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Surging blue economy, increasing conflict risks and mitigation strategies

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The Blue Economy is raising optimism worldwide but the human expansion into, and the overcrowding of, the Ocean threatens increasing conflict between sectors, marine life, and the people who depend on it. Here, we highlight the potential conflicts that may arise between and within blue economy sectors, and provide recommendations on how to minimize such conflicts.

KEYWORDS

blue economy, global challenge, ocean life, crowded ocean, conflict, non-market values

1 The rise of the blue economy

As with the large-scale expansion of agriculture during the pre-industrial revolution era, the 21st century is characterized by the expansion of ocean activities with an increased risk of conflicts. The ocean economy is projected to grow faster than the global economy in the coming decades, reaching $3 trillion by 2030 (OECD, 2016). Given this growth potential, governments, political entities and international agencies are eager to boost economies through the development of the so-called Blue Economy (BE) (Jouffray et al., 2020). While it can be argued that in practice there is little discernible difference between the BE and the ocean economy, from a normative perspective, the BE has been originally conceptualized as a model that incorporates both sustainability and social equity considerations (Silver et al., 2015; IUCN, 2024).

In this paper, BE is described as the ensemble of economic activities of ocean-based industries with sustainable vocation, and the assets, goods, and services of marine ecosystems taking place on, below and/or adjacent to ocean ecosystems (Virdin et al., 2021; Sardá et al., 2023).

There are different laudable private and public initiatives around the world currently underway that are advocating for the BE. For example, PROBLUE, a World Bank-administered Umbrella Multi-Donor Trust Fund was established in 2018 to help countries chart a course towards a BE and had already supported more than 100 activities in 70 countries only 3 years after its launch (World Bank, 2022). More recently, the UN FAO adopted the Blue Transformation Roadmap, which supports the 2030 Agenda through transformation to more efficient, inclusive, resilient and sustainable aquatic food systems (FAO, 2022).

Although these initiatives seem to be promising in terms of economic growth and the enhancement of human livelihoods in the short term, highly ambitious BE targets that demand more goods and services from the ocean could lead to conflicts. The objective of this contribution is to make a strong case for the potential for conflicts between and within the economic sectors of BE. Specifically, we address the following: (i) how fast are blue economy activities growing; (ii) what areas of the ocean do the different blue economy activities take place – continental shelves, Exclusive Economic Zones (EEZs) of countries and/or the high seas; and (iii) what are the potential conflicts that can arise both within and between BE sectors as growth in the BE accelerates. In the final section of the paper, we provide suggestions on how to avoid unprecedented crowding and the potential conflicts that may arise therefrom.

2 How fast are blue economy activities growing?

Blue economy activities are growing rapidly, driven by several key ocean economic sectors, including shipping, offshore renewable energy, fisheries, aquaculture, coastal tourism, marine biotechnology and deep seabed mining. International trade relies heavily on maritime transport, and this sector has seen continuous growth as global trade expands. This includes both container shipping and specialized vessels like liquefied natural gas carriers. The United Nations World Tourism Organization (UNWTO) projected shipping to increase by 3.3% a year, on average, in the period 2010-2030 (United Nations Conference on Trade and Development, 2023; UNWTO, 2023; UNWTO, 2024). The UNWTO monitors global tourism trends, and they reported recently that international tourism doubled in the first quarter of 2023 compared to the same period in 2022, bringing the recovery to an impressive 80% of pre-pandemic levels (United Nations Conference on Trade and Development, 2023).

Offshore wind farms and other renewable energy projects are gaining momentum as nations invest in sustainable energy sources. Offshore wind capacity, particularly in Europe and Asia, has been growing significantly. In 2023, global offshore wind capacity reached a total of 59,009 megawatts (MW) from 292 operating projects, underscoring significant development and investment in this sector. The U.S. alone has an estimated offshore wind energy pipeline of 52,687 MW of capacity, encompassing various stages from installed projects to those under construction and in the permitting process (Office of Energy Efficiency and Renewable Energy, 2023). The global renewable capacity was projected to increase by almost 50% in 2023 compared to the previous year, which would be the fastest growth rate in two decades. This surge is primarily fueled by the economic attractiveness of solar photovoltaics and onshore wind technologies with appropriate sustainable incentives, which now often offer lower generation costs than both fossil and non-fossil fuel alternatives (International Energy Agency, 2023).

