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Institut Royal des Etudes Stratégiques
Royal Institute for Strategic Studies

THE OCEAN, A GLOBAL CHALLENGE AND SOLUTION

STRATEGIC REPORT 2022-2023

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Reading grid

The Royal Institute for Strategic Studies (IRES) 2022/2023 Strategic Report is produced in hybrid layout for the very first time: a Summary Report in both paper and digital versions along with a collection of supporting in-depth Wikis, published on the Foresight Intelligence digital platform.

For easier navigation between the Summary Report and the Wikis available on the IRES website:

- QR codes were included in the print edition alongside the relevant text. To access the reference documents directly, simply scan the QR code with a smartphone,
- Hyperlinks to the corresponding documents were included in the digital version

Terms with an asterisk (*) are defined in the online lexicon.

Legend :

Burgundy: Important elements
Bold: Titles and keywords
Blue: Hypertext links

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Liminary

Oceans are essential to the habitability of the planet. They regulate the Earth's climate and weather patterns, provide water that supports life, supply oxygen and food that sustain life at sea and on land, and perform a wide range of ecosystem functions. Oceans have absorbed some 90% of greenhouse gas-induced heat and 25% of human-induced carbon emissions to date.

The future of the ocean, mankind's collective heritage and lifeblood of our planet, today however, presents significant existential risk to the survival of living beings, at a time when, paradoxically, we need it more than ever.

The fact is that ocean health is deteriorating at an unsuspected pace. Little studied by scientists, hardly or not at all taken into account by politics, neglected by a consumerist civilization unaware of its vulnerability, the world's ocean is in distress.

The multitude of marine and coastal ecosystem services is deteriorating, coastlines are changing and water levels rising, hurricanes are intensifying as extreme climatic phenomena multiply, marine life is suffocating, toxic species proliferate and entire stretches of ocean no longer have the capacity to sustain life. Hence the urgency for robust, efficient and rapid solutions to this state of affairs, which is set to worsen irreversibly in the years to come.

How should we reconsider the Ocean issue in the face of multiple anthropogenic pressures and ongoing global warming? How should we embrace the scope of this matter in social, economic, geopolitical and governance terms? These are the questions that, to be resolved, first require understanding and knowledge of the Ocean, its workings along with man-made and natural disruption risks it faces.

Is there still time to act? The answer is yes, because the stakes are enormous and the ocean's ability to recover is remarkable. The Covid-19 pandemic proved that Nature is able to reclaim its rights and that self-purification of both air and water took place as soon as contaminating activities ceased in the initial phases of the global lockdown.

For if the ocean is the issue, it is also the solution: the only way to slow down climate change giving humanity the time to transform lifestyles and evolve into a civilization that is more responsible towards the planet and future generations.

Morocco, a maritime country, is affected in more than one way by the Ocean question. It cannot remain on the sidelines of global efforts to safeguard the ocean. The Kingdom needs to master the issues in order to fully commit Itself in the same way it has always done. Morocco never ceased to work towards a policy of sustainable development since the 1992 Rio Summit. The country thus pursued a strategy of regional and international cooperation.

As a State Party to the United Nations Convention on the Law of the Sea, which it ratified on May 31, 2007, the Kingdom also signed a number of international conventions for the preservation of marine environments and biodiversity and for the fight against global warming and pollution.

The willingness to join the global effort to combat climate change, which is responsible for ocean warming, permeates to the highest level of the State, as attested by the commitment and efforts of His Majesty King Mohammed VI, notably in:

- ''The Tangier Call'' for strong joint action in favor of the climate, launched on September 20, 2015, by the Moroccan Sovereign and French President François Hollande,
- adhering to the Paris Agreement and to the first ''Because the Ocean'' initiative declaration,
- organizing the COP 22 in Marrakech in November 2016,
- holding an ''Ocean'' thematic day at COP 22, on November 11, 2016 in the Green Civil Society Zone and a special ''Ocean Action Day'' on November 12, 2016 as part of the United Nations Global Action Agenda,
- launching programs and action plans as part of the process of adapting to climate change,
- developing renewable energies, which are expected to account for 52% of installed electrical capacity by 2030.

Morocco established itself as a naval power as early as the Middle Ages, thereby making its mark on history and engaging in trade with neighboring countries and faraway civilizations. The country holds a very special place in :

- the Mediterranean, as a common regional space of peace, stability and prosperity: strengthening the Euro-Mediterranean partnership should lead to reducing the development gap between its two shores.

The development of major infrastructure projects (Tangier-Med port complex, Nador free zone, ...) is part of ''Our strategic project that aims to make the Mediterranean space a powerful driver for national development and take-off, economic partnership and cultural interchange.''

Excerpt from the King's Speech during His Official Visit to the Oriental Region, March 18, 2003.

- the Atlantic is an international space intended not only to facilitate dynamic relations with the American continent but also to create a vast area of close interdependence with the countries of West Africa, particularly on matters of sustainable development and security :

''The Kingdom of Morocco, by virtue of its geostrategic position, could play a constructive role in the extension of the ''Maritime Silk Road'', not only towards Atlantic Europe, but also and above all, towards countries of West Africa, with whom My country holds multidimensional ties.''

Excerpt from the King's Speech addressing attendees of the China-Africa Cooperation Forum Summit, December 5, 2015

''We are committed to making the Moroccan Sahara an axis for trade and human interaction between Africa and Europe.''

Excerpt from the King's Message addressed to participants of the first African Congress ''Maintenance, Preservation of Road Heritage and Technical Innovation'', May 4, 2016.

In addition, Her Royal Highness Princess Lalla Hasnaa, Chair of the Mohammed VI Foundation for Environmental Protection and Patron of the Decade of Ocean Sciences for Sustainable Development Alliance, reiterated Morocco's commitment to achieving the objectives of this Decade, at the ''A Brave New Ocean'' high-level event, held on February 10, 2021, in conjunction with the Executive Council of the Intergovernmental Oceanographic Commission.

In the wake of Royal Guidelines, the Royal Institute for Strategic Studies (IRES) has paid particular attention to marine and maritime issues since 2015:

- Organizing an international meeting on the geostrategic stakes of maritime spaces, in November 2015.
- Drawing of the 2017 Strategic Report on ''Planetary stakes of the biosphere'', which highlights the ocean as a major breaking point in Earth's ecosystems.
- Hosting a day of reflection entitled ''The Strait of Gibraltar: issues, challenges''.
- Organizing an international conference on major issues and sustainable solutions for seas and oceans in February 2020.

Today, it has become more urgent than ever to recognize the global stakes at play for the future of the ocean and coastal areas, not only for sustainable development, but for the very survival of the human species.

This is why IRES, as is now the case with its strategic reports, chose to objectively address the issues to suggest possible response strategies and sustainable actions, in line with the development model outlined in its 2019/2020 Strategic Report.

The IRES 2022/2023 Strategic Report is Morocco's contribution to global reflection and action as part of the ''United Nations Decade of Ocean Sciences for Sustainable Development 2021-2030''.

Devised following the prospective meta-method (Understand, Anticipate, Propose), the present report is based on a new interpretation grid of the world, as adopted by IRES, resting on the five following pillars: refocusing on human beings, reconsidering Man's relationship with Nature, planetarization, exponentiality and governance. It consists of a Summary Report and a digital knowledge platform, comprising more in-depth articles, databases, graphics, videos and other resources.

This hybrid format meets the following four objectives :

- facilitate the appropriation of ocean issues by decision-makers by providing a synthesis of the essence of the analysis,
- enable students, researchers and professionals who require more detailed information to access IRES' extensive data and analysis library, available in the digital platform of this report,
- contribute to raising ocean literacy among young people, elected officials, members of civil society,
- placing the issue addressed in a long-term perspective by updating it over time on the dedicated website.

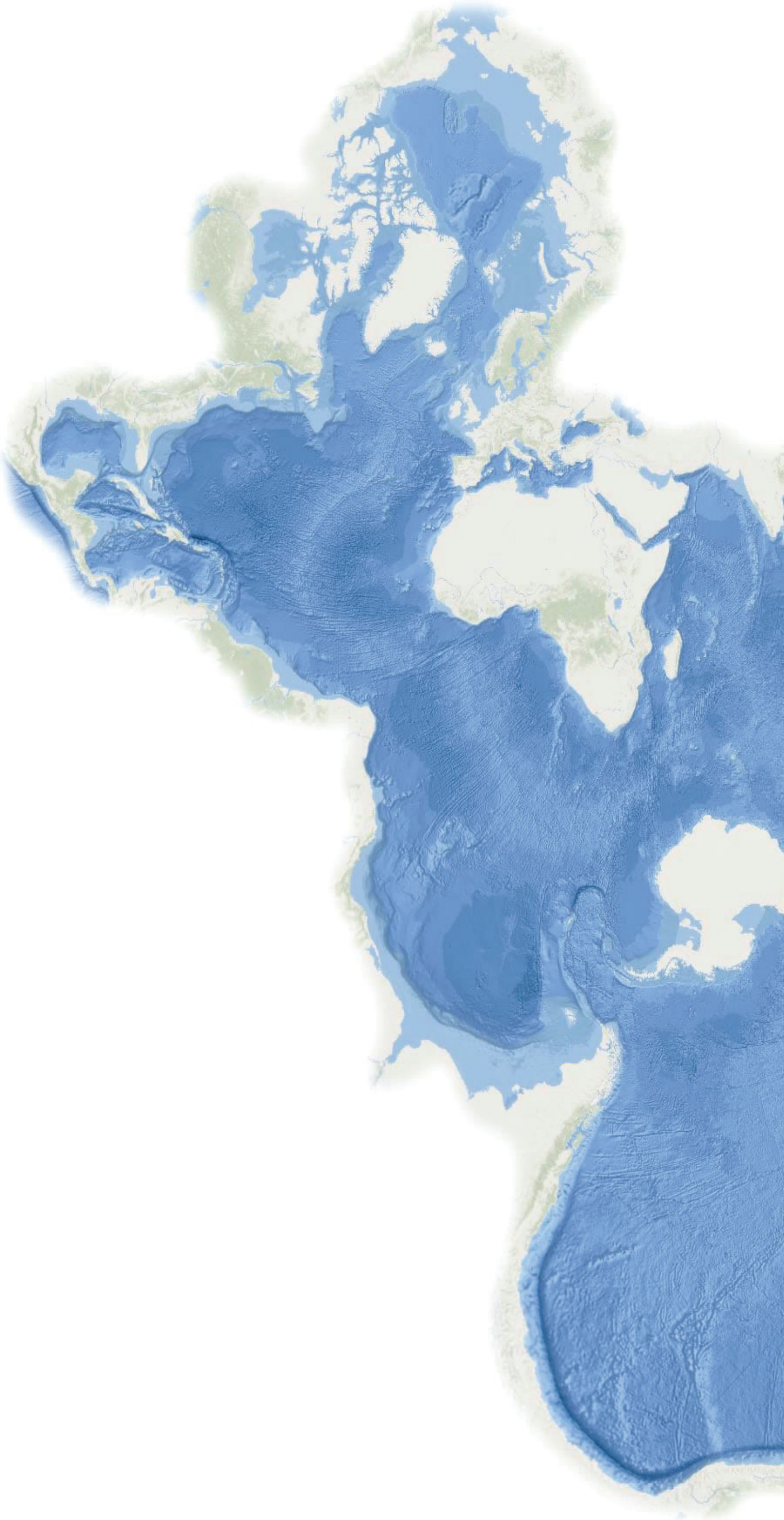
Intended primarily to gain an appreciation for ocean ecosystems as a global and worldwide system: the Ocean Sphere, the first part of this Strategic Report outlines the current status and conditions (Chapter 1) and foresees possible future developments (Chapter 2).

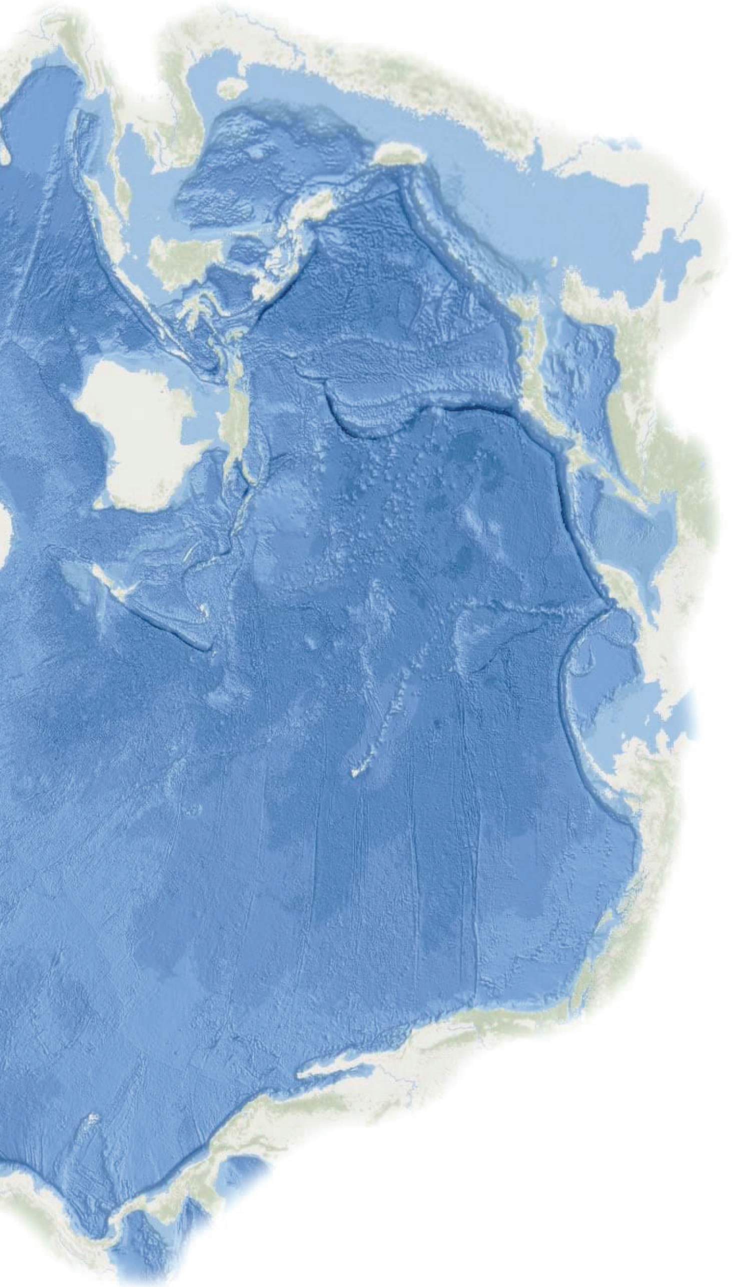
The second part highlights interactions binding humanity and ocean as an interface between nature and culture (chapter 1) and details the damage wrought on the ocean by humanity's recent economic development and potential knock-on effects to be faced in the coming century (chapter 2).

The third part offers solutions to remedy the situation, through reversing the dominant Anthropocene paradigm for a new approach to sustainability (Chapter 1), a significant advance in global governance (Chapter 2) and the ocean development of Morocco, as an aquapreneur, a country with its own vision of the future of the ocean, protector and entrepreneur of the aquatic world (Chapter 3).

Mohammed Tawfik MOULINE
Director General of the Royal Institut
for Strategic Studies

The Spilhaus map depicts the world's oceans as a single body of water.
Projet Spilhaus ArcGIS, CC BY-ND





PART I

The ocean's challenges

The ocean's immensity and inhospitality are behind the lack of knowledge we have of it. Its fauna, flora, geophysical and chemical mechanisms remain largely unknown. Although a component of planet Earth, the ocean can be viewed as a planet in its own right: everything about it is different.

From breathing to breeding, from communication to propulsion, its inhabitants and ecosystems are as foreign as those of Jupiter or Io..

The point here is to view the ocean as a new world to be explored, a highly interdependent, complex and difficult environment to study. It would take mankind centuries, at the current rate of oceanographic* knowledge accumulation, to master the subject. Yet humanity is running out of time.

On September 25, 2019, the Intergovernmental Panel on Climate Change released a report entitled ''The Ocean and Cryosphere* in the Context of Climate Change[1]''.

The report's findings are clear: sea levels are rising at an ever-increasing rate and increased absorption of CO_2 by oceans has brought about acidification, and this is gathering pace.

This, combined with the warming and deoxygenation of waters, is wreaking havoc on ocean systems and marine biodiversity. Impacts are not limited to immediate environments and alarmingly contribute to global warming.

To properly understand these issues, we must first understand :

- the workings of the global ocean's main components,
- the links between the global ocean and climate, and the ocean's role in climate regulation,
- the nature and importance of ocean ecosystem services.

It is only based on this systemic vision that future perspectives can make more sense. Anticipating developments require a detailed assessment of the current situation and better knowledge of both the factors of degradation and those likely to alter things, so-called *game-changers*.

This knowledge is the only way to better assess the magnitude of the impact of ongoing transformations.

Chapter 1 :Understanding the Ocean Sphere

Atlantic ocean, Pacific ocean, Indian ocean, Arctic ocean and Southern ocean... Despite its multiple apparent forms (oceans, seas, straits, ...), to speak of one ocean is no mere figment of the imagination. For it is indeed a single oceanic system on a global scale, with different interconnected environments. To fully understand this particularly poorly understood global ecosystem - the **Ocean Sphere*** - we must approach it as a unique, multidimensional object.

An "alien" planet ?

This salty liquid mass, of some 1.3 billion km^3, covers 71% of Earth's surface, contains 95% **of its biosphere***[2], and has all the constituents of a fully-fledged **planet**: specific physical and chemical conditions, a distinctive fauna and flora, a complete geography (landscape, tectonics, geological conditions) and a complex set of interactions with surrounding environments (lithosphere*, cryosphere*, atmosphere*, biosphere*).

This analogy is particularly relevant to the Ocean Sphere's constituent features :

- **Water instead of air:** the world ocean accounts for 93.9% of the Earth's total hydrosphere volumes (liquid, solid and gaseous water), hence the strong interconnection with the cryosphere and the atmosphere, as well as with the lithosphere it shapes (erosion, accretion).

  Ocean water is also a major reservoir of heat, conditioning coastal temperatures, while thermal differences generate ocean currents. Combined gravitational forces impart perpetual motion to this fluid (waves, tides).

- **Levels of pressure twice as high as those at the surface:** oceanic pressure compounds atmospheric pressure with hydrostatic pressure: this is two kilograms per square centimeter at a depth of 10 meters and one ton per square centimeter at a depth of 10,000 meters.

- **Lethal salinity for most terrestrial animal species:** while ocean salinity is stable in its composition (sodium and chlorine), variable concentrations from one ocean region to another strongly condition ecosystems that develop there, as well as the density and refractive index of salt water (the colder it is, the denser it is), hence the motion of deep ocean masses (thermohaline circulation).

All these factors combine to render the ocean, particularly, hostile to terrestrial living species that are not adapted to breathing underwater, to living under high pressure and to ingesting high concentrations of salt.

A single global ocean

The Ocean Sphere is traditionally subdivided according to marine space size and morphology into oceans, seas, straits and gulfs. It was originally perceived as consisting of 3 oceans, named by European cartographers and travelers in the 19th century, as Atlantic, Pacific and Indian. With the discovery of polar regions at the end of the 19th century[3], two further oceans were added: the Arctic and the Antarctic.

In fact, there is one unique oceanic system: the planetary ocean or the global ocean, for apart from enclosed seas such as the Dead Sea, the Caspian Sea or the Aral Sea, all other marine spaces (the 5 oceans mentioned above as well as open or semi-enclosed seas and straits) are inter-connected and constitute an uninterrupted expanse of salt water surrounding all continents and islands.

A little known space

Since the first oceanographic expedition of the ''H.M.S. Challenger'' in 1872[4], our knowledge of the ocean and its workings advanced by way of research programs and technological breakthroughs in observation platforms and sensors.

Nevertheless, our understanding of the global ocean remains limited. In fact, it is even less well known than outer space[4] : only 250,000 species out of an estimated 10 million species have been identified[6, 7, 8].

Also, little is known of the precise physiography and nature of the seabed and its substratum, particularly in the abyssal zones that cover 60% of the ocean's surface.

Seabed mapping experienced a boom in the scramble to establish exclusive[9] economic zones of the 1980s and the expansion of the continental shelf[10] of the 2000s. Those areas were instituted by the 1982 United Nations Convention on the Law of the Sea[11], but these initiatives were limited to a few coastal States.

On a different note, biodiversity studies started with international programs and networks like the Marine Biodiversity Observation Network[12] and open access platforms were developed including: EurOBIS[13], Aphia and WoRMS[14]. With regard to mapping, UNESCO's Director General[15] pledged in a press release to mobilize the international community to ensure the mapping of a minimum 80% of the seabed by 2030.

The scarcity of knowledge on this strategic space can be attributed to a number of factors[16], falling into two main categories. The first is ocean characteristics and physiological and chemical parameters. The second category is inherent to specificities of ocean sciences.

Consequently, only 10% of all ocean areas below 200 meters in depth have been explored (i.e. 5% of total ocean mass). Whereas 12 astronauts have already walked on the Moon, only 4 people have descended to a depth of over 10,000 meters.

While many ocean mechanisms remain unexplored, two characteristics nevertheless help explain ongoing developments.

A complex and multifunctional global ocean

The global ocean is a complex and multifunctional composite system, however, its functioning should be considered in its entirety. On the one hand, its three components, i.e.: the seabed, the oceanic water masses and the living resources are closely connected and strongly interdependent. On the other, the ocean hosts physical, geochemical and ecosystem process interactions (on multiple scales) that are both forced and intrinsic.

In addition, it lives in full and complex interaction with the atmosphere*[17], the cryosphere*[18], terrestrial biomes and the terrestrial lithosphere*[19].

These interactions are illustrated in the numerous cycles, which manage life on Earth and which contribute to generating non-living resources, namely :

- the water cycle,
- the Milankovitch cycles and climate variations,
- the geological cycle,

- the Wilson cycle,
- biogeochemical cycles: the carbon cycle, the nitrogen cycle and the phosphorus cycle.

There are two main subspaces in the oceanic space :

- **Surface waters** (upper and intermediate layers) regulate global climate by controlling heat and carbon exchange between atmosphere and deep ocean, shape marine ecosystems by hosting most of the ocean's primary production* (including phytoplankton*), and provide oxygenation to deep ocean layers.

- The **deep ocean** is home to a disproportionate and active topography owing to its youth (220 million years) - volcanoes, ridge chains, abyssal plains, trenches, rifts, ... - where extreme environments stand out (hydrothermal zones, brine pools) with complex ecosystems.

Two primary circulation patterns are essential to exchanges between these two subspaces: first, the permanent horizontal thermohaline circulation*, dissipating heat and separating distinct biomes within the global ocean, and second, *upwelling**, the vertical ascent of cold, nutrient-rich water.

This characteristic three-dimensionality of the ocean is materialized by the water column*, which extends from the surface to the bottom of the ocean. Its unique characteristics (temperature, pressure, luminosity, composition) at different depths determine the distribution of living organisms in the ocean.

The underrated universe of marine life

The ocean's habitable volume, 642 times greater than that of the continent, is home to around 20% of the Earth's living species[22,23,24]. This exceptional resource, essential to life on the planet as well as to the well-being and food of humanity, is therefore a major issue. Among these species, micro-organisms and marine animals with superior forms of intelligence are of particular interest.

In fact, marine micro-organisms are the pillars of ocean life and of Earth's oxygenation. Viruses preserve the biodiversity of marine ecosystems and enable genetic mixing. Phytoplankton* (50% of the planet's organic matter) produces over half of Earth's oxygen through photosynthesis* and consumes over half of its CO_2[26,27,28,29]. Essential to marine life, it is at the base of the ocean food chain.

Moreover, a number of marine species are endowed with exceptional cognitive abilities in terms of language, memorization, recognition, awareness of self and others, thoughtful communication and learning[30]. This superior form of intelligence deserves to be studied and considered in conservation strategies.

Yet, an accurate biodiversity assessment is hindered by the scarcity of qualitative and quantitative inventories of marine species, especially those of the deep sea, as well as by the degradation of ecosystems, which has certainly caused the disappearance of un-inventoried[31] species.

A reservoir for the greatest biodiversity, with marine organisms from five groups: animals[32], plants[33], fungi[34] protists[35] and moneras[36]. The ocean is an ecosystem breeding ground.

Life develops along the entire water column* from surface to seabed. The spatial distribution of marine bioresources is determined by a range of factors: living conditions (mobility, nutrition and reproduction), temperature, physical and chemical settings and seabed conditions.

For a long time, it was assumed that life forms thrived mainly on the coastline and the continental shelf. But the latest discoveries have revealed the existence of a diversified fauna in abyssal zones and, above all, the existence of varied ecological niches such as warm-water coral reefs and carbonate cold-water coral mounds, continental and island platforms in tropical regions, oceanic hydrothermal springs and polymetallic nodule fields[37,38,39].

The ocean, essential to Earth's habitability

The ocean plays a fundamental role in the habitability of the planet, i.e. its capacity to host and support life. This critical planetary reservoir provides water, oxygen and food necessary to sustain life at sea and on land, regulates Earth's climate and weather patterns, and provides a range of ecosystem services.

