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Greening the ocean economy

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The ocean economy comprises a wide range of industries—fishing, offshore energy, mineral extraction, shipping and coastal tourism. It generates $1.5 trillion in global value added and is expected to double in size by 2030. If we are to successfully green the ocean economy, we must overcome two major distortions—the underpricing of marine capital and the underfunding of ocean and coastal conservation. Many important values provided by the marine environment are ignored or discounted in our decisions to exploit, convert and pollute our coastlines and seas. The funding gap between current financing of conservation, restoration and sustainable management of marine capital and the most critical funding needs is estimated at $120–$154 billion annually. We urgently need a new global agreement for oceans and coasts that has three principal aims: (1) Phasing out subsidies for fishing, extractive activities, and other ocean industries. (2) Implementing market-based incentives, management reforms, and other regulations to reduce any remaining ecological marine damages. (3) Using any financial savings and revenues generated to support global funds and investments for conserving, restoring and protecting marine capital in an inclusive manner. There should also be more participation by the private sector in developing global marine and in bridging the funding gap for marine conservation. It is estimated that major companies in ocean industries could raise an additional $83–$186 billion each year for marine conservation investment that would also benefit their financial interests and markets.

KEYWORDS

blue carbon, coastal wetlands, fishing subsidies, marine capital, marine environment, ocean economy

1. Introduction

The ocean economy comprises a wide range of industries—fishing, offshore energy, mineral extraction, shipping and coastal tourism. It generates between 3.5 to 7.0% of world gross domestic product and around 31 million jobs. This economy may double in size by 2030 [Organization for Economic Cooperation and Development (OECD), 2016; Duarte et al., 2020; Sumaila et al., 2021].

Ocean-based industries are supported and sustained by a diverse array of *marine capital* comprising estuarine and coastal ecosystems, marine resources, species and habitats that stretch from shorelines to the deep sea. But because we continually exploit our oceans as if it is a limitless frontier, we are running down our marine capital at an unprecedented rate. As this capital depreciates, it undermines the sustainability of the ocean economy and the people dependent on it. Yet we continue to ignore these losses as we deplete and pollute our oceans. Moreover, the loss of marine capital not only affects the ocean economy but also other industries and services that depend on this economy, thus impacting many more incomes and livelihoods.

Since 1970 there has been a nearly three-fold rise in fisheries production, but this is being harvested from a dwindling stock of fish. At least one-third of fish stocks are overfished, one-third to half of vulnerable marine habitats have been lost, and a substantial fraction of our coastal waters suffers from pollution, eutrophication, oxygen depletion and higher temperatures. In addition, illegal, unreported and unregulated catch affects about one-fifth of global fishing, costing up to $50 billion in lost income and $4 billion in foregone tax revenues each year (Cabral et al., 2020; Long et al., 2020; Sumaila et al., 2020). Because of these threats, much of our seafood-producing marine fisheries could collapse by 2050 if not sooner (Worm et al., 2006; Worm and Branch, 2012; Costello et al., 2016; Worm, 2016; Duarte et al., 2020).

Almost 80% of all pollution in seas and oceans comes from land-based activities, and as much as 80% of marine litter consists of plastic. Marine plastic pollution has been rising exponentially. In 1970, there was 30,200 tons of plastics floating in global oceans. By 2020, this amount had risen to nearly 1.2 million tons (Lebreton et al., 2019; Ritchie, 2019). Our exploitation and pollution of the marine environment has now reached the deep sea, which is on the verge of "industrialization," through expansion of oil, gas and mineral extraction and trawling of deeper and deeper waters (Barbier et al., 2014; Van Dover et al., 2014; Danovaro et al., 2017; Da Ros et al., 2019).

Since the 1970s, most of the waters surrounding our coastlines have been designated as exclusive economic zones (EEZs) that are regulated and controlled by the nations with territorial rights over these zones. It may be that national sovereignty of EEZs has led to some control over how these waters are exploited, but they are still treated as if they are unending sources of fish, minerals, energy and other resources, and perpetual sinks for pollution and litter. Even further out from shore, the poorly regulated and managed high seas and deep seabed beyond national jurisdiction are simply inviting unrelenting expansion of oil, gas and mineral extraction and trawling into deeper and deeper waters (Barbier et al., 2014; Van Dover et al., 2014; Danovaro et al., 2017; Da Ros et al., 2019).