Not to be left behind by the need to produce food, global demand for seafood has led to the expansion of both wild fisheries and aquaculture. While wild fisheries face sustainability challenges (Teh et al., 2017), aquaculture continues to grow fast (FAO, 2024) even though the rate of growth seems to have peaked. The growth rate of aquaculture production in Asia, the world's leading aquatic animals farming continent by far, dropped from 22.3% five years to its peak in 1954 to 4.0% in the five years leading up to 2018. Aquaculture, similar to other food systems such as wild fisheries, often undergoes a phase of rapid initial growth in new production activities, which eventually slows down due to factors like diminishing marginal returns on inputs, resource limitations, and the natural effects of compounded growth laws (Sumaila et al., 2022). OECD-FAO Agricultural Outlook (2021–2030) projects global wild fish catch to grow at 1.2% annually up to 2030, with aquaculture expected to grow at 2% annually in the same period (OECD/FAO, 2021).

Coastal tourism is a major contributor to the BE, and demand remains strong, especially in developing regions with growing middle classes. Coastal and marine tourism constitutes approximately 50% of all global tourism, equal to US$4.6 trillion or 5.2 percent of global gross domestic product (GDP) (Schuman et al., 2022; Skyquest, 2024). Coastal tourism is the most important and fastest-growing activity occurring in the sea, and it is an essential activity of the economy for small island and coastal communities (Skyquest, 2024). The global coastal and maritime tourism market size was valued at approximately USD 3.07 trillion in 2022 and is expected to grow to USD 5.06 trillion by 2031, with a compound annual growth rate (CAGR) of 5.7% over the forecast period. This growth is fueled by a range of factors including the increasing popularity of leisure travel among younger generations, more affordable travel options, and advancements in tourism-related technologies (Blue Tourism Initiative, 2024).

On the other hand, there is increasing research and commercial interest in marine biotechnology, particularly in the pharmaceutical, food, and cosmetic industries. Offshore Oil and Gas is a major BE sector that continues to grow. Deep Seabed Mining is still largely in the exploration phase but potential deep seabed mining, areas covering thousands of square kilometers designated in the Clarion-Clipperton Zone in the Pacific Ocean are being contemplated. The marine biotechnology sector is advancing rapidly by leveraging the unique properties of marine organisms to develop valuable products and technologies. From 2022 to 2023, the market for marine biotechnology was expected to grow from $5.35 billion to $5.79 billion, reflecting a CAGR of 8.1%. Looking ahead, the sector's growth is expected to continue, suggesting that the market could expand to approximately $11.7 billion by 2032, which translates to a CAGR of around 7.09% from 2023 to 2032 (Precedent Research, 2023). This growth is driven by several factors including increased demand for sustainable and eco-friendly products, advancements in marine-derived pharmaceuticals, and innovations in biotechnological applications using marine resources (Precedent Research, 2023). The market's expansion is supported by ongoing research and development,

which is opening new applications in medicine, cosmetics, and other industries. For instance, the ocean has been an attractive source of bioactive compounds for the development of novel drugs, and increasing cosmeceuticals and nutraceuticals purposes, generating around 40,000 marine natural products and omega-3 fatty acids (Blasiak et al., 2020).

2.1 Ocean areas occupied by blue economic activities

Quantifying the exact amount of ocean area occupied by various ocean economic activities is difficult due to the dynamic nature of these activities and the vastness of the global ocean. Therefore, we provide some general insights into the coverage of major ocean economic sectors and potential overlaps:

