FERI® Cognitive Finance Institute

# Sustainable Blue Economy

## *Transformation, Value and the Potential of Marine Ecosystems*

*“We have to make sure that as we grow the blue economy, it accelerates in a regenerative way. Moving to a sustainable blue economy would benefit food security, human health, underdeveloped communities — and of course, the environment.”*

Alexandra Cousteau, President and Co-Founder Oceans 2050

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

GEOMAR Helmholtz Centre for Ocean Research Kiel

Fraunhofer

*With insights we see more*

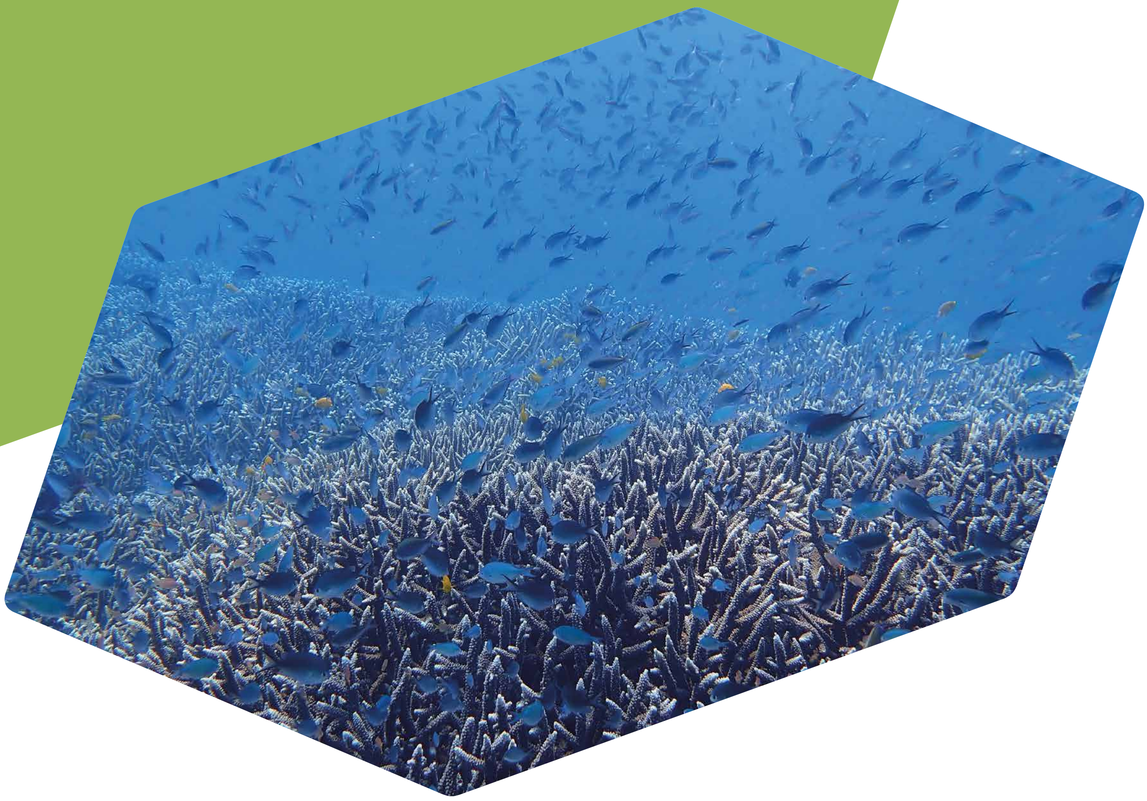
# *Sustainable Blue Economy*

## *Transformation, Value and the Potential of Marine Ecosystems*

*Antje Biber*
*Dr. Steffen Knodt*
*Prof. Dr. Martin Visbeck*

*“To win the “Race to Net Zero”, we must reconnect with the ocean. The conservation and restoration of blue carbon habitats is a cost-effective approach to remove excess carbon dioxide and to make a major contribution to climate action.”*

Carlos M. Duarte, Oceans 2050



Bad Homburg, June 2022

# *Preface*

Dear readers,

The world of the 21st century is not only marked by major geopolitical turning points but also by the massive effects of man's destructive interventions in nature. The resulting issues and repercussions for humanity itself are currently being felt more and more clearly. The progressive climate change and the resulting extreme weather disasters are only "the tip of the iceberg".

New strategies for a more sustainable and at the same time more efficient use of natural resources are necessary and force radical changes in perspective. The so-called "blue economy", which summarizes all economic activities in the marine ecosystem, has an important role and function as it guarantees the life and existence of humans. It also forms the basis of a globalized economy, especially through transport and energy production, as well as protein supply for a large part of humanity. The importance of the oceans is not only based on the extraction of marine resources, but also in the control of the global climate through $CO_2$ absorption and oxygen production, which is often still underestimated.

Global research projects and technological solutions are now subsumed worldwide under the term **Sustainable Blue Economy**. At the same time, numerous initiatives are forming the basis for a new political and regulatory agenda. From the UN SDG published in 2015 on the reorientation of state action to the current EU taxonomy as a common classification system for financing sustainable growth in Europe, states and politicians are striving to lay the foundations for an economic rethink and a change of direction.

Not only the industries of the Blue Economy but also the global financial industry in particular have an important role to play in the global transition. The long-term financing of new technologies, large-scale marine infrastructure projects as well as massive structural changes in both fisheries and marine logistics require economic incentives and new regulatory foundations for investors. The global megatrend of sustainable investment supports efforts to achieve an economically sensible and at the same time ecologically responsible transformation towards a Sustainable Blue Economy. The technological and regulatory changes will create challenges and opportunities by disrupting traditional systems. Strategic investors should be aware of the opportunities of a Sustainable Blue Economy and its potential for environmental, social, and economic change.

The purpose of this study is to consider the interdependencies of ecological, economic, political, and social factors. In addition, the explanations that follow are intended to highlight central ideas, drivers, and impact mechanisms behind the (financial) potential of a Sustainable Blue Economy as an answer to pressing challenges.

We wish you an exciting read!

Dr. Heinz-Werner Rapp

Founder & Head of
the Steering Board,
FERI Cognitive Finance Institute

Antje Biber

Head of SDG Office,
FERI AG

Dr. Steffen Knodt

Head of the Center for
Sustainable Ocean Business,
Fraunhofer IGD

Prof. Dr. Martin Visbeck

Professor for Physical Oceanography,
GEOMAR Helmholtz Center for Ocean
Research Kiel and Kiel University

# *Foreword UN Global Compact*

Oceans are the lifeblood of human and natural life on earth. The world depends on healthy, productive and resilient oceans for food security, climate mitigation, and economic livelihoods. However, unsustainable ocean practices, such as overfishing and pollution, have exacerbated climate change and pushed our oceans to the brink of collapse.

The impacts of climate change have far-reaching consequences including damage to vital ecosystems and habitats, food insecurity, and economic downturn. Simply put, the status quo is damaging our oceans while leaving our physical well-being and economic livelihoods exposed. As the internalized costs of unsustainable business practices continue to grow, industries can minimize these costly externalities by participating in a strong, resilient, and profitable blue economy.

The ocean economy is experiencing rapid growth and is predicted to create a gross value added of around USD 3 trillion by 2030. During this period of growth, industries have the opportunity to address climate change, preserve ocean health, strengthen value chain resilience, and target sustainable profitability by scaling the blue economy and investing in ocean sustainability. In fact, each $1 invested in ocean solutions is expected to yield at least $5 in global benefits by 2050. Furthermore, by committing to this transition, business, governments and financiers can avoid losing an approximated USD 8.4 trillion in ocean-based investments.

Investor appetite for blue investment is rapidly growing whilst businesses are recognizing the need to align their marine operations with the transition to a net-zero, resilient future. As the sustainable finance market continues to experience tremendous growth, blue finance solutions are in the spotlight. The United Nations Global Compact is leveraging these solutions to fuel the transition to a sustainable blue economy. For example, with high investor demand for thematic bonds, there is huge potential for a blue bond label nested within existing green, social, or sustainability-linked bond principles. The UN Global Compact, in partnership with the Asian Development Bank, recently launched a blue bond incubator aimed at scaling blue bond issuance and developing a pipeline of bankable ocean investments.

In order to build strong, resilient, and sustainable economies, forward-thinking solutions must abandon carbon tunnel vision and offer a more holistic approach to sustainable development and economic growth. Using a blue label can show ocean stewardship, beyond emission reduction, in ways that may not be fully expressed in a green instrument. Blue solutions are often able to address a wider range of SDG including gender equality, no poverty, zero hunger, decent work, and reduced inequalities.

As climate change accelerates and ocean health deteriorates, the global economy is at risk. Not only are physical and economic livelihoods threatened, but industries are also on a trajectory of unsustainable profitability. A sustainable blue economy, however, offers a solution in which there is no contradiction between clean oceans, healthy ecosystems, financial profit, and economic prosperity.

Erik Giercksky

Head, Ocean Stewardship Coalition,
UN Global Compact

# Table of Contents

## List of Figures



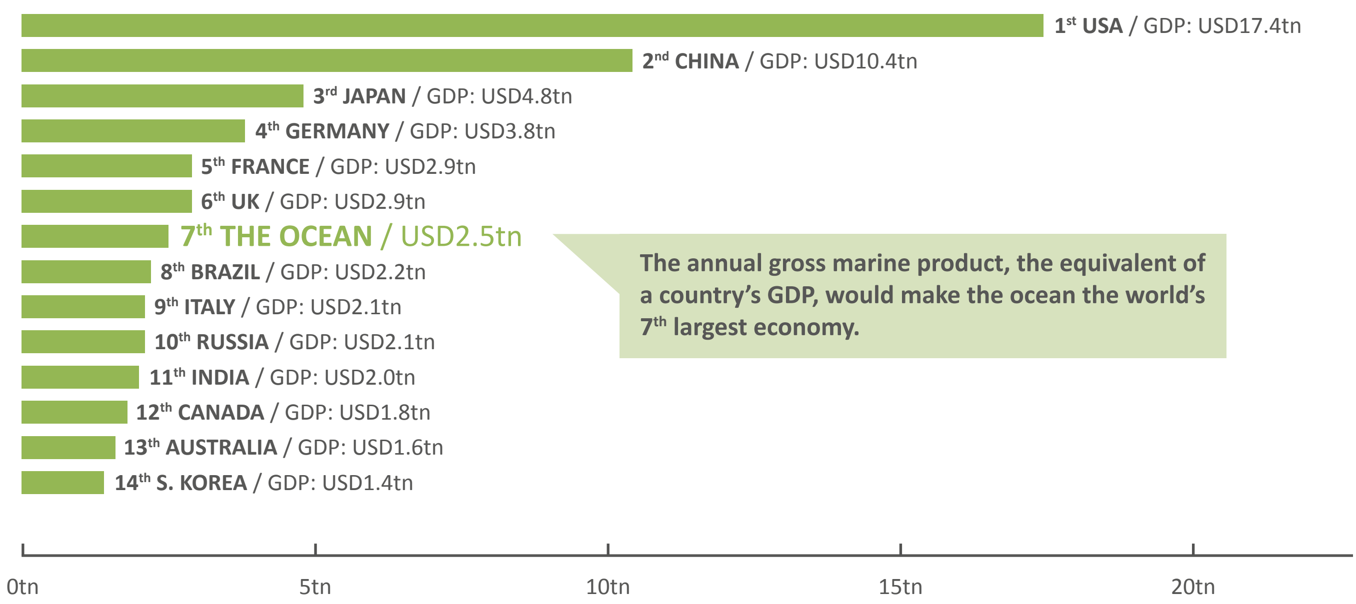
## List of Tables

# 1 Executive Summary

The total sum of the economic activities of ocean-based industries and the assets, goods and services produced by marine ecosystems is summarized under the term **Blue (or Ocean) Economy**.

- Covering more than **70 % of the Earth's surface**, the oceans are a natural wealth that, together with soils and forests, make up the world's stock of natural capital. Natural resources generate a vital ecosystem of goods and services such as food, climate regulation, coastal protection, and cultural values that support life on the planet and the survival and well-being of people worldwide.
- The oceans have not only an **enormous environmental, but also economic value**, as they contain a vast variety of renewable and non-renewable resources (e.g., fisheries, oil and gas deposits, materials, and cosmetics) that provide the inputs for ocean-based industries like renewable energy, food production, resource extraction, and tourism.
- The Organisation for Economic Co-operation and Development (OECD) estimated the **size of the global Blue Economy**, which includes fishing, shipping, offshore wind energy (OSW), maritime and coastal tourism, and marine biotechnology, to be **USD 1.5 trillion**, or 2.5 % of global gross value added in 2010. This value has been growing rapidly and – prior to the COVID19 pandemic, it was projected to increase to **USD 3.0 trillion in 2030**. This is likely an underestimate since many valuations do not include benefits that lack a market value [1].
- Hence the economic value makes the Blue Economy the 7th largest economic power in the world by GDP, behind France and the UK, but ahead of Italy and Brazil (cf. Figure 1 [2]):

*Figure 1: Size of the Global Blue Economy*




Source: Hoegh-Guldberg et al. (2015, Ocean Economy)

The structure of this study focuses on the overall context of marine ecosystems with its key drivers and transforming factors of corresponding industries. Thereby, it highlights the interrelation to potential investment fields, scientific findings, new technologies and transitory changes from the fields of global climate, marine mobility, marine infrastructure, marine resources, and marine conservation.

- **GLOBAL CLIMATE:** Some of the most important services provided by the sea are climate regulation, the production of oxygen, as well as natural water purification through the breakdown of nutrients and pollutants. These are the **basic prerequisites for life on this planet**. The production of 50 % of the oxygen, the entire planetary heat exchange and the absorption of 30 % of all GHG are provided by the marine ecosystem.

- However, the combined pressures of climate change, overexploitation, habitat destruction and pollution are leading to dramatic changes and declines in these valuable ecosystem services. Mitigating climate change and adapting to the inevitable changes are critical to maintaining the vital resources and functions of the sea.

- **MARINE MOBILITY:** The economic importance of **global goods shipping** is particularly evident at present. More than 80 % of all goods and raw materials traded worldwide are transported by ship. Value chains and production processes of all countries depend on the efficiency and speed of large container ships. At the same time, the ecological damage caused by fuel and noise is becoming increasingly clear. New technologies such as **artificial intelligence (AI) and blockchain** are being used to make shipping routes more efficient, controllable, and responsible for nature. **New forms of propulsion and fuels** are not only an answer to $CO_2$ pollution, but also a solution to current energy supply issues.

- **MARINE INFRASTRUCTURE: Global energy supply**, together with the fight against global warming, is one of the core issues of worldwide regulatory initiatives and economic plans for the future. Blue energy, that being energy from and with the sea, could form the basis for global energy supply.

- **OSW power** in particular is already playing a special role in the transformation of the energy industry. The consistency and strength of the wind means that more and longer-lasting electricity can be generated, and the potential for expansion is enormous simply because of the area available. New technologies, such as **floating offshore farms** or **wave power**, enable the development of deep sea regions and can simultaneously offer benefits for the protection of marine species.

- A broad range of **marine infrastructure projects**, ranging from energy production to the redevelopment of **port facilities**, offer a wide range of highly interesting investment opportunities, especially for large investors.

- **MARINE RESOURCES:** Probably the area least considered part by investors within the context of marine ecosystems is **marine resources**. While fisheries and aquaculture are of enormous value to the population, they are not typically a major investment theme. However, this could change in the future. The pressing food supply shortages in poorer regions, the increasing demand for fish in industrialized countries and the growing world population **require new solutions** that not only meet the demand but also operate sustainably and do no harm to the natural ecosystem.

- In addition to innovative solutions for optimization and **ecosystem-friendly fishing methods**, many technological innovations focus on the further development of new **aquaculture** techniques.

- A particularly promising field of marine resources lies also in the commercial use of algae, which offer great potential for both cosmetic and medicinal use while simultaneously contributing valuably to the regeneration of the marine environment. The **microbiological benefits of marine substances** show moreover the potential for exponential growth.

- **MARINE CONSERVATION:** Marine conservation, although it does not appear to have any return-oriented investment potential, is an increasingly vital factor in maintaining the marine equilibrium. It contributes substantially to both coastal protection and efficient solutions to climate change. The protection and regeneration of the most important suppliers of these functions, such as the mangroves, algae, seaweed and coral reefs, is therefore of central significance. Measures such as the establishment of marine protected areas (MPAs) are a core element of numerous resulting economic activities as well as the basic prerequisite for human life.

- On the rise are innovative high-tech solutions like **drones** and **alternative proteins as feed**, for efficient and environmentally conscious aquaculture. Particularly for impact investors, this offers special venture capital (VC) opportunities that are both scalable and promising.

- Investors should also pay special attention to developments in **biotechnology**. The genome of marine organisms contains solutions to humanity's most pressing problems – from medicines to treat previously fatal diseases to cosmetics to formulas for environmentally friendly adhesives, paints and even replacements for plastic. Strong scientific efforts as well as research successes of large commercial companies clearly show the growing importance and the opportunities that lie in marine diversity.

- An enormously important driver for transformation of the traditional blue economy industries, however, is the evolving **regulation** and the **shifting priorities of political decision-making** culture, which correspond directly to the preferences of investors across the globe. In light of a focused orientation of national legislation towards the implementation of the global sustainable development goals (SDG) up to concrete guidelines for sustainable investment (EU Taxonomy), the field of strategic investment decisions must be realigned.

- As everything is interconnected – from the economy to ecosystems, industry to biodiversity – not only emerging **conservation initiatives** but also the banking sector, insurers, and investors are increasingly aware that their financial activities have a **major impact** on the health of the oceans.

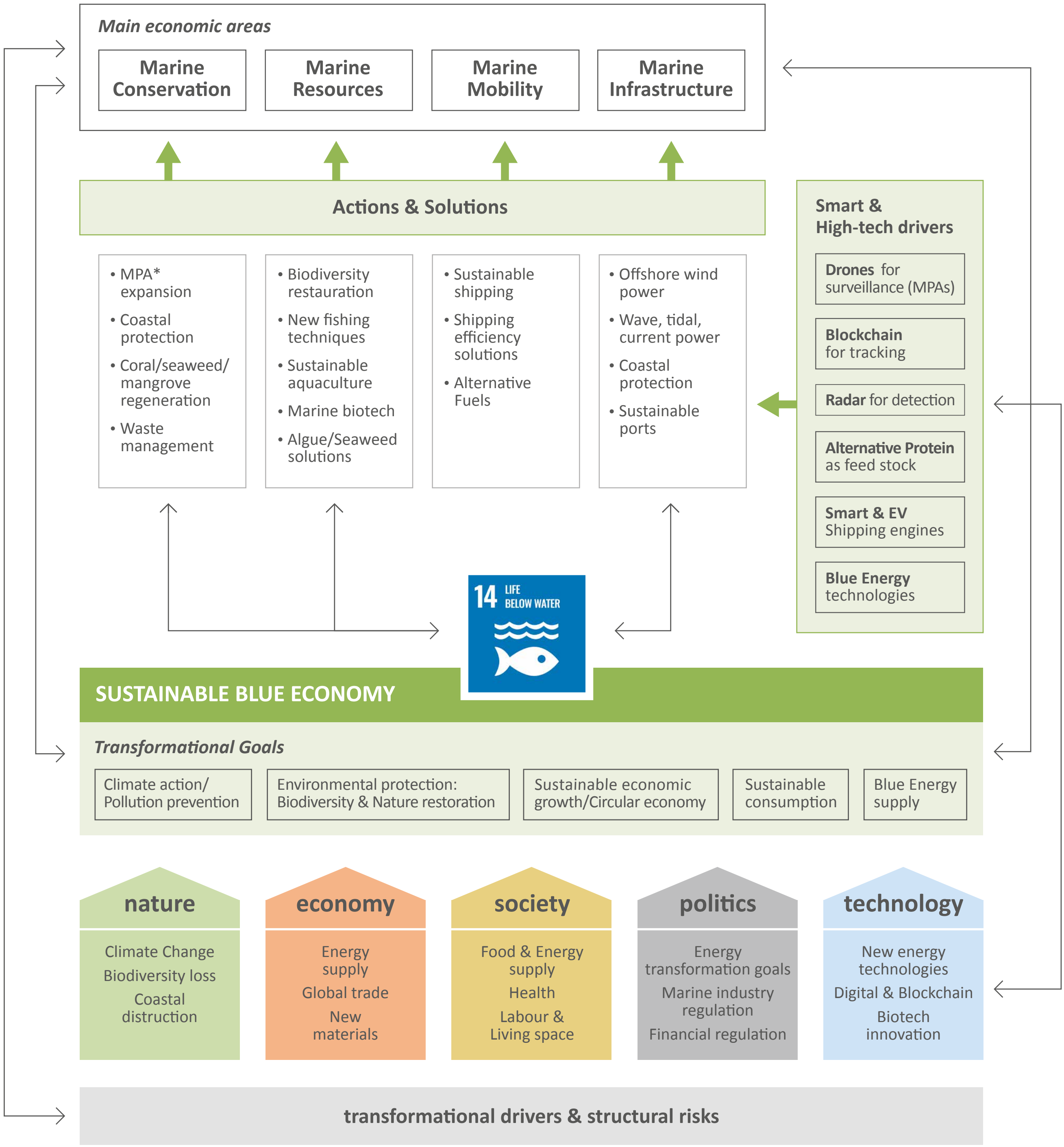
- It is therefore crucial and of great benefit to nature, society, and the global economy that financial flows are directed towards a **Sustainable Blue Economy**.

**The Blue Economy in numbers:**

- More than 50 % of the oxygen breathed by humans is produced by the ocean [4]
- 90 % of heat and 1/3 of anthropogenic greenhouse gas (GHG) emissions are absorbed by the ocean [4)
- 3.2 billion people rely on food from the sea as a source of protein and key nutrients [4]
- Fish accounts for about 15.7 % of the global consumption of animal protein [4]
- Over 350 million people [5] are employed in fishing, aquaculture, seaside and marine tourism
- A square kilometer of healthy coral reef can yield 5–10 tons of fish per year [4]
- Coral reefs provide some level of shelter along over 150,000 km of the world's tropical coastlines, benefiting some 63 million people in over 100 countries [6]
- Over 90 % of the world's traded goods travel by sea; 75 % of the EU's foreign trade is shipped by sea [4]
- OSW could meet 14 % of the demand for electricity in the EU by 2030. [5]

The ***Sustainable Blue Economy*** is defined as an economy that "provides social and economic benefits for current and future generations; restores, protects and maintains diverse, productive and resilient ecosystems; and is based on clean technologies, renewable energy and circular material flows". It is an economy based on circularity, collaboration, resilience, opportunity, and inter-dependence. Its growth is driven by investments that reduce carbon emissions and pollution, enhance energy efficiency, harness the power of natural capital and the benefits that these ecosystems provide, and halt the loss of biodiversity. General economic activity in the context of marine and coastal environments, regardless of sustainability considerations, is referred to as the Blue Economy [3].

## Cognitive Conclusion „Sustainable Blue Economy“




*MPA = Marine protected areas

Source: FERI Cognitive Finance Institute, 2022

# 2 Marine Ecosystems – Significance and Consequences for Society, Environment and Economy

Since the beginning of human existence, a significant part of humanity has lived with and from the ocean. Today, with a world population of nearly 8 billion people, the **consequences** of human activity on oceans are more visible than ever: reefs are dying, coasts are collapsing, and in many places fishermen are hauling in empty nets.

In order to assess the benefits that nature provides to humankind and the harm caused by its degradation, economists and ecologists developed the **concept of ecosystem** services in the 1990s. This concept refers to the functions and processes within an ecosystem that contribute directly or indirectly to human well-being. The **ecosystem services** provided by nature and thus also by the **marine environment** are divided into **four categories** [7].

1. **Provisioning services/Utilities** include the marine functions and processes that form the basis for human communities to provide themselves with products like food and raw materials through labor and technical tools.

   These services also include the spaces and areas used for shipping or renewable energy production. The **benefits or profits** of provisioning services are often **directly measurable and traded** in the market. This means that they usually have a specific market value that can be **precisely quantified**.

2. **Regulating services** refer to the benefits and advantages that humankind derives from the **climate, air and water regulating effect of the ocean**.

   It thus includes services such as **climate regulation** (heat transfer and exchange) by the sea, coastal protection by mangrove forests, dunes, seagrass beds and reefs, the **production of oxygen** by phytoplankton and other marine flora, and **natural water purification** by the breakdown of nutrients and pollutants. Quantifying or monetizing these services is extremely difficult, but the climate and weather regulating effect of the ocean is one of the most important factors for the future of mankind today.

3. **Cultural services** encompass many different functions that **serve human well-being** in a non-material sense. The cultural services may have a special social, religious, or spiritual significance or be part of the traditions of a person. They include benefits such as the aesthetic appeal of a seascape, the recreational function and leisure value of the marine environment, or the inspiration that artists, scientists, architects, and many other social groups draw from the sea.

   The benefits of the cultural services provided by the sea are also **difficult to measure** and hard to monetize. What is available, however, are the turnover figures of the marine tourism industry, whose business model is largely based on the cultural services provided by the sea. According to a study by the European Commission (EC), this sector generates a total gross **value added of EUR 183 billion** with over 3.2 million employees and accounts for more than **1/3 of the maritime economy** [8].

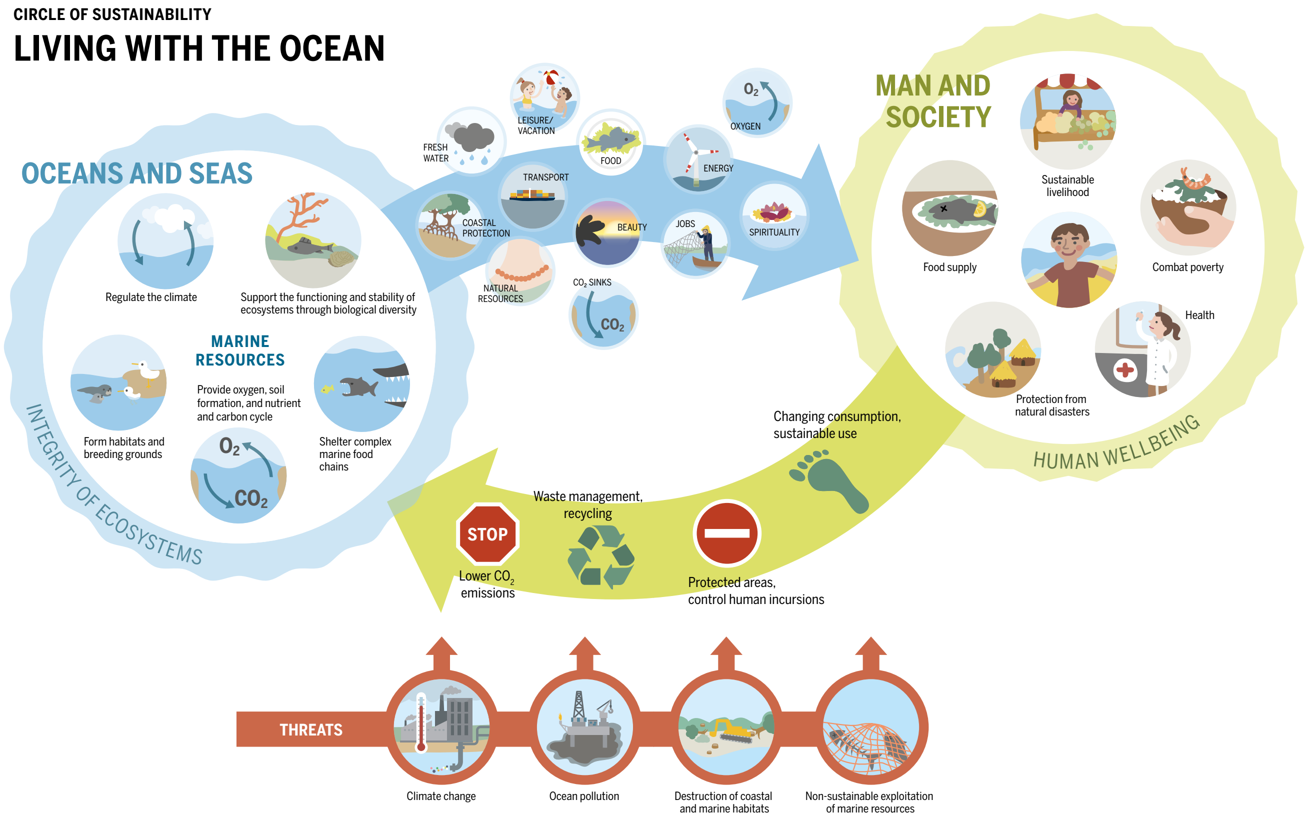
4. **Support services** of the ocean are related to the **basic biological, chemical and physical processes** that occur naturally in the environment and sustainable life on our planet. These include **biomass production** by algae and aquatic plants, nutrient cycles, the contribution of the ocean to the **global water cycle**, and **species and habitat** diversity.

   Humans generally benefit indirectly from all these supporting services, as they form the basis for the cultural, regulating, and provisioning ecosystem services described above.

Many of these marine services must in principle be assigned to more than one category. Coral reefs, for example, with their rich fish stocks, play an important role in food production, falling into the category of provisioning services. Corals also dissipate wave energy and thus protect coasts from erosion and storms, which is a very important regulating services of the marine ecosystem.

To secure the long-term economic and social benefits of the oceans, the concept of **sustainable ocean management** has to be promoted. Economic activities based on circular economy, cooperation, resilience, opportunity, and positive interdependence must be developed. Moreover, an overview of the interdependence, background and relevance of the Sustainable Blue Economy is given in Figure 2 [9].

*Figure 2: Background and Relevance of the Sustainable Blue Economy*




Source: Heinrich-Böll Stiftung (2017, Ocean Atlas)

The following chapter explains the economic interrelationships that determine the influencing factors between global climate, environment, economy, and society.

## 2.1 Global Climate – Relevance of the oceans

The ocean is the biggest influencing factor and **engine of the global climate system**. Through the interactions between air and ocean, it directly affects the weather and climate in our atmosphere.

A changing (atmospheric) climate has a direct impact on the physics and biochemistry of the ocean, its ecosystems and services on which humans depend. These close reciprocal effects are important for both global climate and human-induced climate change.

First, the ocean stores and redistribute large amounts of heat. It **regulates** this way **the seasonal cycles around the world** and ensures a maritime climate with warmer winters and cooler summers, especially in northern Europe. It determines monsoon rain systems and mitigates their variability or coupled ocean-atmosphere phenomena such as El Niño. The global circulation system connects the ocean basins and the upper ocean with the deeper waters, transporting heat from warm to cold regions in the ocean currents.