The climate regulator

The ocean is a complex system essential to sustaining life on Earth by producing oxygen, absorbing carbon dioxide and contributing significantly to our climate

The ocean is the planet's main climate regulator, owing to its capacity for absorbing solar radiation and physicochemical characteristics, enabling it to mechanically interact with climate conditions and exchange with the atmosphere at every latitude (radiative, mechanical and gaseous exchanges).

In fact, the ocean is the essential engine of the water cycle, enabling constant water circulation across various states (gaseous, liquid and solid) between the atmosphere*, the hydrosphere*, the lithosphere* and the biosphere*.

Oceanic water masses, by virtue of their expanse and volume, are the principal contributor to this cycle as they provide 90% of water vapor, which enables rainfall for crops and vital fresh water for life. When it evaporates, water condenses into clouds and returns to the ocean as rain or river discharge from the mainland.

Cloud formation and climate stability are controlled by the dimethyl sulfide, emitted by plankton[28].

Interactions between the atmosphere* and the hydrosphere* account for the bulk of weather phenomena such as :

- cyclones, drawing energy from the heat held in tropical regions of the ocean,
- heat transfer between ocean, atmosphere and continents, through atmospheric circulation.

The ocean lowers temperatures of surface waters in tropical regions by redistributing heat to colder waters at the poles (oceanic gyres*) and to ocean depths (thermohaline circulation*). This distribution occurs along variable time frames, ranging from seasons to millennia.

The ocean is also a primary carbon sink. It pumps and stores (by way of phytoplankton, mangroves, salt marshes, seagrass beds) CO_2 and methane, both sources of global warming.

Therefore, the physical, chemical and biological processes within this planetary reservoir provide water to sustain life and determine the climates of various continents as well as climatic phenomena (winds, ...).

Ocean Ecosystem services

"Ecosystem services", according to the Millennium Ecosystem Assessment[40], refer to the benefits that humans derive from ecosystems. This definition reflects the dependence of human societies on properly functioning ecosystems[29].

Overall ocean processes provide 74 ecosystem services[41], i.e. 60% of all services, which fall into four main categories[40].

- The **7 "life support"** services are at the root of all the others, as they sustain overall ecosystem functioning.

  These include the biogeochemical cycles (water cycle, carbon cycle, oxygen cycle), the cycle of life (flora and fauna) and support of biodiversity, the production of organic matter (biomass) and nutrients, as well as the generation and stabilization of soil.

- **The 26 regulatory services** make life possible and ecosystems viable, sustainable and resilient to change. These services regulate climate, air quality, water quality, erosion, natural disasters, diseases and pests.

  They also control pollination, water purification (by plankton, lamellibranchs and certain fish), weather systems (storage of 25% of anthropogenic CO_2 emissions), erosion prevention (coral reefs absorb 70% to 90% of wave energy[42,43]) and substrate stabilization by sea grass beds.

- The **20 supply services** consist of material products from living and non-living natural resources, provided by ecosystems for human nutrition and all other needs. These include food resources (fisheries, aquaculture, etc.) that nearly 600 million people depend on for their livelihoods or as their sole source of animal proteins[44], fuels (gas, oil), renewable energy, building materials, and organisms and molecules (pharmacology, cosmetology and biotechnology).

- **The 21 cultural services** (non-material services) relate to the social and cultural values of marine and coastal areas and associated human activities: leisure, tourism, education, research as well as artistic, heritage, identity and spiritual enrichment.

The major challenge of sustaining these ecosystem services is to preserve the integrity and stability of biomes and related ecosystems, in particular through the conservation of biodiversity (genetic wealth and diversity of habitats) and the natural balance of ocean functions.

In order to sensitize human communities to the importance of the Ocean Sphere for the quality of life on Earth, a valuation of such assets was conducted. Primarily monetary, it shows that 63% of all global ecosystem services' value is derived from marine ecosystems, that is 20.9 trillion dollars/year[45].

Yet, this valuation faced three main constraints:

- Systemic interactions enabling the existence of these services cannot be quantified as a sum of the individual values of these elements.

- Complexity of some services, such as climate regulation, makes it impossible to measure them.

- Invisibility of the most essential services, which therefore cannot be economically priced, such as carbon capture or biodiversity contribution.

▶ Hence the dual imperative to broaden and deepen our knowledge of the Ocean Sphere - from the complexity of its mechanisms to the fragility of its equilibrium - and to raise awareness through education rather than commodification.

The First World Ocean Assessment found that much of the ocean is now seriously degraded. A continued failure to address these problems is likely to create a destructive cycle of degradation that will ultimately deprive society of many of the benefits currently derived from the ocean[47].

UNESCO, 2017

Chapter 2 : Anticipating its future

The Ocean covers 70% of Earth's surface, generates over 50% of its oxygen, absorbs over half of its anthropogenic carbon and accounts for 95% of its*[2,48]. The ocean's balance, on which its health depends, is essential to our survival.

The current state of the world Ocean is clear, as are the underlying causes[49] : degradation of its different environments as a result of climate change* and human activity, often severely and sometimes irreversibly impacting ecosystems, biodiversity* and ocean mechanisms, thereby generating global disruption.

Despite this degradation, the Ocean was for a long time deemed resilient, able to withstand all forms of pollution by virtue of its currents, circulating and renewing water masses. But the strain generated by global warming and increased anthropic pressure combined, in both space and time, put the limits of its self-purifying power to the test.

Conversely, the pace and scale of future developments, the diversity and severity of potential impacts and the drivers that could alter this trend are not as well known.

Three major existential issues* shape the future evolution of the ocean: increased warming, new environmental conditions and marine biodiversity modification. This chapter reviews the causes and the current state of the ocean, examines the lasting consequences on natural systems and considers their evolution as well as potential ''game changers''.

An ever-warming ocean

Current situation and underlying causes

The world ocean is literally ''mopping up'' excess anthropogenic emissions: it has absorbed over 90% of surplus heat generated in the climate system since 1950 and 30% of excess carbon dioxide since 1980[50], thereby curtailing global warming.

In doing so, its mean temperature has increased since the 1970s, both at the surface (0 to 75 meters deep), and at great depths (below 4,000 meters in the Southern Hemisphere), with significant regional variations.

The upper ocean has warmed by about 0.5 to 1°C over the 20th century[51], and extreme heat waves are on the rise.

Anthropogenic global warming is directly responsible for this situation. Regardless of its likely evolution scenario (see IPCC scenarios), **ocean warming is expected to continue for centuries**[52].

Consequences on natural systems

Ocean warming accelerates global climate change, leading to non-linear, long-term effects that are both longer lasting and less self-reversing.

The disruption of global thermohaline circulation* is already underway. Satellite data shows that the Gulf Stream, once regarded as the most powerful current, has weakened dramatically over recent decades. This is tied to the rapid melting of Greenland's glaciers and the Arctic ice pack.

Similarly, recent observations indicate a gradual slowing of the vertical Atlantic meridional reversal current *[53], which is at its weakest in the last 1600 years. Global warming, by melting glaciers, is causing a thermal disruption of the Gulf Stream, leading to a cooling of Western Europe.

In the Southern Ocean[54], which captures 75% of the heat and 50% of the carbon absorbed by the global ocean, the Antarctic Circumpolar Current, the engine of global ocean circulation, is accelerating as a result of the thermal gradient.

Melting ocean ice impacts the cryosphere*: the Arctic, is warming twice as fast as global average, Greenland and the Southern ocean (very little known despite its importance: 75% of all excess heat stored by the global ocean is held there). Cryosphere* reduction has been perceptible since the end of the 1970s and has accelerated by 65% in the last three decades, with a loss of 87,000 km2 of surface area per year between 1976 and 2016.

This disruption upsets both the climate system and the water cycle (e.g. monsoons) causing floods and droughts and altering entire ecosystems (e.g. the Amazon rainforest)[57].

Caused by glacial melting and expanding ocean water due to its warmth, mean ocean levels are rising ever faster: by some 20 cm between 1901 and 2018 and by 4.5 mm in 2021[58, 59, 60, 61, 62]. According to the IPCC[57], regardless of what may happen, levels will continue to rise in the 21st century, causing more frequent and severe coastal flooding in low-lying areas, as well as salinization and accelerating coastal erosion. Islands are already submerged, cities threatened and coastlines altered.

These major consequences bring about domino effects (see following sections), the extent, speed and collaterals of which are impossible to accurately predict. Nevertheless, the risks of a more severe and rapid shift are increasingly acute, given the latest evidence.

Trends and game-changers

Atmospheric heat will continue to penetrate shallow ocean layers through this century: models suggest that the ocean could store between 3 and 6 times more heat than already absorbed since 1900.

Nevertheless, significant drivers of change could contribute to either increasing the absorptive capacity of anthropogenic emissions or, on the contrary, drastically decreasing it, e.g., changes in CO_2 storage capacity :

- **Kelp forests** are typically found in temperate and polar climates , but were also found in tropical regions in 2007[65].

  They play an essential role in ocean and climate balances. They absorb CO_2 by photosynthesis* and produce oxygen, thus moderating global warming, methane emissions and acidification.

  These forests, which act as major carbon sinks, are progressively disappearing across most regions of the world because of global warming and anthropic stress (pollution and overfishing of species that protect kelp, etc.): 38% of areas studied show a decline over the past fifty years[65].

- **Le phytoplancton*** is the first element of the food chain and an essential component of the carbon cycle. It absorbs a portion of anthropogenic carbon dioxide and produces oxygen[66].

  This invaluable living resource faces a troubling decline. In fact, its stock is declining at a 1% annual rate, with a 40% drop since 1950[67]. Eventually, the disappearance of phytoplankton would increase CO_2 levels in the atmosphere, accelerating climate change and making it harder for humans and land animals to breathe.

- Mud volcanoes and pockmarks* from gas hydrates are found on the ocean floor in a number of regions[68, 69, 70, 71].

  Warming ocean waters cause clathrates* to melt and thus release large amounts of methane gas into the atmosphere, accelerating the rise in temperature, which in turn promotes further release of methane (positive feedback loop).

- Plate tectonics cause continents to break up and displace. A region that is currently in a tropical latitude could, in the long term, find itself in a polar latitude and vice-versa and thereby see its climatic conditions change.

- Atmospheric rivers[72] cover just 10% of the Earth's circumference, but transport over 90% of water vapor from North to South. These air masses draw moisture from the oceans and play a decisive role in setting weather conditions.

"Sea level continues to rise at an increasing rate. Extreme sea level events that are historically rare (once per century in the recent past) are projected to occur frequently (at least once per year) at many locations by 2050 in all RCP scenarios, especially in tropical regions (high confidence)."

special report on the ocean and cryosphere in a changing climate[48]

They often cause extreme rainfall conditions, leading to severe flooding and landslides in many mid-latitude regions[73,74].

Two other "game-changers" could significantly accelerate the rise in water levels: the melting of the Antarctic and increased water stratification.

Carbon dioxide concentrations over 400 ppm (410 ppm in 2019) and global temperatures 2°C above pre-industrial levels could lead to the melting of one third of Antarctica's polar ice cap, which would raise sea levels by 20 meters by 2150. These conditions may occur as early as 2030, leading to a global average rise of 1.2 meter by 2100 (non-linear evolution)[75].

Continued water stratification (see below) would block the transfer of heat to colder waters and thus cause an exponential warming, leading to thermal expansion of ocean surface waters.

An ocean facing new environmental conditions

Current situation and underlying causes

In addition to global warming impacts due to anthropogenic greenhouse gas emissions, the ocean is subject to multi-source and multiform pollution[76,77] stemming from human activity, which substantially alters ocean environments.

Ocean pollution is caused by maritime transport and oil spills. It also comes from urban, industrial and agricultural discharge (gaseous, liquid and solid). This waste is transported by the wind, rain and rivers or simply dumped directly into the ocean.

Consequently, to anticipate the future of the Ocean Sphere*, we need to understand the **structural changes** that impact it, as these will determine long-term evolution.

In fact, while cyclical variations are reversible, structural transformations, which present greater risks, are generally non-reversible on a human scale, hence their significance.

The present insufficient understanding of ocean mechanisms blurs the line between cyclical and structural shifts.

Nevertheless, the latter, in addition to the aforementioned disruption of thermohaline circulation, include worsening water stratification, acidification and deoxygenation. All three processes interact and reinforce each other, directly and/or indirectly.

- A troubling aggravation of water stratification, with increased differentiation in the characteristics of main layers, namely: surface waters, intermediate waters (thermocline) and deep waters. This is tied to warming ocean surface waters and decreasing salinity from melting polar glaciers and rising precipitation.

Ocean stratification is essential for nutrient and oxygen exchange between ocean layers, and sound propagation, which helps many species orient themselves. Its deterioration brings about several consequences, including:

- ✓ limited or no exchange between layers,
- ✓ reduced productivity both on ocean floors and at the surface,
- ✓ diminished ocean carbon dioxide absorption capacity, leading to an increase in greenhouse gas concentrations in the atmosphere,
- ✓ increased intensity of hurricanes.

- Increased ocean acidification evidenced by declining pH levels, a direct result of rising atmospheric carbon dioxide absorption (dissolving excess CO_2 in marine waters and forming carbonic acid)[78,79] rendering the change irreversible for thousands of years (Once dissolved, CO_2 cannot be removed).

Acidification is up 30% over the past 200 years79. This is a major threat to the survival of all species with carbonate skeletons and tests, including plankton, which is the basis of the food chain and a provider of oxygen, and corals, which develop genuine ecological niches. It also disturbs the balance and way of life and metabolism of organisms, which depend on specific pH conditions for proper development[80, 81, 82, 83, 84].

While the ocean cannot turn chemically acidic (pH <7) by virtue of its salinity, this condition demands that marine organisms expend more energy to regulate such change, leaving less energy for growth, reproduction and other necessary adaptations[85].

- Global ocean water mass deoxygenation, oxygen levels essential for life for many marine organisms (vertebrates and invertebrates) have dropped around 2% since the 1950s, especially in the upper 1000 meter depth range. This creates a double hypoxia mechanism.

  - ✓ On the one hand, a phenomenon recognized since the mid-20th century, and that is easily reversible: coastal zone hypoxia* caused by eutrophication* from nutrient runoff (fertilizers, etc.) and fossil fuels nitrogen deposits.

  - ✓ On the other, hypoxia arising from rising ocean temperatures, as identified in the last decade. This reduces oxygen solubility and, because of stratification, reduces the ventilation of deep ocean waters.

  The **oxygen content of the open ocean*, also referred to as the high seas, is progressively depleted, especially at depths between 200 and 2000 meters, worldwide**: an irreversible process on the human scalee[87, 88].

This complex mechanism of deoxygenation thereby combines different origins (natural and anthropogenic) and generates different environments depending on to O_2 saturation levels: hypoxic zones , zones of minimum oxygen[90] and anoxic zones[91].

there is no environmental variable of such ecological importance to marine ecosystems that has changed so drastically in such a short period of time as a result of human activities as dissolved oxygen.

Ocean deoxygenation: Everyone's problem Causes, impacts, consequences and solutions

IUCN report[49]

These sub-oxygenated environments have expanded rapidly over the past 50 years in the Atlantic, Indian Ocean, Mediterranean, Gulf of Mexico, Black Sea and Baltic Sea. Forecasts suggest that oxygen levels will continue to decline, to reach 3 to 4% by 2100[92, 93, 94, 95, 96, 97].

Consequences on the Ocean Sphere

All four major structural changes (slowing thermohaline circulation, ocean layer stratification, acidification and deoxygenation), combine to impact climate, environmental parameters and ecosystems.

- Climate: **global warming** of the ocean translates into increased surface temperature and reduced carbon storage capacity, but also into expanding and intensifying highly hypoxic areas, which release nitrous oxide, a powerful greenhouse gas with a climate change potential 260 times greater than that of CO_2 (denitrification)[98].

- Stratification, which alters ocean circulation and leads to an increase in extreme weather events, such as tropical cyclones, and above all ocean heat waves* (marine heat waves), which have probably doubled in frequency since the 1980s[99, 100, 101].

  Extreme marine events, previously occurring only once a century, may occur every year by 2100.

- Environmental conditions (temperature, salinity and oxygenation, ...) play an essential role in controlling living organisms, ecosystems and ocean functions. Changes in these conditions affect ocean water quality and degrade biogeochemical cycles (micro-nutrients, carbonates, phosphorus, ...).

Specifically, they lead to decreased dissolved oxygen concentration and increased acidity of the ocean. Turbidity* caused by planktonic proliferation (blue-green algae, red algae) and pollution (microplastic) could become permanent in coastal areas (see below).

- Ecosystems: as a result of the combined impact of hypoxia, eutrophication, ecotoxicity, environmental warming, disrupted nutrient and micronutrient cycles, turbidity (resulting in a lack of access to light) and, local imbalance in the food chain (see below), a number of ecosystems are degrading quickly (kelp forests, coral reefs, arctic ecosystems), as are marine productivity and biodiversity.

Minimum oxygen and anoxic zones are spreading: with the Gulf of Oman housing the world's largest minimum oxygen zone, the size of Scotland . 700 zones suffer from low oxygen levels compared to 45 in the 1960s, and anoxic waters have quadrupled in volume over the same period.

These conditions impact the first 1000 meters of the water column where biodiversity and species biomass are the highest[105]. Living organisms, at the end of the impact chain, are both directly and indirectly altered by all these changes. They are therefore examined in the next section.

Evolution and game-changers: new environmental conditions

In short, the Ocean Sphere structure is changing with respect to :

- temperature: the entire ocean mass is warming, regardless of depth and latitude. Temperatures are expected to increase by 1 to 3°C over this century[106],

- stratification, with a thicker mixing layer* of surface waters (5 to 10 meters per decade according to region), altered currents and decreased vertical circulation,

- oxygenation[88] and acidification, with a proliferation and thickening of minimum oxygen zones and an overall drop in ocean pH levels (0.3 to 0.5 units[106]).

These disruptions not only contribute to, and even accelerate, local degradation of ecosystems, but most importantly create new enduring environmental conditions (biogeochemical) in the global ocean, affecting 44.9% of it by 2060 and 87% by 2100.

- The transformation of the Arctic and of Marine Protected Areas is a case in point. Up to 97% of large Marine Protected Areas– are projected to experience significant changes across a range of biogeochemical variables by 2100, including new pH conditions as early as 2030, particularly in tropical areas[107].

- Between 2000 and 2100, broad areas of the world ocean (10-82%) could experience climates that currently do not exist ("new climates"), while certain 20th century climates could disappear[106]. 35-95% of ocean surface waters are forecast to undergo complete transformation.

- The METAL model[109] found unprecedented recent increases in ''climate surprises'', attributed to phenomena such as: El Niño, Atlantic and Pacific thermal anomalies and Arctic warming[109].

While the scientific community agrees that this trend is likely irreversible by the end of this century, it still ponders on the details of this process and its overall systemic consequences :

- By blocking heat transfer to colder areas, stratification could lead to exponential warming of surface waters and a slowing of the so-called carbon pump. As a consequence, by 2100, the ocean may no longer absorb CO_2 or, even worse, become an emitter of it[110].

- Acidification could increase by 150%[111] by 2100 and thereby lead to the extinction of calcifying species.

What is certain is that ocean environmental conditions, as we knew them in the 20^{th} century, will no longer exist, as new environments arise in over half of the global ocean.

The novelty of both the situation and phenomena taking place, along with our limited understanding of the Ocean Sphere, make it especially complicated to pinpoint ''*game changers*'', as uncertainty factors abound. Three phenomena, however, warrant special attention :

- Changes to ocean surface climates as a result of global warming could compel species to ''adapt or die''. However, should climate change beyond what some species are capable of tolerating or at too fast a rate for them to adapt, range shifting could no longer be viable as a strategy.

  As such, new climates could cause reshuffling of communities, new combinations of species, mass extinctions, and unexpected ecological surprises[106].

- Phytoplankton would decline in the subtropics by 2100, with large blooms of phytoplankton emerging around the poles, where temperatures will be warmer. Climate change has already started to alter the development of phytoplankton and this process could extend to 50% of ocean surfaces by the end of the century, thus dramatically impacting the marine food chain[112].

- A much more toxic ocean: by 2100 increased ocean toxicity (for IIP: Focus - Ocean Toxicity) will result from the interplay of a variety of factors, including :

  - ✓ release of substantial amounts of mercury into Arctic waters as a result of permafrost thawing[113],

  - ✓ increase in nitrogen and phosphorus discharges leading to toxic algal blooms like the Florida "red tide" of 2021[114],

  - ✓ destabilization of gas hydrates (clathrates) from mud volcanoes and pockmarks*[115],

  - ✓ anoxic conditions, producing highly toxic hydrogen sulfides[116].

These *game changers* could significantly accelerate the emergence of new oceanic environmental conditions in the 21st century and substantially degrade marine biodiversity.

Changes to the marine biosphere

Situation and causes

A warmer ocean, with new biogeochemical and climatic environmental conditions, can only alter marine biodiversity as a whole, which accounts for an estimated 50-80% of all living species on planet Earth.

This is compounded by causes directly related to human (anthropogenic) activity including changes in usage (coastlines, shipping lines), overexploitation of biological resources, multiform pollution, and conditions conducive to the proliferation of invasive species (see Part II).

Current data reflects both stress on the marine biosphere and the threat of large-scale extinction: ''Over 40% of amphibian species, close to 33% of coral reefs, and over one-third of all marine mammals are at risk'' according to the Foundation for Biodiversity Research*[117].

- A pace of extinction that already causes great concern. Of marine species in decline, local rarefaction, and even disappearance of a number of marine organisms is problematic on several counts :
    - ✓ Half of all coral reefs have been lost since the 1870s. Bleaching of coral reefs, consecutive to heat waves, often heralds their death. For instance, in just two years (2016 and 2017), nearly 50% of Australia's Great Barrier Reefs have died . Worldwide, 14% of corals have disappeared in less than 10 years, between 2009 and 2018[119, 120, 121, 122, 123, 124, 125].

According to the IPCC, a 1.5°C global rise in temperature could lead to the disappearance of 70 to 90% of the world's corals. Coral reefs are authentic ecological niches, hosting one marine species out of four and providing irreplaceable local ecosystem services. One such services is the 70% to 90% attenuation of wave energy[126].

- ✓ Four different coastal ecosystems share the ability to absorb and store CO_2 in large quantities for millennia, host a unique biodiversity and protect against erosion: kelp forests, which cover 28% of coastal areas, are disappearing twice as fast as coral reefs[127, 128, 129, 130].

  Also, 67% of mangroves[131, 132], 50% of salt marshes and 30% of seagrass beds worldwide have already disappeared. All four coastal ecosystems absorb and store CO_2 in large quantities for thousands of years, host a unique biodiversity and protect against erosion.

- ✓ In addition, a number of marine animal species face extinction, including *vaquita*, a small porpoise of which only 10 to 20 specimens remain, sharks and rays, 37% of which now face extinction worldwide, as well as a variety of turtle species , monk seals and blue whales, to the point that scientists have begun envisaging a 6th mass extinction in the world's oceans if temperatures rise beyond 2°C [134, 135, 136, 137, 138, 139, 140, 141, 142].

- Epiphenomena indicative of more complex problems :

  - ✓ Climate change, biodiversity loss and overfishing all combine to make **food resources scarce** for a wide range of marine species: everything from puffins that travel up to 50 km to find fish, to dolphins and pseudo-orcas (prey and predator) that join forces to find food.

  - ✓ A critical species to Arctic marine ecosystems, walruses (like polar bears) have to seek refuge on land where predators decimate them, as the ice floes on which they usually rest are melting (Arctic sea ice is shrinking by 47 800 km^2/year).

  - ✓ Some fish venture to swim near predators or struggle to find a habitat because **CO_2 water concentrations** disrupt their sense of smell, sight and more broadly, their behavior[143].

  - ✓ Algae with calcareous plates and other animals with calcareous skeletons present anomalies when developing in **acidified environments**, which also alter corals and mollusks (oysters, mussels)[144, 145, 146].

  - ✓ The unexplained resurgence of deep-sea fish washed up on beaches indicates that the deep sea is not free of disruption.

A general distress of the marine biosphere is therefore observable, as a result of environmental transformation, exacerbated by anthropogenic degradation.

Consequences

Water warming, along with deoxygenation, acidification and nutrient depletion, cause multiple food chain and ecosystem disruptions, with severe impacts on the abundance (biomass), diversity (biodiversity) and geographical distribution of oceanic life :

- Biodiversity* (diversity of living environments, species and genes), the backbone of ecological resilience and adaptation to structural disruption, has declined dramatically for over 50 years.

  Evidence shows an **acceleration** of biological alterations[109] in connection with increased cumulative impacts of anthropogenic stress (global warming and human activities)[138]. Such impacts affect the ability of populations to grow, recover and adapt, disrupt the food chain, and alter habitats in 66% of the global ocean.

  In addition, disease is on the rise, species behavior is changing, and mortality is up across all fish and shellfish species. Fauna life cycles are changing from long-lived, slow-growing and slow-generating species to small, fast-growing and fast-generating species. Last, species that are tolerant to hypoxia are developing to the detriment of others.