Over the past 150–300 years, human impacts have depleted more than 90% of formerly important marine species, destroyed at least 65% of seagrass and wetland habitat, degraded water quality, and accelerated species invasions (Lotze et al., 2006). Some of the most dramatic declines have occurred for coastal wetlands (Harnik et al., 2012; Friess et al., 2019; Newton et al., 2020). Today, an increasing number of marine species are threatened, with 830 currently classified as critically endangered, endangered or vulnerable. Causes of extinction include not only overexploitation and habitat loss but also pollution, ocean warming and acidification, and anoxia (Harnik et al., 2012). These human impacts are now interacting to damage the marine environment. In 45% of the cases of species loss and 42% of extinctions, multiple human impacts were involved, often with exploitation and habitat loss acting as the main catalysts (Lotze et al., 2006).

To overcome these threats, much of the existing literature emphasizes creating a more sustainable and inclusive ocean economy, through improved governance, integrated management, climate resilience, clean energy developments, and additional financing (Gattuso et al., 2018; Bennett et al., 2019; Johansen and Vestvik, 2020; Lubchenco et al., 2020; Winther et al., 2020; Sala et al., 2021; Sumaila et al., 2021). For example, Lubchenco et al. (2020) suggest five investment priorities for greening the ocean economy: manage seafood sustainably, mitigate climate change, stem biodiversity loss, seize opportunity for economic recovery and manage the ocean holistically. These are laudable and important objectives. However, as this article will argue, realizing these goals will require addressing two major disincentives to building a more sustainable ocean economy: *the underpricing and underfunding of marine capital*.

First, the rapid and accelerating rate of loss of key marine ecosystems, habitats and species stem directly from the *underpricing of marine capital*. We are happy to exploit our oceans and coasts as a source of fish, minerals, energy, transport and other commercially valuable products, and use it as a vast dump for our litter, plastics and waste. But we are not prepared to pay for the marine ecosystems that are degraded or destroyed by these activities. The result is that many important values provided by the marine environment are ignored or discounted in our decisions to exploit, convert and pollute our coastlines and seas. Even worse, we provide substantial subsidies to encourage environmentally harmful fishing practices, mineral and energy extraction, and coastal habitat conversion. In effect, such subsidies put a "negative price" on marine capital, which further incentivizes its degradation and destruction.

Second, we are *underfunding oceans and coasts*. There is a large gap between the investments required to protect, conserve, restore and sustainably manage our oceans and coasts and the current funding levels for marine capital. This funding gap reinforces the undervaluing of marine capital, thus contributing to its continued loss and depreciation. In addition, underfunding marine capital exposes the ocean economy to rising marine environmental risks, such as climate change, species extinction, ecosystem collapse, extreme weather events and sea level rise. In effect, we are willing to live off the $1.5 trillion in global value added provided by the ocean economy, but we are unwilling to invest adequately in sustaining the marine capital that generates this income.

The rest of this article explains further the consequences for our ocean and coasts of the underpricing and underfunding of marine capital. To address these two economic failures, we urgently need a new global agreement. The agreement should foster collective action to phase out subsidies for fishing, extractive activities and other ocean industries, implement market-based incentives, management reforms and other regulations to reduce any remaining ecological marine damages, and use any financial savings and revenues generated to support global funds and investments for conserving, restoring and protecting marine capital in an inclusive manner. Moreover, implementation of this collective action requires not just a commitment by governments but also by the major ocean industries which have a financial stake in more sustainable management in the marine environment.

2. Underpricing of marine capital

A key step in ending the underpricing of marine capital is the removal of environmental harmful subsidies, such as those supporting unsustainable fishing.

Global marine fisheries receive about $35 billion each year in subsidies, of which $22 billion is for capacity-enhancing purposes. The latter subsidies prop up fishery operations that would otherwise be uneconomic and drive exploitation of fisheries beyond sustainable levels (Sumaila et al., 2019). Fishing subsidies also encourage dumping of fish by-catch that has no commercial value, cause excessive trawling of ecologically sensitive seabeds and lead to additional releases of carbon stored in the ocean floor.

This environmental impact, just in terms of carbon releases, is significant. For example, around 4.9 million km^2, or 1.3% of the global ocean, is trawled each year. The resulting disturbance to the seafloor results in an estimated 1.47 billion tons of CO_2 emitted per year. This is equivalent to how much carbon is released annually by the global aviation industry (Sala et al., 2021).