The ocean is in this regard the decisive pacemaker for decades of droughts, centuries of cold spells, the cycles of ice ages.

- ▶ The GHG effect triggered by human-induced emissions of $CO_2$ and methane means that some of the heat radiated from the Earth's surface cannot escape into space, thus heating up the atmosphere and radiating this back to the Earth's surface and the ocean.
- ▶ **Consequently, the planet and the oceans warm up.**

The ocean influences the release of **heat and moisture** into the atmosphere, it modulates the **wind system**, which in turn drives the **ocean currents**. This is called a coupled ocean-atmosphere-climate system. In addition, higher $CO_2$ levels directly lead to an increase in dissolved $CO_2$ in the upper ocean, an "ocean acidification", which changes ocean chemistry and lowers pH.

The Intergovernmental Panel on Climate Change (IPCC) summarizes and assesses human-induced climate change [10]. A special report from 2019 of the IPCC focused on the ocean and cryosphere, clearly illustrating that climate change has led to an **increase** in the **heat content of the oceans, rising sea levels, heat waves** and **coral bleaching**, as well as the **melting of glaciers** and **ice shelfs** around Greenland and Antarctica. Other measurable impacts are growing oxygen minimum zones and the risk that global ocean circulation will slow down in the future. [11]

- More than 90 % of planetary heat is absorbed by the oceans. Without the absorption of heat by the ocean, the warming of the atmosphere would be much more dramatic today. About 2/3 of the excess heat is being absorbed by the upper 700 meters of the ocean alone.
- The ocean currently absorbs 1/3 of global $CO_2$ emissions. If the $CO_2$ concentration in the atmosphere continues to rise, the $CO_2$ gradient between the atmosphere and the ocean will increase, leading to increased $CO_2$ uptake by the ocean.

The exchange process is moderated by the absolute temperature of the ocean. The colder the seawater is, the more $CO_2$ can be dissolved in the ocean. An **increased water temperature thus reduces the $CO_2$ uptake potential**. A significant part of the absorption of $CO_2$-rich surface water is made possible by the oceanic overturning circulation. However, this is expected to decrease.

Consequently, the ocean may not be able to absorb its current share of anthropogenic $CO_2$ emissions in the future, which would increase the impact of climate change per ton of $CO_2$ emitted.

The "global" ocean consists of the interconnected systems of the Arctic, Atlantic, Indian, Pacific and Southern Oceans, all of which are interconnected. The exchange and circulation between the ocean and the atmosphere are crucial for the distribution of heat, freshwater, nutrients, oxygen, carbon dioxide and dissolved chemical components on the planet. The large-scale circulation of the ocean consists of the interaction of the predominantly wind-driven upper-ocean circulation of the various gyres. The vertical exchange between the surface and deeper layers is more complex.

An important scientific finding is the global ***meridional overturning circulation (MOC)*** connecting the sinking regions of the higher latitudes with the upwelling regimes around the globe. This interaction leads to a complex three-dimensional circulation throughout the global ocean.

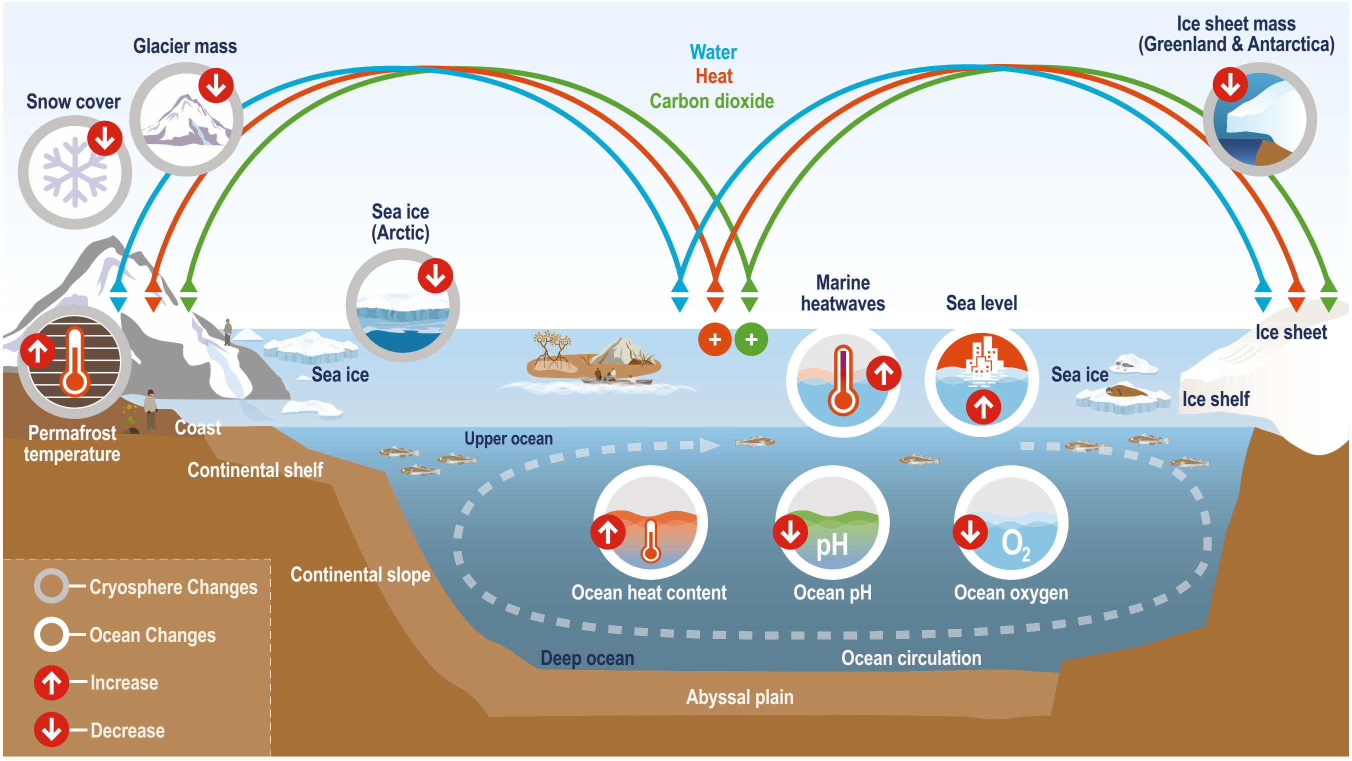
For example, in the Atlantic the upper limbs of the MOC brings warm tropical water poleward and contributes to the Gulf Stream and heating of Western Europe, particularly the Nordic Countries and Seas.

**Global climate change can affect this circulation in two ways.**

1. First, melting of glacial ice due to global warming leads to water with low salinity, which, together with warmer temperatures, increases ocean stratification and reduces the formation of deep water.
2. Secondly, a warmer upper ocean overall makes it more difficult for cold water to mix and rise to the surface from below.

Therefore, experts expect the MOC to slow down over the next few decades. However, the extent of these changes is not yet fully known, and more research and understanding are needed on a global scale.

*Figure 3: Key Components and Changes of the Ocean and Cryosphere*




Source: adapted from Figure TS.2 from IPCC (2019, Ocean and Cryosphere)

Not only the circulation between the different oceans, but especially the **circulation between different water layers and depths** is essential, as it determines the speed at which the deep ocean interacts with the atmosphere.

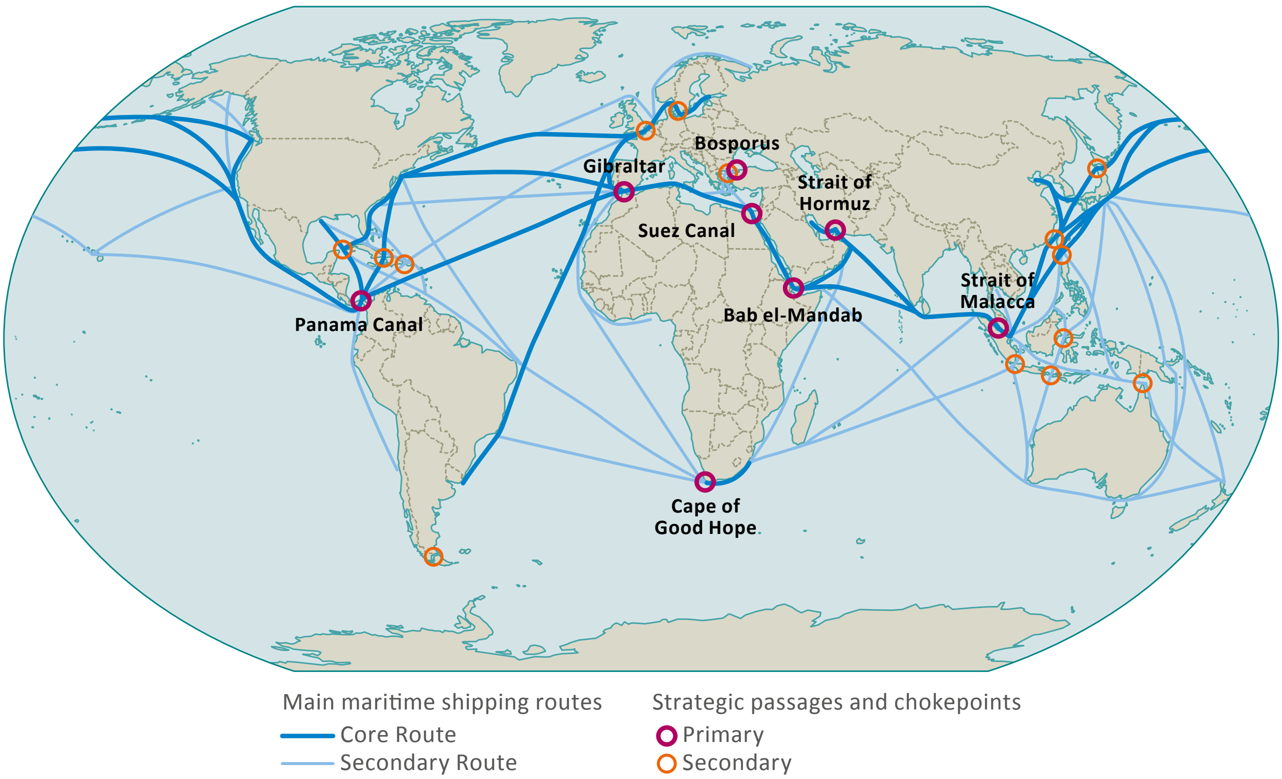
*Note (Figure 3):* Schematic illustration of key components and changes of the ocean and cryosphere, and their linkages in the Earth system through the global exchange of heat, water, and carbon. Climate change-related effects (increase/decrease indicated by arrows in pictograms) in the ocean include sea level rise, increasing ocean heat content and marine heat waves, increasing ocean oxygen loss and ocean acidification (cf. Figure 3 [11]).

## *2.2 Marine Mobility – The global economic driver*

More than **80 % of all goods and raw materials traded worldwide are transported** to their destination **by ship**. Shipping is particularly important for developing countries where mobility by land or air is not possible. In these regions, ships are often the only way to transport large quantities of goods from place to place via rivers, lakes, and coastal waters.

However, especially in the current situation of geopolitical upheaval, as well as the drastic effects of the COVID19 pandemic, have shown that the **economic power of the industrialized countries is also enormously dependent on global shipping**. Figure 4 shows the maritime shipping routes worldwide [14].

*Figure 4: Global Maritime Shipping Routes*




Source: Scheid, for maribus gGmbH (2021, World Ocean Review)

The rationale for maritime transport and mobility is always the same: ships transport goods and products from a region where they can be produced relatively cheaply to places where they can be sold at a much higher price.

Marine Mobility can be divided into three different resp. four categories.

1. The first category includes all **containerized goods** traded worldwide as well as non-liquid general cargo, motor vehicles and livestock.

2. The second category includes the **transport of liquids** such as crude oil, natural gas and petroleum products in tankers.

3. The third category includes **bulk goods**, especially iron ore, grain and coal, which are transported in bulk carriers.

4. **Cruise ships** are a fast-growing rather new industry of marine mobility. However, this industry is under particular public scrutiny and may need to deliver solutions more quickly, especially to the major environmental problems facing the shipping industry. They might therefore play a pioneering role in the Sustainable Blue Economy.

The economic importance of shipping is enormous. At the same time, the capacity of maritime trade is growing due to ever larger and more numerous ships.

According to the United Nations Conference on Trade and Development (UNCTAD) experts, there were around 100,000 ships in operation worldwide at the beginning of 2020. Their total cargo volume was about 2 billion tons.

Bulk carriers, which continue to be the largest business segment, accounted for 43 % and oil tankers with a freight volume share of 29 % made up the second largest division. The available freight volume has more than doubled within the two decades since 2000, when the freight volume was near 800 million tons.

However, the volume of goods transported has not increased to the same extent. This has led to an oversupply of overall capacity, causing freight prices to fall and shipping companies' profits to shrink, especially in the container sector.

Shipping industry: The consolidation of the industry has led to a situation where today only three major groups worldwide control more than 80 % of the global container business. 734 ships are owned by the Danish company APM-Maersk, making it the largest container shipping company in the world by total number of ships (as of February 9, 2022). The shipping companies Mediterranean Shg Co and CMA CGM Group follow in 2nd and 3rd place, respectively [15].

Shipping companies today, however, are no longer limited to transporting goods from one port to another. To fill the large container ships profitably, companies are trying to take control of the **entire transport chain**. As a result, shipping companies have developed into **multitask logistics companies**. They organize ship-based transport, operate the container port terminals and often manage the onward transport of containers inland and run container depots.

This development is particularly difficult for countries and regions that are not located on the major trade routes. Their less advanced trade infrastructures imply that they have to pay higher freight costs than countries located on the established routes.

The most efficient way to transport goods and commodities internationally is still by sea. At the same time, however, motorized shipping has caused more and more **environmental problems** in the form of significantly **higher GHG emissions over the past 10 years**. It is well known that maritime vessels use either heavy fuel oil (75 %) or marine diesel (23 %) as fuel. Other fuels such as liquified natural gas (LNG) account for less than 1 % of the sector.

- The transformation towards a low-emission or even **zero-emission shipping** industry requires a radical change within the industry. **Alternative forms of engines** must be developed, as well as **new fuels** that emit little or no GHG when burnt.
- While battery-powered electric motors would also be a viable option for short distances or inland waters, for maritime shipping, which accounts for 85 % of GHG emissions in shipping, there is still no known system-wide solution that is expected to halve emissions by 2050.

Environmental concerns hardly played a role in the past and at the same time competition is extremely tough. However, it has become clear to many stakeholders and also investors that the sector urgently needs to **reduce its carbon footprint**. This requires **new propulsion systems, strict and globally applicable environmental standards**, and a significant financial **effort to modernize an aging fleet**.

## 2.3 Marine Infrastructure – The future of global energy transition

The ocean plays an essential role in the global transition of energy production. The expansion of OSW energy and developing innovative concepts for storing $CO_2$ under the seabed are pivotal components of current political strategies, both in Europe and especially in China. These technologies represent an important component of the global energy transition and are viable alternatives to fossil fuels.

A wide variety of technologies are currently being tested for their ability to generate renewable energy from the sea. In addition to **OSW**, energy sources also include energy generated from **waves** and **tides**. So-called "blue energy" can also be obtained from **salinity** and the use of **temperature gradients** (e.g., through ocean thermal energy conversion [OTEC] or heat pumps).

At the same time, **floating photovoltaic** (PV) solar systems are also being tested.

There is also the potential to unlock the benefits of **co-location with other offshore industries**. For example, marine energy could meet the growing demand for energy-intensive desalinated seawater or serve marine aquaculture facilities. Almost all thermal power plants rely on large quantities of fresh water for cooling.

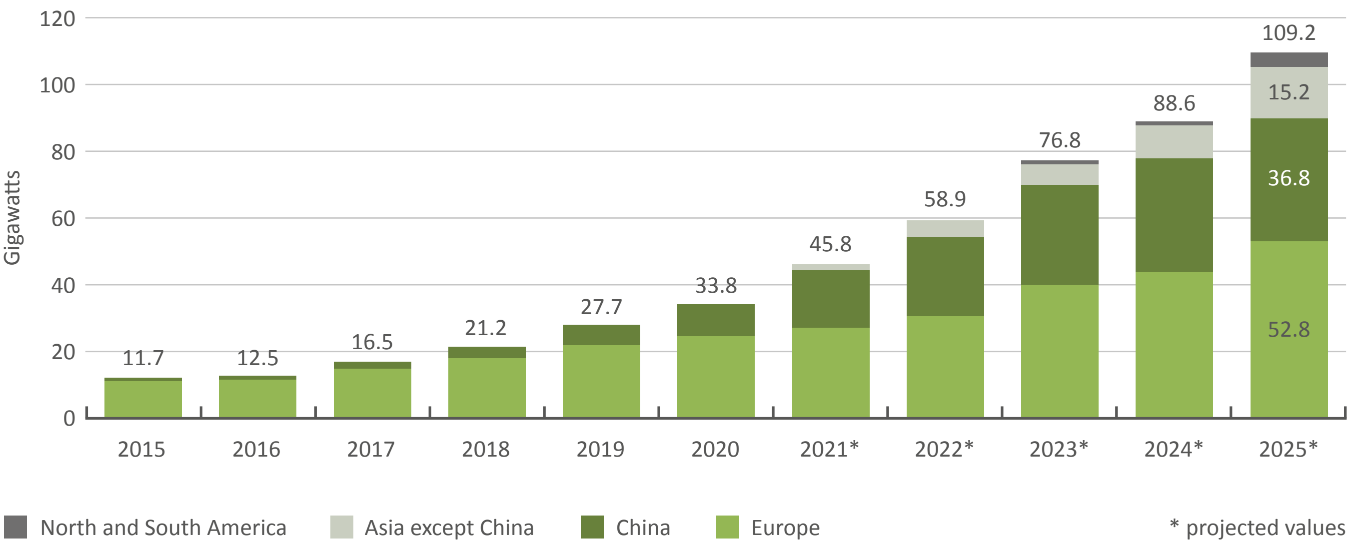
Furthermore, recent studies such as Grubler et al. (2018) show that extensive use of renewables in combination with energy efficiency measures could achieve global lower energy demand scenarios without loss of wealth and well-being [17].

**Therefore, marine renewables in particular have an important role to play in achieving global climate goals and successfully implementing sustainable development.**

The High Level Panel for a Sustainable Ocean Economy addresses two marine renewable energy technologies – OSW power generation and other forms of offshore renewable energy (ORE), such as wave and tidal power. Estimates of the potential for electrical energy generated by **OSW** in 2050 range from **650 to 3,500 TWh/year**. The potential of **ORE** technologies alone in 2050 could be in the range of **110 to 1,900 TWh/year** [18].

Worldwide coastal states are investing massively in the expansion of OSW energy. If all the projects presently planned are carried out, OSW parks with a total capacity of around 110 gigawatts will be connected to the electric grids by 2025 (cf. Figure 5 [19]).

*Figure 5: Installed Offshore Wind Power (OSW) Capacity*




Source: World Ocean Review (2021, Energiequelle Meer)

OSW could play a special role in the transformation of the energy industry for:

1. **Wind consistency and strength:** Compared to wind turbines on land, offshore turbines have the great advantage that the wind at sea is usually stronger and blows more frequently. This means that more and longer-lasting electricity can be generated.

2. **Public opinion:** the resistance of the population to wind farms at sea is usually significantly lower than to turbines on land. Construction projects therefore have a greater chance of being approved.

3. **Expansion potential:** the potential expansion of OSW energy is huge compared to other renewable energy sources simply because of the available area.

4. **Energy supply worldwide:** OSW farms can also be built near smaller islands (little land area, import of fossil fuels) or in remote coastal regions (poor supply of fossil fuels) and thus contribute significantly to supplying areas that have so far been underserved in terms of energy technology with sufficient cheap, clean electricity – one of the 17 SDG formulated by the UN.

## 2.4 Marine Resources – Food, chemistry, and blue biotech

For a long time, the oceans have been considered an **inexhaustible store of food and natural resources**. But the times of abundance are long gone. Due to **overfishing, coastal development** and **climate change**, humans have already deprived many marine creatures of their livelihoods.

According to the Food and Agriculture Organization of the United Nations (FAO), 34.2 % of all scientifically monitored fish stocks were already overfished in 2017. 6.2 % were underfished and 59.6 % were fished at the maximum sustainable level.

In order to sustainably conserve marine resources for food security, marine food production must meet national and local needs and be adapted to the changing climate. These are also necessary measures to create sustainable economic growth and jobs.

### 2.4.1 Marine Resources: Fish

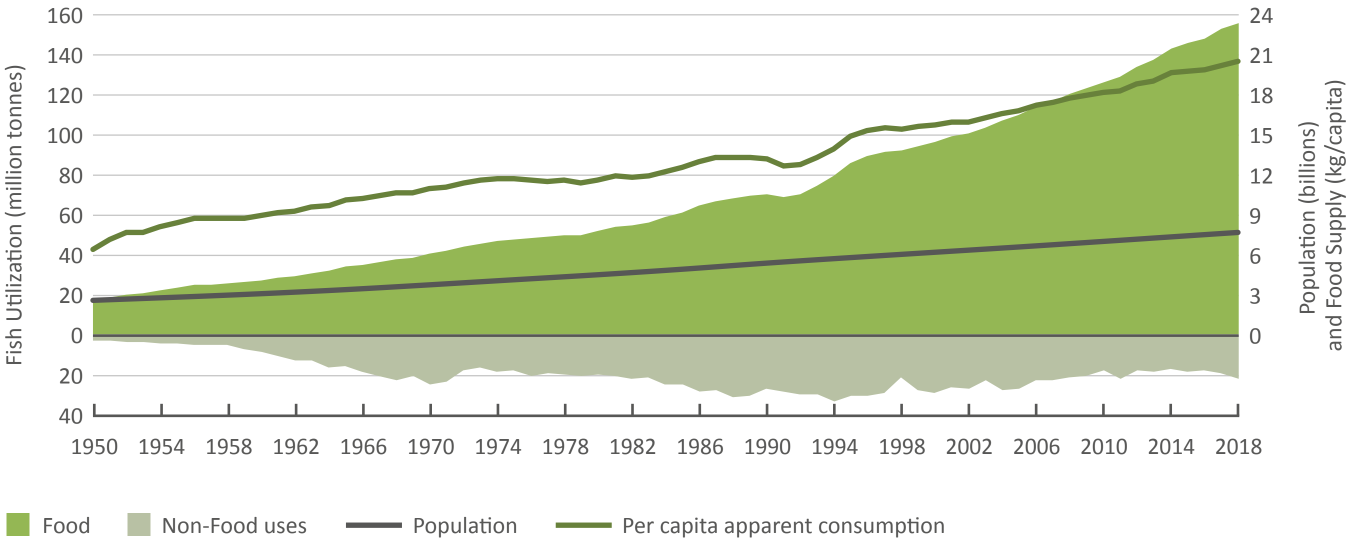
Worldwide, **fish and seafood account for 17 % of the total amount of animal protein** consumed by humans. A detailed study of who eats fishery products indicates that more than **3.3 billion people obtain at least 1/5 of their animal protein requirements** through aquatic foods [20].

The increasing worldwide fish consumption can be attributed to more fish and seafood are being produced, improvements in freezing and delivery chains have contributed to the more frequent appearance of fish on the plates of people in industrial countries, but also in developing countries where urbanization is advancing.

According to the FAO global fish and seafood production was estimated to have reached about 179 million tons in 2018 with a total first sale value estimated at **USD 401 billion**, of which 82 million tons, valued at **USD 250 billion** came **from aquaculture production**.

Marine fisheries still make up the largest proportion of wild catches today. In **2018**, they accounted for around **84.4 million tons**. This is equal to a share of 88 % [20].

*Figure 6: World Fish Utilization and Apparent Consumption*




Note: Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants.

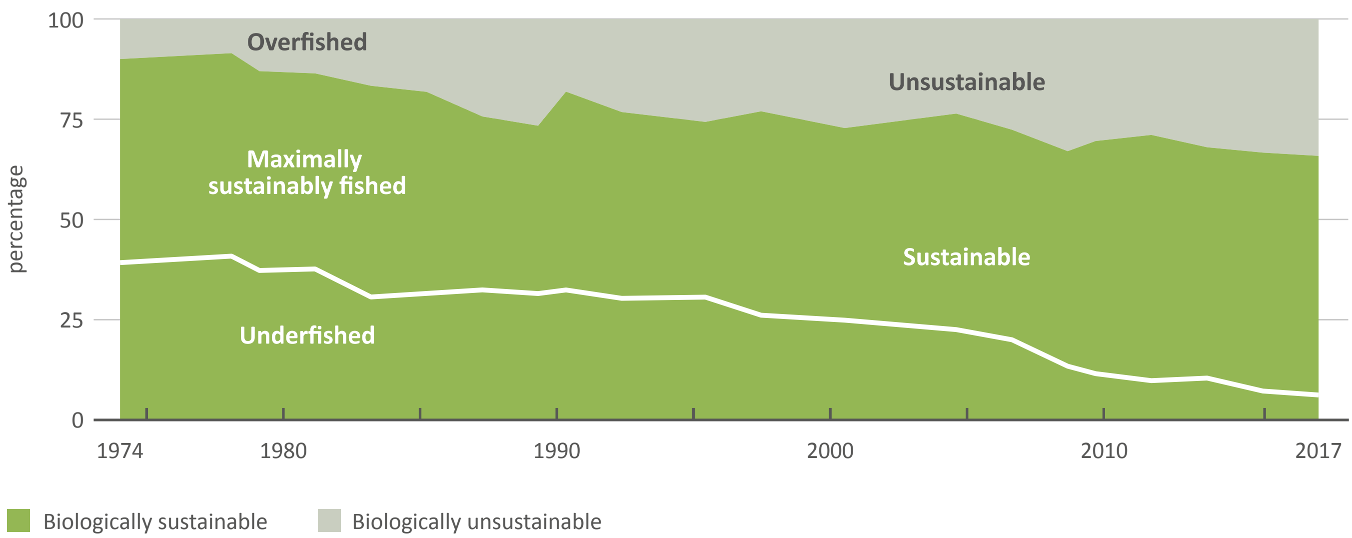
Source: FAO (2020, World Fisheries and Aquaculture)

The extent of the massively increased demand for fish is vividly illustrated in Figure 6 [20]. Fish consumption today already exceeds the world's population many times. A reduction in demand does not seem to be in sight. The exact impact on the marine ecosystem can only be guessed at.

Unfortunately, there is not yet sufficient scientific data to predict the exact tipping points of marine ecosystem exploitation. It is not known how large stocks originally were or how much they have already been depleted by fishing, which is why there are still no sufficient global management or protection concepts for all food fish species. Nevertheless, it is precisely the **unmonitored species** that are fished on such a large scale that catches account for about **half of all global marine fish landings**.

But even if these data sets were available, it is difficult to determine the productivity of a fish population and the maximum number of fish that can be taken under existing environmental conditions without harming the stocks in the long term.

## *Figure 7: Global Trends in the State of the World's Marine Fish Stocks*




Source: FAO (2020, World Fisheries and Aquaculture)

Marine conservationists and many scientists are calling for a move away from the traditional strategy of fishery management by species and instead maximizing sustainable fishing yield. By fishing to the limits, humans also leave no room for species to respond to changing environmental conditions. However, the number of overfished stocks continues to rise because **fishing quotas are too high** and **illegal fishing** is widespread (cf. Figure 7 [20]). The problems of the current fishing conduct are becoming increasingly apparent today.

- Only **stricter regulations** and, above all, new **control technologies** will make it possible to limit or reverse the trend of overfishing. But above all, **political will** is indispensable to ensure that global fish stocks can recover.
- This transition must include **greater transparency** in **global ocean governance** and **supply chains**, and the elimination of inefficiencies and disincentives that undermine the sustainability of food sourced from the ocean.

Essentially, it can be concluded that global fish consumption and demand can no longer be covered by wild catches and that some marine resources have already been exhausted. **Aquaculture** is therefore of particular importance and can be a **long-term solution** if it operates in an environmentally sound and sustainable manner. Chapter 3.2.1 explains which technologies and methods can be promising, scalable and sustainable, and which pitfalls may arise.

### 2.4.2 Marine Resources: Algae and seaweed

In the area of marine resources, much attention and hope are currently focused on the cultivation of **macroalgae**, the **fastest growing sector** of aquaculture. Algae are considered the so-called "superfood of the future". They grow much faster than land plants, do not compete with the limited agricultural land and are rich in nutrients – meaning that they can be a real alternative in terms of security of supply, especially in terms of food security for a growing population.

Even today, the potential of algae for applications in the food sector is huge. They offer solutions for current and future challenges in the food industry. With the plant-based, sustainably cultivated raw material "algae", for example, the salt content and calorie content in food can be reduced, they can be used as natural colorants and vegan food can be produced or enriched with vitamin B12, for example. This meets some megatrends in the food industry.

New research results and product innovations are creating new potential for the sustainable development of new products and product groups. Certain algae are already used as a thermally stable gelling and **thickening agent**, which is used in both the **food and cosmetics industries**.

Today, **China and Indonesia** are the leading producers of macroalgae and seaweed, with more than **85 % of global production**. The global harvest has almost **tripled in the last 20 years**. Seaweed farming is thus the fastest growing sector of aquaculture.

In 2000, **10.6 million tons** of macroalgae and seaweed were harvested. In the reporting year 2018, seaweed farmers mainly based in East and Southeast Asia already produced 32.4 million tons.

The Japanese brown alga Laminaria japonica or the seaweed Wakame (Undaria pinnatifida), are sold directly as **food** and are often used in Asian cuisine, such as an ingredient in soups.

### 2.4.3 Marine resources: Blue Biotech

Since the first successes of marine biodiscovery research, scientists have hoped to find solutions to humanity's most pressing problems in the genome of marine organisms – from **medicines** to treat previously fatal diseases to **cosmetics** for eternally young skin to formulas for environmentally friendly **adhesives** and **paints**.

Marine life is sometimes exposed to extreme environmental conditions and has found remarkable ways to adapt. The information underlying their species-specific survival strategies is encoded in the genetic material of marine organisms. It contains the blueprints for the **secondary metabolites** that marine fauna, flora, fungi, bacteria, archaea, and viruses produce for a **variety of purposes** – and which often have a **major impact** even in small concentrations.