  Consequences of global Ocean Sphere alteration impact not only geo-physical-chemical conditions (water masses and seabed) but the entire marine biosphere, coastal and offshore, all along the water column. Ocean biomass is consequently experiencing radical change in terms of volume, size distribution and spatialization.

- At current CO_2 emission rates, **5 to 17% of all marine animal biomass could disappear** by 2100 as a result of increasing temperatures and declining primary production (excluding fisheries), an average 5% decline per degree of warming[135].

  In waters that are even slightly hypoxic (oxygen saturation levels of 30-50%), in addition to increased mortality, marine organisms may also experience reduced growth and reproduction rates.

  The rate of decline is significantly greater for **species at the top of the food chain** than for those at the bottom. An immutable mathematical rule distributes ocean life, from bacteria to whales, whereby all size brackets have an equal biomass: for example, krill is a billion times smaller than tuna, but a billion times more abundant[147].

  This natural harmony is broken as the biomass of organisms (fish and mammals) weighing over 10 grams has dropped around 60% since 1800. That of larger organisms appears to have declined by almost 90% since 1800. Concurrently, the biomass of bacteria has increased considerably[148] while planktonic populations collapse locally (as in the North Atlantic in response to a slowdown in the vertical current of Atlantic meridional overturning circulation*).

- A general displacement of species is underway. To escape rising temperatures and scarcity of available oxygen, mobile marine species migrate to colder waters where they compete with local species[149, 150, 151].

We therefore note an extension of geographical areas towards the North, and in the tropical Atlantic, as well as a compression of habitats for large pelagic fish (tuna, marlin) and their prey (small pelagic fish) as a result of minimum oxygen areas expansion[152].

This displacement breaks the systemic links that constitute an ecosystem: mobile species leave, sedentary species degrade or die, burrowing species, which oxygenate and mix sediments, remain closer to the surface, contributing to soil degradation.

Thus, the consequences of this global Ocean Sphere alteration impact not only the geo-physical-chemical condition of the environment and seabed (soils and subsoils), but the entire marine biosphere, both coastal and offshore, all along the water column.

Trends and game changers

It is therefore likely that by the end of this century, many marine ecosystems will consist of different species and probably in fewer number than today[153]. The Mediterranean is a prime example. Significant and rapid changes in shallow water ecosystems have already occurred in the Mediterranean, with many species disappearing and new species taking hold[154].

This evolution will affect those areas most vulnerable to acidification and hypoxia, such as coastal regions with freshwater inflows and *upwelling*[155] areas as well as regions exposed to oceanic heat waves (rising temperatures being the main stress factor for marine species).

In the long run, it is likely that the changing oceanic environmental conditions will lead to a new configuration of the marine biosphere :

- Extinction of calcifying organisms, no longer able to complete calcification, and expansion of those able to adapt. Such is the case for the coccolithophore ‘‘*Emiliania huxleyi*’’*, which displays no difficulty developing in CO_2-rich environments. Quite to the opposite, it develops calcareous plates that grow progressively larger as CO_2 levels increase[156].

- Imbalance in the distribution of the biomass resulting in a reduction in the number of species of higher trophic level (large animals) and an increase in the number of species of lower trophic level (micro-organisms, algae).

- Proliferation of hypoxia and eutrophication-tolerant species, such as the Humboldt squid and jellyfish, respectively.

- Toxicity amplified by addition of anthropogenic discharges and biotoxin impacts, constituting a risk to both marine organisms and human health.

Game changers likely to impact this programmed evolution, are primarily of two kinds :

- Aggravating factors likely to accelerate changes in such a way that species are unable to adapt: increased CO_2 concentration in the atmosphere leading to mass extinction in the ocean[157], increased oceanic heat waves (waves of burning water similar to fires)[158, 100, 159], deep-sea disruption, abnormal proliferation of toxic or invasive species.

- Resilience factors, enabling species to restore stocks or at least have sufficient time to adapt. This is true of tuna, for example, where four of the seven most heavily fished species are now recovering after a decade of sustainable fishing quotas (International Union for Conservation of Nature red list[160]). Similarly, in South Africa, the swarms of jellyfish have disappeared. Natural virtuous circles are also observed, as with the reintroduction of the sea otter, which preys on the sea urchin that destroys kelp forests, or with the return of baleen whales, restoring the iron cycle, which benefits krill...

Changes in biodiversity highlighted by recent scientific advances will translate into a global reorganization of ocean species and communities. These changes will necessarily disrupt the ecosystem functions oceans provide to mankind, in positive and/or negative way[109].

▶ The challenge now is to slow down the pace of change sufficiently so that it does not outpace the biosphere's capacity to adapt.

Conclusion of Part 1

An existential risk for mankind

The Ocean Sphere is changing, in a structural and enduring way. In evolutionary terms, it is morphing. In terms of its functions, it is deteriorating.

The problem with disrupting natural equilibria is that it produces very few zero-sum situations: positive effects of an equilibrium, when disrupted, not only disappear but also induce new negative effects which, in turn, exacerbate the situation.

When a number of critical factors accumulate (warming of the waters, alteration of living organisms, expansion of areas with minimal oxygen, etc.), they not only lead to irreversible conditions on a human scale, as evidenced in the current state of the Arctic and the Mediterranean, but also to a threat multiplier effect[161, 162, 163]). Yet without the beneficial effects of the ocean, mankind cannot survive on this planete.

Two urgent issues

To think before acting is essential to making true ''good decisions'', sufficiently effective to remedy the current situation as well as the one in the medium-long term. The urgency of the state of ocean health and its impact on humanity nevertheless requires swift decision-making and implementation.

For these to be effective, it is essential to enhance our knowledge of the Ocean Sphere. While our knowledge of ocean pathogens has improved significantly over the past half century (anthropogenic global warming, overexploitation of marine resources, ocean pollution), our lack of knowledge of their specific repercussions (dynamics, rate, magnitude, systemic consequences) leaves us with a great deal of uncertainty as to the future evolution of the Ocean Sphere's natural mechanisms.

Nature's dangerous decline is unprecedented, but it is not too late to act. Incremental change will not be sufficient – the science shows that transformative change is urgently needed to restore and protect nature.

IPBES Report 2019[163]

Hence, two challenges stand out as priorities:

- The need for a systemic approach to the ocean, as an **Ocean Sphere**, by both decision makers and researchers:

  ✓ The overuse of ecosystem services (e.g. overfishing or destruction of mangroves) causes both imbalance in the functions providing the service (supply, climate regulation, self-purification...) as well as degradation of other related services owing to the interdependence of global ocean system components.

  ✓ The use of vertical indicators, such as Maximum Balanced Yield, fails to account for ecosystem interactions and tends to accelerate rather than curb overexploitation. Hence the need for more global indicators, such as the marine biodiversity index for example.

- The urgent need for massive data collection and processing to enable scientists to improve predictive models. New data collection technologies (drones, sensors) and massive data processing (data science) now offer powerful means of action. This also implies accelerating development of new research fields such as the detailed study of marine biodiversity.

Take away

Understand

The Ocean Sphere is a constituent of the planet Earth, that remains insufficiently known and that humanity ought to both explore and respect to ensure its proper functioning.

Less than 20% of the planet's ocean has been mapped, 90% of its depths remain unexplored and, Although 230,000 known species have been listed, 5 to 10 million remain to be discovered.

The ''deep biosphere'' forms the largest and least known unique ecosystem on the planet. Deep-sea bacteria and archaea constitute nearly one third of the planet's total biomass.

Anticipate

The ocean has been degrading for over a century. This pace has accelerated exponentially over the past fifty years.

Ocean waters are warming, acidifying and losing oxygen; entire ecosystems have already disappeared. Climate change seriously alters living organisms, the condition of which is worsening under the effect of anthropic pressure.

Irreversible mechanisms are at work, heralding new environmental conditions.

But the ocean is highly resilient. Better understanding of its workings and a firm determination to respect its natural balances would be greatly helpful.

PART II

Land-Sea interface stakes

All over the planet, the ocean is suffering, That is a fact. Scientists now concur on the anthropic origin of this massive imbalance. Beyond those natural phenomena discussed in the previous section, human activities directly contribute to this condition.

The complex Ocean Sphere* system does not end at just a short distance from the coast, but rather at the border between the ''Shoreface''*, i.e. the immediate part of the platform, and the intertidal zone*. In the same way it interfaces with the atmosphere, shaping our climate, it also interfaces with land, influencing it considerably, at the coastline.

In turn, human activities carried out in this space also impact the ocean and the sea, the oceanic expanse bordering the shoreline, in particular. There is thereby a dual pattern of influence: from sea to land (ecosystem functions, marine meteorological phenomena, ...) and from land to sea (human activity).

Understanding the structural and cyclical nature of this interface (Chapter 1) helps us anticipate the twofold alteration to come: that of the ocean and that of human activity and habitats.

Indeed, a complex interaction is played out on the coastline :

- between two distinct natural components: the Ocean Sphere on the one hand and the rest of the planet on the other (lithosphere*, biosphere*, hydro and cryosphere* and atmosphere*);

- between the natural environment and human civilization, with its ambivalent attraction,

- between the diverse components of humanity: ocean-"junction", ocean-border, relational space as much geopolitical as economic.

The survival of the ocean, and hence that of the human species on this planet, depends on the capacity of human beings to anticipate changes to this interface and resolve the issues that come with it (Chapter 2).

Current evolutions (pollution, overexploitation, development) and large-scale projects planned or ongoing (mega-ports, underwater exploitation, industrialization of the sea) predict increasingly harmful impacts of the Earth on the sea.

Conversely, climate disruption and oceanic disturbances foretell of major consequences on human communities, both in terms of livelihoods and living conditions.

In this respect, island spaces deserve special attention as the first casualties of such changes.

Chapter 1 : Understanding the land-sea interface

Part I of this report only dealt with natural causes currently affecting the Ocean Sphere*.

Human activities however, contribute to this condition in a much more direct manner than global warming or eutrophication*: physical, chemical, biological, noise and light pollution, overexploitation of ecosystem services (overfishing, coral reefs), destruction of habitats and ecosystems, ..., all contribute directly to the degradation of the Ocean Sphere*.

Consequently, the drivers of change are not as much to be found in nature itself, with its slower pace (notwithstanding natural phenomena that can be instantaneous), as in the relationship of humans to the ocean in this age of omnipotence over nature that is the Anthropocene.

Physical and cultural interface

The interface* between the global ocean and land (continental masses) spans an area that is as yet uncalculated[164]. At a human scale, a relatively narrow portion of this interface represents the physical and human entanglement of ocean and human settlement areas: the coastline (±1,6 million km worldwide[165]).

The concept of coastline

The coastline is an interface between land and sea. Its boundary on the sea side is usually the foreshore (intertidal zone). On land, however, the boundary varies according to discipline (law, geography, geomorphology, ...).

Using the same concept of ecosystem services previously detailed, the coastline can be considered an ecotone[166]*. This approach is particularly interesting in that it reflects the shifting aspect (in time and space) of this boundary on the one hand, and its significant ecological value, highly sensitive to anthropic influence and essential to protect (e.g. mangroves and salt marshes), on the other.

The geomorphological nature of the interface between them often conditions the degree of openness of land to sea: from coasts with difficult access (rocks, cliffs, ...) to easily accessible coasts (beaches, marshes, coasts with vegetation cover).

Two additional settings deserve special attention. The first of these is the sedimentary environment - defined by three components, i.e. water mass, living resources and non-living resources - between land and sea: bays, deltas, estuaries, lagoons, ... places where fresh and saltwater combine, with ecosystems both remarkable and vulnerable. The second is the proportion between the interface* and land mass, which is characteristic of islands.

Admittedly, all land areas surrounded by a coastline are islands[167, 168,169] including the continents. However, smaller oceanic islands stand out when :

- coastal index (coastline to land area) is high, indicating the extent of direct marine influences exerted on the island (atolls for example),
- isolation index is high, indicating remoteness from any other land (''isola effect''),

- endemism index is low, typical of an ecological insularity (cf. Rapa-Nui),

- altitude is low (sea level).

Such islands are particularly **vulnerable** to climatic and oceanic conditions. The land-sea interface impact is such that these spaces cannot be regarded as micro-continents: they are distinct environmental systems, strongly differentiated from larger island models, with higher resilience potential (Madagascar, Sumatra, ...). However, given the stakes at hand, all land-sea interfaces deserve to be considered.

This Island specificity justifies that islands be considered as a major human and economic issue in the future of the ocean.

Humans and the sea

For over 3 billion years, life on Earth was confined to the oceans. It is only gradually - and late on the evolutionary scale - that it emerged to colonize dry land. This hypothesis, however, does not exclude the possibility that life did exist on the continent, but did not fossilize.

Human beings still maintain a special relationship with water: not only because our body is 60% to 65% made up of water or because the nine months of our conception take place in an aqueous environment, but also because water is necessary for our survival (hydration), for our way of life (hygiene), for the vast majority of our activities (agriculture, industry, habitats, ...) and for our overall health (positive ions, blue space[177]). This close bond is at the origin of three major stages in the development of the relationship between humans and the sea.

- Thalassotropism is as old as human history. For over a million years, humans have voluntarily populated coastlines. This attraction to the ocean - the original place for a number of cosmogonies - is expressed in the fundamental myths of humanity, from Noun, the primordial ocean of the Egyptians, to Tiamat, Mesopotamia's salt water, from the quasi-universal Deluge to the Leviathan, endowing shells or fish with mythical (Aztecs) or symbolic (Christianity), and even monetary attributes (China).

  Original cultures were born out of this attraction. Some of these are today on the verge of extinction, such as the Moken (Burma), the Vézos (Madagascar), the Tofins (Benin) and the Vahocas (Mozambique). Others managed to preserve themselves, such as the Inuits, while others, like the Scandinavians, modernized without losing their specificity. All have left their mark on the history of maritime civilizations [172, 173].

- Haliotropism constitutes the second phase of this evolution, beginning with the mastery of navigation on high seas and the expansion of maritime trade[174] (China, Portugal, Spain, the Netherlands, England).

The conquest of the seas came with a mythological surge, sustaining an irrational anxiety towards the ocean (Kraken, killer whale, evil beings lurking in the depths (Cthulhu)). The advent of the steam engine in the 19th century consecrated British maritime hegemony and kick started maritimization*, a prelude to the industrialization of the ocean, which was to come in the 21st century (see next section). The ocean gradually lost its terrifying aspect.

- Heliotropism, the attraction of sunny places, combined with thalassotropism, in the Mediterranean, as early as Antiquity, as evidenced by the seaside towns of the time (Baiae, Barcola, the island of Mersea...). However, it was not until 18th century England that the first true seaside resorts emerged, at the time mainly for urban elites, and only in the 20th century - once the old myths had faded - did the ''beach'' become more democratized, giving rise to massive population movements and large-scale real estate developments, changing the face of coastlines everywhere, with the advent of seaside tourism, while at the same time a genuine recognition of the cultural and social significance of the ocean emerged (*blue humanities*).[175, 176, 177, 178]

The succession of these periods indicates that humankind's relationship with the sea was never linear. Be it because the ocean was an echo of divine punishment (the flood) or a dangerous place to be fled (the pan-African cult of Mami Wata), it was for a long time a source of hostility. That is why the 19th and 20th centuries are a historical turning point in this relationship: the ocean gradually became a source of well-being and spiritual awakening, an escape from the pressures of industrialization and urban development, while at the same time the concept and practice of leisure emerged[179].

Simultaneously, the notion of *seasideness*[180] developed: living by the sea confers a local typicity (genius loci) which, from now on, also inspires historians, ethnologists and archaeologists, both underwater and along coastlines.

Coastalization

As a direct consequence of the evolving relationship between humans and ocean, coastalization* (artificialization of the coastline) grew exponentially during the second half of the 20th century, on a global scale. It manifests itself in three distinct but correlated ways:

- An influx of populations, both perennial and seasonal: in 2000, over 600 million people lived on the coastline at less than 10 meters above sea level (i.e. 10% of the world's population) and 2.5 billion people lived less than 100 km from the coast (i.e. 40% of the world's population)[181].

- Accelerated urbanization along 1.6 million km of coastline to accommodate permanent and temporary populations: the resulting development generally negatively impacted local ecosystems: disruption of ecological corridors, pressure on vulnerable areas (e.g., cliffs), disruption of ecosystem balances, massive waste discharge (pollution) and unsustainable water resource extraction.

- The construction and continued development of industrial port areas (large seaports, shipyards, logistics areas, processing plants, etc.) and related transport infrastructure, both maritime and land-based, on one hand, and of specialized tourist areas (vacation villages, water parks, hotel complexes, etc.) on the other. Consequently, out of 260 million people working directly by the sea, most are no longer seafarers[182] * , (ecotourism, residential economy, public services, ...).

Each year, 9 billion tons of goods are transported by approximately 90,000 ships. The ships are getting bigger and the loading capacities are titanic. The maritime transport industry is present in 170 countries and is a source of employment for more than 1.65 million sailors and crew members: it is the leading international industry.

The ocean Atlas, published by the Heinrich-Böll-Stiftung, and the Future Ocean Cluster of Excellence of the University of Kiel, 2018

Paradoxically, neither the degradation brought about by this massive development (concrete coastlines, seasonal overpopulation, high cost of living), nor the increase in hazards (sea level rise, extreme climatic events) seem to be slowing this exponential trend in coastal settlement.

A socio-economic interface

The physical and cultural land-sea interface has lost its predominance to the socio-economic one. This interface highlights the contours of three distinct but interconnected spaces, mobility, economy and knowledge.

A space of mobility

Human beings very quickly realized that the ocean surface could connect one point to another through navigation.

The **maritime transport of people** serves four different purposes :

- Migration: in its first stages, it enabled people to move ever further along coastlines, hence the dispersal of early settlements in the Paleolithic age (50 to 70.000 years ago), then across larger maritime expanses, hence the settlement of Oceania as of 1500 BC, for example. Still today, at a time of increasing and ever complex migratory flows most ''irregular'' migration occurs by sea[183, 184].

- Long-distance, round-trip travel: regular long-distance transport dates back to antiquity (900 maritime lines in the Roman Empire). After producing the so-called ''floating cities'' of the late 19th century, long-distance ocean liners were replaced by aviation in the second half of the 20th century (late 1960s).

- Leisure: cruise travel dates back to 1844, and the first cruise sailed from London to Cairo. Pleasure travel by sea never stopped developing, in different ways (sailboats, liners, cruise ships, etc.) since then.

- Short distance travel: bus-boats, ferries, high-speed boats (hydrofoils, hovercrafts) can cross bays, straits, and estuaries on a regular basis.

In the West, **maritime transport of goods** began as early as the 9th century BC, driven by the Phoenicians, who developed commercial lines and trading posts all around the Mediterranean, later followed by the Carthaginians and the Romans. These nations built up military fleets to protect their trade from pirates and expand their territories, although these fleets were much smaller in number than their merchant fleets.

The construction and development of ports continued, enabling a flourishing maritime trade for the Mediterranean civilization, dominated by Venice, until the 15th century. Trade globalization accelerated at that time, in the West, with the discovery of America (1492) and the Iberian domination of the seas and, in the East, with Admiral Zheng He's great new Chinese Ming fleet (1403), armed with the best Song era naval technology, which completed seven great crossings to the Indian, Muslim and East African worlds. Maritime globalization continued to develop ever since.

In 2021, the global merchant fleet numbered between 74.500 and 100.000 ships, transporting 9 billion tons of goods, and accounting for 90% of world trade. The global merchant fleet is projected to grow 6.4% by 2025, with LNG tankers and cruise ships showing the most significant growth[185].

The transport of people or goods, maritime navigation thus evolved very early on from an activity of mobility (exploration, travel, sport) to a fully-fledged economic activity[186], relying on a specific population: "seafarers*"[187].

This was sustained by the development of increasingly technical skills, from shipbuilding to cargo insurance, from navigation to ship management, from bareboat loading to container ship operators...

Alongside this activity, a broad sector of ancillary crafts also developed: fittings, shipping companies, coastal signaling (lighthouses, semaphores), sea signaling and communication equipment (radio stations), marine meteorological services, sea rescue, ...

The sustained growth in number of passengers and trade volumes should continue to favor maritime shipping, which emits less CO_2 than aviation or land transport.

An economic area

The socio-economic function of the land-sea interface clearly reflects the anthropization of coastal areas and land-sea exchanges. It includes all economic activities this interface* generates.

These activities generally operate simultaneously in two distinct environments :

- the sea, both as the preferred surface for world trade and recreational activities and as a reservoir of resources (fishing, mining, etc.),
- the land coastline, basis for living (cities), for deploying activities at sea (ports) and for moving from/to onshore (hinterland* and related systems: communication infrastructure, supplies).

There are five categories of major importance for the sea economy*.

- aquaculture* include the harvesting of wild stocks (coastal and deep-sea fishing, shellfish and other marine organism collection) and the farming of marine species (animals and algae) in natural or artificial environments.

  On average, maritime fishing provides 87.2% of total fisheries production (2020), a steady global figure over the medium to long term (according to the FAO). Looking at marine animals only, aquaculture provides 49% of total production (2020). The global fleet in the same year consisted of approximately 4.1 million fishing vessels, 38% of which were non-motorized[188].

- The naval and nautical industries employ similar trades but produce very different vessels.

  - ✓ The shipbuilding industry[189] encompasses all activities related to the design, construction, equipment, repair, maintenance and dismantling of ships and floating structures (offshore platforms for example).

It produces complex structures, of significant size (>24 m) but in small quantities, for trade, transport, defense, ... Since World War II, Asian countries (Japan, China and South Korea) have supplanted Western countries, who historically dominated this sector. China accounted for 44.2% of shipbuilding in 2021, ahead of South Korea with 32.39% and Japan with 17.65%.

Concurrently, the naval and nautical sectors have become more **diversified** with the development of other industries: high-tech equipment, structures, equipment and services for marine energies, surface or submarine drones, cyber security systems, ...

✓ The boating industry is a fraction of the larger nautical sector, which includes all sporting activities practiced on or under water, from pleasure boating to water sports.

  It builds small boats in considerable quantities for pleasure boating, repairs them, maintains them, sells them or rents them. Recent growth here is driven by demand for multihulls[190], despite a sluggish global market.

- Ocean leisure shows continuous growth, fueled in particular, by the coastal regions and islands offer: tourism accounted for nearly 12% of small island developing states' GDP* on average in 2019. Worldwide, travel and tourism is one of the largest industries in the world (10% of global GDP and employment)[191] . Across a variety of sectors, it includes coastal and island activities associated with :

- ✓ marine and coastal tourism, focused on travel and accommodation: hotels, restaurants, tour operators, transport, etc

- ✓ yachting, focused on water sports: diving, sailing, gliding...

- ✓ seaside leisure: local cultural activities (museums, events), entertainment (casinos, water parks, etc.) and recreational activities (aquariums, parks and beaches, etc.).

- Maritime development (coastal part and subtidal zone* or shoreface*) is a broad economic area mainly dominated by the construction and public works sector: urban planning, industrial-port complexes (fishing, trade), specific tourist facilities (marinas, vacation villages) and associated infrastructure (waste treatment, water and energy networks, communications, ...). It now extends to the sea, with polders and the explosion of artificial islands[192].

- Two other specific economic activities should be mentioned :

  - ✓ For nearly two centuries, the submarine cable industry has laid and maintained submarine cables for communications or electric power transmission. In 2013, some 99% of intercontinental data and telephone traffic was transmitted by submarine cables and the number of cables[193] almost doubled in the years 2010 to 2020. Power cables connect islands to nearby mainland, interconnect power grids, power offshore platforms or carry electricity from wind farms.

The single and continuous ocean, surrounding all the lands, [...] is obviously the condition geographical of the final unification.

Halford J. MACKINDER, British geographer, considered to be the founding father of geopolitics[168]

- ✓ Offshore oil and gas extraction from the seabed has expanded steadily since the 1950s, and in 2019 accounted for one-third of global oil and gas production. Offshore wind power emerged in the early 2000s as part of the energy transition, and now competes with floating wind power, which re-uses the floats and anchoring systems of oil platforms. The slowing oil market now drives hydrocarbon operators to invest in offshore wind[194, 195].

Accordingly, in 2015, total economic activities related to the sea accounted for approximately 2.5 trillion dollars, i.e. 2.5% of the world's gross value added - with hydrocarbon exploitation leading the way (> 25% of total value), followed by marine and coastal tourism - and 30 million direct jobs, a third of which in industrial fishing and a quarter in marine and coastal tourism[196].

To make the most of this socio-economic development potential, the ocean has also become a space of knowledge.

A space of knowledge

Studying the Ocean Sphere in its various forms (geophysical, biological, etc.) enables the development of two major areas of knowledge: fundamental science (advancing knowledge) and applied science (research and development of new applications).

In view of the significance of economic activities, it is almost surprising that research and development (R&D) was so slow to take an interest in the Ocean Sphere's potential, particularly in the field of medicine: only in 1960 was a research center for medical oceanography biology (CERBOM) created (France), and only in 1995 was marine biotechnology featured in a report by the National Science Council (USA).