Marine fishing subsidies are also highly inequitable. They benefit mainly large industrial-scale industrial fleets, often at the expense of small-scale fishers. Almost 90% of capacity-enhancing subsidies go to industrialized fleets, thus increasing the unfair competitive advantage that these large-scale fishing operations already have (Schuhbauer et al., 2017). Industrial fleets are, in turn, behind increasing conflicts with small-scale fishers and contribute to the growing problem of illegal, unreported and unregulated fishing in some regions (Belhabib et al., 2019; Long et al., 2020). For example, conflicts over fisheries in the coastal waters of African have mostly been the result of competition between industrial and small-scale fishers. Almost half of fish catches in Africa is illegal, and much of this activity is attributed to industrial fleets. By engaging in illegal fishing, these fleets can hinder access to fishing resources by small-scale sector fishers and drive up their costs through over-exploitation and ecological damages (Belhabib et al., 2019).

The expansion of subsidized industrial fleets at the expense of small-scale fishers impacts global livelihoods and poverty. Between 85 and 98% of the world's 3.2 million active marine fishing vessels are small-scale. They support around 22 million fishers, who make up about 44% of all fishers globally. Additionally, another 100 million people may be involved in the post-harvest activities of small-scale fishing (Schuhbauer et al., 2017). Just in Africa alone, small-scale fisheries and post-harvesting provide sustain 35 million people (Belhabib et al., 2019).

Our coasts and oceans also provide other important benefits. Unfortunately, many of these valuable services of marine capital are "underpriced" in our decisions that impact our oceans and costs. As a result, we allow this capital to depreciate and degrade, thus imperiling its benefits to current and future generations.

To illustrate this problem, we will look more closely at one type of marine capital—estuarine and coastal ecosystems—and the consequences for two vital services they provide—protection against storms and sequestration of carbon.

There is no doubt that estuarine and coastal habitats, such as marsh, mangroves, seagrass beds, tidal flats, kelp forests and near-shore reefs, are suffering considerable loss from the impacts of the expansion of the ocean economy. The main threats are from (i) land reclamation and conversion to agriculture, aquaculture, ports, and urban areas; (ii) construction of dams, dykes, polders, drainage channels, dredging that modify the natural hydrology, connectivity, and sedimentology; (iii) overfishing and overexploitation of other aquatic resources; and (iv), the effects of climate change, sea-level rise, warming oceans, pollution and other human-induced environmental changes (Waycott et al., 2009; Madin and Madin, 2015; Wear, 2016; Friess et al., 2019; Murray et al., 2019; Goldberg et al., 2020; Newton et al., 2020; Richards et al., 2020).

As much as one third of estuarine and coastal habitats may have been lost in the past 100 years or so, although some estimates suggest that well over half of these habitats have disappeared (Davidson, 2014; Hu et al., 2017). Since the 1970s, estuarine and coastal ecosystems have continued to decline, with annual rates of loss of 0.82 to 1.21% per year (Davidson et al., 2018). Between 1996 and 2016, there was a net decline of 5,807 km^2 of mangrove area, equivalent to 4.0% of the 1996 area (Richards et al., 2020). From 1984 to 2016, 16.0% of tidal flats were lost, with 3.1% disappearing from 1999 to 2016 (Murray et al., 2019).

The rapid disappearance of estuarine and coastal ecosystems has raised concerns over their role in protecting coastal communities from storms that damage property, cause deaths, and inflict injuries. This benefit has been largely ignored in the decisions that have led to such habit decline. Yet, many studies indicate that the value of storm protection provided by estuarine and coastal ecosystems is substantial (Beck et al., 2018; Hochard et al., 2019; Barbier, 2020; Menéndez et al., 2020).

The protection provided by estuarine and coastal habitats against storms, sea-level rise and coastal flooding may be especially important to poorer rural populations in low and middle-income countries. Around 267 million people live in the rural low-elevation coastal zones of developing countries, just under half of the total population of these countries living in such zones. Approximately a third of the population (85 million) in rural low-elevation coastal zones are poor, and nearly all of them are found in low-income (47 million) or lower middle-income countries (37 million) (Barbier and Hochard, 2018). For such poor rural populations, the "natural" barriers of mangroves, seagrass beds, coral reefs and other surrounding habitats are the only protection of their homes, livelihoods and lives.

