 97% of the planet´s water and covers approximately 71% of the Earth's surface. Moreover, it encompasses around 90% of the biosphere (OCDE, 2025b), playing a central role in global ecological and economic systems, and being the largest ecosystem on the planet (UNESCO, 2022).

Moreover, 80% of internationally traded goods are transported by maritime routes, forming the backbone of global supply chains (OCDE, 2025b). The strategic importance of these routes is starkly illustrated by the ongoing tensions in the Strait of Hormuz. This narrow passage, linking the Persian Gulf to the Gulf of Oman, serves as a critical checkpoint for global energy and trade flows. Disruptions in this corridor, whether due to geopolitical conflicts, security incidents, or blockades, can lead to significant increases in shipping costs, delays in the delivery of essential goods, and volatility in global oil prices. The situation in the Strait of Hormuz, since February 2026, underscores the vulnerability and interdependence inherent in maritime-dependent supply chains.

Additionally, recent shocks like the conflict between Russia and Ukraine, insecurity in the Red Sea, and drought driven capacity constraints in the Panama Canal have likewise exposed the sensitivity of global supply chains to disruptions in key maritime corridors. This role of ocean waters has become even more significant as developing economies, particularly in Asia, have increased their participation in seaborne trade, rising from 38% in 2000 to 54% in 2023 (UNCTAD, 2025). Adding to this commercial role, the seabed hosts most of the world's digital infrastructure, with submarine fiber optic cables carrying 98% of global internet traffic (OCDE, 2025b), making the ocean indispensable not only to physical commerce but also to digital connectivity.

The ocean is equally crucial from a human development perspective. It ensures food security to more than three billion people (OCDE, 2025b), supplies essential nutrients through fisheries and aquaculture, and supports employment and local economies across coastal regions. In the least developed countries, marine fisheries represent the main source of protein for over half the population (European Commission, 2023), underscoring the importance of sustainable ocean management for vulnerable contexts. Moreover, approximately 2.75 billion people, around one-third of the global population, live within 100 km of the coast, amplifying the socio-economic relevance of resilient coastal systems (World Economic Forum, 2026b). Looking ahead, employment directly linked to the blue economy is projected to reach around 350 million jobs by 2030 (European Commission, 2023), highlighting the sector's increasing socioeconomic relevance for the future.

In ecological terms, the ocean plays a stabilizing role in the Earth system. It produces around half of the planet's oxygen, absorbing nearly a quarter of anthropogenic CO_2 emissions, and taking up approximately 90% of the excess heat generated by global warming (United Nations, 2022). Among its ecosystems, mangroves are exceptionally carbon rich, storing on average one thousand tones of carbon per hectare in biomass and soils. Coral reefs (even under threat), though covering less than 0.1% of the ocean, sustain more than 25% of marine biodiversity and provide up to one billion people with coastal protection, fisheries, medicines, recreation and tourism income (United Nations, 2022).

Nevertheless, recent scientific assessments also show that ocean acidification has now crossed a critical planetary boundary, meaning that one more of the Earth's fundamental life-support systems (ocean) has moved beyond the safe operating space for humanity (Potsdam Institute for Climate Impact Research, 2025). This life-support system is facing accelerating degradation: nutrient enrichment (eutrophication) is rising, plastic loads have increased rapidly since the 1990s, and continued carbon uptake is projected to drive a more than two-fold increase in acidification by the end of the century. These happenings have implications for calcifying organisms, food webs and climate regulation, signaling bigger systemic risk in the Earth system. The described environmental stressors are reflected among long-term environmental risks identified in the World Economic Forum's *Global Risks Report 2026* (World Economic Forum, 2026a), which highlights climate-related and Earth system risks as central to the global risk landscape.

Simultaneously, ocean warming is accelerating, altering currents, raising sea level, and transforming ecosystems (UNESCO IOC, 2024). Therefore, tsunamis emerge as a major hazard to human life and are expected to intensify as climate change and sea-level rise amplify their impacts, highlighting the exposure of coastal populations to ocean-related risks (UNESCO IOC, 2024). Taken together, these pressures underscore the urgent need to protect, restore, and responsibly manage the ocean, positioning it not simply as a biophysical element, but a vital infrastructure for supporting contemporary societies.

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The Purpose of our study

In a context marked by growing ecological, economic, and societal pressures, further intensified by geopolitical uncertainty, this study seeks to address some of the most pressing challenges facing Portugal's blue economy. Building on an assessment of the sector's key structural challenges and the observed progress toward the achievement of SDG 14 targets, we identified 25 priority challenges that require urgent attention. These challenges form the foundation of our analysis and are explored in greater depth in Section 2 and 4 of this report, where we examine their implications and the opportunities they present for businesses and other stakeholders.

Drawing from these critical topics of Portugal's ocean ecosystems identified by key stakeholders, we have developed a business oriented response grounded in actionable business cases (Section 3 and 4). This framework aims to catalyze corporate initiatives that simultaneously generate positive impacts on marine ecosystems and create economic value for companies.

Developing a robust business case for ocean regeneration is not optional but, indeed, strategic. Companies are a primary driving force of the global economy and societal organization: the private sector generates more than 75% of global GDP, accounts for the vast majority of formal employment worldwide (over 80% in many OECD and emerging economies), and corporate revenues rival sovereign economies, with 67 of the world's 100 largest economic entities measured by revenue being corporations rather than nation states (Martins, 2026). This concentration of economic power implies corresponding systemic leverage. If aligned with regenerative principles, capital allocation, innovation capacity, supply chain governance, and market-shaping mechanisms, this power can significantly accelerate the scaling of sustainable blue economy solutions. Conversely, without corporate alignment, the structural drivers of ocean degradation (overexploitation, pollution, carbon-intensive logistics, unsustainable coastal development, etc.) cannot be reversed at the necessary scale.

Therefore, coupling corporate capacity with ocean-positive activities represents a fundamental pathway. Moreover, the exponential growth of the blue economy will only be compatible with planetary stability if it is anchored in scientifically defined ecological thresholds and translated into investable, performance-driven business models, capable of addressing the most severe threats to marine ecosystems while generating long-term economic value.

This is why our study focuses on the business case for action within the Portuguese Blue Economy. Moreover, to support companies in identifying business opportunities arising from blue economy challenges, we have also developed a toolkit (Appendix 1) that serves as a practical blueprint for action for organizations seeking to engage with these issues and develop sustainable business solutions.

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Blue Economy in the context of our study

Broadly, the Blue Economy refers to how marine resources are managed and used, and how these resources are integrated into socioeconomic activities. Therefore, it recognizes the ocean as a central driver of sustainable development. This understanding of the Blue Economy varies significantly across institutions and policy frameworks, reflecting both the breadth of the agenda and the evolving nature of this domain. According to the World Bank, the "The blue economy is the sustainable use of ocean resources for economic growth, improved livelihoods and jobs, while preserving the health of ocean ecosystem." (The World Bank, 2017). This definition reinforces the alignment between the principles of the Blue Economy and the United Nations Sustainable Development Goals (SDGs), in particular SDG 14, SDG 8 and SDG 17, which highlight, respectively, the conservation and sustainable use of oceans and marine resources, the promotion of inclusive and sustainable economic growth, employment and decent work and the promotion of global partnerships geared towards sustainable development of the oceans.

Building on the definition above, this concept is operationalized through 10 sectors (European Commission, 2023) which, together, capture the main streams of economic activity dependent on marine and coastal systems. These sectors comprise: Aquaculture, Blue Biotechnology, Blue Renewable Energy, Blue Technology and Ocean Observation, Coastal and Maritime Tourism, Environmental Protection and Regeneration, Fisheries, Shipbuilding and Refit, Shipping and Ports, and Water Management. Collectively, they reflect the diversity of ocean-based industries and their central role in sustainable development, as shown in further detail in table 1 below.

Key sectors	Short definition
Aquaculture	The **cultivation and farming of aquatic organisms in a way that has minimal impact** on air, water and soil quality.
Blue Biotechnology	The **application of science and technology to aquatic organisms** in order to produce knowledge, goods and services, in compliance with sustainability practices.
Blue Renewable Energy	The **offshore, inshore and nearshore generation of clean and renewable power** from natural sources, including wind, wave, tidal and solar.
Blue Tech & Ocean Observation	The activities, technologies and infrastructure involved in **ocean data** collection, modelling and prediction, including for maritime security and defence.
Coastal & Maritime Tourism	The **activities** involved in **providing services for tourism** in and around coastal or marine environments that contribute to sustainable development in the local area.
Environmental Protection & Regeneration	The **protection** and **regeneration of marine ecosystems**, including activities to **prevent ocean pollution** and **restore** and **strengthen** biodiversity in coastal areas.
Fisheries	The sustainable **harvesting of naturally occurring living resources** in both marine and freshwater environments.
Shipbuilding & Refit	The **products and services** required for **building, maintenance, repair and refitting** of vessels for environmentally responsible water transport.
Shipping & Ports	The activities associated with ensuring a sustainable **maritime transport ecosystem**, including the transportation of freight and passengers by water and port services.
Water Management	The services and infrastructure required for sustainable **water collection, purification, desalination, decontamination and distribution, as well as for sewage and waste treatment**.

Figure 1 – Blue Economy sectors (European Commission, 2023)

As these sectors continue to evolve, the blue economy is entering a decisive moment. Rising pressures, including accelerated demographic changes, productivity challenges, environmental pressures and climate change, uncertain global contexts, and digital and scientific innovation, are reshaping the conditions under which marine activities operate (OECD, 2025). Demographic growth, in particular, increases demand for food, energy, transport, coastal housing, and infrastructure, thereby amplifying pressure on fisheries, aquaculture, maritime trade routes, and coastal ecosystems. Simultaneously, urban concentration in coastal zones heightens exposure to sea-level rise, extreme weather events, and marine pollution. Together, these dynamics are altering both the ecological carrying capacity of marine systems and the economic risk landscape for ocean-dependent sectors.

While significant growth potential remains, this trajectory is increasingly constrained by structural and systemic pressures. Productivity growth across several ocean-based sectors has slowed, partly due to resource depletion and rising operational costs. For instance, the increasing proportion of biologically unsustainable fish stocks (now exceeding one-third of global stocks) implies higher effort and lower returns in capture fisheries (Food and Agriculture Organization, 2024). At the same time, persistent digitalization gaps limit efficiency gains across maritime value chains (uneven adoption of smart port technologies, digital tracking systems, and integrated data platforms), which continues to reduce transparency, logistical performance, and competitiveness, particularly in developing economies (OECD, 2025).

These structural constraints are compounded by escalating climate-related impacts on ocean systems. Ocean warming, acidification, sea-level rise, and intensifying extreme events are already altering marine productivity, redistributing species, increasing coastal vulnerability, and raising insurance and infrastructure costs (United Nations Conference on Trade and Development, 2025). Together, these dynamics indicate that future growth in the blue economy will depend not merely on sector expansion but on systemic transformation grounded in ecological resilience, technological upgrading, and risk-informed governance.

At the same time, global transitions in energy systems and rapid advances in science, technology, and innovation are expected to redefine how societies manage and conserve ocean resources (OCDE, 2025b; OECD, 2025). This is because the shift towards low-carbon energy is relocating critical infrastructure and investment to marine spaces, including offshore renewables, subsea grids, and new maritime fuels. Thereby, intensifying competition for ocean use and requiring more integrated spatial planning and governance.

Simultaneously, digital technologies such as satellite monitoring, artificial intelligence, and real-time ocean data systems are transforming the capacity to track fisheries, monitor biodiversity, enforce regulations, and optimize maritime logistics. Advances in marine science and nature-based solutions further expand the toolkit for ecosystem restoration, climate mitigation, and sustainable resource management. Together, these transitions alter not only the scale of economic activity at sea, but also the mechanisms through which ocean resources are valued, regulated, and conserved, shifting ocean governance from a predominantly extractive logic toward a more data-driven, environmental-aligned, and resilience-oriented model.

Responding effectively to these dynamics requires a strengthened framework of ocean governance, improved data collection and scientific knowledge, accelerated technological innovation, the inclusion of developing countries in ocean-related value chains (OCDE, 2025b), and, as referred, the alignment between the private sector and ocean value creation. When aligned, these priorities create the foundation for an economic model capable of balancing competitiveness with ecosystem protection, ultimately enhancing the strength of the ocean as a source of prosperity for all.

The following section provides a structured assessment of the evolution and governance of the Blue Economy at the international level, subsequently narrowing the scope to a detailed examination of developments in Portugal.

1.1. *Status Quo* of the Blue Economy Worldwide

The ocean economy has emerged as a major pillar of the global economy. According to the OECD, if considered a sovereign economy, it would constitute the world's fifth-largest economy. Its gross value added doubled in real terms from USD 1.3 trillion in 1995 to USD 2.6 trillion in 2020, accounting for approximately 3 to 4% of global economic output (OCDE, 2025b; OECD, 2025). This is an impressive position, even before accounting for the essential ecosystem services that sustain all ocean-based activities, such as marine fisheries and aquaculture, maritime transport and ports, offshore renewable energy, coastal tourism, and shipbuilding, which collectively depend on healthy marine ecosystems to generate economic value (OCDE, 2025b; OECD, 2025).

Current estimates place the value of the ocean economy at over USD 3 trillion (World Economic Forum, 2026b), although this is likely a conservative estimate, as it excludes domestic consumption of marine-derived goods, the dependence of Special Economic Zones (SEZs) and industrial clusters on port and maritime infrastructure, as well as the growing contribution of ocean-focused start-ups.

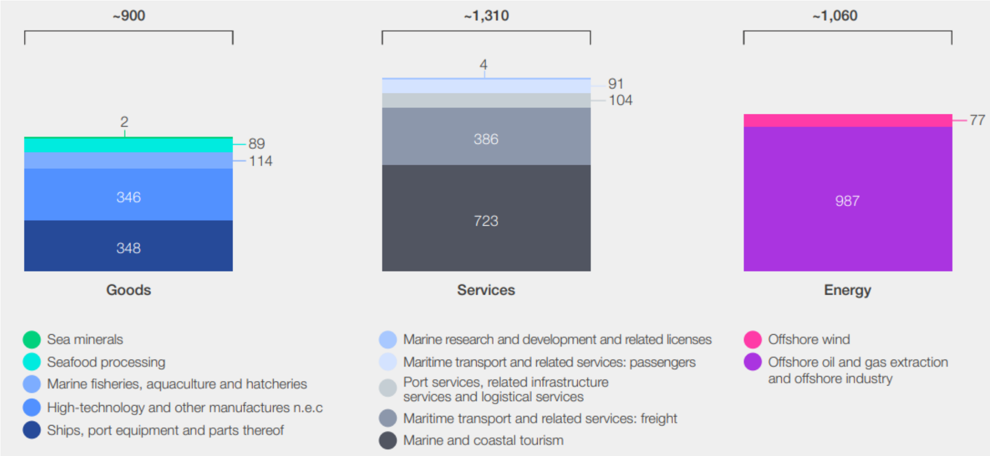

Figure 2: Ocean Economy estimated total value, billion USD (World Economic Forum, 2026b)

This scale reflects a profound transformation over the past quarter-century, as mentioned before, through the shared figures (1.3 trillion in 1995, to USD 2.6 trillion in 2020). This was driven largely by the rapid expansion of Asian and Pacific economies, which together contributed around 75% of total growth (OECD, 2025). Employment followed a more moderate trajectory, rising from 122 million to 134 million full-time equivalents (FTEs) by 2019, before falling sharply to 102 million in 2020 as COVID-19 disrupted tourism and coastal mobility (OCDE, 2025b; OECD, 2025). Looking ahead, annual output could approach USD 3 trillion by 2030 under pre-pandemic growth projections. However, employment growth is expected to remain more gradual and structurally dependent on productivity gains, digitalization, and sectoral transformation (OCDE, 2025b; OECD, 2025).

Looking forward, long-term projects suggest that the global ocean economy could reach nearly four times its 1995 size by 2050 (OCDE, 2025b). However, such trajectories may be overly optimistic if based solely on historical trends. Technological change, environmental pressures, climate impacts and geopolitical instability could significantly reshape sectoral dynamics and regional distributions of growth. This highlights the importance of governance frameworks that align economic competitiveness with environmental integrity and social resilience in ocean topics.

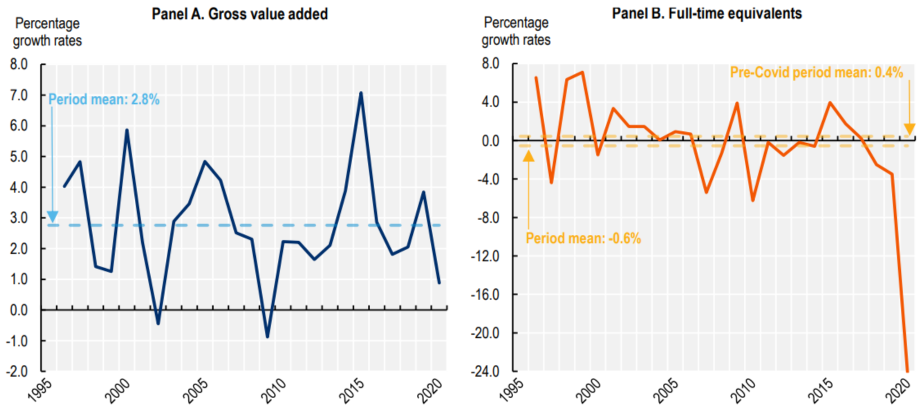

Figure 3: Annual growth rates in global ocean economy real-terms gross value-added and full-time equivalents. (OCDE, 2025b; OECD, 2025).

Given this global pattern of expansion, regional patterns have remained relatively stable, with the ocean economy generally accounting for between 1% and 8% of national gross value added (GVA) and employment between 1995 and 2020 (OCDE, 2025b; OECD, 2025). These "GVA ratios" refer to the share of a country's total economic output generated by ocean-based industries, thus indicating the structural weight of the blue economy within national economies. However, aggregate ranges conceal substantial heterogeneity. In Europe, Norway stands out, with ocean-related industries contributing 26.8% of national GVA and 17.1% of employment, reflecting the central role of offshore oil and gas, maritime transport, and aquaculture in its economic model. Similarly, Northern Africa, Western Asia, and Sub-Saharan Africa display comparatively high GVA ratios due to the prominence of offshore and onshore hydrocarbons. On the other hand, the largest employment shares are observed in Southern, Central, and South-Eastern Asia, where marine and coastal tourism and small-scale fisheries are more labor-intensive, generating significant employment relative to their contribution to total value added (OCDE, 2025b; OECD, 2025). These patterns illustrate the diverse ways in which the blue economy is embedded within national development structures, ranging from capital-intensive energy hubs to labor-intensive coastal economies.

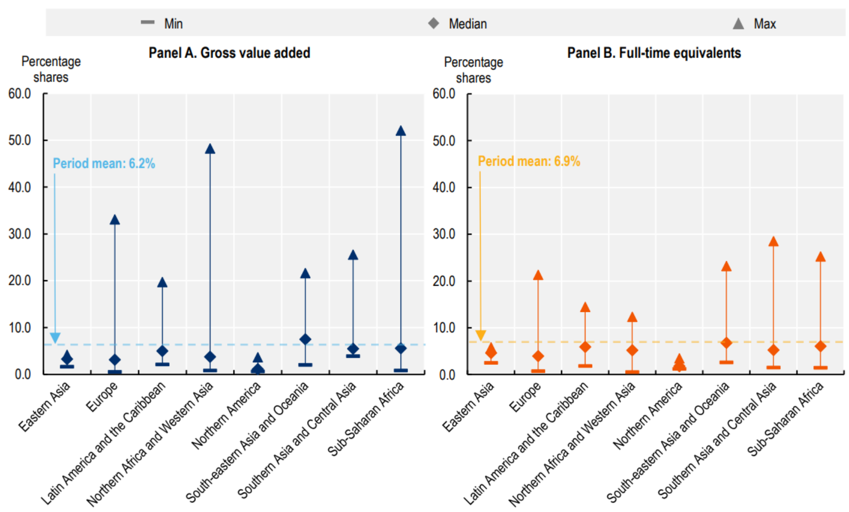

Figure 4: Country-level total economy ocean economy gross value added and full-time equivalents shares by region (OCDE, 2025b)

Country-level patterns mirror these regional dynamics. By 2020, China had become the largest ocean economy, representing 23.6% of global ocean GVA, up from 3.2% in 1995, while other leaders such as Japan, the United States, and the United Kingdom saw their relative shares decline (OCDE, 2025b). Within the OECD, the United States has led in real-terms GVA from 2008 onwards (OCDE, 2025b), while Norway has maintained the highest structural dependence on ocean-based activities, averaging 26.6% of national GVA during 1995–2020 (OCDE, 2025b). Iceland also stands out (average 14.7%), while Greece (7.7%), Mexico (7.2%) e Denmark (6.3%) remained relatively stable (OCDE, 2025b).

At the sectoral level, the composition of the output reflects these structural dynamics. Throughout 1995 to 2020, marine and coastal tourism, together with offshore oil and gas, accounted for roughly two thirds (66%) of global ocean GVA (OCDE, 2025b). Tourism peaked at USD 1.06 trillion in 2019, before contracting to USD 910 billion in 2020 amid Covid‑19 restrictions. Offshore oil and gas reached a record USD 987.4 billion in 2020, temporarily becoming the largest ocean‑based activity (OCDE, 2025b). These leading sectors display contrasting labor profiles: oil and gas generate high value with relatively fewer workers, whereas tourism is both high‑value and labor-intensive. Emerging domains, such as offshore wind and other marine renewables, remain smaller in absolute terms but are expanding rapidly as technologies mature and investment increase.

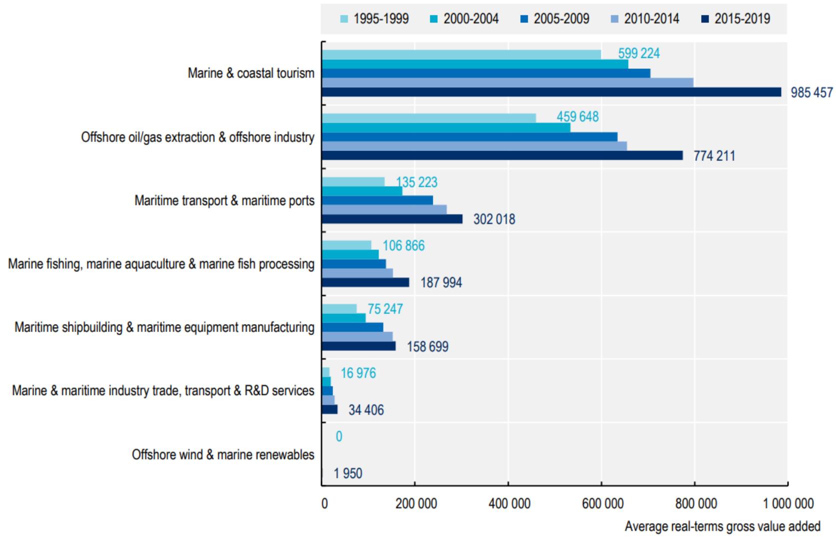

Figure 5: Five-year period average global ocean economic activity group real-terms gross value added. (OCDE, 2025b)

In terms of overall performance, most ocean-based industries outpaced the global economy growth between 1995 and 2020. In 2020, ocean-related activity expanded at roughly 1.3 times the pace of the world economy.

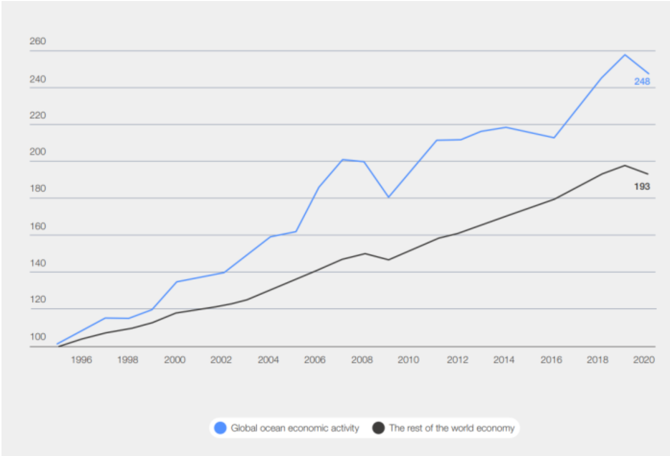

Figure 6: Global ocean economic activity growth Index 1995 = 100, 1995-2020 (World Economic Forum, 2026b)

Maritime shipbuilding and equipment manufacturing were particularly dynamic in 2008–2020, growing up to three times the overall industry growth rate (peak in 2011) (OCDE, 2025b). Maritime transport and ports, marine and maritime trade, transport and R&D services, and offshore oil and gas also consistently outperformed average real-terms GVA growth. While marine and coastal tourism only exceeded global industry averages after 2010, fisheries, aquaculture and fish processing broadly tracked the overall economy. Offshore wind and marine renewables stand out as the fastest-growing activity group: their GVA increased from USD 38.2 million in 2000 to USD 4.6 billion in 2020, outperforming both the broader ocean economy and the global economy as a whole (OCDE, 2025b).

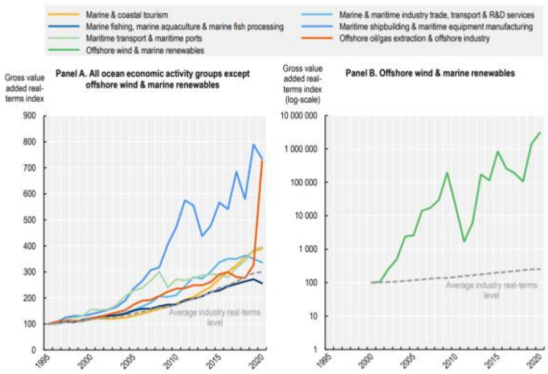

Figure 7: Global ocean economic activity group real-terms gross value-added index and global weighted average industry real-terms gross value-added (OCDE, 2025b; OECD, 2025).

Looking ahead, growth is expected to moderate towards 2050, increasingly driven by two domains: established, fast-scaling investment themes such as aquaculture, desalination and water treatment, decarbonization and digital infrastructure, as well as and emerging industries including marine biotechnology and other early-stage innovations (World Economic Forum, 2026b).

Yet, despite its strategic relevance, the ocean economy remains underfinanced. (World Economic Forum, 2026b). Although blue/water-labelled GSSS bonds reached USD 19 billion in 2015–2024 (58% of which were issued in 2023–2024) current investment flows are still insufficient to support a sustainable transition (World Economic Forum, 2026b). Strengthening ocean finance requires clearer investment theses, better risk and quantification, and scalable instruments across conservation, restoration, infrastructure, innovation, and insurance (World Economic Forum, 2026b). Furthermore, with much of the investment momentum expected to come from the private sector, capital allocation decisions made today will determine whether future ocean-based growth exacerbates environmental degradation or fuels a transition toward regenerative, resilient economic models. This highlights the need for firms and financiers to assess their exposure to ocean-related risks and position themselves early in high-potential ocean industries with unmet financing needs.

1.2. Status Quo of the Blue Economy in Portugal

Portugal is one of the main coastal states of the European Union, with approximately 2,500 km of coastline (European Commission, 2025) and a jurisdiction over a particularly extensive maritime area that comprises around half of all waters under EU responsibility, covering a vast expanse of seabed and subsoil in the Northeast Atlantic. Additionally, Portugal possesses the third-largest Exclusive Economic Zone (EEZ) in the European Union, covering approximately 1.7 million km². This maritime area is also the fifth-largest in Europe and among the twenty largest EEZs worldwide, reflecting the country's significant strategic and economic relationship with the ocean (European Commission, n.d.-b). In parallel, the process for delimiting the extended continental shelf, beyond the 200-nautical-mile limit, is under review within the framework of the United Nations Convention on the Law of the Sea (European Commission, 2025), which may increase the area under national sovereignty or jurisdiction to 4,1milion km² and extend sovereign rights beyond the EEZ regarding the conservation, management, and exploitation of natural resources in the seabed and subsoil (European Commission, 2025).

Within this geostrategic context, economic performance has displayed consistent dynamism. The relative weight of the Blue Economy in Portugal has been strengthening since 2011, following a trajectory only interrupted by the disruption caused by the COVID‑19 pandemic in 2020 (European Commission, n.d.-a). In 2022, the established sectors of this economy directly employed about 295,600 workers and generated €7.8 billion in gross value added (GVA), corresponding to approximately 3.7% of national GVA and 6% of total employment in the country (European Commission, 2025). In comparative terms, Portugal ranked 6th in the EU in employment and 9th in GVA within the Blue Economy domain.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Coastal tourism	2.182 M€	2.124 M€	1.574 M€	1.631 M€	2.118 M€	2.340 M€	2.312 M€	2.663 M€	3.944 M€	4.558 M€	3.987 M€
Living resources	1.087 M€	1.085 M€	1.114 M€	1.050 M€	1.028 M€	1.074 M€	1.152 M€	1.289 M€	1.315 M€	1.356 M€	1.372 M€
Maritime transport	74 M€	61 M€	64 M€	56 M€	65 M€	85 M€	75 M€	81 M€	83 M€	77 M€	98 M€
Non-living resources	4 M€	4 M€	3 M€	4 M€	3 M€	3 M€	4 M€	4 M€	4 M€	4 M€	5 M€
Port activities	310 M€	321 M€	321 M€	322 M€	330 M€	334 M€	321 M€	343 M€	333 M€	368 M€	367 M€
Renewable energy	0 M€	0 M€	0 M€	0 M€	0 M€	0 M€	0 M€	0 M€	0 M€	0 M€	0 M€
Shipbuilding and repair	113 M€	81 M€	72 M€	72 M€	84 M€	90 M€	118 M€	114 M€	124 M€	117 M€	121 M€

Figure 8– Gross Value Added (GVA) by sector (European Commission, 2025)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
PT	2,43%	2,33%	2,04%	2,13%	2,42%	2,60%	2,55%	2,78%	3,43%	3,66%	3,21%	1,74%	2,27%	3,72%

Figure 9 – Blue Economy % of GVA (European Commission, 2025)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Coastal tourism	114	113	86	96	113	122	122	131	182	215	186	94	114	214
Living resources	68	66	67	65	64	64	65	66	67	68	68	67	67	69
Maritime transport	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Non-living resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Port activities	5	5	4	4	4	4	4	4	4	5	5	4	4	5
Renewable energy	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shipbuilding and repair	5	3	3	3	3	3	4	3	4	4	4	4	4	5

Figure 10 – Persons employed (in thousands) by sector (European Commission, 2025)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
PT	4,35%	4,32%	3,78%	4,15%	4,63%	4,70%	4,63%	4,79%	5,79%	6,41%	5,73%	3,81%	4,17%	6,25%

Figure 11 – Blue Economy % of national jobs (persons employed) (European Commission, 2025)

Sectoral composition reveals a marked specialization. Coastal tourism accounts for around 73% of employment and 70% of GVA in the Blue Economy, positioning the country as fourth in GVA and fifth in employment in this segment within the European Union. The second largest contribution comes from marine living resources (including fisheries and aquaculture), with approximately 23% of employment and 21% of GVA. Port activities follow, representing about 4% of GVA and 2% of employment (European Commission, 2025). It is noteworthy that the Port of Sines ranks fifteenth among the largest freight ports in the European Union, reinforcing the logistical significance of the national port system.

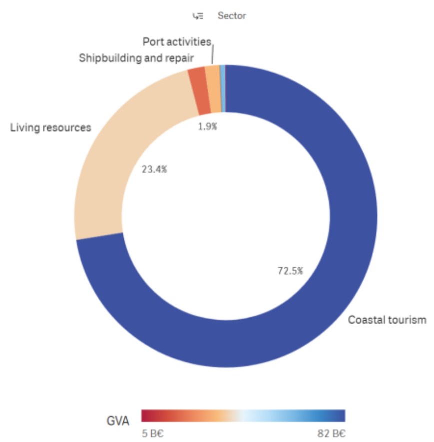

Figure 12 – Contribution to total country GVA (European Commission, 2025)

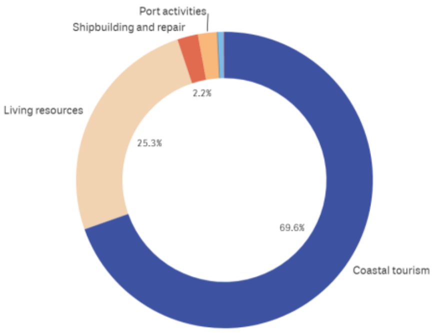

Figure 13 – Contribution to total country FTE (European Commission, 2025)

The governance of this economic system is built upon a complex and integrated institutional architecture that ensures coordination, implementation, and monitoring of maritime policies. The Ministry of Agriculture and Maritime Affairs (Ministério da Agricultura e Mar) plays a central role in formulating and assessing sectoral policies, supported by technical agencies with distinct competences. Among these, the Directorate‑General for Maritime Policy (DGPM) stands out, responsible for coordinating and evaluating maritime public policy, implementing the National Ocean Strategy 2021–2030 (Direção-Geral de Política do Mar, 2021), managing the Blue Economy Observatory, and planning and regulating maritime spatial uses. It is also tasked with overseeing the implementation of the EU Integrated Maritime Policy, promoting national and international cooperation on maritime matters, and supporting ocean literacy initiatives. Complementarily, the Directorate‑General for Natural Resources, Safety and Maritime Services (DGRM) ensures regulation and oversight of maritime activities, covering maritime safety, fisheries, aquaculture, the processing sector, preservation and monitoring of resources, and control of licensed operations. Added to these entities, there is the Portuguese Institute for the Sea and Atmosphere (IPMA), which provides the indispensable scientific and technical foundation through oceanographic and environmental research and monitoring. The *Conta Satélite do Mar* (Satellite Account for the Sea) is likewise an essential statistical instrument for quantifying the contribution of the ocean economy to GDP and employment, enabling monitoring of national strategies. This institutional ecosystem is reinforced by the *Hub Azul*, a network of seven regional poles focused on innovation, digitalization, and decarbonization of maritime sectors, by the professional training system (notably FOR‑MAR), and by higher education institutions providing advanced training in environmental and ocean‑related fields. In parallel, the Oceano Azul Foundation, a private, non-profit organization and the only non-public entity among those mentioned above, contributes to this ecosystem by advancing applied knowledge, strengthening the science-policy interface, mobilizing stakeholders, supporting marine conservation and marine protected areas, promoting ocean literacy, and fostering capacity building and sustainable ocean governance practices.

This institutional arrangement interfaces with a multilevel governance framework incorporating international, European, and national norms and instruments. At the international level, the *United*

Nations Convention on the Law of the Sea (UNCLOS) constitutes the legal-institutional matrix regulating States' rights and obligations regarding zone delimitation, environmental protection, scientific research, maritime navigation, and the sustainable use of resources (UNCLOS, 1982). In this domain, Portugal has strengthened multilateral commitments, notably through the 2025 ratification of the A*greement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (*BBNJ Agreement / High Seas Treaty) and the respective adherence to the target of protecting 30% of the ocean by 2030, thus asserting itself as a committed actor in high-seas biodiversity conservation (BBNJ Agreement, 2023).

Within the European Union, two key instruments structure national practice: the Marine Strategy Framework Directive (MSFD), which requires Member States to adopt marine strategies aimed at achieving Good Environmental Status (MSFD, 2008), and the Maritime Spatial Planning Directive (MSP), which mandates integrated, multisectoral planning for sustainable management of marine uses and coastal resources (MSPD, 2014). In response, Portugal developed the *Plano de Situação do Ordenamento do Espaço Marítimo* (PSOEM), which covers the entire national maritime space and constitutes the central instrument for reconciling uses, balancing conservation, economic exploitation, and ecosystem protection (Conselho de Ministros, 2019).

Domestically, the *Estratégia Nacional para o Mar (ENM) 2021–2030* guides maritime public policy for the decade, aligning with the European Green Deal, the EU Biodiversity Strategy 2030, the Farm to Fork Strategy, and the Horizon Europe Mission "Starfish 2030". The strategy defines ten objectives and operationalizes 185 measures across thirteen priority areas (Direção-Geral de Política do Mar, 2021), incorporating strengthened monitoring and evaluation mechanisms to enhance implementation effectiveness.

Regulatory governance has been consolidated through thematic instruments and environmental precautionary measures. Notable among these is the national moratorium on deep-sea mining, approved in 2025, which prohibits mineral extraction activities in the deep sea until 2050. Its legal enshrinement protects vulnerable ecosystems and positions Portugal as the first European country to adopt a binding prohibition of this nature (Moratória Sobre a Mineração Em Mar Profundo Até 2050, 2025). Complementarily, the National Action Plan for Marine Litter 2024–2028 (PALM2028) constitutes the principal instrument to combat pollution from marine debris, including plastics and microplastics (Conselho de Ministros, 2024), ensuring compliance with obligations under the MSFD, the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention), the European Plastics Strategy, and the Zero Pollution Action Plan for 2030, while connecting to national waste policies such as the National Circular Economy Plan. Finally, the *Plano de Atribuição de Energias Renováveis Offshore* (PAER) establishes the spatial and technical framework for the deployment of ocean-based renewable energy in mainland Portugal's maritime subdivisions, ensuring use compatibility and environmental safeguards (Conselho de Ministros, 2025b). The Portos 5+ Strategy (2025–2035) sets out a framework for modernizing the port system, promoting environmental sustainability, logistical competitiveness, and enhanced operational capacity (Conselho de Ministros, 2025a).

Taken together, these instruments strengthen the governance architecture of the Oceans, providing coherence, robustness, and adaptive capacity in the face of emerging challenges to ocean sustainability.

Parallel to this governance landscape, the private blue-economy is progressively shifting toward higher-value activities, particularly offshore renewables and blue-tech. The PAER is especially influential in this regard, as it delineates maritime areas capable of accommodating approximately 9.4 GW of offshore wind capacity, providing private consortia and their supply chains (engineering, components manufacturing, and Operations & Maintenance) with long-term regulatory visibility and clearer investment horizons (Conselho de Ministros, 2025b).

At the entrepreneurial and innovation level, Portugal's governance architecture for the ocean is increasingly accompanied by a private sector landscape undergoing diversification and technological upgrading. Within this ecosystem, Fórum Oceano plays a key role in structuring cooperation between public and private companies, business associations, R&D centers, educational institutions, local authorities and other associative organizations (Fórum Oceano, n.d.). One of its flagship tools is the Hub Azul Dealroom, a global digital platform for the internationalization of Portugal's Blue Economy, designed to map innovation, investment and emerging ventures in the sector (*Hub Azul Dealroom*, 2026). Drawing on data reported in 2024, the Hub Azul Dealroom identifies 1,210 blue-economy start-ups globally, of which 47 are based in Portugal, and estimates a combined global valuation of €92.8 billion across blue tech and other ocean-economy segments (Compete 2030, 2024). Within the Portuguese group, eight start-ups account for approximately €194 million in valuation, with activity concentrated in robotics, navigation systems, climate-technology applications, clean-energy solutions and energy-efficiency innovations (Compete 2030, 2024). This indicates an emerging basis of innovation-driven firms capable of anchoring new value chains.

However, structural constraints continue to limit the sector's consolidation. A persistent shortage of specialized professionals across multiple maritime value chains hampers the expansion of private activity, and the sector still faces weak coordination between industries and project stakeholders, reducing the overall effectiveness of investment and innovation efforts (Compete 2030, 2024). Investment in the sector also offers some fragilities. Addressing these constraints requires progress in governance and institutional efficiency, particularly through digitalization and simplification of administrative procedures, which remain burdensome for firms. Furthermore, the acceleration of innovation depends on strengthening the interface between universities, research centers, and entrepreneurs, ensuring that knowledge production more effectively transitions into market-ready solutions with measurable economic and environmental impact (Compete 2030, 2024).

Taken together, these dynamics underscore the central role of firms as both economic engines and implementation actors within the ocean economy. The capacity of companies to generate private value, through investment, innovation and competitive positioning, is increasingly intertwined with their ability to address systemic ocean challenges, from decarbonization and ecosystem resilience to digital monitoring and resource efficiency. In this context, this Research Note contributes by examining how private value creation can be strategically aligned with the resolution of ocean-related challenges, identifying pathways through which business competitiveness and marine sustainability can reinforce rather than contradict one another.

1.3. SDG 14 in the Portuguese context: status quo

The Sustainable Development Goals (SDGs), adopted in 2015 by the United Nations as part of the 2030 Agenda for Sustainable Development, constitute a universal framework of 17 integrated goals designed to reconcile economic development, social inclusion, and environmental protection. The SDGs provide a common language for governments, companies, and civil society, guiding public policy, investment and company strategies, as well as accountability mechanisms at national and international levels. Their integrated architecture underscores the interdependence between ecological integrity, social prosperity, and long-term economic resilience.

For Portugal's overall performance towards achieving the Sustainable Development Goals, the country scores 81.13 out of 100 in the Sustainable Development Report 2026 (Sachs et al., 2026b), ranking 17th globally and remaining among the highest-performing countries worldwide. Nevertheless, despite this strong overall performance, important sustainability challenges persist, particularly in relation to SDG 14 - Life Below Water and SDG 12 – Responsible consumption and production.

Figure 14 - SDG Dashboards and Trends, Portugal, 2026. Source: (Sachs et al., 2026b)

SDG 14 aims to ensure the "conservation and sustainable use of the oceans, seas and marine resources for sustainable development" (United Nations Department of Economic and Social Affairs, n.d.). For Portugal, progress towards this goal is particularly strategic. As one of the world's and European Union's leading maritime nations, as well as a strong historical and economic relationship with the ocean, the country's economic development, environmental resilience, and social well-being are closely linked to the health of marine ecosystems. Fisheries, tourism, maritime transport, aquaculture, and emerging offshore renewable energy sectors all depend on the sustainable management of ocean resources.

Despite the strategic importance of SDG 14 for Portugal, its performance reveals persistent challenges. The Sustainable Development Report 2026 indicates that Portugal remains off track to achieve several of the targets associated with SDG 14, reflecting ongoing pressures on marine ecosystems and ocean governance. Furthermore, recent assessments suggest a deterioration in performance across some indicators, pointing to a concerning trend and reinforcing the view that ocean sustainability remains one of the most structurally challenging dimensions of Portugal's sustainable development pathway. These results highlight the need for intensified efforts to protect marine biodiversity, promote the sustainable use of ocean resources, and strengthen the resilience of coastal and marine ecosystems (Sachs et al., 2026b).

Thus, Portugal's ambition to expand offshore renewable energy generation, strengthen maritime transport, develop sustainable aquaculture, support coastal tourism, and promote economic growth through the blue economy must be balanced against the need to preserve biodiversity, protect sensitive habitats, reduce pollution, and ensure the sustainable use of marine resources. Consequently, progress towards SDG 14 requires not only environmental protection measures but also effective governance mechanisms capable of managing trade-offs across sectors and stakeholders.

These challenges are also evident when considering the interactions between SDG 14 and other Sustainable Development Goals. For example, efforts to accelerate the energy transition under SDG 7 may increase pressure on marine space through the deployment of offshore renewable energy infrastructure. Similarly, economic development objectives linked to SDG 8 and SDG 9 can generate additional demands on coastal and marine ecosystems through increased maritime activity, port expansion, and industrial development. At the same time, healthy marine ecosystems contribute directly to climate mitigation and adaptation objectives under SDG 13, while supporting food security, employment, and regional development.

The persistence of these interdependencies highlights the importance of adopting an integrated approach to ocean sustainability. Rather than viewing SDG 14 solely as an environmental objective, it should be understood as a strategic enabler of long-term economic competitiveness, social resilience, and sustainable development. Therefore, for Portugal, achieving SDG 14 will require balancing the opportunities associated with the blue economy with the preservation of the natural capital upon which those opportunities ultimately depend.

Overall, the negative assessment of the SDG 14 in Portugal is consistent with the SDG Dashboard 2026, which provides a comprehensive overview of the current status of the SDGs and progress towards their achievement (Sachs et al., 2026a). For the regional group comprising all OECD member countries, SDG 14 is classified as facing "significant challenges remain", while progress is assessed as "moderately improving". Despite this positive trend, SDG 14 continues to lag behind several other goals in terms of overall performance, reflecting persistent pressures on marine and coastal ecosystems and the need for accelerated action to achieve the targets by 2030. Across other world regions, the situation remains mixed. Most regions continue to face significant or major challenges in achieving SDG 14, with progress ranging from stagnating to moderately improving. These results highlight the widespread difficulties associated with conserving and sustainably using marine resources, reinforcing the global nature of the challenges addressed under this SDG (Sachs et al., 2026b).

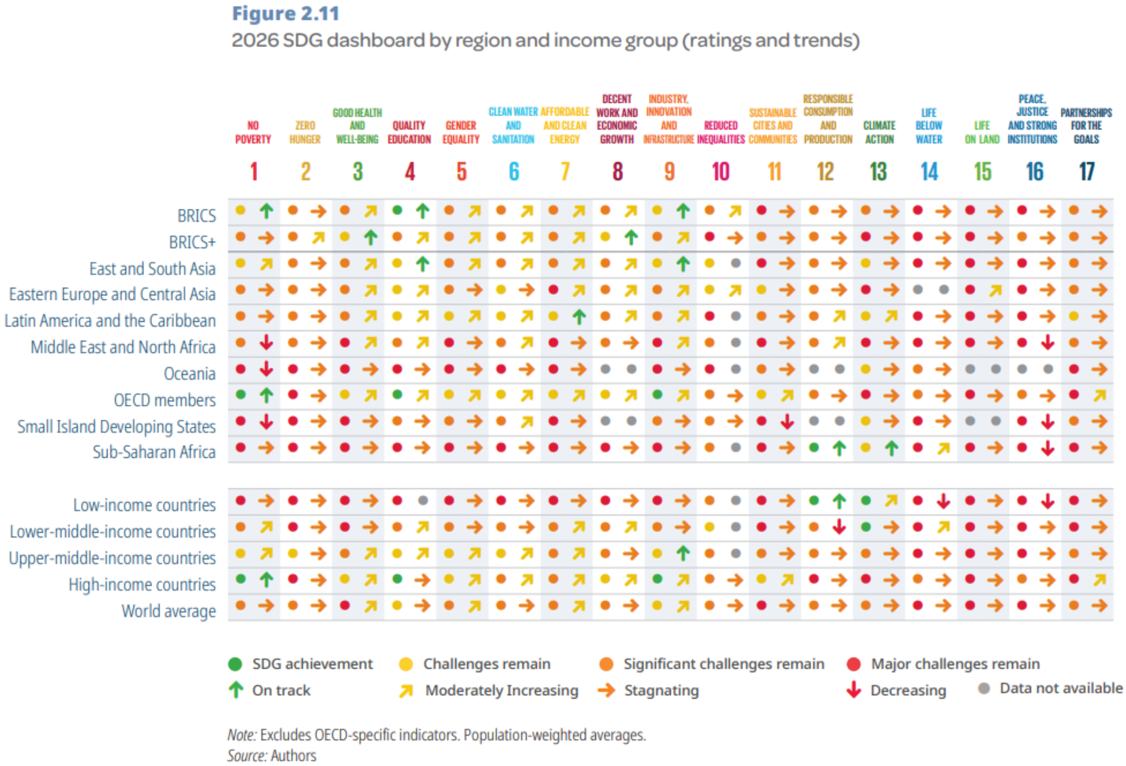

Figure 15 - 2026 SDG dashboard by region and income group (ratings and trends)

As highlighted before, the Sustainable Development Report 2026 indicates that Portugal remains off track to achieve SDG 14 and continues to face significant challenges related to the conservation and sustainable use of marine resources. Comparing to many OECD countries, Portugal's performance on SDG 14 remains comparatively weak, reflecting persistent structural pressures on marine and coastal ecosystems. These findings suggest that, despite the strategic importance of the ocean to the Portuguese economy and identity, the transition towards sustainable ocean management remains incomplete and will require accelerated action if the SDG 14 targets are to be achieved by 2030.

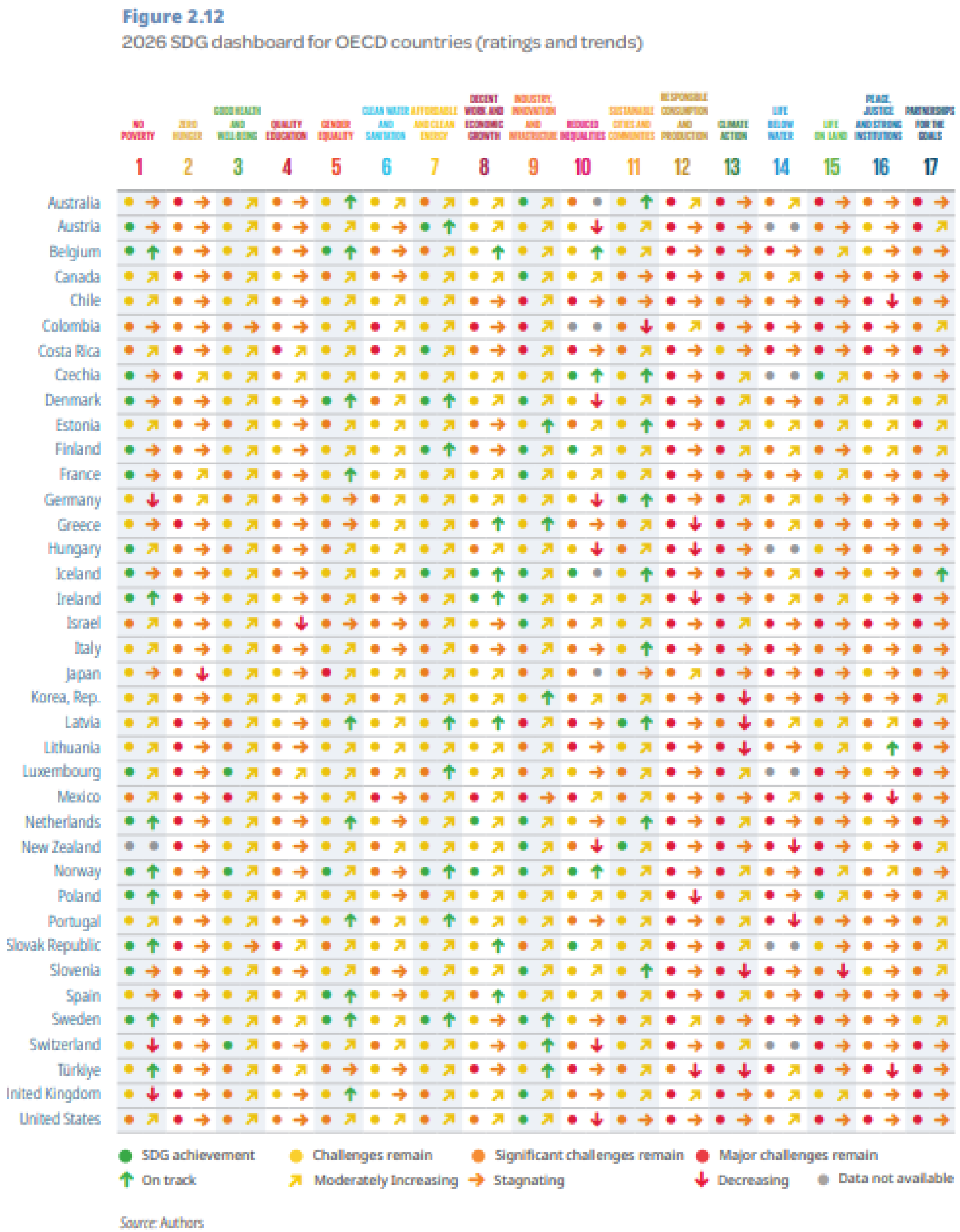

Figure 16 | 2026 SDG dashboards for OECD countries (levels and trends)

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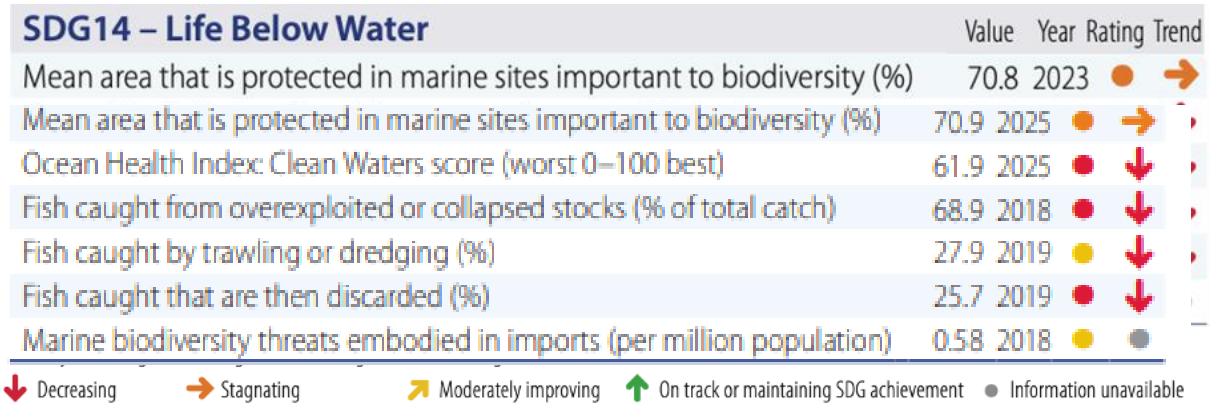
This trend contrasts with Portugal's overall strong performance across the SDGs and underscores the ocean as a policy area where significant sustainability challenges persist. Despite being among the global leaders in overall SDG achievement, Portugal continues to face considerable difficulties in advancing several SDG 14 targets, suggesting that ocean sustainability remains one of the country's most structurally demanding dimensions of sustainable development.

As the 2026 edition of SDG Dashboards states, overall SDG 14 progress status declined in comparison to prior year(s) from "stagnating" to "decreasing". A more detailed picture emerges when examining the underlying SDG indicators. The (Sachs et al., 2026) indicates that Portugal's performance is declining in several indicators. In particular, the report shows that Portugal's score is decreasing for fish caught from overexploited or collapsed stocks, fish caught by trawling or dredging, and fish caught that are discarded (SDG indicator 14.4.1). Moreover, the Ocean Health Index (clean waters score, SDG indicator 14.1.1) is decreasing, while Portugal's efforts are stagnating in protecting marine sites important to biodiversity (SDG indicators 14.2.1 and 14.5.1) (OCDE, 2025a). In the ocean Health Index, the trend shifted from "increasing" in 2024 report to "decreasing" in 2025 and 2026.



SDG14 – Life Below Water	Value	Year	Rating	Trend
Mean area that is protected in marine sites important to biodiversity (%)	70.8	2023	●	→
Mean area that is protected in marine sites important to biodiversity (%)	70.9	2025	●	→
Ocean Health Index: Clean Waters score (worst 0–100 best)	61.9	2025	●	↓
Fish caught from overexploited or collapsed stocks (% of total catch)	68.9	2018	●	↓
Fish caught by trawling or dredging (%)	27.9	2019	●	↓
Fish caught that are then discarded (%)	25.7	2019	●	↓
Marine biodiversity threats embodied in imports (per million population)	0.58	2018	●	●

↓ Decreasing → Stagnating ↗ Moderately improving ↑ On track or maintaining SDG achievement ● Information unavailable

Sustainable Development Report 2025, Country Overview Portugal SDG 14

Figure 17 | Performance by indicator, Portugal

When interpreting the status and progress of SDG 14 targets and indicators in Portugal, it is also essential to consider potential trade-offs between SDGs and their competing uses of marine space, for example between SDG 7.1 (expansion of renewable energy) and SDG 14.2 (sustainable management and protection of marine ecosystems). Offshore renewable energy development can overlap spatially with sustainable fisheries objectives (SDG Target 14.4 and 14.6) and biodiversity protection objectives (especially SDG Target 14.2 and 14.5). Making new areas available for offshore renewable energy can create spatial conflicts with conservation priorities and may challenge the National Ocean Strategy objective of classifying 30% of the national maritime area as protected by 2030, including stricter protection for a share of these zones.