Since then, a number of countries have invested substantially in this field, with the backing of the pharmaceutical and cosmetics industry, to extract biochemical substances from marine organisms for medical purposes. The countries of Africa and the MENA* zone however, remain on the sidelines of this global trend.

Blue biotechnologies*[197] are, today, booming (10% growth per year since 2010, a global market of € 3.8 billion in 2017)[198] . These technologies explore maritime potential for a multitude of applications beyond the medical sphere: agri-food, aquaculture, cosmetics, energy, protection and restoration of marine environments... Norway and France are the leading global suppliers of marine ingredients[199].

The meteorological information industry is yet another example of R&D development with respect to the Ocean Sphere, as evidenced by the transformation of the Mercator System administrator, Mercator Ocean, into an intergovernmental agency (February 2022), in charge of building a digital replica of the ocean, to enhance knowledge and improve ocean predictability.

While it is often difficult to draw a clear line between basic and applied research , ocean research* has suddenly become much more visible since 2019, owing to the impetus provided by the United Nations Decade of Ocean Sciences for Sustainable Developement (2021-2030).

From the study of marine viruses to the bioluminescence of abyssal organisms, to understanding, measuring, warning, assessing and managing ocean-related affairs, the 150 member states of UNESCO's Intergovernmental Oceanographic Commission mobilized to improve ocean research through coordination. This enables the pooling of research programs and multiplication of ocean exploration efforts.

This work relies on important scientific organizations including the French Research Institute for Exploitation of the Sea (IFREMER), the SCRIPPS Institute in the United States, ... and the mobilization of public and private sponsors around key international events such as the World ocean Summit and Expo (organized by World ocean Initiative), One ocean Summit (organized by One Planet Summit), UN ocean Conference (United Nations), ...

A twofold dimension undoubtedly underpins this massive movement to enhance Ocean Sphere knowledge: the realization that oceans are at the heart of socio-economic sustainability (Sustainable Development Goals), climate change (Paris Agreement) and the dangers that face humanity (Sendai Framework) on one hand, and the $3 trillion potential value of the marine economy by 2030[201] on the other.

A geostrategic interface

Ports are traditionally key gateways to the sea. As focal points of maritime façades[202], their significance reflects the increased **maritimization** of activities, i.e. the growth of international trade by sea, which has accelerated since the 1970s. This trend is sustained by four concomitant phenomena:

- Globalization and, more specifically, ''maritime-globalization*''[203] : 90% of world trade flows over the planet's ocean (71% of Earth's surface), connecting coastal areas in a ''world economy''[204]. ''International maritime trade has reached such a level (from 2.6 billion tons in 1970 to 10.7 billion tons in 2017)[205] that it can no longer be suspended without causing vital damage. [...] This acknowledged maritime interdependence has become vital to all, a strategic reality and a source of virtuous regulation of global tensions.''[206]

- Technology: Economies of scale and automation have cut the cost and duration of maritime transport. The gigantic size of ships, the logistical organization of grouping/ungrouping and containerization* are decisive technical tools.

- The relatively recent post-industrial awareness of the sea economy as a powerful engine for development and employment is supported by a new cultural appropriation of the sea, maritimity. ''Maritory'', a neologism now used for maritime territory, is a sign of this appropriation (cf. the Blue Amazon in Brazil).

- The perception, associated with maritimity, of a pacifying influence of the sea: ''In terms of strategy, maritimization implies broad ideas of common good, of world heritage to be preserved, of the beneficial necessity of alliance to exploit wealth, to share resources and technology.''[207]

Three geostrategic drivers have informed maritime relations since the advent of navigation and its relational interface: access to the sea, control of the sea, and insecurity at sea.

Access to the sea

Access to the sea has always been considered essential for trade, supply and expansion (conquests). Yet access is unevenly distributed, with some countries not having a coastline or having lost it over the course of history.

While the development of aviation somewhat eased access to sea claims over the past half-century by reducing the isolation of these countries, renewed interest in the maritime economy has rekindled some tensions, such as in South America where, in 2014, Peru sought and obtained maritime territory lost in the Pacific War (1879-1883) before the International Court of Justice, while in 2018, the same Court refused to grant Bolivia an identical restitution.

In the absence of a definitive right ''of the sea'' (although the Montego Bay Convention was signed by 168 countries, its Article 69 is inherently restrictive and is the subject of reserves by a number of States[207]), this access today stems from :

- geography: Canada holds the world's longest coastline (202.080 km), ahead of Norway (84.022 km) and Indonesia (54.716 km), with the United States (22.450 km), in 8th place[208].

- colonial assets (overseas possessions): France holds the world' second largest maritime space owing to its overseas territories, which add 12.600 km to the 5.858 km of mainland coastline[209].

- the acquisition of ports for economic, military or strategic purposes: this port grabbing* strategy comes in many forms, ranging from the takeover of the port of Berbera in Somalia by Dubai-based DP World to China's port infrastructure development projects under the New Silk Roads *.

As a component of maritimization, maritime transport has become a key factor in the reorganization of trade. With diminishing revenues, maritime players tend to supplement their trade by investing in the land-side of the port hub: road and railway transport, global door-to-door logistics chain, ...

Consequently, States' access to the sea is now combined with equally strategic access to land for maritime players[210].

Controlling the seas

whosoever commands the trade of the world commands the riches of the world, and consequently the world itself.

Sir Walter Raleigh (1552-1618)

Recognizing that economic and military power also depend on control of the seas, States very early on, began vying for control of the seas and subsequently expanding maritime areas in their control: from the Minoan thalassocracy (18th century BC) to the Viking expansion (8th-11th century AD), from the great Chinese explorations (15th century) to the Spanish-Portuguese (16th-18th century) and then British (18th-19th century) maritime empires, up to the US Navy (20th century)... Yet, the principle of freedom of the seas allowed for a quasi-indivision of the world's oceans up until the mid-20th century.

The desire of States to monopolize marine resources drove the progressive reduction of the high seas - where the principle of freedom of the seas applies - under the aegis of international law, starting in 1958. This development reflected the increased competition among States seeking to impose economic and/or military control.

- **International law of the sea**

The law of the sea is of customary and conventional origin and governs oceanic spaces - public international law - unlike maritime law (commercial law, therefore civil law) which regulates navigation and maritime transport. It governs both the division of the ocean (and the arbitration of disputes thus raised) and the preservation of its planetary unity.

As a matter of fact, in the last quarter of a century, the size of the high seas area (international waters) was cut by one-third by the expansion of existing legal spaces (territorial sea) and the creation of new State holds (exclusive economic zone, continental shelf, archipelagic waters) stemming from the Montego Bay Convention.

At the same time, this law upholds an absolute freedom of navigation* in international waters, a right of transit passage[211] in straits and a right of innocent passage in territorial waters, both in times of peace and war, thus guaranteeing the movement of both people and goods. Today, the jurisdictional area of the high seas covers 64% of the ocean's surface, that is, nearly half of the world's surface.

It also seeks to protect ocean heritage :

- ✓ Ocean floor resources in the high seas have been designated as ''common heritage of mankind '' (no State or legal entity can claim ownership over it),
- ✓ Protection of marine areas through a number of international conventions (marine protected areas, pollution prevention, ...).

The universality of the different conventions governing the rights, duties and cooperation of States with respect to the ocean, indicates the extent to which the management of seas and ocean is a global affair, be it out of conviction or fear of prejudice.

- **Geo-economic control of the seas**

The exponential development of maritime globalization rests on :

- ✓ offshore resource extraction (fisheries, offshore wind energy, hydrocarbons), hence the significant geopolitical stakes[212] of exclusive economic zones and new maritime domains,

✓ permanent availability of strategic (choke points): bottlenecks in global maritime traffic (seven out of 14 identified choke points[213, 214], are of particular interest): the Strait of Gibraltar, the world's second most important passage point, Bab el-Mendeb, Hormuz and the Suez Canal, encircling the Arabian Peninsula, the Straits of the Bosphorus and the Dardanelles in Turkey, and the Panama Canal) or the option of circumventing them or using them to project power (the New Silk Roads, or the numerous foreign military installations in Djibouti, for instance),

✓ diversifying maritime routes, computed with ever greater precision to rationalize costs, but which need to be renewed to expand possibilities and meet security challenges. The prospect of permanent summer clearance for new Arctic routes is of crucial importance (shorter maritime route from East Asia to Western Europe ranging from 21.000 km (via the Suez Canal) to 12.800 km (via the Northern Sea Route),

✓ control of world ports, essential nodes in global supply chains: While concentration of maritime flows in Asia directly impacts the world's largest ports - 19 out of 25 of which are Asian (2020), with Shanghai being the world's largest – two-thirds of global trade is loaded or unloaded in ports of developing countries (see next chapter) . This accounts for China's port investment strategy in Europe, Afrique as well as its growing interest in Latin America[218].

✓ Developing international cooperation to combat insecurity (piracy, illegal fishing, looting, etc.), ensure safety (accidents at sea) and preserve marine resources (biodiversity).

In this global economic and maritime competition, geo-economics* are a key driver of international power for developing countries and major world powers (China, Russia, India). Control of the seas, supported by a large fleet and an efficient port network, holds the key to this power, as illustrated by China in this early 21st century.

- **Military control of the seas**

Armed ships have been used to protect merchant ships since ancient times. The build-up of war fleets and related maritime infrastructures followed soon after, be it in the Mediterranean or in Asia, spurring a rich naval military history from the ''sea of victorious fleets'' of Almohad Caliph Yaacoub al Mansour[218, 219] , to the contemporary Chinese naval power.

The States with the largest military navies in the world today are China, Russia, the United States and North Korea. This quantitative ranking of surface and submarine forces fails to take into account the quality of onboard military equipment and current dynamics.

However, it reveals some interesting developments: while some national military fleets remained stable (in volume) over the last 3 years (e.g. China, Russia, Thailand, South Korea, Finland, Morocco ...), others declined slightly (United States, United Kingdom, Colombia, ...), or significantly (North Korea, Iran, Egypt, Italy ...) or, on the contrary, grew slightly (Indonesia, India, Turkey, Greece, United Arab Emirates, ...) or strongly (Sweden, Sri Lanka, Kuwait, Spain, Chile, Nigeria, Vietnam, Lebanon...).

From 2020 to 2022, 21 of the world's top 50 war fleets increased their number of ships (including 3 that more than tripled: Sweden, Sri Lanka, Kuwait), 14 decreased and 15 remained stable[221].

At the same time, the strategic naval landscape has undergone significant reshuffle since 2015:

- ✓ China, today's leading naval power stands out both in terms of quantity (777 ships ahead of Russia's 605 in 2022) and autonomy owing to its expertise in the production of aircraft carriers, submarines and hypersonic missiles, but also in terms of its ability to impede maritime transit through key choke points and block access to the South China Sea (30 per cent of world trade) in case of conflict in the region. It also broke new ground with the creation in 2015 of a hybrid force, the People's Armed Forces maritime militia, bringing together military, professional fishermen and sailors.

- ✓ At the same time, the militarization of the Arctic by Russia is of concern to several neighboring States and those seeking to eventually use the new polar sea routes.

- ✓ Since 2015, the United States has profoundly re-thought its naval strategy, which is now based on the concept of *Distributed Lethality* (geographic dispersion of naval assets, electromagnetic operations).

This situation reflects a tense post-Covid 19 world with a slowing globalization, increased regionalization (cf. Regional Global Economic Partnership*) and a determination to secure supplies (food, pharmaceuticals, strategic materials, ...).

The Indian Ocean, as the object of extensive geo-economic and geopolitical activity from various powers, sums up this tension on a maritime scale and is a leading indicator to watch.

Over the longer term, the high-tech arms race exposes the physical ocean to new virtual dimensions (Internet of Things, electromagnetic bombs, etc.), thus expanding the potential for relational fractures.

Insecurity at sea

As it is impossible to control such a vast expanse and yet the bulk of exchanges - of people as well as goods - transit by it, the ocean can be the scene of acts or mishaps that impact safety (illegal acts) and security (accidents).

Insecurity at sea stems from five main yet diverse causes: :

- Illegal, unreported or unregulated fishing* violates the rights of coastal States and international legislation, but above all jeopardizes marine biodiversity (conservation and protection) and the long-term potential income of local populations. While the issue of flags of convenience is at the core of the problem, States adhering to various international conventions on fishing are also at fault, albeit to a lesser extent.

  Illegal fishing proliferates in response to increased global seafood consumption and the ensuing economic competition. It is made easier by inadequate control of distribution channels (almost no traceability), the difficulty of monitoring fishing areas and by the low efficiency of State efforts to eradicate the phenomenon[223].

- Piracy* (international waters) and armed robbery at sea (territorial waters), while declining in recent years, notably as a result of securing the Gulf of Aden, have nevertheless become increasingly sophisticated, as pirates adapt to constraints imposed upon them by national and international efforts combating the phenomenon. In 2021, a total 132 attacks were recorded worldwide, concentrated mainly in South East Asia (42%) and in the Gulf of Guinea (28%)[224].

  Piracy is supported by vast transnational organized crime networks (mafias, terrorist or separatist groups, etc.) and fueled by the growth of maritime trade, the impoverishment of coastal populations as a result of depleted fishery resources and, more recently, by the development of terrorism (Africa) and the massive theft of fuel (crude oil, liquefied energy) on board ships, platforms and pipelines.

In Asia, the region with the most recorded incidents, «of the 76 incidents, four were incidents of piracy (5%) and 72 were incidents of armed robbery against ships (95%)."

Recaap - Piracy and armed robbery against ships in Asia Annual report 2018

- Maritime transport of illegal goods (drugs, wild animals, wood, works of art, weapons, counterfeit goods, etc.) follows the threefold upward curve of maritime trade, whose ships and trade routes it uses, of cross-border organized crime and of the booming global consumption of these illegal products (from opioids to ivory). Thirty-three percent of all firearms seized by customs for example, come from intercepted vessels, while over 90% of illegal wildlife trade - one of the world's largest illegal trades - travels by sea[226].

- Illegal transport of people refers to particularly lucrative migrant smuggling. Rising economic inequalities (in terms of income, freedom of enterprise) and social inequalities (human development, human rights) along with the emergence of serious threats to human security (conflicts, natural disasters) drive people in precarious situations, economically or humanly, to migrate outside their region of origin.

  Greater restrictions on access to host countries account for recourse to migrant smuggling networks[226]. Whether crossing the Mediterranean or the Atlantic in a cargo ship or crossing the English Channel in an inflatable boat, smuggler networks are part of organized crime and polycriminality (documents forging, human trafficking and exploitation, organ trafficking, drug smuggling, etc.).

- Insecurity at sea is not solely the result of malice, it can also be accidental. This is the case of shipwrecks and damages at sea, caused by storms or collisions.

Increased maritime traffic in some areas, such as the Mediterranean Sea and the straits, growing recreational boating, and extreme weather events due to climate change are all risk factors. However, while in the early 1990s the global fleet with over 100 gross tons of capacity lost upward of 200 vessels per year, since 2018 it has lost only 50 to 75 per year, and there are some 130,000 vessels today compared to around 80.000 30 years ago[228].

States attempt to combat global insecurity using a number of tools, including :

- International and regional cooperation, for example against piracy with the Global Maritime Crime Programme, the Regional Cooperation Agreement to Combat Piracy and Armed Robbery against Ships in Asia, and mobilization of multinational naval forces such as Atalanta (European Union), CTF-151 Group (United States and allies), or ocean Shield (NATO), and against migrant smuggling with the European Migrant Smuggling Centre (Europol, 2016),

- public-private cooperation, as to fight illegal trade of poached goods, under the aegis of the United Nations Development Program, which uses mixed funding (foundations, NGOs, governments, etc.) and partners with private shipping to expand maritime transport surveillance,

- adapting long-established international legal frameworks to changing realities, such as the widespread exploitation of vulnerable people at sea, and raising awareness on the legal obligations and responsibilities of various actors in this area (Protection of Migrants at Sea),

- a total ban on the trade of certain smuggled products on domestic markets, such as ivory, for example, taken by China in 2017 and by the European Union in 2021, under the Convention on International Trade in Endangered Species of Wild Fauna and Flora CITES*,

- the use of efficient technologies to track vessels and catches at sea: drones, beacons, sensors... including seabirds, equipped with GPS.

▶ A better understanding of the land-sea interface and the underlying dynamics that drive it over the long term, highlights five major issues :

- The increasing maritimization of human activities and its relatively recent acceleration.

- The strong dependency binding globalization, maritimization (maritime transport, international seaside tourism, ...) and, as a consequence, coastalization (ports, seaside resorts), hence the concept of maritime-globalization.

- Increased tensions arising from, the growing influence of States on the ocean on one hand, and the growing dependence on marine resources (food, energy) on the other, hence new naval and maritime strategies by major powers.

- Significant efforts in international cooperation to improve safety and security at sea, while a number of illegal activities (trafficking in goods and persons) develop just as significantly.

- Finally, the maritime pre-eminence, alongside the United States, of two countries: Russia, which has undertaken a remilitarization of the Arctic, and China, whose maritime and naval offensive strategy is based on State capitalism and the ability to hybridize civil and military forces (string of pearls strategy, militia...).

Chapter 2 : Anticipated impacts

While understanding the land-sea interface underscores the plurality of interaction between human activity and the ocean, it also shows the often overlooked magnitude of reciprocal structural impacts. Such impacts are far from always positive, both for the ocean and for the Earth and human beings, over the coming decades. To better anticipate them, it is important to identify underlying and emergent trends, change factors and impacts, in both Land-Sea and Sea-Land directions.

Land-Sea issues

Three main directions dominate future developments until 2050 :

- Demographic growth: from 7.795 billion inhabitants in 2020, the world population is projected to reach 8.548 billion in 2030 and 9.735 billion in 2050[229, 230]. This population growth may slow down after 2090 according to the United Nations, and even reverse from 2064 according to the Institute for Health Metrics and Evaluation[231,232]. However, before that, 2 billion additional human beings will be born by 2050, who will have to be fed. By 2060, the world's three most populous countries will be India, China and Nigeria[233], ahead of the United States : three countries for which access to the sea is already essential.

- The economic needs of future populations: in addition to these needs, there are those of current populations, all age segments combined, the consumption of whom continues to grow as more countries accede to development, despite the slowdown caused by the pandemic.

- Climate change* and its consequences on population mobility: in 2020, of 33.4 million internal displacements, 24.9 million were induced by climate-related disasters[234]. By 2050, this number could reach 216 million people, including over 140 million in sub-Saharan Africa, South Asia and Latin America[235,236].

This means increased strain on natural resources, especially food, as already evidenced by the receding Global Overshoot Day.

As for a more specific evolution of the global land-sea system, two additional driving forces should be taken into account: geopolitics (see previous chapter) and technological advances, enabling greater exploitation of the ocean environment.

Consequently, the ocean is increasingly considered both as a response to human food, resource and space needs and as an engine of growth for the world economy. The maritimization* of the economy is therefore a powerful trend that is likely to accelerate over the next half-century.

Impacts of these developments

As early as 1951, the seminal work of marine biologist Rachel CARSON alerted world opinion to the centrality and fragility of the ocean[237]. Yet, in the half-century that followed, the major trends outlined above, combined with growing maritimization (maritime transport, seaside tourism, fishing & aquaculture, offshore extraction), magnified the main factors of Ocean Sphere degradation and are likely to continue until 2050. Beyond climate change and greenhouse gas emissions, direct anthropogenic causes include :

Today, almost a quarter of the fish stocks for which data are available are at risk. Of the remaining stocks, only slightly more than half are sufficiently abundant for catches to reach a maximum value or volume on a sustainable basis.

OECD (2021)[233]

- Pollution, both growing and multiform, generates eutrophication of coastal waters and pollution of the high seas affecting plankton at the surface (see Part I) and all the ecosystems it comes into contact with in its marine journey. Two-thirds of marine pollution and 80% of marine waste originate from land. Once at sea, 90% of this waste ends up on the ocean floor[238]. If marine ecosystems are altered by air pollution (carbon) as well as light and noise pollution, it is chemical pollution that causes the greatest damage.

  Indeed, global chemical pollution now exceeds planetary limits[240]. Marine pollution results from agriculture (runoff of inputs and treatments) and industry (discharge of residues in rivers or in the sea) as well as domestic practices (sewage, insufficient or untreated waste materials e.g. pharmaceutical products).

  Three pollution examples are discussed hereunder:

  ✓ Hydrocarbons: although major oil spills have steadily decreased over the past 50 years, accidental (pumping leaks) and illegal (operational discharges from ships and offshore platforms) oil discharges into the ocean persist (6 million tons per year of hydrocarbons at sea)[241].

    The Mediterranean could be especially impacted in the coming decades by increased offshore exploitation, illegal oil trafficking and maritime accidents[242, 243, 244, 245, 246].

Finally, many oil platforms are nearing the end of their lifespan (470 in the North Sea to be dismantled by 2050, over 3.800 in the Gulf of Mexico), a global dismantling market of over 50 billion euros over the next 15 years, which could prove difficult to finance, which may lead to these structures being abandoned at sea[247].

- ✓ Plastics: 11 million tons of plastic waste end up in the world ocean every year (2020), a statistic that doubles every decade (i.e. 30 million tons per year by 2040[248] or 50 kg of plastic per meter of world coastline[249]), not to mention the additional and unforeseen 8 million tons of plastic waste generated by the Covid-19 pandemic (masks, bottles, syringes, ...)[250].

Although a systemic change could cut this volume by 80%, current measures will only reduce this annual volume by 7% by 2040[251,252]. Regardless of quantities still to come, the question arises as to how to deal with the current mass of plastics in the ocean, ranging from microplastics - found at the bottom of the abyss (11,000 meters), in fish and now human blood[253,254]– to macroplastics, which invade coastlines and ocean gyres[255], through to mega plastics, including small pleasure boats abandoned at the end of their life or after a natural disaster.

Under current policies, the amount of this urban solid plastic waste is set to double by 2040, the amount of plastic released into the oceans is expected to almost triple, and the amount of plastic in the oceans is expected to quadruple.

ONU

- ✓ Radioactive waste: it can no longer be legally disposed of in the high seas since 1990 according to the London Convention. Between 1950 and 1990, 200.000 drums of radioactive waste were dumped in the North-East Atlantic Ocean, with no long-term monitoring (30-year life span). A scientific mission is planned to assess their condition in 2023-2024[256], but no decision has yet been made as to the outcome[257]. No data is available on current illegal dumping of hazardous products.

- Malfishing refers both to fishing without regard to conservation and protection of fish stocks (overfishing, illegal fishing, bycatch) and to destructive practices in exploiting marine resources for food (industrial aquaculture, ghost nets, discards, etc.). Between 1990 and 2018, while marine capture fisheries were broadly stable, totaling 84,4 million tons in 2018, aquaculture grew by 527%, in parallel with a 122% increase in total fish consumption. In the same period, the percentage of fish stocks at biologically sustainable levels dropped from 90% to 65.8%, illustrating the unsustainability of fishing practices. Two major phenomena weigh on the future of marine biodiversity despite all actions taken :

  - ✓ Overfishing (when a species is fished faster than it can breed and develop) comes from two separate sources. **Legal fishing techniques**, such as deep-sea trawling, generate bycatch: almost 30% of global catches (45% of total catches in the North Sea[258,259]) are discarded alive or dead (sharks, turtles, seabirds and dauphins, among others).

Illegal, non-reported or unregulated* fishing (one third of global catches in 2018) does not comply with quotas or protected areas, which primarily damages long-lived and slow-growing species . It is considered a new form of piracy (responsible for up to 50% of catches in an already depleted Indo-Pacific area).

In total, only one fifth of all commercial species are fished in a sustainable way[262].

- ✓ Aquaculture: since 2014, the global population consumes more farmed fish than wild fish (from marine or river fishing). This booming industry (80 million tons excluding plants in 2016), concentrated in Asia (60% of global production is Chinese), is expected to continue growing to meet an 80% increase in global demand for animal protein by 2050. Yet its environmental impact is way too high, both in terms of **fish farming*** - loss of biodiversity* (it takes 20 kg of wild fish to produce 1 kg of farmed tuna), destruction of mangroves (biodiversity and ecosystem services), chemical pollution (pesticides, antibiotics) - and in terms of mariculture (36% of all aquaculture in 2017) - deoxygenation and eutrophication* of coastal waters[263].

20% of the world's mangroves were destroyed by human action between 1980 and 2005, and more than half (52%) due to the introduction of aquaculture. In the Philippines alone, two-thirds of the mangroves have been destroyed to make way for shrimp farms.

Atlas of the Ocean, published by the Heinrich-Böll-Stiftung Schleswig-Holstein, the Heinrich-Böll-Stiftung and the Future Ocean Cluster of Excellence at the University of Kiel.

- Coastal development in the broadest sense refers to all development operations carried out on a coast or in adjacent waters (urbanization, port infrastructure, dykes, polders, ...), as well as all changes in the use of coastal lands and the sea. This accelerated artificialization of coastal areas is the result of both faster than average economic growth of coastal regions (in Europe, for example, they account for 40% of European GDP) and intensification and extension of agricultural areas to the detriment of key ecosystems such as mangroves or salt marshes.