Marine organisms try to extract bioactive molecules and substances, describe the chemical structure and understand their functions. The aim of research is to **identify marine natural products** or active substances that could be **used for commercial applications**. This is done using modern **DNA sequencing, replication and chemical analysis** techniques that allow the sample material to be analyzed quickly and comprehensively and all the genetic information it contains to be stored digitally.

These new technological possibilities have triggered something of a "**gold rush fever**" in the related fields of marine natural product chemistry and **marine biotechnology**. Today, experts assume that every single marine organism contains genetic information that could be commercially exploited in some form in the future.

Natural marine products and substances are already active ingredients in **numerous approved medicines** and are used in food supplements and fertilizers. They are raw materials to produce cosmetics and various other industrial applications.

However, the immense potential raises several fundamental questions that need to be addressed soon. These are:

- Who should benefit from marine genetic resources?
- How can these potential active ingredients and any profits from their commercial use benefit humanity as a whole?
- How can marine biodiversity be effectively protected in the face of increasing commercial interest?

The Nagoya Protocol, a treaty under international law, proposes solutions for access to and sustainable use of marine genetic resources under national jurisdiction. Yet, these regulations are still proving difficult to implement for research and commercial use.

- The oceans hold numerous and untapped opportunities for providing medicines, animal feed, fuel, new materials, and carbon storage solutions. Innovation and investments are needed to expand these opportunities based on science and environmentally sound practices.

## *2.5 Marine Conservation – Nature preservation for securing coastal life*

The conservation of the seas is linked to the question of who is responsible, who can make decisions and, more generally, **who owns the seas**? People have been asking themselves this question ever since they started competing for fishing rights or shipping routes. Since many years large multinational organizations are engaged in developing binding frameworks and clear guidelines for the protection as well as the use of the oceans.

However, with the rapidly increasing economic use of marine resources and the growth of world trade, the conservation of marine areas is becoming more urgent but also more difficult, as national and commercial interests diametrically oppose environmental protection. The following chapter describes the major frameworks and their objectives. These are crucial for the possibility of establishing MPAs at all on an internationally coordinated level. At the same time, it will be explained what economic benefits and important climate contribution MPAs make.

The UN already established a legally binding response almost four decades ago with the **Convention on the Law of the Sea**.

The Convention obliges all littoral states to cooperate on issues like the protection of the marine environment, fisheries, scientific research, and relations with other states and international organizations. It regulates who is responsible for certain activities in the different marine zones and obliges all actors to protect the marine environment.

The term "**integrated coastal zone management**" denotes a **regulatory and governance approach** in which coastal areas are recognized as a complex, dynamic system involving multiple interactions between human communities and marine and coastal ecosystems across zonal and sectoral boundaries.

This means that coastal issues can no longer be dealt with the traditional or single nations sectors alone. However, **areas of responsibility overlap far too often**. Stakeholders from the fisheries, tourism, energy, shipping, resource extraction, and environment sectors compete or have **conflicting interests**. Most of the resulting measures are almost always detrimental to the marine environment.

Therefore, **integrated marine management** aims to provide guidelines for the sustainable use of the sea and its resources in all development areas and sectors.

Currently, this approach is only applied in regional action plans, such as in the European Union (EU), where the EC has developed an integrated maritime policy (EU Marine Strategy Framework Directive (MSFD)) that includes five important and converging policy areas [21]:

1. the Blue Economy,
2. marine data and knowledge,
3. maritime spatial planning,
4. integrated maritime surveillance and
5. sea basin strategies.

However, regional marine conventions are by no means a prerequisite for successful integrated coastal zone management.

Integrated ocean management is also quickly **reaching its limits** due to the division of the sea into different zones and multiple responsibilities. One reason for this is the **ever-increasing number of stakeholders** and authorities involved.

At the local level, this system may still be relatively manageable, but with each successive level (regional, national, superregional, international), decision-making becomes increasingly complex, cumbersome, and inefficient. Another obstacle is the **lack of information** exchange between the numerous sectors and institutions involved and the general lack of awareness of how measures or changes in one sector affect all others.

At the Earth Summit in Rio in 1992, the 196 Parties to the UN Convention on Biological Diversity (CBD) developed an ambitious new plan to protect life on Earth by 2050. The Convention serves to promote sustainable development and could be a helpful basis for discussion in the context of current global efforts to conserve natural biodiversity.

The Convention has three main objectives:

1. The conservation of biological diversity
2. The sustainable use of the components of biological diversity
3. The fair and equitable sharing of the benefits arising out of the utilization of genetic resources

The plan aims to create a "biodiversity framework" for conservation and restoration that integrates many of the goals of the **SDG** and the **Paris Climate Agreement** and defines new milestones and targets for conservation by 2030 and beyond.

In 2016, at the International Union for Conservation of Nature's World (IUCN) congress members from 170 countries adopted *Resolution 50* to declare 30 % of oceans as MPAs by 2030 to ensure the long-term biodiversity and health of our planet.

These measures effectively also help to **remove carbon dioxide** from the atmosphere and thus **limit global warming** (mangroves, for example, can store up to four times more carbon per square meters than tropical rainforests). Natural ocean-based measures to increase natural carbon storage are known as ***blue carbon***. Protected coasts provide additional benefits by creating habitats for rich and **resilient biodiversity**. Intact coastal ecosystems filter pollutants and suspended sediments from the water and provide organisms with shelter, food, and corridors for potential species migration. The benefits are **less stressed species** that have a higher **chance of adapting to climate change**.

Moreover, the reinforcement of natural **coastal protection** (coral reefs, mussel beds, seagrass meadows, kelp forests and mangrove forests) help to **absorb the force of waves**, thus mitigating **flooding** and minimizing the **destruction** and **degradation** of inland coastal areas. After a storm, the mangroves, mussel beds, etc. **repair the damage themselves** and, unlike dikes and protective walls, they grow naturally with rising sea level.

Just 4,000 square meters of seagrass meadow already provide habitat and food for around 40,000 fish and 50 million invertebrates such as lobsters and shrimps.

**MPAs** and **nature-based solutions** can mitigate the extent of local ocean acidification. **Seagrass beds reduce ocean acidification by up to 30 %** by absorbing $CO_2$. Food security for **coastal communities** is ensured at the same time. Healthy coastal ecosystems provide habitat and nursery for many marine organisms and seabirds.

Thanks to favorable habitat conditions and sustainable management, populations of marine life can successfully develop and increase **fishermen's yields**. At the same time, these areas often provide new livelihoods for people. The beauty and biodiversity of healthy coastal ecosystems attract **tourists** and can enable local communities to develop **new sources of income**.

Unfortunately, the ocean today has also become a **sink for pollutants** such as plastics, chemicals, nutrients, and sewage. Global awareness and action have increased but are not sufficient to prevent an increase in marine pollution. The **COVID19 pandemic** alone has led to an increase in the production and consumption of protective gear, much of which contains **single-use plastics** that very often find its way into the ocean.

The fight against marine pollution from land-based sources must also be stepped up as the economy recovers from the pandemic. Urgent action is needed to address the sources and management of pollution. At the UN Environment Assembly, governments agreed on a long-term vision of stopping the discharge of marine litter and microplastics into the oceans.

▶ The 2021 report of the **G20 Osaka Blue Ocean Vision** [22] as well as the **G7 Ocean Plastics Charter** [23] clearly describe and acknowledge the importance of adopting **a lifecycle and circular economy approach** to address plastic pollution of the oceans.

In addition, the **unclarified influx of fertilizers** contributes to the deoxygenation of the ocean but is less considered and addressed. The **interdependence between the land and the sea** needs to be understood in order to address the systemic sources of marine pollution.

In summary, marine, and coastal ecosystems not only **sequester and store vast amounts of** $CO_2$ but also **protect coasts and communities** from climate impacts. They provide **food, economic, medicinal, and recreation** opportunities, habitat, and a range of ecosystem functions to support human well-being. An integrated approach that is **climate-smart and focuses on nature-based solutions**, integrating well-managed MPAs and other effective area-based conservation measures, alongside sustainable infrastructure development will be vital to protect coastal communities and marine habitats.

- By marine conservation, coastal protection and implementation of nature-based solutions, marine resource production can be increased, pharmaceutical and at the same time climate change mitigation and adaptation can be improved and biodiversity can be supported.

# 3 Ocean Technologies – Economic driver and environmental solutions

As outlined in the OECD-Report: The Ocean Economy in 2030 [24], established ocean activities encompass shipping, shipbuilding and marine equipment, capture fisheries and fish processing, maritime and coastal tourism, conventional offshore oil and gas exploration and production, dredging, and port facilities and handling. There are strong signs that the pace of **digital innovation** is set to accelerate in the ocean economy. [26]

Additional **emerging ocean-based industries** and activities are characterized by the key role played by **cutting-edge science and technology** in their operations. They include OSW, tidal and wave energy; offshore extraction of oil and gas in deep-sea; seabed mining for metals and minerals; marine aquaculture; marine biotechnology; ocean monitoring, control, and surveillance.

Although the industry is striving to make **resource exploration** safer and more sustainable, this is certainly one of the **controversial issues of the Blue Economy**. The impact and potential damage of deep-sea mining and offshore oil and gas extraction on the ecosystem has unfortunately already become clear in the past.

The update provided by the OECD-Report **Rethinking Innovation for a Sustainable Ocean Economy** [25] suggests that there has been a further acceleration of interest in the potential applications of a range of technologies, both for commercial purposes and for gaining a better understanding of marine ecosystems.

- It notes an increasingly pervasive spread, throughout the ocean domain, of such generic technologies as **AI, big data, complex digital platforms, blockchain, drones, sophisticated arrays of sensors**, small satellites, genetics, and acoustics. Examples of these technologies include the use of AI and Blockchain technology in monitoring and increasing the efficiency of ship routes, monitoring wind and wave strengths, tracking schools of fish or even lost nets. Drones are used in coastal protection and surveillance of protected areas.
- Many of these are expected to make an important contribution to the sustainable development of the marine economy, not least by significantly improving data quality, volume, connectivity, and communication from the ocean depths to the surface for further transmission.
- In the longer term, the widespread deployment of **digital technologies** has the potential to transform the performance, efficiency, and location of many marine activities, create new activities and contribute significantly to the sustainability of the oceans.

## 3.1 Climate Solutions – Algae, mangroves, seagrass – active $CO_2$ reduction

One of the central findings of today's research is that oceans play an essential role in the global carbon cycle. [27]. The ocean's vegetated habitats, in particular mangroves, salt marshes and seagrasses, cover less than 0.5 % of the seabed. These form earth's blue carbon sinks and account for a large proportion, perhaps as much as 70%, of total carbon storage in ocean sediments.

**Blue carbon** refers to carbon stored and sequestered in marine environments and includes the carbon fixed in coastal blue carbon (mangroves, seagrasses, macroalgae like seaweed or kelp, and salt marshes) and oceanic blue carbon (phytoplankton, marine animals, and other open ocean biota).

Coastal blue carbon ecosystems capture and store carbon through primary photosynthesis (storing carbon in soil and above ground biomass), capturing carbon in runoff from the land and 'exporting' carbon to deep sea sediments.

The **blue carbon storage capacity** of coastal blue carbon ecosystems is **exceptional** compared with the open ocean or terrestrial forests. Field-based projects are critical to developing blue carbon as an approach to conserve, restore and manage coastal ecosystems. According to **Catherine Lovelock and Carlos Duarte**, Blue Carbon ecosystems meet a range of criteria as shown in the table 1 below [28].

## *Table 1: Criteria of Coastal Ecosystems as Blue Carbon Sink*

| | criteria for inclusion as actionable Blue Carbon ecosystems | | | | | |
|---|---|---|---|---|---|---|
| | scale of GHG removals or emissions are significant | long-term storage of fixed $CO_2$ | undesirable anthropogenic impacts on the ecosystem | management is practical/possible to maintain/ enhance C stocks and reduce GHG emissions | interventions have no social or environmental harm | alignment with other policies: mitigation and adaptation |
| mangrove | yes | yes | yes | yes | ? | yes |
| tidal marsh | yes | yes | yes | yes | ? | yes |
| seagrass | yes | yes | yes | yes | yes | yes |
| macroalgae | yes | ? | yes | yes | ? | yes |
| phytoplankton | yes | ? | ? | ? | ? | no |

*Note*: Question marks indicate where additional review of the science or policy is needed. Green shading indicates strong evidence for meeting the criteria, yellow indicates some evidence or inference, grey indicates that the criteria are not met.

Source: Lovelock, Duarte (2019, Dimensions of Blue Carbon)

> Aquacultures with seaweed could thus significantly contribute to carbon emission reduction and be used to promote food and products at the same time.

Seaweed farming can also contribute to climate change adaptation, for example by locally **buffering ocean acidification and oxygen depletion**, while also helping to mitigate GHG emissions by sequestering carbon and/or reducing emissions as an Emission capture and utilization (ECU) technology.

The climate mitigation benefits of seaweed aquaculture as an ECU technology can be expanded much further after harvest. Seaweed feed additives reducing ruminant methane emissions would contribute directly to emission reduction, and so would seaweed biofuel substitutes and seaweed plastic substitutes for fossil carbon sources.

**Seaweed aquaculture** accounts for **51.3 % of global mariculture production** and grows at 6.2 % per year (2000–2018) [29].

Business Case: European Seaweed Sector

According to different reports [30, 31] the GHG mitigation potential from the European seaweed sector could exceed 5.4 million $CO_2$e tons in 2030 (based on direct sequestration and emissions displaced by end-use products), equivalent to offsetting carbon emissions from 773,000 Europeans.

As a result, the industry could also boost local economies and provide new employment opportunities.

The seaweed sector could create up to 85,000 jobs on a full-time employee (FTE) equivalent basis in Europe by 2030. Ultimately, this represents a unique opportunity for coastal communities, where jobs in hatcheries, cultivation, harvesting and some processing will likely be concentrated.

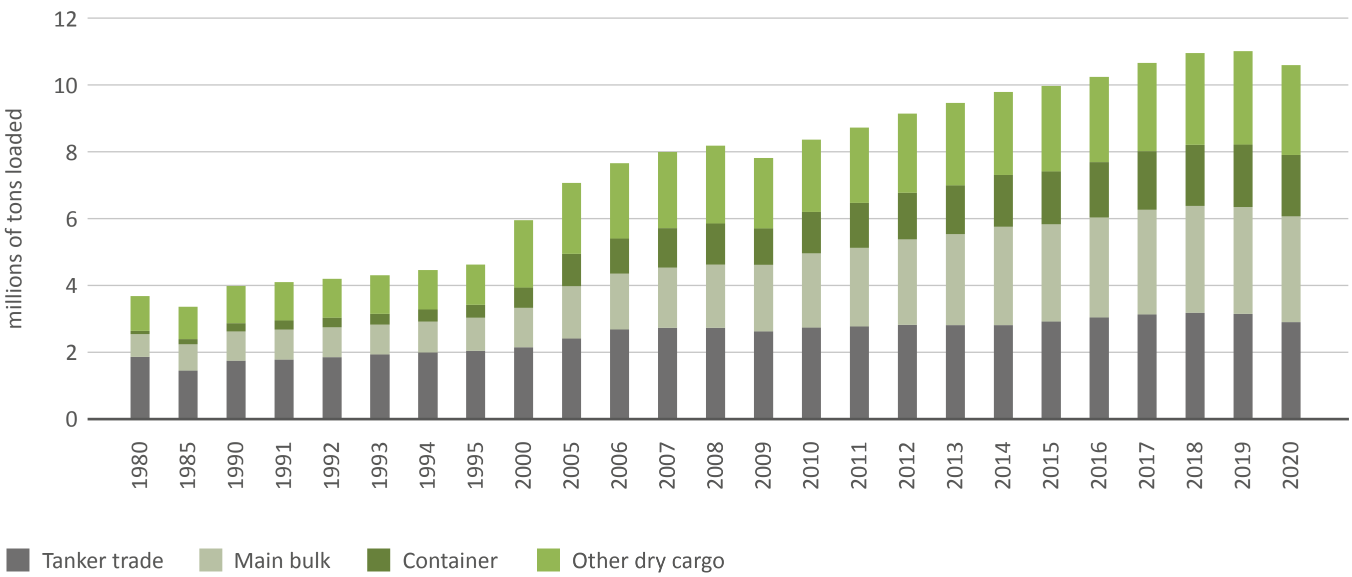
Despite the benefits it offers, the seaweed industry is still nascent in Europe, and must overcome several hurdles before realizing its full potential, such as regulatory constraints, a necessary change of paradigm from harvest to culture, and a necessary scaling-up to reach a competitive cost base.

## 3.2 Marine Mobility – Future solutions for the engine of global economies

The globalized world demands **extremely high transportation capacities** for goods of all kinds. Intercontinental trade keeps the world economy running. Today and in the foreseeable future, **most** of the intercontinental goods transport will take place **by sea**. Worldwide the amount of goods loaded onto different types of cargo ships is increasing almost every year (cf. Figure 8 [32]).

This trend, in combination with increasingly strict environmental goals, leads to **higher requirements for ports and the shipping industry**. The global commercial shipping fleet consist of 99,800 ships of 100 gross tons and above (Jan. 1. 2021), which is the equivalent to 2,134,639,907 dead weight tons [32]. When looking at different approaches for a solution to reduce GHG emissions in the shipping industry, **lowering** the **average cruise speed** of cargo ships seems to be the easiest path to go. Lower cruise speeds however will lead to an increased demand of shipping capacity. With an already existing problem of altering vessels in the shipping fleet, this will result in a **demand-supply gap** of modern, efficient **shipping capacity** that will be hard to close for ship builders.

*Figure 8: International Maritime Trade by Cargo Type*




Source: UNCTAD (2021, Review of Maritime Transport)

Another issue, the shipping industry encounters is the **increasing size of container ships**. The size of commercial ships is measured in "twenty-foot equivalent units" (TEU), which measures the capacity in number of equivalents to twenty-foot standard containers. Since the early 2000s more and more of the world's cargo gets transported by mega-container ships, which have a capacity of above 10,000 TEU. Increasingly huge ships are **difficult to steer** and in case of collisions or groundings even more **difficult to rescue**.

A good example for the scale of disruption in the world economy, a single container ship can evoke, was the "Ever Given". A container ship of 20,000 TEU of capacity, that blocked the Suez Canal for the duration of five days. In this duration hundreds of vessels (cf. Figure 9 [32]) were hindered from passing through the canal, causing supply shortages worldwide. In addition to the challenges at sea, the enormous size of the ships also creates new requirements for port infrastructure [32].

The change towards a sustainable economy comes with extreme challenges for the maritime transportation of goods. Therefore, the **development and use of novel technologies** is necessary to make the freight transport of the future more sustainable.

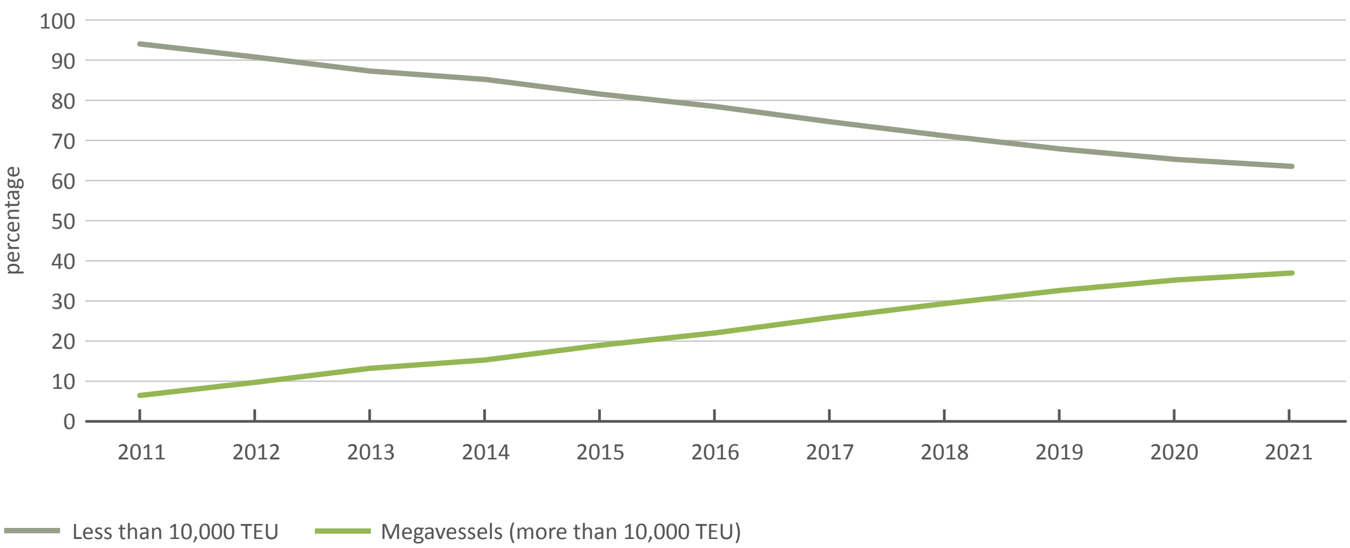
Besides lowering the mean cruise speed of ships, another opportunity for GHG emission reduction in the marine mobility industry would be to use **alternative fuels**.

A German startup has developed a much more efficient and sustainable process for producing methanol. Its expert team sees **methanol as the main fuel for the shipping industry in the future**. Maersk, the world's largest shipping company, shows commitment to this idea by already ordering 12 methanol-powered container ships [33].

Nowadays, the power supply for ships in port is still very often provided by the continuous operation of the ship's engine itself. These GHG emissions which are emitted during mooring period of the ships can be easily avoided by assuring a **connection to the mainland electricity grid**. Some ports including the port of Kiel already feature this possibility. The mainland power supply then could be fed by OSW parks, completing the sustainable cycle.

Smarter and greener ports and **EV mobility solutions** recently receive more interest by investors. With state subsidies supporting investments in green infrastructure more money flows into the development of sustainable ports.

*Figure 9: Share of Mega-Vessels in the Global Container Fleet*




Source: UNCTAD (2021, Review of Maritime Transport)

One example that is on the forefront of modern ports is Yangshan Deepwater Port, located in Shanghai, China. Yangshan's port is 100 % electric and in completion stage consists of 26 bridge cranes, 120 rail-mounted gantry cranes and 130 automated guided vehicles. Using high automation level, the annual throughput is estimated to reach 6.3 million TEU soon. Yangshan Port is connected to the mainland of Shanghai via a 32.5 km long bridge called "Donghai Daqiao". The port can handle the biggest existing Megavessels, especially those with high draught [34].

For **investors**, the field of marine mobility is very diverse. There are opportunities to invest in a wide variety of risk and asset classes. Trends emerging in this area include **digitalized, electrified ports, surging demand for modern transport vessels** and the **use of alternative fuels**.

## 3.3 Marine Infrastructure – The future of clean energy supply

High wind speeds, big waves and more intense sunlight are all not only characteristics of the open sea but also **important preconditions** for the efficient usage of **renewable energy infrastructure**. Also, there is a wide variety of technologies for electricity generation in the maritime space. Nevertheless, the percentage of global **ocean-based electricity generation is still only 0.3 %**.

This percentage changes as maritime renewable energy projects move beyond the scale of pilot projects and more and more investments flow into this area [35]. In the following the different technologies of energy generation in the maritime space, their advantages, disadvantages, and potential are being outlined.

### 3.3.1 Tidal Power Plants

The operation of tidal power plants is based on **potential and kinetic energy differences** of the water caused by the tidal range. There are two fundamentally different approaches to generating energy from tidal power. For the time being, only the so-called "tidal barrage" or "tidal range" approach will be discussed, which uses different water levels between high and low tide to generate energy. This can have economic application in bays and estuaries that have a **water level difference** between low tide and high tide of **at least five meters**. The second option is to use the periodic currents caused by the tides and the associated kinetic energy of the water masses directly to drive turbines. However, this type of energy generation is assigned to ocean current power plants and will be discussed in more detail later [36].

**Tidal barrage power plants** are often built in bays, since separating a basin from the open sea by a dike requires less effort. The dike is equipped with several turbines, which are always situated below the water level. These **turbines** are **driven by inflowing and outflowing water masses**.

At high tide, the water level in the seaside of the dike rises. This temporarily leads to a higher water level on the seaside compared to the basin side of the dike. The water masses then flow from the seaside into the basin through the channels of the dike that connect the two sides. The high kinetic energy of the water in the channels of the dike drives the turbines, converting the kinetic into electrical energy. When the tides change and the low tide situation occurs, the water level in the basin is elevated compared to the seaside and the turbines can be driven by outflowing water masses.

By means of controllable valves on the channels and active turbines, tidal barrage power plants can also be **used for energy storage**. For this purpose, water is pumped into an enclosed area at low water level difference, which can then be selectively discharged again through the turbine channels later, thus generating electrical energy [36].

The largest tidal power plant in operation today is in South Korea. It is called Sihwa-Ho and has 10 bulb turbines with a total capacity of 254 MW. The dam of the tidal power plant is located on the west coast of South Korea in Asan Bay, where the tides cause a tidal range of about 7.5 meters. The installed bulb turbines result in an annual energy output of about 550 GWh (corresponds to the consumption of a city of half a million inhabitants) [37].

Overall, it is assumed that the **sustainably usable energy** from dam tidal power plants worldwide is between **120 and 400 GW**.[38]

At the present time, the **installed capacity** of tidal power plants worldwide is only about **520 MW**. Several large-scale projects in the gigawatt range have failed due to **high investment costs** and **risks related to flooding and negative impacts on the environment**. The untapped potential of tidal power is high. However, the impact on nature of separating basins from the open sea by dams cannot be neglected [36].

### *3.3.2 Wave Power Plants*

Energy generation from ocean wave power can be designed in a **wide variety of ways**. There are a variety of technologies with different basic modes of operation that can be used to convert wave energy into electrical energy. The following is intended to **provide an overview** that shows as broad a spectrum as possible of the fundamentally different ways in which wave power can be used to generate energy.

Waves are mainly generated by the interaction of wind and water surface. The following three variables are of importance:

1) Wind speed
2) Wind duration
3) Stroke length of the wind over the water surface

The **sustainably usable potential of wave power** is given in different sources with **strongly varying magnitudes**. Furthermore, it is often not distinguished whether the estimated quantities are the general potential of wave energy or the usable part of it with wave power plants.

For the reference year 2025, one source indicates that the actual exploitable potential from wave energy is estimated at 2000 TWh, which corresponds to **200 GW** of power. This source appears to be the only one that makes the distinction between actually usable potential and generally available wave energy [36].

Due to the uneven distribution of wave energy worldwide, some countries can generate a significantly larger amount of energy than others. However, a complete utilization of the resources will not yet be profitable in many countries [36]. Regions with **particularly high potential** include the **UK, Australia, Argentina, Chile, Japan,** and the **USA**.

### *3.3.3 Ocean Current Power Plants*

Ocean current power plants use the **kinetic energy of the water masses** generated by the **periodic ocean currents** from the tides or the **constant ocean currents**. There are various types of ocean current power plants, but they are all because one or more **turbines are driven by the water masses flowing through them**.

The turbines are usually mounted on steel piers that protrude out of the water. Studies show that a **water depth between 20 and 35 meters** and **flow velocities of about 2.5 m/s** are the most efficient. However, there are construction methods that provide for anchoring the turbines directly to the seabed. The pier construction method offers several advantages over direct anchoring in the seabed. Among other things, this means that the assembled turbines can be lifted above the water surface by means of a hydraulic device for maintenance and assembly work. This considerably reduces the costs and effort involved. Mounting the turbines on the pier also allows the impellers to be aligned or readjusted for better adaptation to the prevailing flow conditions. Like wind turbines, this also offers the possibility of limiting the power output if the flow velocities are too high [36].

The possibility of using the **piers as fundaments for OSW turbines** is being discussed. Such hybrid plants would offer some advantages, such as a lower number of necessary grid connections and a lower space consumption. However, especially in the case of different wind and water directions, extreme loads could occur, which would require higher stability and better anchoring of the turbine.

Due to the energy density of the water, an ocean a **marine current power plant** requires a significantly **smaller diameter for the same output** than a wind power plant. This significantly increases cost efficiency and makes it possible to operate several plants in close proximity to each other. [39]

The largest ocean current power plant in the world, MeyGen, is currently still under construction and is located north of the castle of Mey in Scotland. It is planned to reach a capacity close to 400 MW using 269 turbines in total. In 2019 the already-installed part of MeyGen's turbines produced 13.8 GWh of electricity [40].

Active companies in the industry estimate the **usable potential** from ocean current power plants worldwide at **90 to 120 GW**. To date, ocean currents of 25 GW have been quantified and localized. However, the potential is very unevenly distributed across the world's oceans. Around the coast of UK alone, the exploitable potential is estimated at about 10 GW, which makes the **UK the country with best conditions worldwide**. Other countries with good conditions for energy production from ocean currents include **Canada, China, Japan, Russia**, and **Australia** [36].

### *3.3.4 OSW Energy: Fixed vs. floating*

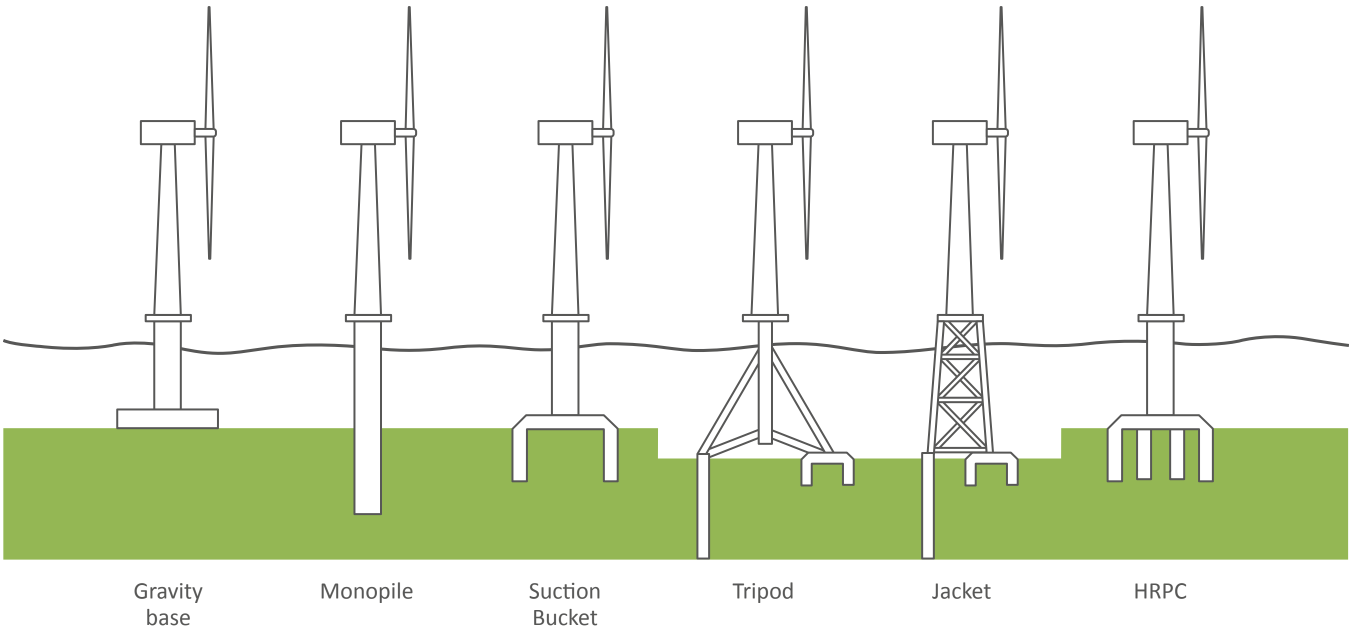
OSW turbines may be the most generally known method of generating renewable energy in the maritime space. The real **difficulties** in the field of OSW energy lie in the **construction, grid connection** and **corrosion protection** of the power plants. Long distances to coastlines and great ocean depths make for challenges in development.