- Shipping routes cover significant portions of the ocean, particularly along major international trade lanes. Current global shipping primarily occurs within EEZs rather than on the high seas, most maritime shipping is conducted within EEZs, leveraging the infrastructure and regulatory frameworks provided by coastal states. The busiest shipping routes include areas like the North Atlantic, the Suez and Panama Canals, and the Strait of Malacca. The rapid expansion of cruise tourism worldwide, while economically advantageous for local communities, raises significant environmental concerns. These impacts stem from various sources throughout a cruise itinerary, affecting multiple biological groups—from birds to marine mammals—and ecosystems, including water, air, and land. Cruise ships contribute to substantial pollution across these domains; their traffic routes often intersect with delicate coastal and shallow regions, especially when vessels approach ports or navigate narrow, sensitive areas such as straits, channels, and marine protected zones. Particularly vulnerable regions like the Mediterranean Sea, the Arctic, and Antarctica face heightened challenges due to these interactions (Lloret et al., 2021);
- Fishing activities span vast areas, especially in rich fishing grounds like the Grand Banks off Newfoundland, the North Sea, and various regions in the Pacific and Indian Oceans. Fishing activities are heavily concentrated within EEZs compared to the high seas. Approximately 90% of global fish catches occur within EEZs, which are areas extending up to 200 nautical miles from the coastlines of sovereign states (Sumaila et al., 2015);
- Aquaculture is predominantly conducted within EEZs rather than on the high seas. In fact, aquaculture operations on the high seas are virtually non-existent due to the challenges posed by the open ocean environment, such as harsher conditions, regulatory issues, and the lack of necessary infrastructure. This concentration within EEZs is due to several factors, including more controlled environments, easier regulation, access to coastal infrastructure, and favorable conditions for farming operations, making them ideal for aquaculture development (Sumaila et al., 2022);
- Offshore oil and gas industries are located primarily on continental shelves and can cover extensive areas. The sector's production is predominantly conducted within EEZs rather than on the high seas. The EEZs provide a more controlled environment for drilling and extraction, benefitting from easier regulatory oversight and proximity to infrastructure. Approximately 97% of offshore oil and gas production occurs within EEZs. This includes significant operations in regions like the Gulf of Mexico, the North Sea, and offshore Brazil. These areas are rich in hydrocarbon resources and have well-established infrastructure for extraction and transportation (International Energy Agency, 2023);
- Offshore wind farms are found mainly in shallower waters near coastlines within the EEZs of coastal nations, where legal frameworks and regulatory oversight are well established. The United Kingdom, Germany, China, and the United States have notable offshore wind farm developments. The total area they occupy is smaller compared to global shipping and fishing but is expanding rapidly as technology and investments in renewable energy grow;
- Deep Seabed Mining, while still largely in the exploration phase, has large areas, particularly in the Clarion-Clipperton Zone in the Pacific Ocean, designated for this potential BE activity. This controversial potential BE activity is envisioned to take place in both the high seas and within EEZs of coastal nations.
- These major ocean economic sectors have the potential to overlap with areas that may be designated as Marine Protected Areas (MPAs) in accordance with the recently agreed Kunming–Montreal Global Biodiversity Framework (GBF), which in Target 3 seeks to protect 30% of land and ocean by 2030 (30 × 30) through protected areas (PAs) and other effective area-based conservation measures (OECMs) (CBD, 2022). The goal of protecting 30% of the Earth is a political ambition claimed to be supported by scientific evidence (Pereira et al., 2024). However, there are power dynamics around MPAs which are part of complex processes in which several interests and actors usually interact, sometimes with conflictive interests exacerbating existing inequalities, minimizing them or benefiting determined actors (Pereira et al., 2024). For instance, the expansion of these economic activities and the objectives of the GBF will likely come into conflict, especially since MPAs typically involve local actors such as small-scale fishers or Indigenous Peoples and local communities, whereas the blue economy involves powerful actors with significant economic power acting on behalf of economic development. This conflict has the potential to exacerbate historical and current injustices experienced by these marginalized groups (Pereira et al., 2024).