At the same time, coastal ecosystems perform essential ecological and socio-economic functions beyond energy production. They support tourism, recreation, and aquaculture, while also providing ecosystem services such as storm protection, carbon sequestration, and habitat provision. Pollution from industrial discharges, agricultural runoff or urban wastewater can undermine these functions, particularly in sensitive estuarine systems such as the Tejo estuary, where land-based pollution sources interact with marine ecosystems.

Offshore aquaculture development introduces additional sustainability trade-offs especially for achieving SDG 14.4 target for sustainable fishing (Indicators 14.4.1), including nutrient loading, biodiversity risks and competition for shared resources such as water quality and marine space. On the other hand, potential reliance on wild fish for feed may indirectly reinforce pressure on capture fisheries. Spatial competition among aquaculture, fisheries, tourism, and maritime transport can also alter fishing patterns, contributing to persistent challenges of overexploitation and discards, even as reductions in trawling and dredging suggest some positive effects of zoning and conservation measures.

All these factors help to explain why ocean health indicators remain under strain despite improvements in governance and advances in many of the issues related to the Blue Economy sector. Moreover, besides the (Sachs et al., 2026b), mentioned before, also the (OCDE, 2023) – the last report to evaluate Portugal **-** shows that the country continues to face significant challenges in achieving SDG 14. Although important progress was made in 2021 with the creation of Europe's largest marine protected area, earlier data show that only 8.9% of marine areas were protected in 2020, missing the Aichi target of 10%[1]. At the same time, biodiversity pressures remain high: around 30% of fish and bird species and 20% of mammals and reptiles are threatened (OCDE, 2023).

The following table is based on OECD Environmental Performance Review and OECD Improving Policy Coherence for Portugal's Ocean Economy 2025 2023 (OECD, 2023, 2025)*:*

SDG 14 Target	**Trend**	**Key Issue**	**Risk Level**
14.1 Marine pollution	Deteriorating	**The Ocean Health Index "clean waters" score (OECD, 2025)** shows a declining trend. Land-based pollution sources remain significant, including waste mismanagement and low circular material use. As a coastal country with extensive shoreline exposure, Portugal remains vulnerable to marine pollution originating from land-based waste streams.	**Medium-Hight**
14.2 Ecosystem protection	Stagnating	Protection of marine ecosystems remains limited by competing uses of ocean space. Maritime spatial planning must balance biodiversity conservation with expanding sectors such as shipping, offshore wind energy, tourism and fisheries (OECD, 2025).	**High**
14.3 Minimize ocean acidification	Stagnating	Dedicated monitoring and targeted policy measures on ocean acidification remain limited (OECD, 2023, 2025).	**Medium-High**
14.4 Sustainable fisheries	Deteriorating	Fish and bird species show high threat levels (around 30%) (OECD, 2023). Portugal's score is decreasing for fish caught from overexploited or collapsed stocks, fish caught by trawling or dredging, and discarded catch (OECD, 2025)	**High**

[1] *Aichi Biodiversity Target 11, states that: "By 2020, at least 10% of coastal and marine areas should be conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective conservation measures." . The Aichi Targets were a set of 20 global biodiversity targets adopted in 2010 under the Convention on Biological Diversity at the Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity (COP10)*

		(OECD 2025). At the same time, Portugal promotes aquaculture expansion , which must be carefully regulated to avoid water pollution, habitat, and conflicts with biodiversity and fisheries (OECD, 2025).	
14.5 Marine protected areas	Coverage improving, effectiveness uncertain	Portugal created Europe's largest MPA in 2021 (OECD, 2023). Marine protected area coverage has expanded and aligns with EU 30% ambitions (OECD, 2025). However, protection of biodiversity-relevant marine sites is stagnating and management effectiveness remains insufficient (OECD, 2023, 2025).	**Medium–High**
14.6 Prohibit of fisheries subsidies which contribute to overcapacity	Progressing but still needs action	Portugal has established robust mechanisms to combat illegal, unreported and unregulated fishing. Moreover, there is limited evidence that harmful fisheries subsidies currently represent a significant barrier to achieving this target.	**Low**
14.7 Sustainable economic benefits	Expanding but exposed to sustainability risks	Portugal positions itself as a key ocean governance actor and promotes aquaculture, maritime transport, and offshore renewables as growth areas (OECD 2025). However, long-term economic benefits depend on sustainable management, productivity improvements, and the pace of the energy transition (OECD 2025).	**Medium–High**

Table 1 | Based on OECD Environmental Performance Review and OECD Improving Policy Coherence for Portugal's Ocean Economy 2025 2023 (OECD, 2023, 2025)

On a global level, progress under SDG 14 remains among the slowest across all SDGs in Portugal**.** However, the world scenario is not good. Fewer than one quarter of countries have formally approved marine spatial plans (Target 14.2), undermining integrated ocean governance. At the same time, ocean acidification continues to intensify (Target 14.3) and the planetary boundary was crossed in 2025, as a direct consequence of rising atmospheric CO_2 concentrations, placing additional stress on marine ecosystems. The share of overfished fish stocks is still increasing (Target 14.4), highlighting persistent failures in sustainable fisheries management. Even under this scenario, funding for SDG 14 remains well below the level required, reflecting a persistent gap between political commitments and the financial resources allocated to achieving the goal (IISD, 2025).

2. The Challenges of the Blue Economy in Portugal

This section explains how the challenges addressed in this report were identified, consolidated, and translated into business cases. It clarifies the methodological starting point, the selection logic used by the Center for Responsible Business and Leadership, the role of stakeholder interviews, and the final portfolio of 25 challenges that are being addressed through SDG 14-oriented business cases.

2.1. Methodological starting point: from ecosystem mapping to actionable challenges

The work developed for this report took as its starting point the set of blue economy challenges previously identified by Hub Azul project: "The Business Case for the Blue Economy: Companies in Alignment with SDG 14". That process was designed not merely as a technical mapping exercise, but as a structured and collaborative approach to mobilizing the Portuguese blue economy ecosystem and converting dispersed knowledge into concrete opportunities for action.

The Project "HUB AZUL – Desafios da Economia Azul em Portugal" methodology combined five main stages: 1) configuration of the process; 2) engagement of relevant actors; 3) study and selection of challenges; 4) dissemination; and 5) a review method. It also combined internal and external sources of evidence, including a strategic kick-off with the Hub Azul network, semi-structured interviews with leaders and specialists, and an open survey to the wider community. Multi-sectoral and/or regional workshops, a validation survey, and a desk search with systemic stakeholder mapping were also done.

This methodology generated a broad evidence base. The process mapped more than 300 entities, involved stakeholder interviews, gathered more than 50 survey responses, engaged more than 200 workshop participants, and identified more than 800 challenges across the blue economy ecosystem. These were then consolidated by eliminating redundancies, moving from approximately 800 mentioned challenges to around 170 consolidated challenges and finally to 100 actionable challenges, corresponding to 10 actionable challenges per sector.

The initial challenge universe was organized across ten areas of the blue economy: blue biotechnology; bluetech and ocean observation; aquaculture; fisheries and processing; blue renewable energy; shipbuilding and refit; maritime transport and ports; coastal and marine tourism; marine environmental protection and regeneration; and water management. This sectoral structure provided the analytical basis for the subsequent business-case selection exercise undertaken by the Center for Responsible Business and Leadership (CRBL).

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Methodological basis used as a starting point

Methodological component	Description	Relevance for this report
Ecosystem mobilization	Strategic kick-off, workshops, interviews and surveys with actors from the Hub Azul network and the wider blue economy community.	Ensured that the report was grounded in real ecosystem needs rather than abstract sectoral analysis.
Challenge consolidation	Broad challenge identification followed by redundancy elimination, clustering and prioritization of actionable challenges.	Created a structured base from which business-relevant challenges could be selected.
Sectoral organization	Challenges were organized across ten blue economy areas, covering both mature and emerging sectors.	Allowed the business cases to cover multiple parts of the value chain and avoid concentration in only one sector.
Validation and prioritization	Validation by ecosystem participants and Hub Azul stakeholders, with attention to relevance, impact and interest in further development.	Provided a first filter of practical relevance before the CRBL business case analysis.

Table 2 | Methodological basis used as a starting point

2.2. From mapped challenges to business cases

Building on this starting point, the Center for Responsible Business and Leadership (CRBL) analyzed the identified challenges through a business-case lens. The objective was not to reproduce the full challenge-mapping exercise already done, but to select those challenges with the strongest potential to be translated into concrete business opportunities for private companies while contributing to SDG 14 - Life Below Water.

For that purpose, the CRBL team aggregated overlapping challenges, refined the description of several challenge statements, and excluded others that, while relevant for public policy or ecosystem coordination, were less suitable for conversion into a business case. From the broader initial evidence base, the team worked from a long list of 45 candidate challenges and applied a selection logic centered on business potential, actionability and contribution to marine sustainability.

The selection process was guided by seven criteria and involved three researchers from Universidade Católica Portuguesa and close interactions with Hub Azul team:

1. Clear link to a material blue economy challenge in Portugal, including mainland, island and coastal territories.
2. Potential for private-sector action, either through products, services, investment, technology, procurement, new partnerships or new market creation.
3. Ability to be framed as a recognized business-case mechanism: reducing costs, increasing prices, increasing market share, reducing risk, or creating a new business model (see next section).

4. Relevance to SDG 14, either directly through reduced marine pollution, conservation, sustainable resource use, and ecosystem regeneration, or indirectly through better monitoring, transparency, financing or governance.
5. Evidence of market demand, regulatory pressure, technology readiness, or emerging commercial models.
6. Availability of national or international benchmark examples capable of demonstrating feasibility and business relevance.
7. Strategic relevance for Portugal, considering existing capabilities, ocean assets, research capacity, industrial potential and the role of the Hub Azul ecosystem.

From this analysis 18 challenges were selected:

1. **Aquaculture** — Real-time precision aquaculture through integrated health and environmental monitoring
2. **Aquaculture** — Valorization of waste and by-products from aquaculture production
3. **Blue Renewable Energy** — Integrated operational intelligence for offshore renewable energy systems
4. **Shipbuilding & Refit + Blue Renewable Energy** — Development of corrosion, fatigue and wear resistant marine-grade materials
5. **BlueTech & Ocean Observation** — Data standardization, integration and interoperability
6. **Coastal & Maritime Tourism** — Quantification and predictive modelling of tourism environmental impact
7. **Environmental Protection & Regeneration** — Integrated open-water environmental monitoring and early warning
8. **Shipping & Ports** — Port environmental monitoring: water, noise and emissions
9. **Shipbuilding & Refit + Blue Renewable Energy + Fisheries** — Improving energy efficiency of vessels and onboard systems
10. **BlueTech & Ocean Observation** — Operational ocean digital twins
11. **BlueTech & Ocean Observation** — Autonomous operations in sensitive or remote areas
12. **Fisheries and Fish Processing** — End-to-end traceability from catch to consumer
13. **Fisheries and Fish Processing** — Valorization of by-products and biological waste
14. **Fisheries and Fish Processing** — Reducing impacts of ghost fishing from lost nets and gear
15. **Shipbuilding & Refit** — Ship recycling and waste valorization
16. **Shipping & Ports** — Smart planning of port operations
17. **Shipping & Ports** — Automation of loading/unloading and gate management
18. **Shipping & Ports** — Energy transition: shore power and multi-fuel systems

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Business-case translation logic

Each selected challenge was transformed into a short business case structured around: (i) an introduction to the challenge; (ii) an explanation of its relevance to SDG 14; (iii) a description of how private companies can address the challenge through a value-creation mechanism; (iv) a mapping of the relevant ESRS topics, including their connection to the challenge and possible indicators to assess progress and impact; and (v) practical examples and benchmarks of organizations already turning similar challenges into business opportunities.

2.3. Stakeholder interviews and additional challenge generation

In a second stage, the CRBL team complemented the initial challenge base with targeted stakeholder interviews from the Portuguese ocean and blue economy ecosystem. The objective of these interviews was to test the relevance of the selected themes, identify gaps that had not yet been sufficiently captured, and surface challenges with stronger potential to become business cases.

Four stakeholders were consulted for this purpose were Hub Azul, Oceano Azul Foundation, Seaentia, CoLab Atlantic. Their inputs helped broaden the challenge portfolio beyond the initial technical and operational focus, adding themes linked to regulation, market perception, offshore renewable value chains, marine bioresources, natural capital and sustainable finance, regenerative tourism, and qualified blue jobs in coastal and island territories.

From these interviews, the team identified 13 additional challenges. These were subsequently consolidated and converted into seven, ensuring that the final report includes both technology-driven and market-building opportunities. This was particularly important because several of the most promising blue economy opportunities do not arise only from improving existing operations, but from creating new services, financing models, knowledge-based businesses and higher-value market propositions.

Seven additional business cases derived from stakeholder interviews

1. Regulatory unlocking to accelerate blue investment.
2. Sustainable aquaculture with higher perceived value by the market.
3. Developing a national value chain for offshore and ocean renewables.
4. Valorization of marine bioresources in health, food, cosmetics, and biomaterials.
5. Integration of marine natural capital into business and financing models.
6. Regenerative coastal and maritime tourism with higher added value.
7. Creation of qualified blue jobs in coastal and island territories.

2.4. Selected challenges addressed in the business cases

The final challenge portfolio combines challenges emerging from the initial selection, based on the HUB AZUL – Desafios da Economia Azul em Portugal project with additional challenges refined through the CRBL analysis and stakeholder interviews. Together, they represent 32 challenges and business opportunities with a practical agenda for translating the blue economy into business cases

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that connect competitiveness, innovation and measurable contribution to SDG 14, with 123 practical examples.
The table below summarizes the challenges being addressed and the dominant business-case logic used to frame each one. Some challenges can support more than one business-case mechanism. The table therefore identifies the primary value-creation lens used in this report.

Challenges addressed in the business cases

#	Origin	Number of initial challenges that where merged	Area / sector	Challenge	Business-case lens	What the business case addresses	Number of practical Examples representing different Business Case
1	HUB AZUL – Desafios da Economia Azul em Portugal	3	Aquaculture	Real-time precision aquaculture through integrated health and environmental monitoring	**Reducing costs / reducing risk**	Sensor networks, AI analytics, environmental monitoring, fish behavior and health indicators to improve welfare, feeding and production consistency.	3
2	HUB AZUL – Desafios da Economia Azul em Portugal	2	Aquaculture	Valorization of waste and by-products from aquaculture production	**Reducing costs / new revenue streams**	Capturing sludge, mortalities and processing by-products and upgrading them into fertilizers, feed ingredients, biomaterials or energy.	5
3	HUB AZUL – Desafios da Economia Azul em Portugal	4	Blue renewable energy	Integrated operational intelligence for offshore renewable energy systems	**Reducing costs / increasing performance**	Digital infrastructure for autonomous inspection, forecasting, asset diagnostics, predictive maintenance and hybrid energy management.	7
4	HUB AZUL – Desafios da Economia Azul em Portugal	1	Shipbuilding & refit / blue renewable energy	Development of corrosion, fatigue and wear-resistant marine-grade materials	**Reducing risk / increasing market share**	Marine-grade materials that improve performance and reduce technical risk in offshore, vessel and ocean infrastructure applications.	3
5	HUB AZUL – Desafios da Economia Azul em Portugal	2	Bluetech & ocean observation	Data standardization, integration and interoperability	**Creating enabling services / reducing costs**	Standards and interoperable data architecture across sensors, platforms and satellites.	3
6	HUB AZUL – Desafios da Economia Azul em Portugal	3	Coastal & maritime tourism	Quantification and predictive modelling of tourism environmental impact	**Increasing prices / reducing risk**	Tools to measure, predict and manage the environmental footprint of tourism operators and destinations.	3
7	HUB AZUL – Desafios da Economia Azul em Portugal	3	Environmental protection & regeneration	Integrated open-water environmental monitoring and early warning	**Creating a new business model / reducing risk**	Distributed sensors, autonomous platforms and real-time pipelines to detect ecological stress, microplastics, pollutants and physical changes.	3

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8	HUB AZUL – Desafios da Economia Azul em Portugal	1	Shipping & ports	Port environmental monitoring (water, noise, emissions)	**Reducing risk / compliance advantage**	Monitoring systems to measure and manage the environmental impact of port operations.	3
9	HUB AZUL – Desafios da Economia Azul em Portugal	2	Shipbuilding & refit / blue renewable energy / fisheries	Improving energy efficiency of vessels and onboard systems	**Reducing costs**	Efficiency solutions for vessels and onboard systems, with relevance for fishing, refit and offshore operations.	6
10	HUB AZUL – Desafios da Economia Azul em Portugal	2	Bluetech & ocean observation	Operational ocean digital twins	**Creating a new business model / reducing costs**	Digital representations of ocean conditions and assets to support planning, simulation, risk management and decision-making.	2
11	HUB AZUL – Desafios da Economia Azul em Portugal	3	Bluetech & ocean observation	Autonomous operations in sensitive or remote areas	**Reducing costs / creating specialized services**	Remote and autonomous systems for monitoring, inspection and operations where human access is difficult, costly or environmentally sensitive.	3
12	HUB AZUL – Desafios da Economia Azul em Portugal	3	Fisheries & fish processing	End-to-end traceability from catch to consumer	**Increasing prices / market access**	Traceability systems, digital product passports and analytical verification to prove origin, legality and sustainability claims.	7
13	HUB AZUL – Desafios da Economia Azul em Portugal	1	Fisheries & fish processing	Valorization of by-products and biological waste	**Creating a new business model / reducing costs**	Transforming fish by-products into collagen, proteins, oils, chitosan, feed, fertilizers, biogas or other higher-value products.	6
14	HUB AZUL – Desafios da Economia Azul em Portugal	2	Fisheries & fish processing	Reducing impacts of ghost fishing from lost nets and gear	**Creating circular services / reducing risk**	Recovery, tracking, recycling and alternative gear models that reduce marine debris and protect marine ecosystems.	3
15	HUB AZUL – Desafios da Economia Azul em Portugal	3	Shipbuilding & refit	Ship recycling and waste valorization	**Reducing costs / new revenue streams**	Compliant dismantling, hazardous material management and valorization of steel, metals and other recoverable materials.	3
16	HUB AZUL – Desafios da Economia Azul em Portugal	1	Shipping & ports	Smart planning of port operations	**Reducing costs / increasing efficiency**	Data-driven planning tools to optimize port operations, reduce congestion and improve asset utilization.	6
17	HUB AZUL – Desafios da Economia Azul em Portugal	2	Shipping & ports	Automation of loading/unloading and gate management	**Reducing costs / increasing efficiency**	Automation, digital gate systems and workflow optimization for port logistics.	7
18	HUB AZUL – Desafios da Economia Azul em Portugal	1	Shipping & ports	Energy transition: shore power and multi-fuel port systems	**Reducing risk / infrastructure business models**	Electrification, shore power, alternative fuels and associated infrastructure to support cleaner maritime operations.	3
From the 45 challenges identified by the HUB AZUL project *Challenges of the Blue Economy in Portugal,* 39 were analyzed in depth. Some of these challenges were strategically consolidated in order to develop more robust, integrated, and actionable business opportunities, resulting in 18 challenges with strong potential for both commercial viability and positive impact generation.							

19	Stakeholder/CRBL addition		Cross-cutting / regulation	Regulatory unlocking to accelerate blue investment	**Reducing costs**	Legal navigation, project preparation, regulatory support and one-stop-shop models to reduce licensing uncertainty.	8
20	Stakeholder/CRBL addition		Aquaculture	Sustainable aquaculture with higher perceived value by the market	**Increasing prices**	Certification, traceability, automation, new feeds, offshore production and communication to improve trust and willingness to pay.	2
21	Stakeholder/CRBL addition		Blue renewable energy	Developing a national value chain for offshore and ocean renewables	**Increasing market share**	Components, cables, maintenance, metalworking, robotics, platforms, sensors and specialized services for domestic and export markets.	6
22	Stakeholder/CRBL addition		Blue biotechnology	Valorization of marine bioresources in health, food, cosmetics and biomaterials	**Creating a new business model**	Marine compounds, algae, collagen, extremophile bacteria, ocean fungi and by-products transformed into ingredients, drugs, cosmetics and biomaterials.	7
23	Stakeholder/CRBL addition		Natural capital / sustainable finance	Integration of marine natural capital into business and financing models	**Creating a new business model**	Metrics, blue carbon, biodiversity credits, reporting models and sustainable finance instruments linked to marine ecosystem services.	8
24	Stakeholder/CRBL addition		Coastal & maritime tourism	Regenerative coastal and maritime tourism with higher added value	**Increasing prices**	Premium tourism experiences linked to conservation, science, maritime culture, citizen science and ecosystem regeneration.	8
25	Stakeholder/CRBL addition		Skills / coastal and island territories	Creation of qualified blue jobs in coastal and island territories	**Creating a new business model**	Blue hubs, specialized training, incubators and pilot projects to address skills gaps in emerging blue economy sectors.	8
The stakeholder interviews enabled the identification of 13 additional challenges. These were subsequently analyzed in depth, leading to the selection of 7 challenges considered to have the greatest potential for further development into robust business cases.							**123**

Table 3 | Source: Authors. Adapted from the Hub Azul Desafios da Economia Azul em Portugal -mapping methodology and from the CRBL working selection of challenges and business-case orientations.

2.5. Implications for the report

The portfolio of challenges selected for this report reflects a deliberate shift from diagnosing problems to identifying where business can become part of the solution. It recognizes that the blue economy is not a single sector, but a system of interdependent activities: food production, ports, vessels, offshore energy, tourism, biodiversity, data, finance, skills, and coastal territories.

Across the selected business cases, four dominant value-creation mechanisms emerge. Some challenges are primarily about reducing costs, for example by improving energy efficiency, automating port operations, reducing maintenance expenses or promoting risk reduction (regulatory, operational, environmental and reputational risk). Others are about increasing prices through certified, traceable or higher-value products and experiences. A third group focuses on increasing market share, particularly where Portuguese companies can capture a larger part of emerging blue economy value chains. Finally, a fourth group, allows several challenges: create entirely new business models, including blue biotechnology, natural capital finance, regenerative tourism, circular by-product valorization and blue skills hubs.

This framing is central to the logic of the report. The blue economy challenges selected here are not treated only as constraints to be mitigated; instead, they are treated as sources of innovation, investment and strategic differentiation. By connecting SDG 14 with concrete business logic and practical benchmark examples, the report seeks to show how companies can contribute to ocean sustainability while building competitive advantage, resilience and new markets.

Methodological sources used in this chapter

Source	Use in this chapter
Hub Azul Desafios da Economia Azul em Portugal	Used to describe the original challenge-identification process, methodology, sectoral scope and quantitative outputs of the mapping exercise.
CRBL coding challenge table	Used to define the final list of 18 challenges addressed and the corresponding business-case orientation.
Stakeholder interviews	Used to identify additional challenges and convert them into seven new challenges.

Table 4 | Methodological sources used in this chapter

3. The Business Case for Addressing Blue Economy Challenges

The previous sections have demonstrated that the Blue Economy is not only an environmental or policy agenda, but also a strategic economic domain. In Portugal, this is particularly evident given the country's extensive maritime jurisdiction, the relevance of ocean-dependent sectors, and the emergence of an ecosystem centered on blue innovation, offshore renewable energy, maritime technologies, fisheries, aquaculture, tourism, ports, and environmental regeneration. Nevertheless, the deterioration of SDG 14 indicators, the persistence of marine pollution, pressure on fish stocks, climate-related risks, and competing uses of maritime space demonstrate that the economic value derived from the ocean cannot be separated from the health and resilience of marine ecosystems.

In this context, the business case for the Blue Economy refers to the strategic rationale through which companies generate economic and financial value while contributing to the sustainable use, protection, restoration, and regeneration of ocean and coastal systems. A business case through sustainability can be understood as an identifiable environmental and/or social practice that creates conditions through which sustainability contributes to the economic and financial success of a company (Carroll & Shabana, 2010; Dyllick & Hockerts, 2002). Applied to the Blue Economy, this means that corporate action related to SDG 14 should not be interpreted merely as philanthropy, reputation management, or regulatory compliance. Instead, it can become a source of competitiveness, innovation, resilience, differentiation, and long-term value creation.

This perspective is particularly relevant because many companies continue to treat ocean sustainability as a peripheral issue, even when their operations, supply chains, logistics, materials, energy use, waste streams, investment decisions, or customer markets depend directly or indirectly on marine and coastal systems. For companies operating in Portugal, the Blue Economy represents an opportunity to align business strategy with national and international sustainability priorities, including the SDG 14, the National Ocean Strategy 2021–2030, and its various objectives, including maritime spatial planning, offshore renewable energy development, circular economy objectives, and marine biodiversity preservation. The central question is, therefore, not whether companies should contribute to ocean sustainability, but rather how they can transform that contribution into a credible and measurable business advantage.

Following the typology developed in the literature on sustainability business cases developed by the Center for Responsible Business and Leadership at Católica-Lisbon SBE, and adapting it to the specific context of the Blue Economy, four main business cases can be identified: 1) reducing costs, 2) increasing prices, 3) increasing market share, and 4) creating a new business model. These business cases draw on the work of (Henderson, 2020), while being applied in this case to ocean-related sectors and to the strategic priorities of sustainable development in Portugal.

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3.1. Reducing costs through resource efficiency and risk prevention

Reducing costs occurs when companies lower operational, production, compliance, or future risk-related costs through more sustainable practices. Within the Blue Economy, this represents one of the most immediate and tangible business cases because many ocean-related activities are highly dependent on natural resources, energy, water, logistics, infrastructure, and ecosystem stability.

Companies can reduce costs by improving efficiency in energy and water use, reducing waste, preventing pollution, adopting circular production systems, and increasing the productivity of materials and resources. In maritime transport, ports, tourism, aquaculture, fisheries, and coastal infrastructure, this may include investments in decarbonization, fuel efficiency, waste management, digital monitoring, water reuse, sustainable packaging, or low-impact operations. These practices can reduce exposure to volatile input costs, improve operational performance, and decrease the likelihood of fines, delays, reputational damage, or regulatory non-compliance.

Reducing costs is also closely associated with risk mitigation. Ocean-dependent businesses are increasingly exposed to climate-related hazards, biodiversity loss, resource scarcity, supply chain disruption, coastal erosion, extreme weather events, and regulatory pressure. By identifying and managing these risks proactively, companies can avoid future costs and strengthen organizational resilience (Kolk & Pinkse, 2008). For example, a tourism company investing in coastal ecosystem protection may reduce exposure to erosion and destination degradation. A seafood company strengthening traceability and sustainable sourcing may reduce reputational and regulatory risks. Moreover, a port operator investing in climate-resilient infrastructure may avoid disruption costs associated with extreme weather events.

In this sense, contributing to SDG 14 can become a mechanism for protecting the economic foundations of the business itself. The preservation of clean waters, sustainable fisheries, healthy coastal ecosystems, and biodiversity is not external to corporate performance. Rather, it constitutes part of the enabling infrastructure upon which many sectors depend.

3.2. Increasing prices through sustainable and ocean-positive value propositions

A second business case emerges when companies are able to increase prices because their products or services are perceived as more sustainable, responsible, traceable, regenerative, or aligned with customer values. In sustainability-oriented markets, companies may justify higher prices when customers recognize additional environmental or social value in the offer (Bain & Company, 2023; Havas, 2015; Shopify, 2022).

Within the Blue Economy, this business case is particularly relevant for sectors such as seafood, coastal and maritime tourism, blue biotechnology, sustainable materials, maritime services, and ocean-related consumer products. Companies may develop premium value propositions based on certified sustainable fish, responsible aquaculture, regenerative tourism experiences, low-carbon maritime logistics, plastic-free products, marine biodiversity protection, or verified contributions to ocean restoration.

However, increasing prices through sustainability requires credibility. Companies cannot simply communicate an “ocean-positive” positioning without evidence. They require clear standards, traceability systems, third-party certifications where relevant, transparent impact measurement, and alignment between brand promise and operational practice. Without such credibility, the risk of bluewashing increases, potentially undermining customer trust and corporate reputation.

For Portuguese companies, this creates an opportunity to connect product and service differentiation with the country’s maritime identity and sustainability ambitions. Portugal’s historical and economic relationship with the ocean can become a strategic asset if companies are capable of translating it into high-quality, science-based, and internationally credible value propositions. In this way, SDG 14 can support not only environmental performance, but also brand differentiation, customer loyalty, and access to premium markets.

3.3. Increasing market share through alignment with emerging demand and unmet needs

A third business case occurs when sustainability enables companies to reach new customers, enter new geographies, or increase their participation in existing markets. This occurs when customers, investors, procurement systems, or business clients prefer more sustainable products or services. Sustainability can therefore become a driver of increasing market share (Hart, 1995; McKinsey & Company, 2023).

In the Blue Economy, increasing market share may occur through several channels. First, demand is growing for low-carbon, circular, traceable, and nature-positive solutions across sectors. Companies that anticipate these expectations may become preferred suppliers for clients with sustainability commitments, public procurement requirements, ESG-related investment criteria, or supply chain due diligence obligations. Second, ocean-related challenges create unmet market needs, including water treatment, coastal protection, pollution prevention, biodiversity monitoring, sustainable aquaculture, port digitalization, clean maritime fuels, and marine ecosystem restoration. Companies capable of developing solutions to these challenges may access new markets while simultaneously contributing to SDG 14.

This business case is particularly relevant for Portugal because the country combines strong ocean exposure with a developing ecosystem of blue technology, research, maritime infrastructure, and entrepreneurial activity. Companies may increase market share by positioning themselves in high-potential areas such as offshore renewable energy services, ocean observation, robotics, environmental monitoring, sustainable tourism, circular plastics systems, marine restoration, and sustainable seafood value chains.

Increasing market share also depends on collaboration. Many ocean-related challenges cannot be addressed by isolated firms acting independently. They require partnerships between companies, ports, municipalities, universities, research centers, investors, public agencies, and civil society organizations. Companies participating in these collaborative ecosystems may gain access to knowledge, innovation pipelines, legitimacy, and new business opportunities. In this sense, SDG 14 can function as a strategic coordination framework, helping firms identify where market needs, environmental priorities, and institutional agendas converge.

3.4. Creating a new business model for a regenerative Blue Economy

The fourth business case involves creating a new business model. This occurs when sustainability leads companies to redesign how they create, deliver, and capture value. A new business model may involve new products, services, technologies, production systems, and therefore, revenue streams. Sustainability can therefore operate as a driver of innovation and business model transformation.

Within the Blue Economy, this is arguably the most transformative business case. The scale and complexity of ocean-related challenges require companies to move beyond incremental improvements and develop models that actively contribute to regeneration, resilience, and long-term value creation. Examples include regenerative aquaculture, blue carbon projects, nature-based coastal protection, circular systems for fishing gear and plastics, digital platforms for ocean data, marine biodiversity monitoring services, low-carbon port ecosystems, sustainable desalination, water reuse solutions, and innovative financing mechanisms for conservation and restoration.

For established companies, creating a new business model may involve adapting existing capabilities to sustainability-driven markets. A logistics company may develop low-carbon maritime transport solutions, an energy company may redirect part of its investment portfolio towards offshore renewable energy, a tourism company may redesign its offer around ecosystem protection and local community value creation, a technology company may apply artificial intelligence, sensors, or satellite data to ocean monitoring, and an industrial company may develop circular solutions that prevent waste from reaching the marine environment.

For start-ups and innovation-driven firms, the Blue Economy represents a field of significant strategic potential. The combination of environmental urgency, regulatory change, underfinancing, technological development, and growing market demand creates opportunities for ventures capable of addressing ocean challenges with scalable solutions. Nevertheless, creating a new business model requires more than technological innovation. It depends on market validation, access to capital, scientific credibility, regulatory clarity, partnerships, and measurable impact.

In Portugal, this business case is particularly relevant given the country’s maritime geography, the emergence of blue-tech ventures, the development of offshore renewable energy, and the need to increase the value-added intensity of ocean-related sectors. The opportunity is, therefore, not only to expand the Blue Economy, but also to shape it in a manner compatible with ecological thresholds and long-term competitiveness.

3.5. From sustainability contribution to strategic advantage

The business case for the Blue Economy involves identifying where ocean sustainability and business performance can reinforce one another. Companies may achieve strategic advantages by reducing costs through resource efficiency and risk prevention, increasing prices through credible sustainable value propositions, increasing market share by responding to emerging demand and unmet needs, and creating a new business model through innovation linked to ocean-related challenges.

For companies operating in Portugal, this approach has a clear strategic implication: contributing to SDG 14 and to a sustainable Blue Economy should be integrated into core business strategy rather than treated as an external sustainability initiative. This requires companies to assess their dependencies and impacts on marine and coastal systems, identify the ocean-related risks and opportunities most material to their sector, define measurable objectives, align investment decisions with sustainability outcomes, and establish partnerships capable of generating systemic impact.

In practical terms, companies can begin by asking five strategic questions:

1. How does our business depend on the ocean, coastal ecosystems, maritime infrastructure, marine resources, water quality, or ocean-related value chains?
2. Where do our operations, products, supply chains, or investments create pressure on marine ecosystems?
3. Which SDG 14-related challenges represent material risks for our business model?
4. Which of these challenges can be transformed into cost savings, differentiation, market growth, or innovation opportunities?
5. What partnerships, metrics, governance mechanisms, and investment decisions are necessary to transform these opportunities into measurable business value?

Answering these questions enables companies to move from a generic commitment to sustainability towards a concrete business case. In the Portuguese context, this transition is particularly important. The country's economic relationship with the ocean is profound, but future value creation will depend on the capacity to reconcile economic growth with marine ecosystem protection. Companies that anticipate this transition will be better positioned to manage risks, respond to regulation, attract investment, strengthen reputation, innovate, and compete in emerging blue markets.

Ultimately, the business case for the Blue Economy reflects the growing interdependence between ocean health and business resilience. A degraded ocean increases costs, risks, and instability, whereas a protected and regenerated ocean creates the conditions for long-term prosperity, innovation, and competitiveness. For companies, contributing to SDG 14 is therefore not only a sustainability responsibility, but also a strategic opportunity to build resilient, regenerative, and future-oriented business models.

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4. From Challenges to Opportunities: Developing the Business Case for Action for the Portuguese ecosystem

CHALLENGE 1: REAL-TIME PRECISION AQUACULTURE THROUGH INTEGRATED HEALTH AND ENVIRONMENTAL MONITORING

Aquaculture is becoming one of the main pillars of global aquatic food supply. In 1974, it provided only 7 percent of fish for human consumption; by 2016, it supplied more than half (O'Donncha & Grant, 2019b). In 2022, aquaculture surpassed capture fisheries for the first time as the main source of aquatic animal production, while global aquaculture production reached 130.9 million tones (Food and Agriculture Organization of the United Nations, 2024). As the sector scales, producers face a growing operational challenge: maintaining productivity, animal welfare and environmental performance under increasingly variable biological and environmental conditions.

Aquaculture management has traditionally relied on farmer experience, observation and periodic data collection, with interventions often occurring only after visible disease symptoms, feed inefficiencies or water-quality problems have already affected production. This creates direct business risks, including disease outbreaks, mortality events, feed waste, poor feed conversion, inconsistent growth, welfare concerns and increased regulatory pressure. These risks are especially relevant in intensive production systems, including onshore tanks, recirculating aquaculture systems and offshore operations, where environmental conditions, stocking densities and biological stressors can change quickly (Føre & Berckmans, 2018; O'Donncha & Grant, 2019b).

This challenge focuses on deploying real-time precision aquaculture systems that integrate continuous environmental monitoring, early health detection, behavioral analysis, and AI-powered decision support (Føre & Berckmans, 2018). By combining sensor networks, biological markers, computer vision and predictive analytics, producers can detect changes earlier, optimize feeding and operational decisions, reduce losses, improve production consistency and scale aquaculture more sustainably (O'Donncha & Grant, 2019b).

SDG 14 ALIGNMENT

As demand for aquatic food continues to grow, aquaculture is becoming increasingly important to global seafood supply. However, its expansion must be managed carefully to avoid shifting pressure from capture fisheries to new environmental risks in farming systems, including nutrient pollution, disease transmission, inefficient feed use, water-quality degradation, and conflicts with ecosystem carrying capacity. Precision aquaculture helps address this challenge by making production decisions more data-driven, allowing producers to monitor environmental conditions, animal health and biological performance in real time.

Precision aquaculture directly supports four key SDG 14 targets:

Target	Relevance to the challenge	Strength of alignment
14.1	Prevent and reduce marine pollution, including nutrient pollution. Data-driven aquaculture can reduce environmental pressure by improving feed efficiency, limiting waste, detecting health issues earlier and supporting better management of water quality and nutrient flows.	Strong in fed systems; medium in low-input systems where the main contribution is environmental monitoring and water-quality control.
14.2	Sustainably manage and protect marine and coastal ecosystems. Precision monitoring helps ensure that aquaculture remains within site-specific environmental limits by tracking water quality, animal health, biological performance and carrying capacity.	Medium to strong, depending on whether the system is connected to carrying-capacity limits, ecosystem indicators and operational decisions.
14.7	Increase the economic benefits from the sustainable use of marine resources. Precision aquaculture can support blue economy growth by improving productivity, survival rates, resource efficiency and production consistency, while strengthening innovation and investment in sustainable ocean industries.	Strong when productivity gains are achieved together with environmental safeguards and local value creation.
14.a	Increase scientific knowledge, develop research capacity and transfer marine technology. Precision aquaculture applies marine biotechnology, hatchery R&D, digital production systems, data analysis and predictive modelling to aquaculture operations.	Strong, particularly when scientific monitoring and digital tools are translated into commercial production and shared across the sector.

Table 5 | SDG 14 alignment - Precision aquaculture directly supports four key SDG 14 targets

Precision aquaculture links production growth to environmental control: by monitoring water quality, animal health, feeding performance, and biological indicators in real time, producers can reduce pollution risks, improve welfare, limit resource waste and align farming decisions with ecosystem carrying capacity. In doing so, businesses contribute directly to marine pollution reduction (Target 14.1), sustainable management of marine and coastal ecosystems (Target 14.2), sustainable blue economy growth (Target 14.7), and the application of marine science and technology to food production (Target 14.a).

THE BUSINESS CASE - BIOLOGICAL RISK REDUCTION + RESOURCE EFFICIENCY + NEW BUSINESS MODEL

Business strategies targeting precision aquaculture create value primarily by reducing biological risk, improving resource efficiency, and increasing production predictability. Aquaculture producers face direct losses from disease outbreaks, mortality events, poor growth performance, water-quality failures and inefficient feeding. In fed aquaculture systems, feed is often the largest operating cost (Asche & Oglend, 2016), so even small improvements in feed conversion ratios, appetite detection, and feeding timing can generate material savings while reducing waste and environmental pressure.

Real-time monitoring systems, including water-quality sensors, behavioral computer vision, health diagnostics, biological markers and AI-powered analytics, allow producers to detect risk earlier and intervene more precisely (Føre & Berckmans, 2018). Instead of responding only when visible symptoms or production losses appear, operators can identify small changes in animal health, stress, appetite, or environmental conditions before they escalate. This improves survival rates, animal welfare, production consistency, and compliance, while reducing the likelihood of costly disease events or emergency treatments (O'Donncha & Grant, 2019a).

The business case varies across production systems. In fed fish aquaculture, value is created through optimized feeding, lower feed waste, improved feed conversion, better growth performance, and earlier disease detection. In low-input systems such as bivalve aquaculture, where animals rely on naturally available food rather than artificial feed, the value proposition is based less on feed optimization and more on seed quality, survival, growth predictability, environmental monitoring, carrying capacity, and food safety compliance. (Antonucci & Costa, 2020)

Simultaneously, the shift toward precision aquaculture is creating new business models in ocean technology, diagnostics and data services. Sensor manufacturers, AI analytics platforms, environmental monitoring providers, digital hatchery systems and health-detection tools can sell hardware, software, data subscriptions or monitoring services to aquaculture operators (Food and Agriculture Organization of the United Nations, 2024). These ventures demonstrate how sustainability and productivity challenges can generate new commercial opportunities, turning biological and environmental data into operational value.

Business case type	How value is created	Typical company opportunity
Cost reduction	Reduces feed waste, improves feed conversion, lowers mortality-related losses, reduces emergency interventions and improves resource use.	Adopt real-time feeding systems, water-quality sensors, farm dashboards and predictive alerts to reduce OPEX.
Risk reduction	Detects disease, stress, welfare and environmental risks earlier, before they become mortality events, compliance failures or production losses.	Use early-warning systems, computer vision, health diagnostics and biological markers to manage operational risk.
Production predictability	Improves growth consistency, survival rates, harvest planning, product quality and supply reliability.	Use data-driven production planning to improve customer commitments, volume forecasting and quality control.
Market share / premium positioning	Supports differentiated products based on welfare, traceability, quality, low-input production or verified environmental performance.	Position as a sustainable aquaculture producer with stronger ESG evidence, traceability and reliability.
New business model	Transforms monitoring, diagnostics, hatchery data and farm intelligence into software, hardware, analytics or monitoring-as-a-service offerings.	Offer sensors, AI platforms, farm-management software, digital hatchery systems, environmental monitoring or advisory services.
Compliance and license to operate	Improves evidence for water quality, carrying capacity, food safety, welfare, treatment use and environmental thresholds.	Integrate ESG, food safety and regulatory reporting into operational dashboards and audit-ready evidence systems.

Table 6 | Business Cases Type

ESRS MAPPING

The ESRS connection is strongest when precision aquaculture is used not only to optimize production, but also to document environmental performance, resource efficiency, animal health and food-safety conditions. The mapping below identifies the most relevant ESRS topics and practical indicators companies can use to connect operational data with sustainability reporting.

ESRS topic	Connection	Possible indicators
E2 Pollution	Relevant where aquaculture operations may generate nutrient loading, suspended solids, chemicals, medicines or water-quality pressures. Precision systems can reduce pollution by improving feeding, detecting water-quality deviations and supporting more targeted interventions.	Feed conversion ratio; feed waste reduction; nitrogen/phosphorus discharge estimates; water-quality threshold breaches; treatment events; antibiotic or chemical use; effluent monitoring results.
E3 Water and Marine Resources	Directly relevant because aquaculture depends on water quality, marine resources and site-specific carrying capacity. Monitoring helps companies understand water conditions, resource dependence and operational impacts on marine systems.	Dissolved oxygen, temperature, pH, salinity and turbidity; water-quality compliance; carrying-capacity indicators; site monitoring coverage; production within license limits.
E4 Biodiversity and Ecosystems	Relevant where aquaculture affects marine ecosystems through habitat pressure, disease transmission, escapes, seabed impacts, interactions with wild species or, in bivalve systems, potential ecosystem services.	Mortality and disease events; escape events; benthic monitoring; parasite/lice levels; habitat indicators; carrying-capacity status; biodiversity monitoring; ecosystem-service indicators for bivalves.
E5 Resource Use and Circular Economy	Precision aquaculture can improve resource efficiency by reducing feed losses, improving biomass conversion, lowering waste and supporting more efficient use of inputs across the production cycle.	Feed conversion ratio; feed use per kg produced; survival rate; biomass yield; waste generated; input efficiency; by-product or waste valorization where applicable.
S1/S2 Workforce and Value Chain	Digital monitoring can reduce high-risk manual sampling, improve farm decision-making and require new skills in data interpretation, animal health and technology-enabled operations. It can also support suppliers and farmers in the value chain.	Manual handling events avoided; safety incidents; training hours; adoption by contracted farms or suppliers; digital tool usage; response time to alerts.
S4 Consumers and End-Users	Relevant when precision aquaculture improves product quality, food safety, traceability and reliability for downstream customers and consumers.	Food-safety incidents; product quality non-conformities; traceability coverage; batch monitoring data; recall events; customer complaints.
G1 Business Conduct	Relevant when data-enabled systems improve auditability, traceability, regulatory compliance and responsible management of environmental and biological risks.	Audit-ready records; compliance events; license breaches; data governance protocols; supplier monitoring; corrective-action closure rate.

Table 7 | ESRS Mapping with SDG 14

PRACTICAL EXAMPLES

Beyond improving operational efficiency, the following examples illustrate how precision aquaculture can create business value by reducing biological risk, improving production consistency and supporting more sustainable use of marine resources.

Oceano Fresco: Precision Aquaculture for Native Bivalves

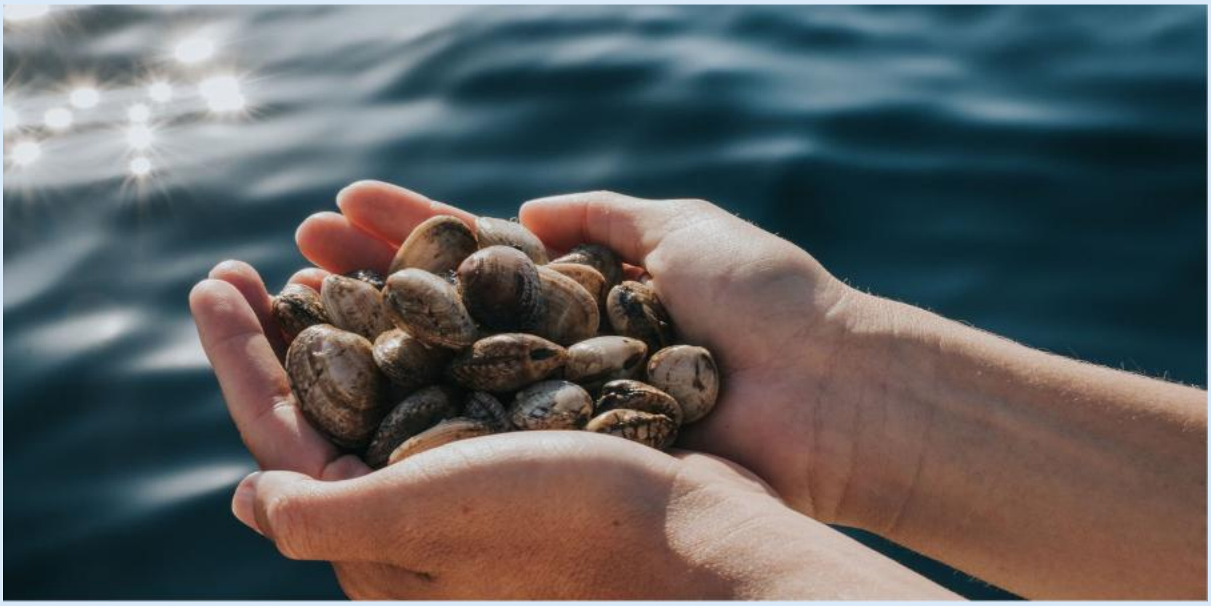
Nazaré and Algarve, Portugal · Portuguese aquaculture and biotechnology company · Raised €17M in 2024

Oceano Fresco applies precision aquaculture to the production of native European bivalves, including the pullet carpet shell clam, the grooved carpet shell clam and the European flat oyster.

The company combines a land-based hatchery and R&D facilities in Nazaré with open-sea farming in the Algarve, allowing it to control key stages of the production cycle, from breeding and seed production to grow-out, harvesting, packaging and commercialization. (Oceano Fresco, n.d.)

Its model addresses one of the main constraints in European native bivalve aquaculture: the reliable supply of high-quality seed. Through hatchery digitalization, production data collection, alarms and predictive modelling, Oceano Fresco can support more consistent seed cultivation and earlier detection of production risks (Digidelta Software, n.d.). Once transferred to open-sea farms, environmental and biological monitoring helps the company manage survival, growth, animal condition, food safety compliance and carrying capacity under variable marine conditions (Da Costa et al., 2020; Ferreira et al., 2018; Rato et al., 2022).

Business model: Oceano Fresco generates revenue through the production and commercialization of native European bivalves, supported by biotechnology, hatchery control, and data-driven farm management. Unlike fed aquaculture systems, its business case is not based on reducing feed waste, since bivalves rely on naturally available phytoplankton. Instead, the company creates value by improving seed reliability, survival rates, production predictability, environmental compliance and scalability in a low-input aquaculture system. Its €17 million funding round in 2024 and recognition as an EU Blue Champion indicate investor confidence in science-based bivalve aquaculture as part of Europe’s sustainable blue economy (BlueCrow Capital, 2024; PwC Luxembourg, 2025).

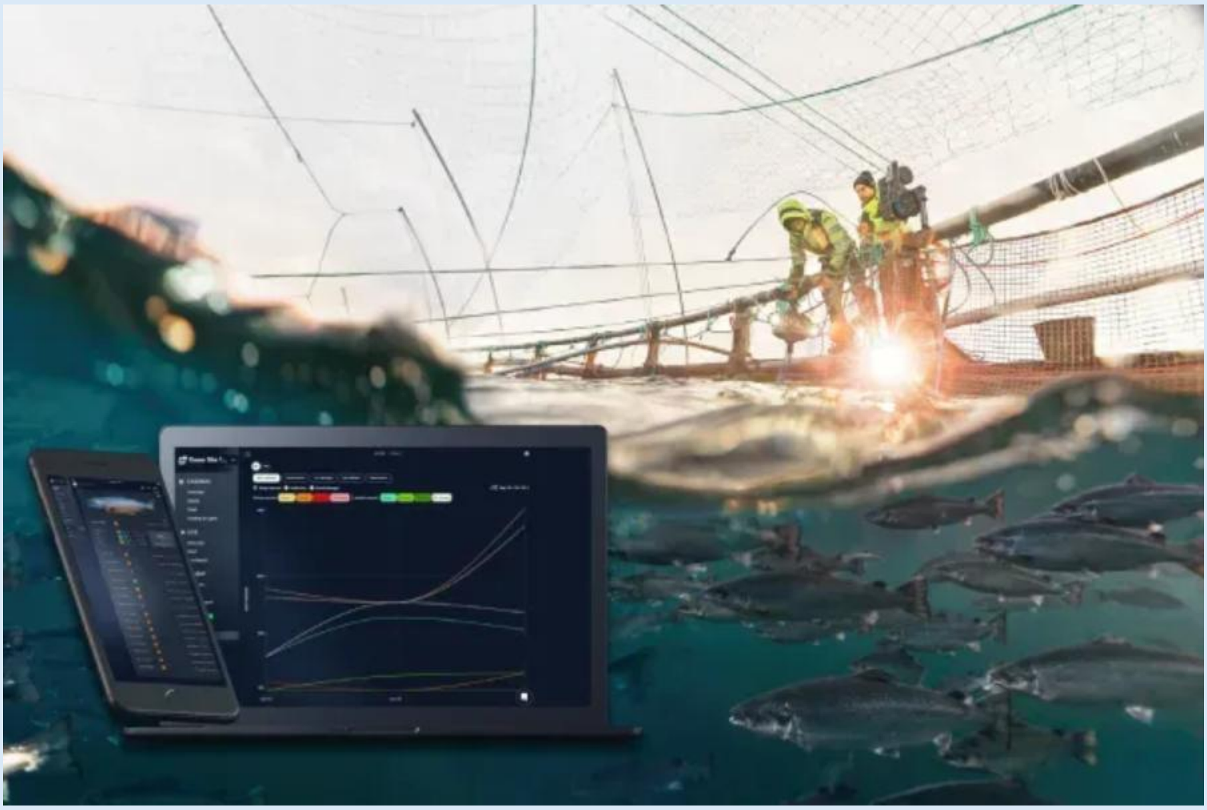


Aquabyte: AI and Computer Vision for Fish Health, Welfare and Growth Monitoring

Bergen, Norway; San Francisco, USA; Puerto Varas, Chile · Founded 2017 · AI-powered aquaculture technology platform

Aquabyte applies artificial intelligence, machine learning, and computer vision to fish farming, providing camera-based monitoring systems for both sea-based and land-based aquaculture. Its platform generates data on fish weight, growth, welfare, and behavior, helping producers move from manual sampling and visual inspections to continuous, data-driven decision-making (Aquabyte, 2026).

The company's technology is particularly relevant to real-time precision aquaculture because it supports early detection of biological and welfare risks. By analyzing underwater images from fish pens and tanks, Aquabyte can provide insights on biomass, lice levels, skin and fin condition, swimming behavior, appetite and production performance. This reduces the need for physical handling, improves visibility over fish health and helps farmers intervene before operational problems escalate (Aquabyte, 2026).



Business model: Aquabyte generates value through camera-based monitoring systems and software-driven decision support for aquaculture operators. Its value proposition is based on improving production efficiency, fish welfare and biological risk management. By turning continuous image data into operational insights, the company helps producers optimize feeding, monitor growth, detect welfare challenges earlier and support more consistent production across both sea pens and land-based systems.

Eruvaka Technologies: IoT and AI-enabled Smart Shrimp Farming

India · Founded 2012 · IoT, automatic feeding and pond monitoring for shrimp aquaculture

Eruvaka Technologies develops IoT and AI-powered solutions for shrimp aquaculture, including automatic feeding systems, pond monitoring devices and farm management software. Its technology allows farmers to monitor pond conditions, automate feed delivery and digitize daily production decisions, helping shrimp farms move from manual management to more precise and data-supported operations (Eruvaka Technologies, 2026).

The company's model is especially relevant to precision aquaculture because shrimp farming is highly exposed to water-quality fluctuations, feed inefficiency, disease risk and production volatility. By combining real-time pond monitoring with automated feeding, Eruvaka helps farmers improve feed efficiency, manage water quality, reduce operational risk and support more consistent shrimp growth. Its systems have been deployed across multiple countries and are used at commercial scale in shrimp production (Aquaculture Magazine, 2023; Eruvaka Technologies, 2026).

Business model: Eruvaka generates value through the sale and deployment of connected aquaculture devices, automatic feeders, monitoring systems and digital farm management tools. Its value proposition is based on reducing feed waste, improving pond management, increasing productivity, and lowering farming risk. Unlike bivalve aquaculture, where value comes mainly from seed reliability and environmental monitoring, Eruvaka's business case is centered on feed optimization, water-quality control and productivity gains in fed shrimp systems.

WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

- Build an integrated data layer that combines water-quality sensors, feeding data, health diagnostics, computer vision, production records and environmental indicators.

- Start with a focused pilot around one production risk, such as feed efficiency, mortality events, water-quality failures, seed survival, disease detection or carrying-capacity monitoring.
- Use early-warning systems to shift from reactive management to preventive decision-making, reducing losses and improving welfare and compliance.
- Adapt the value proposition to the production model: feed optimization for fed fish and shrimp systems; seed reliability, survival, environmental monitoring and food safety for bivalves.
- Partner with technology providers, universities, hatcheries, veterinarians, farms, regulators and buyers to validate the solution in real operating conditions.
- Connect farm-level data to ESG reporting, SDG 14 contribution and ESRS indicators, making sustainability performance measurable and credible.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Business performance	Feed conversion ratio; feed cost per kg produced; survival rate; growth rate; mortality avoided; harvest predictability; biomass yield; production cycle consistency.	Farm-management systems; feeding records; production logs; financial KPIs; harvest data.
Biological health and welfare	Early disease alerts; welfare indicators; lice or parasite levels; skin/fin condition; behavioral deviations; stress indicators; physical handling avoided.	Computer-vision data; health diagnostics; veterinary records; welfare assessments; monitoring platforms.
Environmental performance and compliance	Water-quality threshold breaches; nutrient discharge estimates; treatment use; carrying-capacity status; benthic monitoring; food-safety compliance; environmental incidents avoided.	Sensor data; environmental monitoring reports; license compliance records; food-safety audits; ESG reports.
Resource efficiency	Feed waste reduction; input use per kg produced; energy use per production cycle; water-quality stability; waste generated; by-product valorization where applicable.	Feeding systems; resource-use records; energy and water data; waste-management records.
New business model	Recurring software or monitoring revenue; number of farms or assets monitored; subscriptions sold; pilots converted into commercial contracts; customer retention; data products sold.	Sales data; contracts; platform analytics; customer retention metrics; pilot evaluation reports.
Impact and reporting	SDG 14 targets addressed; ESRS indicators covered; traceability coverage; audit-ready evidence; stakeholder reporting quality; corrective actions closed.	ESG dashboards; audit files; traceability systems; sustainability reports; compliance records.