OSW turbines can be divided into **two categories**.

1. The first category is the **fixed OSW turbine**, which can be installed at **sea depths of up to 60 meters**. Fixed turbines are embedded in the seabed via a **fixed, rigid anchorage**. There are different methods of fixed anchoring. Most wind turbines installed today are using the so called "**Monopile**" anchoring method. This method is suitable for shallow waters areas of **0 – 30 meters** in depth and is relatively cost efficient. Worldwide the percentage of wind turbines installed, using this anchoring method, is around 77 %. Other methods like the "Tripod" or "Jacket" method may be more suitable for even deeper waters but involve higher construction costs (cf. Figure 10 [41]).

2. In addition to fixed OSW turbines, as the second general category, **floating OSW turbines** have become a feasible alternative in the last decade. Installation capabilities in **water depths of up to 1,000 meters** and **preassembly possibility in wharves** are the main advantages of floating turbines. In comparison to fixed OSW turbines, **floating OSW energy projects are still in their infancy stage**. The installed capacity of floating OSW energy is negligibly small when compared to fixed OSW nowadays but is estimated to grow rapidly over the next years.

*Figure 10: Offshore Wind Turbine Foundation Types*




Source: Diaz, Guedes Soares (2020, Offshore wind farms)

- In the long run, floating OSW energy capacity will overtake the installed capacity of fixed offshore turbines. This is due to the wider range of applicability and building restrictions near coastlines, where the water would be shallow enough for fixed turbines. Floating offshore turbines do have different methods of turbine positioning. The method which is used the most in recent projects is the semi-submersible three-legged version (cf. Figure 11 [42]).

When comparing the anchoring methods of fixed and floating OSW turbines it becomes clear, that the **environmental impact of floating turbines is way smaller**. However, the **piles** of fixed turbines **may even provide new habitats** for corals, fish, and algae. The different environmental impacts OSW turbines are not fully researched but it can be said that OSW turbines in general do have a low impact after the construction period is finished.

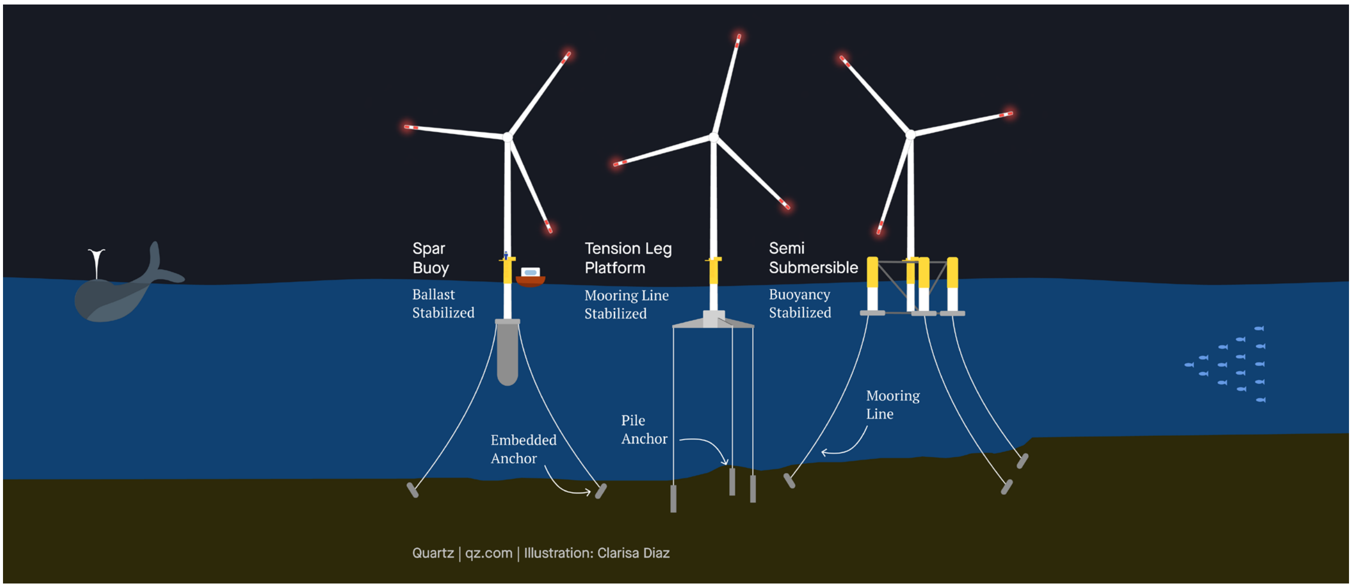
The **capacity** of OSW turbines is **increasing constantly** over the past years. Since construction costs make up for such a big part in OSW, increasing turbine capacity is of particular importance to reduce the cost per MW of capacity.

The untapped technical potential of **fixed OSW** energy generation was estimated at around **36,000 TWh per year** in 2018 by IEA in a geospatial analysis. In **combination fixed and floating** OSW energy generation potential was estimated at around **255,000 TWh**, meeting the world's estimated electricity demand 11 times over in 2040 [43].

In comparison to the other energy generation methods, which are mentioned earlier in this study, OSW energy is already developing to become a **major player in the world's energy market**. However, in the available data of worldwide energy production in 2018, the share of OSW Energy only accounts for 0.3 % of global electricity generation. On first sight this seems to be almost negligible small. This is due to the fact, that a worldwide perspective on OSW is not fair. **The UK, Germany, Belgium, and Denmark account for almost 80 % of the world's OSW energy capacity, demonstrating an enormous head start compared to the rest of the world.**

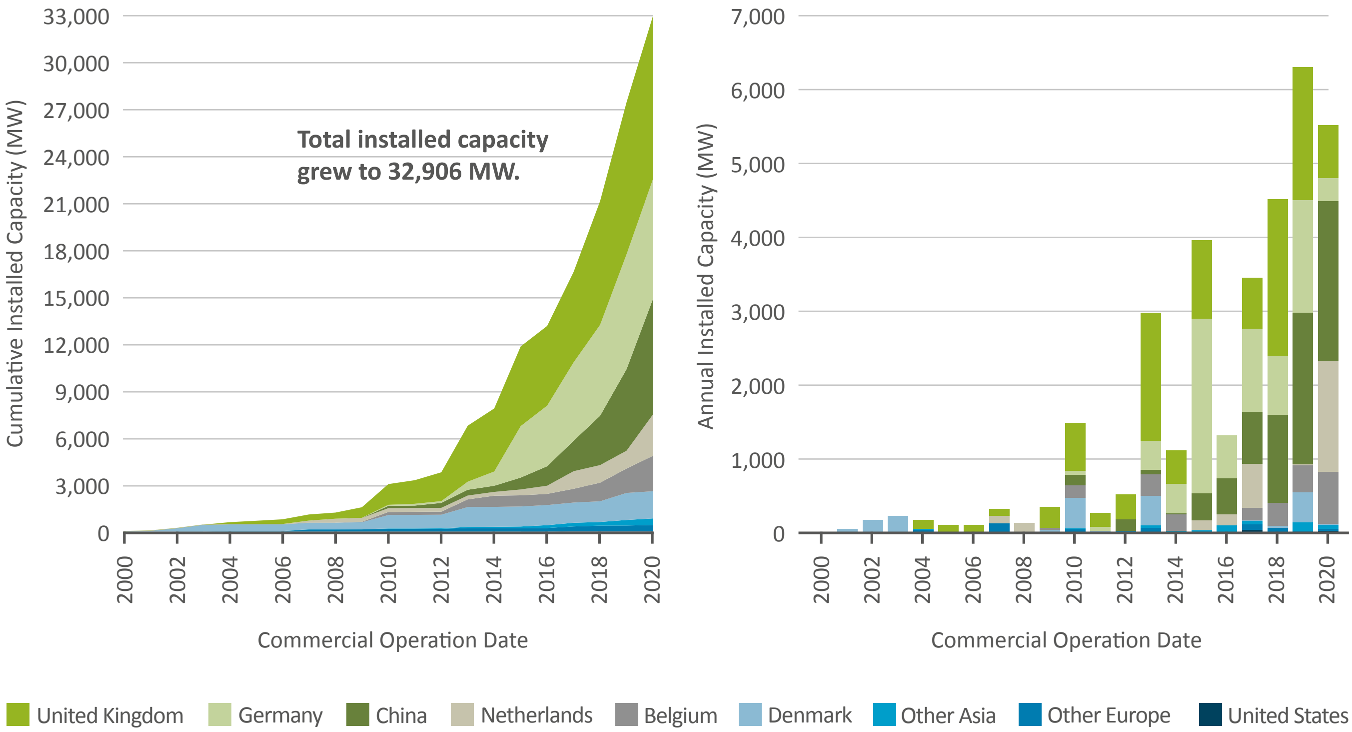
Only China is beginning to rapidly increase their share as a non-European country, with around 18 % of the total operating OSW capacity in 2020. When looking at the worldwide newly installed capacity in the years 2000–2020, it shows that China's share has grown to almost 1/3 in 2020 (cf. Figure 12 [44]).

*Figure 11: Floating Offshore Wind Turbine Technologies*




Source: Diaz et al. (2021, floating turbines )

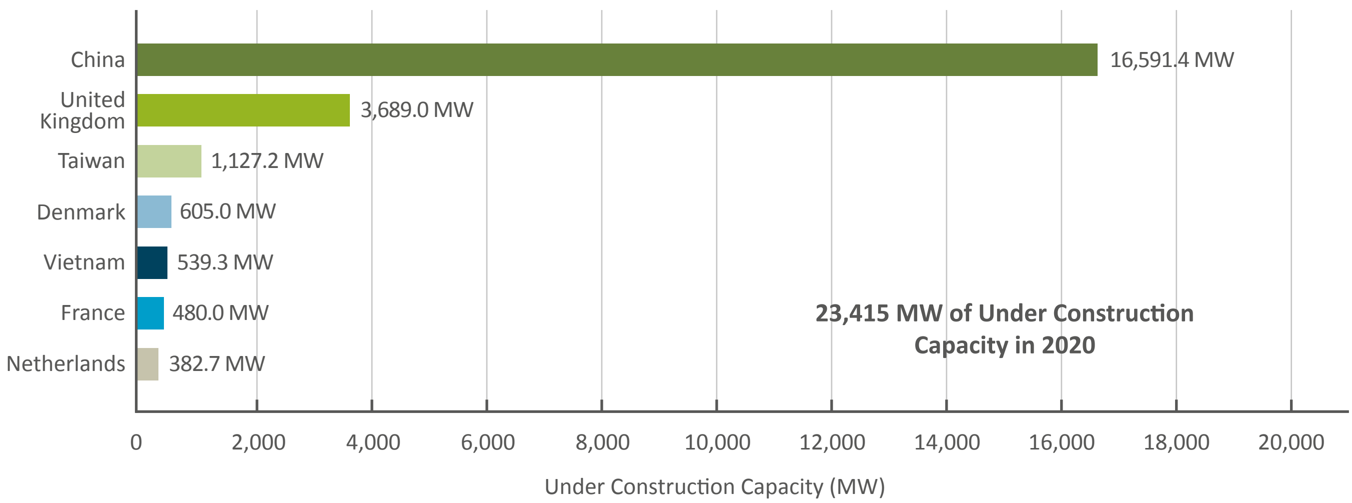
## *Figure 12: Global Offshore Wind Energy Development and Capacity*




Source: US Department of Energy (2021, Offshore Wind Market Report)

When looking at the **OSW projects under construction**, the extreme speed the Chinese market is developing at becomes clear (cf. Figure 13 [44]).

## *Figure 13: Global Offshore Wind Installations under Construction by Country*




Source: US Department of Energy (2021, Offshore Wind Market Report)

## *3.4 Marine Resources – Nature-based solutions*

### *3.4.1 Fish & Aquaculture*

As elaborated in subchapter 2.4.1, overfishing of the oceans suggests that the solution lies in aquaculture which, however, still requires intensive efforts to avoid and reduce risks and damage to nature. Ecological and sustainable aquaculture techniques are on their way to being **a viable solution**.

**Aquaculture** is defined as the controlled cultivation of aquatic organisms such as fish, crustaceans, mollusks, or algae. It is characterized by interventions in the reproduction and/or growth phase to optimize conditions and increase production beyond natural ecological capacities.

In total, more than **600 different species of fish and marine animals** are farmed in aquaculture facilities, and bred or fattened in aquaculture farms. There are various methods of breeding fish or other aquatic organisms, such as mussels or crayfish.

In addition to ponds, some of which can be found in the cultivated landscape, there are recirculating systems that is relatively independent of location and net enclosures installed in natural bodies of water.

- In **indoor systems**, the conditions can be artificially adapted to the needs of the species kept.
- In **outdoor systems**, one is dependent on the climatic conditions of the environment, so that no tropical warm-water species can be bred in Central Europe.

However massive fish production in aquaculture is currently **not possible without ecological consequences**. Aquaculture is in many cases nothing more than **factory farming** with all its negative effects such as nutrient enrichment in the waters or the massive preventive use of antibiotics and the use of ecologically valuable biotopes such as mangrove forests for shrimp farming.

Moreover, there are **particular problems** when farming **predatory fish** like salmon or trout, which require animal protein. For example, there is a danger that wild fish are caught and processed into **fish meal and fish oil** (so-called "mud fishing") to be used as feed in aquacultures. These small fish are also often **already overfished** or no longer available as food for wild fish.

Farms **release** fish stemming from special breeding lines that are **genetically different** from wild populations but mix with them, leading to changes in the wild, which in turn leads to changes in wild fish populations. **Alien species** also repeatedly enter natural waters from breeding facilities.

In Germany, therefore, the breeding and keeping of non-native species in facilities and waters that have a connection to natural waters is prohibited.

Since the 1990s, there have been initiatives for the **certification of organic aquaculture**. The certification was mostly limited to the fact that the fish were fed less drugs or artificial substances.

However, it has become clear that many of these "organic" aquacultures are just as much factory farming, with corresponding effects on nature and the fish themselves. Today, truly sustainable aquacultures are moving much more in the direction of **species-appropriate husbandry**, a significantly reduced impact on the environment and a substitute to feeding fish with **alternative proteins**.

Current research efforts and technological solutions for inland aquaculture in closed-loop systems, as well as growing consumer awareness of the health drawbacks of industrial fish farming, point to a direction that will certainly lead to more sustainable alternatives and methods.

### *3.4.2 Blue Biotech*

Oceans harbor a vast variety of organisms that offer **biological and chemical diversity** with metabolic abilities unrivaled in terrestrial systems. Still, many of the known organisms and bioactive compounds have not been exploited to their full commercial and possibly also functional potential.

Marine biotechnology (or "Blue Biotech") is recognized as a globally significant economic growth sector and viewed as one of the main pillars of bioeconomy.

The field of blue biotech is mostly concentrated in the EU, North America and the Asia-Pacific. **All groups of marine organisms have the potential for biotechnological valorization.**

Marine biotechnology offers a broad range of **bioremediation applications**. Marine invertebrates have been used in **antifouling management** and control, particularly sponges. Marine compounds can be incorporated into **skincare** and make-up products.

Their **drug-like** benefits produce pharmaceutical hybrids in which the bioactive ingredients are added to the topical or oral cosmetics to produce cosmetical products with enhanced properties.

There are examples of products that are already on the market derived mostly from microorganisms (bacteria, microalgae, fungi), but also from macroalgae, fish and corals. Marine organisms, such as algae, sponges, mollusks (including cone snails), cyanobacteria, actinobacteria, fungi, tunicates and fish biosynthesize metabolites with significant biological activities for therapeutic and industrial applications, with **anticancer, anti-inflammatory, anti- and pro-osteogenic**, anti-obesity, antimicrobial, antiviral, and anticoagulant activities. Compounds originating from marine organisms are also used in **nutraceuticals, healthcare, and well-being**.

Marine biotechnology in Europe is still in its early stages, evidenced by a high number of publications, a low number of patents and a high knowledge fragmentation. The development of marine natural products is typically connected with **enormous financial investments** to sustain experimentation costs, especially in the medical sector.

The **translation** of research **laboratory discoveries into commercial** items that entail obtaining and maintaining the supply levels and safety requirements are nowadays recognized as the major hurdles in bringing marine natural-product-based molecules to market [45].

**PharmaMar** was the first company in the world to develop a marine-based cancer drug (invertebrates) from discovery through to commercialization. PharmaMar conducts basic research with marine expeditions, compound isolation, chemical synthesis, and in vitro and in vivo studies to discover and develop new anti-tumor compounds of marine origin [46].

**ArcticZymes Technologies** use access to the marine Arctic to identify and produce new cold-adapted enzymes for applications in molecular research, in vitro diagnostics and therapeutics like gene therapy and vaccine production [47].

**LAGOSTA** farms the European spiny lobster in an organic and sustainable manner and recycle its associated byproducts. As it grows, a spiny lobster molts and loses its hard protective exoskeleton. Retrieving the naturally generated molts enables LAGOSTA to make the best out of this waste without harming the animal at any time. This resulting product exhibits unparallel molecular characteristics for biomedical applications [48].

**OceanBASIS** specializes in the development of extracts from seaweed for health with a maritime natural cosmetic and a food brand. In the field of “ocean biotech”, OceanBASIS studies marine natural substances to develop new products for use in medicine and life science, in skin care and nutrition. The focus is on anti-inflammatory, anti-tumor and anti-infective effects of substances from algae [49].

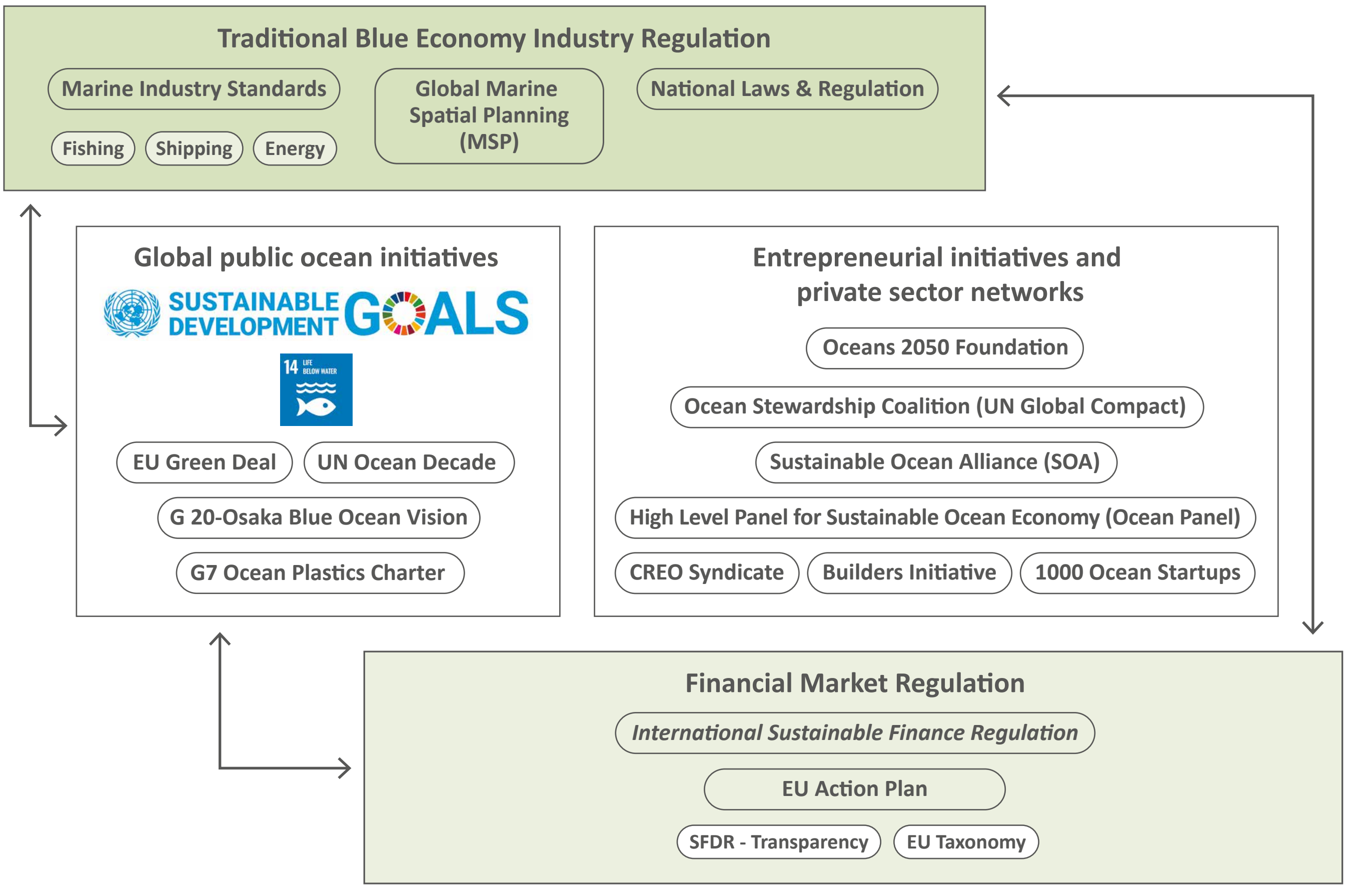
# 4 International Standards for Financing the Transition

The financial industry plays a vital role in **financing the transition** to a Sustainable Blue Economy, helping to rebuild ocean prosperity and restore biodiversity to the ocean. Through their lending, underwriting and investment activities, as well as their engagement strategies, financial institutions have a major impact on ocean health and hold the power to accelerate and mainstream the sustainable transformation of ocean-linked industries.

Current developments in regulation and governance of financial flows contribute to the creation of **standards and guidelines to channel investments** into positive impacts for the economy, society, and the environment. The international community, together with the financial industry, has already built impressive networks and initiatives to support efforts to invest sustainably in the ocean economy (cf. Figure 14).

In addition to the largest international organization, the UN, numerous specialized groups and stakeholders have come together to identify technological innovation, science, and investment solutions. Some of the key initiatives and drivers are described in the following chapters.

*Figure 14: Overview of Regulatory Frameworks*




Source: FERI Cognitive Finance Institute, 2022

## 4.1 UN SDG – Guideline and measurement for global transformation

The UN 2030 Agenda for Sustainable Development was adopted in September 2015. It is based on 17 SDG and 169 targets. National policy makers now face the **challenge of implementing** this agenda and making progress in the economic, social, and environmental dimensions of sustainable development worldwide.

While the SDG were originally intended as targets for nations, they are now more often used as a **basis for investment decisions** and **impact measurement**.

In this sense the **SDG** are increasingly becoming the **market standard** and internationally recognized guidelines for impact-oriented investing. SDG are used to illustrate the positive impact of an investment on environmental or social issues. However, the challenge of measuring impact with the help of the SDG lies in the allocation and interdependencies of the goals among each other. It is crucial to understand potential trade-offs and synergistic relationships between the different SDG.

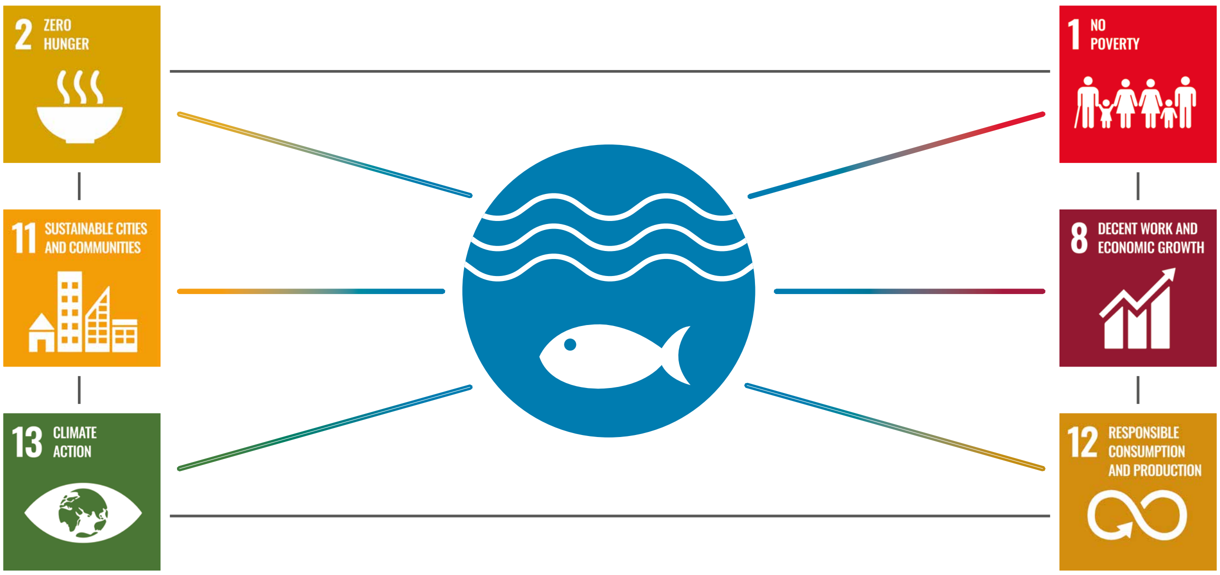
The identification of interactions between the 17 SDG allows for broad multidisciplinary and cross-sectoral discussion-making. It provides the basis for an integrated approach to implementation, measurement, and monitoring of specific social an ecological targets.

In 2017 the ICSU published a **Guide to SDG Interactions** [50]. In this report the nature of **interlinkages between the SDG** is explored (cf. Figure 15 [50]). It is based on the premise that a science-based analysis of the interactions between the different areas of sustainable development can support more effective decision-making and facilitate the monitoring of progress.

It could even help structure **innovative solutions for impact measurement**.

**SDG 14** is mostly used as a reference for any Blue Economy activity. The goal ("Life under Water") relates **broadly to any human interaction with the oceans**, sustainable use of marine resources including coastal zones, as well as capacity building

*Figure 15: The interactions of SDG14*




Source: ICSU (2017, SDG Interactions)

and nature conservation. As oceans are highly interconnected ecosystems not confined by national boundaries or single industry sectors the objectives of SDG 14 are **generally linked to all other 16 SDG**.

The comprehensive importance and overarching impact of SDG 14 can be illustrated by the example of its connection to the six shown goals (1, 2, 8, 11, 12, and 13). Furthermore, the possible maritime investment solutions as well as investment opportunities with high positive impacts on society and the environment are highlighted.

Conserve and sustainably use the oceans, seas, and marine resources for sustainable development:

- Protect marine and coastal ecosystems
- Reduce marine pollution
- Conserve at least 10 % of coastal and marine areas
- Regulate harvesting and end overfishing
- Prohibit fisheries subsidies which contribute to overcapacity and overfishing
- Increase economic benefits from the sustainable use of marine resources, sustainable management of fisheries, aquaculture, and tourism
- Increase scientific knowledge, develop research capacity, and transfer marine technology
- Provide access for small-scale artisanal fishers to marine resources and markets
- Furnish legal framework for the conservation and sustainable use of oceans and their resources

### *SDG 14 and SDG 1 (No poverty)*

- **40 % of human population is living at coasts and depending on direct or indirect income and resources from the ocean. Over 3 billion people rely on marine and coastal biodiversity for their livelihoods [51]**

Poor coastal communities in low-income countries are especially likely to suffer the most from changes in coastal and marine environments. **Protecting, restoring, and managing critical coastal** and marine habitats are directly linked to **eradicating poverty**, improving their livelihoods, and reducing their vulnerability to extreme climate events like extreme storms, high tides as well as ocean level rise.

The potential investment opportunity here lies in **coastal protection. Large-scale infrastructure** projects (such as dams and flood protection technology) are usually only implemented in developed countries due to the high financial requirements. In the mainly and directly affected poorer regions, nevertheless economically interesting mangrove reforestation projects could be an interesting investment option.

### *SDG 14 and SDG 2 (No hunger)*

- **3.2 billion people rely on food from the sea as a source of protein and key nutrients**

Seafood, whether farmed or caught in the wild, is globally important as a source of protein, omega-3 fatty acids, vitamins, calcium, zinc, and iron for one billion people. Today, however, most fishing practices are unsustainable and continue to **massively reduce fish stocks**, leading to an **escalation of food insecurity**.

Most stocks are already fished at or beyond sustainable limits and are additionally often subject to wasteful fishing practices. Industrial fishing often competes with small local fishermen who, however, ensure the necessary basic supply of the local population. The **rules and measures for regulating fishing** therefore concern not only natural resources but also the social stability and conditions.

Solutions are offered by the **creation of MPAs**, stricter laws in fisheries and, above all, new sustainable solutions in fish farming. The creation of MPAs can bring benefits to fisheries and take pressure off important fishing areas such as spawning areas and nursery grounds. This can allow fish stocks in adjacent areas to recover.

However, stricter laws in global fisheries are difficult to implement due to the sheer size of the ocean. They require massive international cooperation and control, which is currently still lacking. The verification of **measures** can only be improved through **innovative tracking solutions**, such as blockchain technology.