By 2035, over 75% of the world's population could be living within 100 km of a shoreline (60% in 2017)[264,265]. The many consequences of this include :

- ✓ erosion of marine biodiversity through, on one hand, the destruction, degradation and fragmentation of coastal habitats (land and sea), particularly seabed abrasion, driving mobile species to migrate and others to disappear and disruption in marine species' rhythm of life (light, noise, vibration, ...), altering biology (stress), feeding, and even reproduction[266], on the othern;

✓ degradation of natural coastal environments and ecosystems and balances, caused by deposits or discharges of port or estuary dredging sludge, alteration of sediment deposits by inadequate dykes, pontoons or coastal embankments, and destruction of beaches through excessive sand removal.

It should be noted that sand is the second most exploited natural resource worldwide after water. Some 40 to 50 billion tons of ocean sand per year (desert sand is unsuitable for construction) are extracted globally, half of which is used in construction:

Hence the magnification of this trend by 2050. This land grab, combined with coastal erosion caused by urbanization and rising sea levels, could cause half of the world's beaches to disappear by 2100, i.e. over one sixth of global coastline[267].

- Maritime transport: after two years of pandemic and amidst a war in Ukraine, global maritime trade trends are somewhat difficult to anticipate. The underlying trend shows an increase in global demand for freight, which should triple the volume of maritime transport by 2050[268].

  Prospective analysis of sector developments is however made difficult by factors likely to slow down or accelerate this momentum, depending on the success or failure of corrective measures implemented by the International Maritime Organisation and countries concerned :

- ✓ The environmental cost of maritime transport translates into water pollution (hydrocarbons, dissemination of invasive species, waste including plastics), air pollution which, in turn, impacts the Ocean Sphere.

  This is largely attributable to the high sulfur content of fuel used by ships (3.5% compared to 0.01% in the fuel used by cars) , which contributes to ocean acidification and damages human health, causing some 400,000 premature deaths each year[270].

  In addition to this, toxic gas emissions and carbon dioxide emissions from ships, accounting for 2.9% of global emissions in 2018 , could increase 50 to 250% by 2050[272].

Also, **cryosphere* pollution** (*black carbon*) in the Arctic and the **disturbance of marine fauna** (collisions with marine animals, noise and light pollution*) should be highlighted. Will the different *Green New Deals* reduce shipping in the first instance and lower its environmental cost in the second?

- ✓ Restructuring of the shipping sector, brought about by price wars (cf. Hanjin Shipping's bankruptcy in 2017) and economic rationalization stemming from greater digitalization (autonomous ships, arrival of outsiders such as Google or Amazon) could breathe new life into a sector plagued by low wages and poor working conditions for crew. But disruption to global supply chains, following Covid-19 lock-downs, the e-commerce explosion (logistical undersizing) and, more recently, the war in Ukraine, could lead to a major overhaul of shipping in the next decade.

- The outlook for seaside tourism remains difficult to draw in 2022, despite a slight recovery in 2021. If pre-pandemic trends resume (3 to 4% per year), with international tourism growing substantially, the number of international tourist arrivals in 2030 could reach 1.8 billion from 1.4 billion in 2018 according to the World Tourism Organization. It is also important to monitor the evolution of maritime tourism (cruises) which is developing into mass tourism (increase in the size of liners), is particularly polluting and bears a significant ecological footprint.

Clearly, ongoing developments favor global economic growth and meeting the food needs of the greatest number of people, but this is to the detriment of the planet and more specifically the Ocean Sphere. Despite the rallying of many States around Sustainable Development Goal 14, the global trend towards coastal and marine pollution, destruction of ecosystems and overexploitation of fish stocks continues: the ocean and the fishing resources it supports are in poor condition and are deteriorating exponentially[274].

These trends, which the Covid-19 pandemic seems to have barely slowed down (with the exception of international seaside tourism), are likely to accelerate as a result of major ongoing and future projects.

Major projects

The more we learn about the sea, the more obvious its benefits become. This should eventually lead to an understanding of the importance of protecting Ocean Sphere* balances. However, a predatory economy still prevails for the time being, that uses the pretext of feeding a world population of some 8 billion people in 2022/2023 and 9.7 billion in 2050, i.e. 21% increase in spite of the global demographic transition.

Similar to the ''Great Acceleration*'' of human activity in the aftermath of the world war II- giving rise to the Anthropocene - a Blue Acceleration has emerged over the last three decades, driven by rapid expansion of activities that make up the marine economy* (maritime transport, fishing, offshore wind power, marine biotechnologies). Anticipating future developments requires consideration of current and announced major projects likely to have a significant anthropogenic impact on the ocean and coasts over the next 10 to 20 years[275, 276].

These major projects are presented as national ''blue'' strategies and public or private projects to exploit marine resources or create new maritime infrastructures.

National and global strategies: directly feed the Blue Acceleration. The maritime economy* plays a significant role in 4 country categories[277]:

- Small island developing states* where tourism and fishing are vital (see below) ;

- Coastal countries, for which marine resources constitute a primary development driver, implementing aggressive policies to develop their maritime economy, including Norway (hydrocarbons, fishing and tourism) and Morocco (Port Plan 2030, Halieutis, Tourism Vision 2020) ;

- **Economically diversified** countries, for which some sectors of the maritime economy are important, without it necessarily accounting for a significant share of GDP (Chile, Mauritius, Singapore) ;

- Finally, **global powers**, for which the sea economy is an integral part of a global geopolitical strategy and which devote considerable resources to it, such as China (Two Ocean Strategy) and India (SAGAR Initiative, Maritime India Vision 2030). China could, by 2030, control 24% of the global merchant fleet as a result of its investment in traditional shipping lines and polar shipping routes. It already manufactures 100% of all refrigerated containers and accounts for 40.3% of worldwide ship production. The economic and environmental sustainability of these strategies are not, however, guaranteed.

Major projects for exploiting marine and submarine resources, directly resulting from the Blue Acceleration: depletion of land resources, exponential demand for energy (+28% between 2015 and 2040) and biological and mineral resources (cobalt, copper, rare earths) are driving major investments in large offshore projects :

- **Energy production and storage** (projects such as Cross WIND - 11GW in 2030 - combining wind, solar, storage and green hydrogen[279]) :

    - ✓ Fixed or floating wind power plants: e.g., The Dutch North Sea Agreement the world's largest wind project under construction, Dogger Bank, in the UK North Sea; the European Union's Strategy for Reneuwable Marine Energy, which calls for an increase in installed offshore wind capacity from 12GW in 2020 to a minimum of 60GW in 2030 (+400%) and 300GW (+400%/2030) by 2050.

- ✓ Floating solar power panels: Cirata, for example, the largest floating photovoltaic power plant project (145 MW) in Southeast Asia.

- ✓ Storage of green hydrogen (produced by offshore wind) in underwater salt caverns (Tractebel).

- ✓ At the same time, major oil projects are underway, such as Canada's Bay du Nord project, which is scheduled to commence operations in 2028 and extract 300 million to 1 billion barrels of oil over 30 years[280].

- **Deep sea mining exploration:** in connection with the emergence of a genuine polymetallic mining industry (nodules, sulfides, crusts) starting in 2010, the International Seabed Authority has since 2001 leased around 1.4 million square kilometers of seabed for exploratory mining activities, i.e. 31 exploration contracts granted to 22 public and private contractors.

  While commercial exploitation has yet to begin, these projects are shaping up while scientists and NGOs, such as the International Union for Conservation of Nature, attempt to oppose them. Following a request from the island state of Nauru, the International Seabed Authority is due to propose mining regulations by 2023, even though risks to the Ocean Sphere are not sufficiently assessed. This opening to mining will kick off a genuine hunt for exclusive economic expansion zones* (EEZ), leading to negotiations between island states and non-maritime states and heightened geopolitical tensions.

Mega-port: port facilities able to handle large volumes of containers, representing an economic value capable of contributing to the regional economy by up to a third, and occupying a significant land and sea area.

The new era of mega-ports, Report of the International transport forum ITF at the OECD 2015

- **Marine Biotechnology**: the United States, France, Australia, Japan and Canada are the leaders in marine biotechnology. Marine biotechnology applications range from cancer treatment to surgical adhesives to universal hemoglobin. Some 99% of marine organism genetic sequences filed for patents were registered since 2000[281].

- **Desalination:** almost two thirds of the world's population could experience severe water shortages as early as 2030 (Middle East, Australia, Africa...) hence the use of seawater desalination, which has tripled since 2000.

  At the same time, non-potable water needs also grow exponentially, from cooling water for the digital industry (3 to 4 billion liters per year for a data center) and thermal and nuclear power plants to sanitary water (80% of Hong Kong's toilet flushes use sea water).[282,283,284]

  These extractions lead to discharges with heavy environmental impact (contaminated water, hot water, brackish water with high salt content).

Finally, major projects related to water structures or directly impacting coastal waters were launched before the Covid-19 pandemic. While some were slowed down or even suspended by the health crisis, others on the contrary were accelerated :

- **Mega-ports:** to address supply chain deficiencies, 84 major port construction projects have begun since 2021, for a projected overall cost of $39 billion. Ten of these projects are mega-ports : in Morocco (Dakhla Atlantique), Algeria, Iraq and Indonesia, among others.

Smart Ports, ports that encompass digitalization and a deep concern for their stakeholders, are changing the future of the maritime and shipping sector

Sinay Hub

While the spatial extension of ports could decline in the years to come in favor of a more intensive use of existing space, major port projects continue, including the Sagar Mala project in India. By 2030, smart ports (cf. Port of the Future 2030), such as Rotterdam, Singapour, Shanghai, will further develop their technology using artificial intelligence and the Internet of Things.

- **Artificial islands:** artificial islands are not new, but the number and scale of the current generation of islands suggests an era of islands, regardless of whether they are built ex-nihilo, such as The Pearl (Qatar) or The Palm (Dubai), on reefs, such as Subi Island (Spratlys), or as oil platforms (Qingdong-5, China). The environmental impact of these structures is a matter of debate, and we might well wonder whether this trend will continue in the long term, possibly replaced by more sustainable floating city developments.

- **Floating cities*:** faced with rising waters, the idea of floating cities is gaining ground. This term covers realities as diverse as floating coastal districts such as IJburg in Amsterdam (since 2011) or maritime urban units (such as Green Float II, 2030), mobile floating structures such as SeaOrbiter or floating hotels and individual habitats, or even true micronations with political autonomy, floating on the high seas (seasteading).

Although the first project to build a floating city (French Polynesia, 2017) has been postponed indefinitely, several other projects are under consideration, including the UN-supported Oceanix City, whose prototype is to be installed in 2025 off the coast of New York.

- **Coastal protection works:** faced with rising waters and coastal erosion (retreat of the coastline by landslides on rocky or sandy shores), a number of projects are currently under consideration or have been initiated to protect the coastline, such as dykes, de-poldering, embankments, etc., in the Netherlands, Spain, Senegal, Benin, Togo and the USA ....

Whether it is because of increasing land pressure in often overpopulated coastal areas, the rise in sea level or the increasingly high safety requirements for industrial activities (which would push them to settle offshore or on a coastline distant from urban centers), the artificialization of the ocean continues. In the same way, the strain on its resources is increasing and accelerating, despite the emerging environmental awareness.

Although the Covid-19 pandemic seems to have put a stop to some of these sometimes pharaonic projects, the trend towards blue acceleration could, on the contrary, emerge strengthened from this period by highlighting the imperative of reviving strong growth to which marine resources can significantly contribute.

Diseases associated with anthropogenic warming and rainfall trends over the past three decades already claim more than 150,000 lives each year.

World Health Organisation, 2014

Sea - Land impacts 2030-2050

Stretching over 71% of Earth's surface, the ocean absorbs 80% of the sun's energy and serves as the world's largest carbon sink, as outlined in Part 1 of this strategic report. It is warming drastically and acidity levels in the ocean are up nearly 30% since the mid-1750s. Coral reefs, plankton and crustaceans are severely impacted.

Warmer sea surfaces restrict the upwelling of nutrients from the deeper ocean and disrupt ocean currents and climate. Ocean thermal expansion and accelerated melting of ice caps cause an inexorable rise in sea levels. Anthropogenic activities responsible for these disturbances are not only likely to continue, but to accelerate by 2050, if nothing changes.

About 10 percent of the world's population will live on coastlines less than 10 meters above sea level, i. e. over one billion people, by 2050[286].

Climate change strongly impacts these coasts, making them extremely vulnerable to higher temperatures, more frequent extreme weather events, scarcity of drinking water and rising sea levels. On top of this, the impact of human activity maritimization, discussed in previous sections, contributes to the vulnerability of these coasts.

These factors combined create an inevitable backlash: marine and coastal environment degradation impacts on human populations and activities. Altered Ocean Sphere conditions will not only directly impact living conditions, but the very existence of human beings. Small island areas are at the edge of these coming changes.

About one billion people could be threatened by coastal climate hazards, in the medium term and in all scenarios

IPCC, February 2022

Ocean impacts on human existence

Many human-caused changes - global warming and pollution - are now deadly threats that impact human beings regularly and significantly.

- Natural disasters include both sudden climatic accidents (hurricanes, ...) and unexpected alterations in the environment (accelerated warming).

    - ✓ During a hurricane (with an increasing number of category 4 and 5 events), gales and floods account for most of the deaths currently occurring. The consequences are however often worse than the event itself, resulting in infectious diseases (cholera, ...), non-communicable diseases (respiratory, ...) and mental health disorders[287].

    - ✓ Heat waves trigger high mortality rates, especially among the elderly and in large cities, in the Mediterranean, India and elsewhere.

    - ✓ The depletion of Arctic sea ice directly jeopardizes the survival of local populations by altering ecosystems (food, travel, economy) and ultimately resulting in migration.

- Marine environmental pollution causes multiple toxicities that can :

- By ingestion of seafood, damage the developing brains of children (methylmercury and PCBs), disrupt endocrine signaling, impair male fertility, increase the risk of cancer (manufactured chemicals), and potentially cause severe neurological impairment and rapid death (harmful algal blooms*).

  - ✓ By exposure, increase the risk of cardiovascular disease and dementia (methylmercury).

  - ✓ By inhalation, cause the early onset of respiratory and cardiovascular diseases (toxic gasses from oil spills) or severe neurological disorders (e.g. fumes from Sargasso decomposition).

  - ✓ Seafood is only the 4th largest source of plastic microparticles. The consequences of this pollution on human health are not yet clearly established[290].

  - ✓ Another form of long-term toxicity, increased ocean acidification could mean the disappearance of bacteria like prochlorococcus*, that produces 20% of atmospheric oxygen.

- Seafood depletion, whether as a result of reduced biodiversity (size, number, species) or toxicity rendering unfit for consumption, is a threat to human health in three different ways :

- ✓ **Starvation** could directly hit populations most dependent on these products (island areas, tropical zones), notably the 27 million indigenous coastal populations, for whom substitute food products are unavailable (drought, salinization, etc.). The United Nations Environment Program assessed in 2016 that, in major ecosystems most impacted by climate change, aggregate catch numbers are projected to drop 8-28% by the 2050s[291].

  As a result, up to 80 million people could go hungry by 2050, mainly in sub-Saharan Africa, South Asia, and Central America, due to declining agricultural and fishery yields[292, 293].

- ✓ Reduced fish consumption creates micronutrient deficiencies with serious consequences: perinatal and maternal mortality, stunted growth, infant mortality, cognitive deficits and weakened immune functions. More than 10% of the world's population could face micronutrient and fatty acid deficiencies as a result of the decline in fisheries over the next few decades, particularly in developing countries located on the equator including island spaces.

- ✓ Conflicts (illegal fishing and unreported catches) could arise over the need to access the resource (Asia, Africa, South America) as ocean warming and global pollution accelerate the phenomenon (e.g., expanding dead zones).

Impacts of the Ocean on Living Conditions

While general Ocean Sphere degradation and its ensuing vicious cycles threatens the living conditions of large parts of the population, it also negatively impacts - albeit less severely, but more widely - the living conditions of one billion people, both directly and indirectly via the social determinants of health (non-medical factors), accounting for 30 to 55% of all health situations, qui contribuent pour 30 à 55% aux situations sanitaires.

Three major developments related to the marine environment currently impact the living conditions of coastal populations:

- Phytoplankton depletion with global production dropping nearly 10% by the end of the century, thereby directly impacting fish stocks in tropical ocean regions.

- Unavoidable rising sea levels[296], - although not easily quantifiable because of the combined impact of thermal expansion, melting polar ice, coastal infrastructure development and degradation of coastal ecosystems, which provide protective barriers - with the associated flooding, soil salinization and coastline retreat.

    - ✓ The projection for 2050, however, is robust: +20 to 30 cm on average worldwide.

    - ✓ By 2100, depending on global warming levels: + 0.5 meters if the Paris Agreement is respected (2°C) to + 0.7 meters based on current trends, or even + 0.84 meters in the worst case scenario.

    - ✓ Polar cap instability is a major risk factor, likely to raise mean ocean levels by 2 meters by 2100.

✓ Deviations from the estimated mean stand at around 30% depending on local conditions, as human-induced land subsidence currently accounts for the bulk of measured change in relative sea levels, particularly in delta regions.

- Extreme sea level events, a combination of mean sea level rise, typhoons, heavy flooding, tidal waves and wave patterns, which previously occurred once a century, could now occur once a year over the course of the 21st century[297, 298].

Each one of these phenomena constitutes an existential risk on its own. Combined, they could doom coastal habitability and seriously impact the economy of coastal countries, especially the developing ones, and island areas.

Thus, by 2050, half of low-lying coastal populations (<10 m) could be affected by rising sea levels (permanent from rising sea levels, or temporary from extreme events), i.e. over 300 million people, three times today's numbers[299,300].

According to the IPCC RCP8.5 scenario, in the absence of coastal adaptation, 48% of the world's land area, 52% of the world's population, and 46% of the world's assets would be at risk of flooding by 2100. A total of 68% of global coastal area flooded will result from tides and storms, including 32% from projected regional sea level rises[301].

Furthermore a number of protective measures usually taken to protect coasts from erosion (groins, dikes) only accelerate coastal retreat.

Consequences of this situation on living conditions will occur at three separate levels :

- Coastal habitability

  ✓ After small island developing states and the Arctic, coastal megacities are particularly affected by sea level rise, from the east coast of the US (Miami, New York) to Southeast Asia (Jakarta, Bangkok for example) by way of New Zealand, as well as delta areas, many of which are subsiding, often at twice average rates of sea level rise, because of sediment deposits, groundwater extraction, and the weight of buildings.

  Asia is projected to be hardest hit by rising sea levels (China, India, Indonesia, Vietnam, Bangladesh). With 1.5° C of warming, cities currently inhabited by 500 million people are likely to be flooded as water continues to rise for centuries[302].

  ✓ Urbanization of coastal wetlands is degrading ecosystems that would have helped protect coastal communities from sea level rise, hurricanes and coastal flooding. The increased frequency of these more intense events has cascading and cumulative effects on people's health, food security, access to clean water, and livelihoods, making them even more vulnerable to future events[303, 304].

  ✓ Where protection is not possible, submerged areas will be abandoned in favor of a retreat of habitable areas inland, and all the social, cultural and political challenges this entails. Several atolls will become uninhabitable by 2050[305].

- According to a ''high city'' versus ''low city'' logic, high altitude habitats will become increasingly expensive, forcing poor populations in submerged or destroyed areas into greater precariousness and migration.

- Economic activities (and associated patrimony):

  - Projected **annual damage** from floods will grow 2 to 3-fold by 2100: Global coastal floodplains assets in 100 years are projected to be worth $7.9 to $12.7 trillion under a medium emissions scenario and $14.2 trillion under a high emissions scenario. In addition to the cost of reconstruction, the cost of protection (coastal protection works costing tens to hundreds of billions of dollars) should be included, which neither rural and poor regions nor small island developing states can afford[306].

  - **Insurance** companies will quickly pull out of these risks or increase premiums to the point where it becomes unaffordable to insure a building in these areas. It is likely that the loss of invested assets along coastlines will result in significant impoverishment, particularly among senior citizens.

  - Damage to **ports** could seriously compromise global supply chains and maritime trade, with potentially significant geopolitical and economic ramifications.

Low-lying coastal areas as well as small island states, where around 745 million people live, will be heavily affected. According to the study, regardless of the additional warming, they will experience extreme weather events every year by 2050. For the group of experts, only adaptation measures will limit the damage.

IPCC, 2019

- ✓ Groundwater and coastal soil **salinization** will shrink the volume of arable land, forcing agriculture to radically restructure to avoid famine.
- ✓ Individually, coastal populations will be hardest hit. But collectively, **national economies**, including those of developed countries, will struggle to cope with costs arising from the loss of coastal territories - where populations and activities are increasingly concentrated - and the transfer of these populations and activities inland (reconstruction).

- Migration: When reconstruction is not possible, or inaccessible to the poorest, the only way out is migration, as is currently the case in India. Massive population displacement, whether internal (up to 216 million climate refugees by 2050, with North Africa being hit particularly hard) or international, raises crucial questions that need to be answered quickly.
  - ✓ The nexus between **climate change, migration and human** *trafficking* is set to become a major human and geopolitical issue.
  - ✓ The question of total displacement of an **island population** will have to be faced, whether to move this population to another part of the often overpopulated island national territory, or transfer nationals of a submerged territory to other countries (Pacific, Caribbean).

- ✓ Finally, more broadly, the question arises as to which **countries** will accept to host these climate migrants, in a context of global economic slowdown and rising nationalism (protectionism, xenophobia).

The combined consequences of Ocean Sphere* degradation and climate change* will have a significant impact both on human existence and on living conditions in coastal areas and, more broadly, as a result of chain reactions triggered by these phenomena. From this perspective, island areas deserve special attention, as the first to be impacted.

The island question

Islands, largely overlooked by industrial development in the 19th and 20th centuries, and great beneficiaries of the growth of international seaside tourism from the late 20th century onwards, take on renewed strategic importance on account of areas of economic expansion (fishing and mining potential) and of maritime globalization, with fleets depending on anchorage)[310].

Concurrently, political decolonization (access to independence) and globalization (territorial archipelago rationale with reticular functioning) also helped give an important place to island spaces . The Rio Summit of 1992 recognized the need for a special status for small island developing states (a group of 38 UN member states and 20 non-member states).

Exposure to social, economic and environmental risks, arising from insularity, warrants international action enabling them to ''respond effectively, innovatively and sustainably to ecological change, as well as mitigate its effects and reduce threats, to coastal and marine resources''[312].

- In 2014, the Third International Conference on Small Island Developing States recognized the need for a **new sustainable development trajectory for these states**, in light of negative climate change and rising sea level impacts on economic development, food security, disaster risk reduction and ocean management.

- The 2019 UN resolution reaffirms the international community's dual concern for small island developing states :

  - ✓ With regard to ongoing climate change* - in the face of the ''devastating effects of climate change, including extreme weather events, slow onset events and increased frequency, magnitude and intensity of disasters'' - and future climate change, as per the scientific findings of the IPCC ''Global Warming of 1.5 °C'' Special Report ;

  - ✓ On the sustainable use of oceans and their resources: ''We reiterate ''The Ocean, Our Future: A Call to Action'' declaration, encourage [...] achievement of Sustainable Development Goal 14 and [...] development of an international legally binding instrument addressing the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction''[313].

The vulnerability of small island areas, whether independent or integrated, is not only environmental but also socio-economic.

- In fact, most small island territories face destruction caused by natural events (cyclones, tsunamis, rising sea levels), while their environment is under pressure from overpopulation (migration, tourism), their economy generally lacks energy or high value-added resources, or even the prerequisites for real agricultural diversity following the destruction of original ecosystems, and their marine resources are dwindling.

- Some of the islands have, however, experienced significant economic success, notably through flags of convenience or more or less legal financial services. While their economic emergence and development are based on openness to the world and flows of globalization, the negative effects of this approach now hinder this development model: Ostracism as a result of an illicit economy (money laundering, trafficking), environmental degradation (overtourism, sand trafficking, overfishing) and degraded living conditions.

- Tourism hyperspecialization, as practiced by many islands, has also begun to encounter its limitations: coastal urbanization, traffic jams, difficulty in supplying drinking water, waste management, infrastructure inadequacy in the face of overtourism, and tourist phobia.

Tourism's collapse in the wake of Covid-19 lock-downs has brought the collapse of development prospects and immediate misery to millions of day laborers dependent on tourism revenues in small island developing states (especially in Asia), but also brought a breath of fresh air to coastal and marine environments (Thailand's Phi Phi Island).

The paradox is that tourism depends highly on the quality of natural ecosystems to attract visitors and, at the same time, contributes greatly to their depletion and fragility, thus endangering its own sustainability[192].

As the communities most exposed to ongoing Ocean Sphere* transformations, small islands are at the forefront of natural and anthropogenic degradation. Achieving sustainable restoration of natural and human environments is vital to improving all coastal ecosystems and communities. However, more often than not, the choice is still between socio-economic development and preservation of coastal and marine resources.

- The study of current and future trends shows exponential momentum for the maritimization of human activity and coastal, natural and migratory demography, on one hand, and its negative impact on the Ocean Sphere, on the other.