Table 8 | Indicative KPIs examples for implementation

CHALLENGE 2: AQUACULTURE WASTE VALORIZATION

Aquaculture is the fastest-growing food production sector globally, now contributing over 50 percent of fish for human consumption (FAO, 2024b). However, this growth comes at an environmental cost. Only about 30 percent of nutrients supplied to farmed fish are actually utilized by the animals – the remainder settles as sludge or dissolves into effluent water (Madariaga, 2022). In Norway alone, salmon aquaculture produced 2.1 million tonnes of fish sludge in 2017, a volume equivalent to the sewage output of 20 million people (Åsgård, 2017; Ramnefjell, 2019). As global aquaculture production continues to scale – the FAO projects it will reach 106 million tonnes by 2030 (FAO, 2024b) – waste volumes will grow proportionally unless circular approaches are adopted.

Aquaculture sludge is rich in nitrogen, phosphorus and organic matter– nutrients that, if discharged untreated, cause eutrophication, oxygen depletion and habitat degradation in receiving waters. Fish mortalities and processing by-products (heads, guts, bones, skin) add further waste streams. In the EU, landfill remains the primary disposal method for these by-products, causing environmental contamination and squandering valuable resources (MDPI Sustainability, 2025). Yet these same waste streams contain recoverable proteins, lipids, collagen, minerals and nutrients that can be transformed into fertilizers, feed ingredients, bio-based materials or energy.

This challenge focuses on capturing, stabilizing and upgrading aquaculture waste streams into valuable outputs. By enabling safe, scalable and regulated valorization pathways, the challenge supports the transition of aquaculture towards circular and resource-efficient production models.

SDG 14 ALIGNMENT

Unmanaged aquaculture effluent is a direct source of marine and freshwater pollution, which is why the valorization of waste and by-products supports two SDG 14 targets:

Target 14.1	By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution. Valorization of aquaculture waste directly reduces nutrient discharge into marine and freshwater environments.
Target 14.2	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience. Preventing pollution from aquaculture operations helps protect and restore surrounding ecosystems.

Table 9 | Alignment with the SDG 14 targets

By converting pollutant-laden waste into marketable products – bio-fertilizers, animal feed, biogas, bioplastics – valorization eliminates the environmental harm of discharge while creating economic incentives that make pollution prevention financially self-sustaining.

THE BUSINESS CASE:

Aquaculture waste valorization creates value through two primary mechanisms. First, it reduces costs by transforming waste disposal from an expense into a revenue-neutral or revenue-positive activity. Sludge disposal, mortality handling and effluent treatment represent significant operational costs for aquaculture producers, particularly in recirculating aquaculture systems (RAS) where waste is concentrated. Valorization technologies– drying, anaerobic digestion, algae-based biofilters – can cut recurring water treatment costs by nearly half over a ten-year period compared to conventional biofilters (Clean Valley CIC, 2024).

Second, valorization enables entirely new business models built on circular economy principles. Aquaculture sludge can be converted into certified bio-fertilizer, replacing synthetic fertilizers whose production emits 1.6 tonnes of CO_2 per tonne via the Haber-Bosch process (PMC, 2025). Fish mortalities can be dried and processed into pet food ingredients or biogas boosters. Algae grown on nutrient-rich effluent become feed for shellfish, creating integrated multi-trophic aquaculture (IMTA) systems that generate additional revenue streams from what was previously waste.

The following examples also illustrate how entirely new commercial ventures are being built around aquaculture waste– demonstrating that sustainability challenges can be the birthplace of new businesses.

ESRS MAPPING

ESRS topic	Connection	Possible indicators
E2 Pollution	Directly relevant because unmanaged aquaculture sludge, effluent, mortalities and by-products can contribute to nutrient pollution, eutrophication, oxygen depletion and contamination of receiving waters.	Nitrogen and phosphorus discharge; COD/BOD; suspended solids; nutrient load captured; effluent quality; pollution incidents; non-compliance events; treatment efficiency.
E3 Water and Marine Resources	Wastewater regeneration, effluent treatment and recirculation can reduce freshwater intake, improve discharge quality and support more responsible use of water and marine resources.	Water reused; freshwater intake avoided; discharge volumes; effluent recirculation rate; water-treatment cost per m3; compliance with water-reuse permits.
E4 Biodiversity and Ecosystems	Reducing nutrient discharge and organic loading helps prevent eutrophication, oxygen depletion and habitat degradation around aquaculture sites and receiving ecosystems.	Environmental monitoring coverage; dissolved oxygen; benthic condition; algal bloom risk; carrying-capacity indicators; habitat disturbance events; ecosystem recovery indicators.
E5 Resource Use and Circular Economy	Core ESRS topic for this challenge. Valorization converts waste and by-products into useful outputs, reducing disposal and improving circularity across aquaculture value chains.	Tonnes of sludge/by-products valorized; waste-to-landfill avoided; nutrient recovery rate; circular products produced; by-product revenue; offtake contracts; resource productivity.
E1 Climate Change	Relevant when valorization reduces synthetic fertilizer demand, generates biogas, avoids disposal emissions or reduces energy-intensive wastewater treatment.	CO2e avoided; renewable energy generated; synthetic fertilizer substituted; methane captured; transport/disposal emissions avoided; energy use per m3 treated.
S1/S2 Workforce and Safety	Waste handling, mortality processing, sludge treatment and by-product valorization require safe operating procedures, worker training and biosecurity controls.	Training completion; health and safety incidents; exposure events; PPE compliance; biosecurity incidents; safe handling procedures implemented.
G1 Business Conduct	Safe valorization depends on regulatory compliance, product safety, traceability, responsible claims, permitting and transparent relationships with offtakers and public authorities.	Permits obtained; certification status; product safety tests; traceability records; audit findings; supplier/offtaker due diligence; corrective actions closed.

Table 10 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

Waister: Sludge & Mortality Valorization for RAS

Norway · EU Horizon 2020 GAIN Project partner

Waister has developed cost-efficient machines that convert aquaculture sludge into a dry, sanitized, stable bio-fertilizer and process fish mortalities into ingredients suitable for pet food or biogas production. Designed specifically for recirculating aquaculture systems (RAS), the machines integrate with existing sludge dewatering systems and can be scaled by installing multiple units in parallel. Life-cycle assessment (LCA) conducted within the EU GAIN project confirmed environmental benefits over conventional disposal, with end-products validated as safe for agricultural and energy use (Cristiano, 2022; Global Seafood Alliance, 2021).

Business model: Waister sells drying and processing equipment to RAS operators, enabling them to eliminate sludge disposal costs and generate revenue from by-product sales (bio-fertilizer, pet food ingredients, biogas feedstock). The solution turns a cost center into a profit center.

Clean Valley CIC: Algae Biofilter Turning Wastewater into Profit

Dartmouth, Canada · Founded 2018 · 6 contracts signed (2026) · Seeking USD 1.5M pre-seed

Clean Valley CIC has developed Poseidon's Biofilter, a nature-based solution that uses algae to absorb nitrogen and phosphorus from land-based aquaculture wastewater. The algae are then fed to oysters housed in the same modular shipping-container system, and the cleaned water is recirculated back into the fish farm. The system mimics natural ocean processes– a "biomimicry" approach that avoids harsh chemicals while producing marketable co-products: algae biomass and IMTA-certified oysters (Government of Canada, 2024; The Fish Site, 2023).

Business model: Clean Valley operates a hardware-as-a-service (HaaS) model, managing the biofilter units on behalf of farmers. Recurring water treatment costs are nearly half those of conventional biofilters over ten years, while the co-products (algae, oysters) create new revenue. The company claims customers can sell IMTA-certified fish at up to 5x current prices. In 2026, Clean Valley signed six contracts spanning Canada, Portugal and Brunei (Entrevestor, 2026).

Regeneraqua: Wastewater Regeneration for Aquaculture Reuse

Spain · Aligned with Real Decreto 1085/2024 on water reuse

Regeneraqua is a Spanish technology company specializing in the construction of wastewater regeneration plants. The company designs and builds systems that transform aquaculture and industrial wastewater into reusable water for agricultural irrigation, industrial applications and environmental purposes. Driven by Spain's new legal framework for water reuse (Real Decreto 1085/2024, 2024), Regeneraqua positions water not as waste but as a valuable, recoverable resource (Regeneraqua, 2024).

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Business model: Regeneraqua designs, builds and operates bespoke wastewater regeneration plants, reducing freshwater intake costs for aquaculture operators while ensuring regulatory compliance with increasingly strict water reuse legislation. The reclaimed water becomes a saleable or internally reusable product.

Additional Benchmark Solutions

Company	Technology	Value Proposition
EasyMining (Ragn-Sells)	Phosphorus & nitrogen recovery from sludge	Chemical processes to extract phosphorus and nitrogen from waste sludge, producing clean fertilizer products and reducing dependence on mined phosphate rock.
AQUAPHOENIX (Horizon Europe)	SludgeCollect valorization platform	EU-funded project developing scalable sludge collection and valorization pathways for aquaculture, establishing the technical and regulatory blueprint for circular waste management.

Table 11 | Additional Benchmark Solutions

WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

- Map and quantify all aquaculture waste streams, including sludge, effluent, fish mortalities and processing by-products, and assess their composition, seasonality, volume and regulatory status.
- Prioritize waste streams with the strongest business case, such as concentrated sludge from RAS, nutrient-rich effluent from land-based aquaculture, fish mortalities or processing by-products with recoverable proteins, lipids, collagen or minerals.
- Pilot one valorization pathway before scaling, for example sludge drying into bio-fertilizer, anaerobic digestion into biogas, algae-based biofiltration, nutrient recovery, water regeneration or by-product processing into feed or pet-food ingredients.
- Secure product safety validation, certification, permitting and offtake agreements before commercial deployment, especially where outputs are used in agriculture, animal feed, pet food, energy or water reuse.
- Build partnerships with aquaculture producers, wastewater technology providers, agricultural buyers, energy operators, feed and pet-food companies, regulators, universities and local authorities.
- Use LCA and techno-economic assessment to compare valorization with conventional disposal and to demonstrate environmental, financial and compliance benefits.
- Integrate waste, nutrient and water data into ESG reporting so that circular economy claims can be linked to ESRS indicators, SDG 14 targets and auditable operational evidence.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Waste capture and valorization	Tonnes of sludge captured; tonnes of mortalities processed; tonnes of processing by-products valorized; percentage of waste diverted from landfill or discharge; nutrient recovery rate.	Waste-management records; treatment-system logs; weighbridge data; operator reports; offtake contracts.
Environmental performance	Nitrogen and phosphorus discharge reduction; COD/BOD reduction; suspended solids reduction; water-quality threshold breaches; eutrophication risk indicators; pollution incidents avoided.	Effluent monitoring; environmental sensors; laboratory analysis; compliance reports; site monitoring data.
Circular products and revenue	Bio-fertilizer produced; feed or pet-food ingredients produced; biogas generated; algae biomass produced; reclaimed water generated; revenue from circular products; disposal costs avoided.	Sales data; production records; energy meters; product certification; financial KPIs; customer/offtake contracts.
Water and resource efficiency	Water reused; freshwater intake avoided; effluent recirculation rate; water-treatment cost per m3; resource recovery yield; input substitution from recovered materials.	Water meters; treatment dashboards; farm-management systems; operational cost data; resource accounting.
Climate and energy	CO_2e avoided; synthetic fertilizer substituted; methane captured; renewable energy generated; transport and disposal emissions avoided; energy intensity of treatment.	LCA calculations; energy meters; fertilizer substitution data; transport records; carbon accounting tools.
Compliance, safety and quality	Permits obtained; product safety tests passed; regulatory breaches; biosecurity incidents; worker safety incidents; certification status; audit findings closed.	Permits; laboratory tests; HSE records; food/feed safety documentation; audit reports; regulatory filings.
Business model and scale	Number of systems installed; recurring service revenue; HaaS contracts; plants designed or operated; pilots converted into commercial contracts; offtake agreements signed; payback period.	Contracts; CRM and sales data; project records; customer retention metrics; financial dashboards.

Table 12 | Indicative KPIs examples for implementation

CHALLENGE 3: INTEGRATED OPERATIONAL INTELLIGENCE FOR OFFSHORE RENEWABLE ENERGY SYSTEMS

Offshore renewable energy is entering a new phase: projects are larger, further from shore, more complex to operate and increasingly dependent on real-time information. Floating offshore wind, wave energy and hybrid marine renewable systems all share a common operational problem: the asset is exposed to harsh marine conditions, weather windows are narrow, access is expensive, and failures or inefficient maintenance can rapidly erode the business case.

Operations and maintenance (O&M) are among the most material cost drivers for offshore energy. Hub Azul's Blue Renewable Energy challenge mapping identifies the same logic: autonomous navigation, forecasting, SCADA integration, decision support and hybrid energy management are all positioned around lower O&M costs, higher uptime, safer operations and stronger project bankability (Hub Azul / imatch, 2026).

This challenge focuses on building an integrated operational intelligence layer for offshore renewable systems. Rather than treating inspection, surveillance, weather forecasting, asset health, environmental monitoring and energy dispatch as separate tools, companies can integrate these functions into a unified digital infrastructure. This infrastructure can combine AUVs, USVs, drones, sensors, SCADA, metocean forecasting, digital twins, predictive maintenance, AI-based anomaly detection and hybrid energy management.

The strategic opportunity is not only operational efficiency. Integrated intelligence can become a new service layer for the offshore energy economy: forecasting-as-a-service, asset-optimization platforms, autonomous inspection services, environmental monitoring packages, digital twins and hybrid energy dispatch solutions. For Portugal, this is relevant because it connects offshore renewables with existing capabilities in ocean observation, ports, robotics, engineering, marine data, environmental monitoring and digital platforms.

SDG 14 ALIGNMENT: LIFE BELOW WATER

The alignment with SDG 14 is indirect and conditional. Offshore renewable energy contributes primarily to the climate transition, but SDG 14 alignment only becomes strong when operational intelligence also reduces marine operational pressure and embeds ecosystem monitoring into offshore energy deployment. A platform focused exclusively on cost efficiency has weak SDG 14 alignment; a platform that integrates environmental data, lower vessel movements, safer operations and ecosystem safeguards can support SDG 14 more credibly.

Target	Relevance to the challenge	Strength of alignment
14.2	Sustainably manage and protect marine and coastal ecosystems. Integrated operational intelligence can include ecological indicators, underwater noise, seabed condition, collision risk and real-time environmental stress monitoring around offshore energy sites.	Conditional / medium if environmental monitoring is included.
14.a	Increase scientific knowledge, develop research capacity and transfer marine technology. Ocean data platforms, autonomous systems and digital twins directly contribute to marine technology development and operational knowledge transfer.	Medium to strong.
14.1 / 14.8	Potential indirect contribution through fewer vessel trips, lower emissions, lower incident risk and higher-value sustainable economic activity in coastal and island territories.	Weak to medium; depends on deployment model.

Table 13 | Alignment with the SDG 14 targets

THE BUSINESS CASE: COST REDUCTION + NEW BUSINESS MODEL

Integrated operational intelligence creates value through two main mechanisms: cost reduction and the creation of new business models.

First, it reduces costs by improving operational planning, maintenance scheduling, asset availability and safety. Offshore operations are strongly constrained by weather, waves and access conditions. Better forecasting and vessel motion prediction can reduce failed trips, waiting time, unnecessary mobilization, safety incidents and downtime. Predictive maintenance and asset health analytics can also shift operators from reactive interventions to planned interventions, reducing emergency repairs and production losses.

Second, it enables new business models. The same platform capabilities used internally by an offshore operator can be offered to the market as software-as-a-service, data-as-a-service, inspection-as-a-service, environmental monitoring-as-a-service or hybrid energy optimization-as-a-service. Companies with expertise in sensors, robotics, metocean modelling, SCADA integration, AI, underwater acoustics, data interoperability or offshore engineering can move from project-based services to recurring digital products.

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ESRS MAPPING

ESRS topic	Connection	Possible indicators
E1 Climate Change	Operational efficiency and energy optimization may reduce fuel use from offshore logistics, improve renewable output and support lower-carbon electricity generation.	Vessel trips avoided; fuel saved; CO2e avoided; energy yield improvement; downtime reduction; renewable dispatch optimization.
E4 Biodiversity and Ecosystems	Relevant only if the platform integrates biodiversity, underwater noise, seabed, species or habitat monitoring into operational decisions.	Environmental baseline data; underwater noise levels; ecological alerts; habitat disturbance indicators; compliance events avoided.
S1/S2 Workforce and Safety	Autonomous inspection and improved weather-window planning can reduce human exposure to hazardous offshore operations.	High-risk offshore hours avoided; safety incidents; near misses; remote inspection rate; training completed.

Table 14 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

MO4: Motion Forecasting and Offshore Data Analytics

Netherlands · Offshore operations software · Motion forecasting, analytics and decision support

MO4 develops software for smarter and faster offshore operations, focusing on the fact that offshore work depends heavily on water, weather and wave conditions. Its tools use operational and sensor data to support planning, performance analysis and motion forecasting. The company positions its products around easier operational planning, fewer delays during critical weather, cost savings, improved safety and lower environmental impact. For offshore renewables, this is directly relevant to maintenance windows, crew transfer, vessel mobilization and workability decisions.

Business model: MO4 monetizes operational intelligence through software products and analytics services. It turns metocean and vessel data into actionable decision support for operators that want to reduce delays, improve safety and increase workability.

Shoreline Wind: AI-Powered Wind Farm Design, Construction and O&M Platform

Norway · Enterprise platform for wind farm design, construction and O&M · Global clients including offshore wind developers

Shoreline Wind provides an AI-powered platform for wind farm design, construction and operation. Its platform integrates logistics, assets, personnel, permits, work orders, weather and operational data. Shoreline states that its O&M design simulation enables detailed long-term simulation of operational logistics and financial KPIs for offshore wind farms. This illustrates how simulation, forecasting and integrated work planning can become part of the strategic and financial business case for offshore renewable assets.

Business model: Shoreline operates as an enterprise SaaS and simulation platform, selling decision-support tools to developers, operators, OEMs and service providers. The business value lies in turning operational complexity into optimized schedules, reduced downtime and better financial planning.

Bedrock Ocean: Autonomous Seabed Intelligence for Offshore Infrastructure

United States · Founded 2019 · AUVs + cloud-native data platform for seabed mapping and monitoring

Bedrock Ocean combines custom autonomous underwater vehicles with a cloud-native data platform to deliver faster, high-resolution seabed intelligence. Its systems support offshore wind and other energy projects through site characterization, cable routing, foundation verification and infrastructure monitoring. This example is relevant because offshore renewable energy requires continuous understanding of the seabed, cables, foundations and surrounding environmental conditions, and autonomous systems can reduce reliance on traditional large-vessel surveys.

Business model: Bedrock illustrates a data-as-a-service and autonomous survey model. Revenue comes from delivering high-value ocean data and monitoring services, not merely from selling hardware. The model converts seabed intelligence into a recurring operational and strategic asset for infrastructure owners.

ADDITIONAL BENCHMARK SOLUTIONS

Company / initiative	Technology	Value proposition
blueOASIS (Portugal)	Underwater acoustics, AI, digital twins and ocean engineering	Develops integrated ocean intelligence solutions, including Hydrotwin, acoustic monitoring and ocean digital twins. Relevant for adding real-time environmental and operational data layers to offshore renewable projects.
Fibersail (Portugal)	Retrofittable wind blade monitoring sensors	Detects internal blade damage to reduce repair costs, prevent failures and improve availability. Relevant for asset-health intelligence and predictive maintenance in wind fleets.
Verlume (UK)	Subsea batteries and autonomous power management	Provides subsea batteries and Axonn, an intelligent energy management system with autonomous decision-making, health monitoring and control of intermittent energy sources.
Ocean Infinity (US/UK)	Marine robotics, AI and data services	Uses software, AI, data and robotics to deliver ocean data faster, safer and with lower environmental impact. Relevant as a benchmark for autonomous marine operations and data-enabled service models.

Table 15 | Additional Benchmark Solutions

WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

- Develop an integrated data layer that combines SCADA, metocean forecasting, asset health, inspection data and environmental indicators.
- Create a pilot with one offshore site, one asset class or one operational process, for example crew transfer windows, underwater inspection, cable monitoring or hybrid energy dispatch.
- Package internal capabilities into a marketable service: forecasting-as-a-service, inspection-as-a-service, monitoring-as-a-service, digital twin development or asset optimization.
- Partner with ports, universities, robotics startups, ocean-observation infrastructures and renewable developers to validate the platform in real operating conditions.
- Make the SDG 14 contribution credible by including environmental monitoring and reporting metrics, not only cost and efficiency metrics.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Business performance	O&M cost reduction; downtime avoided; workability improvement; vessel trips avoided; maintenance schedule adherence; energy yield improvement.	SCADA data; maintenance logs; vessel logs; operational dashboards; financial KPIs.

New business model	Recurring software/service revenue; number of clients/assets under monitoring; subscription renewal rate; data products sold; pilots converted to commercial contracts.	Sales data; contracts; platform analytics; customer retention data.
Impact and compliance	CO2e avoided from reduced vessel trips; environmental monitoring coverage; underwater noise alerts; incident prevention; safety exposure reduced.	Fuel data; environmental sensors; ESG reports; HSE records; monitoring reports.

Table 16 | Indicative KPIs examples for implementation

CHALLENGE 4: DEVELOPMENT OF CORROSION, FATIGUE, AND WEAR RESISTANT MARINE-GRADE MATERIALS

Shipbuilding, refit, and blue renewable energy increasingly rely on materials that can maintain performance for longer under harsh marine operating conditions. In shipbuilding, advanced marine materials are used to improve structural performance, reduce weight, and increase durability (Rubino et al., 2020). In refit operations, hull coatings and antifouling systems are central to reducing biofouling, maintenance needs, fuel consumption, and environmental impact (Venettacci et al., 2023). In blue renewable energy, offshore wind foundations and related structures face corrosion-fatigue risks caused by seawater exposure and cyclic wind-wave loading (Okenyi et al., 2024).

The problem is not simply corrosion, fatigue or wear in isolation. In marine environments, these mechanisms interact through corrosion-fatigue and wear-corrosion processes. Corrosion can create pits and surface defects that become stress concentration points, supporting crack initiation and reducing structural reliability (Shittu et al., 2020). Fatigue loading can accelerate cracking, especially under cyclic offshore loads and seawater exposure (Mehmanparast et al., 2017). Wear and abrasion can remove protective layers and expose the underlying structure to further attack (Wood, 2007). This combination reduces asset lifetime, increases maintenance costs, and creates operational, safety, and environmental risks.

Offshore assets are not exposed to constant or predictable loads. Wind and waves generate variable loading patterns, including cyclic bending, torsional forces, intermittent storm overloads, and complex fatigue histories. This makes material degradation harder to predict and increases the need for materials that can resist combined corrosion-fatigue and wear-corrosion mechanisms over long service lives (Adedipe et al., 2016; Okenyi et al., 2024).

Considering that offshore loads remain variable and difficult to control, value is created by materials that make assets less vulnerable to those conditions. Fiber-reinforced composites, for example, can reduce weight, avoid metallic corrosion, improve fatigue performance, and reduce maintenance needs in marine and offshore applications (Weitzenbock et al., 2010). Advanced materials do not remove environmental uncertainty; they improve asset resilience, extend service life and reduce lifecycle cost (Rubino et al., 2020).

The economic relevance of this challenge is reinforced by recent blue economy investment trends. Capital is increasingly moving toward strategic and deployment-ready solutions, while Shipbuilding & Refit remains one of the largest blue economy value chains, with investor interest focused on vessel efficiency, cleaner maritime technologies and commercial deployment (Fórum Oceano, 2026).

SDG 14 ALIGNMENT:

Corrosion-, fatigue-, and wear-resistant marine-grade materials do not directly restore marine ecosystems or remove pollution already present in the ocean. Rather, their contribution is preventive and enabling: they help make marine and offshore infrastructure safer, more reliable, and more durable, reducing the probability of structural failures, leaks, and debris release that can disturb marine and coastal environments (Adedipe et al., 2016). In shipbuilding and refit, advanced hull coatings and antifouling systems can also reduce biofouling and hydrodynamic drag, helping lower fuel consumption and associated emissions (Venettacci et al., 2023).

This challenge supports three key SDG 14 targets:

Target 14.2	Sustainably manage and protect marine and coastal ecosystems. Durable marine-grade materials reduce the risk of structural failures, leaks, and debris release, helping offshore and coastal infrastructure operate with lower pressure on marine ecosystems.
Target 14.7	Increase the economic benefits from the sustainable use of marine resources. Advanced materials improve the reliability and lifecycle economics of shipbuilding, refit, and blue renewable energy by reducing corrosion, fatigue, wear, downtime, and maintenance costs.
Target 14.a	Increase scientific knowledge, develop research capacity and transfer marine technology. The challenge advances marine technology by transferring innovations in coatings, composites, alloys, corrosion testing, and fatigue modelling into commercial maritime and offshore renewable energy applications.

Table 17 | Alignment with the SDG 14 targets

Advanced marine-grade materials link infrastructure durability to ecosystem protection and blue economy scalability. By reducing corrosion, fatigue and wear, these materials can lower the risk of structural failures, leaks, debris release, and repeated maintenance interventions in marine and coastal environments. At the same time, they improve the reliability and lifecycle economics of shipbuilding, refit, and offshore renewable energy assets. In doing so, businesses contribute to the sustainable management of marine and coastal ecosystems (Target 14.2), sustainable blue economy growth through more durable and cost-effective maritime infrastructure (Target 14.7), and the transfer of marine science and advanced materials technology into commercial ocean applications (Target 14.a).

THE BUSINESS CASE: COST REDUCTION + INCREASING PRICES

The value of corrosion-, fatigue- and wear-resistant marine-grade materials lies in reducing the total cost of ownership of marine and offshore assets. Vessels, offshore platforms, renewable energy devices, and submerged components are expensive to build, difficult to access, and costly to repair. When material degradation occurs offshore, intervention is rarely simple: it can depend on weather windows, specialist vessels, dry-docking capacity, divers, cranes, technical crews and temporary shutdowns. For this reason, corrosion, fatigue and wear are direct costs, reliability, and deployment risks.

In shipbuilding and refit, advanced marine materials create value by improving vessel performance over the operating life of the asset. More durable coatings, corrosion-resistant components and low-friction hull surfaces can reduce coating renewal, hull cleaning, dry-docking frequency and component replacement. Antifouling and foul-release systems are especially relevant because biofouling increases hydrodynamic drag, which raises fuel consumption and emissions. Materials that delay surface degradation and maintain hull efficiency can therefore reduce fuel penalties, lower maintenance needs and support compliance with stricter maritime emissions rules (Venettacci et al., 2023).

In blue renewable energy, offshore wind, floating wind, wave, and tidal energy systems require structures that can operate for decades. Corrosion and fatigue increase inspection, repair, and replacement costs, which may reduce the expected asset lifetime. If advanced materials extend the service life of foundations, fasteners, hulls, blades, moorings or submerged components, they can reduce lifecycle risk and improve the financial viability of offshore renewable energy projects.

The main sources of business value are therefore: i) lower maintenance and repair costs through reduced corrosion, coating failure and component degradation; ii) reduced downtime and higher asset availability; iii) longer service life for vessels, offshore structures, and renewable energy devices; iv) lower fuel consumption and emissions where coatings or surface materials improve hydrodynamic efficiency; v) lower environmental and safety risk from leaks, structural failures, debris release or material degradation; vi) premium pricing potential for certified marine-grade materials, coatings and components with proven lifecycle benefits; and vii) new B2B service models, including coating-as-a-service, lifecycle guarantees, inspection-linked materials, and condition-based maintenance services.

The commercial opportunity is therefore not limited to selling materials as inputs. It is about selling performance, reliability, and risk reduction. Customers are willing to pay more for materials, coatings, and components when they reduce unplanned intervention, extend maintenance intervals, improve efficiency, support regulatory compliance, and make offshore deployment more predictable.

ESRS MAPPING

ESRS topic	Connection	Possible indicators
E1 Climate Change	Relevant where low-friction coatings, lighter materials and more durable components reduce fuel consumption, avoid repeated maintenance mobilizations, or improve the reliability of offshore renewable energy assets.	Fuel saved; CO2e avoided; vessel efficiency improvement; renewable asset availability; maintenance vessel trips avoided; lifecycle emissions reduction.
E2 Pollution	Advanced coatings and materials can reduce toxic antifouling releases, leaks, debris release, coating degradation and waste from repeated maintenance or replacement.	Biocides or copper avoided; toxic releases avoided; coating waste reduced; leaks or spill incidents; debris release events; hazardous maintenance waste.
E3 Water and Marine Resources	Marine-grade materials influence how vessels, offshore structures and submerged components interact with marine waters, especially through antifouling systems, corrosion products, leaching, and material degradation.	Water-quality monitoring results; leaching tests; antifouling compliance; corrosion-product release; marine discharge incidents; submerged asset condition.
E4 Biodiversity and Ecosystems	Relevant when materials lower pressure on marine ecosystems by reducing toxic antifouling use, structural failure risk, debris release, repeated interventions and disturbance in sensitive marine areas.	Operations in sensitive habitats; biodiversity risk assessments; ecosystem disturbance events; biofouling management approach; ecological incident records; environmental monitoring coverage.
E5 Resource Use and Circular Economy	Longer-lasting materials extend asset life and reduce replacement, repair, coating renewal and material waste across shipbuilding, refit and offshore renewable energy value chains.	Service life extension; maintenance interval extension; component replacement avoided; material waste avoided; recycled/recyclable content; end-of-life recovery rate.
S1/S2 Workforce and Safety	Reducing offshore and dry-dock interventions can lower worker exposure to hazardous maintenance, diving, repair, coating application and inspection activities.	High-risk maintenance hours avoided; safety incidents; near misses; exposure to hazardous substances; training completed; remote or condition-based inspection rate.

Table 18 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

The following examples show how advanced marine-grade materials can create business value by reducing maintenance needs, extending asset life, and improving operational efficiency.

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GIT Coatings: Graphene-based marine coatings for vessel efficiency and lower environmental impact
Dartmouth, Nova Scotia, Canada · Graphene-based marine coatings · Biocide-free hull and propeller coating systems

GIT Coatings develops graphene-based marine coatings designed to improve vessel performance while reducing the environmental impact of traditional antifouling systems. Its products target one of the main problems in shipbuilding and refit: the degradation of hull and propeller performance caused by biofouling, friction, cavitation and coating wear (GIT Coatings, n.d.).

The company’s coatings are positioned as biocide-free hard foul-release systems. Instead of relying on copper-based or toxic antifouling chemistry, they create a hard, low-friction surface that makes it harder for marine organisms to attach and easier to remove them during operation or cleaning. In practical terms, these coatings help maintain smoother hull and propeller surfaces over time, reducing hydrodynamic drag and improving vessel efficiency. From a business perspective, GIT Coatings addresses a high-value operational problem: hull and propeller inefficiency increases fuel costs, emissions and maintenance needs across vessel fleets.

The company raised CAD$10 million in Series A funding in 2023 to expand production capacity, develop next-generation coatings and accelerate international commercialization (GIT Coatings, 2023). Its reported deployment across hundreds of vessels suggests market demand from shipowners, fleet operators, and shipyards looking for solutions that reduce operating costs while supporting decarbonization and environmental compliance. The expansion into larger facilities in Dartmouth reinforces the company’s move toward serving global maritime customers at scale.

Business model: GIT Coatings generates revenue by selling high-performance marine coating systems to shipowners, fleet operators and shipyards. Its value proposition is based on selling lifecycle efficiency rather than only a coating product.

Finsulate: Non-toxic antifouling film for hull protection
Netherlands · Biomimetic antifouling film · Technology developed by materials scientist Rik Breur

Finsulate develops a non-toxic antifouling film designed to prevent marine organisms from attaching to vessel hulls and other submerged structures. The technology is inspired by the surface of sea urchins: instead of killing organisms through toxic substances, the film uses a dense layer of small fibers that makes it difficult for algae, mussels, and barnacles to attach.

In shipbuilding and refit, hull protection is a recurring operational and maintenance requirement. Traditional antifouling paints often rely on biocides or other chemical substances that are gradually released into the marine environment. Finsulate offers a physical alternative: the film is applied to the hull and reduces biofouling without relying on toxic leaching. According to the European Patent Office, the material is marketed as Finsulate Antifouling, is directly applied to vessel hulls, and can also be used on maritime structures such as oil rigs and offshore wind turbines (European Patent Office, 2019).

Business model: Finsulate generates revenue through the sale and application of antifouling film systems for vessels and marine structures. Its value proposition is based on reducing biofouling, avoiding toxic antifouling paints, lowering maintenance needs, and supporting more efficient vessel operation. The commercial logic is strongest in refit and maintenance cycles, where customers already face recurring costs from hull cleaning, coating renewal, dry-docking and performance losses caused by biofouling. By offering a longer-lasting and less polluting alternative, Finsulate sells not only a material, but a cleaner hull-protection solution with lifecycle benefits.

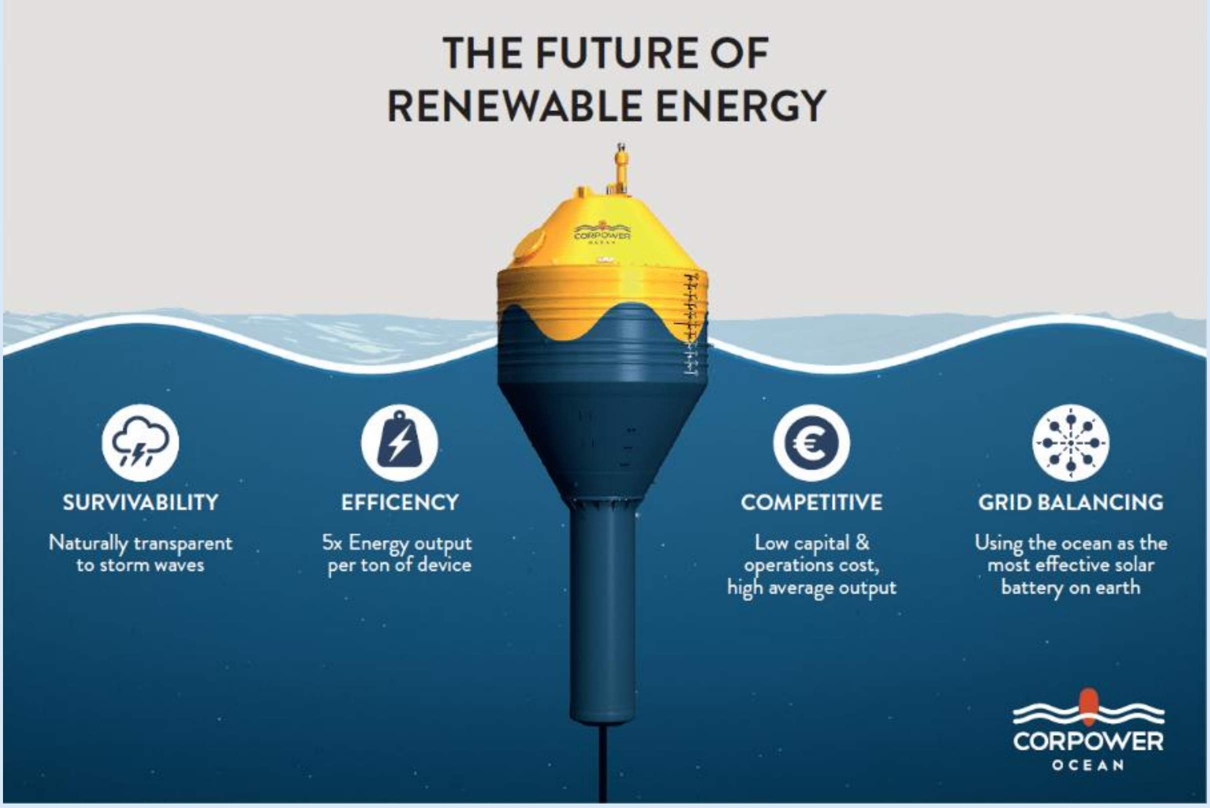
CorPower Ocean: Composite hulls for wave energy converters

Stockholm, Sweden; Viana do Castelo, Portugal · Wave energy technology company · Composite hull structures for marine renewable energy

CorPower Ocean develops and commercializes wave energy converter systems designed to generate electricity from ocean waves. A key material feature of its technology is the use of composite hull structures in its C4 Wave Energy Converter. Wave energy devices operate under continuous cyclic loading, repeated wave impact, saltwater exposure, and fatigue risk. In this context, composite materials can help reduce weight, avoid metallic corrosion, and support more efficient structural design (CorPower Ocean, n.d.).

The company secured €32 million in Series B1 funding in 2024 to support commercialization and reported €95 million in total public and private funding at that stage (CorPower Ocean, 2024). It has also secured €40 million from the EU Innovation Fund for VianaWave, a 10 MW pre-commercial wave energy farm planned off northern Portugal (CorPower Ocean, 2025). Its presence in Viana do Castelo, including an R&D, manufacturing and service center for wave energy converters, strengthens the link between material design, industrial production, and commercial deployment.

Business model: CorPower Ocean generates value by developing and commercializing integrated wave energy converter systems for utility-scale ocean energy projects. Its core business is not the standalone sale of composite materials, nor simply the operation of wave farms; it is the supply of wave energy systems for projects that need reliable, scalable offshore technology. The value lies in improving the performance, manufacturability, and durability of the overall system. Advanced marine-grade composites therefore support the commercial case for blue renewable energy by making offshore energy devices lighter, more corrosion-resistant and easier to scale in harsh marine environments.



WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

- Identify the vessels, offshore structures, components and submerged assets where corrosion, fatigue, wear, biofouling or coating degradation create the highest lifecycle costs.
- Use lifecycle cost analysis to compare conventional materials with advanced coatings, composites, alloys or surface treatments, including maintenance, dry-docking, downtime, fuel penalties and end-of-life costs.
- Integrate durability, corrosion-fatigue performance, antifouling toxicity, recyclability and maintenance interval requirements into procurement specifications and supplier selection.
- Pilot advanced marine-grade materials in high-value use cases, such as hull and propeller coatings, offshore renewable energy structures, moorings, fasteners, blades, foundations or submerged components.
- Monitor material performance under real operating conditions through inspection data, hull-performance data, corrosion testing, fatigue modelling, digital monitoring or class/survey reports.
- Partner with shipyards, refit yards, offshore renewable energy developers, ports, universities, materials laboratories, classification societies and technology suppliers to validate performance and accelerate commercial adoption.
- Develop credible customer value propositions based on measured lifecycle savings, lower environmental impact, longer service life, reduced maintenance exposure and stronger regulatory compliance.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Business performance	Maintenance cost reduction; dry-docking frequency reduction; downtime avoided; asset availability improvement; component replacement avoided; warranty claims reduced; lifecycle cost reduction.	Maintenance logs; dry-dock records; asset-management systems; repair invoices; operational dashboards; financial KPIs.
Materials performance	Corrosion rate reduction; fatigue life extension; wear rate reduction; coating adhesion; hull roughness; foul-release performance; inspection defects avoided.	Laboratory testing; field trials; class/survey reports; inspection records; sensor data; performance certificates.
Energy and climate	Fuel saved; CO2e avoided; vessel efficiency improvement; maintenance vessel trips avoided; renewable energy asset availability; lifecycle emissions reduction.	Fuel data; emissions calculations; voyage data; O&M records; LCA studies; offshore renewable operational data.
Pollution and ecosystems	Biocide or copper avoided; toxic leaching reduction; coating waste avoided; leaks or debris release incidents avoided; environmental disturbance events reduced.	Product specifications; leaching tests; environmental monitoring; HSE incident reports; waste records; compliance documentation.
Resource use and circularity	Material replacement avoided; service life extension; maintenance interval extension; recyclable or recycled content; end-of-life recovery rate; waste generated per maintenance cycle.	Procurement records; material passports; waste-management records; recycling certificates; maintenance plans; supplier data.
Commercial scale and market adoption	Premium price achieved; number of vessels/assets coated or equipped; contracts with shipyards or offshore developers; customer renewal rate; service revenue; pilots converted into commercial contracts.	Sales data; contracts; CRM data; customer retention records; project pipeline; service agreements.
Safety and compliance	High-risk maintenance hours avoided; safety incidents and near misses; hazardous substance exposure; inspections passed; compliance with antifouling and marine environmental requirements.	HSE records; training logs; regulatory filings; class certificates; audit reports; inspection reports.

Table 19 | Indicative KPIs examples for implementation

CHALLENGE 5: DATA STANDARDISATION, INTEGRATION AND INTEROPERABILITY FOR OCEAN OBSERVATION

Ocean observation increasingly depends on the ability to combine data from different sensors, platforms, satellites, models, and operational systems. The challenge is not simply to collect more ocean data, but to make heterogeneous datasets from different origins usable, comparable, and exchangeable across organizations, technologies, and applications (Fórum Oceano, 2026; Snowden et al., 2019).

Ocean observation systems often generate data in different formats, using different metadata structures, quality-control procedures, and spatio-temporal resolutions. This fragmentation creates technical, operational, and commercial barriers. Organizations often need to reconcile datasets each time a new sensor, platform, or data provider is added.

The barriers are not only technical. Marine data are frequently collected for different purposes and held by multiple organizations, which makes it difficult for users to assemble a coherent dataset.

Obstacles include data discovery, access rights, restrictions on use, and lack of coherence between datasets. These barriers reduce working efficiency, increase costs, and can prevent data from being available in time for operational use (European Commission, 2010).

The FAIR data principles — Findable, Accessible, Interoperable, and Reusable — provide a useful framework. In ocean observation, FAIR data means more than making datasets more easily available. It requires rich metadata, standard access protocols, shared vocabularies, clear provenance, and formats that allow both people and machines to find, understand, combine, and reuse data. This is particularly important as ocean observation becomes more dependent on autonomous sensors, satellite data, models, and near-real-time data flows (Tanhua et al., 2019).

SDG 14 ALIGNMENT:

Data standardization, integration, and interoperability support SDG 14 by improving the evidence base for ocean protection, sustainable use, and ecosystem recovery. Although interoperable data systems do not restore marine ecosystems directly, they enable the decisions that make protection and recovery possible: detecting environmental change, identifying pressures, monitoring restoration outcomes, and supporting timely operational responses. They also make environmental action more cost-effective by helping decision-makers identify where to act, what problem to address, and which measures are most likely to work.

This challenge supports three key SDG 14 targets:

Target 14.2	Sustainably manage and protect marine and coastal ecosystems. Interoperable ocean observation data supports better monitoring of marine and coastal ecosystems, helping users detect environmental change, assess pressures, identify risks, and inform management or recovery decisions. The contribution is indirect, but relevant: better-integrated data enables better ecosystem protection and restoration planning.
Target 14.7	Increase the economic benefits from the sustainable use of marine resources. Data standardization reduces duplication, integration costs, and technical barriers for BlueTech users. By making data from sensors, platforms, satellites, and operational systems easier to combine and reuse, the challenge supports more scalable ocean services, including environmental monitoring, offshore renewables, aquaculture, and coastal planning.
Target 14.a	Increase scientific knowledge, develop research capacity and transfer marine technology. This is the strongest alignment. The challenge advances marine data infrastructure by promoting shared standards, metadata conventions, and interoperable workflows. These capabilities improve ocean observation and help transfer marine science and technology into operational, regulatory, and commercial applications.

Table 20 | Alignment with the SDG 14 targets

Data standardization and interoperability connect ocean observation to better decisions and more scalable BlueTech services. By making ocean data easier to combine and reuse, this challenge supports ecosystem management and recovery decisions (Target 14.2), reduces wasted spending and lowers integration costs for sustainable ocean services (Target 14.7), and enables wider use of ocean observation technologies in operational and commercial applications (Target 14.a).

THE BUSINESS CASE:

The value of data standardization, integration, and interoperability lies in reducing the cost, complexity, and risk of using ocean data at scale. Interoperability reduces these costs by limiting the need for parallel data systems, manual reconciliation, and custom engineering (European Commission, 2010). It also improves the reliability of downstream services such as forecasting, environmental monitoring, maritime route optimization, offshore asset management, digital twins, and risk assessment tools.

For BlueTech companies, the business opportunity is not only in collecting more ocean data, but in making ocean data easier to use, integrate, and monetize. Standardized data can be reused across multiple pilots, clients, and applications, improving scalability, and reducing marginal delivery costs.

A solution developed for one use case can be adapted more easily to other users when the underlying data layer is interoperable (Snowden et al., 2019; Tanhua et al., 2019).
Customers are willing to pay for solutions that reduce integration effort, improve reliability, support regulatory compliance, lower operational risk and help them make better decisions. In this sense, data standardization and interoperability can turn fragmented ocean observations into scalable business infrastructure for the blue economy (Fórum Oceano, 2026).
The main sources of business value are: i) lower integration and engineering costs; ii) reduced duplication of data systems and workflows; iii) faster deployment of pilots and commercial services; iv) improved data quality, traceability and usability; v) lower operational risk through better monitoring and decision support; vi) higher scalability across sensors, platforms, satellites and clients; vii) new B2B service models, including data integration platforms, ocean data APIs, analytics services, digital twins, data brokerage, and decision-support tools.

ESRS MAPPING

ESRS topic	Connection	Possible indicators
E1 Climate Change	Interoperable ocean and weather data can support maritime route optimization, offshore renewable energy forecasting, climate risk assessment and operational decision-making that reduces fuel use, emissions and downtime.	Fuel savings from route optimization; CO2e avoided; forecast accuracy; renewable asset availability; weather-window prediction accuracy; climate-risk datasets integrated.
E2 Pollution	Integrated ocean observation data can improve detection, monitoring and response to pollution events, nutrient pressure, water-quality degradation, spills, marine litter and other pressures on marine and coastal environments.	Water-quality parameters monitored; pollution alerts generated; spill detection and response time; nutrient or contaminant datasets integrated; compliance exceedance events detected.
E3 Water and Marine Resources	This is the most direct ESRS connection. Data standardization improves the usability of marine data needed to manage water quality, marine resources, maritime activities and ocean-dependent value chains more sustainably.	Number of datasets harmonized; metadata completeness; API uptime; data reuse rate; users or organizations connected; spatial and temporal coverage of marine data.
E4 Biodiversity and Ecosystems	Interoperable datasets can strengthen biodiversity monitoring, habitat mapping, ecosystem assessment, conservation planning and restoration tracking by combining observations from sensors, satellites, research surveys and operational systems.	Biodiversity datasets integrated; habitat maps updated; species observations standardized; ecological alerts; restoration sites monitored; coverage of protected or sensitive areas.
ESRS 2 / Governance and strategy	FAIR and interoperable data systems require governance on data quality, access rights, provenance, licensing, cybersecurity, accountability and the integration of ocean-related risks and opportunities into strategy.	Data governance policy; data-quality audits; provenance records; licensing clarity; FAIR compliance score; number of datasets with persistent identifiers; user access controls.

Table 21 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

The following examples show how data standardization and interoperability can create business value by reducing integration costs, improving data usability, enabling scalable digital services and supporting better decision-making in BlueTech and ocean observation.

Sofar Ocean: Real-time ocean data for maritime operations

San Francisco, United States · Ocean intelligence platform · Real-time ocean data and voyage optimization

Sofar Ocean develops an ocean intelligence platform that combines marine sensing hardware, a global ocean data network, and software-based decision-support tools. Its Spotter buoys collect real-time observations of ocean conditions such as waves, wind, sea surface temperature, and atmospheric pressure, while Wayfinder uses ocean intelligence and vessel-performance modelling to support dynamic voyage optimization for shipping (Sofar Ocean, n.d.).

The company addresses a common problem in ocean observation: marine data is often fragmented, difficult to access and hard to integrate into operational decisions. Sofar's model turns distributed ocean observations into usable, machine-readable data streams made available through digital platforms and APIs. This helps users move from raw ocean observations to operational intelligence.

The company raised USD 39 million in Series B funding in 2021 to expand its ocean intelligence platform and sensor network (Sofar Ocean, 2021). It also reports a global network of +2,500 Spotters deployed and more than 1.5 million real-time ocean observations per day (Sofar Ocean, n.d.)In maritime operations, Wayfinder reports average fuel and emissions savings of 4–9%, while MOL Group reported an average fuel and GHG emissions reduction of about 6% per voyage during a 2024 deployment (Sofar Ocean, 2024).

The business value is especially clear in shipping. Better ocean and weather data can support improved routing, lower fuel consumption, reduced emissions and lower operational risk.

Business model: Sofar Ocean generates revenue by combining ocean sensors, data services, and software-based decision-support tools. Its customers include shipping companies, offshore operators, researchers, governments and other organizations that need reliable ocean information.

HUB Ocean: Interoperable ocean data infrastructure for research and industry

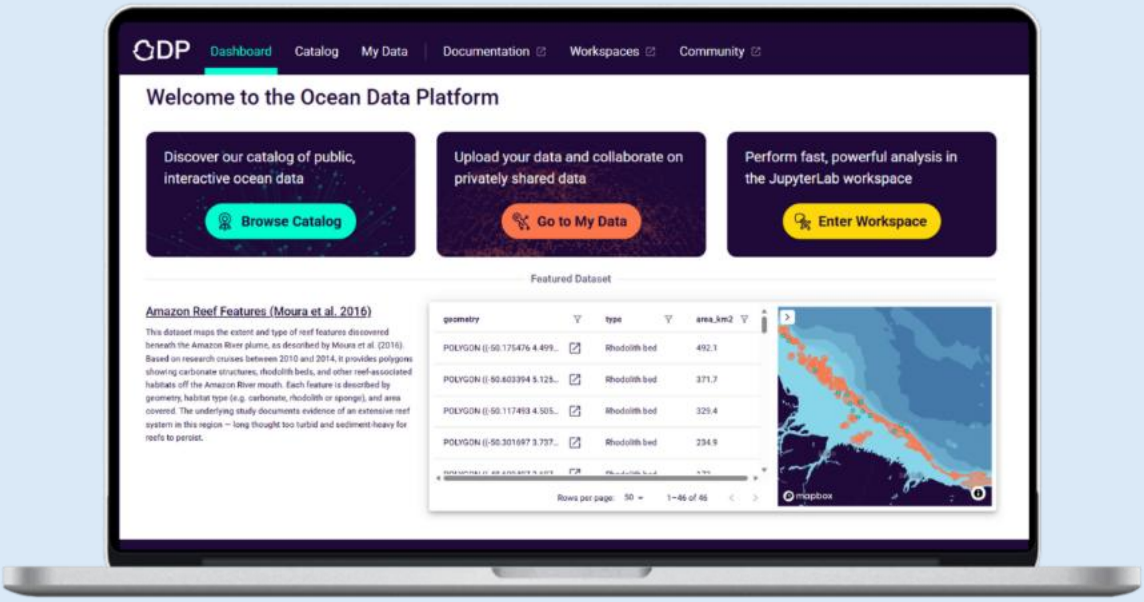
Oslo, Norway · Non-profit ocean data platform · Cloud-based ocean data infrastructure

HUB Ocean operates the Ocean Data Platform, a cloud-based infrastructure designed to make ocean data easier to find, access, analyze, and share. Unlike companies that mainly collect data through their own sensors or vessels, HUB Ocean focuses on the data layer: bringing together ocean datasets from different sources and making them more usable through catalogues, metadata, and APIs (HUB Ocean, n.d.).

The platform addresses a central problem in ocean observation: valuable ocean data often remains fragmented across institutions, companies, research projects, and public databases. This makes it difficult for users to combine datasets, compare information across regions, reuse existing observations or build scalable digital services. By providing a shared environment for data discovery, access, analysis, and publication, the Ocean Data Platform reduces the technical friction between data holders and data users.

Its relevance is not limited to research. Standardized and interoperable ocean data can support maritime operations, offshore energy, marine spatial planning, environmental monitoring, fisheries transparency, conservation, and climate-related decision-making. The platform also allows datasets to be published with metadata and persistent identifiers, making them easier to reuse and cite.

Business model: HUB Ocean is not a conventional commercial data vendor. As a non-profit, it is supported through strategic partnerships, public grants, philanthropic contributions, and collaborations, rather than relying primarily on direct data sales. Its value proposition is based on reducing duplicated data work, improving data reuse, lowering integration costs, and enabling higher-value services such as analytics, digital twins, environmental risk assessment, and decision-support tools.



EMODnet: European marine data infrastructure for interoperable ocean data

European Union · Marine data infrastructure · Open access marine data, metadata and data products

EMODnet, the European Marine Observation and Data Network, is a European marine data infrastructure designed to make fragmented ocean data easier to find, access, combine, and reuse. Unlike companies that mainly collect data through their own sensors or platforms, EMODnet focuses on the data infrastructure layer: it brings together marine data from multiple organizations and makes them available through common services, standards, and data products (EMODnet, n.d.).

The platform is relevant because it provides free and open access to marine data, metadata, and data products across key themes such as geology, chemistry, biology, seabed habitats, and human activities. By harmonizing data from different sources, EMODnet helps users move from isolated datasets to interoperable marine knowledge that can support research, environmental monitoring, maritime spatial planning, offshore activities, and blue economy services.

Business model: EMODnet shows how data standardization and interoperability can create ecosystem-level value for BlueTech and ocean observation. By providing a common marine data infrastructure, it reduces technical friction between data holders and data users, supports the reuse of publicly funded data, and enables new services based on accessible, quality-controlled and interoperable ocean information.

WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

- Audit existing marine and ocean-related datasets to identify duplication, quality gaps, metadata gaps, access restrictions and interoperability barriers.
- Adopt FAIR data principles, shared vocabularies, common metadata structures and standard access protocols for ocean data products and internal monitoring systems.
- Build interoperable data pipelines that connect sensors, satellites, autonomous platforms, models, operational systems and customer-facing dashboards.
- Prioritise pilots in high-value use cases such as maritime route optimization, offshore renewable energy operations, aquaculture monitoring, environmental compliance, marine spatial planning or coastal risk assessment.
- Package data capabilities into scalable services, including ocean data APIs, data-as-a-service, analytics-as-a-service, digital twins, decision-support platforms or environmental monitoring tools.
- Partner with ports, universities, public data infrastructures, sensor providers, satellite companies, offshore operators and regulators to validate data models in real operating conditions.
- Make the SDG 14 and ESRS contribution credible by tracking data quality, provenance, environmental coverage, reuse, decision impact and measurable operational outcomes.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Data infrastructure and interoperability	Datasets harmonized; metadata completeness; API uptime; data latency; number of connected sensors, platforms or data providers; percentage of datasets using shared standards.	Data catalogues; API logs; metadata records; platform dashboards; data-quality reports.

Business performance	Integration cost reduction; time saved in data preparation; pilots deployed faster; recurring data-service revenue; number of clients using APIs or dashboards; reuse of one data layer across multiple applications.	Project budgets; engineering time logs; contracts; sales data; customer analytics; platform usage reports.
Environmental and decision-support impact	Environmental monitoring coverage; pollution or ecological alerts generated; route optimization emissions savings; risk assessments completed; decisions supported by interoperable data products.	Environmental sensors; voyage optimization reports; ESG reports; compliance records; operational dashboards.
Governance and trust	Datasets with clear provenance; data access requests processed; quality-control checks completed; licensing clarity; persistent identifiers used; user satisfaction or stakeholder trust indicators.	Data governance registers; audit trails; licensing records; user surveys; platform governance reports.

Table 22 | Indicative KPIs examples for implementation

CHALLENGE 6: WHAT DOES NOT GET MEASURED CANNOT GET MANAGED: QUANTIFICATION OF ENVIRONMENTAL IMPACT OF TOURISM OPERATORS

Coastal and maritime tourism is a major economic force: in 2023, it directly generated USD 1.5 trillion in GDP, supported 52 million jobs, and accounted for approximately 50 percent of all tourist spending globally (WTTC & Oxford Economics, 2024). Yet this economic contribution comes with an environmental footprint that remains largely unquantified at the destination and operator level. Tourism is responsible for roughly 9 percent of global carbon emissions (Sun et al., 2024), and the WTTC estimates that USD 65 billion per year is needed for mitigation and adaptation in coastal tourism destinations alone (WTTC, 2024).