Another important global benefit of estuarine and coastal habitats is their sequestration of carbon. Marshes, mangroves, sea grass beds and other vegetated coastal and marine ecosystems are among the most prolific carbon sinks on Earth. Protecting and restoring mangroves, salt marshes, seagrasses, and wild seaweed belts could potentially mitigate around 0.50 and 1.38 billion tons of carbon annually by 2050 (Gattuso et al., 2018). As much as one-fifth of all mangrove areas can be conserved through carbon finance and that roughly half of this is cost effective and financially sustainable. If such financing is forthcoming, then it would mitigate nearly 30 million tons of carbon annually (Zeng et al., 2021).

Conservation of mangroves, salt marshes, and seagrasses can also achieve many additional environmental benefits, including increasing biodiversity, coastal resilience and climate change. These benefits can significantly increase the value attributed to marine capital, beyond their use for storm protection or carbon storage. For example, households on average are willing to pay $149 for increased storm surge protection through coastal wetland restoration in southeast Louisiana, but are willing to pay $973 for restoration when the additional ecosystem benefits of supporting wildlife habitat and commercial fisheries are also included (Petrolia et al., 2014).

The various goods and services provided by estuarine and coastal systems are especially significant for sustaining the livelihoods of people living in the coastal areas of low and middle-income countries. Resources harvested and collected directly from these habitats and the small-scale fisheries supported by them are important for food security, subsistence and cash income. For example, local coastal communities in Thailand accumulated gains in income from collecting mangrove products worth $484 to $584 per hectare (ha), and an additional $708 to $987 per ha from coastal fisheries that are supported by mangroves serving as breeding and nursery habitat for the fish. Such benefits are considerable when compared to the average annual income of coastal households in Thailand, which ranges from $2,606 to $6,623, and where typically the poorest households have annual incomes of $180 or lower (Barbier, 2007).

Coastal communities around the world also have a strong cultural connection with their marine environment. A survey of households in coastal areas of Papua New Guinea found that people ascribed most importance to the benefits of estuarine and coastal ecosystems that contributed to their livelihoods, especially for food, income and shelter through activities such as fishing, collecting forest and reef materials. But respondents also stressed the importance of marine habitats for local traditions, environmental knowledge, the heritage for future generations and stewardship of the environment (Lau et al., 2019).

In sum, we are losing our marine capital because it is grossly underpriced. Many important values provided by the marine environment are ignored or discounted in our decisions to exploit, convert and pollute our coastlines and seas. The ocean economy is expanding rapidly, and because marine ecosystems are undervalued, this expansion is occurring at the expense of rapid habit depletion and degradation. In some cases, such as the example of fishing subsidies indicates, over-exploitation of the underlying capital is encouraged, with harmful economic, environmental and distributional consequences. Ending such underpricing is therefore essential for decoupling the ocean economy from the destruction of marine environment.

3. Underfunding of oceans and coasts

There is also a large gap between the investments required to protect and conserve oceans and coasts and current funding levels for marine capital. This *underfunding of oceans and coasts* is yet another reason why our marine environment is in peril.

On the face of it, the underfunding of marine conservation is a puzzle. As Table 1 shows, there are significant returns to investment to several actions that would protect, restore or use more sustainably marine capital. Marine protected area expansion and restoration of mangroves show the lowest returns, but even for these actions the benefits are almost double the costs (see Table 1). The benefits from decarbonizing international shipping could be up to five times more than the costs, and sustainably increasing seafood production is 10 times greater. The largest returns are to conservation of mangroves, which have a benefit-cost ratio of 88 to 1.

Yet, despite these large returns, global marine conservation is woefully inadequate. There is a wide gap between current funding and investment needs. Table 2 illustrates the *marine underfunding* problem.

Global funding for sustainable use, protection and conservation of oceans and coasts amounts to just $1.3 billion each year (see Table 2). In comparison, annual fishing subsidies alone are $35 billion, of which $22 billion are known to be environmentally harmful (Sumaila et al., 2019). In other words, the world is prepared to spend 20–30 more on supporting ecologically damaging fishing operations than we are willing to devote to conserving marine capital.

TABLE 1 Returns to selective marine conservation investments.