3 Economic conflicts in a crowding ocean

Blue economy sectors can and do overlap on the ocean surface, and this can lead to conflicts creating management challenges. Several potential avenues for conflicts to arise include, but are not limited to:

Resource Competition where for example the development of offshore wind farms, wave, and tidal energy projects can occupy large sea areas, potentially reducing fishing grounds and causing conflicts over space. The fishing industry often claims that these installations can disrupt traditional fishing areas and alter marine ecosystems, affecting fish populations. Similarly, the expansion of aquaculture can compete for space and resources with traditional fisheries, leading to tensions over water quality, feed sources, and habitat. *Environmental Impact*: for instance, increased industrial activity, including mining, and tourism, can lead to pollution (oil spills, plastic waste, noise), negatively affecting fish populations and marine ecosystems crucial for fisheries. Increasing maritime traffic can impact marine life, especially in sensitive areas where shipping lanes intersect with migratory paths. Noise pollution from shipping vessels is also known to affect marine mammals like whales. *Habitat Destruction*: Coastal development and seabed mining can destroy critical habitats such as coral reefs and mangroves, which serve as breeding and feeding grounds for many fish species. All of these can and do result in *Regulatory and Governance Issues* such as zoning conflicts, for example, the designation of MPAs and exclusive zones for renewable energy or tourism can restrict access to traditional fishing areas, causing disputes over rights and usage. With increasing regulatory challenges come issues related to *Compliance and Enforcement* related to how to ensure that new industries comply with environmental and fishing regulations can be challenging, leading to overfishing, illegal fishing activities, and inadequate protection of marine resources. *Cultural Conflicts:* Traditional fishing practices and cultural heritage may be threatened by the introduction of large-scale industrial activities, leading to conflicts between modern economic interests and traditional ways of life. *Biodiversity Conservation*, e.g., efforts to protect the economic and cultural value of endangered marine species and biodiversity can sometimes clash with fishing activities, particularly if certain fishing methods or areas are restricted to conserve vulnerable species.

BE activities already overlap and the current overlap would only increase as these activities continue to grow, leading to conflicts or synergistic and spatial planning and management challenges (Frazão Santos et al., 2023). We present in Figure 1 the potential for increasing conflicts between BE sectors as BE surges.

Here we do not provide a systematic review of potential conflicts (Alexander, 2019). Rather, we identified 11 illustrative potential avenues for conflict within BE sectors, i.e., intra-sector conflicts, and determined which among these are likely to arise in each of the BE sectors discussed herein (Figure 2). We see from the figure that each of the sectors has the potential to generate more conflicts in at least 4 to 6 different ways.