- Conversely, ocean degradation impacts humanity in more ways than one. However, natural ocean mechanisms and humans operate on different time-frames: while biodiversity can spread again quite quickly, sea levels will continue to rise for centuries, rapidly and irremediably altering Earth's climate and geography.

Natural ecosystems have produced substantial net gains in human standards of living, wellbeing, and economic development, but these gains have increasingly come at the cost of degrading multiple ecosystem functions, heightening the risk of non-linear changes, and increasing poverty for some people. Unless addressed, these problems will substantially reduce the benefits future generations may derive from ecosystems.

Millennium Ecosystem Assessment, Rapport de synthèse de l'Evaluation des Ecosystèmes pour le Millénaire, p.20, 2009

Conclusion of Part 2

Part 1 of this report shows that Ocean Sphere degradation is an existential risk for humanity, while part 2 underlines that awareness of this risk is not yet sufficient.

An Ocean Sphere in danger today

As the Earth never stops drawing on the sea, the increased maritimization of human activity exerts strong anthropic pressure on environments already strongly degraded by climate change.

As a result, a new atlas of Ocean Sphere red zones takes shape, reflecting forthcoming trends :

- Destruction of biodiversity and marine and coastal ecosystems: in the Mediterranean, the Arctic and in dead zones.
- Rising sea levels: Antarctica, an unpredictable game-changer.
- Deoxygenation of the planet: Surface areas covered by phytoplankton.
- Climate change: all structural oceanic transformations, from water stratification to major ocean currents.

Towards a future threat to humanity

Investments made so far indicate that the sea economy* will accelerate in the coming decades, if only to accommodate (coastal urbanization), feed (fishing and aquaculture*), and provide work, transportation and entertainment (beach tourism) to a world population that will continue to grow until 2050.

Thus, a mirror atlas of the red zones of humanity emerges :

- Destruction of habitats and infrastructures by rising waters: Asia Pacific, Western Europe, Southeast Coast of the United States.
- Coastal land abandonment as a result of coastal erosion and repeated extreme events: the tropics, very low-lying areas (islands, deltas).
- Impoverishment and malnutrition due to the depletion of fishery* resources: West Africa, Pacific.
- Increasing ocean sphere* toxicity, by ingestion, inhalation and exposure: everywhere.

Making the invisible visible

Human' vision of the world is often obscured by ''blind spots'': obvious things that disappear from the field of perception or reflection, thus becoming ''invisible''. The vision of the ocean is no exception.

Seabirds are often excluded from studies on marine biodiversity, the interface between Ocean Sphere* and cryosphere* has long been ignored, polar spaces are considered as devoid of life and small islands as natural paradises not worth worrying about.

To hasten this awareness, a necessary but not sufficient condition for action, we therefore need to not only accumulate knowledge (cf. conclusion of Part 1), but also mobilize all types of communication tools to make visible that which is not: reports, cartography, surveys, popular media as well as scientific press.

Genuine ocean education ought to make it possible to understand what we refuse to see today: the hyper-exploitation of the ocean, this growing industrialization of maritime activities, is not sustainable beyond the very short term (2050).

Making the knock-on effect of marine ecosystem services degradation on human existence and living conditions visible should facilitate reflection, innovation and decision-making in favor of sustainable and durable solutions to this formidable planetary challenge.

Take away

Understand

The history of humanity and the ocean is extraordinarily complex, despite their incompatibility.

The land-sea relationship is that of many interfaces, at once physical and cultural, socio-economic and geostrategic.

A place of junction and knowledge but also of confrontation and crime, the ocean over the ages has at times attracted and at times repelled humanity.

Today, however, it is a victim of growing anthropic activity and economic predation that extends to its deepest reaches.

Anticipate

Current ocean degradation is not sufficiently felt for appropriate action to be taken. Hence the need to clarify the issues at stake without being catastrophic or angelic :

- Coastal habitability: rising sea levels, frequent extreme events, multiple toxicity.
- Food: depletion of animal populations and biodiversity; contamination of fish (microplastics, pollutants) rendering it unsafe for consumption.
- Employment: decrease in fishing and processing of fishery products, salinization of agricultural areas.
- Safety of people, due to natural causes: coastline modification, natural disasters, sargasso, submersion... and human causes: piracy, human trafficking.

The future of not only the planet, but of mankind itself depends on our ability to reverse these trends.

Part III

Keys to sustainability

Many coastal populations are already economically, physically and culturally affected by ocean degradation (rising sea levels, increasing extreme weather events, pollution, toxicity). The ongoing situation, largely invisible to the media and the general public, is indeed quite alarming (high costs of protection against rising sea levels, depletion of fish stocks*, collapse of biodiversity*). Yet, tomorrow, with a sick ocean, the situation could be far worse, as the health of humanity depends on it.

Marine resources currently seem still sufficient to support the socio-economic development we need to keep up with the world's growing population.

However, the more we drain the ocean, the more we plough its surface, the more we dump waste into it and the more it is depleted, both in terms of resources (fish, minerals, hydrocarbons, etc.) and in terms of ecosystem services.

The Ocean Sphere's* disruption is spurred by two inseparable and mutually reinforcing drivers: anthropogenic pressure and climate change. While it is impossible to halt ongoing alterations overnight, it is possible to alleviate anthropogenic pressure on the ocean in the long run.

In such a complex, systemic and highly interdependent context, how to resolve the paradox between protecting the ocean and its necessary exploitation? What are the keys to sustainability, assuming the very notion of it still has any meaning?

It is essential to thoroughly rethink current fragmented and multiple solutions, as well as the concept of blue economy, which is likely to accelerate the ongoing oceanic transformation (Chapter 1).

Regardless of the solutions we adopt, these can only be implemented in time using a new world governance framework that is tighter, more concerted and better planned (Chapter 2), in which Morocco would be both a stakeholder and a model (Chapter 3).

Chapter 1 : Rethinking the problem and its solutions

Most observed adaptation is fragmented, small in scale, incremental, sector-specific, designed to respond to current impacts or near-term risks, and focused more on planning rather than implementation. Observed adaptation is unequally distributed across regions, and gaps are partially driven by widening disparities between the estimated costs of adaptation and documented finance allocated to adaptation.

IPCC Report - Climate Change 2022: Impacts, Adaptation and Vulnerability

Spearheaded by the Decade of Ocean Sciences 2021-2030* – a United Nations ocean mobilization program launched by UNESCO in 2019 - a multitude of existing initiatives have come to light while new ones have blossomed, well beyond the initial framework of ''mobilizing the scientific community, policy makers, businesses and civil society around a common research and technological innovation agenda.

The result is a flourishing initiative landscape, often partial and fragmented despite real progress. Progress still needs to be substantial, and obstacles abound, including the prevailing blue economy paradigm, the vagueness of which is a source of confusion. It is therefore urgent to rethink the problem and determine effective solutions.

The kaleidoscopic landscape of current solutions

Over the last fifty years, public decision-makers have shown considerable awareness of the environmental issue. However, solutions for the ocean, as for climate change, remain fragmented and efforts are constrained by short-term economic imperatives.

A jigsaw of actors and initiatives that have made genuine progress possible thus emerges.

We know what to do. And, increasingly, we have the tools to do it. But we still lack leadership and cooperation

UN Secretary-General António Guterres, June 2022

We urgently need to recalibrate our relationship with the planet and drastically step up action on climate and environment.

International Fund for Agricultural Development (IFAD), June 2022

But, if growing youth denial on several continents is any indication, the largely passive public attitude towards ill-advised decision makers may have begun to erode as people begin to realize that they are harmed by those in power.

Global Footprint Network, 2022

Multiple actors

Since the first Conference on Environmental Protection in Stockholm in 1972, **public decision-makers** have met regularly to examine environmental issues and take appropriate action. This has produced failures, notably those relating to curbing climate change* and the decline in biodiversity*, but also successes such as the total restauration of the ozone layer by 2050, through the elimination of 98% of substances depleting it, and the Great Green Wall, the initial results of which are quite promising.

As such, a number of international institutions devoted to environmental protection have gradually emerged: UN (intergovernmental) organizations including the Intergovernmental Panel on Climate Change and the World Conservation Monitoring Centre, public-private networks such as the International Union for Conservation of Nature, and intergovernmental platforms including the Foundation for Biodiversity Research*, the Intergovernmental Science-Policy Platform on Biodiversity* and Ecosystem Services...

There is however no specific global institution exclusively focused on systemic ocean protection. Activities in this area originate from the above-mentioned institutions, the United Nations' Division for Ocean Affairs and the Law of the Sea, the UNESCO Intergovernmental Oceanographic Commission, the International Maritime Organization, the International Seabed Authority or regional organizations such as the European Union, or national organizations of international importance, such as the US Oceanic and Atmospheric Observation Agency or the French Research Institute for the Exploitation of the Sea.

Along with public actors, a range of associations and NGOs, activist (e.g. *Sea Shepherd*, *Greenpeace*), scientific (Tara Ocean Foundation) or committed to finding innovative solutions, work on protecting the ocean and on its sustainable use (Worldfish), on the local, national and global scales.

Networks, alliances, dialogues and partnerships have also emerged among different actors (private and/or public) such as the World Ocean Council (private sector, 2010), Sustainable Ocean Alliance (youth, 2014), *Ocean Panel* (16 Heads of State, 2021), *Alliance for a Deep Sea Mining Moratorium* (2022) and at the behest of the *World Economic Forum : Friends of Ocean Action*, *Global Plastics Circular Economy*, *Deep-Sea Minerals Dialogues, Getting to Zero Coalition*, ..., Sustainable Blue Partnership Cooperation Network (2022)...

An abundance of initiatives

The number of projects pertaining to the protection or sustainable use of the ocean is such that it is impossible to establish a comprehensive classification, which would be useful (for their efficiency), be it in terms of :

- achievements: projects launched, completed/successful, perpetuated,
- objectives: fight against plastic pollution, against sea level rise or coastal erosion, protection or restoration of species or ecosystems, public awareness, collection of scientific data, adaptation of marine species to climate change, dialogue between decision-makers, ...
- funding type (international, national, private), ...

This multitude of projects often obscures a number of realities :

- **"One-shot" projects**, financed via a request for proposals or for exposure purposes, but with a model that is not sustainable beyond the allotted funding or that produces harmful collateral effects; these projects often make headlines but are not transferable experiences.

- **High-quality actions**, often carried out quietly and without significant budget by relevant local actors; these can be replicated, but do not have enough visibility to be proposed in other similar situations and contexts.

- **Indirect actions**, but with a direct impact on the ocean, such as those carried out by global nature protection organizations, such as One Earth. These actions are therefore more difficult to identify.

- **Private sector** actions, rarely reported in the media, such as the Seafood Project, which aims to reduce the amount of catch lost and wasted in fishing.

Finally, contributing to raising awareness among decision-makers and world public opinion and to highlighting, and indeed financing, possible solutions, a number of international events on the ocean has occurred over the last ten years, including the regular *Our Ocean* (since 2014), *UN Ocean Conference* and *UNCTAD Oceans Forum* (since 2017), *One Ocean Summit* (2022),... However, the proliferation of statements and initiatives runs the risk of drowning them in global news flow.

An outstanding legal and methodological apparatus

This notably includes three essential elements :

- The **International Law of the Sea**, comprising all substantive provisions on the use of the oceans, including the Principle of Freedom of the High Seas, the Montego Bay Convention and Seabed Management (see Part II, Chapter 1).

  This is complemented by UN agreements on specific subjects (biodiversity*, underwater cultural heritage) – or regional agreements to protect marine resources and environments. The latter enabled, for example, the creation and implementation of a pan-European law for the protection of the marine environment.

- **Ambitious objectives** set by the UN community: Sustainable Development Goals* , replacing Millennium Development Goals in 2015. These goals identify climate and environmental protection as a prerequisite for sustainable development. Sustainable Development Goal 14 aims to ''Conserve and sustainably use the oceans, seas and marine resources for sustainable development''.

  Accordingly, 2022 featured a number of international meetings, both to reinforce these ambitions and produce practical outcomes in the future.

- **Resources** that include :

  - ✓ marine Protected Areas* or Partially Protected Areas, which are useful but difficult to define (zoning problem) and costly to manage,

  - ✓ integrated Coastal Zone Management (ICZM)*, a solution for the dilemma of human use of coastal zones and their degradation, encompassing both the principles of ecosystem-based management and an overlapping hierarchy of governance. This solution becomes Integrated Maritime and Coastal Management when it includes Maritime Spatial Planning (MSP), extending its principles to the sea,

  - ✓ various innovative methods to assess coastal landscape sensitivity according to local and tourism contexts , or to enhance fishery management such as the Common Oceans Program (FAO, since 2014),

  - ✓ state of the art reports on current and future developments in the field, suggesting priorities and solutions, such as the *Global Ocean Science Report* (UNESCO, 2020), *Special Report on the Ocean and Cryosphere in a Changing Climate* (GIEC, 2019), *Rethinking Innovation for a Sustainable Ocean Economy* (OCDE, 2019), *Future of the Sea* (United Kingdom, 2018), *New Growth, Proud History* (Norway, 2017).

On October 8, 2021, the United Nations Human Rights Council declared the ''right to a clean, healthy and sustainable environment'' to be one of four goals of the 2021 Stockholm Declaration (Stockholm+49 Summit). The implementation of this right requires structural changes in the legal, economic, social, political and technological spheres of most countries to restore a stable and effective Earth system. ''This is a fundamental step towards establishing a governance system to effectively manage human-Earth system interactions''[319].

Hence, via environmental, shipping and fishery issues, the ocean rose to the forefront of the international agenda in the past decade. Sustainable Development Goal 14 acted as a clear catalyst in 2015, supported by UNESCO's Decade of Ocean Sciences* starting in 2020.

Challenges encountered

The flurry of initiatives proves the motivation of both decision-makers and civil society is present and that multiple instruments can be harnessed to move forward.

Yet, marine biodiversity continues to decline. The ocean continues to acidify, stratify, deoxygenate, ... Food insecurity grows in a number of coastal countries, while more and more plastics and other contaminants end up in the ocean. How is this possible ?

Much of the widespread anxiety over the climate crisis is directed toward attempts to accurately represent the problem. Once we change the representation, the argument goes, the represented too will change — and the problem, thus clearer to see, will be easier to address.

Chiara DI LEONE
Imagine Other Futures

Multiple obstacles to providing a solution

The following are the major obstacles to action:

- Limited accessibility and fragmentation of information hinders the willingness of local decision-makers and investors to commit to change.

- Slow international mechanisms, however effective they may be, are irreconcilable with the immediacy of the situation. The international community was able to react quickly on the ozone layer as the situation was sufficiently well known, the physical mechanism simple and the means of action unique (banning chlorofluorocarbons); this success, however had a side effect in that the gasses (hydrofluorocarbons) used to replace chlorofluorocarbons now contribute to a majority of global greenhouse effects.

In the case of the ocean, the situation is more complex, the mechanism largely unknown and the multiple means of action need to be systemic to be effective. Specialists need time to master the subject, politicians need time to reach a consensus and economic stakeholders are in no hurry to alter processes in a globally difficult economic situation since 2008.

- Human beings still often consider nature in general and the ocean in particular, as a space to be conquered, cleared or replanted according to needs, in a cultural perception where man necessarily dominates nature, which therefore does not require protection.

  The ocean is too vast an object for its fragility and current imbalances to be properly apprehended: we throw everything at it, indiscriminately, incapable of spontaneously assessing the consequences. Hence the need to act directly on these representations (education, awareness), to preserve and use the knowledge of **indigenous peoples**, notably islanders, who are more aware of Nature's frailty.

- Even when there is genuine awareness of the situation, as is the case for many fishermen, inhabitants of eroded coastlines and local elected officials, there are no alternatives. How do you not catch prohibited fish when you have to feed a family? How can you not build/buy on the seashore when life there is far more pleasant than elsewhere? How not to continue coastal urbanization when tourism demand is so high? Confronted with these unanswered questions and in the absence of quick, viable and financially reasonable solutions, the required changes are slow to materialize.

Recognizing this situation, networks such as Friends of *Ocean Action* call for an accelerated development of solutions to the more pressing challenges facing the Ocean Sphere*.

The blue economy: between paradox and confusion

Two categories of economic models are opposed today :

- The dominant model: that of a predatory economy*, the origin of the Anthropocene*, often referred to as the ''brown''* (UNEP) or ''red''* (G. PAULI) economy. This model is considered unsustainable in the long term because of the pressure it puts on both the environment and human beings (inequality, unemployment, etc.).

- Alternative models combining various components: green economy*, circular economy* (recycling), white economy* (non-consumption)... The *Blue economy,* in the sense of G. PAULI, proposes a complete economic, social and environmental system based on biomimicry*, zero-waste production, localism, a sharing economy and open source, ... [320]

Initially included in the second category, the blue economy refers to any economic activity related to the oceans, seas, and coasts, which together determine if ocean resource utilization is sustainable (European Commission 2021; World Bank and United Nations Department of Economic and Social Affairs 2017). These activities occur both off-shore (shipping, fishing and energy production) and on-shore (ports, shipyards, land-based aquaculture* and seaweed production) (European Commission 2021)[321].

This interpretation has since changed significantly :

- As originally envisioned at the Rio+20 summit (2012), the blue economy naturally favored small-scale fishermen whose livelihoods depend on healthy ecosystems and whose production methods are generally both more sustainable and ''cleaner'' than industrialized food production (brown economy*).

- The European Union then latched onto the concept by advancing ''blue growth'', emphasizing growth rather than sustainability and promoting high-value-added growth industries - not including fishing - an outlook supported by statements like ''if the global blue economy were likened to a national economy, it would be the world' s seventh largest[322].''

The global blue economy, were compared to a national economy, it would be the seventh largest in the world.
Tansforming the EU's blue economy for a sustainable future, European Union, 2021

Aware of this drift, the European Commission in 2021 suggested a shift towards sustainability from ''Blue Growth'' to ''*Sustainable Blue Economy*'': ''*The EU blue economy can contribute to meeting this twofold challenge [European Green Deal and Recovery Plan for Europe]: if it embarks on a more sustainable path, it will become a source of innovation-creating actions and ideas, stimulating a swift and sustainable recovery and protecting our planet*[323, 324].''

To build a sustainable ocean economy, we must stop the degradation of the world's marine ecosystems and improve the environmental status of the oceans. This will require action from all of us.

the High Level Panel for a Sustainable Ocean Economy (the Ocean Panel)
Erna SOLBERG, 14 Jan 2019
Prime Minister of Norway

Two fundamentally different interpretations have emerged from this evolution, mirroring the duality between economic growth and environmental protection: the blue economy as the exploitation of economic opportunities provided by the marine environment (brown economy*) in line with the *Blue acceleration** (see Part II - Chapter 2) and the blue economy as the marine dimension of the green economy* and of sustainable development.

It is therefore not surprising that the more environmentally aware proposals are rather referred to as *Sustainable Ocean Economy* (the *Ocean Panel* for exemple).

The recent emergence of new concepts (*blue biotechnology, blue carbone, blue diplomacy, blue energy, blue finance (blue bonds, blue investing, the blueness index), blue food, blue innovation, blue justice, blue mind, blue space, blue tech, blue tourism, ...*) has perpetuated the confusion between the two interpretations.

Over and above the expressed desire to tap into the potential of the seas (exclusive economic zones) to bring about humanity's transition to a ''resilient coastline and a sustainable society''[325, 326], close examination of the different reports on the subject reveals how the benefits and advantages of this operation are invariably proclaimed to be for the benefit of humanity, with no mention of the disadvantages or damage that may accrue to the ocean.

As such, the sought-after sustainability is that of the current development mode, enabling the supply of food to cities and coastal communities. The Blue Energy example is particularly telling: the European Union's plan to deploy 450 gigawatts of offshore* wind generation capacity by 2050 does not take into account the environmental damage these offshore* wind farms are likely to cause, nor does the idea of turning ports into a gateway to future offshore* renewable energy clusters (creation of multifunctional renewable energy islands, maintenance of offshore* wind farms and green fuel production)[327].

A shift in perspective is therefore necessary[328]: Faced with the urgency surrounding the state of the Ocean Sphere*, the question no longer is ''how to derive the greatest benefit from the ocean for humanity'', but ''how to protect the ocean so that humanity can survive[229]'' , as the Norwegian government has for instance, implementing a bold ocean strategy (clean technologies, digitization*, innovative uses of marine resources, international diplomacy, the fight against illegal fishing and plastic pollution, research[330].

Breaking with continuity

This sort of reversal in perspective demands a radical change in the way things are done. This can only happen if a new development model is introduced (see the IRES Strategic Reports 2019/2020 and 2021).

Towards a new development model

Today's development model is based on predation*, i.e., extracting natural resources in excess of renewal capacity. As a result, Earth Overshoot Day* arrives a little earlier with each passing year. Anthropogenic pressure is bound to intensify, along with population increases projected for 2050, the growth trajectories of developed countries (the planet's main polluters) and developing ones (the first victims of climate change), along with the accession of a growing number of countries to advanced economy standards of living.

A shift in the development model is therefore at the core of the debate in both North and South.

Inspired by multiple initiatives emerging worldwide over the past decade, a new development model is gradually taking shape. This model, designed to bring about a post-Anthropocene* world, is based on the vision of an interdependent, systemic world, in perpetual flux that calls for a forward-looking perspective.

The model seeks to reconcile Humanity and Nature in development that benefits both parties (circular* and regenerative economy), promote physically and psychologically healthier living conditions, within a One Health approach and foster individual freedom (human rights, mobility, entrepreneurship) while protecting society (peace, justice, equality, transparency).

This book, The Once and Future Ocean, represents an interesting and important contribution for a better public awareness of the great importance of the oceans - and Water itself - for the survival of our Planet. It is essential to change into a new development paradigm, based on the values of sustainability and democracy

Mario SOARES,
Chair, Independent World Commission on the Future of the Oceans

This generic model put forward by IRES in its 2019/20 Strategic Report is based on five structural pillars :

- Two main objectives: focus development on both Humanity and Nature.

- Two structural trends that must be dealt with: the globalization of our world (geolocation, mobility) and the exponential nature of current phenomena (digitalization*, information, demographics).

- Governance as an essential action medium to support the new model.

This model is based on the following key principles :

- Humanity is one and indivisible, and cannot be reduced to gender, color and group or individual culture.

- Economic development is subordinated to human development.

- Durability refers to the pursuit of a development model, while sustainability relates to the capacity of the planet to preserve equilibrium in the face of human predation. Hence, ''sustainable development'' is ''the process of living within the limits of available physical, natural and social resources, in a way that allows living systems in which humans are embedded to thrive in perpetuity''[331].

- Governance includes collective intelligence, subsidiarity*, *bottom-up* processes*, attentiveness to and inclusion of minorities, rationalization of public resources and ethics.

Sustainability has been a key notion in the societal and scientific discourse about the relationship between human societies and nature at least since the UN report 'Our Common Future' (WCED 1987). Sustainability has become widely agreed upon as a general and abstract objective, but the practical effect has as yet remained small. A major problem is that it is often unclear what sustainability actually means in a concrete decision context. In particular, the large uncertainties with regard to the future ocean and inevitable ocean change challenge simple concepts of sustainability.

The Future Ocean Network_ Association of Kiel researchers

Towards a sustainable ocean economy

This new development model makes it possible to rethink humanity's relationship to the Ocean and to provide the basis of both global and national roadmaps (see Chapter 3 below), all the while preserving current advances.

Indeed, it incorporates and completes key positions emerging in recent years in terms of actions relative to the ocean, including the following :

- the *Friends of Ocean Action* coalition held by the World Economic Forum (WEF) in collaboration with the *World Resources Institute* :
  - ✓ the urgency of ramping up action on ocean health (*The Ocean Super Year Declaration,* 2021),
  - ✓ recognizing the interconnection of food security*, livelihoods, biodiversity* and climate,
  - ✓ the need for inclusive and just approaches to sustainable and effective blue solutions, particularly with regard to indigenous peoples and local communities,
  - ✓ the significance of the Friends of Ocean Action impact pillars: mobilizing ocean finance, building a resilient ocean (equitable and sustainable ocean management), creating a digital ocean (ocean data), feeding billions of humans ans accelerating ocean innovation.

- the High Level Panel for a Sustainable Ocean Economy (Ocean Panel), whose concept of a Sustainable Ocean Economy includes the following 5 key transformation areas :

  ✓ *Ocean Wealth* : sustainability of ocean-related food, energy, tourism and transport, sustainability of new ocean industries, precautionary approach to seabed mining,

  ✓ *Ocean Health* : reduction of greenhouse gas emissions, protection and restoration of marine and coastal ecosystems, reduction of ocean pollution,

  ✓ *Ocean Equity* : transparent and responsible practices in fisheries and ocean industries, recognition of the interests of **indigenous peoples** and coastal communities, inclusive governance, creating the conditions for full participation of women in ocean activities, international cooperation to combat various illegal activitiess,

  ✓ *Ocean Knowledge* : strengthening ocean knowledge and skills, enhancing the value of the ocean, harnessing ocean science, technology and data,

  ✓ *Ocean Finance* : using the principles of sustainable ocean finance, mobilizing private sector funding for a sustainable ocean economy, creating a targeted blended finance capacity, developing and applying ocean risk mapping and global risk indices (insurance).