## *SDG 14 and SDG 8 (Decent work and economy growth)*

- **About 97 % of the world's fishermen live in developing countries and fishing is their major source for food and income. Women account for most of the workers in secondary marine-related activities such as fish processing and marketing.**

Probably the most important stakeholder group of the sustainable Blue Economy are the **small island states and coastal regions. Small-scale fisheries** and local use of marine resources are not only the main source of food in these countries, but also represent a **large part of the labor market** and economic activities. In addition, these countries are particularly affected by climate change and sea level rise. At the same time, the societal impacts on these countries and economies from globalized industrial fisheries are of utmost negative importance. These often result in drastic food shortages and unemployment.

Sustainable growth of marine and maritime sectors such as small-scale fisheries, aquaculture, and tourism promotes employment and economic growth. **Capacity building** and the transfer of **marine technologies** can help build job opportunities and create long-term livelihoods.

In particular, the **employment of young people and women**, their education and training, the **creation of jobs** and the **promotion of innovations** and **new technologies** can enable sustainable and long-term economic growth of these notably affected regions. Thereby, this contributes positively to a stabilization of societal challenges and conflicts and can potentially **slow down the growing trend of migratory movements**.

## *SDG 14 and SDG 11 (Sustainable cities and communities)*

- **Approximately 65 % of all megacities worldwide are located in coastal areas**

Coasts have always been the preferred area for human settlement and urban development. They provide the necessary conditions for successful economic activities and human living conditions in general. Therefore, these regions have always had higher population densities, growth, and urbanization trends than inland areas. This results in a **direct link between marine sustainability and sustainable cities and communities**.

However, the expansive use and almost exponential growth in coastal cities has at the same time enormous negative impacts on marine ecosystems. The **enormous pollution and waste** generated by large metropolises is exacerbated by extensive uses of marine resources and infrastructure, such as aquaculture, coastal protection infrastructure or port construction.

In particular, the necessary measures to **improve sanitation and waste management** simultaneously **improve people's living conditions** and the state of the environment. At the same time, changes in consumption, waste management, energy consumption and sustainable use of marine infrastructure and resources can also **promote new jobs and economic growth**.

Similar **bidirectional benefits** arise between many other sustainable management and conservation measures in the coastal and marine environment and the development of safe, resilient, and sustainable cities.

Conflicts can arise, however, when conservation measures and conservation of marine ecosystems impede or increase the cost of urbanization, infrastructure, or transport development. Promoting the construction of **new buildings using local materials** may also well have a negative impact on coastal ecosystems.

Notwithstanding, **urban habitats are the best possible starting point for improving the marine environment**. This is one of the biggest sources of global plastic waste and untreated sewage pollution. Some large metropolitan regions have already recognized the positive interactions between improving the living conditions of inhabitants and solving global waste problems. [55]

For investors, the segment of waste and waste disposal, water treatment, and efforts towards a circular economy offers highly **interesting investment opportunities** that have both large investment volumes and a demonstrably very **high positive impact** on society and the environment.

### *SDG 14 and SDG 12 (Responsible consumption and production)*

14 LIFE BELOW WATER

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

- **Fish accounts for about 15.7 % of the global consumption of animal protein**

Sustainable consumption and production are critical to **ending overfishing**, sustainably managing marine and coastal ecosystems, and improving ocean health.

In addition to waste and wastewater management, significant reductions in global per capita retail food waste are also important parameters for protecting ecosystems. New methods and technologies for more sustainable fisheries and fish farming and reduced nutrient inputs from agriculture are essential factors for the **regeneration of marine habitats**. Responsible management of chemicals by both land-based and offshore industries is urgently needed.

The **greatest stress factors** on marine ecosystems worldwide are caused by **human consumption** and **unsustainable production methods**.

The question is: How much food can be expected to be **sustainably produce by 2050**? By estimating in the report "The Future of Food" [52] the "sustainable supply curves" of wild fisheries, finfish mariculture and bivalve mariculture, edible food from the sea could increase by 21 to 44 million metric tons by 2050, a **36–74 % increase** compared to current yields. The report suggests that this represents 12–25 % of the estimated increase in all protein needed to feed 9.8 billion people by 2050, with marine sources likely to grow by the most.

The fisheries and agricultural sectors are challenged to take therefore a **transformational approach to the global food systems**. Even though alternative protein sources and the strong trend towards sustainable food are receiving global attention, it is necessary to increase the political pressure on the biggest industry players and financing institutions.

The **regulatory pressure** on the economy and the financial sector manifests itself in the current initiatives of the EU and its member states (see Chapter 5.2).

Here, too, investors have an important role to play, as the far-reaching demand for more sustainable action are forcing large companies to **produce more sustainably** due to financial risks and regulatory pressure. The positive impact that can be achieved in a transitory change in the production economy is enormous.

### *SDG 14 and SDG 13 (Climate action)*

14 LIFE BELOW WATER

13 CLIMATE ACTION

- **< 50 % of the oxygen breathed by humans is produced by the ocean**
- **93 % of heat resulting from anthropogenic GHG emissions absorbed by the ocean**

The role of ocean and coastal ecosystems as **key climate regulators** is unfortunately still underestimated. At the same time, these fragile systems are particularly and directly affected by climate change.

Restoring and protecting the oceans contributes massively to strengthening the resilience and adaptive capacity of both natural and human systems to climate change. In particular, **coastal ecosystems** such as mangroves, salt marshes, and seagrass beds **are indispensable** for both **climate adaptation and mitigation**.

Likewise, indispensable is the resilience of coastal regions in reducing risks and strengthening resilience to climate-related hazards, such as storms or floods. According to the World Economic Forum (WEF) Risk Map, the most severe risks are environmental and in specific climate related (cf. Figure 16 [53]):

*Figure 16: WEF Risk Map 2022*

**"Identify the most severe risks on a global scale over the next 10 years"**

- **1st Climate action failure**
- **2nd Extreme weather**
- **3rd Biodiversity loss**
- **4th Social cohesion erosion**
- **5th Livelihood crises**
- **6th Infectious diseases**
- **7th Human environmental damage**
- **8th Natural resource crises**
- **9th Debt crises**
- **10th Geoeconomic confrontation**

Economic | Environmental | Geopolitical | Societal | Technological

Source: WEF (2022, Global Risks Report)

However, where sustainable ocean management is included as a topic in both **education** and **technology transfer**, this contributes directly to increasing adaptation to climate change. The potential for trade-offs is limited but possible. ORE installations can have negative impacts on the marine environment, especially on marine mammals. On the other hand, the **failure to mitigate climate change** will and reduce global warming will **exacerbate climate-related impacts** on coastal ecosystems coastal ecosystems, such as through warming and ocean acidification, but also via rising sea levels and associated impacts.

## 4.2 Sustainable Blue Economy Finance Principles – Guidelines for investors

Launched in 2019, the Sustainable Blue Economy Finance Initiative created a global community convened by the UN to act as an interface between private finance and the Blue Economy.

As key cornerstone of the initiative the **Sustainable Blue Economy Finance Principles** were developed in 2021. They are the world's first **global guiding framework for banks, insurers, and investors** to finance a Sustainable Blue Economy. The principles promote the implementation of SDG 14 (Life Below Water), and set out **ocean-specific standards**, allowing the financial industry to **mainstream sustainability of ocean-based sectors**.

They are led and supported by the EC, WWF, the World Resources Institute (WRI) and the European Investment Bank (EIB) and managed by UNEP FI. Over 70 Institutions representing USD 11 trillion in total assets have already joined the Sustainable Blue Economy Finance Initiative as Members or Signatories to the Principles.

The principles can be applied in the overall context of and in reciprocity with the SDG, the UNEP FI's Principles for Responsible Banking (PRB), Principles for Sustainable Insurance (PSI) and Principles for Positive Impact Finance (PI), as well as the Principles for Responsible Investment (PRI).

**The 14 principles to which the signatories commit themselves are:**

**1. Protective**
We will support investments, activities and projects that take all possible measures to restore, protect or maintain the diversity, productivity, resilience, core functions, value and the overall health of marine ecosystems, as well as the livelihoods and communities dependent upon them.

**2. Compliant**
We will support investments, activities and projects that are compliant with international, regional, national legal and other relevant frameworks which underpin sustainable development and ocean health.

**3. Risk-aware**
We will endeavor to base our investment decisions on holistic and long-term assessments that account for economic, social, and environmental values, quantified risks and systemic impacts and will adapt our decision-making processes and activities to reflect new knowledge of the potential risks, cumulative impacts and opportunities associated with our business activities.

**4. Systemic**
We will endeavor to identify the systemic and cumulative impacts of our investments, activities, and projects across value chains.

**5. Inclusive**
We will support investments, activities and projects that include, support, and enhance local livelihoods, and engage effectively with relevant stakeholders, identifying, responding to, and mitigating any issues arising from affected parties.

**6. Cooperative**
We will cooperate with other financial institutions and relevant stakeholders to promote and implement these principles through sharing of knowledge about the ocean, best practices for a sustainable Blue Economy, lessons learned, perspectives and ideas.

**7. Transparent**
We will make information available on our investment / banking / insurance actives and projects and their social, environmental, and economic impacts (positive and negative), with due respect to confidentiality. We will endeavor to report on progress in terms of implementation of these Principles.

**8. Purposeful**
We will endeavor to direct investment/banking/insurance to projects and activities that contribute directly to the achievement of Sustainable Development Goal 14 ("Conserve and sustainably use the oceans, seas and marine resources for sustainable development") and other SDG – especially those which contribute to good governance of the ocean.

**9. Impactful**
We will support investments, projects and activities that go beyond the avoidance of harm to provide social, environmental, and economic benefits from our ocean for both current and future generations.

**10. Precautionary**
We will support investments, activities and projects in our ocean that have assessed the environmental and social risks and impacts of their activities based on sound scientific evidence. The precautionary principle will prevail, especially when scientific data is not available.

**11. Diversified**
Recognizing the importance of small to medium enterprises in the Blue Economy, we will endeavor to diversify our investment / banking / insurance instruments to reach a wider range of sustainable development projects, for example in traditional and non-traditional maritime sectors, and in small and large-scale projects.

**12. Solution-driven**
We will endeavor to direct investment/banking/insurance to innovative commercial solutions to maritime issues (both land- and ocean-based), that have a positive impact on marine ecosystems and ocean-dependent livelihoods. We will work to identify and to foster the business case for such projects, and to encourage the spread of best practice thus developed.

**13. Partnering**
We will partner with public, private and nongovernment sector entities to accelerate progress towards a sustainable Blue Economy, including in the establishment and implementation of coastal and maritime spatial planning approaches.

**14. Science-led**
We will actively seek to develop knowledge and data on the potential risks and impacts associated with our investment/banking/insurance activities, as well as encouraging sustainable finance opportunities in the Blue Economy. More broadly, we will endeavor to share scientific information and data on the marine environment.

As a key cornerstone, the initiators of the Sustainable Blue Economy Finance Initiative published in 2021, among other guidelines and analyses, a handbook for the finance industry entitled "Turning the Tide", for the practical implementation of measures to finance a sustainable Blue Economy [54].

The guide gives a detailed breakdown of which activities to seek out as best practice, which activities to challenge, and which activities to avoid financing completely due to their damaging nature. It outlines how to avoid and mitigate environmental and social risks and impacts, as well as highlighting opportunities, when providing capital to companies or projects within the Blue Economy.

## *4.3 Global public ocean initiatives*

Along the activities of the UN and its affiliated organizations, there have been numerous other public approaches and regulatory efforts for many years, most of which aim to establish a framework for the implementation of effective ocean protection measures on a voluntary basis. Unfortunately, voluntariness is often the big obstacle in an interconnected world driven by commercial interests. Here are some examples:

### *Sustainable Blue Economy Partnership (SBEP) – (EU Green Deal) [56]*

The SBEP is a co-funded partnership under the EU Framework Programme for Research and Innovation "Horizon Europe 2021–27". The format is a public initiative with a core group of partners including research and innovation ministries and funding agencies from participating countries. It is based on the Strategic Research and Innovation Agenda (SRIA), which builds on existing knowledge and new research programs to develop a pan-European and regional strategic framework, involving all stakeholders.

The partnership aims to reduce fragmentation by linking existing initiatives to combine and align pan-European, regional, and national investments and socio-political priorities. This should promote a high return on public investment and sustainable economic development. The partnership is expected to make a substantial and measurable contribution to the climate neutrality of the Blue Economy and to the sea-related goals of the European Green Deal and Digital Europe.

### *UN Ocean Decade (2021-2030)*

In 2017, the UN General Assembly proclaimed the UN Decade of Ocean Science for Sustainable Development (2021-2030) ("the Ocean Decade"). The vision of the Ocean Decade is "the science we need for the ocean we want", and it envisages a revolution in ocean science that will trigger a step change in humanity's relationship with the ocean.

It brings together scientists, resource providers, governments, business and industry, philanthropic Foundations, UN agencies and many other stakeholders from diverse sectors to generate scientific knowledge and develop the partnerships needed to support a well-functioning, productive, resilient, and sustainable ocean. The Alliance aims to create a network of eminent partners of the Ocean Decade that can lead by example to catalyze support for the Decade through targeted resource mobilization, networking, and influence.

### *G7 Ocean Plastics Charter (2018)*

The leaders of Canada, France, Germany, Italy, UK, and the EU, commit to a more resource-efficient and sustainable approach to the management of plastics. This will involve adopting a lifecycle approach to the management of plastics on land and at sea.

This aim is to avoid unnecessary use of plastics and prevent waste, while ensuring that plastics are designed for recovery, reuse, recycling, and end-of-life disposal, also to increase the efficient use of resources while strengthening waste prevention systems and infrastructure.

Innovations for sustainable solutions, technologies and alternatives throughout the life cycle are fostered. The signatories recognize the need for action in line with previous G7 commitments and the 2030 Agenda.

*Osaka Blue Ocean Vision – G20 Implementation Framework for Actions on Marine Plastic Litter (2021)*

The objective of the G20 Marine Litter Action Plan is to effectively implement the United Nations Environment Assembly (UNEA) resolution on Marine plastic litter and microplastics 4/7 and the resolution 4/10 on Addressing single-use plastic products pollution. The aim is to encourage members to take voluntary action in accordance with their national policies, approaches, and circumstances [22].

## 4.4 Entrepreneurial initiatives and private sector networks

In addition to public initiatives and regulatory measures, **entrepreneurial activities** of the private sector are a key element of successful change and transformation of the Blue Economy. A comprehensive transformation of the maritime economy and new technologies can only be initiated if private investors also make a long-term commitment. VCs play a particularly important role here, as they are the initiators of **pioneering concepts** and technological innovations.

There are already impressive networks of committed investors and multi-stakeholder groups working on concrete solutions and providing a valuable information platform for donors. In addition to commercial networks, private non-profit organizations, foundations, and initiatives also provide a valuable basis for knowledge building and exchange, for public awareness and for philanthropic investments, which often provide the impetus for innovation. In the following, initiatives and specialized peer groups are presented that are particularly dedicated to the sustainable Blue Economy.

*Oceans 2050 Foundation*

Established in 2018, Oceans 2050's mission is to mobilize a global alliance to restore the world's oceans to abundance by 2050 by enabling and amplifying how people and companies across all sectors can be contributors to a common vision of an abundant future. Founded and led by Alexandra Cousteau, the platform identifies and develops solutions that harness the power of markets to reshape an ocean strategy fit for current and future challenges by producing impact at a scale that is meaningful for the oceans, the climate, and the millions of people that depend on them.

In 2021, Co-Founder Alexandra Cousteau and Chief Scientist Professor Carlos Duarte received a new grant for their work from World Wildlife Fund (WWF). The funding will support the group's work to quantify the role of seaweed aquaculture as a key recovery wedge for the world's oceans and its ability to sequester carbon.

**http://www.oceans2050.com**

*Ocean Stewardship Coalition (UN Global Compact)*

The well-known UN Global Compact Initiative has developed key recommendations for businesses and governments to leverage ocean-based climate solutions, particularly in four action areas: zero-emission maritime transport, low-carbon blue food, harnessing offshore renewable energy and nature-based solutions (focusing on seaweed). The Sustainable Ocean Principles provide a framework for responsible business practices across sectors and geographies. They build upon and supplement the ten Principles of the UN Global Compact on human rights, labor, environment, and anti-corruption.

**https://www.unglobalcompact.org/take-action/ocean**

*Sustainable Ocean Alliance (SOA)*

The SOA is a global community of youth, entrepreneurs and experts collaboratively researching and developing solutions and innovations.

The SOA is a San Francisco-based NGO. Its founder and CEO is Daniela Fernandez. It is now one of the world's largest youth-led network of ocean allies. SOA reaches more than 6,000 people in 165 countries and is designed to accelerate solutions, cultivate leaders, and create a community that will help restore the ocean.

**https://www.soalliance.org/**

*High Level Panel for Sustainable Ocean Economy (Ocean Panel)*

Established in 2018, the High Level Panel on Sustainable Ocean Governance (Ocean Panel) is an initiative of global leaders committed to a sustainable ocean economy where effective conservation, sustainable production and equitable prosperity go hand in hand.

The Ocean Panel works with governments, businesses, financial institutions, academia and civil society to develop pragmatic solutions in the areas of policy, governance, technology and finance to ultimately develop an action agenda for the transition to a sustainable ocean economy. The goal and foundation of the Panel is partnerships, which are essential for cooperation. The Ocean Panel Secretariat, based at the World Resources Institute (WRI), supports analytical and scientific work, communication, and stakeholder engagement.

**https://www.oceanpanel.org**

### *CREO Syndicate*

CREO is a New York-based non-profit organization that aims to invest and catalyze USD 1 trillion of capital in climate and sustainability solutions by 2025 to create the transition to decarbonization. The goal is to attract capital that will drive the necessary transition to a low-carbon, sustainable and prosperous future for all.

CREO is a think-and-do tank providing research and analysis, peer and expert knowledge building, strategic networking and contracting to maximize positive environmental impact through investment. The impact goals are to reduce GHG emissions, remove carbon, conserve biodiversity, improve resource management and circular economy. The main sectors are energy, transport, built environment, chemicals and materials, food and agriculture, aquaculture, forestry, waste management and water.

**https://www.creosyndicate.org/**

### *Builders Initiative*

Builders Initiative is an investor and advocacy community that works with non-profit organizations and helps with investing in companies committed to sustainable solutions to social and environmental challenges. The investments are both philanthropic in scope and designable for impact investors. The initiative focuses on four thematic segments, one of which is the Ocean Economy. Here, alongside renowned partner organizations (WWF), the focus is on finding interesting and promising impact investment opportunities and philanthropic projects.

**https://www.buildersinitiative.org/**

### *1000 Ocean Startups*

1000 Ocean Startups is a coalition to accelerate ocean impact innovation. The initiative was composed of incubators, investors, matching platforms, and VCs supporting ocean impact startups. The goal is to create at least 1,000 transformative startups by the end of the Ocean Decade to restore ocean health and achieve SDG 14. The aim is to create synergies between participants in the network and report on the successes already achieved and the potential of new ideas and technologies to restore ocean health and stimulate investment in scaling for innovations that impact the oceans. The Coalition is working to fulfill its mission and respond to the changes recommended by the Ocean Panel. The Coalition is a founding member and implementing partner of the UN Ocean Decade Program.

**https://www.1000oceanstartups.org/**

### *Ocean Risk and Resilience Action Alliance (ORRAA)*

The ORRAA is a global multi-stakeholder initiative pioneering the development of innovative Blue Economy financial products. The platform is supported by various governments, investors, insurance companies and banks.

The aim is to develop investments that promote marine and coastal natural capital, reduce marine and climate risks, and strengthen the resilience of coastal communities. ORRAA's goals by 2030 are:

- Secure USD 500 million in investment in nature-based ocean solutions.
- Develop 50 new investable and scalable financial products to support these investments.
- Strengthen the resilience of at least 250 million people in communities that need to adapt to climate change.

The idea is to bring together the finance and insurance sectors, governments, environmental organizations, scientists, and communities adapting to climate change to secure a regenerating ocean for a resilient future (#BackBlue).

**https://www.oceanriskalliance.org/**

# 5 Regulatory and transformational developments for investors

Governments around the world are striving to implement the goals and targets of the **UN SDG (SDG)** through various initiatives and regulatory measures. In addition to the realignment of laws and subsidy flows, the financial sector and thus investors have a very important role to play in this.

> The engagement of private capital is indispensable. Together with public activities and regulatory measures the implementation of the global goals can become reality. In addition to the SDG as a target orientation, one of the most important structural factors is the overall planning of ocean use MSP. The driving regulatory measures are exemplified by the new European Action Plan.

## 5.1 Marine Spatial Planning (MSP) – Construction plan of the future of the Oceans

One of the most important decision-making factors for the development and promotion of the Sustainable Blue Economy is MSP. The MSP is a public process for analyzing and distributing the spatial and temporal distribution of human activities in marine areas to achieve environmental, economic, and social goals, usually established through a political process.

This provides the foundation for **new land use plans**, such as OSW farms, ports, but also for the planning of MPAs.

The Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) and the EC adopted a joint project plan in March 2017 to accelerate maritime/MSP processes worldwide. As a result of this partnership, the **International MSP Forum** and the **MSP Global Initiative** were established one year later.

The outcomes of this framework will be **a joint contribution of the IOC, UNESCO, and the EC** to the joint voluntary commitment #OceanAction15346 presented by both institutions during the UN Ocean Conference in June 2017. The plan is also an important contribution to the UN Decade of Oceans for Sustainable Development (2021–2030), adopted by the 72nd UN General Assembly on December 5, 2017.

The following priority actions are determined by the MSP Roadmap:

- **Transboundary MSP,**
- **Sustainable Blue Economy,**
- **Ecosystem-based MSP, and**
- **Capacity Building.**

Only if cooperation succeeds and a **globally binding utilization plan** is created can the necessary projects and measures for the transformation to a Sustainable Blue Economy become reality.

## 5.2 EU Green Deal, EU Action Plan, SFDR and EU Taxonomy – Fostering the Sustainable Blue Economy

The EU has an important global leadership role in the regulatory implementation of a financial transition. The regulatory changes described in the following chapter can mean a **complete transformation of the economy and the financial industry**, which will help to implement the Sustainable Blue Economy on a broad scale.

With the **European Green Deal**, the EC has proclaimed a comprehensive program in 2019 that aims to make the EU climate-neutral by 2050 and to promote a sustainable economy. As part of the European Green Deal and the EU's Sustainable Finance Strategy, there are a number of innovations designed to increase transparency regarding the inclusion of sustainability criteria in decision-making processes for investments. The three most important new EU regulations on corporate transparency are the Corporate Sustainability Reporting Directive (CSRD), the Sustainable Finance Disclosure Regulation (SFDR) and the EU Taxonomy for Sustainable Activities.

### *Sustainable Blue Economy in the EU Green Deal*

The EU had already set a clear agenda for the transformation of the Blue Economy towards a Sustainable Blue Economy by publishing in 2019 the EU Green Deal [59]. In 2021, the EC published an action plan based on the Blue Economy Report [60]. Here, specific targets and measures related to marine resources and economic sectors are defined.

The objective is, in addition to other climate-related measures, to utilize the resources of the oceans to contribute to achieving the goals for a more resilient and climate-neutral European economy.

The concrete measures and goals are:

- A **90 % reduction of GHG emissions from maritime transport**, which accounts for more than 80 % of global trade in terms of volume.
- **Decarbonizing maritime transport** (as well as fishing operations) will decrease GHG emissions, as well as air and water pollution and underwater noise.
- EU incentives for the **deployment of renewable/low carbon fuels** and onshore power supply in ports.
- **Minimizing the environmental impacts of fishing** on marine habitats with measures such as specifications for fishing gear and mesh sizes, closed areas, and seasons.
- **Recycling of large ships** a set of standards in the Ship Recycling Regulation will be launched
- **Expansion of ORE** will be supported by a new EU ORE strategy that aims to multiply five-fold the capacity for ORE by 2030 and 30-fold by 2050.
- **Transition towards a sustainable, low-carbon food system** in line with the EU farm-to-fork strategy, including through developing and promoting low-impact aquaculture (such as low-trophic, multi-trophic and organic aquaculture).
- Development of the **innovative sector of algae** is planned in 2022, which has the potential to become a significant source of low-carbon alternative food and feed materials.
- Developing nature-based solutions to adapt to sea level rise, depollute areas or fight eutrophication.
- Setting new marketing standards to improve consumer information on the environmental and social sustainability of seafood and its carbon footprint.

### *EU Action Plan*

On March 7, 2018, the EC released the EU Action Plan [57] for financing sustainable growth. The plan is generally to bring clarity to the financial market and at the same time reorient capital flows towards sustainable investments. It is an ambitious and comprehensive package of measures that includes clear specifications for the financial market and the design of financial products. The 10 actions relate to all financial market participants and areas of application of capital. By enabling investors to re-orient investments towards more sustainable technologies and businesses, the measures will be instrumental in reaching the global climate and environmental targets.

The resulting new regulation can also encourage large-scale investments in various types of sustainable economic activities, for example in infrastructure projects for energy, transport, and water management to halt climate change and protect nature/ecosystems by delivering a decarbonized, resource-efficient and circular economy. At the same time, different initiatives of European country governments are also going in the same direction, so that public money and private capital for transition support each other.

### *SFDR*

The SFDR, which started in March 2021 with the first reference period, is part of the EU Action plan and was created to help investors make better informed decisions. It establishes sustainability standards in the financial markets, whereby asset managers are required to avoid greenwashing financial products.

The required disclosures enable investors to compare ESG objectives of different financial products, gain valuable insights into risks and opportunities, effect real change on sustainability issues and achieve returns based on sustainable investments.

Almost one third (32 %) of all European fund assets are already classified as sustainable in the sense of Article 8 or 9 of the Disclosure Regulation.

### *EU Taxonomy*

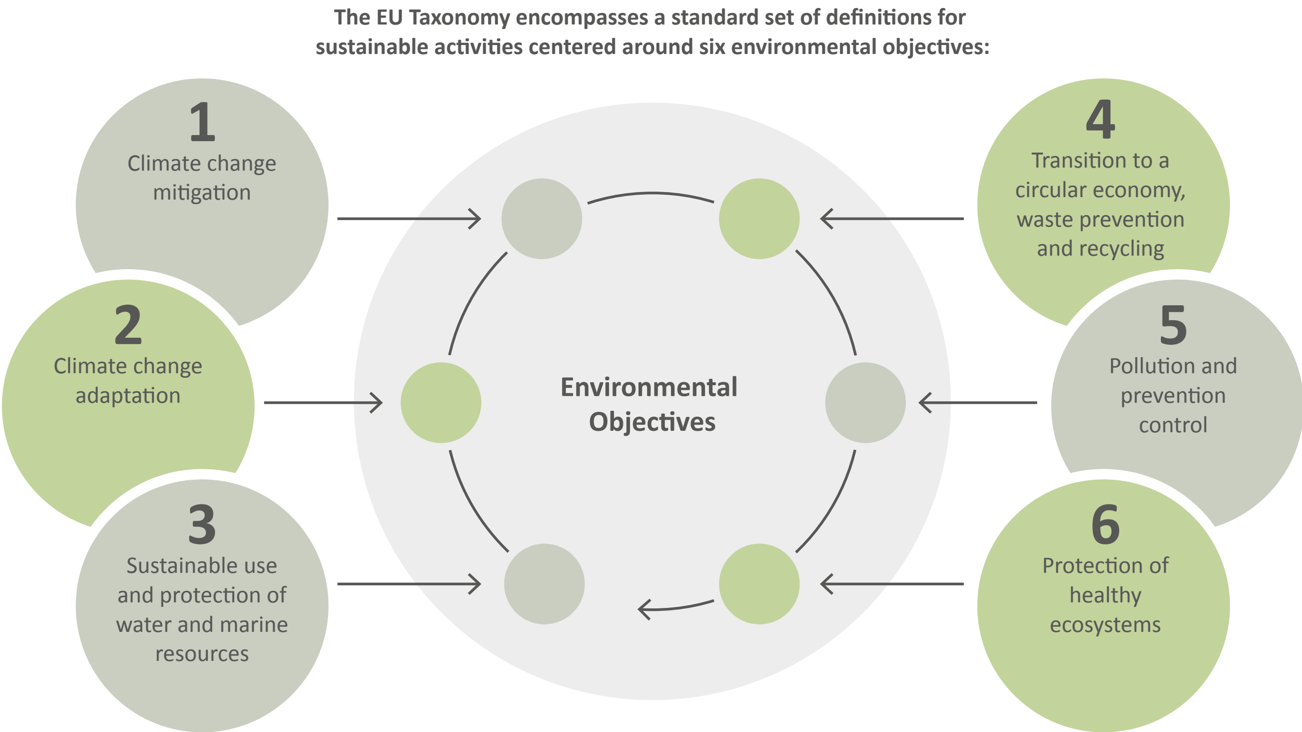
The EU taxonomy is the classification system for environmentally sustainability activities [58]. It plays a crucial role in expanding sustainable investment in Europe and implementing the European Green Deal. The EU Taxonomy provides companies, investors, and policymakers with appropriate definitions of which economic activities can be considered environmentally sustainable.

In this way, it should provide certainty for investors, protect private investors from greenwashing, help companies become more climate-friendly, mitigate market fragmentation, and help direct investment to where it is needed most.

The EU Taxonomy is an ambitious attempt to define these activities and the related technical standards for six environmental objectives (cf. Figure 17 [58]):

1. Climate change mitigation
2. Climate change adaptation
3. The sustainable use and protection of water and marine resources
4. The transition to a circular economy
5. Pollution prevention and control
6. The protection and restoration of biodiversity and ecosystems

*Figure 17: EU Taxonomy – Environmental Objectives*




Source: European Commission (2020, Sustainable finance taxonomy)

All environmental goals of the EU taxonomy can be directly supported by a shift towards a Sustainable Blue Economy. As described in the previous chapters, the use of sea-related economic activities, such as the cultivation of seagrass and algae, can make a significant contribution to the ambitious climate targets.

▶ The financial sector seems to be on its way to orienting its capital flows towards sustainable economic activities, however, implementation is more difficult than many players expected. The embedding of the activities defined in the EU Taxonomy is still partly failing due to a lack of verifiable KPI data.

▶ The assignment of the taxonomy to sustainable marine industries can lead to a significant growth and expansion of positive technologies and a comprehensive transformation of the marine sector.