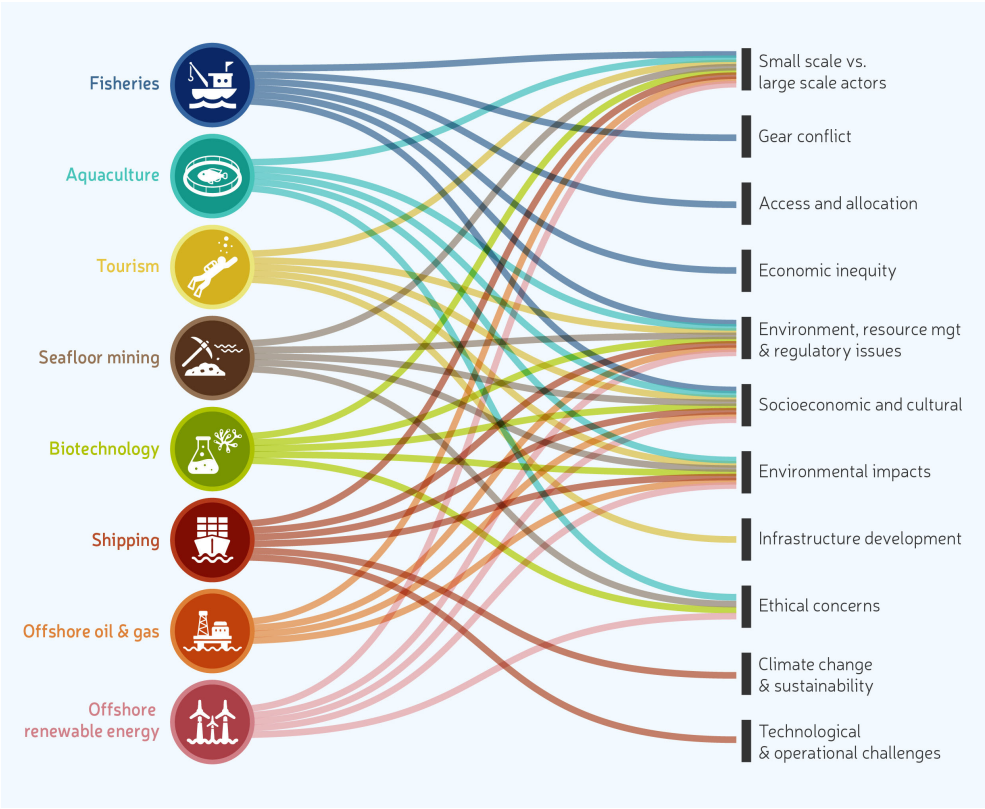

FIGURE 1
A surging Blue Economy and the potential for increasing conflicts between economic activities. Source: own elaboration.

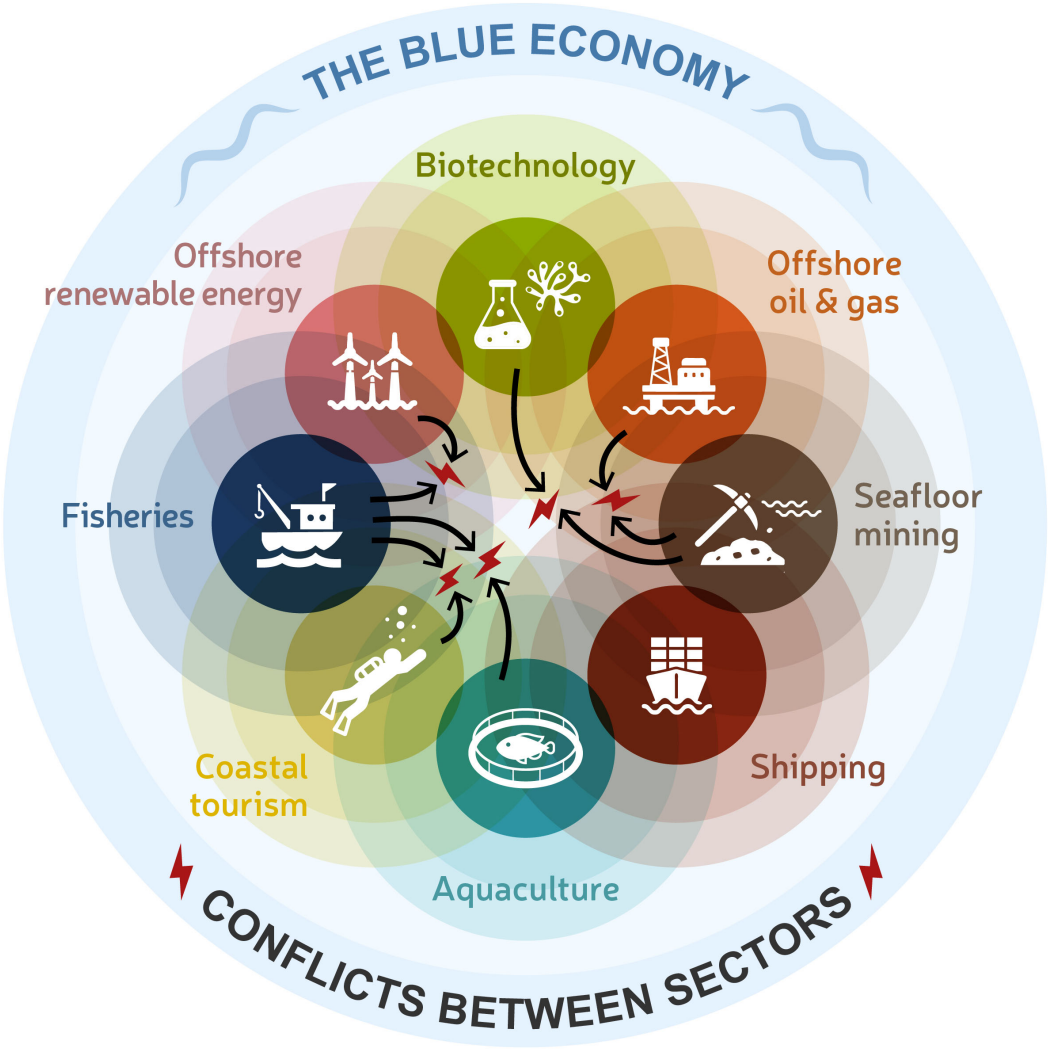

FIGURE 2
Intra-blue economy sector conflicts. Source: own elaboration.