Accordingly, the general principle underlying the generic development model proposed for the ocean is based on the effective protection of the Ocean Sphere*, the sustainable production of ocean goods and services (fishing, tourism, transport, etc.) and equitable prosperity.

What remains to be done now is to establish an *Ocean Governance* that will ensure this general principle is upheld and that a post-Anthropocene* development model is implemented.

- The current enthusiasm for the ocean obscures the following real issues :

  - ✓ Fragmentation and multiplication of initiatives and solutions, suggesting a great waste of energy and means.

  - ✓ Massive production of information, rendering access to this information increasingly difficult.

  - ✓ Institutional lobbying, aimed at protecting the interests of developed countries (mining, overfishing, non-dismantling of obsolete offshore platforms).

  - ✓ Declarations of principle, that struggle to produce significant impact.

  - ✓ Finally, an essential dilemma to be resolved: Is the purpose of this mobilization to continue competitive industrialization in the Ocean Sphere or to save it before it reaches the point of no return ?

Chapter 2 : For global governance of the Ocean

It is crucial today to step out of the aforementioned state of agitation, which is yet to be consolidated, while continuing to mobilize good will. Accordingly, the main solution proposed here is that of global governance of the ocean, which this chapter will attempt to describe, with special emphasis on operational aspects.

All the answers to existing problems cannot be delivered by a general development model, but guiding principles and major orientations can lead to solutions based on systemic and prospective reasoning, supported by a moral code of action and sufficiently operational to be effective.

Implementing guiding principles

The fundamental guiding principles of the above-mentioned generic development model are based on two prerequisites that shape them :

- The foundation for this model is based on the following inalienable principles: oneness of the human race, uniqueness of each person, privatization of intimacy, ethics of care, recognition and respect for the living.

- All governance should be based on respect of human rights, justice, ethics, flexibility of processes implemented, contextual relevance and protection of populations. Governance should also provide meaning to goals and actions.

In this perspective, the compass guiding governance of this model unfolds in six directions (detailed in the IRES Strategic Report 2019/2020 entitled ''Towards a new development model''). Applied to ocean governance, this compass should result in a systemic operating model.

Strengthening collective intelligence

In order to facilitate implementation of best practices, it is essential to promote ownership of why these practices are considered good. This requires strengthening the collective intelligence of ocean stakeholders.

1. Favoring consultation* as a decision-making method

It is essential to draw a clear distinction between international collective intelligence, often referred to as the global community, and collective intelligence at the narrowest decision-making level.

The former establishes a global legislative framework, alerts public opinion and mobilizes funding, while the latter enables local problems to be solved and, to this end, agreement must be reached on a choice of options, a common medium- and long-term vision shared, resources pooled and efforts distributed on the basis of voluntary mobilization.

In the present context of scarce available funding and complexity of marine, maritime and coastal situations, cooperation among stakeholders is more necessary than ever, especially in a single ocean basin (the Mediterranean, the South Atlantic coast, the Arctic, etc.) where multilateralism becomes essential.

2. Encourage territorial projects (coastal or marine) developed in a participatory manner

This measure should be imposed on all project selection processes for national and international public investment.

Shared projects of this type, provided they include a prospective basis, allow for better appropriation of global and specific problems and facilitate consultation* and informed decision-making.

Thus, each stakeholder understands the scope of his/her action and the consequences it has on others, for example, the impact of building a marina on local marine resource users (fishermen, oyster farmers, seaweed farmers, ...).

3. Systematically inform citizens of the structural consequences of public action

This provision, through the press and posters, helps give meaning to the action, facilitates ownership and compliance, opens the possibility of recourse by stakeholders and justifies penalties for violators.

Thus, prohibitions on illegal sand removal, for example, could be better understood and thus better enforced.

4. Facilitate and develop citizen contribution

In the age of the Internet and mass applications (social networks, mobile applications), there are at least three ways to mobilize citizens around ocean issues:

- Crowdfunding of projects or measures (in addition to participatory budgets) for example) for the ocean, such as ocean education, ocean erosion awareness, waste reduction, help for coastal rescuers, ...

- Crowdsourcing, which makes it possible to launch an open call for everyone to participate in a given task, in exchange, possibly, for remuneration or a reward, for example for collecting ocean data or cleaning up beaches[332].

- Citizen science in which the public voluntarily participates in scientific processes to solve real-world problems, through formulating research questions, conducting scientific experiments, collecting and analyzing data, interpreting results, making new discoveries, developing technologies and applications, and solving complex problems. The National Oceanic and Atmospheric Administration relies heavily on this process.

Therefore, mobilizing collective intelligence around ocean issues can contribute to better decision-making (more systemic), greater ownership, enhanced actions and leveraged efforts.

Rationalizing resources and uses

The advent of the Anthropocene*, modifying Earth's major natural balances, on one hand, and the dysfunctions of the current economic development model, which increasingly struggles to cope with crises, on the other, generate a dual need: to limit the loss of both resources (biodiversity*, drinking water, etc.) and means (waste, inefficiency, etc.).

The slowdown in global growth since 2007 and the need for ''multilateral initiatives to address the humanitarian crisis, prevent the global economy from further fragmenting, preserve global monetary balances (inflation, monetary liquidity,...), deal with situations of over-indebtedness, combat climate change and put an end to the pandemic''[333,334], all place considerable pressure on global public funding.

Broadly speaking, rationalizing the utilization of natural resources is essential, as is rationalizing the use of financial, human and material resources. Hence the importance of the aforementioned citizen participation, as efforts to restore Ocean Sphere* balances require a greater investment than human and financial means currently allocated to it.

Rationalizing means ''obtaining better results with less use of means and resources'', which means eliminating useless redundancies and excessive costs, and better inventory of available resources (especially existing data)- at all scales: local, national, regional and international- and, finally, true mutualization of means. Many organizational systems, like fishery cooperatives, already operate according to this model and it would therefore be straightforward for ocean stakeholders to draw inspiration from them.

Pooling and streamlining require :

- effective coordination to avoid redundancy and orchestrate pooling,
- solid institutions to respect and enforce compliance with various regulations,

- reliable means of information concerning resources both in stock (existing resources) and in flow (available or mobilized resources) on one hand, and the needs of various users, both in terms of spatial and temporal distribution, on the other

On a global ocean governance level, the first step towards rationalization is the mutualization that would result from the legal recognition of the entire ocean as a common good* of humanity and the establishment of global community management of this common good*[337,338,339] (cf. infra).

Establishing subsidiarity

The effective resolution of a problem often depends on the level at which it is dealt with.

Thus, the principle of subsidiarity* assigns responsibility for a public action to the entity closest to those directly concerned by that action. In other words, this bottom-up* principle stipulates that only when a situation exceeds the competences of one entity is it passed on to a higher hierarchical level. This authority of proximity is therefore located at the geographical level that is most relevant for dealing with the problem, whether it is local, national, regional or global.

Subsidiarity* is also based on fundamental notions of governance: transparency of public action, empowerment of stakeholders and (*accountability*, *reporting*) of actors.

Applied to ocean governance, it has a three-fold implication

- At the national level, the delegation of competences from the central State to lower levels of action is essential (decentralization, customary law, **indigenous peoples**' rights) for them to address problems that concern them directly.

- At the regional level, concerted actions can thus be decided and carried out in a multilateral framework, in an autonomous manner with respect to instituted regions: for example, an *Ocean Operational Meeting* of Mediterranean countries could settle problems pertaining to this sea, by delegation from regional authorities as the European Union and the African Union, and in respect of their respective rights and principles.

  A consultation platform* already exists (the Mediterranean Action Plan, PAM/ PNUE), offering an institutional, legal and expert framework, but with no decision-making power, since it emanates from the United Nations. A decision-making assembly of this kind would not only allow us to quickly respond to accidents such as oil spills or invasions of toxic species, but also to develop sustainable structural solutions to recurring problems.

- Only those problems that cannot be solved at lower levels would be dealt with at the global level. The delegation of powers to the global level would include the legal, financial and human resources necessary for effective action (see below).

A number of systemic issues need to be addressed at multiple levels simultaneously. Such is the case of global common assets, which require governance at global level and as an integral part of national and regional development. In all cases, coordination and cooperation among relevant actors is the key to effective subsidiarity*, hence the importance of the UN system's coordination mechanism on ocean issues : ONU-Océans.

Subsidiarity*[340] thus implies a complete reversal of the current *top-down* paradigm for a bottom-up operational process. The reluctance of sovereign States to delegate a number of their prerogatives should yield in the face of a succession of upcoming crises to which quick and operational responses must be found.

Basing public action on science and proven facts

Public policy decisions are often made on the basis of ideological assumptions, obsolete knowledge and preconceived ideas, for lack of time or resources to access or process the required objective information. This is why it is important to follow a three-step protocol: real and updated field knowledge, precise and systematic identification of the issue at hand based on scientific investigation, and field validation of proposed solutions through experimentation and evaluation[341].

The term ''science'' here refers to a dynamic understanding of it: it is knowledge that is observed and processed objectively, whether or not it has already been subject to a recognized causal explanation. In such cases, it is customary to speak of ''proven facts''. This definition makes it possible to incorporate the broad scope of indigenous knowledge.

This scientific principle is particularly applicable to ocean governance as recalled by the Oceans 2022 Conference aimed at ''implementing much needed science-based innovative solutions to open a new chapter in global ocean action and mobilize action'', citing projects already contributing to advancing scientific knowledge of the Ocean Sphere* :

- international, such as the Mercator project to map the world ocean (of which only 21% is mapped in 2021) and the International) Argo Ocean Observation Program (sensors),

- or national, such as Costa Rica's development of an ocean knowledge bank for improved sustainable management of marine resources and mangrove restoration.

Still, public funding for ocean sciences* is globally modest in developed countries and alarmingly low in developing countries, particularly those most vulnerable to ocean changes such as Africa and Small Island Developing States*.

The issue of deep-sea mining, governed by the International Seabed Authority, shows the importance of this knowledge for making the right decisions.

Stepping up exchange activities to expand scientific and technological cooperation, while including indigenous and local knowledge bearers , is essential but not sufficient. To ground public action in science and evidence, specifically with respect to the ocean, three overarching measures need to complement scientific cooperation :

- **Consistent adherence to basic methodological elements**: application of systems thinking to all research and action processes; experimentation before generalization; in-situ assessment (diagnostics); and data interoperability.

- Ability to call upon the **global epistemic and scientific communities to inform** decision-makers prior to action. For this purpose, a global portal could be created for decision-makers to address their questions and for those who know (scientists or practitioners) to answer them.

- Creating a national or regional **scientific and technical oversight authority** (Science & Technology, Research & Development, Technology and Innovation) for the ocean, verifying and synthesizing new information before making it available in the language of the largest number of speakers concerned.

This would help combat media shortcuts and *fake news*, and ensure a follow-up of political intentions (cf. moratoriums) and international programs of Research & Development, Technology and Innovation.

Upholding justice and ethics

All notions of governance are tied to a framework, which determines what is acceptable and what is not. That framework is both legal and ethical.

Compliance with moral standards (justice, honesty, fair treatment, helping others) rests with each individual. It is therefore up to public authorities to establish conditions that enable this compliance: an effective legal framework (legislative apparatus, courts, etc.), a moral framework (through education, training and selection of civil servants) and arbitration bodies (mediators, appeals, ...).

All objects of governance fall under this principle of honesty (justice and ethics), but with regard to ocean governance, four broad measures arise:

- Fighting corruption (of fishermen, controllers, distributors, ...), for example by digitizing and automating those steps subject to this risk.
- Banning speculation on essential goods from the ocean: price of raw materials, price of food.
- Incorporating ecological costs in pricing, so as to support sustainable ocean activities (fishing, transport, tourism, etc.).
- Prohibiting practices that damage the coastal and marine environment (prohibited fishing techniques, quotas on endangered species, obligation to treat effluents, etc.).

It is equally important to provide special attention to populations in precarious circumstances, particularly in coastal communities, and to fight discriminatory practices, such as those that favor industrial fishing to the detriment of small-scale fishermen or those that are carried out to the detriment of indigenous populations.

Building a more responsive and flexible government

Although collective intelligence and subsidiarity* are progressing, one of the causes of the inefficiency of public authorities remains their difficulty in perceiving new needs and adapting to them, as evidenced by the delays often incurred in the process participatory processes, digitization* or modernization of the legislative corpus.

Using the triptych favored by corporate governance, public authorities should systematically :

- develop a forward-looking culture to sharpen vision and take proactive rather than reactive action ,
- reduce hierarchical channels and promote project and mission-based management to be more effective,
- adopt a raison d'être (purpose) of safeguarding and facilitating citizen's lives (simplification of administrative procedures) rather than appearing to fight them, which perpetuates and widens the divide between State and citizens.

This applies to ocean governance as well as to all public action.

Governing a shared resource of Mankind

''We are therefore deeply alarmed by the emergency facing the ocean on a global scale. Sea levels are rising, coastal erosion is worsening, and the ocean is warmer and more acidic. Marine pollution continues to rise at an alarming rate, one-third of fish stocks are overexploited, marine biodiversity continues to decline and about one-half of all living corals have been lost, while invasive alien species are a significant threat to marine ecosystems and resources. While some progress has been made toward achieving some targets under Goal 14, advances are not being made at the speed or scale necessary to meet the goals we set for ourselves.

We deeply regret our collective failure to achieve Goals 14.2, 14.4, 14.5, and 14.6, which expired in 2020, and we renew our commitment to urgent action and cooperation at global, regional, and subregional levels to achieve all targets as soon as possible and without undue delay.'' Extract from the ''Our Ocean, Our Future, Our Responsibility'' Political Declaration of the Heads of State meeting in Lisbon (UNOC, 2022).

In addition to this situation, there are three other elements that justify specific interest in the idea of a common good* (commons) :

- The ocean absorbs 25% of all carbon dioxide emissions and over 90% of excess heat in the climate system, it generates over 50% of the oxygen that sustains life on earth. However, by 2100, the ocean could warm by 2 to 7 times, depending on the scenario, compared to changes observed since 1970[344].

- Fish products are the main source of protein for over 50% of the population of least developed countries and 15% of animal protein intake worldwide: these resources are therefore essential to feeding humanity. However, over 10 million tons of fish are lost each year to malfishing and over 50% of the world's marine species could potentially vanish by 2100[345].

- And 61% of the ocean (the high seas) lies outside the legal boundaries of states[346].

All these reasons highlight the importance of the Ocean Sphere* for humanity as a whole. Yet, the ongoing anthropogenic degradations and the prospect of important economic profits (Blue Acceleration*) put it at great risk.

This situation supports the idea of managing the ocean as a universal common good* of the planet.

From Common Heritage of Mankind to Common Good[347]

The concept of ''common heritage of humanity'' (common heritage) refers to the idea of a legacy bequeathed by previous generations and to be transmitted unaltered or increased, to future generations. Although originally without legal basis, this concept was a major innovation in the law of the sea, which up until then had only known freedom (of the high seas) and exclusivity (of the exclusive economic zones), as the Montego Bay Convention stipulated that ''the seabed and ocean floor delimited by the outer limits of the continental shelves - known as the 'common heritage of mankind' - may be exploited only for the benefit of all''.

The issue of the future exploitation of the seabed in the high seas, however, highlights the limits of the ''for the benefit of all'' declaration. Therefore, faced with the prospects of increased industrialization of maritime activities (increase in volume and diversity), a worldwide movement[348] is emerging for recognition of the ocean as a global commons*[349] of humanity.

A common good* can be defined as a natural or cultural resource shared by a group, with specific rules for distribution, preservation and valorization[350]. Commons are non-exclusive (open access) and rival goods (rival agents in resource consumption)[351].

If the notion of commons* has become central to thinking about development aid and the challenges of climate change, it is because it offers a fresh vision :

- The State alone cannot ensure the transmission of an unaltered, or even enriched, legacy to future generations: *commons are the exact opposite of a purely bureaucratic and state-run management of resources*[352, 353] This is why the notion of commons* goes beyond the concept of a ''public good''.

- Communities are able to preserve, develop and promote common cultural or natural resources.

Oceans are highly dynamic and interconnected; around two-thirds of the world's oceans are areas beyond the national jurisdiction of states. Their specific characteristics and status imply a shared global responsibility and the need to cooperate and coordinate across boundaries and borders to take meaningful action.

International ocean governance, EU

A commons* must therefore be protected for the benefit of future generations, in a non-bureaucratic way, involving user communities.

Today, while the debate surrounding the creation of a legal category for common goods is underway in a number of countries (France, Italy, etc.)[354,355] , no such legal status yet exists. The question does, nonetheless, have the merit of clearly laying out the stakes of the ocean in terms of resources, communities and rules. The three components of a common good* are as follows :

- The resource is the entire Ocean Sphere*, including the ecosystem services it provides to the planet and humanity.

- The community is humanity without exception (since it is impossible to prohibit access to a common good* which, by definition, is shared).

- The rules should be, for all users, to preserve and, if possible, improve its condition[356].

Yes, we are still moving too slowly to catch up on the accelerating crisis. But we know the solutions.

Inger ANDERSEN,2022 Executive Director, UN Environment Programme, PNUD

In the case of global commons*, it is therefore up to all mankind to take care of them, which, in reality, often means ''nobody'', as a result of dilution of responsibilities. For this reason, the recognition of the global ocean as a global common good* requires the creation of a community capable of managing it as such.

For global ocean government

Today, there is a form of global governance of the ocean: non-governmental organizations and States are in dialogue within international institutions and at world summits.

But from declaration to action, at such a level of individualization of responsibilities, considerable time is necessary to reach decisions such as ending plastic pollution for example (2024) or a mining code for exploring and exploiting the international seabed (2023).

However, the rate of degradation of natural cycles is no longer compatible with the pace of international public decision-making as it is practiced today. An alternative approach is imperative.

International bodies constitute a de facto form of global legislative power, based on dialogue and cooperation between stakeholders. However, what we lack for a swift transition to action is to provide these bodies with binding prerogatives in specific areas.

In fact, the international community is currently split around several major issues facing the ocean :

- International seabed mining, governed by the International Seabed Authority. Some States support extractive companies, others have formed a coalition for a moratorium, while other stakeholders (NGOs) want an outright ban

- Plastic pollution, the focus of the United Nations Environment Assembly. The UN Environment Assembly agreed in March 2022 to start negotiations for a binding global treaty on the use and disposal of plastics. However, global waste markets, the plastics recycling industry and sectors including healthcare are not yet ready for such a measure.

- Malfishing, dealt with by the World Trade Organization. The WTO has reached a general consensus on banning subsidies for harmful fishing.

- Marine biodiversity protection, administered by the Intergovernmental Conference on a legally binding international instrument (Intergovernmental Conference on Marine Biodiversity in Areas beyond National Jurisdiction).

  A treaty is currently being negotiated in this forum to regulate the high seas, specifically as regards marine genetic resources and marine protected areas*. The divide is essentially over the distribution of benefits from marine genetics and the degree of protection of marine protected areas*[357].

As evidence of these tensions, alliances and declarations (as signed by stakeholders) seek to shape different negotiations and express different positions:

The underlying unity of the oceans requires effective global management regimes
Brundtland Report
/Chapter 10. Managing the Commons, 1987

We need to forge a new ethico-political relationship between humanity and the oceans, a relationship with a political and juridical basis which creates an atmosphere of sharing and solidarity and which provides for a new universalism centered on knowledge of the oceans; a relationship capable of unifying the citizens of the world under one banner, a common, unique and irreplaceable asset: the sea which all the continents share.
Mario SOARES,
The ocean Our Future (1998)[338]

- Protect 30% of marine areas under national jurisdiction by 2030" (High Ambition Coalition for Nature and People, 84 countries).

- "Ending overfishing and verifying, controlling and sanctioning illegal, unreported and unregulated fishing* " (14 countries participating in the *One Planet Summit for the Ocean* in Brest, February 2022).

- A call on public authorities to limit the impact of sea level rise on cities and coastal communities (Sea'ties Declaration by some 30 local authorities).

While some of these alliances are short-lived (such as the 2012 Global Ocean Partnership, which now seems forgotten), there is growing pressure to translate these intentions into binding international law of the sea.

Hence the interest in a global ocean government, bringing together the various initiatives in a systemic approach, oriented towards a long-term vision, to facilitate the achievement of set objectives and coordinate collective action that is currently fragmented. This approach could be inspired by the one currently being implemented in the Pacific: the 2050 Strategy for the Blue Pacific.

Accordingly, in light of the current urgency surrounding ocean degradation and rising sea levels, exceptional measures are necessary, such as **establishing a binding governance** based on the following :

- Establishing an international body, with binding powers, to deal with ocean issues :

  ✓ appointed by international bodies,

  ✓ representing all stakeholders (NGOs, trade associations, marine artisans and industries, communities, ...) - each sending one single delegate - and deciding collegially to implement decisions and resolutions,

  ✓ directly administering various ocean management institutions, such as the International Seabed Authority, and coordinating the multiple alliances and partnerships (rationalization and mutualization).

- Binding decision-making power over the entire ocean outside national jurisdictions, as is already in place for the International Seabed Authority and over all processes impacting the entire Ocean Sphere* (such as plastic pollution); a number of international institutions are already working on developing such binding measures: the World Trade Organization , the International Maritime Organization and the United Nations Environment Assembly[359].

- An obligation to implement international conventions and action programs :

  ✓ clearly and precisely explain the intentions of signatory countries to facilitate implementation by stakeholders: deliberately vague international decisions leave a wide scope of interpretation to States, as is the case with marine protected areas*, and the real issue, i.e. protection levels, is rarely addressed ;

- ✓ finding ways and means for implementation, using mixed financial mechanisms (private and public), relying on volunteers (crowdsourcing, in particular), facilitating microcredit and mechanisms for a quick return on investment for aquapreneurs*;

- ✓ assess proposed action programs (rating) to orient funding towards those with the most impact and optimize these based on the urgency level experienced by local stakeholders (poverty, coastal threats, etc.).

- A duty of centralizing open information (databases and portals), for example :

  - ✓ tools for awareness raising and training of populations on a global scale, on Ocean issues ,
  - ✓ main scientific and technical research results related to implementation ,

  - ✓ main research centers in oceanography* and oceanology*, by region ,

  - ✓ follow-up of programs launched (which should put an end to idle declarations).

A decentralized world organization of this nature, acting with relevant local authorities (subsidiarity*), would make it possible to pool means and resources for more immediate and effective action, in keeping with global ocean issues, a common good* of humanity.

The principles set out in Article 5 (p.8) of the Revised draft agreement of the Intergovernmental Conference on Marine Biodiversity in Areas beyond National Jurisdiction would be adopted and further developed :

- 4 principles: common good* of humanity, fair and equitable benefit sharing and non-patentability of marine genetic resources, polluter pays precaution.

- 4 obligations: strengthening resilience and restoring integrity of ecosystems, respecting the rights of **indigenous peoples** in protecting biodiversity*, both within and beyond national jurisdiction, prohibiting displacement of harm or risk from one area to another, prohibiting substitution of one type of pollution for another.

- 4 method elements: systemic and ecosystemic approach, integrated approach, use of the most reliable scientific knowledge and relevant traditional knowledge of indigenous populations, anticipatory approach.

Finally, priorities that this body - limited to ocean issues (policy and mission administration) - should address through binding provisions include :

- combating malfishing (illegal fishing and overfishing), through :

    - ✓ a world ocean police force, Maripol, like Interpol or Europol, acting at sea (surveillance drones, human and technology based monitoring networks) and on land (control of fish distribution), ensuring quota compliance,

    - ✓ a rigorous enforcement of an arsenal of deterrents, some of which already exist but are not sufficiently enforced: seizure of offending vessels, seizure of illegal goods, referral of offending States to the International Court of Justice, blacklisting of rogue States, ...

- the fight against coastal and maritime pollution (avoidable), in support of most affected developing countries :

  ✓ Identification of polluters at sea (Maripol) and on land (satellite observations).

  ✓ Enforcement of the polluter-pays principle.

  ✓ Ban on insuring offending vessels and letting them access ports.

  ✓ Mandatory dismantling and recycling of fixed structures (offshore platforms*) at end of life: seizure of corresponding amounts from the accounts of offending companies.

  ✓ Aid program for developing waste treatment in poorest countries.

- Sanctuarization of highly vulnerable areas (at the request of relevant States, such as French Polynesia or the Mediterranean) or areas critical to the global Ocean Sphere system* (such as Antarctica) following an audit of these areas (at the request of stakeholders) to identify the root causes of the problem :

  ✓ Regular assessment to ascertain restoration effectiveness (blue carbon*, erosion protection).

  ✓ Determine the level of protection applicable to the assessed area and apply immediately.

  ✓ Enforce heavy fines on offending states, which should be allocated to restoring the ecosystems concerned.

- ✓ Possible amendment of the Montego Bay Convention, enabling increased international control of altered sectors of Exclusive Economic Zones.

Such measures may seem excessive, but without the threat of firm, prohibitive sanctions, no global ocean regulation is likely to be useful.

New ways of bringing countries together are required today to address emerging global issues such as ocean degradation and climate change.