**German Regulatory Initiatives – Maritime Agenda, Federal Maritime and Hydrographic Agency**

In addition to Europe-wide regulatory measures and changes in the financial world, there are further initiatives and institutions at country level that have a direct influence on the maritime industries. These are decisive for the concrete implementation even long-term planning of large-scale projects, such as OSW farms. Two examples from the German environment are mentioned exemplarily in the following:

- The **Maritime Agenda 2025** [61] of the German Federal Government defines the key goals, areas of action and proposals for coordinated measures that contribute to the sustainable use of the seas and a high level of protection and that also further strengthen Germany’s competitiveness in the medium and long term as a technology, production, and logistics hub. The aim of the Agenda is to formulate parameters that apply to the whole maritime sector for addressing key challenges such as the automation and digitalization of products and services, production and logistic processes, increasing competition on global markets, demand for skilled labor and demographic change, maritime security and increasing environmental and climate standards.
- The **Bundesamt für Seeschifffahrt und Hydrographie (BSH – Federal Maritime and Hydrographic Agency)** [62] is a higher federal authority within the portfolio of the Federal Ministry for Digital and Transport (BMDV). It is the public institution for maritime tasks. This concerns tasks such as averting dangers at sea, issuing official nautical charts and surveying tasks in the North Sea and Baltic Sea, as well as forecasting tides, water levels, and storm surges. In addition, the BSH is responsible for the surveying of ships, flag law, the testing and approval of navigation and radio equipment and the issue of certificates for seafarers. Regarding construction projects in the North and Baltic Seas, the BSH is responsible for spatial planning and for the testing and approval of power generation systems (OSW turbines), cables and other systems within the scope of federal responsibility. BSH is supporting shipping and the maritime economy while promotes sustainable marine use. Within the scope of their legal mandate, the BSH concentrate on safety and environmental protection and represent German interests internationally.

# 6 Investing in Sustainable Blue Economy – Opportunities, new technologies and high impact

The Sustainable Blue Economy is addressing the demand for and supply of financial capital for investment in ocean-related economic activities and governance. For the ocean economy to be sustainable, ocean finance must be **appropriate and geared towards sustainable use** and **management of the ocean** and its resources.

Marine finance plays therefore an important role in supporting sustainable development of the marine economy by investing in activities, policies, and measures that minimize marine risks and maximize social equity and environmental sustainability.

The opportunities of new technologies and high impact for a Sustainable Blue Economy in numbers [2, 5, 11]:

- double expected growth rate of the annual contribution to global GDP (today USD 1,500 billion)
- 80 % of goods exchanged globally by shipping
- 20 % growth of global fish demand by 2030 (30 million additional tons of fish per year)
- x15 increase of global OSW capacity to 2040
- 7–20 % growth per year of aquaculture economy
- USD 400–950 billion socio-economic benefit of the MPAs regeneration

Financial capital can be generally used in a variety of ways to support a Sustainable Blue Economy. Companies can use capital to **finance the development of more sustainable products and technologies** and to access new sustainability-friendly markets. Governments and non-governmental organizations can use the funds to **implement conservation measures** or to invest in strengthening the framework for the private sector to finance and insure sustainable economic activities in the ocean.

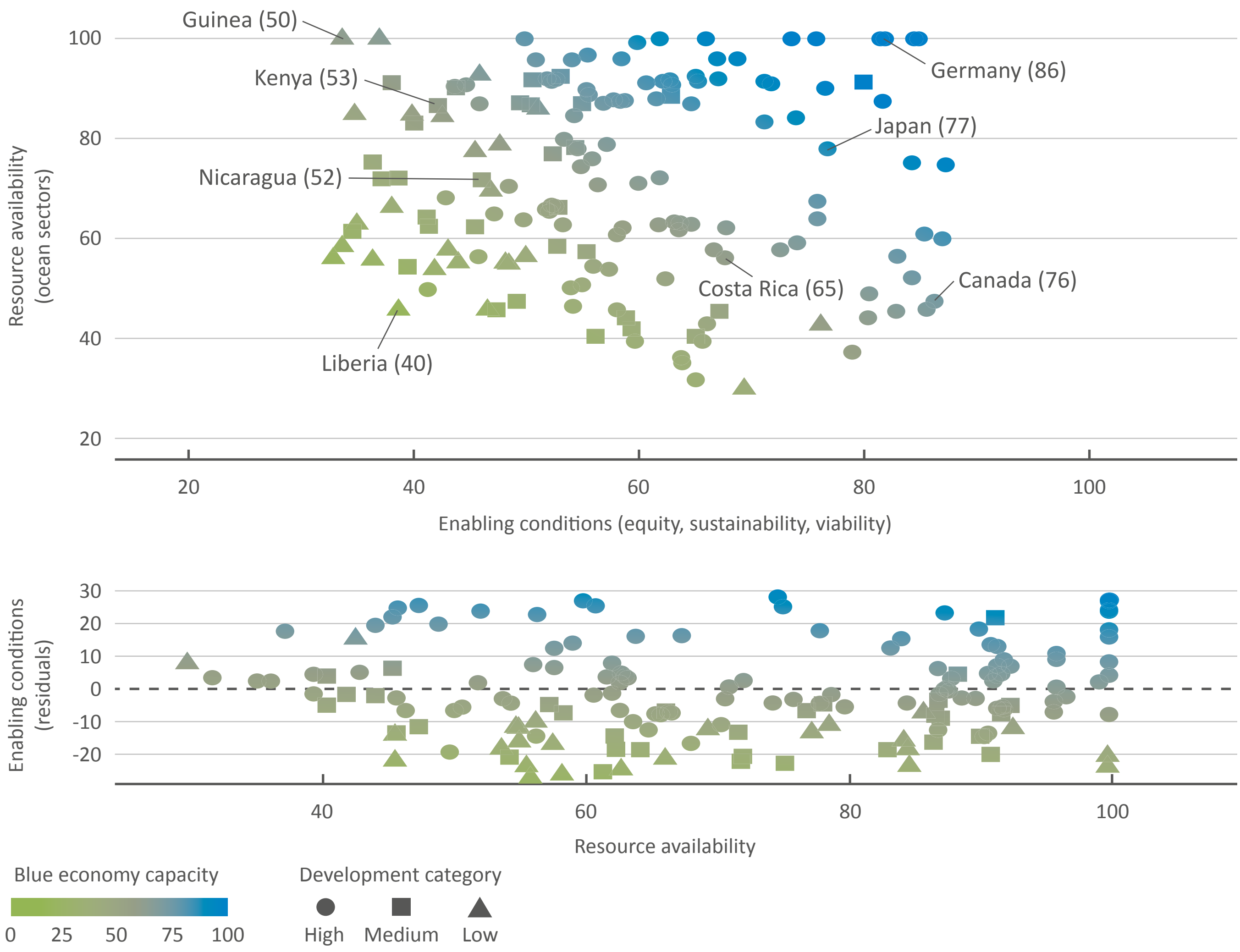
However, the **funding gap** for the conservation of all ecosystems, including funding for a Sustainable Blue Economy is estimated at **USD 300 billion** worldwide. Although its share has not yet been identified, the funding gap for oceans is likely to be very large.

A 2019 report by Libes and Eldridge found that SDG 14: Life Below Water, currently receives the lowest impact investment of all the SDG [63]. On a positive note, the overall **interconnectedness of marine ecosystems** and the global economy are becoming an increasingly important issue in the world of investment. Global transport, food and energy supply have become the focus of public attention.

The entire Biotech industry in Germany had in 2020 a turnover of EUR 6.49 billion with a growth rate of 36 % and about 37,415 jobs [64]. Notably, in the “Enabling conditions for an equitable and sustainable blue economy” study published in Nature, Germany was ranked worldwide **among the highest in all dimensions for its blue economy capacity** with respect to enabling conditions and resource availability [65]. Therefore, the Blue Economy in Germany offers interesting growth opportunities particularly within the emerging sectors and in global markets.

According to a recent study the economic activities in Germany of the maritime industry in 2020 **generate EUR 86.3 billion turnover** and a total of **449,800 jobs**. As a cross-industry sector, the total economic effect of marine technology in Germany, across various effects, adds up to EUR 34.2 billion in turnover and 180,000 jobs [66]. However, Blue Biotech is yet not considered as a separate category within this study.

*Figure 18: Resource Availability and Enabling Conditions Scores for Coastal Territories*




*Note*:

**Top figure 18 [65]:** Symbol shapes indicate UN HDI (Human Development Index) development category: circle, high and very high; square, medium; triangle, low.

Symbol colours indicate a higher or lower capacity to establish blue economy sectors that are equitable, sustainable and viable ('blue economy capacity'); some territories are labelled as examples.

scores do not reflect the current relative importance of oceans to particular territories

**Lower figure 18:** Indicates residual fits between enabling conditions and resource availability dimensions scores showing the effect on blue economy capacity scores.

Dashed line is at 0, showing the distribution of positive and negative residual values.

Source: Cisneros-Montemayor et al. (2021, Nature)

In the analysis of the **priorities of a long-term investment in a sustainable blue economy**, the distribution of resources and local availability must be put in relation to the development capacity of the individual countries. The figure above shows that natural resource availability is widely but unevenly distributed across the oceans. However, availability needs to be related to enabling conditions. Only the combination of high availability and the capacity to use these resources economically will lead to a fast positive transformation of the Blue Economy.

There are **widespread gaps in key enabling conditions** (e.g. economic and group equity, human rights protection, environmental regulations, infrastructure) required for sustainable and viable ocean development in many regions and development categories.

Some of the African countries (e.g. Guinea) have a high availability of resources, but a very low economic exploitation capacity. The Americas, Europe and Oceania generally had better results in terms of enabling conditions than in terms of resource availability, but factors such as infrastructure, economic equity can vary widely between and within countries.

Developed countries show very different resources and have mostly focused on sectors such as offshore wind and mariculture. Of particular note is the **position of Germany**, which has both very high resource availability and extensive potential for economic exploitation. The EU's comprehensive plans for the sustainable use of fisheries, aquaculture and algae can further expand this significant status.

In all regions, participatory development of contextual objectives and strategies could help align economic incentives and identify local investment needs. **Unequal local capacities** can lead to **unequal sharing of benefits** from such resources. Planning and developing ocean-based sectors can be particularly challenging due to the nature of ocean spaces. These challenges include highly interconnected and changing resources and impacts, often less well-defined responsibilities and accountabilities.

A particularly important aspect is the use of **technological innovations**. With their economic capacity and financial strength, industrialised countries are the **key drivers** of global transformation. Even if a developed country may have fewer marine resources, it can still make a significant contribution to less developed countries through its globalised economy and technological progress.

“

*We believe that the opportunity to drive the necessary change to create a sustainable and regenerative blue economy will come from the transformation of the existing industry – there is a huge swathe of investable growth stage companies out there. We will invest in these businesses and combine the best new innovations to build data lead, technology enabled, circular and regenerative by design industrial scale platforms throughout the blue economy – these platforms will be highly prized assets that will have a hugely positive impact on our ocean.*

Chris Gorell Barnes, CEO and Founding Partner Ocean 14

”

The conjunction of regional availability, the use of modern technology, local economic and political changes, and the global realignment of financial flows can lead to a **positive upward trend** in investment opportunities.

However, the translation into scalable and appropriate **investment vehicles** is **just beginning**.

Especially **infrastructure projects** that meet both the long-term return expectations and the risk profile of large institutional investors offer **particular opportunities**. The **debt financing** of these infrastructure projects is covered **by blue bonds**, which, similar to green bonds, represent a structured and highly targeted **impact investment** through their transparent project focus.

- The **public capital market** opportunities, those being **listed companies**, are still hard to pinpoint. Many companies that use and produce sustainable solutions for and with the Blue Economy usually have a very extensive product range, making the direct **impact on marine** issues **difficult to identify or measure**. The mutual fund sector is still underdeveloped.

- **Private market investments**, such as private equity (PE) or VC involve increased investment risks, but offer very **interesting investment opportunities** in new or at least transformable areas of the Sustainable Blue Economy.

At the same time, corporate sustainability criteria from the areas of ESG already play an important role in the investment decisions of many investors. Both the active investment or divestment decision and the shareholder engagement of shareholders will especially drive large and established companies towards a more sustainable and thus also partly more crisis-resistant orientation of their business activities.

This trend is clearly reinforced by the comprehensive **regulatory initiatives** at global, European, and national level, which specifically focus on the financial sector and regulated large investors. The overarching goal of the regulatory measures is to steer global financial flows towards a more sustainable economy by making the above-mentioned investing with ESG criteria mandatory.

The players of the Sustainable Blue Economy can benefit from this trend if they succeed in creating investment solutions that reconcile the conditions and restrictions of large investors with the needs and requirements of the transformation of the marine economy.

A special focus in long-term investments is always on the long-term risks, such as political and regulatory influence, price fixing of purchase contracts, default risks and technological risks. Here, cooperation between the public and private sectors can be a solution. Public institutions and banks can mitigate credit default risks, guarantee long-term contracts, cash flows and interest rates, and stabilize political decision-making paths.

## 6.1 Investment opportunities and structures

The transformation of large segments of the Blue Economy is progressing. Growing awareness of environmental impacts, economic efficiency and disruptive innovation are driving the development of sustainable technologies and business models. The Sustainable Blue Economy thus already offers a variety of promising investment themes and investment opportunities.

To obtain a first impression of which technologies and companies could be used in the various investment themes, the following overview apply to selected topics with an interdisciplinary function.

*Table 2: Investment Topics Overview*

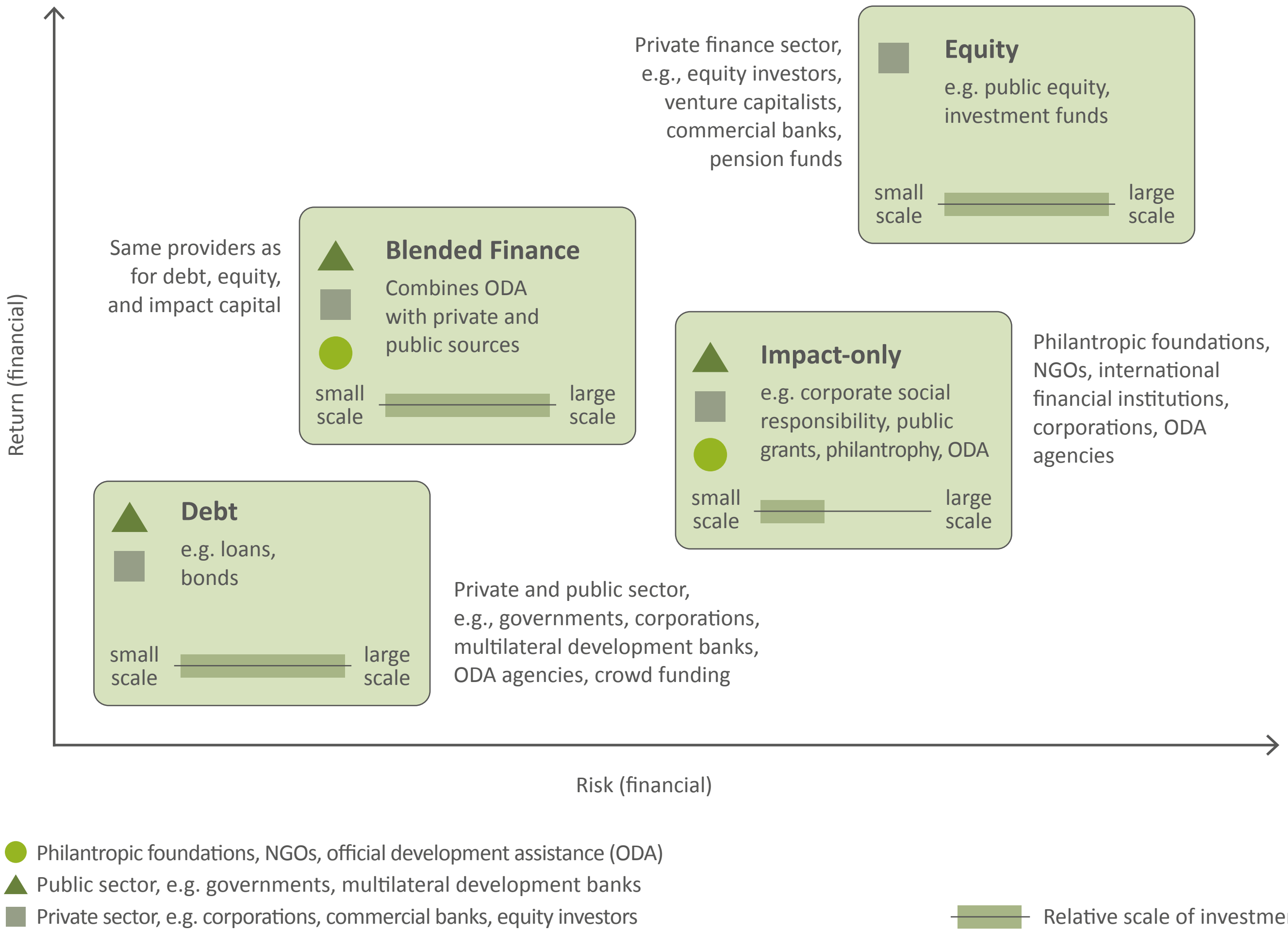
| | |
|---|---|
| **1. Climate Solutions:** | - Ocean afforestation (Seaweed, Seagrass, Mangroves, etc.)<br>- Blue Carbon Technologies<br>- Methods for Carbon Sequestration and Storage |
| **2. Marine Mobility** | - New Engine and Power Technology<br>- EV Ships<br>- Efficiency Technologies for Container Shipping<br>- Digitalization of Ship Equipment |
| **3. Marine Infrastructure/ Energy** | - OSW<br>- Floating OSW<br>- Wave & Tidal power<br>- Smart, Green Ports |
| **4. Marine Resources:** | - Sustainable Fishing Technologies: AI for Bycatch Management, Blockchain Technology for Net Tracking<br>- Seaweed Farms<br>- Regenerative Ocean Farming: Aquaculture (Land-based, Offshore, Deep-water Farms)<br>- Automation & Robotics in Fish Farming: Adoption of Sensors, imaging & monitoring Solutions<br>- Sustainable Aquafeed: Scaling alternative and novel Feed Ingredients<br>- Seaweed & Algae Commercialization: Food, Feed & Biorefining |

| | |
|---|---|
| **5. Marine Conservation** | - Coral Reefs Restoration (3D printing, etc.)<br>- Coastal Protection Projects<br>- Eco-tourism |
| **6. Pollution Reduction & Ocean Plastic** | - Recycling/Waste Management<br>- Environmental Services (Waste Collection Systems)<br>- Plastic Recycling Technologies |

Source: Lovelock, Duarte (2019, Dimensions of Blue Carbon)

In addition to innovative technologies and structural changes in marine industries, **adequate financing instruments in all different capital types (cf. Figure 19 [67])** must be created at the same time to generate the necessary financial capital needed for the transformation to a sustainable Blue Economy.

## *Figure 19: Characterization of Major Capital Types*




Source: Sumaila et al. (2021, Financing)

Selected examples of scalable and even existing investment solutions are described in the following chapters.

*Table 3: Overview of Asset Classes and Blue Economy Investment Themes*

| | | Investment Opportunties | | | | | |
|---|---|---|---|---|---|---|---|
| Asset Class | Explanation | Climate Solutions | Marine Mobility | Marine Infrastructure | Marine Ressources | Marine Conservation | Pollution controll |
| Blended Finance | Investment instruments that combine public and private capital of public & private financing | Blue Bonds (Public issuer) | | PPP Offshore Wind | | PPP Conservation Projects | |
| | | Blue Carbon Credits (Public issuer) | | PPP Coastal Protection Projects | | | |
| | | | | PPP Ports | | | |
| Private Debt, Credit / Loans | Provision instruments of debt or loan financing for companies or projects | Green Bonds | Green/ Blue Loans | Offshore Wind Debt | Private corporate debt | Eco tourism project debt | Private corporate debt |
| | | Blue Carbon Bonds | Green ship financing | Ports Debt | | | |
| | | | | Coastal protection Debt | | | |
| | | Blue Carbon Credits | | Wave/Tidal Power Debt | | | |
| Equity | PE: Seed / Venture | Ocean Afforestation | New Fuels | Carbon sequestation | High Tech for Fishing | | Plastic Technologies |
| | | Blue Carbon Technologies | New Engine Systems, Digitalisation | Tidal, Wave, Green Ports | Seaweed, Algue Farming, new Aquaculture | Eco tourism corporates | environmental services (waste collection systems) |
| | PE: Buy Out / Growth / Infra | Carbon Sequestation Projects | Shipping Efficiency, Logisitics tracking systems | Offshore Wind | Regenerative Aquaculture Companies | | recycling/ waste management companies |
| | Public Equity | | Shipping Companies | Wind Energy Companies | Fishing, Aquaculture, Marine Tech solutions | | Waste Companies, High Tech |

Source: FERI, 2022

## *6.2 Sustainable/Blue Bonds – Targeted impact opportunity with suitable size*

A special investment opportunity to support large scale capital flows towards a sustainable economy are so called "**Sustainable Bonds**". Growing awareness among stakeholders of the climate emergency has spurred the development of the Sustainable Bond market to the point where more investors now see it as an attractive alternative to conventional debt (cf. Figure 20 [70]).

*Figure 20: Development of Sustainable Bond Market 2021*


Source: Climate Bond Initiative (2021, Sustainable Bond Report)

The "**Sustainable**" or "**Labeled**" or "**Green**" or "**Blue**" or "**Impact**" Bonds are debt financing instruments issued by governments, development banks or even companies to raise capital from private investors to **finance environmental or climate-related projects**, like renewable energy or large environmental infrastructure projects. In addition to environmental project financing, there are of course also social project structures called social bonds.

Despite the fact that the lack of standardization of designations might lead to confusion, this new "instrument class" is showing strong positive momentum. All sustainable bonds have the advantage that the invested projects must always be described precisely and explicitly in the issuing prospectus and is usually also continuously monitored and reported on. This enables capital providers to invest in sustainable technologies and infrastructure projects in a targeted manner and according to their preferences and sustainability strategies, even if the bonds are issued by companies from other or rather "non-sustainable" sectors.

Claudia Kruse, Chief Responsible Investment Officer, APG:

"Sustainable ('labeled') Bonds offer ideal opportunities to combine long-term returns, scale suitable for pension funds and targeted impact."

"As the responsible manager of a very large pension fund, we face the challenge of finding investments that meet both our risk-return requirements and our need for substantial and measurable added value and impact on the environment or society. Sustainable bonds, or we call them 'labeled' bonds, offer a perfect way to combine the two.

For us, labeled bonds offer both a good and stable return for our pension fund participants and the targeted impact. APG is one of the largest investors in labelled bonds globally (2020: EUR 12.2 billion). Our engagement with companies and other stakeholders is a key driver for the development of the labeled bond market.

It is important for us to promote growth, but at the same time we want to maintain the integrity of the market. This also means that we need to remain vigilant against greenwashing. We help develop standards, including for labeled bonds, and ensure their quality. APG has championed the market for labeled bonds and will continue to do so, but we do not participate in every issue. We only invest if a labeled bond meets our risk, return, cost, and sustainability requirements."

**Labeled Bonds**: Bonds issued by companies, governments, and agencies for the financing of green, social, or sustainable (a combination of green and social) projects. For labeled bonds the same requirements for return, risk, and cost apply as for all our investments.

The **European Green Bond Standard (EUGBS)** is a voluntary standard to help scale up and raise the environmental ambitions of the green bond market. Its establishment was an item in the Commission's 2018 action plan on financing sustainable growth and is part of the European Green Deal.

The regulation of the green bond market also affects the **blue bond market** and helps to invest capital flows in a targeted and transparent manner [68].

The **Blue Bond** is the equivalent debt instrument issued by governments, development banks or even companies to raise capital from private investors to finance marine and ocean projects that have a positive impact on the environment, economy, and climate. **Government Blue Bonds** are used, for example, to finance special ocean-related large-scale projects of island states, such as the establishment and monitoring of MPAs. In the corporate bond sector, this source of debt capital is used to finance the following.

**The Climate Bond Initiative** recorded strong growth in **sustainable bond market** in its report from 2021, showing more than 16,000 GSS+ debt instruments with a cumulative volume of USD 2.8 trillion.

UN Global Compact believes that the **blue bond market** will see a similarly strong market development. [69]

An interesting example of a public blue bond is the Seychelles conservation and climate adaptation trust: The Government of the Seychelles entered a debt conversion program with the Paris Club (a group of 22 creditor countries), with the assistance of The Nature Conservancy. One of the conditions linked to the debt conversion was the development of the Seychelles Marine Spatial Plan. A new law was also passed to create the Seychelles Conservation and Climate Adaptation Trust (SeyCCAT) in 2015, which provides a well governed funding mechanism (USD 75,000 in competitive grants per year) for long-term financing of activities relating to the stewardship of Seychelles' ocean resources and Blue Economy. This has enabled the completion of projects that range from improving knowledge about the Seychelles artisanal fishery, to assessing the effectiveness of a Marine Park in protecting lemon sharks. We recommend that additional debt conversions be designed and implemented to support developing countries to implement ocean governance.

## *6.3 Blue Carbon credits – A solution for combating climate change*

The rise of the term "**blue carbon**" – **carbon captured and stored by coastal and marine ecosystems** – indicates a shift in understanding of the important, planet-saving role of the ocean in the fight against climate change. Consequently, "blue carbon" has slowly begun to permeate **business models** and **investment decisions** in a burgeoning blue technology sector.

As companies begin to reduce their GHG emissions and investors become aware of their potential impact on ocean health, many companies are turning to market-based approaches – particularly carbon credits. Once part of an underdeveloped and overly complicated system, carbon credits are now easier to manage.

These findings have encouraged CEOs of investment institutions to look critically at investments and more positively at market-based mechanisms to **mitigate climate change**. Governments are also putting pressure on large companies to achieve net-zero targets and become aware of their responsibilities regarding climate change. As a result, demand for **carbon credits** is expected to **increase 15-fold by 2030**, bringing the value of the carbon credit market to USD 50 billion, according to a 2021 McKinsey report [71].

A **carbon credit** is a transferable instrument that is certified by a third party, usually a government or an independent company. Each credit represents the reduction of one ton of GHG. Regulators then approve the development of the methodology and project design and monitor the results to approve a carbon offset project.

Companies buy credits to "offset" their emissions and use the credits to show their customers progress towards their net-zero targets. After purchasing credits, companies receive a certificate stating that they are responsible for a certain number of GHG reductions. As more and more companies **commit to net-zero targets** but are **unable to reduce** their GHG emissions "internally", they **turn to carbon credit projects** as a response.

Restoring a degraded coastal ecosystem through mangrove reforestation is an example of a blue carbon offset project. The reforestation of mangroves, which removes carbon from the atmosphere, also creates new carbon credits that enter the blue carbon market.

- VCs have invested **USD 150 million since 2014** in early-stage companies that monitor carbon capture and storage in oceans, land, and forests, according to Bloomberg NEF [72].

- Land-based companies working with certified carbon registries have traditionally received the most investment. However, angel investment groups that focus on the intersection of ocean, sustainability and innovation are currently on the rise.

Today, there are only **four major GHG crediting schemes** that can issue carbon credits after completing a rigorous verification process by an ISO-accredited third-party verifier: **Verified Carbon Standard (VCS), Gold Standard (GS), American Carbon Registry (ACR) and Climate Action Reserve (CAR)**. Credits are tracked across all registries so they are not double counted, and credits can be traded within their respective registry.

Although the first global carbon market scheme originated in the 1997 Kyoto Protocol, certain obstacles continue to prevent carbon markets from gaining momentum. Fundamentally, market failure in the carbon market is often due to a lack of access to information and price transparency. Supporters of the carbon market insist that increased competition will help the market find its natural price equilibrium. However, due to the **voluntary nature** of the market and the large number of unique projects, it is **doubtful** that market failures **can be corrected without policy intervention** at the global level.

The future of the Blue Carbon Market lies in the importance of the oceans to the global economy. The **Blue Economy contributes USD 2.5 trillion to annual global GDP**, while playing an essential role in reducing GHG and combating climate change. Blue carbon credits can provide a market-based solution to climate change, but they are not a panacea for the real challenge – reducing emissions. Cap and trade policies allow companies to continue emitting harmful $CO_2$ when they buy carbon credits, which can be a cheaper option than operationally reducing emissions. On the other hand, a market for blue carbon credits raises the **interest of private companies** and **philanthropic investors** and enhances awareness of the ocean's value in the fight against climate change. The monetization of ecosystem services can **incentivize companies** to **shift to climate-friendly practices** and stimulate blue-tech innovations and technologies, as well as increased investment in the ocean, leading to progress on SDG 13 and 14 [73].

## 6.4 Private Market Opportunities & Impact Investments

As shown in Table 3, private equity solutions (seed, VC, PE, infrastructure) offer the greatest diversity of investment opportunities. They provide the necessary startup financing for new technologies, are the most important financing basis for large-scale projects and thus pioneers, executors, and implementers.

There are, however, major challenges in this regard as well. Many of the necessary technological and structural changes operate in **underdeveloped and small-scale market segments**. As a result, there is a partial **lack of high-quality**, investable projects of an **appropriate size** and with an **appropriate risk-return ratio**.

Additionally, many marine interventions **require grant capital** with very low or no financial returns. Many projects that do generate a financial return are either still **too small** to be financially viable and have a **high risk-return profile** due to their relatively unpredictable conditions.

The higher risk profile of the marine sector is caused by a series of difficult framework conditions, such as the lack of international regulation in some cases, high administrative hurdles, political influence and countervailing commercial interests of established marine industries (e.g., the fishing industry).

To attract large-scale investments, it is crucial to find ways to mitigate these risks.

In addition to public-private partnerships and guarantees, marine insurance also offers a strategic solution for managing commercial risks for shipping, aquaculture, fisheries, and other offshore industrial activities. Nevertheless, especially infrastructure projects offer highly interesting, large investment opportunities that also meet the demands of institutional investors.

- ▶ Startup financing and the provision of VC for high-tech developments are a crucial factor in the transformation.

- ▶ Even though these investments have a significantly higher risk profile, their high growth and return potential, as well as high positive impact, are also attracting increasingly larger investors.

Even innovative financing solutions such as blockchain and tokenisation are already being developed for the financing of marine conservation projects and coastal protection. [77]

Specialized fund managers and pooled investment solutions offer a real opportunity to diversify risk, benefit from the expertise of the managers, and participate in the growing earnings potential.