Ocean governance efforts have frequently neglected or insufficiently integrated social equity dimensions, which can often have substantial negative impacts on coastal communities, further marginalizing resource-dependent populations, rights-holders and vulnerable groups (Bennett et al., 2022).

Looking specifically at fisheries as an example, there can be significant direct intra-sectorial conflicts between small-scale fishers (SSF) and large industrial fleets, and this is likely to increase with an increasing BE growth (Figure 2). It is important to highlight that not all conflicts will generate similar impacts, as these impacts will depend on the effects of key factors such as demographic evolution, food demand and ecosystem services, and regulatory changes due to geopolitical shifts. For example, Individual Transferable Quotas (ITQs) were originally developed to enhance fisheries sustainability by reducing stock pressure and encouraging responsible management. However, they have often resulted in the increasing financialization and consolidation of fisheries under corporate control, while increasing the economic inequality between the two sectors (Figure 2) (Edwards and Pinkerton, 2019). Also, SSF often find themselves at a disadvantage due to the limited resources and access to prime fishing areas dominated by larger, more technologically advanced vessels. Conflicts can arise between fishers using sustainable practices and those using more destructive methods like bottom trawling or the use of unregulated fishing gear. Destructive fishing gear can cause significant damage to the marine environment, leading to long-term impacts on fish populations, habitats and the livelihoods of millions of people worldwide (Figure 2) (Bailey and Sumaila, 2015). Disputes over the allocation of fishing quotas are common, especially when there are changes in fish stock assessments or management plans. Quota reductions can hit SSF hardest, leading to economic hardships and disputes over fairness and equity in resource distribution (Ding et al., 2020). SSF may struggle to compete with larger operations in terms of market access, pricing and commercialization of seafood. Larger fleets often benefit from economies of scale, better market networks, and subsidies (Schuhbauer et al., 2020), which can marginalize small-scale operators including women and youth and create economic disparities within the sector (Evans et al., 2023).

Variability in fish stocks due to climate change can lead to conflicts over shifting fishing grounds and changing species availability. Fishers may need to adapt to new conditions, which can create disputes over new or traditional fishing areas (Miller et al., 2013; Sumaila et al., 2020). Also, traditional fishing communities may find their practices and cultural heritage under threat from modern, more industrialized fishing methods. This can lead to conflicts over maintaining traditional livelihoods and ways of life in the face of economic pressures and modernization (Evans et al., 2023).

Establishing clear ethical standards for the sustainable development of aquaculture (including animal welfare, environmental impact, and social justice) is also crucial (Ciliberti et al., 2023). Ensuring strict animal welfare standards, fostering sustainable farming methods, implementing environmental management policies, leveraging innovative technologies, and training staff to evaluate and manage fish welfare are all essential (Ciliberti et al., 2023). Moreover, educating consumers about sustainable practices and their environmental impacts is vital for influencing ethical purchasing decisions (Grigorakis, 2010). A more transformative approach is addressing these ethical concerns through the Rights of Nature, which have been increasingly recognized in different national laws around the world. A Rights of Nature approach therefore bases the governance on an assumption that the rights of all living species must be respected (Harden-Davies et al., 2020). Infrastructure development for coastal tourism is the most documented impact on SSF, which usually expands amenities and services (including hotels, restaurants, bars, and stores) and ultimately can lead to displacement or limit access to fishery resources (Miller, 2022).