Investment	Benefit-cost ratio	Description and source
Marine protected area expansion	1.4:1–2.7:1	Based on six different scenarios for protection and expansion (Brander et al., 2020).
Restoration of mangroves	2:1	184,000–290,000 hectares per year (Konar and Ding, 2020)
Decarbonize international shipping	2:1–5:1	Konar and Ding (2020)
Increase production of sustainably sourced ocean-based food in diets	10:1	Konar and Ding (2020)
Conservation of mangroves	88:1	Conservation of 15,000–30,000 hectares per year based on halting annual mangrove loss (Konar and Ding, 2020)

Yet, the benefits of that capital in terms of supporting the ocean economy are substantial. Currently, ocean industries, such as fishing, shipping, offshore wind, maritime and coastal tourism and marine biotechnology, generate $1.5 trillion in global value added, which is expected to double to $3.0 trillion by 2030 [Organization for Economic Cooperation and Development (OECD), 2016].

As Table 1 indicates, there are also five beneficial marine conservation investments that urgently need funding: expansion of marine protected areas, restoration of mangroves, decarbonizing international shipping, sustainable seafood production and mangrove conservation. Table 2 provides estimates of the likely annual costs of each of these marine conservation priorities, which total to between $122 and $154 billion each year.

For example, only 2.7% of the marine environment is currently fully or highly protected. Expanding the coverage of these marine protected areas to 10% of the ocean and coasts would cost nearly $8 billion per year (Sumaila et al., 2021).

Restoring degraded mangrove areas could cost another $3 to $6 billion annually over 30 years (Konar and Ding, 2020). The bill is likely to be even higher if conserving and restoring other ecologically and economically important estuarine and coastal ecosystem, such as marsh, seagrass beds, tidal flats, kelp forests and near-shore reefs, are also included. A review of the cost and feasibility of global marine restoration found that mangroves were the least expensive ecosystem to restore, whereas corals were the most expensive (Bayraktarov et al., 2016). The other ecosystems with mid-range restoration costs are seagrass beds, salt marshes and oyster reefs.

The annual costs of decarbonizing international shipping could amount to $77 billion over the next 30 years (Konar and

TABLE 2 Underfunding of oceans and coasts.

Category	Amount per year	Description and source
1. Funding from all sources	$1.3 billion	Based on $13 billion from all sources over the past 10 years (de Vos and Hart, 2020)
Public international finance	$0.5 billion	Based on $5 billion in official development assistance over the past 10 years (de Vos and Hart, 2020)
Private sector finance	$0.8 billion	Based on $8.3 billion in philanthropic spending and private contributions to conservation NGOs over the past 10 years (de Vos and Hart, 2020)
2. Funding needs	121.7–154.4 billion	Based on the five investments listed in Table 1
Costs of increasing fully protected marine areas	$7.7 billion	Costs of increasing fully protected marine areas from 2.7% to 10% of the ocean (Sumaila et al., 2021)
Costs of mangrove restoration	$3.5–$5.5 billion	Costs of restoring all degraded mangroves globally over 30 years (Konar and Ding, 2020)
Costs of decarbonizing international shipping	$76.7 billion	Based on $12.3 trillion operating and capital costs over 30 years for decarbonizing shipping (Konar and Ding, 2020)
Costs of sustainable management of marine fisheries	$5–$7 billion	Additional costs of management reform ($13–$15 billion) compared to current management costs ($8 billion) for marine fisheries (Mangin et al., 2018)
Costs of mangrove conservation	$28.8–$57.5 billion	Costs of halting global mangrove loss (Konar and Ding, 2020)
3. Funding gap	$120.4–153.1 billion	2.—1.

Ding, 2020). This action could have a considerable impact on global greenhouse emissions. Currently, shipping is responsible for around 1 billion tons of carbon emission each year, which is 3% of global emissions from human activity. The emissions from international shipping are expected to double by 2050 (Konar and Ding, 2020).

Implementing management reforms for global fisheries will require around $5 to $7 billion annually (Mangin et al., 2018). Such reforms are essential to end the chroming underpricing of fishing capital that is perpetuating unsustainable overfishing around the world. It is also vital to ensuring that seafood production can sustainably meet growing global demand. However, sustainably producing food from our oceans will also require improved management of species farmed in the ocean, or mariculture. Although the production of wild fisheries is approaching its ecological limits, current mariculture production is not. It therefore could be sustainably increased through policy reforms and technological advancements. If such reforms and innovations are forthcoming, the mariculture's current share of 16% of seafood production could rise to 44% by 2050 (Costello et al., 2020).