Here are some examples of experienced asset managers and special Sustainable Blue Economy funds:

- Mirova Asset Management
- 8F Asset Management
- DNB
- Ocean 14 Capital
- Credit Suisse/Rockefeller Ocean Engagement Fund
- Blue Impact Fund
- AQUA-SPARK
- S2G VENTURES
- HATCH BLUE
- KATAPULT OCEAN

## 6.5 Public Markets Opportunities (Stocks/Mutual Funds)

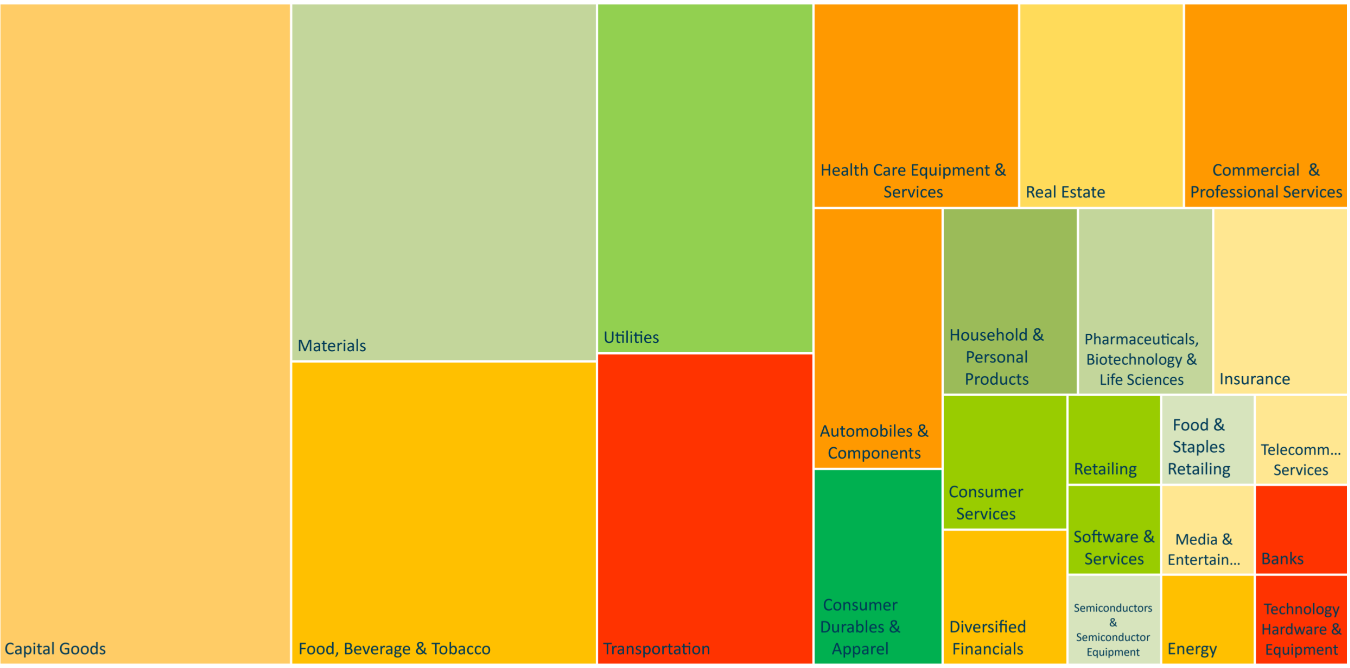
In principle, the relevant investment universe in the equity market and in liquid listed securities is still very limited. To date, research has identified only a **small number** of funds of well-known asset managers that clearly invest in the "Blue Economy" theme.

The funds invest predominantly in securities of **issuers** that have a **direct or indirect** connection to **marine or freshwater resources**. In this context, the Blue Economy primarily includes companies whose operations contribute to the **restoration, protection or maintenance** of diverse, productive, and resilient marine ecosystems or promote the availability of clean water and sanitation.

However, it also includes companies whose objectives are **linked to marine or water health**, or that are involved in managing water risks, or that have a clear intention to reduce risks to the marine environment or to make their businesses more solution oriented.

The following (cf. Figure 21) is an analysis of the universe of stocks in which various sustainable blue economy investment funds currently invest. The different sizes of the boxes represent the size/number of companies selected in the respective sectors. The different colors describe the average performance of the companies in these industries in relation to SDG 14. The transport industry stands out as a relatively large industry in the Blue Economy, with poor performance relative to SDG 14.

*Figure 21: Blue Economy Stocks – Size and Impact on SDG 14 by GICS Industries*




Source: FERI, Data by ESG Screen 17, 2022

From these findings, it can be concluded that the universe of available equity companies that make a positive and substantial contribution to the Sustainable Blue Economy may still be very expandable. It is currently difficult to define and measure exactly what contribution and impact the economic activities of companies have on the marine economy. In addition, companies are allocated that have a link to the Blue Economy only in small sub-segments of their service or product range.

Investing in equity companies also requires a very **precise and thorough fundamental analysis** of the **business model**, the effects of the **value chain** and, above all, the **strategic targeting** in terms of environmental responsibility and impact on the oceans. Available data and valuation models are still in their infancy but are also significantly driven by investor demand and regulation.

## *Mutual funds*

An analysis of the universe of available mutual funds has shown that there are only a small number products on the market so far that have an explicit reference to the Sustainable Blue Economy (registered in Germany).

The available mutual funds include actively managed equity funds and ETFs. The active funds have a very competitive management fee of less than 1 %, especially considering the recent development of this investment theme. Most of them were **launched between 2020 and 2021** and some of them already manage between USD **300 million and USD 600 million**.

Only a very limited number of funds have a valid track record though. All funds are classified as Article 8 under the EU Transparency Regulation 2019/2088.

In addition to the actively managed funds, there are also some thematic ETFs worth mentioning as of May 2022, though neither have a valid track record nor manage less than USD 20 million. Their investment strategy is based either on customized sustainable indices or indices explicitly geared to the Blue Economy.

The investment potential in the Blue Economy sector is only just beginning to develop. However, to record such high fund volumes despite a lack of track records and an almost completely untapped investment theme speaks for a **very high demand** on the part of investors. The tranches for private investors of ETFs are especially showing **rapidly increasing volumes**, and the pressure for returns is rising.

Important developments that could increase the relevance of this investment theme would be an increasing number of listed "**pure players**" in the Blue Economy sector, as well as the expansion of business activity of large, already existing, and investable companies. This expansion of investable stocks should strongly favor the launch of further interesting investment funds in this thematic complex.

Also, further sharpening of investment policies and an accompanying reclassification from ESG funds/Article 8 to impact funds/Article 9 could make such an investment **more palatable** to investors. This would make it clear that not "only" primarily ESG criteria are taken into account when selecting securities, but that there is a **clear focus on the economic activities of the companies**.

For interested investors who do not have the opportunity to invest directly in private markets, the public market increasingly offers exciting alternatives. Here, at least, it is worthwhile to continue to follow the development.

## 6.6 Role and challenges of large scale and institutional investors

Investors generally should rethink their strategy for long-term risk assets. The COVID19 pandemic and the geopolitical tipping point of the Ukraine war represent both a negative demand shock and a negative supply shock in macroeconomic terms. The drivers and breaking points of the global economy and global trade have been very evident in these two time-shifting events and will continue to change dramatically in the coming years. The focus is now much more clearly on which asset classes and companies offer the greatest resilience and rapid adaptability in the still uncertain and unstable market conditions.

At the same time, the industry of large investors, pension funds, and asset managers is also currently undergoing a transformation process. Due to **national and international regulatory initiatives**, they are obliged to integrate sustainability parameters and risks into their long-term investment policies (see Chapter 5.2). The orientation of the **investment objective** is being **expanded or realigned**. Regulated investors must assess **sustainability risks**, analyze and monitor whether the companies they invest in are causing **significant harm** to the environment, and set positive targets as well for the allocation of assets with a **positive impact** on the environment and society.

This not only means significant procedural change within the institutions but also entails far-reaching change processes among the invested companies. In particular, the companies in the marine and maritime industry must introduce **environmental protection measures**, more sustainable production processes, new **governance guidelines** and minimum social standards.

Concurrently, the projects and technologies of the Sustainable Blue Economy reveal highly interesting **strategic investment opportunities**. Disruptive processes create a **dynamic** environment and foster **innovative** and agile market players whose success and growth are positively supported by the feedback effects of aligning global capital flows with a Sustainable Blue Economy.

One could thus speak of an **internally and externally indexed turning point**. The three main drivers of institutional investment decisions – **return, risk, and regulation** – are supplemented by **sustainability aspects, risks, and opportunities**.

This "new" perspective not only uncovers new investment opportunities but also presents some inherent challenges and hurdles that need to be overcome.

**Requirements, obstacles, and solutions** of institutional investing in the sustainable Blue Economy are:

1. **Know-how and strategic decision-making:** many of the emerging investment areas are new to investors. Risks and long-term impacts are difficult to assess

   *Solution:* Start focusing on well-known asset classes and instruments (e.g., infrastructure projects, blue bonds.)

2. **Research and data:** Product markets are still underdeveloped, specialized managers are not yet numerous, market evolution and its risks are still poorly researched. Substantial information on impact and sustainability risks is lacking. (ESG and impact data)

   *Solution:* Take first steps in cooperation with specialized asset managers, companies and focus on clearly definable investments.

3. **Appropriate due diligence methodologies that consider impact and sustainability:** Screening, monitoring of companies and managers in the private market sector for sustainability is not yet established among many investors.

   *Solution:* Gradual build-up of in-house and external resources.

4. **High-quality investment opportunities with track record and size:** The selection criteria of professional investors always include a review of the managers' track record and experience. New funds and young asset managers are at a disadvantage here and are less likely to get a chance. The overall size of the projects and funds must fit the investors' requirements.

   *Solution:* Cooperation with established managers and overall consideration of the personal experience of the acting persons. Pooling solutions (specialized fund portfolios) for smaller projects and companies.

5. **Impact measurement and monitoring:** A special aspect of sustainable investment strategies today is also impact measurement, which is also required by regulation. This is one of the biggest challenges. New procedures, innovative technologies and comprehensive governance guidelines must be implemented at the companies and projects seeking funding.

   *Solution:* Cross-industry efforts are needed here. Global standards, such as the SDG, as well as established structures, such as IRIS+ measurement, provide initial approaches to solutions.

# 7 Measurement Challenges – How to Measure Impact and Credibility

The measurement and availability of data is one of the biggest challenges facing the marine economy. The sheer size of the oceans makes accurate measurement and verification of ocean related business activities almost impossible. Accurate data are scarce due to the lack of digitalization.

Nonetheless, not only the actual data availability of large parts of the Blue Economy sectors is insufficient so far: transparency regarding the sustainability of operating companies and projects can also only be measured gradually.

Only a small proportion of market participants are regulated and listed on the stock exchange and thus have to meet at least certain minimum standards of disclosure of their own practices. Valid information and data on compliance with environmental or social standards are not collected from the vast majority of stakeholders and involved parties.

## 7.1 Data and Traceability technologies – High-tech for transparency

According to the UNCTAD-report **Harnessing blockchain for Sustainable Development**, blockchain can be applied in solutions that contribute to the achievement of the Sustainable Development Goals. There are several examples of such applications, both in the context of developed and developing countries [74].

Many of the given examples – like for SDG14: "Rewards for protecting biodiversity for Australia"– are still in the pilot phase or have been deployed, yet no assessment of actual impact is available.

- The Commonwealth Bank of Australia, in partnership with BioDiversity Solutions Australia, has developed a prototype platform to facilitate the protection of environmental ecosystems, while also creating an alternative source of income for landowners and rewarding them for preserving biodiversity on their land and marine resources. The platform enables the creation of tradeable digital tokens named **BioTokens**, representing biodiversity credits for the Biodiversity Offsets Scheme of the government of New South Wales, within an efficient **blockchain-enabled marketplace** [75].

- Another example is **Fishcoin**, that incentivizes supply chain stakeholders to share data from the point of harvest to the point of consumption. To address the **fragmentation of most seafood supply chains** Fishcoin has been designed as a peer-to-peer network that allows independent industry stakeholders to harness the power of blockchain using a shared protocol so that data can be trusted, transparent, and secure [76].

The flow of digital vouchers (tokens) moves from buyers to sellers in supply chains, thus rewarding those who make the extra effort to capture and communicate data. This shifts the economic burden to downstream actors such as hotels, restaurants and retailers who benefit most from traceability.

Unlike many blockchain initiatives, Fishcoin is not based on a central company or entity. Instead, it is designed to be a **decentralized ecosystem** that **incentivizes data capture** so that an ecosystem of companies and 3rd party developers can benefit by adding value to the network.

These examples are intended to illustrate the innovative power that lies dormant in current technological developments. New data collection systems and innovative solutions for financing structures are opening up new markets. It remains to be seen how quickly a digital transformation of the Blue Economy can also lead to scalable results.

## 7.2 ESG and Impact data – The challenge of measuring

All investors in sustainable investments expect the operational implementation of corporate sustainability (ESG factors) and the impact of the investment to be measurable, verifiable, and reportable.

However, measuring the impact on nature and people poses major challenges for the entire industry. Impact assessment requires the consideration of entire impact chains. In the case of investments, this means that the impact along the entire value chain — the supply chain, production, further processing, use and disposal of the products and services — must be covered.

Corresponding assessment methods have so far only been applied by a few providers. Publicly available methodological bases are currently being developed, such as in the form of EU taxonomy (see chapter 5.2). This should help impact assessment to become more widely accepted in the coming years.

Nevertheless, the bulk of current sustainability analyses and ratings of companies is still predominantly based on traditional **ESG assessments and less impact-oriented measures**. Thus, although large and listed companies show the willingness and ability to integrate and improve environmental aspects, social standards, and governance processes in operational procedures over time. As a result, some companies that are rated quite positively according to ESG criteria may nevertheless pose **high transition risks** because their products or services are facing changes or even **disruptive developments** due to political, regulatory, or environmental decisions.

An additional challenge is that the known criteria and data on ESG-related factors usually do **not include ocean-specific analyses**. Measurement factors and data points that explicitly focus on a company's activity in the context of the blue economy or ocean-specific issues are scarce.

Impact measurement of the impact on ocean-related developments, such as fish stocks, marine biodiversity or even the overall ecosystem are still in their infancy or not available at all. The new **EU taxonomy** definitions offer a glimmer of hope, as they encourage companies active in the Blue Economy to make the impact of their activities on biodiversity and climate transparent.

**Large Scale Asset Owner Initiative for measurement and mapping of the SDG**

Building on earlier work by APG Asset Management om behalf of its clients including ABP (Dutch pension fund, AuM EUR 530 billion, 2021) together with PGGM (Dutch pension fund, AuM EUR 266 billion, 2021), the two pension investors together with British Colombia Investment Management Corporation (AuM USD 158 billion) and Australian Super (AuM USD 3.5 trillion) established the Asset Owner Platform for Investing into the SDG (SDI AOP) in 2020. The investors have developed the SDI Taxonomy & Guidance translating the SDG and its subgoals into investable opportunities to determine which companies contribute to the SDG with their products and services. These companies are than called "Sustainable Development Investments" (SDI). The SDI AOP provides a common definition, taxonomy, and data source for investments into the SDG, offering insights that can be used by investors to analyze, select and engage with their worldwide investments. The SDI classification focuses on companies' product and service-related contributions to the SDG, and is based on financial metrics, most often revenues. The Platform's goal is to help accelerate investments that contribute to the SDG and was established with the aim to standardize and create greater efficiencies for financial institutions who would like to commit to investing into the SDG. The SDI standard is now being used by investors with more than USD 10 trillion and the Platform's members actively contribute to advancing the standard further.

Speaking a common language also improves engagement with companies and eventually should drive more meaningful disclosures by companies. As asset owners report on the same basis on their investments into the SDG, their disclosures become comparable and provide stakeholders with more transparency. The SDI framework is gaining traction and leading the way as to how institutional investors can contribute to the SDG, as it has become available to the market for all investors to use.

# 8 Challenges for the Future and Tipping Points of Existing Systems

## 8.1 Key barriers of financing a Sustainable Blue Economy

There are some major obstacles to financing a sustainable marine economy. It is essential to find ways to mitigate them, to incentivize the kind of public and private investments needed for innovative technology and economical power in support of a sustainable ocean economy. [81]

The barriers and reasons for the funding gap are manifold and are caused by different factors and stakeholders and should be seen from multiple perspectives:

**Politics/Regulatory Transition:**

- Missing effective and stable Regulatory and Policy Environments
- Limited internationally binding Laws that are strictly monitored (see Fisheries)
- Wrong incentives by Taxation
- Detrimental or unstable Pricing Rules
- Harmful Subsidies
- Governmental Commitment

**Marine Projects/Corporate Requirements:**

- Conflicting existing Business Practices
- Lacking Sustainability Awareness (Profit vs. Environment)
- Grant Capital Requirements
- Very low, or no Financial Returns
- Small local Projects
- New Technologies still in the Trial Phase or lacking Scalability

**Investor Restriction:**

- Long-term Risks and fiscal Stability
- Lack of high-quality, investment-ready Projects
- Appropriate Deal Size and Instruments
- Matching Risk-Return Ratios
- Small number of Private-Public Partnerships (PPP)
- Shortage of Risk Mitigation Tools (insurance, PPP)
- Knowledge and Appetite of "special" Investment Topic and Technologies

**Lack of Data and Measurement**

- Global Marine Data Infrastructure
- Compliance Audit Data
- Impact & ESG Measurement

To turn challenges into opportunities, intensive cooperation is needed, especially between the public and private sectors. New financial instruments and concepts, legislation, insurance, tax, and market incentives need to be created to mobilize new capital. By providing clear **principles, frameworks, guidelines, and metrics**, and proactively avoiding known illicit and harmful activities, significant amounts of funding would be redirected and bring about long-term and positive systemic change.

Seagrass Industry Challenges: As a concrete example, the seagrass industry can be highlighted here. Main hurdles of this promising industry are related to regulatory constraints: for instance, seaweed production license requests are evaluated against inappropriate criteria combined within complex to navigate and lengthy processes. While stimulating supply and demand for high value-added seaweed crops and outputs at the same time, a necessary scaling-up to reach a competitive cost base is needed. Three elements are critical to allow the European seaweed industry to enter this scale-up / fast growth cycle: de-risking mechanisms, offtake agreements and vertical integration [31].

Furthermore, a necessary change of paradigm from harvest to culture is required along with a cultural change among the different economic actors of the blue economy.

- A significant and general challenge of the Blue Economy is sheer size. The unevenly distributed capacities of the blue economy, the extremely diverse framework conditions (social, economic, environmental) and the concentrated availability of resources unfortunately often cause community efforts and international initiatives to fail due to local circumstances, laws, or conditions.

According to an article by Andrés Cisneros-Montemayor in the journal Nature, one of the main obstacles to achieving a blue economy is **societal and economic** and, interestingly, rather less environmental.

- First, natural resources are widely but patchily distributed across the oceans, so **not** many areas will be able to **competitively develop multiple sectors** simultaneously.

  Prior research has shown that development based on living marine resources—including blue carbon, ecotourism, fishing, and mariculture — can be important at local scales but may not be ecologically sustainable or socially desirable at larger scales. In these cases, stakeholders may feel misled by growth projections revealed to be unattainable.

- Second across regions and development categories there are **widespread gaps** in **key enabling conditions** (for example, economic and group equity, protection of human rights, environmental regulations, infrastructure) needed to ensure equitable, sustainable and viable ocean development.

It is these socioeconomic and governance factors related to enabling conditions—and not available resources—that account for the most differences in the current capacity of geographic or jurisdictional areas to establish sectors consistent with a blue economy, but they are also ones that can be addressed by targeted investment [78].

## 8.2 Drivers and tipping points of implementation

The ocean, driven in part by technological innovation, is widely seen as the next economic frontier and the solution to sustainable human development. However, this development is taking place in a complex and uncertain governance landscape, and concerns have been raised about what this new ocean reality will entail and who it will benefit [80].

Therefore, one of the most important key factors is **international legislation**, clear **guidelines** and **control processes** and **mandatory compliance** with the guidelines and commitments, both countries and the participating companies.

The **tipping point** of this stricter legal framework could be the **emerging transformation of the financial industry**, which is demanding a change towards more sustainable corporate responsibility due to its own regulatory requirements and risk aspects.

The conversion point in the **availability of investable projects**, companies or instruments is proving to be the most diverse, as different economic segments also offer very different investment options.

While many large-scale projects in the field of renewable energies are emerging in the **marine infrastructure segment**, the investable solutions in **innovative technologies** or in the field of marine resources (algae, fish, biotech) are still very young, small, and hence riskier.

The risk-return profile of Sustainable Blue Economy investment opportunities is determined by

- new regulatory frameworks,
- concerted cooperation between public guarantors and private investors, and
- the degree of predictability of conditions under which the maritime sectors of the economy operate compared to those on land.

A particularly important aspect of predictability and risk control is of course the availability of **data**.

A more detailed **examination of the value** of marine services and activities – with **econometric estimation and attribution of specific data flows to economic performance** – would support the move towards a sustainable blue economy [79].

**Tipping points and crucial transformational paradigms**

- Geopolitical development and energy prices drive innovation growth in marine engine solutions
- Maritime goods transportation is demanding high numbers of modern transport vessels
- Smart, green ports play a big role for a more efficient and sustainable maritime economy
- Floating OSW energy is superior to fixed OSW energy in terms of scalability
- High tech innovations on generating renewable energy are on the rise
- Algae as a climate solution: technology can help harness algae's ability to capture and sequester carbon, scaling, and commercialization is under development
- Novel ingredients from the sea play a major role as a sustainable and commercially viable feed alternative as well as valuable biotech solutions.
- Expansion of the use of digital solutions to improve water quality, health and well-being, and increase efficiency in marine operations.
- Increasing use of data collected through sensors, imagery and monitoring to measure control processes, operational efficiencies, and environmental conditions.
- Development of sustainable innovations in aquaculture, such as automation to optimize labor costs and reduce environmental risks, as well as the use of alternative feed materials and feeding methods.

**"Internet of Things" for the Oceans – Marine High-tech and Digital Solutions**

Currently, there is an explosion of new data and technologies for the ocean in high-tech areas such as drones, satellites, and autonomous vehicles, as well as data analytics, AI and blockchain. Coordinated efforts by industry, research and governments are underway to create advanced sensor networks that provide high-resolution, real-time information as an "Internet of Things" for the ocean. To capitalize on the data and technology revolution, breakthroughs are needed to overcome technical and non-technical barriers and create a digital ecosystem for the ocean.

**High-frequency Radar for Fish Tracking:** The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) uses high-frequency (HF) radar data to understand the relationship between the sea state and the small Pacific bluefin tuna (< 30 kg) catch by the setnet to alert the local fishers of the potential risk of young tuna entering their setnets in large numbers. [82]

**New Energy from Temperature Difference:** Founded in 2012, Seatrec was set up to commercialize technology developed at the NASA Jet Propulsion Laboratory. Seatrec aims to harvest clean, renewable energy from naturally occurring environmental temperature differences to power scientific research, industry and defense in remote, off-grid locations both at sea and on shore. [83]

**Automated Data gathering of Seafloor:** 95 % of the world's oceans remain unmapped. Xocean runs a platform that gathers data for survey companies and other organizations, using unmanned surface vessels (USVs). Xocean operates 24/7 and gathers data to support the sustainable economic growth of the ocean. [84]

**Big Data for Vessel Monitoring:** ioCurrents provides data analytics to maritime vessels through two main components – an onboard mini-computer that collects and analyses data locally, and a remote analytics cloud platform. [85]

**AI for Shipping Security:** Orca AI's main goal is to prevent marine collisions by using AI to reduce human error, which accounts for 75pc of collisions at sea, according to the start-up. The startup, founded in 2018, uses AI and vision sensors to detect and identify possible obstructions, informing crew of the distance between the ship and a potential hazard. [86, 89]

**AI/Underwater Satellites for Pollution Tracking:** Planblue builds a global seafloor database with the use of underwater satellites. Planblue uses hyperspectral and RGB imaging with underwater navigation and AI to scan and map the seafloor automatically. Users can train the system to identify and map plastic waste pollution on the seafloor, the effectiveness of seafloor restoration efforts, and the impact of climate change. [87]

**Sensor Technology for Aquaculture:** Innovasea is startup that provides open ocean and land aquaculture solutions for sustainable food production. Innovasea's open ocean precision aquaculture solutions integrate hardware with intelligent sensors, cameras, and environmental monitoring systems while utilizing predictive modeling and machine learning to optimize food production. Further, the startup supports farmers with aquaculture intelligence and fish tracking that allow production process optimization, thus reducing overall costs. [88, 90]

“

*Financiers can help build resilience to these ocean risks by either redirecting investments towards more sustainable and equitable practices by deciding what to finance and under which conditions, or by unlocking capital and increasing finance where it is. Let's not forget that SDG 14 remains the least financed goal.*

Albert Norström, Head of Knowledge and Evidence, Stockholm Resilience Center [81]

”

“

*Governments, businesses, and financiers must come together with coastal communities to develop innovative financial projects and products that are relevant to the unique environments within which they are focused and garner economic returns from which coastal communities, especially SIDS and LDCs can benefit from.*

Karen Sack, Executive Director, ORRAA [81]

”

# 9 Conclusion

**Final theses:**

1. **The ocean and the sustainable blue economy play a significant role in combating climate change and actively reducing GHG emissions.**
2. **Large parts of the world's population depend on a functioning marine ecosystem.**
3. **The ocean offers an abundant variety of services and products that, if used responsibly, can provide huge benefits to climate, environment, people, and economy.**
4. **Innovative technologies, global demand changes and a shift in investor preferences will drive and foster the transition to a Sustainable Blue Economy.**
5. **This reveals a wide variety of attractive investment opportunities for strategic investors in a rapidly growing market.**
6. **At the same time, conventional blue economy industries face increasing disruption risks that should be explicitly assessed.**

The importance of marine ecosystems for both the global climate and economy cannot be underestimated and is currently being addressed in numerous policy initiatives. However, it is now undisputed that the ocean and its inhabitants are under massive pressure from the effects of human civilization: noise, pollution, and destruction.

At the same time, it is becoming increasingly clear that the Blue Economy based on marine resources can no longer be answered in the long term by the **massive exploitation** of planetary resources.

A **transformation of the core maritime industries**, such as shipping and fishing, and a substantial change in the way the marine environment is managed are urgently needed and are increasingly being initiated - not least through new political guidelines and technological innovations.

Simultaneously, the marine ecosystem offers **large-scale opportunities** for global **energy supply**, not least through its inexhaustible supply of wind, waves, and tides. As the need for alternatives to fossil fuels becomes more urgent, especially in today's world.

The potential of solutions for the sustainable use of **marine resources** is equally enormous. In addition to securing basic supplies for millions of people, there are **medical** solutions, technologies for the application and use of completely **new materials, alternative food** and – last but not least – the great **multiple benefits** of algae, seaweed, and marine plants.

Already today, the contours of a completely new Sustainable Blue Economy are emerging, which will function significantly differently from traditional structures.

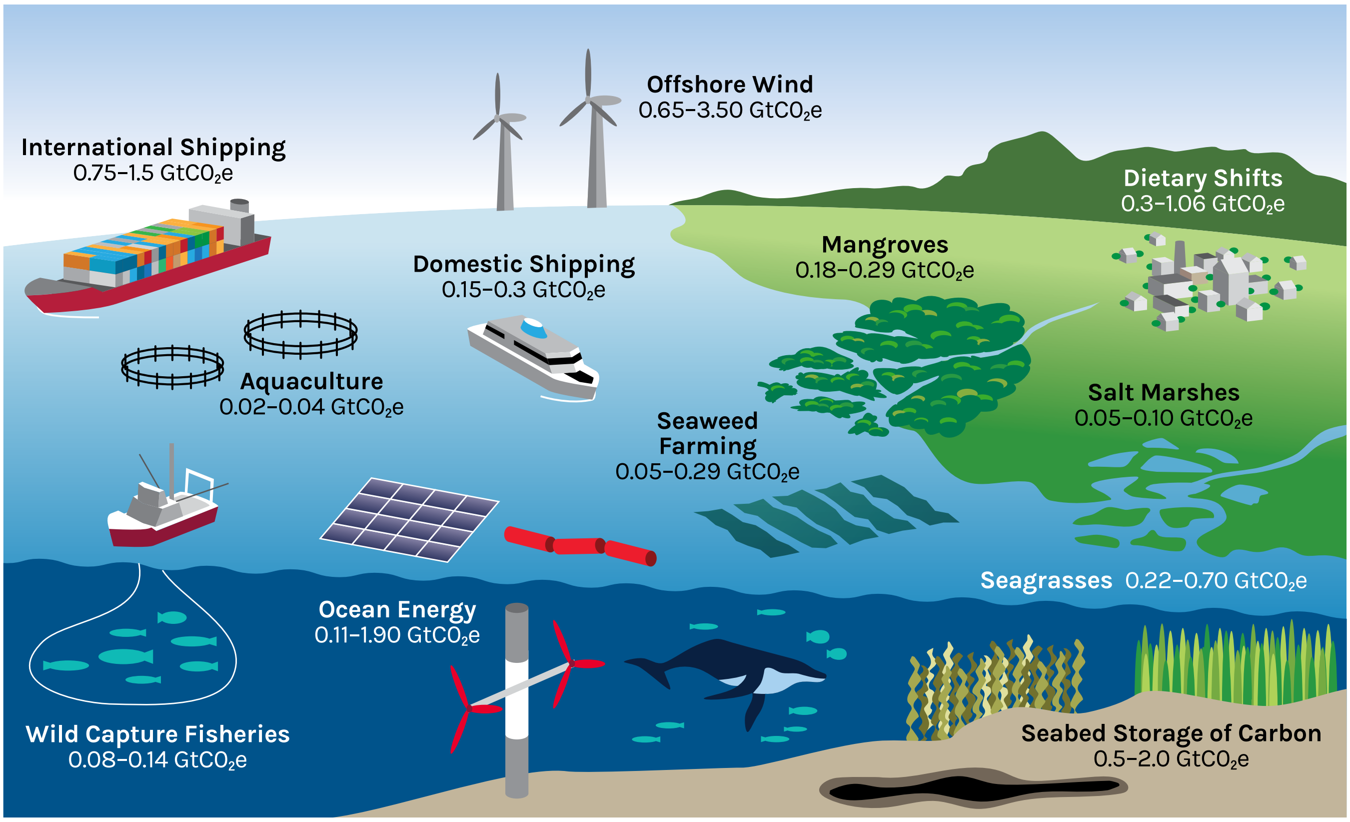
The diverse developments in the field of **innovative marine solutions**, like the use of ocean energy and new materials, will lead to massive changes due to very significant influencing factors at every stage of the value chain. Thus, the system of traditional marine industries is at the beginning of a drastic disruption and transformation.