There are also indirect intra-sectorial conflicts that are important to highlight. For example, the fishmeal industry owned by foreign companies in West Africa is targeting small-pelagic species to feed aquaculture, exacerbating conflicts between artisanal fishers in a race for fish (Bara Dème and Failler, 2024). Instead of being destined for direct human consumption due to their highest nutritional value for humans, these small-pelagic fishes are being processed into fishmeal, fish oil, and other by-products used to feed species such as Norwegian salmon, Chinese trout, and French pigs (Kaczynski and Fluharty, 2002; Shea et al., 2025).

In addition, many Indigenous Peoples have profound connections to the oceans, defining their sacred and spiritual identities and practices in relation to the oceans (IPBES, 2024). However, many emerging technologies to develop DSM activities also depend on ocean resources in response to rising demand for critical minerals like lithium, cobalt, and graphite from the ocean floor (Arato et al., 2024). DSM activities can undermine peoples' spiritual values linked to deep oceans. For numerous African and Afro-descendent communities, the Atlantic seabed holds profound significance in shaping their collective identity, serving as a vast underwater gravesite for those who perished during the transatlantic slave trade. The remains of millions rest in the depths of the ocean, and their memories are preserved and honored through songs, storytelling, and other cultural practices that perpetuate and strengthen these enduring connections to the sea (IPBES, 2024).

TABLE 1 Strategies for minimizing conflicts In blue economy activities.

Strategy	Action	References
1. Safe and just boundaries	1.1. Interspecies justice	Rockström et al. (2023)
	1.2. Intergenerational justice between past, current and future generations	Rockström et al. (2023)
	1.3. Intergenerational justice between countries, communities and individuals	Rockström et al. (2023)
2. Stakeholder Engagement	2.1. Inclusive Decision-Making	Depellegrin et al. (2022)
	2.2. Transparent Communication	Röckman et al. (2017)
3. Effective Governance	3.1. Integrated Coastal Zone Management (ICZM)	Sumaila (2012)
	3.2 Marine Spatial Planning (MSP)	Issifu et al. (2024)
	3.3. Clear Regulations and Enforcement	Melnychuk et al. (2021)
4. Sustainable Practices	4.1. Ecosystem-Based Management (EBM)	Bastardie et al. (2021)
	4.2. Sustainable Development Goals (SDGs)	Giron-Nava et al. (2021)
5. Adaptive Management	5.1. Training and Education	Ebbers and Gregory (2008)
	5.2. Research and Innovation	Bahri et al. (2021)
6. Capacity Building and Education	6.1.Training and Education	Ebbers and Gregory (2008)
	6.2. Research and Innovation	Macfadyen and Huntington (2004)
7. Economic incentives	7.1. Incentivize Sustainable Practices	Dasgupta (2021)
	7.2. Compensation Mechanisms	Costello et al. (2010)
8. International Cooperation	8.1. Transboundary Collaboration	Palacios-Abrantes et al. (2020)
	8.2. Global Standards and Agreements	Haas et al. (2021)

4 Charting the way to minimize conflicts and promote justice in the face of an acceleration of BE activities

Minimizing conflicts in the face of an acceleration of blue economy activities requires just and integrated ocean management approaches (including ecological, economic and cultural dimensions), stakeholder engagement, sustainable practices, and effective policy frameworks to balance the interests of different sectors while ensuring the long-term health of marine ecosystems. We suggest 8 strategies and 2 to 3 actions that can be used to implement them in Table 1. Many of these strategies are not new, what is new is that we highlight the need for each of these to be implemented individually and/or collectively to synergies and achieve complementarity across them. Also, we argue that perquisites for success include: (i) quantifying safe and just planetary boundaries for the global ocean, (ii) taking stock of all BE activities currently taking place on, below and adjacent to each country's EEZs and in the high seas. Taking these steps systematically from the local to the national and global scales, would help each country to understand how crowded or not their waters are, and therefore the 'true' potential for sustainable and just BE development.

We have highlighted how the anticipated surge of the BE poses critical risks for an increase in both inter- and intra-BE sector conflict. We then provide strategies and actions that could be taken to minimize the chances of conflicts escalating as a result of an accelerating BE.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding authors.

Author contributions

US: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. SV: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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