Finally, halting global mangrove deforestation completely could cost at least $29 billion annually, and possibly even double that amount to $58 billion (Konar and Ding, 2020).

In sum, the estimates in Table 2 suggest that the *funding gap* between current financing of conservation, restoration and sustainable management of marine capital and the most critical funding needs amounts to around *$120 billion to $154 billion annually*. The bill could be even larger if the costs of controlling marine pollution are also included, which may require an additional $87 billion per year (Johansen and Vestvik, 2020). Closing the funding gap for marine capital should be an urgent priority for the global policymaking community. Moreover, the failure to invest in key marine actions, such as estuarine and coastal habitat conservation and restoration, decarbonizing international shipping, sustainable seafood production and expansion of marine protected areas, is a missed economic opportunity. Addressing the underfunding of ocean and coasts and ending the underpricing of marine capital must be the main focus of collective action to save and protect our seas and shores.

4. Actional recommendation: A global agreement on oceans and coasts

What is urgently needed is a new global agreement on oceans and coasts that has three principal aims:

- Phasing out subsidies for fishing, extractive activities and other industries in the ocean economy.
- Implementing market-based incentives, management reforms, regulations and other incentives to reduce ecological damages from ocean economy industries.
- Using any financial savings and revenues generated to support global funds and investments for conserving, restoring and protecting marine capital in an inclusive manner.

We can also envision these aims as three distinct steps in the process of fostering global collective action on oceans and coasts (see Figure 1).

An immediate aim is for all coastal nation states to agree on removing subsidies for fishing, extractive activities and other sectors of the ocean economy operating in their territorial waters, EEZs and areas beyond national jurisdiction. As we have seen, fishing subsidies alone cost $35 billion a year, benefiting mainly industrial fishing fleets, contribute to overfishing and ecological damages, exacerbate illegal fishing, and worsen inequality and poverty (Sumaila et al., 2019). Subsidies may also be driving increased exploration and industrial exploitation of the vast and fragile deep sea, not only by fisheries but for energy and minerals. For example, there are significant annual subsidies for the exploration and exploitation of new reserves of fossil fuels (Bast et al., 2015; SEI, 2021).

Phasing out the subsidies that are most environmentally damaging should be a priority. For example, $22 million of current fishing subsidies are largely capacity enhancing and thus the most environmentally damaging (Sumaila et al., 2019). Such fishing

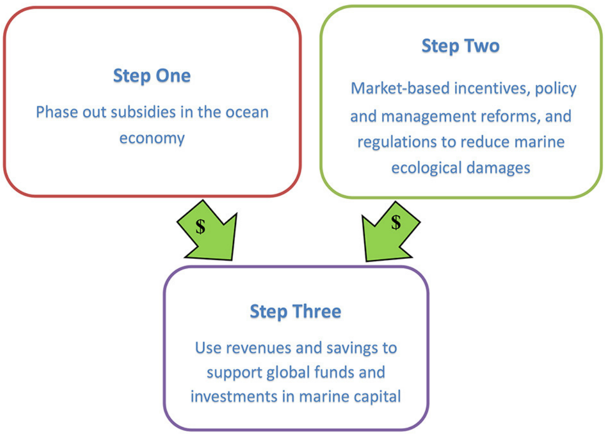

FIGURE 1
The three steps required for global collective action on oceans and coasts.

subsidies should be phased out first. Although care should always be taken for the employment and income implications of subsidy removal, such effects are likely to be minimal in this case. Where livelihood impacts from eliminating subsidies are significant, the resulting savings could be recycled to support programs to reduce such effects, such as job retraining, compensatory payments or income dividends.

Countries should also agree to adopt policy reforms and regulations to promote more sustainable management of marine capital, and to adopt taxes, license fees, tradable quotas and other market-based incentives to deter marine ecological damages incurred by various ocean industries. Coastal states should adopt such reforms for industries in their own territorial waters and EEZs and push for them as well for industries operating in the marine environment beyond national jurisdiction. For example, in the case of fisheries, such reforms are important to control the race to fish, reduce illegal fishing and support marine protected areas (Worm et al., 2006; Worm and Branch, 2012; Costello et al., 2016; Worm, 2016; Duarte et al., 2020). Similar reforms, regulations and incentives should be applied to other sectors of the marine economy, from energy and mineral activities to ocean transport to marine tourism.