The core problem is a measurement gap. While carbon footprints from transport are increasingly well understood, the broader environmental impacts of tourism on coastal and marine ecosystems–water quality degradation, habitat disturbance, waste generation, noise pollution, biodiversity loss–remain poorly quantified. A 2025 systematic review found that only 50 studies worldwide have attempted to assess tourism impacts on marine and coastal ecosystem services, with most focused narrowly on cultural services rather than ecological pressures (Baltranaitė, 2025). There is no standardized methodology to evaluate the full environmental footprint of a tourist destination or operator beyond basic carbon accounting.

This challenge targets the quantification and predictive modelling of the environmental impact of tourism operators and destinations in coastal and maritime settings.

SDG 14 ALIGNMENT

Unlike challenges that directly reduce pollution or prevent overfishing, impact quantification and predictive modelling is an enabling tool. It does not itself protect marine ecosystems – but it provides the evidence base without which protection and management decisions cannot be effectively made. The alignment with SDG 14 is therefore indirect but foundational:

Target 14.2	Sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts and strengthen their resilience. Impact modelling provides the evidence base for management decisions that protect ecosystems from tourism-related pressures.

Target 14.5	By 2020, conserve at least 10 percent of coastal and marine areas. Quantifying tourism's impact on protected areas enables authorities to set and enforce carrying capacities and visitor management plans.

Table 23 | Alignment with the SDG 14 targets

The value of impact quantification lies in enabling informed decisions: if a coastal authority can predict that a projected increase in visitors will degrade water quality below safe thresholds, it can intervene before the damage occurs– rather than paying for expensive ecological restoration after the fact.

THE BUSINESS CASE: COST REDUCTION + NEW BUSINESS MODEL

Business strategies built around tourism impact quantification create value through two mechanisms. First, they can reduce costs by avoiding emergency ecological interventions and regulatory penalties. Unmonitored tourism degradation of coastal ecosystems can trigger expensive clean-up operations, habitat restoration programs, beach closures or fines under EU environmental directives. Predictive modelling enables early warning and preventive action at a fraction of the remediation cost. For tourism operators, demonstrating quantified environmental performance also reduces the risk of reputational damage and loss of eco-certification–increasingly a prerequisite for market access.

Second, the challenge enables entirely new business models in the form of impact-quantification-as-a-service. This can take several forms: subscription-based modelling platforms sold to coastal authorities for destination management; impact assessment services bundled with certification support and ESG reporting for tourism operators; and predictive analytics tools that help hotel groups, tour operators and cruise lines forecast and reduce their environmental footprint ahead of regulatory requirements.

The following examples, while not all specific to coastal tourism, illustrate how environmental impact quantification is already being commercialized – and point toward the market space that a dedicated coastal tourism modelling platform could occupy.

ESRS MAPPING

ESRS topic	Connection	Possible indicators
E1 Climate Change	Tourism impact quantification can measure and forecast emissions from travel, accommodation, activities, events and local transport, while helping operators identify lower-carbon scenarios and adaptation needs in coastal destinations.	CO2e per guest-night, trip, event or itinerary; Scope 1, 2 and 3 tourism emissions; emissions reduction scenarios; climate-risk exposure of coastal assets; mitigation and adaptation investment.
E2 Pollution	The challenge is directly relevant where tourism activities generate or intensify wastewater, litter, chemical pollution, noise pollution, light pollution or water-quality degradation in coastal and marine environments.	Water-quality exceedances; wastewater indicators; litter or marine debris collected; noise/light disturbance indicators; pollution incidents; beach closure days; compliance alerts.
E3 Water and Marine Resources	Coastal tourism depends on water availability and marine ecosystem quality. Quantification tools can assess water use, discharge, bathing-water quality, coastal pressures and the relationship between visitor flows and marine resource condition.	Water consumption per guest-night; water reuse rate; bathing-water quality; discharge monitoring coverage; freshwater stress indicators; coastal pressure indices.

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E4 Biodiversity and Ecosystems	Impact modelling can connect visitor flows, activities, vessel traffic, accommodation density and protected-area use with habitat disturbance, species pressure, ecosystem-service degradation and carrying-capacity thresholds.	Visitor pressure in sensitive areas; protected-area carrying capacity; habitat disturbance indicators; species disturbance records; biodiversity monitoring coverage; restoration outcomes tracked.
E5 Resource Use and Circular Economy	Tourism operators generate waste through accommodation, food services, events, packaging and activities. Environmental impact quantification can make waste streams visible and support circular procurement, waste prevention and reduction measures.	Waste generated per guest-night or event; recycling and diversion rate; food waste; single-use plastic reduction; circular procurement share; supplier packaging data.
ESRS 2 / Governance and strategy	Credible quantification requires methodology, baseline definition, data governance, thresholds, stakeholder accountability and integration into destination-management, investment and operational decision-making.	Methodology documented; data coverage; baseline year; model accuracy; thresholds defined; management actions triggered; certification or audit status; stakeholder reporting.

Table 24 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

Greentour: LCA-Based Environmental Impact Tool for Tourist Destinations

Spain & Portugal · EU Interreg project · Published 2025

Greentour is the first tool of its kind to evaluate the environmental impact of accommodation, restaurants and tourism activities using nine LCA-based indicators–going far beyond carbon footprint alone. Developed through an EU Interreg project, the tool applies a hybrid bottom-up and top-down approach, integrating data from individual establishments and destination managers. It was tested in four coastal and inland destinations across Spain and Portugal: Rías Baixas, Camino Lebaniego, Lloret de Mar, and Guimarães (Sustainability MDPI, 2025).

Relevance: Greentour demonstrates the feasibility of a destination-level impact quantification tool tailored to the tourism sector. Its nine-indicator LCA framework provides a template for how a commercial modelling platform for coastal authorities could be structured–extending beyond carbon to cover water quality, waste, biodiversity and ecosystem service impacts.

Deloitte Travel Emissions Calculator: Forecasting and Reducing Travel Footprints

UK · Open-access tool · Part of Deloitte WorldClimate initiative

Deloitte developed a free, open-access Travel Emissions Calculator that enables organizations to forecast the approximate carbon emissions of a project, event, or single trip–covering long-distance travel, hotel stays and local transport. The tool supports scenario modelling (exploring lower-emission alternatives) and provides data to support stakeholder conversations about travel plans. It is part of Deloitte's broader WorldClimate initiative and is designed to help organizations reduce one of their largest Scope 3 emission sources (Deloitte UK, 2024).

Relevance: While Deloitte's calculator focuses on corporate travel rather than destination-level impact, it demonstrates the commercial viability of emissions forecasting tools and the demand for pre-trip predictive modelling. A coastal-tourism-specific version could bundle emissions calculation with ecosystem impact prediction and regulatory compliance reporting.

Greengage Solutions: Impact Portal for Events and Tourism Venues

UK · Founded 2013 · Hardware-as-a-Service + SaaS model

Greengage Solutions developed the Impact Portal, a platform that enables hotels and venues to measure the environmental footprint of events and meetings–including those too small to be covered by traditional sustainability audits. The platform tracks carbon emissions, enables offset integration through Carbon Footprint, supports green transportation planning, and generates portfolio-wide sustainability reports. Greengage also offers ECOsmart certification, combining sustainability audits with consulting and staff training (Greengage Solutions, 2026; Micebook, 2025).

Business model: Greengage operates as a sustainability-as-a-service provider: impact measurement bundled with certification, consulting and reporting. This is the closest existing model to what an impact-quantification-as-a-service platform for coastal tourism could look like–extended to cover marine and ecosystem indicators alongside carbon.

WHAT PRIVATE COMPANIES CAN DO

- Implementation opportunities for companies
- Define the scope of impact measurement beyond carbon, including water use, wastewater, waste, biodiversity pressure, habitat disturbance, noise, visitor flows and protected-area impacts.
- Establish a baseline for destinations, properties, activities or itineraries using comparable indicators such as impact per guest-night, per visitor, per trip, per event or per tourism activity.
- Integrate operational data from bookings, occupancy, transport, procurement, waste contractors, water utilities, activity providers and local environmental monitoring systems.
- Use predictive modelling to test scenarios before decisions are made, including peak-season visitor flows, new accommodation capacity, cruise arrivals, events, route design or protected-area access.
- Set thresholds and early-warning systems for sensitive coastal and marine areas, including carrying capacity, bathing-water quality, habitat disturbance and waste-management capacity.
- Link quantified results to concrete management actions, such as visitor-flow management, water-efficiency investments, wastewater upgrades, waste-prevention measures, supplier requirements or low-impact tourism product design.
- Partner with municipalities, destination-management organizations, protected-area managers, research centres, certification schemes and local businesses to create shared data and comparable methodologies.
- Use measurement outputs to support ESG reporting, eco-certification, investment decisions, transparent customer communication and credible claims about coastal and marine impact reduction.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Measurement coverage and quality	Percentage of properties, activities, itineraries or destinations covered; number of indicators measured beyond carbon; data completeness; baseline established; model accuracy; frequency of data updates.	Impact assessment platform; LCA datasets; booking systems; operator records; destination-management datasets; methodology documentation.
Business performance	Avoided clean-up or remediation costs; certification retained or achieved; regulatory penalties avoided; insurance or financing benefits; revenue from impact-quantification services; subscription or consulting revenue.	Financial records; certification audits; compliance files; contracts; platform subscriptions; customer reports.

Environmental performance	CO2e per guest-night or trip; water use per guest-night; waste per guest-night; recycling rate; water-quality exceedances; litter reduction; biodiversity or habitat disturbance indicators.	Environmental sensors; utility bills; waste contractor data; carbon accounting tools; biodiversity monitoring; beach and water-quality reports.
Destination and ecosystem management	Carrying-capacity thresholds defined; visitor-flow interventions triggered; beach closure days avoided; protected-area pressure reduced; restoration or mitigation actions implemented; early warnings issued.	Destination dashboards; protected-area records; municipal data; monitoring reports; intervention logs; stakeholder meeting records.

Table 25 | Indicative KPIs examples for implementation

CHALLENGE 7: SEEING THE OCEAN IN REAL TIME

The open marine environment is vast, dynamic and insufficiently monitored. While satellite remote sensing provides broad spatial coverage, it cannot capture subsurface conditions, localized pollution events, or the early biological signals of ecosystem stress. Traditional monitoring relies on periodic ship-based surveys and manual sampling, which are expensive, infrequent and inherently reactive methods. By the time degradation is detected through conventional means, the damage is often already done and remediation costs have multiplied.

This challenge targets comprehensive, continuous, multi-parameter monitoring of the open marine environment, covering ecological indicators (species, habitats, sediments), microplastics and pollutant detection, and physical parameter changes (temperature, currents, noise). By combining distributed sensor networks, autonomous platforms (buoys, AUVs) and real-time data pipelines, the challenge enables integrated observation that improves detection of environmental stress, supports evidence-based decision-making and reduces response times to emerging threats.

The global marine sensors market was valued at USD 37.7 billion in 2025 and is projected to reach USD 59.5 billion by 2035, growing at a CAGR of 4.7 percent (Fact.MR, 2025). The ocean observation instruments segment alone is forecast to grow from USD 1.5 billion to USD 2.8 billion by 2032 (Dataintelo, 2024). This growth reflects a fundamental shift from periodic, manual ocean sampling toward continuous, automated, IoT-enabled monitoring.

SDG 14 ALIGNMENT

It is important to note that this challenge operates at the observation layer: it monitors pollution and ecosystem change but does not directly prevent or reduce it. However, it builds the evidence base without which timely and targeted intervention is not possible. The SDG 14 alignment is therefore partial and enabling rather than direct:

Target 14.1	Prevent and significantly reduce marine pollution of all kinds. Microplastics and pollutant detection monitors pollution but does not directly prevent or reduce it. The value lies in enabling timely intervention by those who can act.

Target 14.a	Increase scientific knowledge, develop research capacity and transfer marine technology. Integrated monitoring directly builds the ocean knowledge base that underpins all other SDG 14 targets.

Table 26 | Alignment with the SDG 14 targets

The core value proposition is that continuous monitoring transforms marine management from reactive to proactive: detecting harmful algal blooms before they kill fish stocks, identifying pollution plumes before they reach protected areas, and tracking temperature anomalies before they trigger coral bleaching events.

THE BUSINESS CASE

The primary business case for integrated marine monitoring is avoiding the escalated costs that result from late detection. A single undetected pollution event in a coastal tourism zone can trigger beach closures, emergency clean-up operations and regulatory penalties that dwarf the cost of continuous monitoring.

Early warning systems shift the cost curve: by detecting threats hours or days before they escalate, they enable targeted, low-cost interventions instead of expensive emergency responses. For coastal authorities, aquaculture operators and port managers, integrated monitoring represents a form of risk insurance – a predictable operational expense that prevents unpredictable, catastrophic costs.

The following examples illustrate how companies are already commercializing integrated monitoring as a service–selling hardware, data pipelines and predictive analytics to public and private clients who need continuous environmental intelligence.

ESRS MAPPING

ESRS topic	Connection	Possible indicators
E1 Climate Change	Real-time ocean monitoring can detect climate-related changes such as marine heatwaves, temperature anomalies, storm-related conditions and other oceanographic shifts that affect coastal assets, aquaculture, ports and ecosystem resilience.	Sea temperature anomalies; marine heatwave alerts; extreme-event warnings; climate-risk thresholds; response actions triggered; assets or sites under climate monitoring.
E2 Pollution	This is one of the most relevant ESRS links. Monitoring systems can detect pollution events, microplastics, nutrient pollution, harmful algal blooms and water-quality deterioration, enabling earlier intervention and better compliance evidence.	Pollution events detected; microplastics concentration; nutrient levels; chlorophyll; pH; dissolved oxygen; turbidity; harmful algal bloom alerts; response time to incidents.
E3 Water and Marine Resources	Continuous monitoring improves understanding of marine and water conditions, supporting sustainable use of marine resources by aquaculture operators, ports, coastal authorities, tourism destinations and offshore infrastructure owners.	Monitoring coverage; number of parameters tracked; water-quality status; current, salinity and temperature data; real-time data availability; marine resource condition indicators.
E4 Biodiversity and Ecosystems	The challenge is relevant where monitoring includes species, habitats, seabed condition, sediments, acoustic disturbance, ecosystem stress or protected-area indicators. Its contribution is enabling: data supports management and intervention decisions.	Species observations; habitat condition indicators; protected-area monitoring coverage; ecosystem stress alerts; acoustic/noise indicators; invasive species detections; biodiversity trend data.
ESRS 2 / Governance and strategy	Real-time monitoring only creates value if data are translated into governance, decision-making and response protocols.	Monitoring governance defined; sensor uptime; data completeness; QA/QC procedures; thresholds

	Companies need defined thresholds, responsibilities, data quality standards and escalation procedures.	documented; alerts escalated; corrective actions implemented; management reviews completed.

Table 26 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

e.Ray Europa: WAMO Autonomous Water Monitoring Platform

Darmstadt, Germany · Founded 2015 · Galileo Masters Award winner · Nasdaq-listed ambition

e.Ray developed WAMO (Water Monitor), a self-sufficient floating platform that provides continuous, automated real-time monitoring of water quality parameters including water level, temperature, pH, chlorophyll, nitrates and precipitation. Powered by solar energy and equipped with satellite navigation, WAMO transmits data in real time via satellite, removing the limitations of traditional shore-based measuring stations. The platform integrates manufacturer-independent, multispectral sensors and can measure at various depths. It has been deployed in Germany's Mecklenburg-Western Pomerania lake region and in the "Smart Water Darmstadt" project, partnering with s::can for spectrophotometric water quality sensing (Business Norway, 2024; e.Ray Europa, 2024).

Business model: e.Ray provides an integrated hardware-software system for continuous, automated water monitoring, sold to municipalities, counties and water management authorities. The platform also includes a low-power ultrasound device to suppress blue-green algae development without harming aquatic life–combining monitoring with active intervention. Revenue comes from platform sales, data-as-a-service (DaaS), and partnerships with government smart-city programs.

Microbia Environnement: Genetic Biosensors for Harmful Algal Bloom Early Warning

Argelès-sur-Mer, France · Patented C.A.R.L.A. technology

Microbia Environnement's core innovation is its patented C.A.R.L.A. (Cellular Activity RNA-based Elisa) technology – genetic biosensors that detect and measure the activity of living microorganisms in aquatic environments. By targeting the genetic signatures of toxin-producing cyanobacteria and microalgae, C.A.R.L.A. provides an early warning system for harmful algal blooms (HABs) days before traditional methods can detect them. The company offers a unique "bloom forecast" concept based on near-real-time monitoring, enabling clients to shift from reactive crisis management to proactive risk anticipation (Environmental XPRT, 2024).

Business model: Microbia sells C.A.R.L.A. biosensor kits (96-well microplate format) to water utilities, aquaculture operators and environmental agencies, along with monitoring and forecasting services. The value proposition is direct cost avoidance: early HAB detection prevents fish mortality events, beach closures, water treatment surcharges and public health interventions whose costs vastly exceed continuous monitoring expenditure.

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Envisad: Digital Twins for Environmental and Water Management

Spain · Founded December 2022 · Technology-based environmental monitoring

Envisad is a Spanish technology company providing comprehensive services spanning data acquisition through to digital twin creation for environmental and water management applications. The company offers monitoring facility design, big data management for water quality control, hydraulic works planning, climate change impact engineering, and civil protection and safety in aquatic environments. By integrating real-time sensor data into digital twin models, Envisad enables clients to simulate scenarios, predict outcomes and optimize interventions before committing resources (Envisad, 2024).

Business model: Envisad operates as a full-service environmental intelligence provider–from sensor deployment and data collection through to predictive digital twin modelling. This end-to-end approach reduces costs for clients by replacing fragmented consulting engagements with an integrated monitoring-to-decision platform.

WHAT PRIVATE COMPANIES CAN DO

- Implementation opportunities for companies
- Identify the highest-risk environmental variables for their operations, such as water quality, harmful algal blooms, pollutant plumes, microplastics, sediment condition, temperature anomalies, currents, noise or ecosystem stress indicators.
- Deploy continuous monitoring pilots in priority sites, including aquaculture farms, ports, coastal tourism zones, offshore infrastructure, desalination intakes, protected areas or industrial discharge zones.
- Combine different observation layers - sensors, buoys, AUVs, satellite data, laboratory analysis and modelling - into a single operational dashboard rather than treating monitoring as isolated data collection.
- Define thresholds and early-warning protocols that clarify when data should trigger operational action, escalation to authorities, stakeholder communication or emergency response.
- Integrate monitoring data into operational decisions, such as aquaculture feeding and health management, port environmental management, coastal tourism risk management, infrastructure maintenance or pollution response planning.
- Ensure data quality, traceability and interoperability so that monitoring results can support compliance, ESG reporting, certification, insurance, investment due diligence and collaboration with public authorities.
- Partner with universities, research centres, technology providers, municipalities and environmental agencies to validate monitoring methodologies and strengthen credibility.

- For technology providers, package monitoring capabilities into scalable services such as monitoring-as-a-service, data-as-a-service, early-warning subscriptions, digital twin platforms or environmental intelligence dashboards.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Monitoring coverage and data quality	Area, sites or assets monitored; number of parameters tracked; sensor uptime; data completeness; update frequency; calibration frequency; detection limits; data latency; QA/QC compliance.	Sensor platforms; monitoring dashboards; calibration records; laboratory validation; data logs; platform analytics.
Early warning and response	Number of alerts issued; time from detection to response; harmful algal bloom early warnings; pollution plume detections; temperature anomaly alerts; false positive/false negative rates; interventions triggered.	Alert logs; operational response records; incident reports; environmental authority notifications; digital twin scenarios.
Business performance	Emergency clean-up costs avoided; downtime avoided; beach or site closures avoided; fish mortality events avoided; water-treatment surcharges avoided; monitoring service revenue; clients/assets under monitoring.	Financial records; contracts; customer dashboards; insurance/compliance documentation; aquaculture production records; port or tourism operating data.
Impact and compliance	Pollution incidents detected early; water-quality exceedances reduced; environmental thresholds met; regulatory reports submitted; protected-area monitoring coverage; ecosystem stress events tracked; corrective actions completed.	Environmental reports; ESG reports; compliance files; water-quality records; biodiversity surveys; monitoring reports; audit documentation.

Table 27 | Indicative KPIs examples for implementation

CHALLENGE 8: PORT ENVIRONMENTAL MONITORING (WATER, NOISE, EMISSIONS)

Maritime transport carries around 80% of the volume of international trade in goods, making ports key nodes in supply chains, logistics and industrial activity (United Nations Conference on Trade and Development, 2024a). At the same time, shipping, cargo handling, industrial operations, and vessel berthing generate water pollution risks, air emissions, noise, odors, and operational pressures that affect nearby communities and coastal environments.

Environmental monitoring is becoming a standard component of port environmental management. According to the ESPO Environmental Report 2023, based on responses from 90 European ports across 20 countries, 92% of surveyed ports reported having an environmental monitoring program. Water quality was the most commonly monitored issue, with 82% of ports monitoring it, followed by port waste (81%), energy efficiency (76%), air quality (70%) and noise (64%) (European Sea Ports Organization, 2023).

Water quality is central to port environmental monitoring, as port waters are exposed to accidental discharges, runoff, and contamination from maritime and industrial activities. Monitoring typically covers pollutants such as oil, heavy metals, chemicals and nutrients, alongside parameters such as pH, temperature, salinity, dissolved oxygen, and turbidity, helping ports detect contamination events earlier and assess pressures on marine ecosystems (Puig & Darbra, 2024).

Odor and noise also create direct management challenges for port authorities. In the heavily industrialized and densely populated Rotterdam region, odor nuisance has historically generated around 5,000–6,000 resident complaints per year, requiring 24/7 response capacity from environmental authorities (Milan et al., 2012). Berth noise is another growing concern, especially as residential development expands near port areas. Ships at berth often run large engines at low capacity, supplemented by systems like fans and pumps, generating low-frequency noise and local emissions under real operating conditions (Peutz Group, 2025).

Air quality is another clear pressure point. Recent modelling of six major European port cities found that shipping can account for between 6.5% and 62% of NO_2 concentrations in city centers, with an average contribution of 28% (Tokaya et al., 2024). These impacts vary by port layout, distance to urban areas, wind speed, meteorology, and vessel activity, which makes high-resolution monitoring and source attribution essential for effective mitigation.

Recent advances in port environmental monitoring, including remote sensing, Geographic Information Systems, drones, big data analytics, and artificial intelligence, create new opportunities to collect and analyze environmental data more accurately and in real time (Puig & Darbra, 2024).

SDG 14 ALIGNMENT:

Ports are critical nodes in the blue economy, but their operations can generate environmental pressures affecting coastal ecosystems and nearby communities. Integrated environmental monitoring supports SDG 14 by helping ports detect risks earlier, identify pollution sources more accurately, and link environmental data to targeted mitigation measures.

Integrated environmental monitoring in ports directly supports three key SDG 14 targets:

Target 14.1	Prevent and reduce marine pollution of all kinds. Continuous monitoring of water quality, air emissions, odours, noise, and operational conditions helps ports detect pollution events earlier, identify their sources, and support targeted mitigation measures.
Target 14.2	Sustainably manage and protect marine and coastal ecosystems. By combining environmental data with operational decision-making, ports can better manage the environmental pressures created by shipping and port activities, reducing risks to coastal ecosystems and nearby urban areas.
Target 14.7	Increase the economic benefits from the sustainable use of marine resources. Smart environmental monitoring strengthens sustainable port management by improving operational efficiency, reducing regulatory risk, supporting better investment decisions, and reinforcing the role of ports as infrastructure for a cleaner and more competitive blue economy.

Table 28 | Alignment with the SDG 14 targets

By turning environmental data into earlier detection, better decisions and more targeted mitigation, port environmental monitoring contributes to marine pollution reduction (Target 14.1), the sustainable management of coastal ecosystems (Target 14.2), and a more resilient blue economy (Target 14.7).

THE BUSINESS CASE: COST REDUCTION + NEW BUSINESS MODEL

Integrated port environmental monitoring turns environmental data into operational intelligence. IoT sensors and hydro-meteorological platforms support real-time operational decision-making (Port of Rotterdam Authority, 2019a). Water-quality monitoring helps ports detect contamination events and assess pressures on marine ecosystems (Puig & Darbra, 2024). Air-quality monitoring and source-attribution analysis help ports understand where emissions impacts are most significant (Tokaya et al., 2024), while e-nose networks and acoustic monitoring extend this approach to odor and berth-noise management (Milan et al., 2012; Peutz Group, 2025). Together, these tools help ports detect events earlier, pinpoint pollution sources, document environmental performance, and prioritize mitigation measures where they generate the greatest impact.

The business case is not only environmental. Real-time monitoring can also improve service quality and port efficiency by supporting safer vessel traffic management, reducing waiting times, and optimizing berthing, loading, unloading and departure decisions. More broadly, data-driven analytics can improve planning and decision-making across port activities (Filom et al., 2022; Port of Rotterdam Authority, 2019a).

ESRS MAPPING

ESRS topic	Connection	Possible indicators
E1 Climate Change	Air-quality and emissions monitoring can support port decarbonization, shore-power deployment, electrification of cargo-handling equipment and better understanding of vessel-related emissions in and around port areas.	NO_2, SOx, PM and CO_2e estimates; auxiliary engine hours avoided; shore-power connections; percentage of calls using onshore power; emissions intensity per vessel call or tonne handled; clean-energy use in port operations.
E2 Pollution	This is the most directly relevant ESRS topic. Integrated monitoring helps ports detect, measure and manage water pollution, air pollution, odors, noise and contamination linked to shipping, cargo handling, industrial activity and runoff.	Water-quality exceedances; oil, heavy metal, nutrient and chemical concentrations; turbidity and dissolved oxygen; odor alerts; noise exceedances; spill detection time; incident response time; mitigation actions completed.
E4 Biodiversity and Ecosystems	Port activities can create pressures on coastal habitats and marine ecosystems. Monitoring water quality, sediment conditions, pollutant levels and operational pressures can help ports reduce ecosystem disturbance and prioritize mitigation.	Habitat or ecological monitoring coverage; biodiversity-sensitive areas monitored; sediment quality indicators; contamination events near habitats; ecological risk alerts; mitigation measures linked to sensitive sites.
S3 Affected Communities	Ports operate close to cities and coastal communities. Monitoring and public reporting of air quality, noise, odor and incident response can reduce community exposure, improve transparency and strengthen trust.	Number of complaints; response time to odor/noise/air-quality events; public data availability; community engagement sessions; exceedance notifications; grievance resolution rate; stakeholder satisfaction.
G1 Business Conduct	Reliable environmental monitoring strengthens governance by improving compliance evidence, auditability, source attribution, accountability and the quality of environmental decision-making.	Permit compliance records; monitoring reports submitted; audit findings; corrective actions closed; data-quality procedures; number of compliance events avoided; documented decision logs.

Table 29 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

The following examples show how ports can turn environmental monitoring into practical management tools. They illustrate how real-time data can improve operational decisions, support faster responses to environmental risks, guide targeted mitigation investments and strengthen trust with public authorities and nearby communities.

Port of Rotterdam: IoT-enabled Environmental Monitoring for Port Management

Rotterdam, Netherlands · IoT, environmental monitoring and AI-supported decision-making

The Port of Rotterdam uses integrated environmental and operational monitoring to support safer, cleaner, and more efficient port management. Its approach combines continuous hydro-meteorological data, odor detection, acoustic monitoring, and operational data to help port authorities anticipate risks, improve vessel traffic decisions and respond to regulators and nearby communities with evidence (Milan et al., 2012; Port of Rotterdam Authority, 2019a; Tokaya et al., 2024).

Rotterdam's IoT platform collects data on tides, wind speed, wind direction, and visibility through a network of sensors and forecasting models. These data support real-time decisions on berthing windows, departures, loading and unloading operations, and broader port planning (Port of Rotterdam Authority, 2019a). In parallel, the port uses e-nose networks to detect changes in air composition, odors, and abnormal releases, turning dispersed complaints and isolated observations into operational information that can trigger faster and more targeted responses (Milan et al., 2012).

The port is also applying artificial intelligence to acoustic monitoring near berthing locations, allowing noise from moored vessels to be measured under real operating conditions and translated into useful information for public authorities and urban planners (Peutz Group, 2025). This monitoring is linked to mitigation measures such as Onshore Power Supply, which allows vessels at berth to use electricity from shore instead of running auxiliary engines, reducing local emissions and noise (Krämer & Czermański, 2020).

Business model: The Port of Rotterdam creates value by turning environmental monitoring into decision-support infrastructure. Continuous and documented data reduce regulatory risk, improve incident detection, support more accurate source attribution and help direct mitigation investments to the areas where they have the greatest impact. Rather than treating environmental compliance as a reactive obligation, Rotterdam's model shows how IoT and AI-supported monitoring can strengthen operational efficiency, environmental performance, and trust with public authorities and surrounding communities.

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San Pedro Bay Ports: Clean Air Monitoring and Shore Power for Emissions Reduction

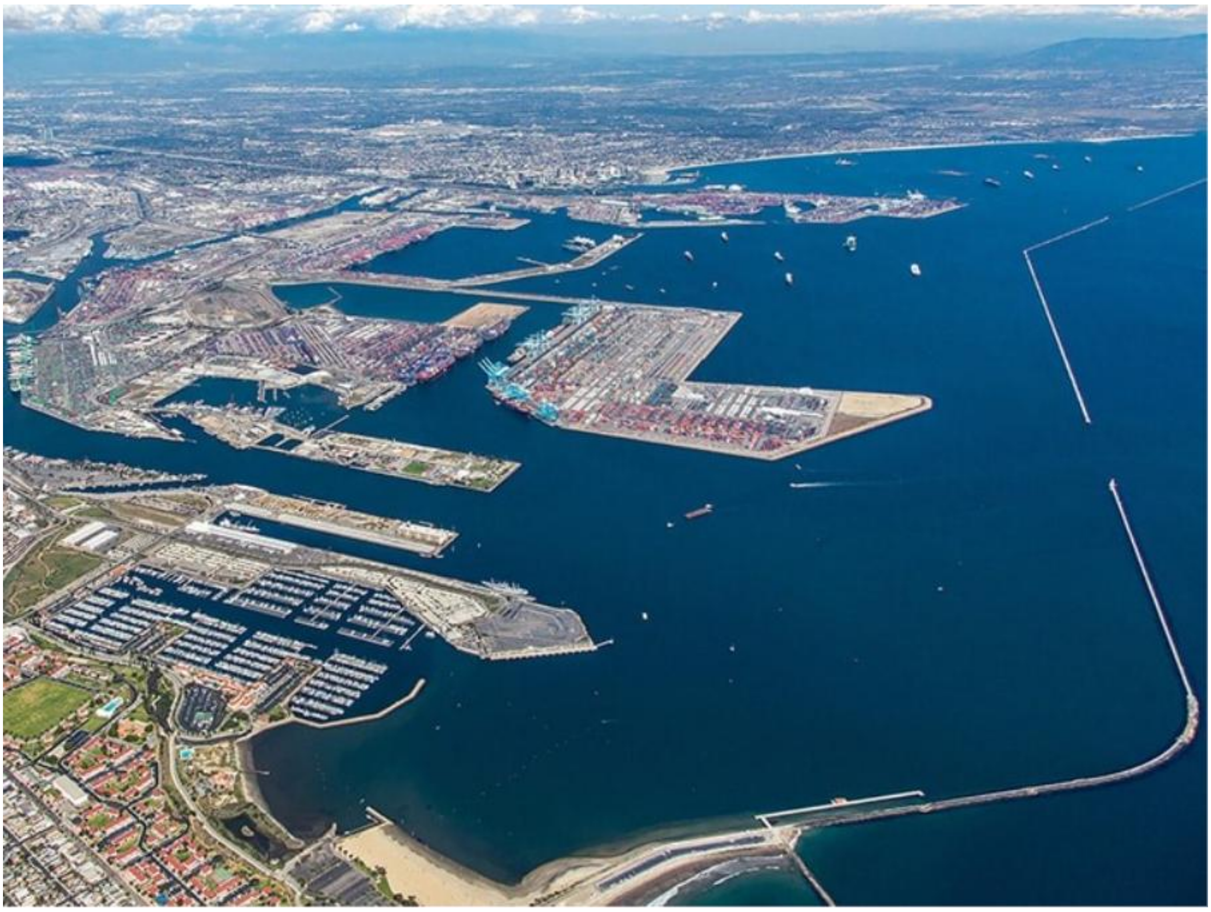
Los Angeles and Long Beach, USA · Clean Air Action Plan, real-time air monitoring and shore power

The ports of Los Angeles and Long Beach provide a relevant example of port environmental monitoring focused on air emissions and public health. Through the San Pedro Bay Ports Clean Air Action Plan, the ports track environmental performance using detailed emissions inventories, real-time air-quality monitoring, and reports on technology demonstrations (Port of Los Angeles & Port of Long Beach, n.d.). This allows port authorities to measure progress, assess whether emission-reduction strategies are working and respond to air-quality concerns with data.

Since 2005, the Port of Los Angeles has operated an air-quality monitoring program in Los Angeles Harbor, using four monitoring stations to measure pollutants. The program is supported by meteorological monitoring equipment and provides real-time data for public review through the San Pedro Bay Ports air-monitoring platform (Port of Los Angeles, n.d.).

The Port of Los Angeles' Alternative Maritime Power program complements this monitoring approach by allowing suitably equipped vessels to connect to shore-side electricity while at berth, reducing the need to run diesel auxiliary engines (Port of Los Angeles, n.d.-b). This helps reduce local emissions from docked vessels, while supporting compliance with increasingly strict at-berth emissions regulation (Port of Los Angeles & Port of Long Beach, n.d.).

Business model: The San Pedro Bay Ports create value by turning air-quality monitoring into a tool for regulatory compliance, risk reduction, and clean-port investment. Continuous emissions tracking helps port authorities demonstrate progress, prioritize mitigation measures and support investment in cleaner technologies. The business case is based less on direct revenue generation and more on protecting the port's license to operate, reducing health and regulatory risks, and maintaining competitiveness as environmental standards tighten.



Valenciaport: Environmental Monitoring for Port-City Sustainability

Valencia, Spain · Mediterranean port authority · Environmental management, resource monitoring and stakeholder coordination

Valenciaport provides a useful example of how a Mediterranean port can integrate environmental monitoring into day-to-day port management. By measuring and managing environmental impacts linked to port activity, the port can address emissions, discharges, noise, resource use, and energy while maintaining its role as a logistics and trade hub.

This approach connects environmental performance with operational management. Regular assessment of activities that may interact with the environment, monitoring of natural resources and energy use, and measures to prevent or minimize emissions, discharges, noise and waste help the port manage environmental risks more consistently (Autoridad Portuaria de València, 2016).

Business model: Valenciaport creates value by using environmental monitoring to manage port-city impacts, improve compliance and guide preventive action. By embedding environmental data into port management, the port can reduce regulatory and reputational risk, support more efficient resource use and strengthen trust with public authorities, port users and nearby communities.

WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

- Deploy integrated monitoring across water quality, air emissions, noise, odours, meteorology and operations, starting with the highest-risk berth, terminal or industrial zone.
- Connect sensor data to dashboards so environmental alerts can influence berthing, loading, shore-power use, maintenance and incident response decisions.
- Use source-attribution analytics to identify the activities, vessels, terminals or weather conditions driving the highest environmental pressures.
- Link monitoring to mitigation measures, including shore power, electrified equipment, runoff control, spill prevention, noise barriers, cleaner fuels and targeted maintenance.
- Create transparent reporting channels for regulators, customers and nearby communities, using data to demonstrate performance, respond to complaints and strengthen the port's licence to operate.
- For technology companies, package sensors, acoustic monitoring, e-nose networks, dashboards, predictive analytics and compliance reporting into monitoring-as-a-service solutions.
- Link port environmental monitoring to ESRS reporting, environmental management systems, investment planning and measurable SDG 14 contributions.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Monitoring coverage	Port area, berths or terminals covered by water, air, noise and odor monitoring; sensor uptime; measurement frequency; number of parameters monitored.	Sensor network records; environmental monitoring dashboards; maintenance logs; coverage maps.
Water quality and marine pollution	Pollutant concentrations; pH, temperature, salinity, dissolved oxygen and turbidity; exceedances; spills detected; detection-to-response time; contamination events avoided.	Water-quality sensors; laboratory analysis; incident records; port environmental reports.
Air emissions and climate	NO_2, SOx, PM and CO_2e estimates; shore-power connections; auxiliary engine hours avoided; fuel avoided; emissions per vessel call; clean equipment deployed.	Air-quality stations; emissions inventories; shore-power logs; vessel-call data; energy consumption records.
Noise and odour management	Noise exceedances; low-frequency noise events; odor alerts; complaints; response time; mitigation measures implemented; hotspot reduction.	Acoustic sensors; e-nose networks; complaint systems; response logs; mitigation records.
Operational and financial performance	Waiting time reduction; berth-planning improvements; disruption costs avoided; fines or non-compliance events avoided; mitigation investments prioritized.	Port operations systems; financial data; regulatory records; investment plans; incident-response records.
Community, compliance and trust	Public reporting frequency; stakeholder engagement; complaints resolved; regulatory submissions completed; audit findings closed; monitoring data transparency.	Stakeholder records; public dashboards; regulator correspondence; ESG/ESRS reports; audit documentation.

Table 30 | Indicative KPIs examples for implementation

CHALLENGE 9: IMPROVING ENERGY EFFICIENCY OF VESSELS AND ONBOARD SYSTEMS

Improving energy efficiency in vessels and onboard systems is one of the most immediate and implementable ways to reduce operating costs and climate-related pressures across the blue economy. The challenge is relevant to Shipbuilding & Refit, Fisheries and Fish Processing, and Blue Renewable Energy because vessels, service craft and offshore operations all depend on fuel-intensive propulsion, auxiliary engines, hydraulic systems, refrigeration, pumping, onboard power, route planning and hull/propeller performance.

For fishing fleets, fuel is often one of the most sensitive operating costs and can directly affect the economic resilience of fishers and processors. For shipbuilders, refit yards and equipment suppliers, efficiency creates a market for retrofits, coatings, digital energy-management systems, propulsion optimization, batteries, hybridization, waste-heat recovery and smarter onboard power systems. For offshore renewable energy and maritime services, efficient vessels and better operational planning reduce mobilization costs, weather-related delays and emissions associated with maintenance and inspection activities.

The challenge is therefore not only about replacing fuels. It is also about reducing the energy required to perform the same maritime function. In practice, this includes lower-friction hull and propeller surfaces, improved maintenance, real-time fuel monitoring, voyage optimization, regenerative or hybrid power management, digital twins, operational analytics and crew decision-support. These measures are particularly relevant because the FuelEU Maritime Regulation has applied from 1 January 2025 and sets progressively tighter greenhouse gas intensity limits for energy used by ships above 5,000 gross tonnage calling at European ports, while allowing operators to choose the technologies and fuels best suited to their operational profile (European Commission, 2026).

For Portugal, the opportunity lies in connecting vessel operators, shipyards, refit companies, ports, fisheries organizations, maritime technology providers and blue economy hubs around practical efficiency pilots. These pilots can deliver measurable fuel or energy savings while creating a market for domestic technical services, monitoring, maintenance, data analytics, retrofit engineering and operational optimization.

SDG 14 ALIGNMENT: LIFE BELOW WATER

The alignment with SDG 14 is moderate and mostly indirect. Vessel and onboard energy efficiency primarily contributes to climate mitigation and should therefore be mapped mainly to ESRS E1 Climate Change. It becomes more relevant to SDG 14 when the efficiency intervention also reduces marine pollution risks, improves environmental performance of fishing and maritime operations, or supports more sustainable use of marine resources.

This is not a strong SDG 14 case by default. It should not be presented as an ocean regeneration solution unless the company can show credible evidence of reduced pressure on marine or coastal ecosystems. However, when efficiency reduces fuel burn, exhaust emissions, lubricant or coating-related pollution risks, unnecessary vessel movements, and operational pressure in sensitive marine areas, the connection to SDG 14 becomes more defensible.

Target	Relevance to the challenge	Strength of alignment
14.1	Potential contribution through reduced risk of marine pollution if efficiency measures are linked to lower fuel use, cleaner coatings, fewer spill risks, reduced exhaust pollutants or lower operational pressure.	Weak to moderate; strongest when pollution reduction is measured.
14.2	Possible contribution where energy-efficiency measures reduce vessel activity, disturbance or emissions in sensitive marine and coastal ecosystems, especially in fisheries, protected areas or offshore operations.	Conditional; depends on operational context and ecological safeguards.
14.7	Relevant where lower operating costs and cleaner maritime operations increase the economic benefits from more sustainable use of marine resources, including fisheries, ports and coastal territories.	Moderate if business value and sustainability outcomes are both evidenced.
14.a	Relevant when pilots generate technical knowledge, data, skills and marine technology transfer around vessel performance, monitoring and energy optimization.	Moderate where knowledge transfer and local capability-building are explicit.

Table 31 | Alignment with the SDG 14 targets

THE BUSINESS CASE: COST REDUCTION

The primary business case is cost reduction. Fuel, electricity, maintenance, downtime and regulatory exposure are direct cost drivers for vessel owners, fisheries operators, ship managers, ports and offshore service providers. Efficiency measures create value when they reduce fuel or energy consumption per voyage, per fishing trip, per tonne landed, per nautical mile, per operating hour or per maintenance intervention.

The logic is simple: if the same vessel, fleet or onboard system can perform the same operational function with less fuel, less energy, less downtime or lower performance degradation, the company reduces operating expenditure and improves resilience against fuel price volatility and future carbon-related costs. In commercial shipping, propeller condition, hull resistance, voyage planning and onboard energy management can affect fuel consumption, CII performance, EU ETS exposure and operating costs (Graphite Innovation & Technologies, 2026).

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There is also a secondary new business model opportunity for technology providers, shipyards, refit companies and maritime data companies. They can convert efficiency expertise into recurring services: monitoring-as-a-service, energy optimization software, predictive maintenance, coating-performance management, retrofit packages, route intelligence and performance-based contracts. For companies operating vessels, however, the business case should be framed first as cost reduction and risk reduction, not as a broad sustainability narrative.

ESRS MAPPING

ESRS topic	Connection	Possible indicators
E1 Climate Change	Main ESRS fit. If fuel or energy savings are explicit and quantifiable, the case should be classified as E1 Climate Change rather than as a weak or no-fit sustainability case.	Baseline fuel/energy use; fuel saved; kWh saved; CO2e avoided; percentage efficiency gain; emissions intensity per voyage, tonne landed or nautical mile.
E2 Pollution	Only relevant when the solution also reduces marine pollution, exhaust pollutants, leakage, biocide leaching, oil spill risk, waste or water contamination.	Pollutants avoided; biocide-free coating use; spill incidents avoided; NOx/SOx/PM reductions where measured.
E5 Resource Use and Circular Economy	Relevant where refit extends vessel lifetime, optimizes materials, reduces replacement needs or converts equipment maintenance into circular service models.	Lifetime extension; components refurbished; waste avoided; materials reused; maintenance intervals extended.
S3 Affected Communities / S4 Consumers and End-users	Relevant where fishing communities, port communities or customers benefit from more resilient, cleaner or more affordable maritime services.	Fuel-cost exposure reduced for fishers; training delivered; safety improvements; local suppliers engaged.

Table 32| Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

Graphite Innovation Technologies (GIT): Graphene-based Marine Coatings for Hull and Propeller Efficiency

Canada - Biocide-free hard foul-release coatings - Hull and propeller performance management

GIT develops graphene-based marine coatings designed to improve vessel performance and reduce environmental impact. Its coatings are positioned as biocide-free hard foul-release solutions that reduce fuel consumption, protect the environment and support fleet decarbonization. The company presents XGIT-VORTEX as a propeller coating designed to maintain a cleaner and smoother propeller surface over time, with claimed fuel savings of up to 5% and lower emissions (Graphite Innovation & Technologies, 2026).

This is highly relevant to the challenge because hull and propeller condition directly affects resistance, propulsion efficiency, fuel use, emissions and operating costs. It is also relevant to shipbuilding and refit, because coatings can be implemented during dry-docking, maintenance cycles or vessel-performance programs.

Business model: GIT creates value by selling and supporting coating solutions that allow shipowners and operators to reduce fuel use, protect vessel performance and improve lifecycle efficiency. The model can also support performance-management services where coating data, hull condition and fuel savings are tracked over time.

Sofar Ocean: Real-time Ocean Data and Voyage Optimization for Fuel and Emissions Reduction

United States - Wayfinder voyage optimization - Spotter real-time ocean data network

Sofar Ocean operates an ocean intelligence platform that combines real-time ocean data, marine weather, vessel performance models and commercial constraints. Its Wayfinder solution recommends route, speed and schedule decisions for shipping companies, commercial operators

and vessel performance managers, and the company reports an average fuel reduction of 4-8% for its voyage optimization solution (Sofar Ocean, 2026).
Although not limited to fishing vessels, this benchmark is relevant because it shows how operational data can become a direct efficiency lever. Real-time ocean conditions, route optimization and speed guidance help operators reduce fuel use, improve schedule reliability and avoid weather-related inefficiencies.
Business model: Sofar monetizes voyage intelligence and real-time ocean data as a software and data service. For vessel operators, the value proposition is cost reduction through lower fuel use and better operational decisions. For the blue economy ecosystem, the model shows how ocean data can be converted into measurable operational and climate value.

Marine Edge: Machine-learning Power Management for Smarter Vessel Efficiency
Israel - Machine-learning regenerative power management - Maritime transport efficiency
Marine Edge is positioned in Hub Azul / Dealroom as a maritime sustainability startup focused on reducing ship fuel consumption through smarter, machine-learning-based regenerative power management. The company's proposition is to optimize propulsive efficiency and onboard power management, helping ship operators reduce fuel consumption and emissions (Hub Azul Dealroom; Marine Edge).
This example is useful because it addresses the onboard systems dimension of the challenge. Instead of looking only at hull or route efficiency, it focuses on the interaction between propulsion, electrical loads, power management and data-driven optimization.
Business model: Marine Edge represents a software and systems-efficiency model that can be implemented as a retrofit or onboard optimization service. The business value for customers is lower fuel consumption and improved vessel efficiency; the business opportunity for technology suppliers is recurring analytics, software licensing and performance-based savings models.

ADDITIONAL BENCHMARK SOLUTIONS

Company / solution	Technology focus	Value proposition
Marorka / marine energy management systems	Onboard and shore-side energy monitoring, fuel analytics and decision-support for vessel performance.	Relevant as a benchmark for fisheries and commercial fleets because energy management systems can monitor fuel use, identify inefficient operating patterns and support operational change.
Machine-learning fuel-consumption modelling	Data fusion using voyage reports, AIS/onboard data, weather, sea-state and vessel-performance models.	Academic evidence shows strong potential for machine-learning techniques to predict ship fuel consumption when vessel data are combined with climate and sea data, supporting route, speed and trim optimization (Mohamed et al., 2025; Marijan et al., 2026).
Shipyard/refit energy-efficiency packages	Retrofit engineering, propulsion optimization, coatings, auxiliary systems, hybridization and onboard monitoring.	Creates a practical opportunity for shipbuilding and refit companies to move from one-off maintenance to efficiency-driven service packages with measurable fuel, CO_2e and cost savings.

Table 33 | Additional Benchmark Solutions

INDICATIVE KPIs

For this business case to be credible, companies need to define a system boundary before implementation. The baseline should state which vessel, voyage type, fishing trip, onboard system

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or operational profile is being measured. Without a baseline, it is not possible to claim fuel savings, CO2e reductions or cost reductions with credibility.

Evidence needed	Why it matters
Baseline fuel or energy use by vessel, route, trip, operating hour or tonne landed	Defines the starting point for cost and emissions reduction.
Operating profile and system boundary	Prevents overclaiming by clarifying whether savings relate to propulsion, auxiliary loads, route choice, refrigeration, pumps, hull performance or total vessel operation.
Efficiency gain (%) and absolute fuel/kWh saved	Allows both financial value and climate benefit to be calculated.
CO2e avoided and calculation method	Supports ESRS E1 Climate Change reporting and credible external communication.
Maintenance, downtime and performance degradation data	Shows whether the solution reduces lifecycle cost and not only fuel use.
Evidence of pollution reduction where relevant	Needed before mapping to E2 Pollution or making SDG 14.1 claims.

Table 34 | Indicative KPIs examples for implementation

Portugal can use this business cases and challenge to connect three blue economy agendas that are often treated separately: fisheries competitiveness, shipbuilding and refit modernization, and maritime/offshore energy services. A practical pilot could involve one fishing vessel, port service vessel or offshore maintenance vessel, a Portuguese shipyard or refit provider, a technology company, a fuel/emissions-data partner and a research or blue economy hub.

The most credible starting point is not a broad decarbonization claim, but a measurable efficiency pilot: baseline fuel use, select one intervention, monitor savings, calculate CO2e avoided, test operational feasibility and evaluate whether the model can be replicated across a fleet. This creates a clear business case for companies while contributing to a more efficient and lower-impact blue economy.

CHALLENGE 10: DIGITAL TWINS: BRIDGING OCEAN DATA AND OPERATIONAL DECISIONS

Maritime operators, coastal authorities and offshore energy companies make high-stakes decisions daily – on vessel routing, port scheduling, infrastructure maintenance, environmental permitting and emergency response –without reliable access to the current or predicted state of the marine environment. The problem is not only a lack of data – in many coastal and infrastructure-heavy environments, data exists in abundance. The deeper problem is that even where data exists, it remains fragmented, incompatible and disconnected from the workflows where decisions are actually made.

There is often no live connection between what the ocean is doing and what operators can do about it. An offshore wind farm operator cannot model how a developing storm will affect structural loads before deciding whether to evacuate personnel. A port authority cannot predict sediment dynamics well enough to optimize dredging schedules. A coastal regulator cannot quantify the cumulative noise impact of simultaneous construction activities on protected species in time to enforce compliance.

This challenge targets the integration of heterogeneous real-time ocean data into operational decision workflows. Operational ocean digital twins is the technological form this integration takes: A digital twin is defined by ISO/IEC 30173:2023 as a digital representation of a target entity with live data connections that synchronize physical and digital states.

The marine digital twin market was valued at USD 0.59 billion in 2025 and is projected to reach USD 2.40 billion by 2032 at a CAGR of 23.2% (MarketsandMarkets, 2026).

SDG 14 ALIGNMENT: LIFE BELOW WATER (ENABLING)

This challenge operates as an enabling layer: it does not directly prevent pollution or protect ecosystems, but it builds the decision-support infrastructure without which environmental management decisions cannot be made effectively or in time. When integrated into operational workflows, digital twins actively improve the quality of decisions that determine environmental outcomes.

Target 14.2	Sustainably manage and protect marine and coastal ecosystems and strengthen their resilience. Operational digital twins provide the real-time situational awareness and predictive modelling needed for evidence-based coastal management – enabling authorities to detect environmental stress, model cumulative impacts and intervene before damage becomes irreversible.
Target 14.a	Increase scientific knowledge, develop research capacity and transfer marine technology. Operational ocean digital twins represent the most advanced current expression of marine technology transfer – building the technical infrastructure and human capacity for data-driven ocean management at scale.

Table 35 | Alignment with the SDG 14 targets

The value of connecting data to decisions is that it changes the cost structure of environmental management: detecting a pollution event or ecosystem stressor in near-real-time enables a targeted, low-cost intervention, whereas discovering the same problem weeks later through periodic surveys triggers expensive remediation, regulatory action or reputational damage.

THE BUSINESS CASE: REDUCED COSTS & NEW BUSINESS MODEL

The primary value of operational ocean intelligence is replacing expensive reactive decisions with model-driven planning. Port operators who can predict tidal conditions, sediment dynamics and vessel interaction effects hours in advance optimize berth scheduling and prevent costly incidents. Offshore energy operators who model structural fatigue and maintenance windows in a digital environment avoid unplanned downtime that can cost millions per day. Coastal authorities with predictive environmental models intervene before ecosystem degradation triggers regulatory enforcement or remediation programs.

Simultaneously, continuously updated decision-support platforms represent a fundamentally new product category–a SaaS business model for sectors that have historically relied on one-off consultancy reports or static software licenses. Instead of commissioning an environmental impact assessment, a port operator subscribes to a living model of their harbor. Instead of procuring a hydrographic survey, a coastal manager accesses continuously updated current and bathymetric data through a dashboard. This shift from project-based consulting to operational subscriptions opens an entirely new commercial structure for the ocean data and marine technology sectors.

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The following examples illustrate how companies are already commercializing this transition building businesses around the connection between ocean data and the decisions that depend on it.

ESRS MAPPING

ESRS topic	Connection	Possible indicators
E1 Climate Change	Operational digital twins can improve climate-risk assessment, adaptation planning and low-carbon operational decisions by modelling storms, waves, currents, sea-level conditions, vessel routing, offshore renewable operations and infrastructure resilience.	Climate-risk scenarios modelled; extreme-event alerts; routing or scheduling changes; fuel/CO2e avoided; downtime avoided; offshore asset availability; climate adaptation measures triggered.
E2 Pollution	Digital twins can integrate pollution monitoring, source attribution, oil-spill modelling, sediment plume modelling and underwater noise scenarios into operational decisions, enabling earlier response and more targeted mitigation.	Pollution events modelled; response time; oil-spill or plume scenarios; noise exceedance alerts; mitigation actions triggered; compliance breaches avoided; corrective actions closed.
E3 Water and Marine Resources	This is highly relevant where digital twins model currents, bathymetry, dredging needs, sediment dynamics, water quality, coastal processes or marine spatial use, helping companies and authorities manage marine resources more efficiently.	Data layers integrated; current and bathymetry updates; dredging optimization; water-quality thresholds; model coverage; operational decisions supported; marine-space conflicts identified.
E4 Biodiversity and Ecosystems	Digital twins can support biodiversity and ecosystem management when they include habitat data, protected species, underwater noise, cumulative impacts, ecosystem stress and restoration outcomes in predictive models.	Protected species risk alerts; habitat or ecosystem layers integrated; cumulative impact assessments; biodiversity monitoring coverage; restoration outcomes modelled; environmental thresholds exceeded/avoided.
ESRS 2 / Governance and strategy	Digital twins create value only when they are embedded in governance and decision workflows. Companies need defined data ownership, model validation, accountability, escalation protocols and decision rights.	Governance roles defined; data quality controls; model validation frequency; decision protocols documented; user adoption; audit trail of decisions; regulatory reporting supported.

Table 36 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

HydroTWIN: Acoustic Digital Twin for Real-Time Ocean Noise Intelligence

Azores, Portugal · Founded May 2023 · Spin-off of blueOASIS · Portugal Ventures portfolio

HydroTWIN connects a specific, high-value ocean data stream–underwater acoustics–directly to the operational decisions that depend on it. Its SCOUT device integrates AI, IoT and high-performance computing to monitor, detect, classify and geolocate underwater noise sources in real time: cetacean calls, ship engines, offshore construction. Data is processed at the edge and transmitted via satellite to HydroTWIN's cloud platform. The system integrates with Sofar Ocean's Spotter buoy and has been deployed in the EU PHAROS project as part of the European Digital Twin of the Ocean (Portugal Ventures, 2024; SOM-INNPORT, 2025).

The key business problem HydroTWIN solves: offshore energy operators and port authorities currently cannot demonstrate continuous environmental compliance with underwater noise regulations–they rely on periodic surveys that leave long gaps in evidence. HydroTWIN replaces those gaps with always-on compliance monitoring, transforming a regulatory burden into a continuous data product and reducing the risk of enforcement action or project delays.

ILIAD: Federated Ocean Digital Twin Infrastructure

EU Horizon Europe / Green Deal · 56 partners · 18 countries · 22 validated operational digital twins

ILIAD directly addresses the interoperability problem at the core of this challenge: ocean data exists but cannot flow between systems. The project built a federated, OGC-standard Digital Twin of the

Ocean architecture connecting diverse data sources–IoT sensors, satellites, citizen science, AUVs–into a unified, queryable ocean data space. It validated 22 operational digital twins across use cases including harbor safety, oil spill modelling, offshore renewable energy, fisheries and water quality, and demonstrated live interoperability with the European Digital Twin of the Ocean (EDITO). Its ILIAD Marketplace hosts over 100 products with 315 active users (CORDIS, 2025; OGC, 2025).
Relevance: ILIAD is the closest existing proof-of-concept for the interoperable API layer this challenge requires. Its harbor safety DTO in Crete–built on Apache Kafka with real-time sensor integration, alert generation and direct triggering of oceanographic models–demonstrates exactly how ocean data can be connected to operational decisions rather than stored in isolated repositories.

WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

- Identify high-value operational decisions that depend on ocean conditions, such as vessel routing, berth allocation, offshore maintenance, dredging schedules, environmental permitting, aquaculture management, emergency response or construction timing.
- Map the data needed to support those decisions, including sensors, satellite data, bathymetry, metocean models, ecological datasets, noise measurements, asset data, maintenance logs and regulatory thresholds.
- Develop a focused digital twin pilot around one operational use case before scaling to a full system, for example harbour safety, offshore wind maintenance windows, sediment management, underwater noise compliance or pollution response.
- Connect real-time and historical data through interoperable APIs, common standards and clear metadata so that the twin can be updated continuously rather than treated as a static model.
- Define decision rules, thresholds and response protocols that clarify how model outputs should trigger operational actions, escalation, stakeholder communication or regulatory reporting.
- Validate model outputs against real observations and operational outcomes to build trust with users, regulators, insurers, investors and affected stakeholders.
- Integrate digital twins into existing workflows and dashboards used by operations, HSE, sustainability, engineering, compliance and management teams.
- For technology providers, package digital twin capabilities as subscription-based products, including digital-twin-as-a-service, compliance monitoring platforms, scenario-modelling tools, environmental intelligence dashboards or API-based decision-support services.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Data integration and model quality	Number of data sources integrated; data latency; sensor uptime; model update frequency; model accuracy; forecast skill; metadata completeness; API availability; interoperability standards used.	Digital twin platform logs; sensor and API logs; model validation reports; data catalogues; QA/QC documentation.
Operational performance	Downtime avoided; maintenance windows optimized; berthing or routing decisions improved; dredging volumes or costs reduced; incidents avoided; planning time reduced; response time to events; asset availability improvement.	Operational dashboards; maintenance logs; port management systems; vessel-routing records; dredging

		records; incident reports; financial KPIs.
Environmental and compliance	Pollution events modelled or detected early; underwater noise exceedances avoided; cumulative impacts assessed; protected species alerts; environmental permits supported; compliance reports generated; corrective actions completed.	Environmental monitoring data; compliance reports; permitting files; HSE records; acoustic monitoring systems; biodiversity monitoring reports.
New business model	Subscription revenue; number of active users; clients/assets/sites under digital twin management; pilots converted to paid contracts; API calls; platform retention rate; products listed or services delivered through the platform.	Sales data; contracts; platform analytics; customer retention data; product marketplace records; service-level reports.

Table 37 | Indicative KPIs examples for implementation

CHALLENGE 11: OPERATING WHERE HUMANS CANNOT OR SHOULD NOT GO

Large portions of the marine environment remain effectively unmonitored and uninspected, not because the need is absent but because the cost and risk of sending humans there is prohibitive.
Offshore energy infrastructure (e.g. pipelines, cables, foundations, mooring systems) requires regular inspection, but crewed vessel operations with diver teams or tethered ROVs are expensive, weather-dependent, and in some cases dangerous. Marine protected areas, sensitive habitats and remote ocean zones require environmental monitoring, but periodic ship-based surveys are too infrequent and too disruptive to provide meaningful data continuity.

The global subsea inspection market exceeds USD50 billion, yet fewer than 1 percent of vessels entering EU ports currently undergo underwater inspection (Seedblink, 2025).
The economic impact of biofouling alone – the accumulation of marine organisms on ship hulls that increases drag, fuel consumption and emissions – costs the US maritime industry an estimated USD36 billion annually (Seedblink, 2025). Traditional inspection relies on divers and manually piloted tethered ROVs:slow, expensive, reactive, and heavily constrained by weather, visibility and trained personnel availability.
This challenge targets the deployment of autonomous and semi autonomous platforms to perform inspection, monitoring and data collection missions in areas that are currently too sensitive , too remote or too costly to access through conventional crewed operations. By removing the human from the most hazardous or inaccessible parts of the operation, autonomous platforms enable higher inspection frequency, lower cost per mission and access to environments previously out of reach.

SDG 14 ALIGNMENT: LIFE BELOW WATER

Autonomous operations support SDG14 by enabling more frequent and higher-quality environmental monitoring of sensitive marine areas, providing the evidence base for protection and management decisions.

Target 14.2	Sustainably manage and protect marine and coastal ecosystems. Autonomous platforms enable continuous, low-disturbance monitoring of sensitive habitats – coral reefs, seagrass beds, deep-sea environments – that crewed vessels cannot access without causing harm. This provides the data continuity required for evidence-based ecosystem management.
Target 14.5	By 2020, conserve at least 10 percent of coastal and marine areas. Autonomous monitoring platforms are a key enabler of Marine Protected Areas (MPA) management: they can operate within protected area boundaries with minimal ecological disturbance, tracking compliance with conservation objectives and detecting human activity or ecosystem change in near-real-time.

Table 38 | Alignment with the SDG 14 targets

The MPA use case is particularly compelling: Autonomous platforms are not exempt from MPA regulations, but where scientific monitoring is permitted, they offer a significantly lower disturbance footprint than crewed vessels or diver teams. This makes them the preferred tool for authorized monitoring missions in sensitive areas, enabling data collection with a footprint that would otherwise be impossible to justify in ecologically sensitive zones.

THE BUSINESS CASE: REDUCED COSTS & NEW BUSINESS MODEL

The primary value proposition is enabling inspections that are currently not happening at all, beca use they are too dangerous, too expensive, or physically impossible with conventional methods. Autonomous platforms do not simply replace existing operations: they make new ones viable, expanding the scope of what can b e monitored. Furthermore, subdron, subdron, an autonomous underwater inspection company, re ports its autonomous inspection system is up to 5x faster and 50% more cost-effective than traditional diver-led or tethered ROV methods, with the additional advantage of operating in zero-visibility conditions where conventional approaches fail entirely (Subdron, 2025).

For an offshore wind farm operator running quarterly mooring inspections across dozens of turbin e foundations, that cost reduction compounds significantly across a maintenance program.

The second business opportunity this challenges offers is a new business model: monitoring-as-a-service in areas previously inaccessible or unaffordable to monitor. Environmental agencies, port a uthorities and energy operators do not need to own or operate autonomous vehicles – they subscr ibe to inspection and monitoring services delivered by specialist providers with their own fleets of AUVs and ROVs. This shifts capital expenditure to operational expenditure, lowers the barrier to a doption, and enables service providers to build scalable businesses around recurring mission contr acts rather than one-off hardware sales.

The following examples illustrate how companies are already building commercially viable busines ses in this space – from fully autonomous inspection services to compact deployable ROV platforms th at democratise access to subsea operations.

ESRS MAPPING

ESRS topic	Connection	Possible indicators
E1 Climate Change	Autonomous and remotely operated inspection can reduce the need for large support vessels, repeated crew mobilization and inefficient inspection campaigns. In shipping, more frequent hull and biofouling inspection can support fuel-efficiency actions and lower emissions.	Vessel days avoided; crew mobilization avoided; fuel saved; CO2e avoided; inspection frequency; hull biofouling scores; fuel-efficiency actions triggered; offshore downtime avoided.
E2 Pollution	Autonomous platforms can detect leaks, debris, contamination, hull fouling, damaged infrastructure and pollution risks earlier, supporting targeted intervention before	Leaks or anomalies detected; response time; pollution events identified; debris observations; corrective actions triggered; compliance breaches avoided; water-quality alerts; inspection reports submitted.

	environmental damage or regulatory non-compliance escalates.	
E3 Water and Marine Resources	Autonomous inspection and monitoring create higher-resolution understanding of marine assets, water conditions, seabed areas, moorings, cables and infrastructure, improving the management of marine resources and ocean-dependent operations.	Area surveyed; assets inspected; mission frequency; water-quality parameters collected; bathymetric or sonar coverage; data gaps reduced; marine-space monitoring coverage; operational decisions supported.
E4 Biodiversity and Ecosystems	This is relevant when autonomous platforms are used for low-disturbance monitoring of sensitive habitats, MPAs, species, seabed condition or ecosystem change, especially where crewed vessels or diver teams would be disruptive.	Habitat area surveyed; MPA monitoring missions; species observations; biodiversity baseline data; disturbance footprint; protected-area alerts; ecosystem-change indicators; conservation reports generated.
S1/S2 Workforce and Safety	Autonomous platforms reduce human exposure to hazardous offshore, subsea and low-visibility operations by replacing or reducing diver work, difficult vessel operations and manual inspection in dangerous environments.	Diver hours avoided; hazardous offshore hours avoided; safety incidents; near misses; remote inspection rate; training completed; zero-visibility missions executed; emergency interventions avoided.

Table 39 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

subdron: First Fully Autonomous Underwater Inspection Platform

Lauterach, Austria · Founded 2018 · €5.9M raised · EIC Seal of Excellence · Porto subsidiary

subdron has built the first fully autonomous underwater inspection system combining AI, robotics and proprietary Relative Object Navigation (RON) technology that enables inspection vehicles to navigate at close proximity to complex underwater structures without human piloting–including in zero-visibility conditions. The system generates high-resolution 3D point clouds of port walls, ship hulls, pipelines and offshore infrastructure at 12,000+ data points per m², with automated processing for anomaly detection. subdron has run pilot projects with ports including Hamburg and Rotterdam, engaged defense clients including the German and Royal Dutch Navies, and secured 38+ Letters of Intent from shipowners and maritime authorities. A subsidiary has been opened in Porto, with strategic access to the Port of Leixões (EU-Startups, 2023; Seedblink, 2025).

Business model: subdron operates as a Robotics-as-a-Service provider, executing autonomous inspection missions on behalf of clients rather than selling hardware.

Blueye Robotics: Compact ROV Platform with Cloud-Based Mission Intelligence

Trondheim, Norway · Founded 2015 · X7 & X3 Ultra platforms · Blueye Cloud launched 2025

Blueye Robotics develops compact, professional-grade underwater ROVs designed for rapid deployment by non-specialist operators – eliminating the need for dedicated ROV pilots and large support vessels. Its latest platforms, the Blueye X7 (seven-thruster, six degrees of freedom, seven sensor ports) and X3 Ultra, target infrastructure inspection, mooring monitoring, environmental research and aquaculture. The company simultaneously launched Blueye Cloud – a browser-based fleet and mission management platform enabling dive replay, AI-assisted reporting, and data sharing–signalling a deliberate shift from hardware vendor to end-to-end subsea operations platform (Hydro International, 2025).

Business model: Blueye's move to integrate hardware, edge AI and cloud mission control creates a full-stack inspection-as-a-service model. Smaller teams can execute complex subsea operations with faster turnaround on data – addressing a key market constraint where subsea inspection demand is growing but skilled offshore personnel remain scarc e. Research with NTNU has validated Blueye X3 for autonomous mooring inspection in aquaculture and offshore wind, reducing O&M costs signific antly (Frontiers in Robotics and AI, 2025).

Aquatica: Professional ROV for Inland and Marine Monitoring
Poland · Early stage · Environmental monitoring and infrastructure inspection
Aquatica is developing a professional underwater ROV designed to democratise access to subsea monitoring across inland and marine environments. The vehicle integrates visual and sonar imagin g, water quality sensors and sample collection capabilities – covering bathymetric surveys, environ mental protection monitoring, aquaculture inspection, port and ship infrastructure assessment, an d security applications. Its design targets professional users who need precise data collection without the cost and complexity of traditional work-class ROV deployments (Aquatica, 2024).
Business model: Aquatica addresses the access gap in environmental monitoring: many agencies and operators who need subsea data cannot justify the cost of conventional ROV operations. By combining multi-sensor capability in a deployable platform, Aquatica enables monitoring programs–particularly in freshwater and coastal environments–that were previously unaffordable.

WHAT PRIVATE COMPANIES CAN DO

- Identify inspection and monitoring tasks where human access is unsafe, too expensive, too infrequent or too disruptive, such as hull inspection, mooring checks, cable surveys, port infrastructure inspection, MPA monitoring or sensitive habitat surveys.
- Prioritise one high-value pilot where autonomous or semi-autonomous platforms can reduce cost per mission, increase inspection frequency or open access to data that is currently unavailable.
- Compare the full lifecycle cost of conventional inspections with autonomous alternatives, including vessel mobilisation, diver teams, downtime, weather-window constraints, reporting time, safety risk and repeat mission requirements.
- Adopt Robotics-as-a-Service, inspection-as-a-service or monitoring-as-a-service models where ownership of vehicles, pilots, maintenance and data processing is better handled by specialist providers.
- Integrate autonomous inspection outputs into asset management, maintenance planning, HSE, compliance and ESG reporting systems so that data directly supports operational decisions.
- Use autonomous platforms for authorised low-disturbance monitoring in sensitive areas, ensuring alignment with MPA rules, environmental permits, scientific protocols and biodiversity safeguards.
- Define minimum data-quality requirements for autonomous missions, including geolocation accuracy, image or sonar resolution, repeatability, anomaly classification, metadata, chain of custody and reporting format.

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- For technology providers, package platforms and analytics into recurring services, including autonomous inspection missions, subsea data subscriptions, environmental monitoring packages, AI-assisted reporting or fleet management platforms.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Operational efficiency	Cost per inspection; mission duration; inspection frequency; assets inspected per mission; area surveyed; time from mission to report; downtime avoided; weather-window dependency reduced; repeat inspections avoided.	Mission logs; service invoices; asset management systems; maintenance records; operational dashboards; project cost data.
Safety and workforce exposure	Diver hours avoided; crewed vessel hours avoided; hazardous offshore hours avoided; zero-visibility missions completed; safety incidents; near misses; remote inspection rate; operator training completed.	HSE records; vessel logs; dive logs; training records; incident and near-miss reports; remote operations dashboards.
Data quality and decision support	3D point-cloud density; image or sonar resolution; geolocation accuracy; anomaly detection accuracy; percentage of assets with baseline data; data turnaround time; reports accepted by client/regulator; decisions supported.	Platform analytics; QA/QC reports; geospatial datasets; client acceptance records; regulatory submissions; AI model validation reports.
Environmental and compliance	MPA or sensitive habitat missions; habitat area surveyed; biodiversity observations; pollution or leak events detected; biofouling inspections completed; corrective actions triggered; environmental compliance reports generated.	Environmental monitoring reports; biodiversity survey data; compliance files; inspection reports; sensor data; client ESG or HSE reports.
New business model	Recurring mission contracts; Robotics-as-a-Service revenue; number of active clients; assets/sites under monitoring; fleet utilization rate; subscription renewal rate; pilots converted to commercial contracts; data products sold.	Sales data; contracts; CRM records; platform analytics; customer retention data; service-level reports; fleet utilization dashboards.

Table 40 | Indicative KPIs examples for implementation

CHALLENGE 12: FISHERIES TRACEABILITY

The global seafood supply chain faces a deep crisis of transparency. Illegal, unreported and unregulated (IUU) fishing accounts for one in every five fish caught worldwide, imposing an estimated annual economic toll of USD 26–50 billion (World Economic Forum, 2024). A 2026 FAO report confirmed that up to 20 percent of the USD 195 billion global fisheries and aquaculture trade is affected by fraud, including species substitution, origin mislabeling and falsified sustainability claims (FAO, 2026). In the United States alone, a 2025 meta-analysis found a mislabeling rate of 39.1 percent across tested seafood products (Ahles & Hellberg, 2025).

This challenge targets full end-to-end traceability across the seafood value chain – from capture or harvest to final consumer. By combining standardized data models (EPCIS/GS1), cold-chain monitoring, digital product passports and complementary analytical techniques (e.g. stable isotopes, DNA barcoding), traceability enables verifiable origin, integrity and sustainability claims, while reducing fraud and information asymmetry.

SDG 14 ALIGNMENT: LIFE BELOW WATER

The FAO's landmark Review of the State of World Marine Fishery Resources 2025 – assessing 2,570 individual stocks with input from over 650 experts across 90 countries – found that 35.5 percent of all fishery stocks are classified as overfished, with the global share rising by approximately 1 percent per year (FAO, 2025). Global efforts failed to meet the SDG Target 14.4 deadline to end IUU fishing by 2020.

This challenge, targeting end-to-end seafood traceability, directly supports two key SDG 14 targets:

Target 14.4	Effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices, and implement science-based management plans.
Target 14.6	Prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, and eliminate subsidies that contribute to IUU fishing. (Indirect support)

Table 41 | Alignment with the SDG 14 targets

Without reliable data on where, when, how and by whom fish was caught, it is impossible to enforce harvest regulations or implement science-based management. Traceability systems that cross-reference catch data against official records create a verifiable chain of custody, making it significantly harder for IUU products to enter legitimate markets. As regulatory frameworks tighten, including the EU catch certification scheme and the emerging EU Digital Product Passport (DPP) framework, businesses with robust traceability gain both compliance advantage and market access.

THE BUSINESS CASE: INCREASING PRICES + MARKET SHARE GROWTH

Business strategies oriented toward seafood traceability can advance SDG 14 objectives while enhancing business outcomes through two complementary mechanisms.

First, traceability enables the transparent verification of sustainability claims. It is important to note that traceability is a transparency tool, not a sustainability claim in itself – it reveals what exists in a supply chain, for better or worse. Companies whose sourcing is already well-managed can use traceability to credibly prove their practices, differentiating themselves from competitors who make unverifiable or fraudulent claims. Those with problematic sourcing may find that transparency exposes weaknesses. The business incentive is therefore twofold: invest in sustainable practices and adopt traceability to prove them. Research consistently shows that consumers are willing to pay premiums for traceable, sustainably sourced seafood. A study across eight European countries found willingness-to-pay premiums of 7 to nearly 20 percent for sustainability claims, depending on attribute and country (Ankamah-Yeboah & Nielsen, 2017).

Second, traceability drives increased market share through regulatory compliance. The EU catch certification scheme, the US Seafood Import Monitoring Program (SIMP) and the emerging EU Digital Product Passport (DPP) framework increasingly require proof of legal origin and chain-of-custody documentation. Companies without robust traceability infrastructure risk being locked out of major markets entirely. Those that invest early gain first-mover advantage, securing access to markets where non-traceable products are simply excluded.

Companies can also leverage digital platforms and blockchain to reach buyers more efficiently, enabling scalable solutions that protect domestically caught seafood from being undercut by mislabeled or illegal imports. The following examples also illustrate how traceability creates entirely new business models – from blockchain-based fish marketplaces to cross-commodity verification platforms, offering solutions for Challenge of end-to-end traceability.

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ESRS MAPPING

ESRS topic	Connection	Possible indicators
E4 Biodiversity and Ecosystems	Fisheries traceability is directly relevant to biodiversity and ecosystem impacts because it links seafood products to catch area, species, gear type, stock status, legal origin and management rules. It helps companies identify and reduce exposure to overfishing, IUU fishing, destructive practices and high-risk sourcing.	Share of volume traceable to vessel/farm and catch area; species-level traceability; stock-status coverage; volume from verified legal sources; high-risk sourcing reduced; IUU-risk flags; certified or verified sustainable sourcing; bycatch or gear-risk data captured.
E2 Pollution	Traceability can support monitoring of cold-chain conditions, product integrity and fishing or aquaculture practices associated with pollution risks, especially when linked to vessel data, gear information, farm inputs or processing records.	Lots with cold-chain data; rejected lots due to integrity issues; gear type recorded; incidents linked to supplier practices; processing waste traceability; pollution-related supplier non-conformities; corrective actions completed.
G1 Business Conduct	Seafood traceability helps prevent fraud, mislabeling, falsified sustainability claims and non-compliant market entry. It supports supplier due diligence, anti-fraud controls, responsible sourcing governance and stronger evidence for legal origin claims.	Supplier due diligence coverage; chain-of-custody completeness; mismatches detected; fraud incidents prevented; audit pass rate; non-compliant lots blocked; recall events avoided; regulatory documentation completeness; third-party verification coverage.
S2/S4 Value Chain Workers and Consumers	Traceability can strengthen consumer information and product safety, and may also support value-chain due diligence where vessel, supplier or labor-risk data are integrated. Its social relevance is strongest when traceability goes beyond product origin to include labor and human-rights risk indicators.	Consumer-facing QR scans; product information accuracy; complaints related to labelling; food safety incidents; labor-risk screening coverage; suppliers with social compliance checks; vessel-level due diligence; corrective action closure rate.
E1 Climate Change	When combined with catch method, vessel activity, cold-chain, logistics and processing data, traceability can help companies understand and report emissions linked to seafood sourcing and distribution.	Products with carbon or transport data; cold-chain energy data; logistics distance; emissions by product line; low-carbon sourcing share; refrigerated transport performance; data availability for Scope 3 reporting.

Table 42 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

Legit Fish: Government-Verified Seafood Traceability

Boston, USA · Founded 2018 · USD 1.57M raised (Tracxn, 2026)

Legit Fish is a seafood traceability company providing cloud-based software to the US domestic commercial fishing industry. Its patented technology generates unique tracking identifiers that are cross-referenced against official government harvest records – making it the first system that concretely verifies seafood against public data (Legit Fish, 2024). The platform tracks species, gear type, catch volume and location from vessel to processor, with on-pack QR codes enabling consumer verification. Partners including Northern Wind and Mission Driven Meat & Seafood have launched fully traceable products across multiple species (SeafoodSource, 2021).

Business model: Legit Fish doubles as a dockside ERP system, absorbing traceability costs within a broader business tool. Verified provenance enables partners to command premium prices by guaranteeing products are domestically harvested and not illegal substitutes.

Wholechain: Blockchain Supply Chain Transparency

Bloomfield Hills, USA · Fish 2.0 Winner at Stanford · GDST-verified

Wholechain is a blockchain-based traceability solution serving clients including Chicken of the Sea, Wegmans, Topco Associates and Estée Lauder. Using the Algorand blockchain, the platform creates immutable lot-level traceability records aligned with the Global Dialogue on Seafood Traceability

(GDST) standard and GS1 EPCIS (Wholechain, 2024). Wholechain has piloted fully traceable shrimp with Fair Trade USA and Mastercard, traced over one million pounds of Alaska sockeye salmon with Northline Seafoods, and partnered with the Yucatan Government and Environmental Defense Fund for small-scale fisher (SeafoodSource, 2024).
Business model: Wholechain enables enterprises to coordinate and share supply chain data, raising prices through verifiable consumer storytelling about product provenance. In one documented case, the system caught accidental origin mislabeling at a distribution center before products reached retailers, averting a potential recall (Algorand, 2024).

Bitcliq: Blockchain Marketplace for First Sale of Fish
Caldas da Rainha, Portugal · Founded 2013 · €600K raised (EU-Startups, 2019)
Bitcliq developed Lota Digital, the world's first blockchain marketplace for fish trading, in partnership with Docapesca, Portugal's stateowned fish quality assurance entity. The platform c onnects fishing fleets directly with buyers, enabling purchase of fish the moment it is caught at sea . Using IoT, edge computing, satellite transmission and Ethereum blockchain, it provides real-time fleet monitoring and full chain-ofcustody documentation with consumer-facing smart labels. The company has also developed international projects with fleets across Afric a, Asia, the USA and Europe (Bitcliq, 2024).
Business model: Bitcliq disrupts the traditional fish auction system by connecting fishermen directl y to buyers while fish is still at sea, enabling better prices for fishermen and fully traceable product for consumers. The consumer brand "Saber a Mar" sells traceable fresh fish from sea to plate.

Additional Benchmark Solutions

Company	Technology	Value Proposition
Shellcatch	Camera/AI onboard monitoring	Automated species ID and catch documentation via computer vision at point of harvest.
Provenance	Blockchain transparency platform	Blockchain-backed proof points for brands to verify and communicate sustainability claims.
FishLog Int.	Tech-driven supply chain	Curated marketplace connecting sustainable producers with food service and distributors.
TRACE4EU	EU Digital Product Passport (EBSI)	EU-funded pilot implementing DPPs for seafood, establishing the regulatory blueprint for mandatory traceability.

Table 43 | Additional Benchmark Solutions

WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

- Map the full seafood value chain from vessel, farm, landing site or auction through processing, logistics, retail and final consumer, identifying where data is lost, duplicated or manually reconciled.
- Adopt interoperable traceability standards such as GS1 EPCIS and GDST-aligned data models so that suppliers, processors, retailers and regulators can exchange chain-of-custody data consistently.
- Define minimum data fields for each lot, including species, scientific name, catch or harvest area, vessel/farm, gear type, date, landing documentation, batch transformation, cold-chain conditions and certification status.

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- Prioritise high-risk species, geographies and supply chains where IUU fishing, mislabelling, origin fraud or sustainability claims are most material to the company.
- Cross-check internal traceability records against official catch certificates, landing declarations, government records, laboratory tests, supplier documents and third-party certifications.
- Use complementary verification methods such as DNA barcoding, stable isotope analysis, mass-balance checks or random audits to test whether digital records match the physical product.
- Integrate traceability into ERP, procurement, quality control, supplier due diligence and ESG reporting systems, rather than treating it as a separate communication or compliance add-on.
- Develop credible consumer-facing transparency tools, such as QR codes or digital product passports, but only where the underlying data is verified, complete and aligned with responsible sourcing practices.
- Prepare for tightening regulation by building evidence for legal origin, chain of custody, product integrity and sustainability claims before these become mandatory market-access requirements.
- For technology providers, package traceability into scalable platforms, marketplaces, compliance modules, verification services or digital product passport solutions that reduce the burden on fishers, processors and buyers.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Traceability coverage and data quality	Percentage of products, lots or volume traceable to vessel/farm; species-level traceability; catch-area documentation; chain-of-custody completeness; data-field completion rate; time needed to trace product origin; number of suppliers onboarded.	Traceability platform; ERP; procurement records; supplier declarations; GS1/EPCIS records; QR or DPP data; audit trails.
Compliance and fraud prevention	Lots cross-checked against official records; mismatches detected; non-compliant lots blocked; mislabeling incidents; recall events avoided; supplier audit pass rate; documentation completeness for EU catch certification, SIMP or DPP requirements.	Government catch records; customs files; lab test results; supplier audits; compliance logs; recall records; regulatory submissions.
Sustainable sourcing and SDG 14 contribution	Share of volume from verified legal sources; certified or verified sustainable seafood share; high-risk sourcing reduced; IUU-risk suppliers removed; sourcing by stock status; gear-type coverage; bycatch-risk data captured.	Sourcing policies; certification data; fishery improvement project data; stock-status databases; supplier due diligence; NGO or scientific datasets; ESG reports.
Commercial performance	Price premium for traceable products; sales growth of verified products; access to regulated or premium markets; number of retail or food-service buyers requiring traceability; customer retention; QR scans; consumer engagement with provenance information.	Sales data; contracts; retailer requirements; customer analytics; QR scan dashboards; pricing data; market access documentation.
Platform and new service performance	Active platform users; lots traced per month; transaction volume; marketplace sales; recurring software or service revenue; data integrations completed; suppliers trained; pilots converted into commercial contracts.	Platform analytics; CRM; contracts; subscription data; transaction records; training logs; implementation reports.

Table 44 | Indicative KPIs examples for implementation

CHALLENGE 13: FISH BY-PRODUCT VALORISATION

Global fisheries and aquaculture production reached 223.2 million tonnes in 2022, with a first-sale value of USD 472 billion (FAO, 2024). Yet fish processing generates enormous volumes of by-products: between 30 and 75 percent of the raw material – an estimated 50 to 130 million tonnes per year – ends up as heads, bones, skin, scales, viscera and trimmings (Discover

Food / Springer Nature, 2026). Much of this material is discarded as waste, dumped back into the sea or sent to landfill, despite containing recoverable components like proteins, lipids and collagen as well as bioactive compounds with high-value applications in nutrition, cosmetics, pharmaceuticals and agriculture.

The fish waste management market was valued at USD 5.7 billion in 2025 and is projected to reach USD 7.6 billion by 2035 (Future Market Insights, 2025). However, the broader food waste valorization market is forecast to reach USD 132.2 billion by 2034 (ScienceDirect, 2024), indicating that fish by-product valorization represents only a fraction of its potential. A 2024 FAO/INFOFISH study across five countries confirmed that fishery by-products, previously discarded as trash, attract substantial local and international market demand when properly processed into collagen, chitin, chitosan, fishmeal and fish oil (INFOFISH, 2025).
This challenge focuses on valorization of by-products and biological waste in fisheries and fish processing.

SDG 14 ALIGNMENT: LIFE BELOW WATER

The relationship between fish by-product valorization and SDG 14 centers on pollution prevention. When fish processing waste is discharged into marine environments, it contributes to nutrient loading, oxygen depletion and habitat degradation. Target 14.1 calls for the prevention of marine pollution of all kinds. Fish processing waste, at industrial volumes, unambiguously qualifies.

Target 14.1	Prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities. Valorization of fish processing by-products diverts organic waste from marine discharge and landfill. At industrial volumes, this reduces nutrient loading and localized ecosystem degradation in coastal waters.

Table 45 | Alignment with the SDG 14 targets

By creating economic incentives to capture and process by-products rather than discard them, valorization aligns pollution prevention with commercial interest – making environmental protection financially self-sustaining rather than dependent on regulatory enforcement alone.

THE BUSINESS CASE:

Fish by-product valorization creates value through two complementary mechanisms. First, it reduces disposal costs. Waste handling, transport and landfill fees represent a significant operational expense for fish processors, particularly as environmental regulations tighten. Every by-product stream that is reclassified from “waste requiring disposal” to “raw material for processing” eliminates a cost and, in many cases, generates revenue.
Second, valorization enables entirely new business models and revenue streams. Fish skins and scales yield marine collagen for cosmetics and nutraceuticals – a high-margin product. Shrimp and crab shells produce chitosan for agricultural, pharmaceutical and industrial applications. Viscera and trimmings are processed into fishmeal, fish oil and protein hydrolysates for animal feed and human nutrition. Organic waste can be converted into biogas through anaerobic digestion. Companies that develop these valorization pathways become suppliers to industries far beyond seafood, creating diversified revenue from what was previously a disposal liability.
The following examples illustrate how companies around the world are already building commercially viable businesses around fish by-product valorization – offering fish processors dedicated collection and processing services while creating new revenue streams from what was previously a disposal cost.

ESRS MAPPING

ESRS topic	Connection	Possible indicators
E5 Resource Use and Circular Economy	This is the most material ESRS connection. Fish by-product valorization turns biological residues from fisheries and fish processing into secondary raw materials for food, feed, cosmetics, pharmaceuticals, agriculture, biomaterials or energy. It reduces disposal needs and increases resource productivity across the seafood value chain.	Tonnes of by-products recovered; percentage of by-products valorized; waste-to-product conversion yield; disposal avoided; revenue from by-product streams; share of secondary raw materials used; number of circular products developed; landfill or sea-discharge diversion rate.
E2 Pollution	Valorization prevents organic waste, nutrient-rich residues and processing by-products from being discharged into water bodies or sent to landfill. It can reduce local nutrient loading, odor, leachate, oxygen depletion and contamination risks associated with unmanaged biological waste.	Tonnes of organic waste diverted from discharge; nitrogen/phosphorus load avoided; BOD/COD reduction; landfill avoided; effluent quality; incidents of waste discharge; compliance events avoided; odor complaints; wastewater treatment load reduction.
E4 Biodiversity and Ecosystems	By reducing disposal of fish residues into coastal or marine environments, valorization can reduce pressure on habitats affected by nutrient enrichment, oxygen depletion and localized ecosystem degradation. The link is strongest where processors are located near sensitive coastal ecosystems.	Sensitive coastal sites protected; local ecosystem monitoring indicators; habitat degradation incidents avoided; waste discharge near marine protected areas avoided; by-product capture at coastal processing sites; biodiversity risk assessments completed.
E1 Climate Change	Valorization can reduce GHG emissions associated with landfill, waste transport and production of virgin inputs. Waste-to-energy routes can generate renewable biogas, while collagen, chitosan, proteins and oils can substitute more carbon-intensive inputs in other industries.	GHG emissions avoided; biogas produced; fossil energy substituted; transport avoided; landfill methane avoided; carbon footprint per valorized product; avoided emissions from substituted materials; renewable energy generated from organic residues.
S4 Consumers and End-Users / Product Safety	When by-products are transformed into ingredients for food, nutraceuticals, cosmetics, pharmaceuticals or animal feed, product safety, quality control, traceability and transparent claims become essential. Consumer relevance increases when products are sold as premium marine ingredients.	Food/feed/cosmetic safety tests passed; traceability to processing origin; non-conforming batches; product recalls; allergen or contaminant controls; certifications obtained; customer complaints; verified claims on circular or marine-origin ingredients.
G1 Business Conduct	By-product valorization requires robust governance over waste classification, permits, supplier contracts, quality claims, safety standards and responsible marketing. It also helps companies demonstrate compliance with waste, food safety, environmental and circular economy regulations.	Permits obtained; supplier agreements; audit pass rate; regulatory non-compliances; chain-of-custody documentation; claims substantiation; third-party verification; corrective actions closed; compliance documentation for waste-to-product reclassification.

Table 46 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

3F Waste Recovery: Marine Collagen from Cod By-Products

Newfoundland, Canada · 2x Ocean Startup Challenge winner · Clean biotech manufacturing

3F Waste Recovery (Fish, Farm, Forest) is a Newfoundland-based clean biotech company that transforms by-products from the cod fishery into premium marine collagen, protein powders and oils for the nutraceutical, cosmetic and pharmaceutical sectors. The company works directly with local fish processors to source cod skins, bones, fins and heads – materials that were previously landfilled or dumped at sea. Its consumer brand "Collaskins" markets marine collagen products directly. At full operational capacity, 3F anticipates diverting over 5,000 metric tonnes of organic waste from landfill per year and generating more than USD 20 million per year in additional value from recovered materials (3F Waste Recovery, 2024; CBC News, 2018).

Business model: 3F operates as both a by-product processor and technology licensor. Revenue comes from sale of premium marine ingredients, consulting services for other processors, and licensing of its modular collagen extraction technology for deployment in fisheries worldwide.

WASE: Electro-Methanogenic Reactor for Organic Waste-to-Energy

UK · Proprietary EMR technology · Waste-to-bioenergy platform

WASE has developed a proprietary Electro-Methanogenic Reactor (EMR) technology that enhances anaerobic digestion to convert organic waste and wastewater – including fish processing effluent– into renewable energy (biogas), reusable water and agricultural inputs (digestate). The EMR achieves significantly faster processing times and higher biogas yields than conventional anaerobic digestion, making it viable for small and medium-scale food processors who previously could not justify the capital cost of biogas infrastructure (WASE, 2024).

Business model: WASE works directly with food and fish manufacturers to turn unavoidable waste into three revenue streams: bioenergy, clean water for reuse, and fertilizer. The technology converts a disposal cost into a triple output, making waste treatment economically self-sustaining.

AtlanticBioCorp: Chitosan Biopolymers from Fisheries Waste

Canada · Chitosan-based biopolymer solutions

AtlanticBioCorp transforms crustacean shells – shrimp, crab and lobster processing waste–into chitosan-based biopolymer solutions for industrial, agricultural and pharmaceutical applications. Chitosan, derived from chitin (the second most abundant natural polymer after cellulose), has applications ranging from water purification and wound dressings to agricultural crop protection and biodegradable packaging. By sourcing raw material from fisheries waste streams, AtlanticBioCorp eliminates a disposal problem while producing a high-value biomaterial (AtlanticBioCorp, 2024).

Business model: AtlanticBioCorp operates as a bio-materials manufacturer selling into multiple end-markets – agriculture, pharma, industrial–creating diversified revenue from a single waste feedstock. The company's value proposition to shellfish processors is simple: we take your waste and pay for it, rather than you paying to dispose of it.

Additional Benchmark Solutions

Company	Technology	Value Proposition
Biosolvit (Brazil)	Biotech products from discarded biomass	Develops new products from renewable sources and waste biomass, creating value from organic residues across aquaculture and agriculture.
Hofseth BioCare (Norway)	Marine by-product upcycling (salmon)	Upcycles salmon processing by-products into pharmaceutical-grade proteins, oils and calcium for human health, pet nutrition and aquaculture feed.
Acuinuga (Spain)	Flash dehydration of fish waste	Rapid dehydration technology that stabilizes fish processing waste at source, reducing volume and transport costs while preserving nutrient value for animal feed and fertilizer markets.

Table 47 | Additional Benchmark Solutions

WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

- Map by-product streams across species, processing lines and sites, quantifying volumes, seasonality, composition, current disposal routes and associated costs.

- Separate by-products at source and preserve quality through appropriate handling, cold chain, hygiene protocols and rapid stabilisation, since higher-value applications require cleaner and more consistent inputs.
- Segment valorisation pathways by value and regulatory requirements: food and nutraceutical ingredients, collagen, chitosan, protein hydrolysates, fish oil, feed ingredients, fertilisers, biomaterials or biogas.
- Start with one high-volume or high-value waste stream, such as fish skin, scales, viscera or crustacean shells, and run a pilot to test conversion yield, product quality, logistics and customer demand.
- Partner with biotech companies, feed producers, cosmetic and nutraceutical firms, agricultural-input companies, waste-to-energy providers, universities or technology licensors to accelerate route-to-market.
- Assess regulatory classification early, including whether the material can move from waste status to by-product, food/feed ingredient, cosmetic input, fertiliser, biomaterial or energy feedstock.
- Build collection agreements with fish processors, ports, auctions, aquaculture producers or shellfish processors to guarantee feedstock volume and quality.
- Use life-cycle assessment and product-level impact data to demonstrate avoided landfill, reduced discharge, avoided emissions and resource-efficiency benefits.
- Develop commercial contracts that share value between the waste generator and valorisation provider, turning disposal liabilities into recurring supply or revenue agreements.
- For technology providers, package valorisation into modular processing units, licensing models, processing-as-a-service, ingredient platforms or waste-to-energy systems that can be deployed close to fish-processing hubs.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Resource efficiency and circularity	Tonnes of by-products collected; percentage of by-products valorized; disposal volume avoided; by-product streams mapped; conversion yield; volume of secondary raw materials produced; share of waste reclassified as raw material.	Waste records; production logs; material-flow analysis; processor records; weighing tickets; batch records; circularity dashboards.
Environmental impact	Tonnes diverted from landfill or sea discharge; nitrogen/phosphorus load avoided; BOD/COD reduction; GHG emissions avoided; biogas produced; wastewater treatment load reduced; avoided virgin material use.	Environmental monitoring data; LCA results; effluent tests; landfill/disposal records; energy metering; digestate/fertilizer analysis; ESG reports.
Business performance	Disposal cost avoided; revenue from by-product products; gross margin per valorised product; number of paying customers; contracts with processors; payback period for valorization technology; logistics cost per tonne.	Financial accounts; sales data; contracts; invoices; procurement records; cost accounting; project financial models.
Product quality and compliance	Contaminant tests passed; microbiological safety; moisture/protein/collagen/chitin content; batch rejection rate; permits obtained; certifications; traceability to processing site; recalls or non-conformities.	Laboratory analysis; QA/QC records; certification audits; permits; traceability systems; batch documentation; regulatory submissions.

New business model and market development	Number of products commercialized; licensing agreements; modular units deployed; recurring service revenue; technology pilots converted to commercial contracts; new end-markets entered; customer retention.	CRM; licensing contracts; subscription/service contracts; deployment reports; sales pipeline; product portfolio records; customer analytics.

Table 48 | Indicative KPIs examples for implementation

CHALLENGE 14: GHOST FISHING

Every year, between 500,000 and one million tonnes of fishing gear are lost, abandoned or discarded in the world's oceans (WWF, 2020). This so-called "ghost gear"– including nets, traps, pots and longlines-constitutes approximately 10 percent of all marine litter and represents the most lethal form of marine plastic debris (FAO, 2024a). Discarded nets and ropes now make up roughly 46 percent of the Great Pacific Garbage Patch (WWF, 2020). Globally, an estimated 5.7 percent of all fishing nets, 8.6 percent of traps and pots, and 29 percent of fishing lines are lost to the marine environment (IISD/SDG Knowledge Hub, 2024).

Once lost, ghost gear continues to catch and kill marine life indiscriminately for years or even centuries. Made from durable synthetic materials such as nylon and polypropylene, lost traps and nets become "perpetual killing machines" (Resqunit, 2023): captured animals die and become bait, attracting further catches in a destructive cycle. Beyond ecological damage, ghost fishing imposes direct economic losses on fishers through lost equipment, depleted stocks, and reduced future income. In the Mediterranean alone, ghost fishing and related plastic pollution cause annual losses of €641 million (WWF, 2019).

This challenge focuses on reducing the impacts of ghost fishing to improve operational performance, reduce risk, and enable scalable deployment.

SDG 14 ALIGNMENT:

The FAO's Review of the State of World Marine Fishery Resources 2025 – assessing 2,570 individual stocks with input from over 650 experts across 90 countries – confirmed that 35.5 percent of fishery stocks are overfished, with the global share rising approximately 1 percent per year (FAO, 2025). Ghost gear compounds these pressures by continuing to extract biomass from already stressed stocks outside any management framework.

Reducing ghost fishing caused by lost or discarded fishing gear directly supports two key SDG 14 targets:

Target 14.1	By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution. Ghost gear reduction directly reduces marine plastic pollution.
Target 14.4	Effectively regulate harvesting and end overfishing, illegal, unreported, and unregulated fishing, and implement science-based management plans. Ghost gear prevention enhances sustainable fishing by reducing uncontrolled mortality on fish stocks.

Table 49 | Alignment with the SDG 14 targets

Ghost gear operates entirely outside fisheries management: it catches indiscriminately, across seasons and closed areas, without any harvest control. By preventing gear loss and recovering lost equipment, businesses contribute directly to marine pollution reduction (Target 14.1) and to sustainable fishing practices (Target 14.4) by eliminating a source of unregulated, unmonitored mortality on marine stocks.

THE BUSINESS CASE:

Business strategies targeting ghost fishing create value primarily through reduced costs for fishing operations. Gear loss represents a significant direct expense: crab and lobster traps cost hundreds of dollars each, and reactive recovery programs spend up to USD 400 per unit to retrieve lost equipment from the seabed (Resqunit, 2024). Preventive solutions–smart buoys, IoT tracking, timed-release retrieval devices–eliminate these losses at a fraction of that cost, while also reducing fuel consumption by enabling fishers to locate and manage their gear more efficiently.
Simultaneously, the ghost gear challenge has given rise to entirely new business models in the circular economy, depicting the connection to SDG 12, Target 5 "Substantially Reduce Waste Generation". End-of-life fishing nets and ropes (previously destined for landfill) are now collected, processed and recycled into raw plastic pellets for products ranging from kayaks and sunglasses to outdoor clothing and office furniture. These ventures demonstrate how sustainability challenges can be the birthplace of new commercial enterprises, transforming waste streams into revenue.

ESRS MAPPING

ESRS topic	Connection	Possible indicators
E2 Pollution	Ghost gear is a form of marine plastic pollution. Prevention, retrieval and recycling of fishing gear reduce pollution pressure in marine and coastal environments and can support more targeted pollution-prevention programs.	Tonnes of ghost gear prevented, retrieved or recycled; number of retrieval missions; gear-loss rate; end-of-life gear collected; pollution incidents avoided; share of gear with tracking or marking.
E4 Biodiversity and Ecosystems	Lost gear continues to catch fish, marine mammals, seabirds, turtles and other species outside any harvest-control system. Preventing gear loss and removing abandoned gear reduces uncontrolled mortality and habitat disturbance.	Estimated ghost-fishing mortality avoided; number of entanglement events prevented or reported; gear removed from sensitive habitats or MPAs; species affected; habitat area cleared; monitoring coverage in priority zones.
E5 Resource Use and Circular Economy	End-of-life nets, ropes and traps can be collected, processed and recycled into new materials, reducing landfill, leakage to the ocean and demand for virgin plastics.	Tonnes of end-of-life gear collected; percentage of gear recycled; recycled polymer output; virgin plastic displaced; circular material revenue; number of port collection points or take-back agreements.
E1 Climate Change	Gear tracking and retrieval can reduce unnecessary vessel trips and fuel use. Recycling fishing gear can also reduce demand for virgin plastic production, depending on the material substitution pathway.	Fuel saved; vessel trips avoided; CO2e avoided from reduced search/retrieval trips; CO2e avoided through recycled material substitution; energy used in recycling operations.
S3 Affected Communities	Fishers and coastal communities are affected by lost gear through replacement costs, reduced stock productivity, safety risks, navigation hazards and degraded coastal environments.	Participating fishers; gear replacement costs avoided; income protected; community collection partnerships; jobs created in repair/recycling; stakeholder complaints or engagement records.
G1 Business Conduct	Digital gear tracking, producer responsibility schemes and documented recycling chains increase transparency and accountability in gear ownership, loss reporting, recovery and end-of-life management.	Gear registry coverage; verified chain-of-custody records; compliance documentation; loss-reporting rate; supplier take-back clauses; audit trail for recovered and recycled material.

Table 50 | Alignment with the ESRS topic and possible indicators

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PRACTICAL EXAMPLES

Beyond enabling cost savings, the following examples also illustrate how ghost fishing solutions create entirely new business models – from smart retrieval devices to circular-economy recycling platforms.

Resqunit: Preventive Ghost Fishing Retrieval System

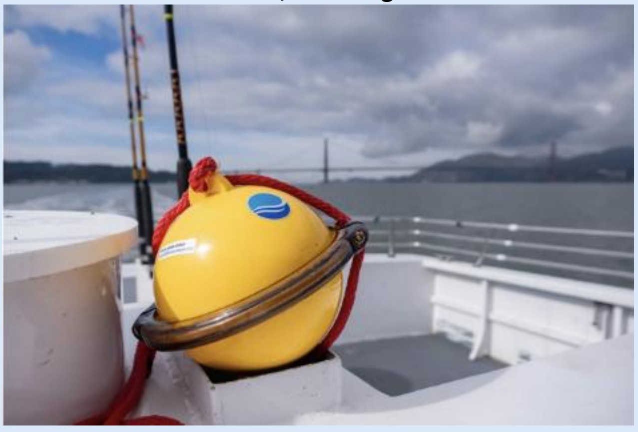
Sandnes, Norway · Founded 2017 · Nasdaq First North GM listed (RESQ)

Resqunit developed the world's first preventive solution to ghost fishing: a smart flotation buoy mounted on fishing gear such as lobster traps and crab pots. If a trap remains in the water beyond a set time (indicating it has been lost), the buoy's automatic release mechanism activates, floating the gear to the surface for retrieval. The solution has been endorsed by Captain Sig Hansen of "Deadliest Catch" fame, who stated: "Resqunit not only protects our bottom line by saving gear and stock, it also protects our oceans" (Business Norway, 2024).

Business model: Resqunit generates revenue through direct product sales of smart buoys and partnerships with gear manufacturers and distributors. The company launched pilot projects with the Global Ghost Gear Initiative and has expanded from Norway to Canada, Australia, Florida and Jamaica. By preventing gear loss rather than recovering it after the fact, Resqunit reduces costs for fishers while eliminating an environmental hazard at source (Dealroom, 2024).

Blue Ocean Gear: IoT Smart Buoys for Gear Tracking

Sausalito, USA · Founded 2015 · USD 2M NOAA/NFWF grants awarded



Blue Ocean Gear designs and builds GPS-enabled Smart Buoys that allow fishers, aquaculture operators and marine researchers to track and monitor deployed gear in real time, anywhere in the world. The patented Farallon Smart Buoy transmits position and motion data via

Iridium satellite, is compatible with all types of static fishing gear, and integrates with standard navigation plotters (Garmin, Furuno, Raymarine). The company has partnered with NOAA, the Alaska Department of Fish & Game, and the Australian Fisheries Research and Development Corporation (Blue Ocean Gear, 2024).
Business model: Blue Ocean Gear sells its Smart Buoy hardware and data platform to commercial fishers, generating value through reduced fuel costs, reduced gear loss, and real-time operational insights previously unavailable. The company also addresses whale entanglement prevention through a ropeless fishing system developed in partnership with NOAA's SBIR program (Ground Control, 2026).

Net Your Problem: Circular Economy for Fishing Gear
Seattle, USA · Founded 2018 · Maritime Blue Accelerator alumnus

Net Your Problem is a for-profit company that provides recycling services for end-of-life fishing gear, creating a pathway for waste that would otherwise go to landfill or the ocean. Founded by former fisheries observer Nicole Baker, the company collects worn-out nets, trawls, cod ends, ropes and other gear from commercial fishing ports, processes and bales the material, and ships it to recycling partners who transform it into plastic pellets for products such as kayaks, sunglasses, outdoor clothing (including Grundens apparel lines) and office furniture (Net Your Problem, 2024).
Business model: Net Your Problem operates as a for-profit waste management and recycling business–a deliberate choice over the non-profit model to ensure long-term sustainability. Since launch, the company has recycled over one million pounds of fishing gear plastics. It now operates across Alaska, Washington, California, Maine and Massachusetts, using NOAA's top-ports-by-landings data to identify where recycling is most needed (National Fisherman, 2024; Port of Seattle, 2022).

WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

- Deploy gear-tracking solutions, smart buoys, digital marking or registries for high-value or high-risk fishing gear.
- Use preventive retrieval technologies, including timed-release flotation devices, ropeless systems or other mechanisms that reduce the probability of abandoned gear remaining on the seabed.

- Create port-based collection and take-back schemes for end-of-life nets, ropes, traps and lines in partnership with fishers, port authorities, recyclers and gear manufacturers.
- Design procurement criteria that favour durable, repairable, recyclable and trackable fishing gear.
- Develop circular-economy partnerships that convert recovered or end-of-life fishing gear into recycled polymers, components or consumer products.
- Integrate ghost gear prevention into fisheries improvement projects, supplier codes of conduct, certification schemes and ESG reporting.
- Measure and disclose avoided gear loss, recovered material, recycled content and biodiversity-related outcomes using credible data and traceable documentation.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Business performance	Gear replacement costs avoided; retrieval costs avoided; fuel savings from improved gear location; revenue from smart buoys, monitoring services or recycled materials; customer retention or recurring contracts.	Sales data; vessel logs; gear purchase records; platform analytics; contracts; financial reports.
Pollution and circularity	Tonnes of ghost gear retrieved; tonnes of end-of-life gear collected; percentage recycled; landfill avoided; virgin plastic displaced; number of port collection points.	Collection records; recycling partner certificates; waste transfer notes; port records; chain-of-custody documentation.
Biodiversity and ecosystem impact	Estimated ghost-fishing mortality avoided; number of traps/nets retrieved from sensitive habitats; MPA or habitat area cleared; entanglement events prevented or reduced.	Retrieval mission reports; biodiversity monitoring; underwater surveys; fisheries agency data; NGO or scientific partner assessments.
Operational and compliance	Share of deployed gear with tracking or marking; loss-reporting rate; retrieval success rate; response time to lost gear; compliance with gear-management requirements.	IoT platform data; gear registries; fisher reporting systems; audit records; regulator or certification documentation.
New business model	Number of clients using gear-tracking services; subscription or data-service revenue; volume of recycled product sold; number of take-back agreements; pilots converted into commercial contracts.	CRM data; invoices; platform subscriptions; partnership agreements; product sales records; pilot evaluation reports.

Table 51 | Indicative KPIs examples for implementation

CHALLENGE 15 : SHIP RECYCLING AND WASTE VALORISATION

An estimated 16,000 vessels – representing approximately 700 million deadweight tonnes – are expected to be dismantled over the coming decade, nearly double the volume recycled in the previous ten years (BIMCO, 2025). The global ship recycling market was valued at USD 7 billion in 2024 and is projected to reach USD 13 billion by 2030 at a CAGR of 7.4 percent (ResearchAndMarkets, 2025). Yet the industry remains dominated by practices that pose severe environmental and human health risks: South Asia handles over 85 percent of global ship recycling by tonnage, much of it through beaching methods where vessels are run aground on tidal flats and dismantled with minimal containment of hazardous materials (Lloyd's List, 2025).

End-of-life vessels contain a complex mix of recoverable and hazardous materials: steel and non-ferrous metals, machinery and reusable components, but also asbestos, heavy metals, PCBs, tributyltin (TBT) anti-fouling coatings and hydrocarbon residues. When dismantled irresponsibly, these substances contaminate soil, groundwater and marine environments. Even at compliant facilities, waste disposal represents a significant cost center – hazardous materials must be safely extracted, classified and either treated or sent to licensed disposal facilities, all at considerable expense.

With the IMO Hong Kong Convention in force since June 2025 and the EU Ship Recycling Regulation (SRR) tightening hazardous material requirements for all EU-flagged vessels, shipyards and refit operators face growing volumes of regulated waste from maintenance, repair and conversion activities. (IMO, 2025; European Parliament and Council, 2013; EMSA, 2018). Compliant valorization of these waste streams – from anti-fouling coatings to metal residues – reduces disposal costs and can generate additional revenue. This challenge focuses on recycling and waste valorization within shipbuilding and refit operations.

SDG 14 ALIGNMENT:

Irresponsible ship recycling is a direct source of marine pollution. Hazardous substances released during beaching operations enter tidal zones, contaminate sediments and accumulate in marine food chains. Even non-hazardous waste streams, if improperly managed, contribute to coastal and marine debris.

Target	Relevance to the challenge	Strength of alignment
14.1	Prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution. Green ship recycling and waste valorization directly reduces marine and on-land waste from end-of-life vessels.	Strong alignment when hazardous materials are safely contained and recyclable materials are recovered through compliant ship recycling and refit waste-management systems.

Table 52 | Alignment with the SDG 14 targets

By ensuring that hazardous materials are safely contained and that recyclable materials are valorized rather than dumped, green ship recycling directly prevents pollutants from entering the marine environment. Every tonne of steel recovered through compliant recycling also avoids the emissions associated with primary steel production – ship-derived scrap can reduce Scope 3 emissions for steel mills by up to 60 percent compared to virgin ore (Market Reports World, 2026).

THE BUSINESS CASE: COST REDUCTION + NEW BUSINESS MODEL

Ship recycling and waste valorization create value through two mechanisms. First, valorization of waste materials reduces disposal costs. Hazardous waste disposal is expensive and tightly regulated. Every material stream that can be reclassified from "waste" to recovered "resource" – eliminates a disposal expense and generates revenue. A typical large vessel yields 10,000–20,000 tonnes of recyclable steel, plus copper, aluminum, brass and zinc. Long-term offtake agreements between recycling yards and steel mills now secure up to 500,000 tonnes per year of ship-derived scrap at stabilized pricing (Market Reports World, 2026).

Second, the regulatory transformation of the sector is driving entirely new business models: green recycling consultancies that guide shipowners through compliance, specialized yards that command premium pricing for EU/HKC-compliant dismantling, and metal valorization companies that process ship-derived materials into high-quality secondary raw materials. The entry into force of the Hong Kong Convention and the expansion of the EU List are creating a market where compliance is not just a cost but a competitive differentiator.

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The following examples illustrate how companies are already building commercially viable businesses around green ship recycling and waste valorization – demonstrating that sustainability challenges in the maritime sector can be the birthplace of new ventures.