The **key dynamics** behind this development are manifold and should be analyzed and understood holistically:

- The decisive factor for the change in the Blue Economy is the **paradigm shift in global climate and environmental policy**, with new societal demands for a sustainable future and necessary measures to address the climate crisis.

The tremendous importance of the Blue Economy, especially for **climate change mitigation**, is illustrated in Figure 22 [35]. It shows the savings potential of marine energy production and global shipping, as well as the importance of marine resources such as wild fisheries and aquaculture. The $CO_2$ values shown illustrate the reduction capacity up to 2050, with particular emphasis on the high potential for **carbon storage** in the seabed by seagrass and mangroves.

*Figure 22: Ocean-based Mitigation Options*




Source: Hoegh-Guldberg et al. (2015, Ocean Economy)

- The **global demand for energy** and the obvious benefits of using renewable ocean energy, combined with comprehensive policy and regulatory timelines, is acting as an accelerator for the expansion of wind and hydropower generation worldwide.

- The progress, penetration and interactive interaction of the **new technologies** that are already driving the advance of a more **sustainable production of fish, algae, new materials, and energy** represent great potential for investors.

- The targeted use of biotechnology, but also robotics, sensor technology, AI and the increased use of adaptive systems play an important and strongly synergetic role.

Long-term investors who want to make a significant contribution to climate protection and climate change mitigation should familiarize themselves with existing and emerging investment opportunities in the Sustainable Blue Economy. "New" asset classes such as carbon credits or blue bonds, marine infrastructure projects and innovative technologies not only open up interesting return opportunities, but also hold the potential to achieve a high positive impact on the environment and society.

As the results and key messages of this study clearly show, a broad spectrum of new approaches to these challenges and opportunities is currently developing with great dynamism.

## List of Abbreviations

| | |
|---|---|
| ACR | American Carbon Registry |
| AI | Artificial Intelligence |
| AOP | Asset Owner Platform |
| ASC | Aquaculture stewardship council |
| BMDV | Federal Ministry for Digital and Transport (Bundesministerium für Verkehr und digitale Infrastruktur) |
| BSH | Federal Maritime Agency (Bundesamt für Seeschifffahrt) |
| CAR | Climate Action Reserve |
| CBD | UN Convention on Biological Diversity |
| CEO | Chief Executive Officer |
| $CO_2$ | Carbon dioxide |
| CSR | Corporate Social Responsibility |
| DAO | Decentralized Autonomous Organizations |
| EC | European Commission |
| ECU | Emission capture and utilization |
| EIB | European Investment Bank |
| ESG | Environmental, social and governance |
| ETF | Exchange Traded Fund |
| EUGBS | European green bond standard |
| EV | Electric vehicles |
| FAO | Food and Agriculture Organization of the United Nations |
| FTE | Full-time employee |
| GHG | Greenhouse gas |
| GICS | Global Industry Classification Standard |
| GS | Gold Standard |
| GW | Giga watts |
| GWh | Giga watt hours |
| ICSU | International Council for Science |
| IEA | International Energy Agency |
| IOC-UNESCO | Intergovernmental Oceanographic Commission of UNESCO |
| IPCC | Intergovernmental Panel on Climate Change |
| IUCN | International Union for Conservation of Nature's World |
| JAMSTEC | Japan Agency for Marine-Earth Science and Technology |
| KPI | Key Performance Indicators |
| LDC | Least Developed Countries |
| LNG | Liquified natural gas |
| MOC | Meridional overturning circulation |
| MPA | Marine protected area |
| M/S | Metre per second |
| MSFD | EU Marine Strategy Framework Directive |
| MSP | Marine spatial planning |
| MW | Mega watts |
| NFT | Non-fungible-Token |
| NGO | Non-Governmental Organization |
| ODA | Official development assistance |
| OECD | Organisation for Economic Co-operation and Development |
| ORE | Offshore renewable energy |
| ORRAA | Ocean risk and resilience alliance |
| OSW | Offshore wind |
| OTEC | Ocean thermal energy conversion |
| PE | Private Equity |
| pH | Potential of Hydrogen |
| PI | Principles for Positive Impact Finance |
| PPP | Public Private Partnership |
| PRB | Principles for Responsible Banking |
| PRI | Principles for Responsible Investment |
| PSI | Principles for Sustainable Insurance |
| PV | Photovoltaic |
| RGB | Red, Green, Blue |
| R&D | Research and Development |
| SBEP | Sustainable Blue Economy Partnership |
| SDG | Sustainable Development Goals |
| SDI | Sustainable Development Investments |
| SeyCCAT | Seychelles Conservation and Climate Adaptation Trust |
| SFDR | Sustainable Finance Disclosure Regulation |

| | |
|---|---|
| SIDS | Small Island Development States |
| SLB | Sustainability-Linked Bonds |
| SOA | Sustainable Ocean Alliance |
| SRIA | Strategic Research and Innovation Agenda |
| TCFD | Task Force on Climate-Related Financial Disclosures |
| TEU | Twenty-foot equivalent units |
| TWh | Terra watt hours |
| UK | United Kingdom |
| UN | United Nations |
| UNCTAD | United Nations Conference on Trade and Development |
| UNEA | United Nations Environment Assembly |
| UNEP | United Nations Environment Programme |
| UNEP FI | United Nations Environment Programme Finance Initiative |
| VC | Venture Capital |
| VCS | Verified Carbon Standard |
| WEF | World Economic Forum |
| WRI | World Resources Institute |
| WWF | World Wildlife Fund |

## Bibliography


[1] OECD (2016): The Ocean Economy in 2030. https://www.oecd.org/environment/the-ocean-economy-in-2030-9789264251724-en.htm. Retrieved on 28.04.2022.

[2] Hoegh-Guldberg, O. et al. (2015): Reviving the Ocean Economy: The case for action – 2015. WWF International, Gland, Switzerland, Geneva. https://www.worldwildlife.org/publications/reviving-the-oceans-economy-the-case-for-action-2015. Retrieved on 28.04.2022.

[3] UNEP FI (2021): Turning the Tide: How to finance a sustainable ocean recovery – A practical guide for financial institutions. Geneva. https://www.unepfi.org/publications/turning-the-tide/. Retrieved on 28.04.2022.

[4] Stuchtey, M., Vincent, A., Merkl, A., & Bucher, M. et al. (2020): Ocean Solutions That Benefit People, Nature and the Economy. Washington, DC: World Resources Institute. www.oceanpanel.org/ocean-solutionsjd. Retrieved on 28.04.2022.

[5] BNP Paribas (2022): The blue economy in numbers. DG Mare Blue economy, Europa.eu in bnpparibas-am.com/investing/the-blue-economy-in-numbers. Retrieved on 28.04.2022.

[6] Spalding, M. D, Brumbaugh, R.D, & Landis, E (2016): Atlas of Ocean Wealth. The Nature Conservancy. Arlington, VA. https://www.nature.org/content/dam/tnc/nature/en/documents/Atlas-of-Ocean-Wealth.pdf. Retrieved on 28.04.2022.

[7] World Ocean Review (2021): The Ocean, Guarantor of Life – Sustainable Use, Effective Protection. https://worldoceanreview.com/de/wor-7/. Retrieved on 28.04.2022.

[8] EC (2022): Coastal and maritime tourism. https://ec.europa.eu/growth/sectors/tourism/offer/maritime-coastal_en. Retrieved on 28.04.2022.

[9] Heinrich-Böll-Stiftung, University of Kiel's Future Ocean Cluster of Excellence (2017): Ocean Atlas 2017 – Facts and Figures on the Threats to Our Marine Ecosystems. https://www.boell.de/sites/default/files/web_170607_ocean_atlas_vektor_us_v102.pdf. Retrieved on 28.04.2022.

[10] IPCC (2022): IPCC Synthesis Report, 2014, 2021 and 2022.

[11] IPCC (2019): Technical Summary. In H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, et al. (Eds.), IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (pp. 39–69). Cambridge University Press, Cambridge, UK and New York, NY, USA. https://doi.org/10.1017/9781009157964.002. Retrieved on 23.05.2022.

[12] Instituto Antartico Uruguayo (2022): Why is it important? http://www.iau.gub.uy/?page_id=124&doing_wp_cron=1651152113.9110510349273681640625&lang=en. Retrieved on 28.04.2022.

[13] Talley, L. D. (2013): Closure of the global overturning circulation through the Indian, Pacific and Southern Oceans: schematics and transports. Scripps Institution of Oceanography, UCSD. https://doi.org/10.5670/oceanog.2013.07. Retrieved on 28.04.2022.

[14] World Ocean Review (2021): The Ocean, Guarantor of Life – Shipping at a turning point. https://worldoceanreview.com/en/wor-7/transport-over-the-seas/shipping-at-a-turning-point/. Retrieved on 23.05.2022.

[15] Statista (2022): Largest container shipping companies worldwide by total number of vessels. https://de.statista.com/statistik/daten/studie/12373/umfrage/fuehrende-container-reedereien-nach-anzahl-der-schiffe/#:~:text=734%20Schiffe%20besitzt%20das%20d%C3%A4nische,an%20zweiter%20und%20dritter%20Stelle. Retrieved on 28.04.2022.

[16] Hoegh-Guldberg, O. et al. (2019): The Ocean as a Solution to Climate Change. High Level Panel for a Sustainable Ocean Economy. https://oceanpanel.org/sites/default/files/2019-10/HLP_Report_Ocean_Solution_Climate_Change_final.pdf. Retrieved on 23.05.2022.

[17] Grubler, A., Wilson, C., Bento, N. et al. (2018): A low energy demand scenario for meeting the 1.5 °C target and SDG without negative emission technologies. Nature Energy 3, 515–527 (2018). https://doi.org/10.1038/s41560-018-0172-6. Retrieved on 23.05.2022.

[18] Ocean Panel (2019): The Ocean as a Solution to Climate Change https://oceanpanel.org/sites/default/files/2019-10/HLP_Report_Ocean_Solution_Climate_Change_final.pdf. Retrieved on 23.05.2022.

[19] World Ocean Review (2021): The Ocean, Guarantor of Life – The Ocean as energy source – potential and expectations. https://worldoceanreview.com/en/wor-7/energy-and-resources-from-the-ocean/the-ocean-as-energy-source-potential-and-expectations/. Retrieved on 23.05.2022.

[20] FAO (2020): The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. https://doi.org/10.4060/ca9229en. Retrieved on 23.05.2022.

[21] European Commission (2022): EU Marine Strategy Framework Directive (MSFD). https://ec.europa.eu/info/research-and-innovation/research-area/environment/oceans-and-seas/eu-marine-strategy-framework-directive_en. Retrieved on 28.04.2022.

[22] G20 Ministry of the Environment (2021): G20 Report on Actions against Marine Plastic Litter. https://www.env.go.jp/press/files/jp/117136.pdf. Japan.

[23] G7 (2018): OCEAN PLASTICS CHARTER. https://www.consilium.europa.eu/media/40516/charlevoix_oceans_plastic_charter_en.pdf. Retrieved on 23.05.2022.

[24] OECD (2016): The Ocean Economy in 2030. OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264251724-en. Retrieved on 23.05.2022.

[25] OECD (2019): Rethinking Innovation for a Sustainable Ocean Economy. OECD Publishing, Paris. https://doi.org/10.1787/9789264311053-en. Retrieved on 23.05.2022.

[26] OECD (2021): A new era of digitalisation for ocean sustainability? OECD Publishing, Paris. https://doi.org/10.1787/23074957. Retrieved on 23.05.2022.

[27] Nellemann, C., & Corcoran, E. et al. (2009): Blue Carbon - A Rapid Response Assessment. GRID-Arendal Report, United Nations Environment Programme.

[28] Lovelock C. E., & Duarte C.M. (2019): Dimensions of Blue Carbon and emerging perspectives. Biol. Lett. 15: 20180781. http://dx.doi.org/10.1098/rsbl.2018.0781. Retrieved on 23.05.2022.

[29] Duarte, C. M, Bruhn, A., & Krause-Jensen, D. (2022): A seaweed aquaculture imperative to meet global sustainability targets. Nat Sustain 5, 185–193. https://doi.org/10.1038/s41893-021-00773-9. Retrieved on 23.05.2022.

[30] Seaweed Europe (2021): Seaweed for Europe – Hidden Champion of the ocean. (https://www.seaweedeurope.com/wp-content/uploads/2020/10/Seaweed_for_Europe-Hidden_Champion_of_the_ocean-Report.pdf. Retrieved on 23.05.2022.

[31] Seaweed Europe (2021): Investor Memo – The case for seaweed investment in Europe. https://www.seaweedeurope.com/wp-content/uploads/2021/10/S4E-InvestorMemo-MainReport-16OCTOBER2021.pdf. Retrieved on 23.05.2022.

[32] UNCTAD (2021): Review of Maritime Transport. https://unctad.org/webflyer/review-maritime-transport-2021. Retrieved on 23.05.2022.

[33] Circular Carbon Chemistry (2022): With quantum chemistry and prominent investors to green methanol. Press Release. https://uploads-ssl.webflow.com/62386ab454a40d6f-52c39913/6244b80c7598dd2117ff8e6c_PM%20C1%20EN.pdf. Retrieved on 23.05.2022.

[34] Zhang Ying (2019): Phase IV of Shanghai Yangshan Deepwater Port | Touch Shanghai (shio.gov.cn). http://touch.shio.gov.cn/en/proposed-interviews/detailindex.aspx?id=160. Retrieved on 23.04.2022.

[35] Hoegh-Guldberg, O. et al. (2019): The Ocean as a Solution to Climate Change: Five Opportunities for Action. Report. Washington, DC: World Resources Institute. http://www.oceanpanel.org/climate. Retrieved on 23.05.2022.

[36] Ruff, R. (2016): State of the art for the use of marine hydropower. TU Darmstadt, Darmstadt

[37] Academic (2022): Gezeitenkraftwerk Sihwa.ho. https://de-academic.com/dic.nsf/dewiki/2379541. Retrieved on: 23.05.2022.

[38] Mueller, M., & Polinder, H. (2013): Electrical Drives for Direct Drive Renewable Energy Systems. https://www.sciencedirect.com/book/9781845697839/electrical-drives-for-direct-drive-renewable-energy-systems. Retrieved on 15.05.2022.

[39] Ghasemi, A. (2013): Computational Simulation of the Interaction Between Moving Rigid Bodies and Two-Fluid Flows. University of Massachusetts Dartmouth, Massachusetts. DOI:10.13140/RG.2.1.4518.9604. Retrieved on 28.04.2022.

[40] Simec Atlantis Energy (2022): Meygen. https://simecatlantis.com/projects/meygen/. Retrieved on 28.04.2022.

[41] Díaz, H., & Guedes Soares, C. (2020): Review of the current status, technology and future trends of offshore wind farms. https://doi.org/10.1016/j.oceaneng.2020.107381. Retrieved on 28.04.2022.

[42] Diaz, C., & Upton, J. (2021): The future of wind energy is floating turbines on the ocean, https://qz.com/2024592/the-future-of-wind-energy-is-floating-turbines-on-the-ocean/. Retrieved on 15.05.2022.

[43] IEA (2019): Offshore Wind Outlook 2019. IEA, Paris https://www.iea.org/reports/offshore-wind-outlook-2019. Retrieved on 23.05.2022.

[44] US Department of Energy (2021): Offshore Wind Market Report: 2021 Edition. https://www.energy.gov/sites/default/files/2021-08/Offshore%20Wind%20Market%20Report%202021%20Edition_Final.pdf. Retrieved on 23.05.2022.

[45] Rotter, A., Barbier, M., Bertoni, F. (2021): The Essentials of Marine Biotechnology. https://doi.org/10.3389/fmars.2021.629629. Retrieved on 23.05.2022.

[46] PharmaMar (2022): https://pharmamar.com/en/. Retrieved on 28.04.2022.

[47] ArcticZymes Technologies (2022): https://arcticzymes.com/. Retrieved on 28.04.2022.

[48] Lagosta (2022): https://lagosta.com/. Retrieved on 28.04.2022.

[49] OceanBasis (2022): https://www.oceanbasis.de/. Retrieved in 28.04.2022.

[50] ICSU (2017): A Guide to SDG Interactions: from Science to Implementation. [D.J. Griggs, M. Nilsson, A. Stevance, D. McCollum (et al.)], Paris.

[51] UN Ocean Conference New York (2017): Factsheet: People and Oceans. https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/05/Ocean-fact-sheet-package.pdf. Retrieved on 23.05.2022.

[52] Costello, C. et al. (2020): The future of food from the sea. Nature. https://www.nature.com/articles/s41586-020-2616-y. Retrieved on 25.05.2022.

[53] WEF (2022): The Global Risks Report 2022. ISBN: 978-2-940631-09-4. https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2022.pdf. Retrieved on 25.05.2022.

[54] UNEP FI (2021): Turning the Tide: How to finance a sustainable ocean recovery—A practical guide for financial institutions. Geneva. https://www.unepfi.org/publications/turning-the-tide/. Retrieved on 25.05.2022.

[55] Environment Assembly of the UNEP (2022): Draft resolution – End plastic pollution: Towards an international legally binding instrument.

[56] European Commission (2020): Open Consultation on the Blue Economy Partnership. https://ec.europa.eu/info/news/open-consultation-blue-economy-partnership-2020-nov-25_en. Retrieved on 23.05.2022.

[57] European Commission (2021): Overview of sustainable finance. https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/overview-sustainable-finance_en#action-plan. Retrieved on 23.05.2022.

[58] European Commission (2020): Sustainable finance taxonomy – Regulation (EU) 2020/852. https://ec.europa.eu/info/law/sustainable-finance-taxonomy-regulation-eu-2020-852_en. Retrieved on 23.05.2022.

[59] European Commission (2019): The European Green Deal. Brussels https://ec.europa.eu/info/sites/default/files/european-green-deal-communication_en.pdf. Retrieved on 23.05.2022.

[60] European Commission (2021): The EU Blue Economy Report. https://ec.europa.eu/oceans-and-fisheries/system/files/2021-05/the-eu-blue-economy-report-2021_en.pdf. Retrieved on 23.05.2022.

[61] Federal Ministry for Economic Affairs and Climate Action (2017): Maritime Agenda 2025 – The future of Germany as a maritime industry hub. https://www.bmwk.de/Redaktion/EN/Publikationen/maritime-agenda-2025.html. Retrieved on 23.05.2022.

[62] BSH (2022): About us. https://www.bsh.de/EN/The_BSH/About_us/about_us_node.html. Retrieved on 23.05.2022.

[63] Libes, L., & Eldridge, M. (2019): Who, what, where and how: 440 investors A deepening view of impact investing. http://investorflow.org/ wp-content/uploads/Investorflow-Report-440-Investors-March-2019.pdf. Retrieved on 23.05.2022.

[64] EY (2021): Biotech am Tipping Point. https://assets.ey.com/content/dam/ey-sites/ey-com/de_de/news/2021/04/ey-deutscher-biotechnologie-report-april-2021.pdf. Retrieved on 23.05.2022.

[65] Cisneros-Montemayor, A. M., Moreno-Baez, M., & Reygondeau, G. et al. (2021): Enabling conditions for an equitable and sustainable blue economy. Nature. https://www.nature.com/articles/s41586-021-03327-3. Retrieved on 23.05.2022.

[66] Bräuninger, M., Fiedler, R., & Friedrich, T. et al. (2021): Maritime Wertschöpfung und Beschäftigung in Deutschland. https://www.bmwk.de/Redaktion/DE/Publikationen/Maritime%20 Wirtschaft/Maritime-Wertsch%C3%B6pfung-Studie-Endbericht.pdf?__blob=publicationFile&v=10. Retrieved on 23.05.2022.

[67] Sumaila, U.R., Walsh, M., & Hoareau, K. et al. (2021): Financing a sustainable ocean economy. Nature Communication, 12(3259). https://doi.org/10.1038/s41467-021-23168-y. Retrieved on 23.05.2022.

[68] European Commission (2019): European green bond standard. https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/european-green-bond-standard_en. Retrieved on 23.05.2022.

[69] UN Global Compact (2022): Blue Bonds: Accelerating sustainable ocean business. https://unglobalcompact.org/take-action/ocean/communication/blue-bonds-accelerating-sustainable-ocean-business. Retrieved on 23.05.2022.

[70] Climate Bond Initiative (2021): Sustainable Debt Global State of the Market. https://www.climatebonds.net/resources/reports/sustainable-debt-global-state-market-2021. Retrieved on 23.05.2022.

[71] Blaufelder, C., Levy, C., & Mannion, P. et. al (2021): A blueprint for scaling voluntary carbon markets to meet the climate challenge. McKinsey. https://www.mckinsey.com/business-functions/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge. Retrieved on 23.05.2022.

[72] Callens, J. (2021): The Role of Carbon Capture and Storage in Getting to Net-Zero by Mid-century: New Energy Outlook 2021, Bloomberg NEF. https://about.bnef.com/blog/the-role-of-carbon-capture-and-storage-in-getting-to-net-zero-by-mid-century-new-energy-outlook-2021/. Retrieved on 23.05.2022.

[73] Rose, A. (2022): Blue Carbon and Its Role in Combating Climate Change. https://impactentrepreneur.com/blue-carbon-and-its-role-in-combating-climate-change/. Retrieved on 23.05.2022.

[74] UNCTAD (2021): Harnessing blockchain for sustainable development: Prospects and challenges. https://unctad.org/system/files/official-document/dtlstict2021d3_en.pdf. Retrieved on 23.05.2022.

[75] Commbank (2019): Blockchain 'Biotokens' create new marketplaces for biodiversity investment and protection. https://www.commbank.com.au/guidance/newsroom/blockchain-biotokens-biodiversity-marketplace-201908.html. Retrieved on 23.05.2022.

[76] Fishcoin (2022): Seafood Traceability powered by Blockchain. https://fishcoin.co. Retrieved on: 23.05.2022.

[77] Moonjelly DAO (2022): Decentralizing Ocean Conservation. https://www.moonjelly.io/home?hsLang=en., https://drive.google.com/file/d/1R6p9cTtLNb7h2c6FKPp6wPXhtP8Dli5p/view. Retrieved on: 23.05.2022.

[78] Cisneros-Montemayor, A. (2021): The key barriers for achieving a Blue Economy are social and economic, not environmental. https://sustainabilitycommunity.springernature.com/posts/the-barriers-for-achieving-a-blue-economy-are-social-and-economic-not-environmental. Retrieved on 23.05.2022.

[79] World Ocean Initiative (2022): Value among the waves – The promise of ocean observation data for growth in the blue economy. https://ocean.economist.com/innovation/articles/value-among-the-waves. Retrieved on 23.05.2022.

[80] Jouffray, J.-B., Blasiak, R., & Nyström, M. et al. (2021): Blue Acceleration: An ocean of risks and opportunities. https://oceanrisk.earth/documents/ORRAA-Blue-acceleration.pdf. Retrieved on 23.05.2022.

[81] Stockholm Resilience Center (2021): Why the blue economy is at a tipping point. https://www.stockholmresilience.org/research/research-news/2021-10-20-why-the-blue-economy-is-at-a-tipping-point.html. Retrieved on 23.05.2022.

[82] Leape, J., Abbott, M., & Sakaguchi, H. et al. (2020): Technology, Data and New Models for Sustainably Managing Ocean Resources. Washington, DC: World Resources Institute. www.oceanpanel.org/ Technology-data-and-new-models-for-sustainably-managing-ocean-resources. Retrieved on: 23.05.2022.

[83] Seatrec (2022): Energy harvesting for ocean drones. https://seatrec.com/. Retrieved on: 23.05.2022

[84] XOCEAN (2022): Offering Ocean Data Collection as a Turnkey Service. https://xocean.com/. Retrieved on: 23.05.2022

[85] ioCurrents (2022): Optimize your fleet with purposeful digitization. https://iocurrents.com/. Retrieved on 23.05.2022

[86] Orca-AI (2022): Avoid Collisions, Save Lives. https://www.orca-ai.io/. Retrieved on 23.05.2022.

[87] Plan Blue Homepage: https://www.planblue.com/. Retrieved on: 23.05.2022.

[88] Innovasea (2022): Aquatic Solutions for Aquaculture and Fish Tracking.

https://www.innovasea.com/. Retrieved on 23.05.2022.

[89] Early, K. (2020): 7 start-ups with sights set on the seas. https://www.siliconrepublic.com/start-ups/7-start-ups-with-sights-set-on-the-seas. Retrieved on: 23.05.2022.

[90] Startups Insights (2021): Discover 5 Top Startups working to Restore Ocean Ecosystems. https://www.startus-insights.com/innovators-guide/discover-5-top-startups-working-to-restore-ocean-ecosystems/. Retrieved on: 23.05.2022.

## *List of Authors*

### *Antje Biber*

**Head of SDG Office, FERI AG**

As a member of the Management Board and head of the SDG Office of FERI AG, Antje Biber is responsible for the sustainability strategy and implementation of the FERI Group. Public commitment, knowledge transfer and the development of innovative consulting and investment concepts in the field of sustainable investments are core elements of her work. She is involved in numerous public initiatives, gives lectures and advises investors on their way to sustainability. All of which aim to promote sustainable financial activities and support the integration of SDG into the real economy and financial markets.

### *Dr. Steffen Knodt*

**Head of the Center for Sustainable Ocean Business, Fraunhofer IGD**

Dr. Steffen Knodt is the Head of the Center for Sustainable Ocean Business at Fraunhofer IGD in Rostock and Lübeck. He is an expert in the Blue Economy and holds a PhD in engineering from RWTH Aachen. Dr. Steffen Knodt worked over his career in applied research at Fraunhofer and industry at Hilti, Aker Solutions, Maersk, and Wärtsilä as well for the startup KLEO Connect. Currently, he is also advisor for the BlueTech startup platform SeaAhead. Dr. Steffen Knodt serves a member of the board in the German Association for Marine Technology GMT and in the board of the German Committee for the UN Ocean Decade of Science for Sustainable Development.

### *Prof. Dr. Martin Visbeck*

**Professor for Physical Oceanography, GEOMAR Helmholtz Center for Ocean Research Kiel and Kiel University**

Martin Visbeck is head of research unit Physical Oceanography at GEOMAR Helmholtz Center for Ocean Research Kiel and professor at Kiel University, Germany. His research interests revolve around ocean's role in the climate system, integrated global ocean observation, digital twins of the ocean, and the ocean dimension of sustainable development. He led the "Future Ocean" Network in Kiel to advance integrated marine sciences by bringing together different disciplines to work on marine issues. He serves on several national and international advisory committees including member of the Governing Board of the International Science Council (ISC), Joint Scientific Committee of the World Climate Research Programme (WCRP) and leadership council of the Sustainable Development Solutions Network (SDSN). Moreover, he was elected fellow of the AGU, AMS, TOS, and the European Academy of Sciences.

**The team of authors would like to thank the following people for the support and valuable input from Julia Bahlmann (FERI Cognitive Finance Institute) and Björn Traenckner (FERI SDG Office).**

# *List of Publications*
# *FERI Cognitive Finance Institute:*

## *Studien:*

1. Carbon Bubble und Dekarbonisierung (2017)
2. Overt Monetary Finance (OMF) (2017)
3. Die Rückkehr des Populismus (2017)
4. KI-Revolution in der Asset & Wealth Management Branche (2017)
5. Zukunftsrisiko „Euro Break Up“ (2018)
6. Die Transformation zu einer kohlenstoffarmen Wirtschaft, (2018)
7. Wird China zur Hightech-Supermacht? (2018)
8. Zukunftsrisiko „Euro Break Up“, 2. aktualisierte und erweiterte Auflage (2018)
9. Risikofaktor USA (2018)
10. Impact Investing: Konzept, Spannungsfelder und Zukunftsperspektiven (2019)
11. „Modern Monetary Theory“ und „OMF“ (2019)
12. Alternative Mobilität (2019)
13. Digitalisierung – Demographie – Disparität (2020)
14. „The Great Divide“ (2020)
15. Zukunftstrend „Alternative Food“ (2020)
16. Digitalisierung – Demographie – Disparität, 2. aktualisierte und erweiterte Auflage (2020)
17. „The Great Progression“ (2021)
18. „Blockchain und Tokenisierung“ (2021)
19. „The Monetary Supercycle” (2021)
20. Wasserstoff als Energiequelle der Zukunft (2022)

## *Cognitive Comments:*

1. Network Based Financial Markets Analysis (2017)
2. Zwischen Populismus und Geopolitik (2017)
3. „Neue Weltordnung 2.0“ (2017)
4. Kryptowährung, Cybermoney, Blockchain (2018)
5. Dekarbonisierungsstrategien für Investoren (2018)
6. Innovation in blockchain-based business models and applications in the enterprise environment (2018)
7. Künstliche Intelligenz, Quanten-Computer und Internet of Things - Die kommende Disruption der Digitalisierung (2019)
8. Quantencomputer, Internet of Things und superschnelle Kommunikationsnetze (2019)
9. Was bedeutet die CoViD19-Krise für die Zukunft? (2020)
10. Trouble Spot Taiwan – ein gefährlich unterschätztes Problem (2021)
11. Urban Air Mobility – Flugdrohnen als Transportmittel der Zukunft (2021)
12. „Longevity“: Megatrend Langlebigkeit – Die komplexen Auswirkungen und Konsequenzen steigender Lebenserwartung (2022)

## *Cognitive Briefings:*

1. Ressourcenverbrauch der Digital-Ökonomie (April 2020)
2. Globale Bifurkation oder „New Cold War“? (Mai 2020)
3. Digitaler Euro: Das Wettrennen zwischen Europäischer Zentralbank und Libra* Association (Dezember 2020)
4. Herausforderung „Deep Fake“ (Dezember 2021)
5. Geoökonomische Zeitenwende (April 2022)

More information and publications can be found on our website: www.feri-institut.de

Erkenntnisse der Cognitive Finance
ISSN 2567-4927

FERI AG | FERI Cognitive Finance Institute
Das strategische Forschungszentrum der FERI Gruppe
Haus am Park
Rathausplatz 8 – 10
61348 Bad Homburg v.d.H.
T +49 (0)6172 916-3631
umwelt@feri-institut.de
www.feri-institut.de

Fraunhofer-Institut für Graphische Datenverarbeitung IGD
Standort Rostock
Joachim-Jungius-Straße 11
18059 Rostock
www.igd.fraunhofer.de

GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel
Duesternbrooker Weg 20
24105 Kiel, Germany
www.geomar.de