The revenues and finances saved from ending the underpricing of marine capital could be directed to the investments and conservation actions identified in Tables 1, 2. Global funds could assist low and middle-income countries in conserving and restoring estuarine and coastal habitats, sustainably producing food from capture fisheries and mariculture, decarbonizing international shipping and expanding marine protected areas.

Developing countries may also need global assistance to control illegal fishing and reduce plastic pollution.

Illegal, unreported and unregulated fishing in poorer countries can involve illegal encroachment by foreign industrial fleets in EEZs and territorial waters, incursion of fleets in waters reserved for small-scale fishers, and poaching in marine reserves. Reducing these activities requires improving monitoring, control and surveillance, especially in many low and middle-income countries. It may also require the development of catch documentation systems as well as third-party certification of fisheries. These are costly investments, often with little immediate economic returns. When a country is plagued by high levels of illegal fishing by foreign fleets, addressing this encroachment can lead to recovery of fisheries and increases in local catch and profit. But if local fleets and small-scale fishers are behind illegal fishing, then there can be significant initial losses incurred if this practice is curtailed, which can be especially significant for small-scale fishers. Consequently, control of illegal fishing may also require additional expenditures on compensating for any negative impacts on the poor and most vulnerable fishers (Sumaila et al., 2019, 2020; Cabral et al., 2020).

One use of the money raised or saved from ending the underpricing of marine capital is to establish a global fund for assisting low and middle-income countries in reducing illegal fishing. The first step could be to aid countries to adopt a policy similar to that of Indonesia, which curtails illegal encroachment of foreign fleets in its EEZ and where international assistance of Indonesia's monitoring, control and surveillance efforts has been key (Cabral et al., 2020). The second step is to expand policies to include catch documentation systems, third-party certification, control of artisanal illegal fishing, and compensation schemes to reduce any burdens on poorer coastal households.

Developing countries may need global assistance for control of marine plastic pollution. Although plastic production occurs mainly in richer countries, most marine debris comes from low and middle-income countries, with more than 50% originating from China, Indonesia, the Philippines, Vietnam, and Sri Lanka. Plastic pollution is also a transboundary challenge, especially when it comes to removal of plastic debris from areas beyond national jurisdiction. Significant reductions in plastic pollution can nevertheless be achieved through the adoption of pricing policies and regulations, such as bans or charges on plastic use and landfilling, disposal fees and deposit-refund systems, which encourage a shift from producing, using and disposing of plastics to increased substitution, recycling and reuse (Raubenheimer and McIlgorm, 2018; Abbott and Sumaila, 2019; Almroth and Eggert, 2019).

Critical to reducing plastic pollution in oceans could be the establishment of a global fund to assist developing countries in stemming their outflow of plastic waste (Raubenheimer and McIlgorm, 2018). The main aim of the fund would be to enhance adoption of preventative measures, focusing on improving collection services, closing leakage points in collection facilities, improved disposal technologies, and recycling. The fund could also assist developing countries in devising economic incentive schemes that reduce plastic use and products that cannot be easily recovered, reused or recycled. Examples include taxes and bans on the landfilling of plastic waste, and government procurement policies and tax incentives for manufacturers that incorporate recycled content in products.

A global fund may also be needed for ecosystem monitoring of the deep sea. Such monitoring is essential for expanding our capacity to protect and restore deep-sea ecosystems and their resources. Estimates suggest that it would cost $2 to $3 billion for implementing and deploying of 20 strategically placed monitoring networks, with additional maintenance costs of $200 to $300 million per year (Danovaro et al., 2017).

TABLE 3 Revenues and potential conservation investments of 8 major ocean industries.

Industry	Industry annual revenues ($ billion)	Revenue share of top 10 companies (%)	Top 10 annual revenues ($ billion)	Potential top 10 annual conservation investment ($ billion)	Potential industry annual conservation investment ($ billion)
Offshore oil and gas	830	51%	423	42	83
Offshore wind	37	48%	18	2	4
Seafood	276	15%	41	4	28
Container shipping	156	85%	133	13	16
Shipbuilding and repair	118	67%	79	8	12
Port activities	38	82%	31	3	4
Marine equipment and construction	354	18%	64	6	35
Cruise tourism	47	93%	44	4	5
All industries	**1,856**		**833**	**83**	**186**

Potential conservation investment based on 10% of annual revenues. Top 10 companies in each industry together account for 45% of revenues from all industries.
Source: Virdin et al. (2021).