ESRS MAPPING

ESRS topic	Connection	Possible indicators
E2 Pollution	This is one of the most material ESRS connections. Irresponsible ship recycling can release asbestos, heavy metals, PCBs, TBT anti-fouling residues, oils and other hazardous substances into soil, water and coastal environments. Compliant dismantling and waste valorization reduce pollution risks by ensuring identification, containment, safe extraction, treatment and documented disposal or recovery.	Inventory of hazardous materials completed; tonnes of hazardous substances safely removed; spill/release incidents; compliant disposal certificates; water/sediment quality results; non-compliance events avoided.
E5 Resource Use and Circular Economy	Ship recycling turns end-of-life vessels, refit waste and dismantled components into secondary raw materials. Steel, non-ferrous metals, machinery and reusable components can be recovered, reused or recycled, reducing waste disposal and dependence on virgin materials.	Tonnes of steel and non-ferrous metals recovered; material recovery rate; percentage of waste diverted from landfill; components reused; scrap sold; value of recovered materials.
E1 Climate Change	Using ship-derived scrap can reduce embodied emissions by substituting virgin steel and primary raw material production. More efficient recycling and shorter material loops can also reduce Scope 3 emissions for steel mills, shipyards and shipowners.	CO2e avoided from recycled metals; recycled content supplied to steel mills; Scope 3 emissions reduction; energy use per tonne processed; transport emissions avoided.
E4 Biodiversity and Ecosystems	Compliant ship recycling helps prevent contamination of tidal flats, coastal habitats and marine ecosystems from hazardous materials, oils, coatings and debris. The biodiversity relevance is strongest where recycling practices prevent pollutant release into sensitive coastal or marine areas.	Sensitive coastal areas protected; sediment contamination avoided; habitat disturbance indicators; pollutant releases avoided; environmental monitoring results around yards.
S1/S2 Workforce and Safety	Ship recycling has significant worker health and safety implications, particularly where dismantling involves hazardous materials, heavy equipment, cutting operations and confined spaces. Companies need to consider both own workers and workers in the value chain, especially when using external recycling yards.	Lost-time injury rate; fatalities; safety training hours; PPE compliance; hazardous material exposure monitoring; yard audit results; certified contractor use.
G1 Business Conduct	Green ship recycling depends on robust governance, due diligence and compliance with the Hong Kong Convention, EU Ship Recycling Regulation, inventories of hazardous materials and waste shipment rules. Governance is also relevant to yard selection, traceability, contractor oversight and anti-corruption safeguards.	Use of EU-listed or HKC-compliant yards; IHM completeness; supplier due-diligence records; audit findings closed; legal non-compliance events; documented chain of custody for recovered materials.

Table 53 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

Leyal Ship Recycling: EU-Compliant Green Dismantling at Scale

Aliaga, Turkey · Founded 1981 · 39+ years of operation · EU SRR & HKC certified

Leyal is the leading ship recycling company in Turkey and one of the most experienced facilities worldwide. Operating on a 60,000 m² site in Aliaga, the company was the first non-EU ship recycling facility to be included on the European List of approved yards (2018) and was certified compliant with the IMO Hong Kong Convention by Lloyd's Register in 2016. Leyal recycles vessels for major shipping lines including Hapag-Lloyd, which specifically chose the facility for its German-flagged vessels to ensure compliance with the highest environmental standards (Hapag-Lloyd, 2024; Lloyd's Register, 2018).

Business model: Leyal generates revenue through green ship dismantling services and recovered material sales. By operating to EU/HKC standards, Leyal commands competitive pricing from European shipowners who are legally required to use approved facilities–a regulatory moat that secures market share as more vessels come under EU SRR and HKC obligations. The company is also a founding member of the International Ship Recycling Association (ISRA).

Galloo Group: Industrial-Scale Metal Recycling and Valorization

Ghent, Belgium · International recycling group · EU-listed ship recycling yard
Galloo is an international metal recycling group that operates Van Heyghen Recycling in Ghent, Belgium–an EU-listed ship recycling facility with an environmental license secured until 2032. The yard has recycled vessels for clients including the UK Ministry of Defense. Galloo's broader operations process ship-derived ferrous and non-ferrous metals into high-quality secondary raw materials, feeding directly into European steel and manufacturing supply chains (Safety4Sea, 2011; Ship Recycling Lab, 2022).
Business model: Galloo operates as a vertically integrated recycler: dismantling end-of-life vessels and processing the recovered metals in-house into secondary raw materials for resale. This integration captures value at every stage–from dismantling fees paid by shipowners, through material processing, to the sale of recycled metals at commodity prices–while ensuring full traceability and compliance with EU waste regulations.

Sea2Cradle: Green Ship Recycling Consultancy
Rotterdam, Netherlands · Founded 2011 · 190+ projects completed
Sea2Cradle is a specialist consultancy that manages the entire ship recycling process from start to finish, applying health, safety and environmental standards from the offshore sector with a target of zero pollution, zero incidents and zero accidents. Founded in 2011 by former P&O Nedlloyd and Maersk ship recycling professionals, the company has completed over 190 projects. Sea2Cradle contributed directly to the development of both the Hong Kong Convention and the EU Ship Recycling Regulation, and continues to advise the European Commission, IMO and national governments (Sea2Cradle, 2025).
Business model: Sea2Cradle operates as a new business model: recycling-as-a-service consultancy. Services include yard audits and suitability assessments, hazardous materials inventories (IHMs), ship recycling plan preparation, EU List application support for yards, last-voyage management, on-site supervision during dismantling, and policy development for corporate clients and governments. Revenue comes from consulting fees rather than material sales–a pure knowledge-based business built entirely around the green recycling transition.

WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

- Prepare and regularly update inventories of hazardous materials for vessels, floating assets and refit projects before dismantling or major conversion works.
- Select EU-listed, HKC-compliant or independently audited recycling yards, and include environmental, safety and traceability requirements in contracts.
- Separate waste and material streams at source, including steel, non-ferrous metals, machinery, reusable components, coatings, oils and hazardous residues.
- Create valorisation partnerships with metal recyclers, steel mills, component refurbishers, and licensed hazardous-waste handlers to maximise recovery and reduce disposal costs.
- Use digital chain-of-custody records to document where materials go, how they are treated, and which recovered resources are reintroduced into supply chains.

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- Develop green recycling or refit-waste services, such as IHM preparation, yard audits, dismantling supervision, recycling-as-a-service, material brokerage or secondary raw material supply.
- Report ship recycling and refit waste KPIs in sustainability, procurement and ESG reporting, linking cost savings, compliance and avoided pollution.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Circular material recovery	Tonnes of steel recovered; tonnes of non-ferrous metals recovered; material recovery rate; percentage of waste diverted from landfill; reusable components recovered; scrap revenue.	Weighbridge tickets; material-flow records; invoices; scrap sales records; component reuse logs; recycling certificates.
Hazardous materials and pollution prevention	Tonnes of asbestos, PCBs, TBT coatings, oils and hazardous residues safely removed; number of spills or releases; compliant disposal rate; pollutant load avoided.	Inventories of hazardous materials; hazardous-waste manifests; disposal certificates; incident logs; environmental monitoring data; audit reports.
Business performance	Disposal cost avoided; revenue from recovered materials; dismantling/refit waste margin; cost per tonne processed; value of offtake agreements; premium contracts from compliant recycling.	Financial accounts; contracts; invoices; offtake agreements; project cost data; procurement records.
Climate impact	CO_2e avoided through use of recycled metals; Scope 3 emissions reduction for steel or maritime clients; energy use per tonne processed; transport emissions avoided.	LCA calculations; emissions factors; energy bills; logistics data; steel mill procurement data; ESG reports.
Worker safety and compliance	Lost-time injury rate; fatalities; near misses; safety training completed; PPE compliance; certified yard use; audit findings closed.	HSE records; training logs; contractor audits; certification records; corrective action logs; insurance or incident reports.
New business model and market development	Number of green recycling projects completed; IHM or audit contracts; recycling-as-a-service contracts; clients served; material buyers secured; recurring service revenue.	CRM data; consultancy contracts; service agreements; project records; client reports; sales dashboards.

Table 54 | Indicative KPIs examples for implementation

CHALLENGE 16: SMART PLANNING OF PORT OPERATIONS

Business case type: Reducing costs and enabling new business models

Maritime transport remains the backbone of international trade, carrying more than 80 percent of the volume of global merchandise trade (United Nations Conference on Trade and Development, 2024b). Ports are therefore not only logistics assets; they are operational systems where vessel arrivals, berth allocation, terminal equipment, gates, trucking, rail and barge connections, labor, energy and environmental constraints interact. When these flows are planned through fragmented information, manual coordination or disconnected systems, ports face vessel waiting time, congestion, truck idling, inefficient use of labor and equipment, delayed cargo flows and higher local emissions.

This challenge focuses on using data, AI, digital port community systems and predictive planning to improve port operations. The Hub Azul challenge one-pager positions smart port planning as a Shipping & Ports challenge linked to reduced congestion and emissions, higher operational efficiency, stronger community and environmental performance and accelerated energy transition (Hub Azul / imatch, 2026). It includes port planning, port call optimization, berth allocation, AIS and port data integration, terminal automation, gate OCR, digital port community systems and environmental monitoring networks as relevant enablers (Hub Azul / imatch, 2026).

SDG 14 ALIGNMENT

Smart planning of port operations is not a direct ocean conservation intervention. Its SDG 14 relevance is conditional: it becomes relevant when planning measurably reduces pollution, congestion, idling, fuel use, local air pollutants, noise, spill risk or operational pressure on coastal ecosystems. On that basis, the contribution is indirect but credible if supported by robust operational and environmental evidence.

Target	Relevance to this challenge
Target 14.1	Prevent and reduce marine pollution of all kinds. Smart planning can support this target when it reduces vessel waiting, truck idling, fuel consumption, air pollutants, noise, or operational events that increase pollution risk. The link is indirect and must be evidenced through KPIs such as CO2e avoided, NOx/PM reductions, berth waiting time, truck turn time or incident reduction.
Target 14.2	Sustainably manage and protect marine and coastal ecosystems. Integrated planning can help ports manage operational pressure on coastal areas by linking berth, gate, traffic, energy and environmental data to preventive decision-making. The link is moderate only if the planning system is connected to environmental controls or ecosystem-pressure indicators.
Target 14.7	Increase the economic benefits from sustainable use of marine resources. Efficient and cleaner ports support a more competitive blue economy by reducing delays, improving logistics reliability and enabling lower-emission maritime activity.

Table 55 | Alignment with the SDG 14 targets

THE BUSINESS CASE: COST REDUCTION + NEW BUSINESS MODEL

Smart planning of port operations creates value through two main business mechanisms: cost reduction and new business models.

First, it reduces costs by increasing operational efficiency. Better berth planning, vessel ETA/ETD coordination, gate appointment systems, real-time visibility, workforce scheduling and predictive analytics reduce waiting time, idle time, overtime, rework, equipment underutilization and congestion. These are material cost drivers for port authorities, terminal operators, shipping lines, inland logistics providers and cargo owners. The emissions case is also material: the IMO has reported that Just-in-Time arrivals can reduce container ship fuel consumption and CO2 emissions by 14.16 percent when speed is optimized over the whole voyage, and by 5.90 percent when optimization occurs over the last 24 hours before arrival (IMO, 2022).

Second, it enables new business models. Smart planning can be commercialized as software-as-a-service, port-call optimization platforms, berth-alignment networks, workforce optimization tools, digital port community systems, operational digital twins, data-as-a-service products, and decision-support solutions for port authorities and terminal operators. In this model, the business opportunity is not only to make one port more efficient; it is to build replicable digital infrastructure that can be sold or scaled across multiple ports and logistics ecosystems.

The ESRS mapping should be disciplined. This case should be mapped to ESRS E1 Climate Change when planning reduces fuel use, energy demand, vessel waiting time, truck idling or CO2e emissions. It should only be mapped to ESRS E2 Pollution when there is evidence of reduced air pollutants, water pollution, noise, spill risk or other pollution pressures. Until quantified, the ESRS strength should remain weak to moderate. The minimum evidence base should include baseline waiting and idling times, fuel or kWh saved, CO2e avoided, vessel or truck operating profile, port air pollutants, noise indicators where relevant, and the system boundary used for calculations.

ESRS MAPPING

The ESRS mapping should be disciplined. This case should be mapped to ESRS E1 Climate Change when planning reduces fuel use, energy demand, vessel waiting time, truck idling or CO2e emissions. It should only be mapped to ESRS E2 Pollution when there is evidence of reduced air pollutants, water pollution, noise, spill risk or other pollution pressures. Until quantified, the ESRS strength should remain weak to moderate. The minimum evidence base should include baseline waiting and idling times, fuel or kWh saved, CO2e avoided, vessel or truck operating profile, port air pollutants, noise indicators where relevant, and the system boundary used for calculations.

ESRS topic	Connection	Possible indicators
E1 Climate Change	Relevant when smart planning reduces vessel waiting, truck idling, auxiliary engine running time, equipment energy demand, fuel consumption or CO2e emissions.	CO2e avoided; fuel saved; kWh saved; vessel waiting time; truck idling time; auxiliary engine running time; terminal equipment energy demand; Just-in-Time arrival adoption rate.
E2 Pollution	Relevant only when the planning system is connected to measured reductions in air pollutants, water pollution, noise, spill risk or congestion-related pollution pressures.	NOx, SOx and PM reductions; noise levels; congestion incidents; spill-risk events; pollution alerts; response time to environmental incidents; water-quality exceedances avoided.
S3 Affected Communities	Relevant where reduced congestion, emissions, noise or port-city friction improves conditions for nearby communities and strengthens port license to operate.	Community complaints; noise complaints; air-quality indicators near port areas; truck queue length; public reporting frequency; stakeholder engagement records; mitigation actions completed.

Table 56 | Alignment with the ESRS topic and possible indicators

PRACTICAL EXAMPLES

The following examples show how smart port planning can move from an operational improvement to a business case. They also illustrate the importance of linking digital planning to measurable outcomes, rather than treating digitalization as an impact claim in itself.

Portchain: Berth Alignment and Just-in-Time Port Calls

Denmark / global · Berth planning, port-call optimization and terminal-carrier coordination

Portchain provides cloud-based berth alignment and quayside planning solutions for terminals and shipping lines. Its platform aims to replace spreadsheets, emails and fragmented berth-planning tools with integrated, real-time schedule alignment and predictive analytics. The company positions its products as a way to improve berth-window stability, stakeholder alignment, planning speed and quayside efficiency (Portchain, 2026).

The environmental relevance comes from Just-in-Time port calls. By aligning terminals and shipping lines earlier, vessels can adapt speed to berth availability instead of arriving early and waiting at anchor. Portchain states that its network reduces idle time, optimizes berth allocation and supports lower fuel consumption; it also reports 800,000 tonnes of CO2 emissions prevented since the network was launched in 2022 (Portchain, 2026). This should be treated as a company-reported figure and, in a corporate implementation, should be verified against a clear calculation methodology.

Business model: Portchain monetizes smart planning through digital berth alignment and quayside planning platforms. The value proposition combines cost reduction for terminals and carriers, lower operational uncertainty, improved reliability and, when quantified, fuel and emissions savings.

Port of Rotterdam: IoT, Hydro-Meteo Decision Support and KING Berth Booking

Netherlands · Port authority digital infrastructure, berth optimization and port planning

The Port of Rotterdam has implemented an Internet of Things platform with a hydro-meteorological application for planning and managing shipping. The system combines 44 sensors, prediction models, Rijkswaterstaat data and astronomical calculations to generate data on tide height, tidal stream, salinity, wind speed, wind direction and visibility. According to the Port Authority, the platform processes around 1.2 million data points per day and contributes to reducing waiting times and optimizing berthing, loading/unloading and departure times (Port of Rotterdam Authority, 2019b).

Rotterdam also provides a relevant example of berth-market transparency through the KING application. The system allows shipping agents to digitally book buoys, dolphins and, through a pilot, commercial berths offered by market parties. The Port Authority states that this increases flexibility, improves use of existing infrastructure and helps vessels find available berths more quickly, resulting in shorter waiting times, reduced emissions and more sustainable port operations (Port of Rotterdam Authority, 2025).

Business model: The business model is infrastructure-led: the port authority creates value by using digital planning tools to increase the productivity of existing assets, improve service quality for shipping agents and terminals, reduce congestion and strengthen environmental performance without necessarily expanding physical infrastructure.

Ensemble Analytics / Athena: Smart Workforce Management for Ports

United Kingdom / European benchmark · Workforce planning, skills allocation and operational flow

Ensemble Analytics provides Athena, a workforce management platform designed for ports, terminals and port workers. The platform supports faster planning, automatic scheduling, skills management, time and attendance, compliance rules and real-time operational visibility. It is designed to help terminals assign the right skills at the right time, reduce manual administration, improve workload balance and support greater flow and productivity (Ensemble Analytics, 2025).

This example matters because port efficiency is not only about vessels and berths; it also depends on the synchronization of people, equipment, skills and operational demand. Better labor allocation can reduce delays, overtime and bottlenecks, with indirect environmental benefits where faster turnaround reduces idling, congestion or energy use. These environmental benefits should not be assumed: they must be measured through vessel turnaround time, crane or gang productivity, overtime, truck queueing, berth occupancy and idling-related emissions.

Business model: The business model is a specialized SaaS solution for port workforce optimization. It creates value by improving workforce allocation, compliance, planning speed and operational productivity, while opening a scalable service model for ports and terminals with complex labor and equipment planning needs.

Additional Benchmark Solutions

Benchmark	Solution logic	Business value	Evidence needed
Digital berth alignment networks	Connect terminals, shipping lines and agents around shared berth windows, ETA/ETD updates and digital handshakes.	Lower coordination costs, reduced waiting time, more reliable vessel schedules and potential fuel savings.	Baseline waiting time, fuel saved, CO2e avoided, berth-window adherence, number of manual coordination steps removed.
Gate appointment and OCR systems	Use digital gate slots, truck appointment systems and automated recognition to smooth truck arrivals and terminal access.	Reduced truck queues, shorter turn times, lower yard congestion and better landside productivity.	Truck turn time, queue length, idling time, NOx/PM/CO2e reductions, gate throughput.
Operational digital twins for ports	Combine AIS, terminal, berth, gate, weather and environmental data into simulation and decision-support environments.	Better scenario planning, risk management and infrastructure utilization.	Forecast accuracy, avoided delays, capacity utilization, incident reduction, resilience indicators.

Table 57| Additional Benchmark Solutions

WHAT PRIVATE COMPANIES CAN DO

For companies, this business case should start with one operational bottleneck rather than a generic digital-transformation ambition. A strong pilot could focus on a defined terminal, berth cluster, truck gate, workforce planning process, port call corridor or shipping line-terminal interface. The pilot should establish a baseline, define the decision that the tool will improve, connect the relevant data sources and measure whether the intervention actually reduces waiting, idling, cost, emissions, pollution risk or planning effort.

- Select one high-value operational decision to improve, such as berth allocation, vessel arrival coordination, truck gate scheduling, workforce planning or terminal equipment deployment.
- Establish a quantified operational and environmental baseline before implementation, including waiting time, idling, throughput, energy use and emissions where relevant.
- Connect operational data sources such as AIS, terminal operating systems, port community systems, gate systems, hydro-meteo data, workforce schedules and environmental monitoring data.
- Run a contained pilot with clear decision rules, ownership, operational users and a defined system boundary for impact measurement.
- Verify whether the intervention reduces cost, delay, emissions, pollution risk or planning effort before scaling across terminals, ports or logistics corridors.
- Use measurable outcomes, rather than digitalization claims alone, to support ESG reporting, investment decisions and commercial positioning.

INDICATIVE KPIs

KPI category	Examples of indicators	Evidence source
Business performance	Vessel waiting time; vessel turnaround time; berth occupancy; gate throughput; truck turn time; labor utilization; overtime; planning effort; cost per move; service reliability.	Terminal operating system; port call records; AIS data; berth logs; gate systems; workforce management systems; finance and operations dashboards.
Climate / energy	Fuel saved; kWh saved; CO2e avoided; reduced auxiliary engine running time; reduced truck idling; lower energy demand from equipment.	Fuel consumption data; electricity meters; AIS and voyage data; truck gate and queue data; emissions factors; energy management systems.
Pollution / local impacts	NOx, SOx, PM and noise reductions where measured; fewer congestion-related incidents; fewer spill-risk events or faster response triggers where environmental controls are integrated.	Air-quality sensors; emissions inventories; noise monitoring; environmental monitoring systems; incident logs; port environmental reports.
Learning and scalability	Data quality; system interoperability; number of stakeholders connected; prediction accuracy; adoption rate; partner readiness; replication potential across terminals or ports.	System analytics; data-quality logs; stakeholder onboarding records; user adoption dashboards; model validation reports; pilot evaluation reports

Table 58 | Indicative KPIs examples for implementation

CHALLENGE 17: AUTOMATION OF LOADING/UNLOADING AND GATE MANAGEMENT

Area: Shipping & Ports | Business case: Cost reduction and new business model

Ports are critical infrastructure for international trade and blue economy competitiveness. Maritime transport carries more than 80 percent of world trade by volume, while disruptions, congestion and route instability continue to raise costs, fuel use and operational risk across maritime supply chains (United Nations Conference on Trade and Development, 2024b). In this context, the automation of loading/unloading and gate management is not simply a productivity upgrade: it is a way to reduce operational friction at the points where vessels, yards, trucks, rail, cargo owners and terminal operators interact.

The challenge focuses on automating the most operationally sensitive parts of port terminal activity: ship-to-shore handling, yard transfers, stacking, truck and rail handover, terminal gate access, appointment systems, cargo identification, and exception management. Technologies include automated or remote-controlled cranes, automated stacking cranes, automated guided vehicles (AGVs), optical character recognition (OCR) gates, vehicle booking systems, terminal operating systems, AI-supported scheduling and real-time gate/yard orchestration.

The business challenge is that loading/unloading and gate management remain vulnerable to bottlenecks, labor availability constraints, safety risks, weather disruption, truck queues, rehandling and poor coordination between quay, yard and landside operations. These bottlenecks increase cost, reduce asset utilization and can also generate unnecessary fuel consumption and local emissions from idling vessels, trucks and cargo-handling equipment. (United Nations Conference on Trade and Development, 2024b) explicitly identifies digitalization, artificial intelligence and automation as key levers for improving port operations, reducing waiting times, improving cargo tracking and strengthening supply-chain efficiency.

SDG 14 ALIGNMENT:

The alignment with SDG 14 is real but indirect. Automation of loading/unloading and gate management does not, by itself, restore marine ecosystems or prevent pollution. However, when it reduces vessel waiting time, truck idling, equipment fuel consumption, accidental releases, air pollutants or inefficient port movements, it can contribute to reducing the environmental pressure associated with maritime activity. The link should therefore be treated as conditional and evidence-based, not as an automatic SDG 14 claim.

Target	Relevance to the challenge	Strength
14.1	Prevent and reduce marine pollution of all kinds. Automation can make an indirect contribution only when it measurably reduces vessel waiting, truck idling, fuel consumption, air pollutants, accidental spills or other pollution risks linked to port activity.	Weak / conditional
14.7	Increase the economic benefits from sustainable use of marine resources. More efficient and resilient port operations can support blue economy competitiveness, but the connection is indirect and depends on whether efficiency gains are linked to sustainable port management.	Weak

Table 59 | Alignment with the SDG 14 targets

From an ESRS perspective, the default classification should not be “E2 Pollution” or “E1 Climate Change” unless the company can demonstrate a measurable environmental pressure reduction. If the automation reduces fuel use, electricity demand, truck idling, vessel waiting or equipment energy consumption, it can support ESRS E1 Climate Change. If it reduces local air pollutants, noise, spill risk, dust, waste, water pollution or accident-related contamination, it can support ESRS E2 Pollution. Without quantified baselines and measurable improvements, the ESRS fit should remain weak or “no fit”.

ESRS MAPPING

The ESRS mapping should be disciplined. The default classification should not be ESRS E2 Pollution or ESRS E1 Climate Change unless the company can demonstrate a measurable environmental pressure reduction. Without quantified baselines and measurable improvements, the ESRS fit should remain weak or no fit.

ESRS topic	Connection	Possible indicators / evidence
E1 Climate Change	Relevant when automation reduces fuel use, electricity demand, truck idling, vessel waiting, equipment energy consumption or CO2e emissions. The fit is stronger when automation is combined with electrification and renewable electricity.	Fuel or kWh use per move; CO2e emissions per move; vessel waiting time; truck idling time; auxiliary engine running time; equipment utilization; share of electric equipment; energy intensity per TEU or move.
E2 Pollution	Relevant only when automation measurably reduces local air pollutants, noise, spill risk, dust, waste, water pollution or accident-related contamination linked to terminal activity.	NOx, SOx, PM and noise indicators; gate queue length; truck turn time; spill-risk events; incident frequency; dust complaints; water contamination incidents; response time to exceptions.
S1/S2 Workforce and Safety	Automation and remote operations can reduce human exposure to hazardous cargo-handling environments, but they also require reskilling, change management and clear worker-safety procedures.	Safety incidents; near misses; high-risk exposure hours avoided; training hours; reskilling participation; remote operation rate; workforce redeployment; contractor safety indicators.

Table 60 | Alignment with the ESRS topic and possible indicators

THE BUSINESS CASE: COST REDUCTION + NEW BUSINESS MODEL

Automation of loading/unloading and gate management creates value through two main business case mechanisms: cost reduction and new business model creation.
First, it reduces costs by improving asset utilization, lowering vessel and truck turnaround time, reducing rehandles, reducing manual data entry, improving workforce allocation, increasing gate predictability and lowering safety-related disruption. Loading/unloading operations are tightly interdependent: quay crane productivity, yard capacity, AGV or shuttle availability, gate flows and truck appointment systems all affect each other. Academic work on container terminal optimization shows that integrated modelling can reduce ship service time in case-study conditions (Said & El-Horbaty, 2014), while more recent optimization of dual-cycling and yard rehandle reduction reports potential reductions of total operation time for large vessels when loading and unloading are optimized together rather than separately (Rahman & Mridha, 2024).
Second, automation creates new business models for technology providers, terminal operators and specialized service companies. These include automation-as-a-service, OCR gate systems, automated yard management, predictive maintenance, digital twins, AI labor allocation, remote crane operation platforms, terminal operating system modules, truck appointment optimization and data-driven exception management. For port operators, automation can also increase market share by improving reliability and service levels; however, the clearest business case is cost reduction, because efficiency gains can be translated into lower unit handling costs, higher berth productivity and reduced operational variability.
The positive impact logic should remain disciplined. The environmental benefit is not automation itself, but the measurable reduction of wasteful movements, idling, fuel use, emissions, accident risk and congestion. Evidence should therefore include baseline and post-implementation data on vessel turnaround time, crane productivity, truck turn time, gate waiting time, yard rehandles, fuel or kWh use, CO_2e emissions, air pollutants, incidents and noise complaints where relevant.

PRACTICAL EXAMPLES

The following examples illustrate how automation can move from an operational efficiency project to a strategic business case. The common pattern is not the replacement of people by technology, but the redesign of the operating model around data, automated equipment, remote operations, safety and measurable performance.

DP World London Gateway: Semi-automated container terminal and automated gate management

United Kingdom · Semi-automated container handling, automated stacking cranes and vehicle booking/gate processes

DP World London Gateway is a relevant benchmark for port automation because it combines deep-water container handling, automated stacking cranes, integrated logistics space and gate processes designed to manage truck access more predictably. The terminal uses automated stacking cranes to manage containers as they move between ship-to-shore cranes, yard stacks, trucks and rail, while haulers access the terminal through booked slots and gate processes supported by digital systems (DP World London Gateway; Port of London Authority).
This model shows that gate management should not be treated separately from yard automation. Truck booking, gate identification, yard slot availability and equipment planning must work together

to reduce congestion and avoid simply moving the bottleneck from the terminal gate into the yard or quay.

Business model: For the port operator, automation reduces the cost and variability of terminal operations, improves safety by limiting direct interaction between people and container stacks, and supports more reliable service to shipping lines, haulers and logistics customers. For technology providers, the opportunity lies in modular systems for gate automation, yard planning, crane control, truck appointment management and terminal operating system integration.

Relevance: strong for gate management, yard automation and cost reduction; conditional environmental relevance if truck idling, energy use and local emissions are measured.

PSA Singapore / Tuas Port: Fully automated terminal model as strategic infrastructure

Singapore · Automated wharf and yard functions, electric AGVs and integrated terminal automation

Tuas Port is being developed as one of the world's largest fully automated container terminals, consolidating Singapore's port activities into a high-capacity, technology-enabled hub. Publicly available information describes automated wharf and yard functions, fully electric automated guided vehicles and large-scale terminal integration, with expected long-term capacity of approximately 65 million TEUs when fully developed (CNA, 2022; The Straits Times, 2019).

The case is important because it treats automation as core infrastructure, not as an isolated equipment upgrade. Loading/unloading, yard movement, gate flows, port planning, workforce skills and data systems are designed as one integrated operating model. This reduces the risk that automation produces only local efficiency while leaving terminal-wide bottlenecks unresolved.

Business model: PSA's model creates value by protecting Singapore's position as a global maritime hub, improving productivity, supporting labor transformation and developing automation capabilities that can potentially be transferred across a wider terminal network. For technology and engineering providers, Tuas illustrates the scale of demand for integrated automation systems, control platforms, sensors, energy management and maintenance services.

Relevance: strong for large-scale automation and strategic capacity; environmental claims should focus only on documented reductions in energy use, idling or emissions.

HHLA Container Terminal Altenwerder: Highly automated terminal operations and electrified AGVs

Hamburg, Germany · Automated guided vehicles, automated stacking and remote/automated handling operations

HHLA's Container Terminal Altenwerder is widely recognized as a highly automated container terminal, using automated guided vehicles and automated stacking systems to move containers between the quay and yard. Public reporting also describes the progressive electrification of AGVs and the use of renewable electricity in terminal operations (HHLA; Saputra & Rijanto, 2021; Welt, 2022).

The case is relevant because it shows how automation can be linked to both productivity and decarbonization when automated equipment is electrified and powered with renewable energy. It also highlights that highly automated terminals require skilled employees for supervision, control, maintenance and exception management, which means the business case must include human capital and reskilling as part of implementation.

Business model: The terminal creates value through lower operational variability, safer equipment flows, higher yard predictability and reduced exposure to fuel-price and emissions-related risks. The

model is particularly relevant for ports seeking to combine automation with electrification and climate-performance objectives.
Relevance: strong for automated yard movement and equipment electrification; ESRS E1 fit is stronger where energy and emissions baselines are available.

Ensemble Analytics: AI-supported labor allocation for port operations
Netherlands / United Kingdom · Advanced analytics, machine learning and port workforce planning
Ensemble Analytics, referenced in the Hub Azul benchmark, focuses on automating and optimizing labor allocation in ports through bespoke algorithms, advanced analytics, machine learning and artificial intelligence. The company's value proposition is to align operative allocation with operational objectives, improving workforce efficiency and supporting faster vessel turnaround (Ensemble Analytics; Hub Azul Dealroom).
This example is relevant because automation in ports is not limited to cranes, gates and vehicles. Labor allocation, shift planning, exception management and coordination between teams are also part of the automation opportunity. In many terminals, the performance constraint is not only equipment availability but the ability to allocate people, machines and tasks dynamically.
Business model: Ensemble Analytics represents the "smart planning as a service" and "automation software" side of the business case. Its value lies in providing decision-support tools that reduce operational inefficiency without requiring a full physical rebuild of the terminal. This is especially relevant for existing ports that cannot immediately invest in full terminal automation.
Relevance: strong for new business models in port automation software; environmental relevance is conditional on measured reductions in turnaround time, idling and energy use.

ADDITIONAL BENCHMARK SOLUTIONS

Company / solution	Technology focus	Value proposition
Kalmar / Cargotec automation portfolio	Automated cranes, automated guided vehicles, terminal automation and equipment control	Supports terminals in moving from manual equipment operation to automated and remotely supervised cargo handling, improving safety, utilization and predictability.
Kaleris / Navis N4 terminal operating systems	Terminal operating system, vessel/yard/gate planning and equipment orchestration	Enables better coordination between quay, yard, gate and hinterland flows; creates a software-based business model for terminal optimization.
OCR and gate automation providers	Automatic container, truck and license-plate identification; appointment and exception management	Reduces manual checks, errors, queues and truck turn time, creating direct cost and service benefits for terminal operators and haulers.

Table 61 | Additional Benchmark Solutions

WHAT PRIVATE COMPANIES CAN DO

Automation should be implemented only where the operational baseline is clearly defined. For a port authority or terminal operator, the starting point should be a bottleneck diagnosis: where does the inefficiency occur - quay, yard, gate, truck appointment, customs interface, labor planning or exception handling? A weak implementation risk is to automate one node while leaving the rest of the operating system unchanged.

- Start with a bottleneck diagnosis and select one operational process where automation can materially reduce waiting time, rehandles, manual checks, safety exposure or planning effort.
- Establish a baseline before implementation, including operational, energy, emissions, safety and service-quality indicators.

- Connect quay, yard, gate and workforce data so that automation improves the whole operating system rather than shifting the bottleneck to another node.
- Pilot automation modules such as OCR gates, truck appointment systems, automated stacking, remote crane operations, AGV orchestration or AI-supported labour allocation.
- Integrate environmental measurement from the start, including fuel or electricity use, truck idling, vessel waiting, local air pollutants and noise where relevant.
- Include workforce planning, training and safety procedures, because automation changes job profiles and requires new supervision, control, maintenance and exception-management capabilities.
- Use the results of pilots to define a scaling roadmap across terminals, berth clusters, gates or port-community interfaces.

INDICATIVE KPIs

KPI category	Examples of indicators	Evidence source
Business performance	Crane moves per hour; vessel turnaround time; berth occupancy; yard rehandles; truck turn time; gate waiting time; appointment adherence; equipment utilization; cost per move; service reliability.	Terminal operating system data; berth and yard logs; gate records; equipment telemetry; customer/hauler service data.
Climate / energy	Energy or fuel use per move; CO2e emissions per move; reduced auxiliary engine running time; reduced truck idling; share of electrified equipment; kWh saved; fuel saved.	Fuel records; electricity meters; AGV/crane telemetry; AIS/berth data; emissions calculations; energy management systems.
Pollution / local impacts	NOx, SOx, particulate matter and noise where measured; spill-risk events; congestion-related incidents; water contamination events; dust or nuisance complaints.	Air-quality monitoring; acoustic monitoring; environmental incident logs; port-community complaint systems; HSE records.
Safety and workforce	Incident rates; near misses; high-risk exposure hours avoided; training completed; reskilling participation; remote operation rate; system downtime.	HSE records; training records; HR data; remote-operations dashboards; maintenance logs.
Learning and scalability	Prediction accuracy; system interoperability; adoption rate; number of stakeholders connected; exception-resolution time; replication potential across terminals or ports.	Platform analytics; project reviews; stakeholder onboarding records; data-quality audits; pilot evaluation reports.

Table 62 | Indicative KPIs examples for implementation

CHALLENGE 18: ENERGY TRANSITION (SHORE POWER, MULTI-FUEL)

Ports are critical infrastructure for global trade and the blue economy, but they are also major energy hubs where shipping, logistics, and industrial activity generate significant greenhouse gas emissions, local air pollution, and noise. As climate regulation tightens and vessels capable of using lower-carbon fuels begin entering operation (Port of Antwerp-Bruges, 2024), ports face a growing operational challenge: decarbonizing maritime and port activity while preserving safety, reliability, competitiveness, and global connectivity. Climate change, energy efficiency, air quality, and noise are now among the leading environmental priorities for European port authorities (Puig et al., 2024). The energy transition in ports is not only a question of replacing fossil fuels. It requires ports to convert climate objectives into reliable infrastructure, safe procedures, and commercially viable services (Notteboom et al., 2020). This challenge therefore focuses on how ports can make decarbonisation practical, scalable, and economically sustainable.

SDG 14 ALIGNMENT:

Port energy transition contributes to SDG 14 by reducing the environmental footprint of maritime activity while preserving the economic role of ports in sustainable ocean-based trade. Shore power can reduce emissions and noise from vessels at berth (Krämer & Czermański, 2020); electric port service vessels can lower emissions from harbour operations (Devarapali et al., 2024); and multi-fuel bunkering infrastructure can support the adoption of cleaner maritime fuels (Klopott et al., 2023).

Port energy transition directly supports three key SDG 14 targets:

Target 14.1	Prevent and reduce marine pollution of all kinds. Shore power, low-carbon port vessels, and alternative-fuel bunkering can reduce emissions and noise from vessels at berth and port operations, mitigating the operational impact of shipping on coastal areas.
Target 14.2	Sustainably manage and protect marine and coastal ecosystems. By reducing air pollution, greenhouse gas emissions, and operational impacts from port and shipping activities, energy-transition measures help ports better manage pressures on coastal and marine environments.
Target 14.7	Increase the economic benefits from the sustainable use of marine resources. Port energy transition strengthens the blue economy by maintaining efficient maritime trade while preparing infrastructure for cleaner vessels, alternative fuels and lower-carbon logistics.

Table 63| Alignment with the SDG 14 targets

Port-related emissions do not stop at the port boundary: greenhouse gases, local air pollution and noise from vessels and port operations can affect coastal ecosystems, nearby communities and the wider climate system. By integrating shore power, low-carbon port vessels and alternative-fuel bunkering into normal port operations, ports contribute directly to marine pollution reduction (Target 14.1), sustainable management of coastal and marine ecosystems (Target 14.2), and a more resilient blue economy (Target 14.7) by turning decarbonisation infrastructure into cleaner, safer, and more competitive maritime trade.

ESRS MAPPING

The ESRS alignment for port energy transition should be evidence-based and operational. Shore power, electric harbor vessels and multi-fuel bunkering only create a strong ESRS link when companies can demonstrate measurable reductions in greenhouse gas emissions, local air pollutants, noise, fuel-related risks or energy intensity. The strongest connection is with ESRS E1 Climate Change, while ESRS E2 Pollution and social standards become relevant when local air quality, noise, fuel-handling safety, worker training and community exposure are monitored and managed.

ESRS topic	Connection	Possible indicators / evidence
E1 Climate Change	Core ESRS link. Shore power, electric harbor vessels and lower-carbon fuel infrastructure can reduce greenhouse gas emissions from vessels at berth, port service craft and related logistics when compared with fossil-fuel baselines.	CO_2e avoided; MWh of shore power supplied; number/share of vessel calls connected to OPS; auxiliary engine running hours avoided; electric tug operating hours; charging sessions; renewable electricity share; low-carbon fuel volumes supplied; EU ETS or FuelEU Maritime exposure reduced.
E2 Pollution	Relevant where port energy transition reduces local air pollutants, noise or pollution risks from port and vessel operations. Also relevant where alternative-fuel bunkering requires robust spill-prevention, containment and emergency-response procedures.	NO_x, SO_x and particulate matter avoided; noise levels at berth; odor/air-quality indicators; fuel spill incidents; containment inspections; emergency-response events; local emissions monitoring; complaints related to air quality or noise.
E3 Water and Marine Resources	Relevant when alternative-fuel bunkering, port vessel operations or energy infrastructure affect harbor waters or require safeguards to prevent marine contamination.	Water-quality monitoring results; fuel-handling incidents affecting water; bunkering safety checks; stormwater/runoff controls; harbor contamination events; preventive maintenance records.

S1/S2 Workforce and Value Chain Workers	New shore-power, charging and alternative-fuel systems require worker and contractor training, updated safety procedures and clear operational responsibilities.	Training hours; certified operators; safety drills; near misses; incidents; contractor compliance checks; emergency-response readiness; maintenance competence records.
S3 Affected Communities	Reduced berth emissions and noise can lower exposure for nearby urban and coastal communities, especially in ports located close to residential areas or cruise terminals.	Noise complaints; community complaints; local air-quality exposure indicators; stakeholder engagement records; public reporting on OPS and emissions reductions; port-city monitoring dashboards.

Table 64 | Alignment with the ESRS topic and possible indicators

THE BUSINESS CASE: COST REDUCTION + NEW BUSINESS MODEL

The value proposition is based on turning decarbonisation into usable port infrastructure. Onshore Power Supply (OPS) allows vessels at berth to switch off auxiliary engines and use electricity from shore (Krämer & Czermański, 2020). In Rotterdam, large-scale OPS implementation is estimated to prevent around 500 kilotonnes of CO_2 emissions per year (Port of Rotterdam Authority & Municipality of Rotterdam, 2025). Battery-electric tugboats allow ports to test lower-carbon propulsion in demanding but geographically contained operations (Devarapali et al., 2024). In parallel, multi-fuel bunkering capacity enables ports to serve vessels capable of using methanol, biofuels, and other lower-carbon fuels (Klopott et al., 2023).

The commercial challenge is operational integration: these solutions only create lasting value if they can be integrated into routine port operations without compromising safety, reliability or throughput. This requires grid capacity, charging systems, fuel-handling procedures, metering systems, safety protocols, and coordination between terminals, vessels, fuel suppliers and port authorities (Notteboom et al., 2020).

Therefore, the transition creates new business opportunities for energy providers, bunkering operators, terminal operators, grid infrastructure companies, equipment manufacturers, and port authorities. These actors can generate value through shore-power services, charging infrastructure, alternative-fuel supply, vessel retrofitting, emissions-reduction technologies, and compliance support. For ports able to provide reliable low-carbon infrastructure, decarbonisation becomes not only a regulatory requirement, but also a competitiveness strategy.

Potential revenue streams may include electricity sales through shore power services, charging fees for electric harbour vessels, bunkering fees for alternative fuels, long-term service contracts with shipping lines, and compliance-related value for operators exposed to EU ETS and FuelEU Maritime costs.

PRACTICAL EXAMPLES

Beyond reducing emissions, the following examples show how port energy transition can create business value by lowering regulatory exposure, improving operational readiness, supporting cleaner maritime fuels, and strengthening port competitiveness. All three examples come from the Port of Antwerp-Bruges, illustrating how a single port can combine several decarbonisation pathways rather than relying on one solution alone.

Port of Antwerp-Bruges: Shore Power for Cruise Ships at Zeebrugge

Zeebrugge, Belgium · Onshore Power Supply · Cruise terminal electrification

The Port of Antwerp-Bruges is deploying OPS at the Zweedse Kaai cruise terminal in Zeebrugge, allowing cruise ships at berth to switch off auxiliary diesel engines and use electricity from shore. The installation is expected to allow two cruise ships to connect simultaneously from 2027, ahead of the 2030 European requirement for passenger and container ships to use shore-side electricity or equivalent zero-emission technologies in covered EU ports (European Commission, 2026a; Port of Antwerp-Bruges, 2025).

Business model: The business case is based on reducing local emissions and noise from ships at berth, lowering regulatory exposure and preparing port infrastructure for tightening European climate and air-quality requirements. Shore power also helps strengthen the port's social and regulatory acceptance in urban and coastal areas by addressing one of the most visible sources of local environmental impact (European Commission, 2026b; Krämer & Czermański, 2020).

Port of Antwerp-Bruges: Battery-electric Tugboat Operations

Antwerp-Bruges, Belgium · Battery-electric port vessel · Operational testing under real port conditions

The Port of Antwerp-Bruges is using its own tugboat fleet as a test environment for low-carbon propulsion. Volta 1, Europe's first fully battery-electric tugboat, combines a 70-tonne towing capacity that matches that of conventional diesel vessels, with up to 12 hours on a full charge, delivered via a dedicated 1.5 MW charging system, demonstrating the potential of battery-electric propulsion (European Alternative Fuels Observatory, 2025).

Business model: The business case lies in reducing emissions from port service operations while testing whether battery-electric propulsion can meet the power, reliability, and operational requirements of harbour towage. Battery-electric tugboats are relevant for geographically contained services, where vessels operate within a defined area and can rely on dedicated charging infrastructure. By testing Volta 1 under real port conditions, the port reduces transition risk, builds operational knowledge and assesses the scalability of battery-electric propulsion before wider fleet deployment (European Alternative Fuels Observatory, 2025).

Port of Antwerp-Bruges: Multi-fuel Bunkering for Low-Carbon Shipping

Antwerp-Bruges, Belgium · Green methanol and biodiesel bunkering · Simultaneous refuelling and cargo operations

The Port of Antwerp-Bruges is also positioning itself as a bunkering hub for lower-carbon maritime fuels. In 2024, the deep-sea container vessel Ane Maersk completed its first bunkering operation in European waters at the port, receiving 4,300 tonnes of green methanol and 1,375 tonnes of biodiesel (B100) while cargo loading and unloading continued at the terminal (Port of Antwerp-Bruges, 2024). This is operationally important because alternative-fuel bunkering will only scale if it can be integrated into the workflows of ports without creating delays or additional idle time.

Business model: The business case is based on maintaining port competitiveness as shipping companies deploy vessels capable of using methanol, biofuels, and other lower-carbon fuels. By developing multi-fuel bunkering capacity, the port can attract low-carbon and dual-fuel vessels, reduce regulatory exposure, and strengthen its role as an energy-transition platform for maritime transport (European Commission, 2026a, 2026b; Port of Antwerp-Bruges, 2024).

WHAT PRIVATE COMPANIES CAN DO

Implementation should begin with the specific operational point where decarbonization infrastructure can create measurable value: vessel berthing, harbor towage, alternative-fuel supply, terminal energy use or compliance exposure. The strongest projects will connect infrastructure investment to commercial use, metering, safety procedures and verified emissions reduction.

- Establish a baseline for berth emissions, auxiliary engine running hours, harbour vessel fuel use, local air pollutants, noise and current energy costs.

- Identify priority vessel segments or terminal areas where shore power, electric charging or alternative-fuel bunkering can generate the strongest operational and environmental value.
- Develop the commercial model for shore power, charging or bunkering services, including tariffs, service contracts, utilisation assumptions and responsibility for grid or infrastructure investment.
- Coordinate early with shipping lines, terminal operators, fuel suppliers, grid operators, technology providers, classification societies and public authorities.
- Integrate metering and reporting systems that can support customer billing, regulatory compliance, EU ETS/FuelEU Maritime exposure analysis and sustainability reporting.
- Build safety procedures for alternative fuels, high-voltage connections and battery-electric operations, including training, emergency response and contractor requirements.
- Use pilots to test operational reliability before scaling, ensuring that decarbonisation infrastructure does not create avoidable delays, safety risks or throughput constraints.

INDICATIVE KPIs

KPI category	Examples of indicators	Evidence source
Business performance	OPS utilization rate; number of connected vessel calls; charging sessions; alternative-fuel bunkering operations; revenue from shore power, charging or bunkering; service uptime; average connection time; impact on vessel turnaround time.	Port operating systems; billing records; OPS/charging platform data; bunkering logs; terminal and vessel call records; service-level agreements.
Climate / energy	CO_2e avoided; MWh of shore power supplied; auxiliary engine hours avoided; electric tug operating hours; diesel fuel displaced; low-carbon fuel volumes supplied; renewable electricity share; energy cost per vessel call.	Electricity meters; vessel fuel records; emissions factors; tug operating logs; fuel supplier records; grid certificates; EU ETS/FuelEU Maritime calculations.
Pollution / local impacts	NO_x, SO_x and particulate matter avoided; noise levels at berth; reduction in complaints; odor/air-quality indicators; fuel spill incidents; water-quality alerts linked to bunkering or port operations.	Air-quality monitoring; acoustic monitoring; port-community complaint systems; environmental monitoring dashboards; HSE and incident logs; water-quality sensors.
Safety and reliability	Connection failures; equipment downtime; alternative-fuel safety incidents; emergency drills completed; trained/certified operators; near misses; maintenance compliance; response time to incidents.	Maintenance logs; training records; safety management systems; emergency-response records; contractor compliance records; audit reports.
Market and compliance	Number of long-term service contracts; share of low-carbon vessel calls; customers using OPS or alternative fuels; compliance with EU shore-power requirements; EU ETS/FuelEU Maritime cost exposure reduced; port competitiveness indicators.	Commercial contracts; customer records; port statistics; regulatory compliance reports; shipping-line agreements; sustainability reporting data.
Learning and scalability	Pilot-to-scale conversion rate; grid capacity secured; CAPEX per berth or charging point; stakeholder readiness; replication across terminals; interoperability with port community systems.	Pilot evaluations; investment plans; grid connection documentation; stakeholder agreements; port digital platform records; board/investment decision papers.

Table 65 | Indicative KPIs examples for implementation

CHALLENGE 19: REGULATORY UNLOCKING TO ACCELERATE BLUE INVESTMENT

Business case type: Reducing costs, with secondary potential to create new business models

Licensing and permitting remain one of the most important hidden costs in the blue economy. Sea-related projects often depend on multiple public authorities, overlapping legal regimes, environmental requirements, maritime spatial planning rules, stakeholder processes and technical

studies. For promoters, this creates long repeated information requests and difficulty in presenting projects as bankable to investors (European Commission, 2020; European Commission, 2023).
This challenge is particularly relevant for capital-intensive sectors such as offshore renewables, aquaculture, port infrastructure, coastal restoration, marine biotechnology infrastructure and low-impact maritime tourism. In these sectors, regulatory uncertainty does not only delay implementation; it increases the cost of capital, raises the probability of sunk development costs, and can prevent otherwise viable projects from reaching financial close.
The opportunity is not to weaken environmental safeguards. The business case is to make good regulation easier to navigate: clearer permitting pathways, early-stage risk screening, better project-preparation services, digital regulatory navigation, one-stop-shop interfaces, standardized evidence requirements and structured engagement with authorities and stakeholders.
Well-designed regulatory support reduces transaction costs while improving the quality, transparency and environmental robustness of blue economy projects.

In Portugal, where the ocean is central to economic development and where blue investment depends on the alignment between maritime spatial planning, environmental assessment, sector-specific permits and financing requirements, this type of solution can help convert ambition into investable projects. It is especially relevant for companies and investors that do not lack interest in the blue economy, but lack the practical pathway to move from concept to licensed, financeable and evidence-based implementation.

SDG 14 ALIGNMENT:

Regulatory unlocking has an enabling, rather than direct, relationship with SDG 14. Its contribution depends on the type of projects it accelerates and on whether the permitting support embeds environmental screening, spatial suitability, stakeholder engagement and measurable safeguards. When designed responsibly, it can help channel capital towards projects that create economic value from the sustainable use of marine resources, while reducing the likelihood of poorly sited or weakly evidenced projects (United Nations, 2015; European Commission, 2021).

Target	Alignment with the challenge
Target 14.2	Sustainably manage and protect marine and coastal ecosystems. Regulatory navigation can support better project siting, earlier ecological screening, stronger environmental baseline studies and mitigation hierarchy requirements, reducing the risk that blue investment damages sensitive ecosystems.
Target 14.7	Increase the economic benefits to coastal and island economies from the sustainable use of marine resources. By reducing permitting uncertainty and project-preparation costs, this challenge can help bring more sustainable blue economy projects to investment readiness.
Target 14.a	Increase scientific knowledge, research capacity and marine technology transfer. Project-preparation and permitting-readiness services can help R&D pilots, demonstration projects and marine technology solutions move from research to field deployment, provided they comply with environmental and regulatory requirements.

Table 66 | Alignment with the SDG 14 targets

Overall SDG 14 alignment should be considered moderate and conditional. The challenge does not directly reduce marine pollution or restore ecosystems by itself. Its value lies in enabling better, faster and more evidence-based deployment of projects that support a sustainable blue economy. For that reason, any business case should include safeguards to avoid treating speed as the only success metric.

ESRS MAPPING

The ESRS alignment for regulatory unlocking should be treated primarily as governance-related. The challenge is not about accelerating approval at any cost; it is about improving transparency, due diligence, documentation, stakeholder engagement and the quality of project preparation. Environmental ESRS topics become relevant only when the regulatory support demonstrably accelerates or strengthens projects with clear climate, pollution or biodiversity outcomes.

ESRS topic	Connection	Possible indicators
G1 Business Conduct	Primary relevance. The challenge relates to governance, regulatory compliance, transparent decision-making, due diligence, responsible stakeholder engagement, anti-corruption safeguards and documented interactions with public authorities.	Permitting pathway documented; competent authorities mapped; decision logs; stakeholder engagement records; due diligence packs completed; conflicts of interest identified and managed; repeated information requests reduced.
E1 Climate Change	Secondary relevance when the service supports renewable energy, energy-efficiency or decarbonization projects, such as offshore wind, port electrification or low-carbon maritime infrastructure.	Renewable or decarbonization projects supported; capacity reaching permit-readiness; permitting time/cost reduced; project-specific CO2e reduction potential or monitored CO2e avoided.
E4 Biodiversity and Ecosystems	Relevant when the service includes ecological screening, spatial suitability assessment, biodiversity baselines and mitigation hierarchy requirements before formal application.	Ecological constraints identified early; sensitive areas avoided; projects redesigned or re-sited; baseline studies completed; mitigation hierarchy actions defined; biodiversity safeguards included in applications.
E2 Pollution	Relevant only when regulatory support enables projects that reduce marine pollution or strengthens pollution safeguards for project deployment.	Pollution risks screened; discharge, waste, water, noise or contamination controls included; pollution-reduction projects supported; monitoring requirements mapped; compliance conditions integrated into project design.

Table 67| Alignment with the ESRS topic and possible indicators

THE BUSINESS CASE: COST REDUCTION + NEW BUSINESS MODEL

This challenge creates value primarily through cost reduction. Regulatory uncertainty generates direct costs, such as legal advice, technical studies, repeated submissions, project redesign and administrative delays. It also generates indirect costs, including delayed revenue, higher financing costs, weaker investor confidence, increased internal management time and the risk of losing development windows. For offshore and maritime projects, these costs can be material before any physical investment has started.

A regulatory unlocking solution reduces these costs by making the project pathway more predictable. This can include early permitting diagnostics, spatial and environmental constraint mapping, sequencing of authorizations, stakeholder-risk assessment, evidence checklists, template documentation, authority engagement plans, and financing-readiness packs. The goal is to help companies understand, before committing major capital, whether a project is feasible, what evidence is required, which entities must be involved, and what risks could block implementation.

The opportunity also supports new business models. Private companies can build regulatory navigation platforms, permitting-as-a-service, project-preparation facilities, marine spatial intelligence tools, compliance dashboards and investor-readiness services. These solutions can be sold to project developers, infrastructure investors, ports, aquaculture operators, renewable energy companies, municipalities, technology startups and financial institutions. For investors, the value is faster due diligence and lower uncertainty. For promoters, the value is reduced development cost and a stronger route to financing. For public authorities, the value is better-prepared projects and fewer fragmented interactions.

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PRACTICAL EXAMPLES

The following examples show how regulatory complexity can be converted into an operational and commercial opportunity. They do not imply that permitting should be simplified at the expense of environmental scrutiny. Instead, they show how structured processes, digital tools and project-preparation services can reduce transaction costs and make sustainable blue investment easier to execute.

Danish Energy Agency: One-stop-shop model for offshore wind permitting

Denmark · Public coordination model · Offshore wind development and permitting pathway

Denmark is widely cited as a benchmark for the one-stop-shop approach in offshore wind. The Danish Energy Agency acts as the central authority for offshore wind procedures, coordinating key permitting steps and interactions with other public bodies. This reduces the burden on project promoters, who otherwise need to navigate multiple agencies separately (Danish Energy Agency; IEA, 2023).

The model is relevant because offshore wind projects are complex, high-CAPEX and highly exposed to development delays. By clarifying the sequence of site identification, tendering, preliminary investigations, construction permission and operation, the one-stop-shop approach reduces administrative uncertainty and improves investor confidence.

Business model: The primary value is cost and risk reduction. While the one-stop-shop is a public model, it creates a benchmark for private advisory, data and project-preparation services. Companies can replicate parts of this logic by building regulatory pathway tools, evidence-pack services and permitting-readiness support for offshore renewable developers and their investors.

Portugal: From maritime spatial planning to permit-readiness services

Portugal · Maritime spatial planning, licensing navigation and project-preparation opportunity

Portugal has important institutional foundations for blue investment, including maritime spatial planning instruments and digital public services for sea-related procedures. However, promoters still need to translate spatial rules, environmental requirements, use rights, technical studies, stakeholder expectations and financing documentation into a coherent project pathway (Direção-Geral de Política do Mar, 2021; PSOEM).

This creates a practical opportunity for companies, legal teams, engineering consultancies, environmental advisors and blue economy platforms to develop permit-readiness services. These services can help promoters identify the relevant authorities, understand constraints, prepare evidence, test environmental and spatial suitability, and reduce the risk of late-stage redesign.

Business model: The business model can combine advisory fees, digital tools and project-preparation packages. For developers, the value is lower transaction cost and fewer avoidable delays. For investors, the value is a clearer due-diligence file. For public authorities, the value is receiving more complete, better-structured and more evidence-based applications.

EU BlueInvest: Investment-readiness support for blue economy companies

European Union · Advisory and investor-readiness platform for sustainable blue economy SMEs

BlueInvest is an EU initiative designed to improve access to finance for blue economy companies by providing investor-readiness support, advisory services and connections with investors (European Commission, n.d.-a). While it is not a licensing authority, it addresses a related friction: many blue projects struggle to translate technical ambition into financeable, investment-ready propositions.

The relevance for this challenge is that regulatory readiness and investment readiness are connected. Investors need evidence on permits, environmental risk, spatial suitability, stakeholder issues, revenue model and policy alignment. A strong project-preparation service can combine these components into a single finance-ready package.

Business model: The model creates value by reducing the cost of becoming investable. A private equivalent could provide bundled services: permitting pathway, ESG and ESRS mapping, financial model review, technical evidence checklist, partner map and investor memorandum. This is particularly useful for startups, SMEs and project developers entering regulated blue economy markets.

SeaSketch: Digital marine spatial planning and stakeholder engagement

International · Geospatial platform for marine planning, participation and conflict reduction

SeaSketch is a digital platform used in marine spatial planning and ocean management processes to support map-based collaboration, stakeholder input and analysis of spatial trade-offs (SeaSketch). Tools of this type help promoters and public actors visualize constraints, competing uses and ecological sensitivities before projects reach formal permitting stages.

For blue investment, early spatial intelligence can reduce costly mistakes. If a project location conflicts with protected areas, fisheries, shipping routes, military uses, cultural values or ecosystem sensitivities, the cost of discovering that conflict late can be high. Digital spatial planning tools help move these questions earlier in the project-development cycle.

Business model: The business model can be platform-based, combining subscriptions, licensing, consulting and data services. The value proposition is not only better planning; it is reduced development risk, stronger stakeholder legitimacy and a more credible environmental and spatial evidence base for permitting.

ADDITIONAL BENCHMARK SOLUTIONS

Benchmark	Model	Value proposition
MARA / Ireland	Maritime Area Consent and marine consenting authority	Creates a clearer statutory gateway for offshore and maritime-area projects, reducing uncertainty before project-level development.
Netherlands North Sea / Noordzeeloket	Public information and coordination portal	Centralizes practical information on North Sea uses, rules and competent authorities; useful benchmark for reducing search costs and fragmented guidance.
EU BlueInvest	Investment-readiness and advisory support	Helps blue economy SMEs and promoters become more financeable by improving business planning, investor materials and project readiness.
SeaSketch	Spatial planning and stakeholder engagement software	Supports participatory marine spatial planning, conflict mapping and early site screening, reducing the risk of late-stage opposition or unsuitable site selection.

Table 68 | Additional Benchmark Solutions

IMPLEMENTATION IMPLICATIONS FOR COMPANIES

Companies interested in this business case should avoid positioning regulatory unlocking as a promise of faster approval at any cost. The stronger positioning is “better prepared, more transparent and more financeable projects”. The commercial offer should therefore be built around evidence quality, predictability, risk reduction and early alignment with competent authorities and stakeholders.

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WHAT PRIVATE COMPANIES CAN DO

Companies interested in this business case should avoid positioning regulatory unlocking as a promise of faster approval at any cost. The stronger positioning is better prepared, more transparent and more financeable projects. The commercial offer should therefore be built around evidence quality, predictability, risk reduction and early alignment with competent authorities and stakeholders.

- Develop regulatory pathway mapping tools that identify competent authorities, applicable permits, sequencing, expected evidence requirements and critical decision points.
- Build spatial and environmental constraint-screening services that help promoters identify ecological sensitivities, competing uses, protected areas and potential site conflicts before formal submission.
- Create project documentation and evidence checklists that reduce repeated information requests, improve application quality and support investor due diligence.
- Offer stakeholder and authority engagement plans that document interactions transparently and reduce the risk of late-stage opposition or reputational concerns.
- Bundle permitting-readiness, ESRS/ESG mapping, technical evidence and financial documentation into investor-readiness packs for blue economy promoters, SMEs and infrastructure projects.
- Integrate safeguards into the service model, including mitigation hierarchy requirements, anti-corruption safeguards, responsible lobbying principles and documented decision trails.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Project preparation and cost reduction	Average time to complete pre-permitting diagnosis; reduction in external legal/advisory cost per project; reduction in repeated information requests; number of project redesigns avoided or completed early.	Project management records; advisory invoices; client baselines; application logs; project-preparation reports.
Governance and compliance	Number of authorities and permits mapped; number of critical regulatory risks identified before application; documented authority interactions; conflicts of interest managed; due diligence packs completed.	Compliance dashboard; permitting pathway maps; meeting logs; risk registers; due-diligence files.
Environmental safeguards	Number of environmental risks identified; projects redesigned or re-sited before formal submission due to early environmental screening; baseline studies completed; mitigation hierarchy actions defined.	Spatial screening outputs; ecological baseline studies; environmental assessment records; mitigation plans.
Investment readiness and scalability	Percentage of projects reaching investment-readiness; financing stage reached; investor due-diligence satisfaction; number of platform users or projects supported; subscription or advisory revenue.	Investor feedback; financing documents; CRM data; platform analytics; contracts and client reports.
Impact outcomes where applicable	Permits obtained for sustainable blue economy projects; renewable energy, restoration, pollution-reduction or marine technology projects enabled; project-specific CO2e, biodiversity or pollution KPIs where implementation occurs.	Permit records; ESG reports; project monitoring data; impact assessments; financing and commissioning documents.

Table 69 | Indicative KPIs examples for implementation

CHALLENGE 20: AQUACULTURE'S REPUTATION PROBLEM

Aquaculture now supplies over 50 percent of fish for human consumption and is the fastest-growing food production sector globally (FAO, 2024a). It has the potential to meet rising protein demand while reducing pressure on overfished wild stocks. Yet the sector faces a persistent perception gap: consumers broadly prefer wild-caught seafood over farmed, associating aquaculture with lower quality, environmental damage, antibiotic use and poor animal welfare (Budhathoki, 2024). This negative reputation depresses the market value of farmed fish relative to its actual quality and sustainability performance.

The problem is partly one of undifferentiated perception: consumers conflate the worst practices in global aquaculture (e.g., open-net pen pollution, high antibiotic use, habitat destruction) with all farmed fish, including operations that use recirculating aquaculture systems (RAS), hold third-party certifications and produce without chemicals or antibiotics. The result is that producers who invest in sustainability cannot capture the value of those investments through the prices they charge.

Beyond reputation, the sector faces structural barriers: high capital costs (especially for RAS), complex and slow licensing processes, technological challenges in species diversification, and feed sustainability concerns. This challenge focuses on closing the gap between actual sustainability performance and market perception.

SDG 14 ALIGNMENT: LIFE BELOW WATER

Sustainable aquaculture has a dual relationship with SDG 14. On one hand, certification frameworks (ASC, GlobalG.A.P.) and science-based management directly address pollution prevention and ecosystem protection. On the other, aquaculture's core promise, which is reducing pressure on wild fish stocks, aligns with sustainable harvesting goals.

Target 14.1	Prevent and significantly reduce marine pollution of all kinds. Certification standards (ASC, GlobalG.A.P.) impose measurable limits on effluent discharge, chemical use and habitat impact. Certified aquaculture operations demonstrably reduce their pollution footprint.
Target 14.4	Effectively regulate harvesting and end overfishing. Sustainable aquaculture directly reduces pressure on wild stocks by providing an alternative protein source.

Table 70 | Alignment with the SDG 14 targets

Improving aquaculture's market reputation is therefore not just a commercial objective – it is an environmental one. If consumers continue to reject farmed fish due to perceived quality and sustainability concerns, demand shifts back to wild stocks, undermining SDG 14.4.

ESRS MAPPING

From an ESRS perspective, this challenge should be mapped only where companies can substantiate the link between aquaculture practices, verified sustainability performance and credible market communication. Reputation alone is not an ESRS impact. The mapping becomes relevant when claims are supported by certification, traceability, environmental monitoring, audited production data and transparent governance of sustainability communication.

ESRS topic	Connection	Possible indicators
E2 Pollution	Relevant where certified or controlled aquaculture systems reduce effluent discharge, chemical use, antibiotic use, nutrient loading or other pollution risks associated with production.	Effluent quality; nutrient discharge; chemical and antibiotic use; treatment events; water-quality compliance; pollution incidents; certification audit results.
E3 Water and Marine Resources	Relevant where producers manage water withdrawal, recirculation, discharge, marine ingredients in feed, and dependency on marine resources. RAS and controlled	Water withdrawal; recirculation rate; discharge volumes; feed conversion ratio; fish-in/fish-out ratio; share of certified or

	systems can be material where they reduce water impacts or improve resource efficiency.	alternative feed ingredients; water-quality monitoring results.
E4 Biodiversity and Ecosystems	Relevant where aquaculture operations reduce pressure on wild stocks and manage biodiversity-related risks such as escapes, habitat impacts, disease transmission and sensitive-site interactions.	Escapes; mortality rates; disease outbreaks; habitat impact assessments; site carrying-capacity studies; certified production volume; protected-area proximity; biodiversity safeguards.
S4 Consumers and End-users	Relevant because the business case depends on consumer-facing information, food safety, product transparency, labelling quality and substantiated sustainability claims.	Product labelling accuracy; QR-code scans; traceability coverage; food-safety incidents; consumer complaints; certification visibility; share of products with verified sustainability information.
G1 Business Conduct	Relevant to the governance of claims, anti-bluewashing safeguards, certification processes, supplier controls, auditability and responsible marketing.	Third-party certifications; audit findings; claims-substantiation files; supplier due diligence; non-compliance cases; corrective actions; governance procedures for sustainability communication.

Table 71 | Alignment with the ESRS topic and possible indicators

THE BUSINESS CASE: INCREASING PRICES + MARKET SHARE GROWTH

The core business case is straightforward: producers who can credibly demonstrate sustainability and quality can command higher prices. A 2025 Korean study found that sustainability certification was the most influential factor in consumer seafood purchasing decisions significantly increasing willingness to pay for certified over non-certified aquaculture products (Go & Yi, 2025). US research confirms this pattern for farmed salmon, particularly when consumers have greater confidence in food safety (Britwum & Bernard, 2025).

The tools to bridge the perception gap already exist: third-party certification (ASC, GlobalG.A.P., IFS Food), blockchain-based traceability, real-time water quality monitoring, digital product passports, and transparent consumer communication. The challenge is not technological but strategic: integrating these tools into a coherent value proposition that the market recognizes and rewards.

Producers who combine sustainable practices with effective communication can differentiate their products in a market where most farmed fish is sold as an undifferentiated commodity. This is also an opportunity to reshape the broader narrative: responsibly managed aquaculture is not the problem – it is part of the solution, reducing pressure on overfished wild stocks and contributing directly to SDG 14. Producers who make this case credibly do not just raise prices for their own products – they help rebuild trust in the sector as a whole, expanding the overall market for responsibly farmed seafood.

PRACTICAL EXAMPLES

The following Portuguese examples illustrate how aquaculture producers are already investing in sustainability, certification and brand communication to reposition farmed fish as a premium, trustworthy product.

SEAentia: World's First Commercial RAS Corvina Production

Peniche, Portugal · Founded 2017 · €24M investment (Indico Capital + MAR2030) · Commercial production target 2028

SEAentia is a Portuguese startup pioneering the world's first commercial-scale production of corvina (meagre) in recirculating aquaculture systems (RAS). Founded by biologists João Rito and Nuno Leite, the company operates a proof-of-concept facility at the Port of Peniche and is building a large-

scale facility targeting 700 tonnes per year of premium corvina following strict sustainability criteria with a long-term ambition of 5,000 tonnes per year. SEAentia produces without chemicals or antibiotics and participates in the EU's SEA2SEE project, implementing blockchain traceability for full supply chain transparency (EU-Startups, 2025; Landing Aquaculture, 2021; SEAentia, 2024).
Business model: SEAentia positions corvina as a premium, fully traceable, sustainably farmed product with a verifiable sustainability narrative. By controlling the full production cycle from hatchery to market size in a closed RAS system, the company eliminates the environmental concerns that damage aquaculture's reputation – no marine discharge, no escapes, no antibiotic use–and can communicate this directly to consumers via blockchain-verified provenance.

Flatlantic: Europe's Leading Flatfish Producer with "Seastainability" Branding
Mira, Portugal · Founded 2006 (as Acuinova) · 3,500+ tonnes/year · Project of National Interest (PIN)
Flatlantic is the second largest producer of flatfish in Europe and the leading aquaculture company in Portugal, producing over 3,500 tonnes of turbot and sole per year at its 40-hectare "Seastainable Flatfish Village" in Mira, using water pumped directly from the Atlantic Ocean. The company holds GlobalG.A.P. and IFS Food certifications and is investing in RAS technology, omega-3 enriched fish (OmegaPeixe project), and microalgae-based effluent bioremediation (AQUA4ALL project). Flatlantic plans to expand to 6,000 tonnes of turbot and 10,000 tonnes of sole, with a workforce growing from 194 to over 450 (ArcelorMittal, 2026; Portugal Resident, 2024).
Business model: Flatlantic's approach is to embed sustainability into brand identity. The "Seastainable" branding is not a label added to an existing product – it is the company's entire market positioning. By combining certified production standards with visible investments in R&D, animal welfare and environmental stewardship, Flatlantic differentiates its flatfish in European export markets (80–90% of production) where sustainability expectations are highest.

WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

- Start with a claims and perception audit: identify what consumers, retailers, chefs, distributors and investors currently believe about the product and where the company has evidence to challenge that perception.
- Build the evidence base before building the communication campaign: certification, production data, water-quality monitoring, feed transparency, animal welfare protocols, antibiotic and chemical-use records, and traceability should support every sustainability claim.
- Translate sustainability performance into product differentiation through clear labelling, digital product passports, QR-code traceability, verified origin stories and transparent explanations of why the farming method reduces specific environmental concerns.
- Prioritise third-party validation where possible, including ASC, GlobalG.A.P., IFS Food or other relevant standards, and make audit outcomes and corrective-action processes part of the credibility architecture.
- Work with retailers, foodservice buyers, chefs and export-market partners to position responsibly farmed seafood as a premium and trustworthy alternative, rather than as a lower-value substitute for wild catch.

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- Develop category-level communication that explains why well-managed aquaculture can reduce pressure on wild stocks, while being transparent about the conditions under which aquaculture creates positive environmental outcomes.
- Avoid bluewashing risk by distinguishing clearly between traceability, certification, environmental performance and marketing language. Traceability proves origin and chain of custody; it does not automatically prove sustainability.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Commercial performance	Average selling price; achieved price premium versus non-certified or commodity products; gross margin; export-market penetration; retailer listings; foodservice contracts; repeat purchase rate.	Sales data; distributor contracts; retailer data; pricing analysis; export records; customer retention data.
Market perception and demand	Consumer willingness to pay; brand trust scores; consumer awareness of certification or farming method; QR-code scans; campaign engagement; customer satisfaction; sentiment analysis.	Consumer surveys; market research; digital analytics; QR platform data; social listening; customer feedback.
Certification and traceability	Share of production certified; share of products with verified traceability; number of audits passed; non-conformities resolved; product batches with digital product passport; labelling accuracy.	Certification bodies; audit reports; traceability platforms; internal quality systems; labelling controls.
Environmental and production performance	Effluent quality; water recirculation rate; chemical and antibiotic use; feed conversion ratio; survival rate; mortality rate; escape incidents; share of certified or alternative feed ingredients.	Farm management systems; water-quality sensors; veterinary records; feed supplier documentation; certification audits; environmental reports.
SDG 14 and ecosystem contribution	Evidence of reduced pressure on wild stocks; certified sustainable production volume; absence of marine discharge in RAS where applicable; habitat-impact controls; compliance with environmental permits.	Sustainability reports; environmental impact assessments; permit compliance data; certification records; production and sourcing data.
Governance and claims integrity	Number of substantiated sustainability claims; claims reviewed before publication; bluewashing complaints; corrective actions; supplier due diligence coverage; management review of sustainability communication.	Claims substantiation files; legal/compliance review; marketing governance records; audit reports; complaint registers.

Table 72 | Indicative KPIs examples for implementation

CHALLENGE 21: DEVELOPING A NATIONAL VALUE CHAIN FOR OFFSHORE AND OCEAN RENEWABLES

Offshore and ocean renewables are moving from demonstration to industrialization. In Europe, marine renewable energy is becoming a strategic blue economy sector: the EU offshore wind sector reached EUR 5.3 billion in gross value added in 2022, while offshore wind supported approximately 47,000 full-time equivalent jobs in the EU in 2024 (European Commission, 2025). EU policy also points to rapid expansion, with an offshore wind deployment objective of approximately 111 GW by 2030 and 317 GW by 2050 (European Commission, 2025).

Portugal is particularly well positioned because deep Atlantic waters favor floating offshore wind and because the country has a long record of testing ocean energy technologies. The Offshore Renewable Energy Allocation Plan (PAER) identifies maritime areas along the western continental coast with the best conditions for commercial offshore renewable energy, preferably floating, with

total potential capacity close to 10 GW (Diario da Republica, 2025). National targets include assigning 2 GW of offshore wind and 0.2 GW of wave energy capacity by 2030 (OES, 2025).
However, Portugal does not yet have a robust national value chain across the industrial and technological layers required by offshore and ocean renewables: components, dynamic and export cables, substations, maintenance, metalworking, floating platforms, moorings and anchors, robotics, sensors, digital monitoring, port logistics, certification and specialized marine services. Without deliberate value-chain development, Portugal risks capturing only a limited share of the value created by projects located in its maritime space, while high-margin equipment, intellectual property and O&M services are imported.
This challenge focuses on transforming offshore and ocean renewables into a national industrial opportunity. The objective is not only to install capacity in Portuguese waters, but to enable Portuguese companies to supply domestic projects and participate in international value chains. A national value chain can turn maritime resources into exportable products, skilled employment, port activity, applied research and long-term technological capabilities.

SDG 14 ALIGNMENT: LIFE BELOW WATER

Offshore renewables are directly connected to SDG 7 and SDG 13, but they can also contribute to SDG 14 when they are planned, built and operated as part of a responsible blue economy. The SDG 14 relevance lies in sustainable use of maritime space, protection of marine ecosystems, scientific knowledge generation and transfer of marine technology.

Target	Relevance to the challenge
14.2	Sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience. A national value chain can embed environmental monitoring, low-impact engineering, biodiversity-sensitive planning and responsible O&M into offshore renewable projects.
14.a	Increase scientific knowledge, develop research capacity and transfer marine technology. Floating offshore wind and wave energy require metocean data, sensors, modelling, marine robotics, subsea systems and environmental assessment capabilities - all of which strengthen national marine technology capacity.
14.7 (indirect)	Increase economic benefits from the sustainable use of marine resources. Offshore and ocean renewables can generate blue economy value through skilled jobs, exports, port activity and technology services, provided development is compatible with marine ecosystems and existing ocean users.

Table 73 | Alignment with the SDG 14 targets

By building domestic capabilities in environmental monitoring, digital ocean data, port-based industrialization and low-impact marine operations, Portugal can ensure that renewable energy deployment is not only decarbonizing but also ocean-compatible. This is essential because the long-term social license of offshore renewables depends on credible evidence that projects coexist with fisheries, biodiversity, navigation and coastal communities.

ESRS MAPPING

The ESRS relevance of this challenge depends on whether national value-chain development is connected to measurable climate, biodiversity, pollution, workforce and governance outcomes. Offshore and ocean renewables should not be mapped only as clean energy deployment; the strongest reporting logic emerges when companies can show how their products, services and partnerships reduce lifecycle emissions, embed biodiversity safeguards, strengthen responsible supply chains and build safe, skilled employment in offshore operations.

ESRS topic	Connection	Possible indicators
E1 Climate Change	Relevant where the value chain supports offshore and ocean renewable energy deployment, lower-carbon	Renewable capacity enabled; energy generated or supported; CO2e avoided or displaced; lifecycle emissions

	electricity generation, electrification of maritime activities, or lower lifecycle emissions in project development and operations.	of components; share of renewable electricity used in manufacturing; fuel savings from localized O&M logistics.
E4 Biodiversity and Ecosystems	Relevant where companies embed biodiversity-sensitive siting, environmental monitoring, mitigation hierarchy, low-impact construction, underwater noise management and responsible O&M into offshore renewable projects.	Environmental baseline studies completed; biodiversity monitoring coverage; marine mammal/seabird interaction data; seabed disturbance indicators; mitigation actions implemented; ecosystem coexistence indicators with fisheries and protected areas.
E2 Pollution	Conditional relevance where offshore renewable value-chain activities reduce pollution pressures or manage construction, port, vessel, coating, cable, waste, underwater-noise or accidental-release risks.	Underwater noise levels; spill incidents; hazardous materials managed; waste generated and recovered; water-quality indicators; pollution events avoided; compliance events.
S1/S2 Workforce and Value Chain Workers	Relevant because national value-chain development depends on skilled labor, offshore safety, supplier capability, training and responsible working conditions across manufacturing, marine operations and O&M.	Skilled jobs created; training hours; offshore certifications; HSE incidents; near misses; supplier workforce standards; reskilling programs; retention of specialized technicians.
G1 Business Conduct	Relevant where companies build transparent supplier qualification, responsible procurement, anti-corruption safeguards, public-private partnerships, certification processes and traceable supply-chain governance.	Supplier qualification rate; certified suppliers; procurement transparency; contract compliance; stakeholder engagement records; responsible lobbying safeguards; audit findings.

Table 74| Alignment with the ESRS topic and possible indicators

THE BUSINESS CASE: INCREASING MARKET SHARE + NEW BUSINESS MODEL

Developing a national value chain creates value primarily through increasing market share. Offshore renewable energy is not only an electricity generation business; it is an industrial system with high-value segments before, during and after commissioning. For floating wind, the strategic value pools include platform and foundation fabrication, mooring systems, anchors, dynamic cables, electrical modules, ports, heavy logistics, vessels, corrosion protection, inspection, predictive maintenance, environmental monitoring, data services and asset-life extension.

Portuguese companies can increase market share in three ways. First, they can position early in the domestic project pipeline enabled by PAER and future auctions. Second, they can export products and services to other floating wind and ocean energy markets, especially Atlantic, Mediterranean and island regions where deep-water technologies are relevant. Third, firms in adjacent sectors - metalworking, shipbuilding, ports, electronics, robotics, software, environmental consulting and marine engineering - can diversify into offshore renewables with higher margins and long-term demand.

This is also a secondary new-business-model opportunity. Companies can move beyond one-off manufacturing contracts into recurring O&M, monitoring-as-a-service, digital twins, robotics inspection, marine biodiversity data, cable integrity services, training and certification. These services can generate stable revenues throughout the 20-30 year operating life of offshore assets.

The opportunity is not restricted to the Portuguese market. The Aveiro region already demonstrates that Portuguese industry can manufacture wind towers and offshore foundations for international markets. If Portugal combines port infrastructure, supplier qualification, certification, testing sites, university-industry collaboration and developer partnerships, private companies can become part of European and global offshore renewable value chains rather than only local subcontractors.

Private companies can address this challenge by forming supplier consortia with developers and OEMs; investing in port-based manufacturing and assembly; certifying products to offshore standards; developing robotic inspection and sensor packages; building environmental monitoring services; training maritime and electrical technicians; and creating export partnerships in markets where floating offshore wind and wave energy are moving from demonstration to commercial deployment.

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PRACTICAL EXAMPLES

WindFloat Atlantic: Portugal as a Reference Site for Floating Offshore Wind

Viana do Castelo, Portugal · 25 MW · 3 turbines of 8.4 MW · Operational since 2020

WindFloat Atlantic is the world's first semi-submersible floating offshore wind farm. Located around 18 km off Viana do Castelo in approximately 100 m water depth, the project connects three WindFloat platforms to the Portuguese electricity grid and supplies electricity equivalent to the annual consumption of approximately 25,000 households (WindFloat Atlantic, 2026). Beyond electricity generation, the project is strategically important because it created an operational reference asset for floating wind in Atlantic conditions, generating know-how in installation, marine logistics, grid connection, monitoring and long-term O&M.

Business model: The asset generates revenue through clean electricity production, but its wider business value is technological de-risking and market positioning. For private companies, WindFloat Atlantic creates demand for marine operations, subsea inspection, data monitoring, safety services, environmental assessment and O&M. It also strengthens Portugal's credibility as an operating base for floating wind projects abroad.

CS Wind / ASM Industries and Port of Aveiro: Component Manufacturing for Export Markets

Aveiro, Portugal · Wind towers and offshore foundations · Port-based industrial platform

ASM Industries, integrated into the CS Wind group, is a major Portuguese manufacturer of wind towers and offshore foundations. Its industrial unit at the Port of Aveiro is dedicated to wind towers and foundations for maritime applications and benefits from port infrastructure designed for large project cargoes. The Port of Aveiro has highlighted the role of the facility in creating an offshore industry cluster and strengthening Portugal's ability to serve the wider European market (Port of Aveiro, 2021). CS Wind later took full ownership of ASM Industries, linking Portuguese manufacturing capacity to a global wind tower manufacturer (OffshoreWind.biz, 2022).

Business model: The business model is industrial export. By manufacturing towers and foundations in a port-based location, the company captures value from component production, logistics and global supply-chain integration. This is the clearest example of how Portuguese companies can increase market share beyond national projects, serving international offshore wind demand.

CorPower Ocean / HiWave-5: Building a Wave Energy Technology Ecosystem in Portugal

Aguçadoura / Northern Portugal · Full-scale wave energy converter demonstration · Technology-led industrialization

HiWave-5 is a full-scale wave energy conversion demonstration project installed at the coast of Aguçadoura, Póvoa de Varzim. The project's own positioning emphasizes its relevance for the energy transition and for building a new industry (CorPower Ocean / HiWave-5, 2025). For Portugal, the strategic value is not only the electricity generated by a wave device, but the creation of a test, deployment and service ecosystem around wave energy: anchoring, cable routing, marine operations, monitoring, certification, environmental studies and port services.

Business model: CorPower's model is technology-driven: develop and validate a wave energy converter platform that can be deployed in commercial wave farms. Portuguese companies can capture value by supplying fabrication, installation, grid connection, marine operations, testing, inspection and O&M services. This creates a bridge between Portugal's maritime engineering capabilities and a future global wave energy market.

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Additional Benchmark Solutions

Company	Technology	Value Proposition
AW-Energy / ONDEP (Finland / Portugal)	WaveRoller array deployment	The Horizon Europe ONDEP project received EUR 19 million to deploy a 2 MW wave energy array with four WaveRoller devices in Peniche. It shows how Portugal can attract international ocean energy developers while building local marine services, grid connection and O&M experience.
Offshore Wind Growth Partnership (United Kingdom)	Supply-chain acceleration and funding	A dedicated program supporting companies to develop products, expand capacity and strengthen capability across the offshore wind supply chain. It is a useful benchmark for a Portuguese supplier-development platform focused on SMEs, certification and export readiness.
Navantia Seanergies / Windar (Spain)	Shipbuilding and metal working diversification	Builds substations, fixed foundations and floating foundations for offshore wind. It demonstrates how shipyards and heavy industry can reposition into offshore renewables and become export suppliers to European projects.

Table 75 | Additional Benchmark Solutions

WHAT PRIVATE COMPANIES CAN DO

Private companies should treat offshore and ocean renewables as an industrial positioning opportunity rather than only as a local energy project pipeline. The strongest entry points are those where existing capabilities can be translated into offshore standards, certified performance, recurring services and exportable solutions.

- Map current industrial, engineering, digital, environmental or maritime capabilities against offshore renewable value-chain segments, including fabrication, moorings, cables, sensors, ports, O&M, robotics, data, environmental monitoring and certification.
- Form supplier consortia with developers, OEMs, ports, universities and testing centres to qualify Portuguese capabilities early in the project pipeline.
- Invest in offshore certification, quality assurance, HSE systems, marine corrosion standards, documentation and supplier-readiness processes required by international developers.
- Develop port-based manufacturing, assembly, staging, maintenance or logistics services that can serve both domestic projects and export markets.
- Convert project-based activities into recurring services, including monitoring-as-a-service, robotics inspection, digital twins, cable integrity monitoring, biodiversity data services, training and O&M support.
- Embed biodiversity, fisheries coexistence, underwater noise, seabed and environmental monitoring into project services so that market growth remains compatible with SDG 14.
- Create export partnerships in Atlantic, Mediterranean and island markets where floating wind and wave energy are moving from demonstration to commercial deployment.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Market share and revenue	Share of domestic offshore renewable project spend captured by Portuguese suppliers; export revenue from offshore and ocean renewable products/services; number of international clients; contracts won; value of long-term O&M/service contracts.	Sales data; procurement records; export contracts; project pipelines; developer/OEM supplier databases; port activity records.
Industrial capability	Number of certified suppliers; manufacturing capacity; components produced; port assembly capacity; supplier	Certification records; supplier audits; production records; port throughput data;

	qualification completed; local content share; number of companies entering offshore renewable value chains.	tender documentation; industry cluster reports.
Innovation and new business models	Recurring service revenue; monitoring-as-a-service contracts; digital twin clients; robotics inspection missions; training/certification programs; pilots converted into commercial projects.	Platform analytics; service contracts; pilot reports; customer retention data; training records; R&D project outputs.
Environmental and SDG 14 performance	Environmental monitoring coverage; biodiversity baseline and follow-up studies; underwater noise monitoring; coexistence measures with fisheries; incidents avoided; mitigation actions implemented; renewable capacity supported with ecosystem safeguards.	Environmental impact assessments; monitoring reports; sensor data; biodiversity surveys; fisheries engagement records; compliance documentation.
Workforce and safety	Skilled jobs created; training hours; offshore safety certifications; HSE incidents; near misses; technician retention; supplier workforce standards.	HR records; training certificates; HSE logs; supplier assessments; project safety reports.

Table 76| Indicative KPIs examples for implementation

CHALLENGE 22: VALORIZATION OF MARINE BIORESOURCES IN HEALTH, FOOD, COSMETICS AND BIOMATERIALS

Blue biotechnology is one of the most promising frontiers of the sustainable blue economy. It uses marine biological material - including algae, cyanobacteria, microalgae, fishery by-products, marine microorganisms, bacteria, fungi, invertebrates and their bioactive compounds - to create higher-value products across pharmaceuticals, cosmetics, feed ingredients, biomaterials and specialized chemicals (European Commission, 2025). The emerging blue bioeconomy can transform aquatic biomass into food, feed, nutraceuticals, pharmaceuticals, cosmetics, packaging, clothes and other bio-based products (European Commission, 2026).

The opportunity is significant but difficult to capture. Blue biotechnology is capital-intensive, scientifically complex and exposed to long development cycles. Commercialization depends on the nature of each bioresource and target market: a food ingredient may require safety, quality and regulatory validation; a cosmetic active requires efficacy, stability and formulation performance; a biomaterial needs mechanical performance and scalability; a drug candidate requires pre-clinical studies, clinical trials, intellectual-property protection and licensing. The same marine compound can therefore lead to very different business models depending on the application pathway.

Marine bioresources are particularly attractive because they contain unique molecules and functionalities shaped by extreme marine environments: antifouling compounds, pigments, enzymes, polysaccharides, collagen, chitin, chitosan, omega-3 lipids, peptides, exopolysaccharides and metabolites produced by extremophile bacteria or ocean fungi. These compounds can support new products in healthy ageing, chronic pain, wound care, respiratory health, sustainable protein, food texture, animal feed, biofertilizers, skin care, biodegradable packaging and advanced materials.

The core challenge is to move from scientific potential to scalable business. This requires sustainable sourcing, traceability, biorefinery design, extraction and purification capacity, regulatory dossiers, product validation, intellectual property, corporate partnerships and compliance with access-and-benefit-sharing principles. The Nagoya Protocol requires fair and equitable sharing of benefits arising from genetic resources, making responsible governance a strategic requirement rather than a secondary issue (CBD, 2026).

SDG 14 ALIGNMENT: LIFE BELOW WATER

Marine bioresource valorization aligns with SDG 14 when it is based on sustainable sourcing, low-impact cultivation, circular use of by-products and scientific capacity building. The opportunity is not to extract more from the ocean, but to create more value from responsibly sourced marine biomass and from streams that are currently underused or treated as waste.

Target 14.1	Prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution. Valorizing fish by-products, algae residual streams and biodegradable marine-based materials can reduce organic waste, landfill and plastic pollution pressures.
Target 14.2	Sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts. Responsible blue biotechnology depends on ecosystem-based sourcing, aquaculture integration, low-impact cultivation and monitoring to avoid overharvesting or biodiversity loss.
Target 14.7	Increase economic benefits from the sustainable use of marine resources. Blue biotechnology can generate high-value products, skilled employment and export opportunities from sustainable marine biomass, especially where local marine resources are linked to research, processing and industrial capacity.
Target 14.a	Increase scientific knowledge, develop research capacity and transfer marine technology. Marine bioresource valorization is research-intensive and directly strengthens marine biotechnology, bioprospecting, bioprocessing, analytical chemistry and applied ocean science capacity.

Table 77 | Alignment with the SDG 14 targets

The SDG14 contribution is strongest when blue biotechnology follows a
circular and regenerative logic: using byproducts rather than virgin extraction where possible; culti vating algae and microalgae in controlled systems; designing biodegradable alternatives to persist ent materials; and ensuring that benefits from marine genetic resources are shared fairly and trans parently.

ESRS MAPPING

The ESRS relevance of this challenge depends on how marine bioresources are sourced, cultivated, processed, validated and brought to market. A marine-derived product should not be treated as sustainable by default. The strongest ESRS mapping emerges when companies demonstrate responsible sourcing, circular use of by-products, pollution prevention, biodiversity safeguards, safe products, traceable supply chains and responsible governance of marine genetic resources.

ESRS topic	Connection	Possible indicators
E2 Pollution	Relevant where valorization reduces organic waste, landfill, plastic pollution, nutrient discharge or the use of persistent fossil-based materials. It is strongest for biodegradable materials, by-product valorization and substitution of pollution-intensive inputs.	Tonnes of by-products or residual biomass valorized; landfill avoided; plastic units or tonnes replaced; biodegradable material output; nutrient or effluent reductions; pollution incidents avoided.
E3 Water and Marine Resources	Relevant where companies depend on marine biomass, seawater, aquaculture systems, microalgae cultivation or marine resource extraction. The mapping should focus on responsible use, traceability, water efficiency and marine-resource stewardship.	Share of traceable marine biomass; water use per kg of output; sourcing permits; cultivation system type; biomass yield; nutrient recycling rate; proportion of by-product or residual streams used.
E4 Biodiversity and Ecosystems	Relevant where sourcing, cultivation or bioprospecting may affect marine ecosystems, or where companies implement safeguards to avoid overharvesting, habitat disturbance, biodiversity loss or irresponsible use of marine genetic resources.	Biodiversity risk screening; sourcing from controlled or certified systems; no-harvest zones respected; ecosystem monitoring coverage; Nagoya/access-and-benefit-sharing documentation; mitigation actions implemented.
E5 Resource Use and Circular Economy	Highly relevant where the model uses fishery by-products, algae residual streams, biorefinery approaches or renewable bio-based inputs to create higher-value products while reducing waste.	Material circularity rate; conversion yield; number of co-products extracted per biomass stream; waste-to-product ratio; renewable material content; residual waste after processing; reuse or valorization rate.
S4 Consumers and End-users	Relevant for food, nutraceutical, cosmetics, health and biomaterials applications where product safety, substantiated claims, transparent labelling and consumer trust are material.	Safety tests completed; regulatory approvals; claims substantiation files; contaminant testing; product recalls; labelling transparency; customer complaints; certifications.
G1 Business Conduct	Relevant because marine bioresources can involve intellectual property, research partnerships, access-and-benefit-sharing obligations, supplier governance and responsible commercialization of marine genetic resources.	Access-and-benefit-sharing agreements; provenance documentation; supplier codes; research collaboration agreements; patents/licenses; ethics review; anti-biopiracy safeguards; due diligence records.

Table 78 | Alignment with the ESRS topic and possible indicators

THE BUSINESS CASE: CREATING A NEW BUSINESS MODEL

Valorization of marine bioresources creates value primarily through new business models. The bus iness opportunity is not simply to sell raw marine biomass at commodity prices; it is to transform marine molecules, extracts and residues into differentiated, IP-protected and scientifically validated products. This changes the revenue logic from volume-based extraction to knowledge-based value creation.

Companies can build several models around this challenge. One model is the B2B ingredient platform: companies cultivate or source marine biomass, extract functional compounds and sell standardized ingredients to food, nutraceutical, cosmetics, animal feed or biomaterials manufacturers. A second model is the biorefinery model: multiple compounds are extracted from the same biomass stream, increasing margins and reducing waste. A third model is the licensing model: discovery companies identify marine-derived molecules and license drug candidates, formulations or technologies to larger pharmaceutical, health or consumer-goods partners. A fourth model is the branded-product model, where companies convert marine ingredients into their own consumer-facing products.

This business case is especially relevant for private companies because demand for natural, bio-based, traceable and low-impact ingredients is increasing across several sectors. Food and feed companies need sustainable proteins, omega-3 alternatives, texture systems and functional ingredients. Cosmetic companies need natural actives with antioxidant, hydrating, anti-ageing or skin-barrier functions. Pharmaceutical and medtech companies seek novel mechanisms of action for unmet clinical needs. Packaging and materials companies need biodegradable alternatives to fossil-based plastics.

The commercial risk is high, but so is the strategic upside. Companies that solve scale-up, quality control, regulatory approval and market access can create defensible businesses with p atents, trade secrets, proprietary strains, certified supply chains, long-term offtake agreements and recurring B2B revenues.

In this sense, marine bioresource valorization is not a marginal sustainability activity; it is a platform for building new industries from ocean science.

Private companies can address this challenge by investing in marine bioprospecting, strain libraries, controlled cultivation, extraction technologies, analytics, regulatory expertise, co-development with universities, corporate partnerships and product validation. The most robust strategies will combine scientific credibility with clear market entry points: one lead market, one validated ingredient or compound, one regulatory pathway and one scalable sourcing model.

PRACTICAL EXAMPLES

Sea4Us: Marine-Origin Drug Discovery for Unmet Medical Needs

Sagres and Lisbon, Portugal · Founded 2013 · Marine biotechnology and human health

Sea4Us is a Portuguese biotechnology company with facilities in Sagres and Lisbon. It specializes in the discovery and development of new substances and molecules of marine origin for unmet medical needs, using a platform built on marine biology and cellular excitability, particularly ion channels. Its pipeline is associated with areas such as chronic pain, epilepsy, diabetes, cardiac arrhythmia, hypertension and skin diseases, with activity spanning bioactivity screening,

biotechnological or synthetic production, pharmaceutical development and early clinical stages (NOVA University Lisbon, 2022; P-BIO, 2026).
Business model: Sea4Us represents a high-risk, high-upside licensing and IP model. The company creates value by converting marine-derived molecules into proprietary drug candidates. Revenue potential comes from patents, licensing, co-development agreements and future pharmaceutical partnerships rather than from selling biomass. It is a clear example of blue biotechnology as a new business model for health innovation.

Allmicroalgae: Industrial Microalgae Platform for Food, Feed, Nutraceuticals and Cosmetics
Leiria / Pataias, Portugal · Industrial microalgae production · Certified natural ingredients
Allmicroalgae - Natural Products S.A. is a Portuguese company dedicated to microalgae solutions. Its mission is to provide high-quality natural microalgae solutions at global scale, serving human nutrition, nutraceuticals, animal feed, agriculture and cosmetics with pure and safe microalgae products. The company highlights certifications including European Organic Production and Halal, positioning itself as a quality and food-safety reference in premium microalgae ingredients (Allmicroalgae, 2026).
Business model: Allmicroalgae operates as a B2B ingredient and production platform. It captures value by cultivating, processing and commercializing standardized microalgae biomass and ingredients for multiple end-markets. This diversifies revenue across food, feed, nutraceutical, agriculture and cosmetics, while enabling clients to replace conventional ingredients with traceable bio-based alternatives.

Notpla: Seaweed-Based Biomaterials Replacing Single-Use Plastic
London, United Kingdom · Earthshot Prize winner 2022 · Seaweed packaging and biomaterials
Notpla develops biodegradable packaging materials from seaweed. Its products include seaweed-coated food containers, edible liquid packaging, rigid cutlery, paper and sachets. The company emphasises that seaweed grows quickly, needs no freshwater, land or fertiliser, captures carbon and offers material properties that can replace persistent fossil-based packaging. Since winning the Earthshot Prize in 2022, Notpla has scaled commercial partnerships; Earthshot reports that Notpla replaced 4.4 million units of plastic with its products in 2023 and that its packaging was recognized as plastic-free under the European Single Use Plastics Directive (Notpla, 2026; Earthshot Prize, 2026).
Business model: Notpla's business model is a materials platform for B2B and B2B2C markets. It sells and co-develops seaweed-based packaging formats for foodservice, events, retail, personal care and home care applications. The model creates a new biomaterials category: marine-derived alternatives designed to biodegrade without persistent microplastic pollution.

Additional Benchmark Solutions

Company	Technology	Value Proposition
Algaia (France)	Seaweed biorefinery and ingredients	Produces seaweed extracts for food, cosmetics, health, agriculture and bio-based materials. Its model shows how one marine biomass stream can support several higher-value markets through extraction know-how and global sales channels.

Marinomed / Carragelose (Austria)	Red algae-derived health platform	Carragelose is an iota-carrageenan polymer derived from red algae used in products for respiratory infections, allergic rhinitis and dry or irritated eyes. It demonstrates how a marine polysaccharide can become an OTC health technology platform.
Necton / PremiumAlgae (Portugal)	Zero-waste microalgae biorefinery	PremiumAlgae aims to valorize microalgae biomass and production supernatants into fucoxanthin, phycobiliproteins, exopolysaccharides and extracellular vesicles for nutraceutical, cosmetic and aquaculture applications.
Algenesis / Soleic (United States)	Biodegradable bio-based polyurethane	Develops plant/algae-based fully biodegradable polyurethane materials designed to avoid persistent microplastic pollution, targeting footwear, textiles and consumer goods applications.

Table 79| Additional Benchmark Solutions

WHAT PRIVATE COMPANIES CAN DO

Private companies should approach marine bioresource valorization as a staged innovation pathway, not as a generic sustainability claim. The most credible strategies combine responsible sourcing, science-based validation, regulatory clarity, product-market focus and evidence that marine biomass is being used more efficiently or with lower environmental pressure.

- Define one lead application pathway first - for example food ingredient, cosmetic active, biomaterial, nutraceutical, feed ingredient or health technology - and identify the regulatory, safety and evidence requirements for that market.
- Establish responsible sourcing and traceability systems for marine biomass, including access-and-benefit-sharing checks where genetic resources are involved.
- Prioritise circular inputs such as fishery by-products, algae residual streams, production supernatants or controlled cultivation systems before relying on wild extraction.
- Develop extraction, purification, analytics and quality-control capabilities that can deliver consistent batches at commercial scale.
- Use a biorefinery logic where possible, extracting multiple products from the same biomass stream to increase margins and reduce residual waste.
- Build partnerships with universities, research centres, contract manufacturers, consumer-goods companies, pharmaceutical partners, packaging companies or feed producers to accelerate validation and market access.
- Protect the knowledge base through patents, trade secrets, proprietary strains, licences or long-term offtake agreements, while ensuring transparent governance of marine genetic resources.
- Support market claims with credible evidence, including safety, efficacy, traceability, biodegradability, circularity and environmental-performance data.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Business model and market validation	Revenue from marine-derived products; B2B customers; licensing agreements; patents filed or granted; co-development partnerships; offtake agreements; gross margin by product line; pilots converted into commercial contracts.	Sales data; contracts; IP records; partnership agreements; customer pipeline; management accounts; market validation reports.
R&D and product development	Number of compounds, strains or extracts screened; validated ingredients; TRL progression; product prototypes; regulatory dossiers submitted; safety and efficacy studies completed; time from discovery to pilot.	Laboratory records; R&D reports; regulatory files; validation studies; pilot documentation; quality-control records.
Circularity and resource efficiency	Tonnes of by-products or residual biomass valorized; conversion yield; number of co-products per biomass stream; residual waste after processing; renewable or bio-based material content; plastic or fossil-based material replaced.	Production records; mass-balance calculations; LCA studies; supplier data; waste records; product specifications.

Responsible sourcing and biodiversity	Share of traceable biomass; sourcing from controlled/certified cultivation; biodiversity risk assessments; Nagoya/access-and-benefit-sharing documentation; supplier due diligence completed; ecosystem monitoring coverage.	Traceability records; supplier audits; permits; ABS agreements; biodiversity assessments; monitoring reports; certification files.
Product safety and compliance	Batch consistency; contaminant tests; product safety tests; claims substantiation; certifications obtained; customer complaints; recalls; compliance with food, cosmetics, health or materials regulations.	Quality assurance records; lab tests; certification documents; regulatory submissions; customer-service records; recall logs.
Environmental and SDG 14 contribution	Organic waste avoided; landfill avoided; plastic pollution avoided; biodegradable material output; water use per kg of product; nutrient recycling; pollution reductions; scientific capacity or technology-transfer outputs.	ESG reports; production and waste data; LCA results; water and energy data; research outputs; project reports; environmental monitoring data.

Table 80 | Indicative KPIs examples for implementation

CHALLENGE 23: INTEGRATION OF MARINE NATURAL CAPITAL INTO BUSINESS AND FINANCING MODELS

The ocean provides a wide set of ecosystem services that underpin business continuity, human wellbeing and climate resilience: biodiversity, coastal protection, carbon sequestration, oxygen production, fisheries productivity, water quality regulation, tourism value and cultural identity. Yet these services are still weakly reflected in corporate accounts, investment decisions, insurance pricing and public-private financing models. Ocean health is therefore often treated as an externality, even by sectors whose revenues depend directly on functioning marine and coastal ecosystems.

This gap is increasingly material. The European Commission notes that the ocean has an annual economic value estimated at USD 2.5 trillion, provides the oxygen for every second breath we take and hosts an estimated 80 percent of the planet's biodiversity. At the same time, marine ecosystems are being degraded by pollution, overfishing, coastal development, climate change and ocean acidification. When biodiversity loss, coastal erosion or water-quality decline are not measured or priced, companies and investors systematically underinvest in the natural assets that reduce risk and sustain long-term value.

The policy and finance context is changing quickly. The Taskforce on Nature-related Financial Disclosures (TNFD) provides a framework for companies and financial institutions to identify and disclose nature-related dependencies, impacts, risks and opportunities. The EU Corporate Sustainability Reporting Directive and ESRS E4 are increasing expectations for biodiversity and ecosystem disclosures. UNEP FI's Sustainable Blue Economy Finance Principles give banks, insurers and investors ocean-specific guidance for sustainable finance. In parallel, blue bonds, debt-for-nature swaps, blue carbon projects, biodiversity and water-quality credits, and natural capital accounting are creating new ways to channel capital towards measurable ocean outcomes.

This challenge focuses on transforming marine natural capital from an invisible dependency into a measurable, investable and governable asset class. It requires credible metrics, science-based baselines, transparent monitoring, verification and reporting (MRV), robust benefit-sharing with local communities, and strong safeguards to ensure that credits or financial instruments do not become a substitute for avoiding and reducing harm. If designed with integrity, these tools can create new markets while improving decision-making and scaling finance for ocean protection and restoration.

SDG 14 ALIGNMENT: LIFE BELOW WATER

Integrating marine natural capital into business and financing models is directly aligned with SDG 14 because it creates the economic logic, data infrastructure and financing mechanisms needed to protect, restore and sustainably manage marine ecosystems.

Target	Business relevance
Target 14.2	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience. Natural capital accounting and finance mechanisms help companies identify ecosystem dependencies, price degradation risks and fund restoration or protection.
Target 14.5	By 2020, conserve at least 10 percent of coastal and marine areas, consistent with national and international law and based on the best available scientific information. Blue bonds, blended finance facilities and long-term MPA revenue models can provide durable financing for protected and conserved areas.
Target 14.a	Increase scientific knowledge, develop research capacity and transfer marine technology. Biodiversity MRV, eDNA, satellite monitoring, digital nature data platforms and natural capital metrics provide the knowledge infrastructure required to link finance with verified ocean outcomes.

Table 81| Alignment with the SDG 14 targets

The central contribution to SDG 14 is the conversion of ecosystem value into decision-useful information and investable cash flows. When the benefits of mangroves, seagrasses, reefs, fisheries nurseries and marine protected areas become measurable, companies can integrate them into risk management, capital allocation, product design, insurance models, sustainability-linked finance and credible impact claims.

ESRS MAPPING

The ESRS mapping for this challenge should focus on whether marine natural capital is translated into measurable dependencies, impacts, risks, opportunities and governance processes. The strongest alignment is with biodiversity and ecosystem management, but the mapping can also extend to water and marine resources, climate resilience, governance, and affected communities when supported by evidence and safeguards.

ESRS topic	Connection	Possible indicators
E4 Biodiversity and Ecosystems	Primary relevance. Marine natural capital accounting, biodiversity MRV and nature-positive finance directly support the identification, management and disclosure of dependencies, impacts, risks and opportunities related to marine and coastal ecosystems.	Area of habitat protected/restored; species richness or abundance indicators; biodiversity baseline coverage; ecosystem condition scores; nature-related risks identified; mitigation hierarchy applied; verified biodiversity outcomes.
E3 Water and Marine Resources	Relevant where the model addresses water quality, marine resource use, reef protection, fisheries nurseries, coastal resilience or ecosystem services linked to marine and coastal systems.	Water-quality improvements; nutrient/sediment reduction; marine resource dependency mapping; coastal protection value; ecosystem-service valuation; projects with marine-resource safeguards.
E1 Climate Change	Relevant when marine natural capital protects or enhances blue carbon, coastal resilience or climate adaptation, particularly through mangroves, seagrasses, salt marshes, reefs and other coastal ecosystems.	Blue carbon tonnes verified; avoided emissions; climate adaptation benefits; coastal assets protected; resilience value; finance mobilized for climate-nature projects.
G1 Business Conduct	Relevant to governance, due diligence, transparency, responsible financing, benefit-sharing, avoidance of greenwashing/bluewashing and the integrity of environmental markets.	MRV protocols; third-party verification; benefit-sharing agreements; safeguards; governance bodies; anti-corruption controls; credit integrity criteria; disclosure quality.
S3 Affected Communities	Relevant where marine natural capital projects affect coastal communities, small-scale fishers, Indigenous peoples or local livelihoods, especially in MPAs, blue carbon, tourism and conservation finance.	Community participation; benefit-sharing payments; local employment; grievance mechanisms; Free, Prior and Informed Consent where applicable; livelihood co-benefits; social safeguards.

Table 82 | Alignment with the ESRS topic and possible indicators

THE BUSINESS CASE: NEW BUSINESS MODEL

The business case is primarily the creation of new business models. Marine natural capital is not a single product market; it is an enabling layer that can generate new data services, advisory services, financial products, project-development models and nature-positive revenue streams across the blue economy.

First, companies can build new measurement and reporting businesses. As TNFD, CSRD and investor expectations increase, corporates need defensible data on impacts and dependencies across sites, value chains and portfolios. This creates demand for biodiversity baselines, eDNA monitoring, satellite-based coastal ecosystem mapping, natural capital accounts, nature-risk analytics and digital dashboards. The business model is typically software-as-a-service, data-as-a-service or specialist consulting, with recurring revenue from monitoring and reporting cycles.
Second, companies can develop or finance verified outcome markets. Blue carbon projects monetize carbon sequestration and avoided emissions from mangroves, seagrasses and salt marshes. Biodiversity and water-quality credits translate measurable ecological improvements into tradable units. These markets remain young and require high-integrity safeguards, but they can create revenue for landholders, coastal communities, project developers and conservation managers while giving companies a way to fund measurable nature-positive outcomes beyond their own operations.
Third, financial institutions can create new sustainable finance instruments. Blue bonds, debt-for-nature swaps, sustainability-linked loans, insurance products, blended finance facilities and MPA investment vehicles can link capital to ocean outcomes. For investors, this opens exposure to climate resilience, sustainable fisheries, coastal protection, eco-tourism and restoration. For companies and governments, it can lower financing barriers, attract concessional or impact capital and convert conservation from a grant-dependent activity into a long-term investment proposition.
Private companies can address this challenge by mapping marine dependencies and impacts, integrating natural capital indicators into strategy and reporting, procuring verified ocean outcomes, co-developing investable restoration projects, and embedding nature-related KPIs into financing agreements. The strongest business case arises when natural capital metrics are not treated as a communications tool, but as a management system that informs capital allocation, procurement, risk management and innovation.
The following examples illustrate how companies and market platforms are already turning marine natural capital into new business models: biodiversity intelligence for corporate reporting, tradable reef water-quality credits, and bankable marine protected areas financed through blended capital and reef-positive enterprises.

PRACTICAL EXAMPLES

NatureMetrics: Biodiversity Intelligence for Nature Reporting and Marine Risk Management
United Kingdom · Founded 2014 · USD 25M Series B announced in 2025 · eDNA and nature intelligence platform
NatureMetrics uses environmental DNA (eDNA), Earth observation and data analytics to help businesses measure biodiversity and track nature impacts at scale. Its platform provides species, habitat and portfolio-level indicators that can support corporate nature strategies, environmental impact assessments, offshore project monitoring and TNFD-style disclosure. The company explicitly serves offshore sectors, including energy, shipping and marine infrastructure, where marine biodiversity data are increasingly needed to reduce permitting risk and demonstrate responsible development.

Business model: NatureMetrics sells biodiversity monitoring and nature intelligence as a recurring data and analytics service. The company converts a historically fragmented and project-by-project ecological survey market into a scalable digital intelligence model. For marine-facing companies, this creates a practical pathway to move from qualitative biodiversity commitments to measurable baselines, monitoring, reporting and adaptive management.

Reef Credit Scheme: Turning Water-Quality Improvements into Tradable Natural Capital Credits
Queensland, Australia · Launched in 2020 · Developed by GreenCollar and administered by Eco-Markets Australia
The Reef Credit Scheme is a voluntary environmental market designed to improve water quality flowing into the Great Barrier Reef catchment. Landholders generate credits by implementing verified actions that reduce dissolved inorganic nitrogen, sediment or other pollutants entering reef catchments. According to the scheme's documentation, one Reef Credit represents either one kilogram of dissolved inorganic nitrogen or 538 kilograms of fine sediment prevented from entering the Great Barrier Reef catchment. Buyers include governments, corporates, investors and philanthropic organizations seeking measurable reef protection outcomes.
Business model: The scheme creates a market for verified water-quality outcomes. Landholders receive a diversified income stream for improved land management, project developers earn revenue from designing and aggregating projects, and buyers can finance quantified outcomes linked to reef health. It shows how a marine ecosystem service - clean water supporting coral reef resilience - can become a measurable and tradable unit without relying solely on public subsidies.

Blue Alliance / Blue Finance: Bankable Marine Protected Areas
Global South · Founded 2015 · Blended finance and delegated MPA management model
Blue Alliance, formerly Blue Finance, develops long-term financing and management models for Marine Protected Areas (MPAs). Through delegated management agreements with governments, it helps professionalize MPA operations and develop reef-positive businesses. Its Blue Finance Facility combines grants with impact loans: grants fund management capacity during early implementation, while loans finance revenue-generating businesses such as sustainable tourism, sustainable fisheries, blue carbon, community enterprises and other nature-positive activities.
Business model: Blue Alliance treats MPAs as investable natural capital platforms. Revenue generated by associated blue economy businesses is used to support conservation management, while investors can participate through impact loans and blended finance structures. This model directly addresses a chronic challenge in ocean conservation: MPAs are often created through public policy or philanthropy but lack durable operational finance. By creating a revenue model around ecosystem stewardship, the MPA becomes a long-term blue natural capital asset rather than a recurring cost center.