5. Discussion

The three-step process outlined in Figure 1 should be the basis for a comprehensive global agreement on oceans and coasts. This process is critical to building a more sustainable and inclusive ocean economy that reduces the main threats to our seas and shores. The overall aim must be to decouple the ocean economy from continued depreciation and loss of marine capital. The economics of increasing fragile oceans and rising costs must be based on the principle that ignoring the decline in marine capital is neither efficient nor sustainable. This means tackling the two most important economic failures that are preventing the decoupling of the ocean economy from marine environmental degradation: the underpricing of marine capital and the underfunding of conservation and restoration of habitats.

However, global collective action to save oceans and coasts should not just come from governments. The private sector must also contribute, both through investment and financing.

We have already noted that ocean industries generate $1.5 billion in global value added, which is expected to double by 2030 [Organization for Economic Cooperation and Development (OECD), 2016]. Ten companies dominate each of the eight main ocean industries, and these large companies together account for 45% of all revenues (see Table 3). If these companies and industries set aside some of their revenues to protecting marine capital, it could make a significant difference in bridging the current gap in conservation funding vs. needs.

If the top 10 companies in every ocean industry set aside 10% of their revenues, this could raise an additional $83 billion each year for marine conservation investment (see Table 3). If all companies participated, the amount raised would be $186 billion.

An extra $86 to $183 billion would go a long way to meeting some of the key funding needs for marine conservation, restoration and sustainable management (see Table 2). Moreover, companies in specific industries should be contributing to some of these investments anyway. For example, the shipping industry comprising container shipping, ship building and repair, port activities and marine equipment and construction should be contributing to the $77 billion required each year to decarbonize maritime shipping (Konar and Ding, 2020). Offshore oil and gas should offset its own greenhouse gas emissions by investing in mangrove conservation and restoration and other blue carbon actions. Cruise tourism could devote its 10% of revenues to helping expand marine protected areas and conservation and restoration of coral reefs and other estuarine and coastal habitats.

Recent conservation efforts in the seafood sector offer some promise that the private sector may be moving toward such cooperation. For example, 10 of the 13 seafood companies that control up to 16% of the global marine catch and 40% of the largest and most valuable stocks have committed to the Seafood Business for Ocean Stewardship initiative for more sustainable management of seafood resources and the oceans (Österblom et al., 2017). They now need to back up such commitments with actual investments to improve management and conservation of fishing capital (Österblom et al., 2020; Virdin et al., 2021). As Table 3 indicates, the seafood industry could contribute anywhere from $4 to $28 billion each year for such objectives. Such an investment makes perfectly good financial sense for seafood companies. The seafood industry should view this investment as a down payment on the $58 billion in additional profits that it would receive each year from more sustainably managed fisheries. For example, based on the $53 billion in additional annual profits it would receive from more sustainable management of global fisheries as estimated by Costello et al. (2016), the seafood industry could afford to contribute $5 to $10 billion annually on investments and management reforms that lead to more conservation of marine biomass stocks (Barbier et al., 2018).

An alternative to voluntary contributions of the ocean industries is to impose a tax on their revenues and profits. For example, the High-Level Panel for a Sustainable Ocean Economy has called for implementing a global tax on the profits of ocean industries to generate revenue for marine capital investments, such as conservation and restoration, sustainable management, and capacity-building in poorer countries. A 0.1% tax levied on the 100 largest ocean corporations could yield $1.1 billion each year for such actions (Österblom et al., 2020; Virdin et al., 2021).

In sum, more comprehensive cooperation between the international community, national governments, and the private sector is required to develop global policies to protect vulnerable coastal populations and the deep sea, and especially to bridge the funding gap for marine conservation (Barbier et al., 2018; Duarte et al., 2020; Österblom et al., 2020; Sumaila et al., 2021; Virdin et al., 2021). It is clear that ocean industries have the most to gain from such conservation, and consequently, the focus should be on their contributing more to preserving and protecting marine capital that is vital to their businesses.

Author contributions

EB designed the review, wrote the manuscript, and approved the submitted version.

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Conflict of interest

The author declares 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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