Additional Benchmark Solutions

Initiative	Instrument / model	Value proposition
Blue Azores / Oceano Azul Foundation	Public-philanthropic implementation finance for MPAs	The Blue Azores program, led with the Regional Government of the Azores, Oceano Azul Foundation and partners, supports implementation of a network protecting 30% of Azorean waters. It demonstrates how science, policy, philanthropy and implementation finance can enhance the value of blue natural capital.
Seychelles Blue Bond	Sovereign blue bond	The World Bank-supported USD 15M blue bond mobilized private capital for sustainable fisheries and marine conservation, creating a replicable model for ocean-linked sovereign finance.

Belize Blue Bonds for Ocean Conservation	Debt conversion / blue bond	The 2021 USD 364M debt conversion reduced public debt, created long-term marine conservation finance and locked in commitments to protect 30% of Belize ocean area.
Mikoko Pamoja	Community blue carbon credits	The Kenya mangrove project is widely recognized as the world first community-led blue carbon project, funding conservation and local development through carbon-credit sales.
Blue Natural Capital Financing Facility	Project preparation and de-risking facility	Managed by IUCN with Luxembourg support, BNCFF helps developers build investable blue natural capital projects with clear ecosystem-service benefits and financial longevity.

Table 83| Additional Benchmark Solutions

WHAT PRIVATE COMPANIES CAN DO

Companies should treat marine natural capital as part of strategy, risk management, financing and innovation, rather than as a stand-alone communications claim. The strongest approach is to combine rigorous measurement with investment decisions and credible governance safeguards.

- Map marine dependencies, impacts, risks and opportunities using a structured approach such as TNFD LEAP and double-materiality assessment.
- Establish science-based baselines for priority habitats, species, water quality, ecosystem services and community dependencies before making claims or financing decisions.
- Integrate marine natural capital indicators into capital allocation, procurement, project development, insurance, risk management and sustainability-linked finance.
- Develop or procure verified ocean outcomes, such as blue carbon, biodiversity or water-quality credits, only where robust MRV, additionality, permanence and safeguards are in place.
- Co-develop restoration, conservation or resilience projects with universities, NGOs, public authorities, local communities and MPA managers.
- Use natural capital data to inform product design, site selection, permitting, supply-chain decisions and investment due diligence.
- Embed benefit-sharing, transparency and anti-bluewashing safeguards so that credits or finance instruments complement, rather than replace, avoidance and reduction of harm.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Natural capital measurement	Marine dependencies mapped; biodiversity baselines completed; hectares of habitat assessed; species or habitat indicators monitored; ecosystem-service values estimated.	TNFD/CSRD assessments; biodiversity surveys; eDNA results; satellite data; natural capital accounts; environmental baselines.
Finance and business model	Capital mobilized for ocean protection/restoration; recurring nature-intelligence revenue; number of clients using marine nature data; value of blue bonds or sustainability-linked instruments; projects reaching investment readiness.	Contracts; finance documents; bond frameworks; investor reports; platform analytics; project-preparation records.
Verified nature outcomes	Hectares restored or protected; blue carbon tonnes verified; water-quality credits generated; nutrient/sediment reductions; biodiversity uplift; MPA management effectiveness improvement.	MRV reports; third-party verification; credit registries; monitoring dashboards; MPA management assessments.
Governance and integrity	Projects with mitigation hierarchy applied; benefit-sharing agreements; third-party verification rate; safeguards implemented; grievances resolved; disclosure completeness.	Governance records; assurance reports; stakeholder engagement logs; benefit-sharing contracts; grievance mechanisms.
Community and social co-benefits	Local jobs created; community revenue share; local enterprises supported; training delivered; fishers or coastal communities engaged in project design and monitoring.	Community agreements; payroll and procurement data; training records; stakeholder consultation records; social impact reports.

Table 84 | Indicative KPIs examples for implementation

CHALLENGE 24: REGENERATIVE COASTAL AND MARITIME TOURISM WITH HIGHER ADDED VALUE

Coastal and maritime tourism is one of the most visible interfaces between citizens, companies and the ocean. Globally, coastal and marine tourism represents at least half of all tourism and is one of the largest economic activities in many coastal and island destinations (Ocean Panel, 2022)(; WRI, 2023). In Europe, coastal tourism remains the dominant sector of the EU Blue Economy: almost 1.5 billion nights were spent in tourist accommodation in coastal areas in 2024, a 3.6 percent increase from the previous year (EU Blue Economy Observatory, 2025). Portugal is exceptionally well positioned within this trend: a long Atlantic coastline, the Azores and Madeira, surfing, sailing, marinas, cruises, marine protected areas, fisheries culture, seafood gastronomy and a strong international tourism brand.

Yet the value captured by maritime tourism is still below its potential. Much of the offer remains concentrated in conventional beach, sun-and-sea, cruise or recreational activities, where price competition, seasonality, overcrowding and ecological pressure can limit both profitability and impact. Portugal's tourism boom shows the scale of the opportunity and the challenge: tourism-linked consumption reached almost EUR 44 billion and accounted for 16.5 percent of GDP in 2023, while record visitor numbers have intensified pressure on housing, infrastructure and local communities (Reuters, 2024). The question is therefore not simply how to attract more tourists, but how to increase value per visitor while improving the ecosystems, communities and cultural assets on which tourism depends.

Regenerative coastal and maritime tourism responds to this challenge by creating new premium experiences linked to conservation, science, ocean literacy, maritime culture and ecosystem regeneration. This is not about replacing existing tourism. It is about adding higher-value segments: scientific tourism, citizen-science expeditions, expert-led whale watching, blue carbon restoration visits, marine protected area experiences, conservation diving, responsible surf and sailing programs, cultural routes linked to fishing communities and regenerative cruise or marina models. These products can command higher prices because they offer scarcity, authenticity, expert knowledge, measurable contribution and emotional connection to the ocean.

The opportunity is particularly relevant for Portugal because conservation and tourism are increasingly converging. In 2024, the Azores approved the largest marine protected area network in the North Atlantic, covering nearly 300,000 km2 and approximately 30 percent of Azorean waters, with half fully protected from fishing (Reuters, 2024). This type of marine conservation infrastructure can become the basis for high-value tourism experiences if it is paired with science, interpretation, community benefit-sharing and strict visitor management. The challenge is to develop products that raise prices and margins without increasing ecological pressure.

SDG 14 ALIGNMENT: LIFE BELOW WATER

Regenerative coastal and maritime tourism contributes to SDG 14 when it shifts tourism from passive consumption of marine landscapes towards active financing, monitoring, education and restoration of marine ecosystems.

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Target	Business relevance
Target 14.2	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts. Regenerative tourism can finance monitoring, habitat restoration and low-impact management of coastal and marine ecosystems.
Target 14.5	By 2020, conserve at least 10 percent of coastal and marine areas. Marine protected areas can become platforms for higher-value tourism when visitor fees, interpretation, science and conservation revenues are reinvested into effective protection.
Target 14.7	By 2030, increase the economic benefits from the sustainable use of marine resources, including sustainable tourism. Although this target focuses on SIDS and LDCs, its logic applies to coastal and island territories: more value should be created from healthy marine ecosystems, not from their degradation.

Table 85 | Alignment with the SDG 14 targets

The key SDG 14 contribution is the creation of economic incentives for keeping marine ecosystems intact and improving them. When visitors pay more for conservation credibility, scientific interpretation and participation in restoration, tourism becomes a mechanism for ocean stewardship rather than only a source of pressure.

ESRS MAPPING

The ESRS mapping is strongest when regenerative tourism models can demonstrate that premium tourism revenues are linked to measurable ecosystem protection, restoration, responsible visitor management and community value creation. The mapping should not rely only on marketing claims: it should be supported by evidence on visitor pressure, conservation funding, biodiversity outcomes, pollution prevention, climate performance and benefit-sharing with local communities.

ESRS topic	Connection	Possible indicators
E4 Biodiversity and Ecosystems	Highly relevant when tourism activities depend on marine protected areas, wildlife, habitats, reefs, seagrasses, dunes, beaches or marine biodiversity, and when the business model includes restoration, monitoring, carrying-capacity limits or conservation finance.	Area restored or protected; conservation revenue generated; visitor numbers against carrying-capacity limits; wildlife disturbance incidents; biodiversity monitoring data; habitat condition indicators; MPA or restoration funding provided.
E1 Climate Change	Relevant when operators reduce emissions from boats, transport, accommodation and operations, or when tourism is linked to verified blue carbon restoration such as seagrass or mangrove projects.	CO2e per visitor or experience; fuel use per trip; renewable energy share; low-carbon transport use; blue carbon area restored or financed; emissions avoided through operational changes.
E2 Pollution	Relevant when tourism activities reduce waste, wastewater impacts, plastic leakage, fuel spills, water-quality pressures, underwater noise or other local pollution linked to coastal and maritime operations.	Waste generated per visitor; single-use plastic avoided; wastewater compliance; water-quality indicators; spill incidents; underwater noise or vessel disturbance indicators; clean-up or prevention outcomes.
S3 Affected Communities	Relevant because regenerative tourism depends on local communities, fisheries culture, maritime heritage, employment, access to coastal resources and fair distribution of tourism value.	Local employment; percentage of local suppliers; revenue shared with community or conservation partners; community satisfaction; stakeholder engagement; grievances received and resolved; cultural heritage initiatives supported.
G1 Business Conduct	Relevant where companies make conservation, regeneration or ocean-positive claims. Governance is needed to avoid bluewashing and to ensure transparent use of conservation fees and credible partnerships.	Transparent allocation of conservation fees; third-party verification; partnership agreements; public impact reporting; claims substantiated; governance process for conservation funds and scientific data.

Table 86 | Alignment with the ESRS topic and possible indicators

THE BUSINESS CASE: increasing prices

The business case is primarily increasing prices. Regenerative coastal and maritime tourism allows companies and destinations to move away from volume-based competition and towards high-value, low-impact experiences. The value proposition is not simply accommodation, transport or access to the sea; it is expert-led access to meaningful ocean experiences that are scientifically credible, culturally rooted and linked to measurable conservation outcomes.

First, regenerative tourism can increase willingness to pay through differentiation. A generic boat trip competes mainly on price and convenience. A marine-biologist-led whale watching experience, a citizen-science sailing expedition, a seagrass restoration visit or a conservation diving program competes on expertise, purpose and exclusivity. This enables higher prices per visitor, smaller group sizes, lower environmental pressure and stronger destination positioning.
Second, it creates new bundled revenue streams. Companies can combine tourism services with conservation fees, memberships, data collection, research partnerships, corporate volunteering, educational programs, premium accommodation, local gastronomy, cultural interpretation and branded merchandise. Marinas, cruise operators, hotels, surf schools and tour operators can reposition part of their offer around ocean literacy and ecosystem regeneration, creating new premium products without abandoning their core businesses.
Third, it strengthens long-term asset value. Coastal tourism depends directly on clean water, biodiversity, beaches, waves, reefs, seagrasses, marine wildlife and cultural identity. Investing in regeneration protects the destination asset itself. For companies, this can reduce reputational risk, support licensing and community acceptance, improve seasonality through learning-based products, and attract higher-spending visitors who seek authenticity and positive impact.
Private companies can address this challenge by creating small-group science-based experiences, partnering with universities and NGOs, embedding conservation fees in the price, training guides in ocean literacy, using carrying-capacity limits, measuring ecological contribution, sourcing locally, and ensuring that a share of revenues funds restoration or MPA management. The following examples show how higher-value tourism products are already being built around marine conservation, science and regeneration.

PRACTICAL EXAMPLES

Futurismo Azores Adventures: Science-Based Whale Watching and Marine Ecotourism

Azores, Portugal · Founded 1990s · Whale watching, marine research and nature tourism operator

Futurismo is one of the most established whale watching and nature tourism operators in the Azores. Its offer is built around the archipelago's exceptional cetacean diversity: more than 25 cetacean species have been reported in Azorean waters, and the region is recognized internationally as a whale and dolphin watching hotspot (International Whaling Commission, 2026; World Cetacean Alliance, 2026). Futurismo integrates marine biologists into its whale watching tours and reports that sightings and scientific data are collected during tours for its research program (Futurismo Azores Adventures, 2026). The company also offers premium learning-oriented products such as 'Be a Marine Biologist for a Day', turning marine science into an experiential tourism product.

Business model: Futurismo converts the Azores' marine biodiversity into a higher-value, knowledge-rich experience rather than a basic wildlife excursion. The price premium is justified by expert interpretation, responsible wildlife protocols, scientific data collection, ocean literacy and the broader destination story of the Azores as a marine conservation leader. This is directly relevant for Portugal: the recent creation of a large Azorean MPA network can strengthen the basis for even more science-led, conservation-linked tourism products.

Ocean Missions / North Sailing: Citizen-Science Expeditions at the Edge of the Arctic

Husavik, Iceland · Founded 2019 · NGO-tourism partnership for research, education and conservation

Ocean Missions is an Icelandic organization based in Husavik that combines sailing, research, education and conservation. Its programs invite participants to become 'Ocean

Ambassadors' through citizen-science activities focused on plastic pollution, whale research, plankton studies and marine protection (Ocean Missions, 2026). In partnership with North Sailing, the 'Whales, Sails and Science' experience allows visitors to participate in ocean research, microplastic analysis and deeper learning about whales, birds and marine conservation in Skjalfandi Bay (North Sailing, 2026).

Business model: This is a clear example of turning scientific participation into a paid tourism experience. The value is not only the whale sighting or the sailing trip, but the opportunity to contribute to real monitoring and leave with scientific knowledge. For Portugal, the model is replicable in the Azores, Madeira, Algarve and mainland coastal areas through partnerships between tour operators, universities, marine labs, MPAs, marinas and NGOs.

Red Sea Global: Regenerative Luxury Coastal Destination Development

Saudi Arabia · The Red Sea and AMAALA destinations · Regenerative tourism developer

Red Sea Global is developing large-scale coastal destinations around a regenerative tourism framework. The company states that its model is designed to deliver a 30 percent net conservation benefit by 2040, supported by science-led spatial planning, habitat restoration, coral relocation, real-time environmental monitoring and biodiversity safeguards across land and sea (Red Sea Global, 2026). Its approach positions nature not as background scenery but as the core value proposition of a premium tourism destination.

Business model: Red Sea Global links high-value tourism pricing to measurable environmental quality and regeneration. The model is based on scarcity, quality, design, conservation credibility and long-term protection of natural assets. Although the scale and capital intensity differ from most Portuguese operators, the principle is relevant: premium coastal tourism can be designed around net-positive ecological outcomes, not only around luxury infrastructure.

Additional Benchmark Solutions

Company / initiative	Model	Value proposition
Misool Resort & Foundation	Private-island ecotourism funding a marine reserve	A luxury dive resort in Raja Ampat surrounded by a 300,000-acre privately funded marine reserve and two no-take zones. The resort converts conservation quality into premium tourism value while financing ranger patrols and community partnerships.
Six Senses Laamu / Maldives Underwater Initiative	Resort-based marine conservation platform	Combines hospitality with marine research, education and community outreach. Its seagrass and reef programs show how resorts can turn conservation into brand differentiation and guest engagement.
Ocean Alive	Community-based seagrass conservation and ocean literacy	Portuguese NGO in the Sado estuary protecting seagrass meadows through community engagement, science and education. It offers a useful benchmark for future regenerative tourism products linked to blue carbon, dolphins and fishing communities.
Blue Safari Seychelles / Alphonse Island	Remote luxury eco-tourism and conservation research	Positions outer-island tourism around low-impact access to biodiversity, marine research and conservation-focused guest activities, showing how remote marine ecosystems can support high-value, low-volume tourism.
Azores MPA network / Blue Azores	Marine protected area as destination asset	The new Azores MPA network creates a conservation platform for premium tourism linked to whales, seamounts, science, diving and ocean literacy, provided visitor use is managed carefully and revenues support protection.

Table 87 | Additional Benchmark Solutions

WHAT PRIVATE COMPANIES CAN DO

Implementation opportunities for companies

• Redesign existing coastal and maritime tourism products into small-group, expert-led experiences with clear carrying-capacity limits.

• Partner with universities, marine labs, NGOs, MPA managers and local communities to make the scientific and conservation contribution credible.
• Embed conservation or restoration fees into the price and report transparently on how revenues are allocated and what outcomes are achieved.
• Train guides, skippers, hotel teams and customer-facing staff in ocean literacy, responsible wildlife protocols, visitor safety and local cultural interpretation.
• Develop premium bundles that combine tourism with citizen science, restoration activities, marine education, local gastronomy, responsible accommodation and community experiences.
• Reduce the operational footprint of tourism activities through lower-emission boats, waste prevention, local sourcing, responsible anchoring and clear wildlife-interaction rules.
• Measure and communicate impact carefully, using verified indicators rather than generic ocean-positive claims.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Business performance	Average price per visitor; revenue per visitor; margin per experience; premium-product revenue share; repeat bookings; off-season bookings; group size; customer satisfaction; conversion rate from basic to premium experiences.	Booking systems; accounting data; CRM; visitor surveys; product-level P&L; seasonality and occupancy data.
Conservation and ecosystem contribution	Conservation revenue generated; percentage of revenues allocated to restoration or MPA management; area restored or monitored; number of monitoring surveys; biodiversity observations; habitat condition; carrying-capacity compliance.	Partner reports; MPA records; monitoring data; scientific protocols; restoration dashboards; biodiversity datasets; annual impact reports.
Operational footprint	CO_2e per visitor or trip; fuel use per trip; renewable energy share; waste generated per visitor; single-use plastic avoided; water use; wastewater compliance; wildlife disturbance incidents; vessel approach-distance compliance.	Fuel logs; GHG calculations; utility bills; waste records; operational checklists; wildlife protocol logs; environmental monitoring data.
Community value and social licence	Local jobs supported; percentage of local suppliers; revenue shared with local partners; community-led experiences; training hours; stakeholder satisfaction; grievances received and resolved.	Supplier records; payroll data; partnership agreements; community engagement records; grievance logs; stakeholder surveys.
Learning and scalability	Citizen-science participants; data points collected; research partnerships; staff trained in ocean literacy; number of products replicated in other destinations; certifications obtained; third-party verification of claims.	Program records; training logs; research agreements; certification documents; verification reports; data-platform analytics

Table 88 | Indicative KPIs examples for implementation

CHALLENGE 25: CREATION OF QUALIFIED BLUE JOBS IN ISLANDS AND COASTAL TERRITORIES

The blue economy is increasingly presented as a source of future growth, innovation and territorial regeneration, but its expansion depends on a workforce that many coastal and island regions do not yet have. The EU Blue Economy Report 2025 estimates that established EU blue economy sectors directly employed 4.82 million people in 2022 and were expected to employ around 4.88 million people in 2023, generating EUR 250.7 billion in GVA in 2022 and an estimated EUR 263 billion in 2023 (European Commission, 2025) . Yet this growth potential is constrained by a structural mismatch between emerging blue economy opportunities and the skills available locally.

Many islands and coastal territories have exceptional conditions to test and scale blue economy solutions: access to the ocean, ports and marinas, fishing communities, marine biodiversity, tourism flows, universities, research centers and protected areas. They can become living laboratories for aquaculture, ocean monitoring, marine robotics, offshore renewables, regenerative tourism, conservation, blue biotechnology and nature-based coastal resilience. However, these territories often face weak talent retention, seasonal employment, limited industrial diversification and a shortage of technicians, operators, data specialists, business developers and field professionals able to work across science, technology and the sea.

This challenge is therefore not limited to the Azores or Madeira. It applies to a wider geography of island, port and coastal territories where blue economy potential exists but cannot be transformed into local prosperity without human capital. The strategic opportunity is to create new business models that combine training, incubation, applied research, pilot infrastructure and corporate partnerships, allowing companies to develop talent locally while creating qualified jobs in emerging blue economy sectors.

SDG 14 ALIGNMENT: LIFE BELOW WATER

Qualified blue jobs are not only an employment agenda; they are an enabling condition for SDG 14 implementation. Marine conservation, sustainable aquaculture, ocean monitoring, pollution prevention, coastal restoration and sustainable maritime tourism all require trained people capable of collecting data, operating technology, managing projects and translating scientific knowledge into viable services and businesses.

Target 14.a	Increase scientific knowledge, develop research capacity and transfer marine technology, in order to improve ocean health and enhance the contribution of marine biodiversity to development. Blue skills, applied training and local innovation capacity directly operationalize this target.
Target 14.7	Increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including sustainable fisheries, aquaculture and tourism. Qualified blue jobs allow coastal and island territories to capture higher-value activities instead of remaining limited to low-margin extraction or seasonal services.

Table 89 | Alignment with the SDG 14 targets

By investing in blue skills, companies and territories increase the capacity to manage marine ecosystems responsibly while ensuring that the economic value created by ocean-based activities remains closer to coastal communities. In practical terms, this means shifting from low-margin, seasonal or extractive activities toward higher-value knowledge, service and technology jobs that improve ocean outcomes.

ESRS MAPPING

The ESRS relevance of this challenge is primarily social, because the core issue is the creation of qualified employment, skills, local capacity and fair participation in emerging blue economy sectors. The mapping should focus on measurable workforce development and local community outcomes, while environmental ESRS topics should only be used when the jobs created are directly linked to activities such as conservation, restoration, ocean monitoring, pollution prevention or low-carbon maritime solutions.

ESRS topic	Connection	Possible indicators
S1 Own Workforce	Relevant for companies that create qualified blue jobs, reskill existing employees, establish apprenticeships, improve career pathways and invest in safe work across marine, coastal and port-related activities.	Number of qualified blue jobs created; training hours; certifications completed; retention rate; internal mobility; safety incidents; share of employees reskilled for blue economy roles.
S2 Workers in the Value Chain	Relevant where companies rely on contractors, suppliers, field operators, vessel crews, technicians or local service providers to deliver blue economy projects and need to build capability across the wider value chain.	Supplier training hours; certified local suppliers; contractor safety performance; number of local service providers integrated; decent-work clauses in contracts; supplier capability assessments.
S3 Affected Communities	Strongly relevant for island and coastal territories where blue economy development can support local prosperity, talent retention, youth employment, community resilience	Local hires; youth participation; jobs retained in coastal/island territories; community partnerships; local procurement; community benefit agreements;

	and diversification beyond seasonal or low-margin activities.	participation of fishers, tourism workers and local organizations.
G1 Business Conduct	Relevant when training, incubation and living-lab models depend on transparent partnerships between companies, universities, municipalities, ports, foundations and public bodies.	Governance model; partner agreements; transparent selection criteria; anti-corruption safeguards for public funding; documented stakeholder engagement; responsible procurement practices.
E1 / E4 / E2 Climate, Biodiversity and Pollution (conditional)	Applicable only when qualified jobs are demonstrably linked to climate, biodiversity or pollution outcomes, such as offshore renewables, restoration, marine monitoring, circular economy or pollution-prevention services.	Jobs linked to restoration, monitoring or decarbonization projects; hectares or sites monitored/restored; pollution-prevention services delivered; CO_2e avoided where relevant; biodiversity or water-quality indicators supported by trained teams.

Table 90 | Alignment with the ESRS topic and possible indicators

THE BUSINESS CASE: creating new business model and reduce costs

The business case is primarily creating a new business model. The shortage of qualified human resources can itself become an entrepreneurial opportunity: companies, universities, municipalities, ports, foundations and investors can create blue talent platforms, island innovation hubs, coastal living labs, specialized academies and pilot-as-a-service infrastructures that generate revenue while solving a structural bottleneck for the sector.

First, companies can develop training-as-a-service and talent-pipeline models. Instead of recruiting scarce specialized workers from outside the territory, firms can co-design short-cycle training, apprenticeships and certification programs with local schools, universities and vocational centers. These programs can prepare technicians for aquaculture systems, ROV and drone operations, biodiversity monitoring, offshore maintenance, maritime data management, restoration fieldwork and regenerative tourism experiences. Revenue can come from corporate training fees, public procurement, EU funds, foundation grants and placement services.

Second, coastal and island territories can become living laboratories and pilot hubs. Emerging blue economy companies need real-sea testing environments, local operators, environmental data, safety procedures, vessels, regulatory support and community engagement. A coastal hub that offers these services reduces the cost and risk of testing new solutions, while generating specialized jobs in operations, monitoring, permitting, engineering support and project management.

Third, blue incubators and venture studios can create new businesses rather than only train workers for existing sectors. By connecting researchers, entrepreneurs, fishers, tourism operators, ports and investors, these platforms can transform local problems into investable ventures: aquaculture monitoring services, seaweed restoration businesses, citizen-science tourism, marine data products, circular fish by-product companies or coastal adaptation services. The commercial logic is not only job creation but the creation of new local companies able to retain talent and capture higher-value parts of the blue economy.

PRACTICAL EXAMPLES

Iceland Ocean Cluster: Turning Marine Dependence into Qualified Blue Entrepreneurship

Reykjavik, Iceland · Blue economy innovation hub · 100% Fish movement · Around 70 companies in the cluster ecosystem

The Iceland Ocean Cluster is a benchmark for how an island economy can move beyond traditional marine resource extraction by building an ecosystem of entrepreneurs, processors, researchers, designers and technology companies. Its flagship 100% Fish approach promotes full utilization of fish by-products and has helped position marine resources as inputs for food, nutraceuticals, cosmetics, materials and design-led products. More importantly for this challenge, the cluster creates a physical and relational environment where specialized knowledge circulates among companies, researchers and entrepreneurs, generating qualified employment in value-added blue economy activities rather than only in primary fishing.

Business model: The cluster operates as an innovation hub and business accelerator. Value is created through membership, workspace, convening, consultancy, international partnerships and the export of its cluster model to other coastal regions. For coastal territories, the lesson is that qualified blue jobs emerge when training, entrepreneurship, industry problems and applied innovation are integrated in one ecosystem.

AltaSea at the Port of Los Angeles: Blue Economy Campus and Workforce Development

Los Angeles, USA · 35-acre port campus · Ocean technology, aquaculture, ocean energy and education

AltaSea is transforming a port area in Los Angeles into a blue economy research, innovation and workforce development campus. Its mission combines scientific collaboration, business innovation, job creation and education. The campus hosts ocean-focused companies and projects in areas such as aquaculture, blue technology, clean energy and marine innovation, while connecting them to universities, community colleges and public engagement programs. In 2026, AltaSea and USC Sea Grant announced a partnership to advance port and marine transportation research, develop a skilled ocean workforce through hands-on training and strengthen coastal community engagement.

Business model: AltaSea combines campus tenancy, philanthropy, public funding, corporate partnerships, research collaboration and workforce programs. Its model shows how ports can become platforms for qualified blue jobs by hosting companies, pilots and training pathways in the same place, giving students and workers direct exposure to emerging ocean industries.

PLOCAN: Island Test Infrastructure for Marine Technology and Skilled Employment

Gran Canaria, Spain · Oceanic Platform of the Canary Islands · Offshore test site and marine technology infrastructure

PLOCAN was created to build, equip and operate marine research infrastructures for marine science and technology. Its facilities include an offshore platform and a marine test site that enables enterprises and researchers to trial ocean technologies in real conditions. The test site has supported pilots in ocean energy, environmental monitoring and AI-based marine waste monitoring, illustrating how island territories can provide the physical and technical conditions required for emerging blue economy sectors. This creates demand for specialized roles in engineering support, vessel operations, environmental monitoring, data analysis, safety, maintenance and project coordination.

Business model: PLOCAN operates as a shared research and innovation infrastructure: it provides access to test facilities, technical services, scientific capacity and project participation. The model is particularly relevant for islands and coastal territories because it turns geographic remoteness and

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ocean exposure into a competitive advantage for technology testing, skills development and specialized employment.

Additional Benchmark Solutions

Company / initiative	Model	Value proposition for qualified blue jobs
European Marine Energy Centre - EMEC (Orkney, UK)	Marine energy test center and skills ecosystem	Provides operational, environmental, consenting and metocean services for wave, tidal and clean energy pilots, building a specialized local supply chain in an island territory.
Campus mondial de la mer (Brest, France)	Ocean science, education and business cluster	Connects research centers, companies, public authorities and training actors to strengthen a regional ocean innovation workforce and international cooperation.
Blue Generation / Next Blue Generation (EU)	Career guidance and youth engagement platform	Makes blue economy careers visible to young people through toolkits, MOOCs, games, webinars and employer-facing career pathways.
OceanHub Africa (Cape Town, South Africa)	Blue economy startup accelerator	Supports ocean-impact startups through business coaching, technical mentoring and investor access, creating entrepreneurial employment in coastal communities.
BlueBio Alliance / Blue Bio Value (Portugal)	Blue bioeconomy accelerator and network	Connects startups, researchers and investors in marine bioresources, supporting specialized entrepreneurship and talent development in a high-potential blue sector.

Table 91 | Additional Benchmark Solutions

WHAT PRIVATE COMPANIES CAN DO

Private companies can turn the qualified blue jobs gap into a strategic opportunity by building talent pipelines around real business needs rather than generic training offers. The strongest approaches connect skills development with pilots, local employment, commercial projects and measurable environmental outcomes.

- Map the specific skills needed for target blue economy activities, such as aquaculture operations, offshore maintenance, marine robotics, biodiversity monitoring, port digitalization, regenerative tourism or blue biotechnology.
- Co-design short-cycle training, apprenticeships and certification programs with universities, vocational schools, ports, municipalities and research centres.
- Create paid traineeships and entry-level technical roles that allow local workers to move from seasonal or low-margin employment into higher-value blue economy careers.
- Use coastal and island territories as living labs for pilots, combining technology testing with local operators, vessels, monitoring teams and project managers.
- Build local supplier networks for marine services, environmental monitoring, maintenance, logistics, tourism interpretation and field operations.
- Partner with NGOs, schools and community organizations to increase youth participation, ocean literacy, gender inclusion and career visibility in blue economy sectors.
- Embed decent-work, safety and career-progression standards into blue economy projects, especially where fieldwork, vessel operations or hazardous marine environments are involved.
- Measure the value created locally, including jobs, wages, retention, local procurement, new ventures, skills certification and links to SDG 14 outcomes.

INDICATIVE KPIs

KPI category	Examples	Evidence source
Business performance	Revenue from training, incubation, pilot services or living-lab activities; number of companies served; number of pilots hosted; placement fees; occupancy rate of hub or test infrastructure; repeat clients.	Contracts; invoices; hub management data; training platform records; pilot agreements; CRM data.
Employment and skills	Qualified blue jobs created; local hires; apprenticeships completed; certifications obtained; training hours; job placement rate; retention rate after 12 and 24 months; wage progression; share of youth and women participants.	HR data; training records; certification databases; placement records; payroll data; participant surveys.
Territorial value creation	Share of jobs retained in coastal or island territories; local procurement spend; number of local suppliers integrated; startups incubated; new ventures created; partnerships with schools, universities, municipalities and ports.	Supplier records; procurement data; partnership agreements; incubator records; local economic impact assessments.
Innovation and scalability	Number of technologies tested; pilots converted into commercial contracts; research-to-market projects; investment attracted by startups; export partnerships; replication of the hub or academy model in other territories.	Pilot reports; investment data; project documentation; accelerator records; export contracts; partnership memoranda.
SDG 14 and environmental contribution	Number of jobs linked to marine monitoring, restoration, pollution prevention, sustainable aquaculture, regenerative tourism or offshore renewables; monitoring days delivered; habitats or sites monitored/restored; environmental datasets produced.	Project reports; monitoring logs; ESG reports; MPA or restoration records; environmental data platforms; client impact reports.
Governance and inclusion	Transparent selection criteria; stakeholder engagement sessions; community satisfaction; safety training completion; incident rates; public/private funding leveraged; documented benefit-sharing with local communities.	Governance documents; stakeholder minutes; HSE records; community surveys; funding agreements; impact evaluation reports.

Table 92 | Indicative KPIs examples for implementation

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5. Conclusion

The future of Portugal's Blue Economy will depend not only on the capacity to protect marine ecosystems but also on the ability to transform sustainability into a driver of competitiveness, innovation, and long-term economic resilience. Throughout this report, it becomes evident that the ocean should no longer be regarded merely as a natural resource to be managed, but as a strategic asset upon which the country's environmental integrity, economic prosperity, and international competitiveness increasingly depend. While Portugal has developed a strong policy framework and possesses exceptional natural advantages, significant gaps remain in achieving several SDG 14 targets, highlighting the need for accelerated and coordinated action across public institutions, businesses, and civil society.

This report demonstrates that many of the challenges currently affecting Portugal's ocean economy are also emerging business opportunities. Climate adaptation, marine ecosystem restoration, sustainable fisheries, offshore renewable energy, circular solutions, digital ocean technologies, blue biotechnology, and sustainable maritime logistics all represent areas where companies can simultaneously generate commercial value and contribute to ocean regeneration. Rather than treating sustainability as a compliance exercise, organizations have the opportunity to embed SDG 14 into their core business strategies, creating new products, services, markets, and business models that strengthen both competitiveness and environmental performance.

Ultimately, achieving SDG 14 will require moving beyond isolated initiatives towards a systemic transformation of the Portuguese Blue Economy. Governments, academia, financial institutions, and businesses all have complementary roles in accelerating this transition. The business community, in particular, possesses the investment capacity, innovation capabilities, and market influence necessary to scale solutions at the speed required by current environmental challenges. By aligning economic incentives with ocean regeneration, Portugal has the opportunity not only to protect one of its greatest natural assets but also to position itself as an international reference in building a competitive, resilient and regenerative Blue Economy capable of generating lasting value for society, the economy and future generations.

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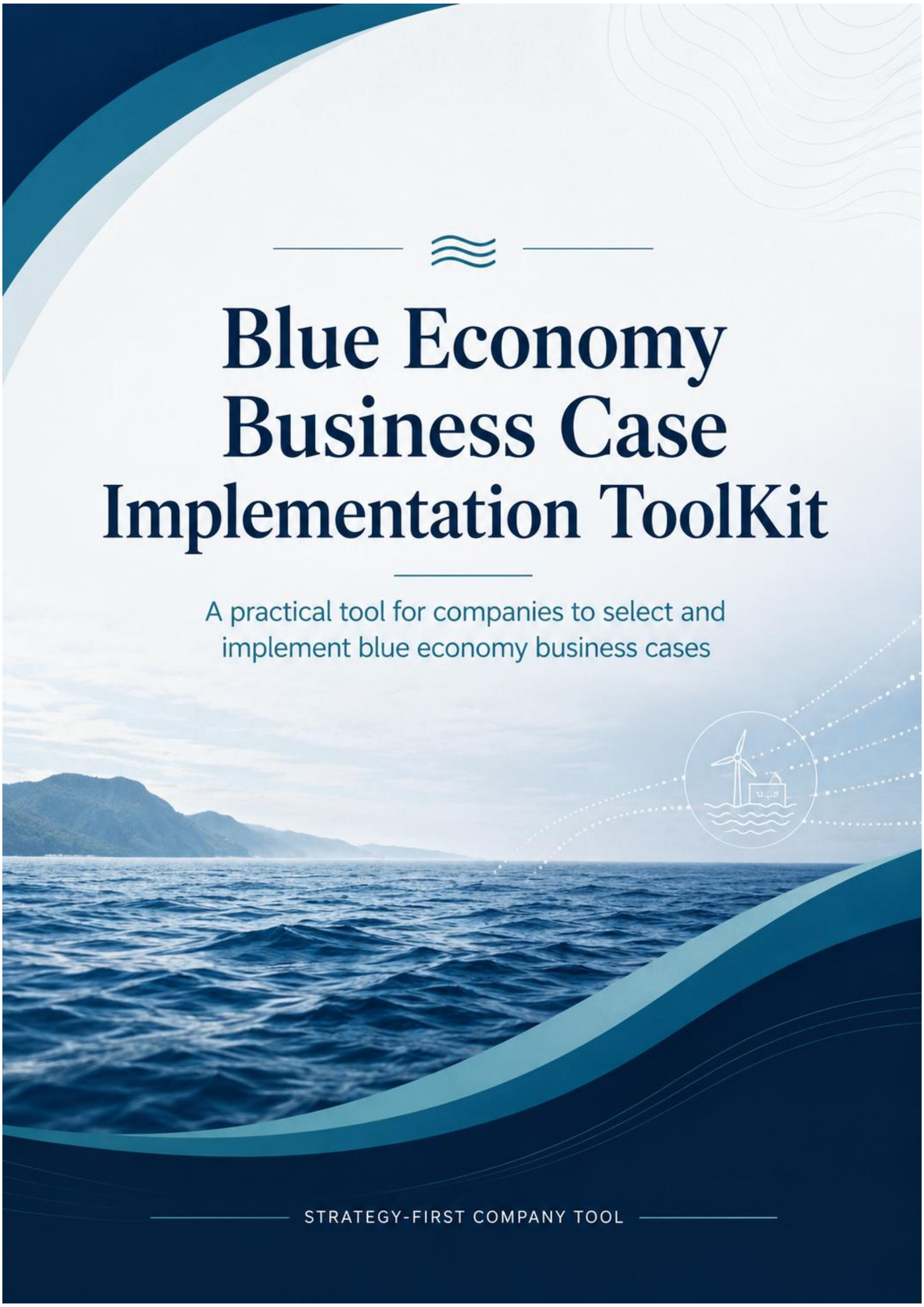
Appendix 1. Practical Toolkit: Building the Business Case for Action in Portugal's Blue Economy



Blue Economy Business Case Implementation ToolKit

A strategy-first framework for selecting one business case, designing a pilot and making an evidence-based implementation decision.

This tool translates the business cases presented in the study into a structured company process. It is designed for concise, cross-functional working sessions and produces a decision-ready implementation sheet.

Purpose	Working method	Final output
Connect a relevant Blue Economy opportunity to an existing company priority.	Move in sequence: strategy, value chain, portfolio, selection, implementation and communication.	One company-specific sheet with a selected case, pilot, KPIs, risks and decision gate.

Six-step pathway

01 Strategy Define what the company already needs to achieve.	**02 Map** Locate material Blue Economy touchpoints in the value chain.	**03 Cross** Match the strategy with the portfolio of 25 business cases.
04 Select Choose one case using evidence and implementation fit.	**05 Implement** Design the pilot, KPIs, risks and decision gate.	**06 Communicate** Use only claims supported by the evidence generated.

How to use the tool

- ☐ Complete the steps in order; do not begin with a preferred solution.
- ☐ Use short answers and record missing evidence explicitly.
- ☐ Keep only options linked to a real company activity, asset, product, market or partner.
- ☐ Select one case and one pilot. The purpose is a decision, not a long list of ideas.

Working principle
Strategy first. Value-chain grounded. One business case. One pilot. Evidence-based communication.

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STEP 1 Define the company strategy

OBJECTIVE	LEAD CONTRIBUTORS	OUTPUT
Establish the strategic starting point before considering a business case.	Business owner, strategy, finance and ESG/sustainability.	A strategy anchor and explicit selection boundaries.

Decision rule
A business case should move forward only when it reinforces an existing company priority and has a credible path to business value and positive ocean impact.

Strategic starting point

Top strategic priority 1	*Enter priority and target outcome*
Top strategic priority 2	*Enter priority and target outcome*
Top strategic priority 3	*Enter priority and target outcome*
Business pressure	*Select: revenue | cost | risk | regulation | innovation | talent | reputation | market access*
Current Blue Economy exposure	*Ocean, coast, water, ports, maritime infrastructure, marine resources, biodiversity, tourism, energy or related markets*
Leadership support condition	*What result or evidence would justify investment?*
Credible positive impact	*What ocean, coastal or community outcome would be material and meaningful?*

Strategy anchor

Because our company needs to **[strategic priority]**, the selected Blue Economy business case must help us **[business result]** in **[specific business area]**, while contributing to **[positive impact]**.

Selection boundaries

Must fit	Must create	Must avoid
Geography, market, business unit or value-chain area: Enter response	Minimum business value and positive impact: Enter response	Regulatory, operational, reputational or claim risk: Enter response

STEP 2 Map the company and its value chain

OBJECTIVE	LEAD CONTRIBUTORS	OUTPUT
Locate the strongest opportunity inside real company activities.	Business owner, operations, commercial, procurement, innovation and ESG.	A focused map of high-priority opportunity areas.

Decision rule
Do not map the whole company. Focus on touchpoints with material business relevance or credible impact potential.

Value-chain mapping canvas

For each relevant area, identify the touchpoint, the business pain or opportunity, the possible Blue Economy link and its priority.

Inputs and suppliers Touchpoint: [enter] Pain / opportunity: [enter] Blue Economy link: [enter] Priority: ☐ High ☐ Medium ☐ Low	**Operations and production** Touchpoint: [enter] Pain / opportunity: [enter] Blue Economy link: [enter] Priority: ☐ High ☐ Medium ☐ Low
Logistics and infrastructure Touchpoint: [enter] Pain / opportunity: [enter] Blue Economy link: [enter] Priority: ☐ High ☐ Medium ☐ Low	**Products and services** Touchpoint: [enter] Pain / opportunity: [enter] Blue Economy link: [enter] Priority: ☐ High ☐ Medium ☐ Low
Customers and markets Touchpoint: [enter] Pain / opportunity: [enter] Blue Economy link: [enter] Priority: ☐ High ☐ Medium ☐ Low	**Product use, maintenance and end-of-life** Touchpoint: [enter] Pain / opportunity: [enter] Blue Economy link: [enter] Priority: ☐ High ☐ Medium ☐ Low
Enabling functions Finance, data, people or governance touchpoint: [enter] Pain / opportunity: [enter] Blue Economy link: [enter] Priority: ☐ High ☐ Medium ☐ Low	**Partners, ecosystems and territories** Partner / place / community touchpoint: [enter] Pain / opportunity: [enter] Blue Economy link: [enter] Priority: ☐ High ☐ Medium ☐ Low

Opportunity statement

Strongest opportunity area	*Enter concise response*
Business reason	*Enter concise response*
Positive impact opportunity	*Enter concise response*
Evidence already available	*Enter concise response*
Main evidence or capability gap	*Enter concise response*

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STEP 3 — Cross the strategy with the 25 business cases | Portfolio navigator 1 of 3

OBJECTIVE	LEAD CONTRIBUTORS	OUTPUT
Identify the business cases that naturally fit the strategy and value-chain map.	Business owner, strategy, finance, innovation and ESG.	A shortlist of no more than two candidates.

Decision rule

Drop cases that are interesting in principle but do not connect to the strategy, value chain, evidence base or implementation capability.

Four value-creation lenses

Reducing costs Resource efficiency, lower waste, downtime, compliance costs and operational or environmental risk.	**Increasing prices** Premium, trusted, certified, traceable or higher-value products, services and experiences.
Increasing market share Entry into emerging value chains, stronger positioning and access to new demand.	**Creating new business models** New offers, services, platforms, technologies, financing models or circular revenue streams.

Use the "Select" column to mark the cases that fit the Step 1 strategy anchor and the Step 2 opportunity statement. Some cases combine more than one value lens.

Portfolio navigator — cases 01–08

ID	Area / sector	Business-case opportunity	Dominant value lens	Select
01	Aquaculture	Real-time precision aquaculture through integrated health and environmental monitoring	**Reducing costs / reducing risk**	☐
02	Aquaculture	Valorisation of waste and by-products from aquaculture production	**Reducing costs / new revenue streams**	☐
03	Blue renewable energy	Integrated operational intelligence for offshore renewable energy systems	**Reducing costs / increasing performance**	☐
04	Shipbuilding, refit & offshore energy	Corrosion-, fatigue- and wear-resistant marine-grade materials	**Reducing risk / increasing market share**	☐
05	Bluetech & ocean observation	Data standardisation, integration and interoperability	**Creating enabling services / reducing costs**	☐
06	Coastal & maritime tourism	Quantification and predictive modelling of tourism environmental impact	**Increasing prices / reducing risk**	☐
07	Environmental protection & regeneration	Integrated open-water environmental monitoring and early warning	**Creating a new business model / reducing risk**	☐
08	Shipping & ports	Port environmental monitoring: water, noise and emissions	**Reducing risk / compliance advantage**	☐

Portfolio titles and value lenses are aligned with the 25 business cases presented in the study.

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STEP 3 | Cross the strategy with the 25 business cases | Portfolio navigator 2 of 3

Portfolio navigator — cases 09–17

ID	Area / sector	Business-case opportunity	Dominant value lens	Select
09	Vessels & onboard systems	Improving energy efficiency of vessels and onboard systems	**Reducing costs**	☐
10	Bluetech & ocean observation	Operational ocean digital twins	**Creating a new business model / reducing costs**	☐
11	Bluetech & ocean observation	Autonomous operations in sensitive or remote areas	**Reducing costs / creating specialized services**	☐
12	Fisheries & fish processing	End-to-end traceability from catch to consumer	**Increasing prices / market access**	☐
13	Fisheries & fish processing	Valorisation of by-products and biological waste	**Creating a new business model / reducing costs**	☐
14	Fisheries & fish processing	Reducing ghost fishing from lost nets and gear	**Creating circular services / reducing risk**	☐
15	Shipbuilding & refit	Ship recycling and waste valorisation	**Reducing costs / new revenue streams**	☐
16	Shipping & ports	Smart planning of port operations	**Reducing costs / increasing efficiency**	☐
17	Shipping & ports	Automation of loading, unloading and gate management	**Reducing costs / increasing efficiency**	☐

Fit test while reviewing the portfolio

Strategic fit	Operational fit	Evidence fit
Which priority does the case reinforce? What business result could it influence?	Where does it sit in the value chain? Which asset, product, market or partner is involved?	What data, benchmark, technology or partner makes it testable? What is still uncertain?

Portfolio review notes

Cases marked for further review	*List portfolio IDs and titles*
Evidence or benchmarks to gather	*List the main information required before shortlisting*
Stakeholders or partners to consult	*List internal and external contributors*

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STEP 4 Cross the strategy with the 25 business cases | Portfolio navigator 3 of 3

Portfolio navigator — cases 18–25

ID	Area / sector	Business-case opportunity	Dominant value lens	Select
18	Shipping & ports	Energy transition: shore power and multi-fuel port systems	Reducing risk / infrastructure business models	☐
19	Cross-cutting / regulation	Regulatory unlocking to accelerate blue investment	Reducing costs	☐
20	Aquaculture	Sustainable aquaculture with higher perceived market value	Increasing prices	☐
21	Blue renewable energy	Developing a national value chain for offshore and ocean renewables	Increasing market share	☐
22	Blue biotechnology	Valorisation of marine bioresources in health, food, cosmetics and biomaterials	Creating a new business model	☐
23	Natural capital & sustainable finance	Integration of marine natural capital into business and financing models	Creating a new business model	☐
24	Coastal & maritime tourism	Regenerative coastal and maritime tourism with higher added value	Increasing prices	☐
25	Skills / coastal and island territories	Creation of qualified blue jobs in coastal and island territories	Creating a new business model	☐

Candidate fit cards

Candidate A

Business case / ID: [enter]
Strategic priority supported: [enter]
Value-chain area: [enter]
Business value hypothesis: [enter]
Positive impact hypothesis: [enter]
Main uncertainty: [enter]

Candidate B

Business case / ID: [enter]
Strategic priority supported: [enter]
Value-chain area: [enter]
Business value hypothesis: [enter]
Positive impact hypothesis: [enter]
Main uncertainty: [enter]

Shortlist check

- ☐ It reinforces an existing strategic priority.
- ☐ It sits in a real company activity or value-chain area.
- ☐ It has a specific business value hypothesis.
- ☐ It has a measurable positive impact hypothesis.
- ☐ It can be tested with accessible data, technology, resources or partners.

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STEP 5 Select one business case to implement

OBJECTIVE	LEAD CONTRIBUTORS	OUTPUT
Move from a shortlist to one explicit decision.	Executive sponsor, business owner, finance, ESG and technical input.	One selected case, rationale and launch condition.

Decision rule

The strongest option is not necessarily the most inspiring idea. It is the case with the best combined strategic fit, value potential, impact credibility and implementation path.

Selection scorecard

Selection question	Score 1–5	Evidence	Decision note
Reinforces company strategy	[1–5]	*Enter supporting evidence*	*Enter implication for the decision*
Fits the value chain, assets or capabilities	[1–5]	*Enter supporting evidence*	*Enter implication for the decision*
Creates credible business value	[1–5]	*Enter supporting evidence*	*Enter implication for the decision*
Creates measurable positive impact	[1–5]	*Enter supporting evidence*	*Enter implication for the decision*
Can be piloted with available resources or partners	[1–5]	*Enter supporting evidence*	*Enter implication for the decision*
Can generate reliable evidence for a decision	[1–5]	*Enter supporting evidence*	*Enter implication for the decision*

Scores structure the discussion; they do not replace executive judgement. Record the evidence and assumptions behind each score.

Selected business-case hypothesis

Selected case and ID	*Enter case title and portfolio ID*
Primary business-case type	*Reducing costs | Increasing prices | Increasing market share | Creating a new business model*
Business and impact hypothesis	*If we implement [action], we expect [business result], while contributing to [positive impact], because [evidence / logic].*
Go / no-go condition before launch	*Specify the minimum evidence, approval, partner, budget or legal condition required*
Decision owner	*Name and role*

STEP 6 | Implement the selected business case | Pilot design

OBJECTIVE	LEAD CONTRIBUTORS	OUTPUT
Convert the selected case into a practical and decision-oriented pilot.	Business owner, project lead, technical owner, finance, ESG and partners.	An approved pilot brief and implementation path.

Decision rule

Keep the pilot small enough to learn quickly and concrete enough to support a decision to scale, adapt, integrate or stop.

Pilot brief

Pilot title	*Enter title*
Selected business case	*Enter case title and ID*
Objective in one sentence	*Define the business result and positive impact to be tested*
Scope	*Business unit, location, asset, process, product, customer or territory*
Internal owner	*Name, role and decision authority*
External partners	*Technology, scientific, operational, community, finance or regulatory partners*
Core activities	*List 3–5 actions*
Resources required	*Budget, people, data, technology and procurement needs*
Pilot timing	*Start, end and key milestones*

Implementation path

1 Mobilise	2 Test	3 Decide
Confirm scope, owner, approvals, partners, baseline and data access. Output: approved pilot brief.	Run the core activities, capture business, project and impact evidence, and resolve barriers. Output: evidence dashboard.	Compare results with the agreed thresholds and make the decision at the gate. Output: decision note.

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STEP 7 Implement the selected business case | KPIs and evidence controls

OBJECTIVE	LEAD CONTRIBUTORS	OUTPUT
Define how business performance, project delivery and positive impact will be measured.	Project owner with finance, technical, data, impact and partner input.	A KPI dashboard with clear baselines, targets and evidence ownership.

Decision rule

Do not report impact without a baseline, a defined measurement period, a data source and a named evidence owner.

KPI dashboard

KPI category	KPI	Baseline	Target	Data / evidence source	Owner & frequency
Business	Cost, revenue, price premium, market access, productivity or risk exposure	*Enter*	*Enter*	*System, monitoring, partner or report*	*Name / cadence*
Business	Second business KPI	*Enter*	*Enter*	*System, monitoring, partner or report*	*Name / cadence*
Project	Milestone, adoption, participation, quality, budget or delivery time	*Enter*	*Enter*	*System, monitoring, partner or report*	*Name / cadence*
Project	Second project-delivery KPI	*Enter*	*Enter*	*System, monitoring, partner or report*	*Name / cadence*
Impact	Emissions, water, waste, biodiversity, ecosystem condition, jobs or skills	*Enter*	*Enter*	*System, monitoring, partner or report*	*Name / cadence*
Impact	Second positive-impact KPI	*Enter*	*Enter*	*System, monitoring, partner or report*	*Name / cadence*

Evidence protocol

Measurement boundary What activity, asset, geography and period are included? Enter response	**Baseline method** What reference period or counterfactual will be used? Enter response	**Data quality** What validation, assumptions and limitations apply? Enter response
Evidence owner Who is responsible for collection and sign-off? Enter response	**Partner data** What external data access or permissions are required? Enter response	**Review cadence** When will the dashboard be reviewed and by whom? Enter response

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STEP 8 | Implement the selected business case | Risks and decision gate

OBJECTIVE	LEAD CONTRIBUTORS	OUTPUT
Manage implementation risks and define in advance how the pilot decision will be made.	Executive sponsor, project owner, finance, technical, ESG and legal/compliance.	A risk register and pre-agreed decision criteria.

What is a decision gate?
A decision gate is the formal review point at which the sponsor compares pilot evidence with pre-agreed thresholds and decides whether to scale, adapt, integrate or stop.

Risk register

Risk	Likelihood / impact	Mitigation action	Owner	Trigger / warning sign
Enter risk	*L / M / H*	*Enter mitigation*	*Name / role*	*Enter trigger*
Enter risk	*L / M / H*	*Enter mitigation*	*Name / role*	*Enter trigger*
Enter risk	*L / M / H*	*Enter mitigation*	*Name / role*	*Enter trigger*

Decision outcomes

Scale Evidence supports broader rollout, additional investment or replication. Evidence threshold: [enter]	**Adapt** The opportunity remains credible, but the design, scope, partner model or target must change. Evidence threshold: [enter]
Integrate The tested solution should become part of normal operations, procurement, product or governance processes. Evidence threshold: [enter]	**Stop** Evidence is insufficient, risks are unacceptable, or the case no longer supports the strategy. Evidence threshold: [enter]

Gate governance

Decision date / milestone	*Enter date or milestone*
Evidence pack required	*Dashboard, financial analysis, technical results, partner input, legal or impact validation*
Decision owner and participants	*Name the sponsor and required functions*
Investment or change required after the gate	*Enter budget, people, systems, contract or governance changes*

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Financiado pela União Europeia NextGenerationEU

STEP 9 Communicate with evidence

OBJECTIVE	LEAD CONTRIBUTORS	OUTPUT
Prepare responsible communication based on what the pilot can demonstrate.	Communications, ESG, legal/compliance, business owner, sponsor and partners.	A concise evidence-based communication brief.

Decision rule

Communicate demonstrated results as results, assumptions as assumptions and future intentions as commitments—not as completed impact.

Evidence-based communication canvas

Problem and solution	*What business and ocean-related issue was addressed, and what was tested?*
Evidence-supported statement	*Write the clearest factual statement the pilot evidence supports*
Results and KPIs	*Which business, project and impact results support the statement?*
Audience and purpose	*Internal decision, customer information, partner update, investor communication or public disclosure*
Channel and timing	*Report, website, event, customer communication, investor materials or internal briefing*
Context and limitations	*State the pilot boundary, period, assumptions and any validation limits*
Approval owner	*Who confirms the wording, data and partner attribution?*

Evidence level

Internal learning	External factual update	Externally validated claim
Use while the evidence is incomplete or still being tested.	Use precise statements with an explicit pilot scope, period and limitations.	Use when the claim is supported by baseline data, monitoring and appropriate validation.

Pre-release check

- ☐ The wording matches the evidence and measurement boundary.
- ☐ The baseline, period and source of each stated result are clear.
- ☐ Partner names, data and attribution have been approved.
- ☐ Legal/compliance review has been completed where relevant.

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Final output — Company Business Case Implementation Sheet

Complete this page after Steps 1–6. It consolidates the evidence and decisions required for internal approval and the next implementation stage.

Company / business unit	*Enter company, unit and owner*
Strategy anchor	*Enter the final Step 1 statement*
Priority value-chain area	*Enter the Step 2 opportunity area*
Selected business case	*Enter portfolio ID and title*
Business-case type	*Reducing costs | Increasing prices | Increasing market share | Creating a new business model*
Business value hypothesis	*Enter expected business result and logic*
Positive impact hypothesis	*Enter expected ocean, coastal or community contribution*
Pilot scope	*Enter unit, asset, process, product, geography, timing and partners*
Key KPIs	*List the principal business, project and impact KPIs*
Main risks and controls	*Summarise the most material risks and mitigations*
Decision gate	*Enter the evidence threshold, review point and decision owner* The decision gate is the formal point for choosing scale, adapt, integrate or stop.
Communication brief	*Enter the evidence-supported statement, audience, channel and approval owner*
Next action and owner	*Enter the immediate action, responsible person and date*

Completion check

- ☐ The selected case is strategically relevant and value-chain grounded.
- ☐ The pilot has owners, resources, KPIs, risks and a defined evidence protocol.
- ☐ The decision gate and communication boundary are agreed before launch.

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