While one key role of global institutions is to build consensus on how to address transboundary issues and problems, this emerging model of global governance lacks a decision-making body capable of prioritizing solidarity in natural resource management over mercantilist, short-termist and individualistic interests.

Recognizing the need for a coherent and coordinated long-term global vision.
UN Environment Assembly, Résolution du 2/03/ 2022
Mario SOARES,

The ocean Our Future (1998)

The purpose is not to create a supra-state government, on the model of existing national governments, but to invent a system that is :

- cross-cutting wherein cooperation between stakeholders is essential, notably support from regional organizations (European Union, development communities, federal states, regional fisheries organizations, ...),

- *bottom-up** to channel information and empower all local stakeholders, starting on the ground (from small-scale fishermen to indigenous communities) and not from States, and,

- *top-down** to enforce genuine compliance with decisions and implement action programs on the ground that are the fruit of international cooperation and adapted to local context.

For this system to function and not be a simple management body for international funding, it needs a capacity for reflection, vision and anticipation, in addition to the means for its action.

Governiong means foreseeing

Governing a common good* as vast and complex as the Ocean Sphere* requires a true proactive intelligence policy. This begins with a long-term strategic vision, builds upon it with a method and progresses with priorities.

Vision and priorities

A strategic vision defines the purpose that we set out to achieve. The purpose is not a target but rather a reason for being: it is determined by meaning (sense-making), it is underpinned by values (religious, ideological or ethical) and it is shaped by a global, systemic understanding of the world (worldview). The value of such a vision is that it provides a compass for action that enables the setting of priorities.

As far as the ocean is concerned, the new vision emerging today out of the multiple events that occurred and the different declarations that ensued, is that of a future in which ocean mechanisms regain equilibrium and ecosystems once again flourish, enabling the ocean to dampen climate change* while its resources contribute significantly to feeding 10 billion human beings (by 2050) and to their economic, social and personal development.

The novelty lies in the awareness of the ocean's dual contribution to humanity and the planet, as well as the need for it to be healthy in order to save both.

Guided by this long-term vision, a number of priorities arise :

- Reality principle indicates that not everything can be saved, for example :

  - ✓ in terms of rising sea levels, land will have to be given up to sea. It is therefore necessary to start planning today for areas to be relinquished within 30 years so as to orchestrate this withdrawal with the least possible harm to inhabitants,

  - ✓ as regards biodiversity*, climate-induced fish migration and size alterations (see Part 1, Chapter 2) are impossible to avoid. It is therefore necessary to consider these elements to protect migrating species as well as indigenous species confronted with this migration,

  - ✓ In the case of proliferation of certain species to the detriment of others, jellyfish for example, innovative solutions to limit any damage will have to be found, such as the introduction of predators and the collection of surpluses (food for example).

- Not all necessary resources can be mobilized, hence the importance of :

  - ✓ implementing systematic cost rationalization and resource pooling principles, including through transboundary ecological zones such as the *Kavango-Zambezi Transboundary Conservation*,

- ✓ concentrating action programs on systemic emergencies on a global scale, in cooperation with regional levels, to create significant synergies: strong protection for a few years allows for greater ecosystem restoration than indefinite weak protection,

- ✓ delegation active conservation efforts, such as OECMs*, to local levels of government (subsidiarity*) so as not to hinder local development,

- ✓ organizing blue finance: identifying projects on which funding should be urgently concentrated, listing and facilitating access to financing tools and blue investments and developing new financing tools such as public-private partnerships, similar to the Blue Finance model,

- ✓ pooling research and development efforts (globalized research teams such as the IPCC), giving free access (open source) to resulting work when it originates from the use of a common good* of humanity (marine genetics, deep-sea resources) and enforcing the rule of non-patentability of life.

- Protecting nature and human survival cannot be done at the expense of one another. Any solution must therefore ensure both simultaneously in order to be viable in the short term and sustainable in the long term. Tourism, shipping and coastal urbanization are at the heart of the integrated transformation processes needed to guide, facilitate and scale up. Critical ocean ecosystems such as mangroves, salt marshes and coral reefs (blue carbon storage*) must be restored without delay, as reiterated in Lisbon.

- The strategic global assessment[360] of the global state of the ocean and its coastline must be the prerequisite for any determination of priorities for the action program. This assessment must be both scientific - based on quantified, recent and reliable data - and anthropological - based on human and societal data, qualitative, observed on the ground. This dynamic assessment should regularly take stock of progress made so as to quickly identify problem areas to be addressed in order to move forward, good practices to be disseminated and resources to be mobilized.

Implementation

Implementing a global agenda to save the ocean and humanity, on a planetary scale, requires a methodology, beyond the very operational and complex project management it represents.

This methodology is based on three key words: virtual centralization, awareness and knowledge development and anticipation.

Virtual centralization of knowledge: in view of the urgency of actions to be implemented, the handicap of fragmented data needs to be overcome.

Achieving and promoting improved knowledge centralization and organization should not only enable replication of experiences that have proven to be effective but also facilitate collaboration between institutional actors (blue finance) and citizens (*crowdsourced innovation*).

This fulfills a number of objectives :

- Collect what is today fragmented and therefore not very accessible, to avoid redundancies (rationalization of resources), allow access to knowledge for all actors (as requested by Small Island Developing States*) and focus energies.

- Advance science more rapidly by incorporating the knowledge of local communities (which is rarely the subject of scientific publications) and by offering free access to non-research practitioners.

- Create a systemic, global overview of the evolving state of research, topics, research concentrations and, by contrast, issues not covered.

- Bring together not only scientific knowledge but also tested solutions (practical knowledge and field experience).

To accomplish this, we need an **artificial intelligence*** capable of indexing this knowledge in interconnected, interoperable and easily accessible databases (web portals, mobile applications). The utility of such a database, once in place, will drive researchers and practitioners to update it, along the lines of user communities (like Waze).

As education is a key to the future, awareness and knowledge development are essential to build the future and disseminate the systemic and prospective thinking necessary to face tomorrow's challenges for the ocean and humanity (disappearance of habitable and arable land, climate change).

In conjunction with specialized international organizations such as UNESCO, the mission of improving and disseminating knowledge on the ocean would aim to :

- publicize existing educational tools, such as UNESCO's *The Ocean Literacy Portal* and training platform l'*OceanTeacher Global Academy*, as well as initiatives such as the *World Ocean Observatory*, and promote the 7 principes of Ocean Literacy,

- popularize key research findings (IPCC Ocean, in particular) by rendering them, for example, in entertaining and intelligible computer graphics, to facilitate appropriation by all ,

- provide a global portal, by global region, of the multiple training programs on ocean sciences or management (academic or professional), to increase the number of oceanographers, oceanologists and ocean professionals and to publicize the specialized, noncommercial organizations active in this field and which share the same vision, e.g. the IMO's *World Maritime University* the NGO *International Ocean Institute*,

- make recommendations to training organizations on specific skills to include in curricula: systems thinking, contextualization, anticipation, multidisciplinarity,

- provide thesis funding for candidates from developing countries ,

- coordinate global research on topics not covered so far (at the request of stakeholders), with results of this research available to all ,

- globalize activities of the European intergovernmental organization *Mercator Ocean** and support its flagship project of creating a digital twin of the ocean, from a complete mapping of it.

Last, a proactive approach is needed to:

- act judiciously, take medium- and long-term effects of both action and inaction into account, and develop and assess possible options,

- consider innovations in development or planned so as to have sufficient time to evaluate and decide on whether or not to adopt them,

- contextualize the impact of future changes by looking at various actions at regional level (conservation, coastal protection, etc.) so as to schedule actions according to the chronology of expected events (sea level rise, erosion, oceanic heat waves, etc.),

- apply a prospective meta-method: understand, anticipate and propose solutions.

The implementation of such an anticipatory intelligence, shared and mutualized, based on multiform knowledge and open to innovation, should be assigned to a global organization (to be created) under the direct aegis of a multilevel world government: the *Ocean Spearhead Institute*.

This nucleus of highly competent specialists in their areas of expertise would be staffed by a small but effective team, working closely with a network of partner organizations. The Institute would have the following tasks, similar to a lean and specialized mission administration :

- As a coordination entity, coordinate different such organizations, arrange consultations* between stakeholders and networks, facilitate efforts (visibility, focus) and inject its priorities into actions.

- As a commissioner of research on a global scale, provide priority treatment for non-covered areas required for decision making.

- As an awareness-raising organization, bring together a range of tools to raise awareness (among children, young people, the general public and decision-makers) of ocean issues and ''right'' behaviors to adopt.

- As a watchdog organization, identify current developments, new actors and new issues (scanning horizon).

- As a foresight organization, connect the various elements brought to its knowledge through monitoring, study trends, identify probable problems over the next 50 years, develop alternative strategies to give decision-makers a choice (foresight) and alert them to emergencies (future nodes, early-warning).

- As an ocean risk analysis organization, identify risks, centralize assessment of these risks and inform public authorities on major threats and suggest appropriate prevention or management policies.

- As recalled by the 1987 Brundtland Report three imperatives are central to ocean management :

  - ✓ Ocean unity requires an effective global management government.

  - ✓ Shared resource characteristics of many regional seas require regional forms of management.

  - ✓ Primary land-based threats to oceans require effective national actions based on international cooperation.

- Faced with the current trend towards greater fragmentation of initiatives and sectoralization of solutions, the challenges of coordination and consultation* among stakeholders at multiple scales and between actions taken, makes global centralization by a single actor with a global and comprehensive vision advisable[362].

▶ Beyond reorganizing powers on a global scale, it is an entire development model that needs to be rethought and quickly implemented.

Chapter 3 : Morocco aquapreneur

Despite the global mobilization of multiple stakeholders and the emergence of a stronger commitment to protect the ocean, the degradation of this ecosystem intensifies under the dual impact of climate change* and anthropogenic factors, notably the ''blue acceleration*'' (industrialization of the sea), which constitutes an exponential threat (see previous chapters).

A new development model is therefore necessary, one that respects both nature and human beings. Morocco falls within this perspective.

With two maritime façades - Atlantic and Mediterranean - the longest coastline in Africa (3,500 kilometers) and an Exclusive Economic Zone* of over one million square kilometers, Morocco has a long maritime tradition.

Throughout its millennial history, the Kingdom has always considered the sea a key asset to its prosperity, security and expansion. Management of maritime issues has always been at the heart of Royal concerns, dating back to the Middle Ages. Leading a Mediterranean empire that stretched from the mouth of the Tagus in the northwest to Tripoli in the southeast, the Almohad Sultans (12^{th}-13^{th} centuries) personally supervised shipbuilding and training of seafaring personnel.

Under the Reigns of Moulay Hassan I (1873-1894) and Moulay Abdelaziz (1894-1908) of the Alaouite Dynasty, the Ministry of the Sea was one of the three Ministries that made up the Government. It was headed by the Sultan's representative ''na'ib al-Sultan'' in Tangier, who was in charge of foreign affairs and Morocco's foreign trade.

Recognizing the need for a coherent and coordinated long-term global vision.
United Nations Environment Assembly of the United Nations Environment Programme
28 February–2 March 2022

The ocean Our Future (1998)
Mario SOARES

The Kingdom's maritime vocation never faded. A number of major initiatives were launched in recent decades. In addition to actions designed to modernize the fishery sector, such as the Halieutis Plan (2009), Morocco undertook the construction of world-class infrastructure, such as the port of Tanger Med (first container transshipment port in the Mediterranean, first container port in Africa and second largest free zone in the world in 2020[363]) and the port of Dakhla Atlantique currently under construction. These initiatives indicate Morocco's intention to push ahead and renew its commitment to a major maritime policy.

Proposals outlined below envisage Morocco as a true entrepreneur of the aquatic world - an ''aquapreneur'' - turned towards the sea, at three levels: global, regional and national. This vision first requires international posture and particular attention to security before fully committing to a sustainable ocean socio-economy.

Ocean diplomacy

A number of roles are to be assumed by actors of goodwill as part of the broad movement calling for a radical paradigm shift: champions, who convey the message, engage and help build momentum; drivers, who provide evidence and identify replicable solutions; catalysts, who provide necessary funding, policy framing and technical support; and conveners, who create the platforms for dialogue, facilitate discussion and mobilize new actors[364].

Morocco can play two separate roles at two different levels.

Global champion of the ocean cause

The Kingdom has often played a leadership role in the concert of nations, e.g., as host of COP7 in 2001 and COP22 in 2016, the Global Compact for Safe, Orderly and Regular Migration in 2018, and as a sponsor of the *Ocean Decade Alliance in 2021, through the Mohammed VI Foundation for Environmental Protection.*

It is essential that Morocco continue on this path to clearly assert its vision for the future of the ocean, based on two compelling observations :

- The severity of the state of the Ocean Sphere* - the common good* of humanity - requires transformative and rapidly implementable actions, in keeping with planetary limits.

- Given the threats of ocean industrialization brought about by the concept of blue economy, it is best to replace it with the term sustainable ocean economy, defined by *OceanPanel* as ''The use of ocean resources for economic growth, improved livelihoods and jobs, while preserving the health of ocean ecosystems and associated services''.

As such, Morocco could formally join the following organizations:

- *Friends of Ocean Action* : a coalition of over 70 leaders from all walks of life designed to drive transformative, high-impact, scalable actions and initiatives for ocean health by 2030. Except for Small Island Developing States*, only two African states are part of it: Kenya and Tanzania. Only Jordan and the United Arab Emirates have joined the coalition in the Arab world. In joining the coalition, Morocco would show its commitment to the ocean cause and its willingness to contribute to developing future solutions to ocean issues.

- *High Level Panel for a Sustainable Ocean Economy* (*Ocean Panel*) : The High Level Panel for a Sustainable Ocean Economy is a unique global initiative, reflecting the political will to build momentum for a sustainable ocean economy in which effective **protection, sustainable production and equitable prosperity** go hand in hand. The goal is to achieve sustainable ocean management in 100% of areas under national jurisdiction by 2025 and to support the protection of 30% of the high seas by 2030. The group works alongside Friends of the Ocean and the World Resources Institute. Of its 16 membre countries, three are African (Ghana, Kenya and Namibia).

- *Global Commons Alliance* : A partnership of 50+ organizations (philanthropy, science, business, lobbying) aiming to deploy systemic, science-based actions to protect the commons that support life on Earth and to keep planetary limits from being breached.

Regional Ocean Solutions Engine

Beyond this championing role, the most significant role Morocco can play today is certainly that of a driver that both points to scalable solutions and demonstrates their effectiveness by example, a role it must play both nationally and regionally.

In accordance with the new development model mentioned above, the principles of governance detailed above (Chapter 2) and its proactive vision for safeguarding the Ocean Sphere*, Morocco should intervene in the two maritime areas to which it belongs: the Mediterranean and the North Atlantic.

The future of the Mediterranean is at a tipping point, and three broad courses of action are possible, starting in Morocco and subsequently transposed across the region :

- Conduct awareness work with countries of the Southern and Eastern Mediterranean encouraging them to mobilize for protecting it, for example, by forming an alliance devoted to the marine environment, in connection with the Islamic Education, Sciences and culture Organization, based in Rabat. This action would seek to develop environmental awareness in these countries through, among other things, educational materials in Arabic and English, promote scientific vocations in the ocean field, and open ocean science and research to the public*.

- Actively participate in the work of various bodies dealing with the Mediterranean environment, particularly on the question of marine area protection levels: while 60% of the Mediterranean is classified as a marine protected area, only 0.1% is under strong protection.

- Persuade regional partners of the importance of carrying out regular assessments of :

  - ✓ actions driven by the Barcelona Convention's Mediterranean Action Plan Mediterranean Action Plan, the Union for the Mediterranean (of which Morocco holds the chair of the parliamentary assembly from 2022 to 2026) and Euro-Mediterranean partnerships (thus the Euro-Moroccan agreements),

  - ✓ commitments made at COP 22 on wastewater treatment, reduction of greenhouse gas emissions from maritime transport, notably heavy in the Mediterranean (see Part II), and plastic pollution of sea and coastlines, as well as sustainable fishing: MedFish4Ever, Blue Belt Initiative.

On the Atlantic coast, Morocco, having submitted an application to join the Economic Community of West African States, could take the following initiatives (most of which are extendable to the Mediterranean) :

- To strengthen regional cooperation on marine and maritime issues: call for the creation of an intergovernmental organization for strengthening regional cooperation and sustainable ocean development, similar to the *Indian Ocean Rim Association*.

- To address overexploitation, often of foreign origin, and pollution of national origin of coastal waters, while seafood is a major source of protein nutrition for many African populations (6 sub-Saharan African countries depend on fish for over half of their animal protein, but the region still has the lowest global per capita fish consumption[365]) :

    ✓ Propose the drafting of a pan-African law for the protection and sustainable exploitation of marine environments within the African Union, providing a regional, binding framework to the international community's regulatory corpus, from a blue diplomacy[366]. perspective. Its scope could extend beyond this corpus, given certain issues of lesser importance to the African continent for the time being (such as the exploitation of the high seas).

    ✓ Conduct a collective reflection on the tools this regional law could adopt, such as Rights-based Fishery Management Tools, which attribute individual fishing rights to local fishermen and fishing communities, a model successfully adopted in Australia, Iceland and Mexico[367].

- Develop sustainable ocean-based economic activities (fishing, aquaculture*, oyster and seaweed farming) based on attentive protection of the oceans (integrated coastal observation systems) :

- ✓ Propose, within the African Union, to lead the work of the Special Strategic Working Group in charge of laying the foundations of the Common Exclusive Maritime Zone of Africa.

  This zone, extending over the entire African maritime domain, would create an ideal framework for establishing harmonized rules and standards with regard to fisheries and marine pollution. It would be an asset in the fight against transnational crime, notably illegal fishing, piracy* and illegal migration, extending prosecution rights provided for by certain sub-regional mechanisms to the African level.

- ✓ Establish and lead a regional task force on the Blue Belt Initiative, with resources, clear operational objectives and an annual evaluation. The commitment made at the United Nations Conference on the Oceans (Lisbon, 2022) to protect at least 30% of national maritime areas by 2030 could be coordinated by this organization.

- ✓ Organize and ensure the proper functioning of a Regional Fisheries Action Network - ideally part of a Global Action Network: A governance arrangement, focused on a specific common good* through an inter-organizational network - at ECOWAS level. This network would promote and enforce *WorldFish Center* [368] priorities adapted to the region :

  - Recognize and address structural weaknesses in access regimes (i.e. the design of fishing rights).

- Minimize subsidies to fishing industries that are environmentally destructive or inconsistent with sustainable development (fuel, etc.).

- Combat illegal, unreported and unregulated fishing*.

- Ensure the inclusion of poor and/or marginalized people in the value chain.

- Integrate environmental externalities into the cost of fishing, in order to reward sustainable fishing efforts.

✓ Propose the creation, at the level of the Regional Economic Communities of which Morocco is a member and which have an Atlantic coastline, of an operational Ocean Cluster, combining maritime industries in the sub-region, a robust interface* between researchers and decision-makers, a research and knowledge dissemination tool (cf. the Blue Belt platform) and innovations[369]. This cluster would be charged with the following :

  - Provide a forum for consultation*, coordination and training to bolster the regional maritime sector economically, socially, environmentally and scientifically. It could house the two previous initiatives: the Blue Belt Task Force and the Regional Fisheries Action Network.

– Given the low (or even non-existent) investment in ocean research* and observation systems in Africa and in Small Island Developing States* (even though they are heavily dependent on the oceans) : reinvigorate ocean sciences* in the service of sustainable development by pooling resources and implementing joint projects (cooperation, partnerships), because ''we can only manage well what we know''[371].

In order to ensure compliance with regional and international law, a regional body devoted to the surveillance and security of regional waters must be set up to collectively combat (through pooled resources) piracy*, criminal networks (illegal goods, human trafficking) and illegal fishing, and advocate for Maripol (see Chapter 2), a world maritime police.

The Kingdom's contribution to securing the Atlantic area could extend beyond regional waters, through membership in the Zone of Peace and Cooperation of the South Atlantic, a military alliance that brings together all the states on the Atlantic seaboard of Latin America and Africa, with the current exception of Morocco and Mauritania.

Finally, it should be recalled that 23 African countries, concentrating 46% of the continent's population and nearly 52% of its GDP, have an Atlantic frontage: another regional dimension with which Morocco has already forged strong ties (see IRES Strategic Report 2018 - For an autonomous development of Africa).

Thus, by proposing, supporting, implementing and evaluating such initiatives, both at the global and regional levels, Morocco would reaffirm its centuries-old maritime commitment and deploy an ocean diplomacy positioning it not only as a Champion but also, and above all, as a Driver of the much-needed ocean transformation.

The challenge of security

The ocean is a source of insecurity, currently often more indirect than direct, something that is likely to be reversed with climate change. There are three main ways in which this insecurity manifests itself :

- Environmentally, the Ocean Sphere* is subject to a number of threats, from sea level rise to coastal erosion, from the proliferation of toxic or invasive species to tsunamis,
- Economically, the different sectors of activity that depend on the ocean (fishing, maritime transport, tourism, ...) are threatened both by the state of the ocean and by abuses that might occur there (piracy*, smuggling, ...),
- Geopolitically, oceanic spaces and coastlines are potential battlefields and points of invasion.

It is natural that a State, whose main duty is to protect its populations, should guard against such insecurity as much as possible.

For Morocco, three issues in particular require protection measures. The matter of surveillance is commensurate with these challenges.

Three key security issues

Supplies are an essential factor for Morocco's economic development, beyond the regular supply of domestic markets.

- In fact, the reorganization of global supply chains following the Covid-19 crisis has led several European countries to consider Morocco as a new industrial base. Moreover, the success of the future mega-port of Dakhla Atlantic, with a trade area and a major industrial-logistics zone, will depend heavily on the reliability of these supplies.

  The emergence of Morocco as a potential producer of renewable energy is leading developed countries, such as Great Britain, to invest locally in lithium-ion phosphate technology.

- It is therefore essential for the Kingdom to diversify and secure its supply sources, taking the international geo-economic and geopolitical environment into account, particularly the Chinese domination of global maritime chains, vulnerability of choke points and their proximity to areas of tension. The availability of critical minerals (copper, lithium, cobalt, etc.), which are essential to the electronics industry and the manufacture of electric batteries, in Africa would warrant a regional reorientation of supply flows to Morocco.

As key gateways to Morocco's national territory, ports are a de facto security issue.

- A number of threats apply: possible takeover of port areas and terminals by foreign companies, entry into the country of illegal products (drugs from South American cartels, products of illegal, undeclared and unregulated* fishing, etc.), illegal migration, human trafficking, etc...

- A significant fight is already successfully waged on illegal migration, as well as on drug and arms trafficking. In August 2022, Morocco joined the Port State Measures Agreement, the first binding international agreement to specifically target illegal fishing.

  Existing measures could usefully be complemented by a prohibition on the transfer of more than a specified percentage of port holdings to foreign investors, thereby ensuring proper functioning of ports in the service of the Kingdom.

Pollution of coastal waters and coastlines is a major factor of insecurity, affecting fishermen, bathers, the tourism industry and ecosystems.

- This pollution can result as much from the discharge of waste at sea by vessels (chemical waste, hydrocarbons) as from national coastal activities: the Moroccan Atlantic coastline is home to over 80% of permanent industrial units, 35% of tourist capacity and 92% of maritime traffic.

- Measures to combat this problem include modernizing the Moroccan Maritime Code, introducing far more dissuasive administrative penalties for the deterioration of ports, systematically enforcing the polluter-pays principle, including at the individual level, and, as is already the case for the Southwestern Mediterranean, setting up a regional contingency plan in the event of accidental pollution on the Atlantic coast.

Monitoring means

Any management, and therefore any policy by definition, requires means of monitoring proper compliance with instructions and results.

Concerning maritime and coastal policy, monitoring compliance with applicable laws is a problem commensurate with the surface area covered. Three types of action could, nevertheless, be taken.

- With illegal, unreported and unregulated fishing considered a growing global scourge, the Global Initiative against Transnational Organized Crime releases an annual ranking of countries according to state responsibility: while Morocco's degree of vulnerability to this type of fishing has decreased slightly between 2019 and 2021, the Kingdom is still ranked 8th among the most vulnerable countries, which calls for implementing adequate surveillance and control measures[372].

- ✓ With regard to illegal, unreported and unregulated fishing and bottom trawling, which devastates the environment and is practiced by fishing vessels at considerable distances , surveillance of the over one million square kilometers of Morocco's Exclusive Economic Zone* could be reinforced using a variety of different but complementary means: observation satellites from the Royal Center for Space Remote Sensing as they pass over the area, marine (*Ocean of Things*) or on-board sensor networks (conteneurs, e-monitoring des pêches), and shared crowdsourcing applications (Waze-type) fed in real time with reports from vessels in the area...

- ✓ This kind of monitoring could cover a transboundary regional area with almost no marginal cost, as part of the pooling of resources on West Africa's coast.

- ✓ Some of these measures (satellite observation, cameras, application of alerts) could be used to report other types of trafficking, such as illegal sand extraction on beaches, ...

- The fight against the enslavement of crews through corruption and debt bondage to unscrupulous operators of large foreign fleets requires specific measures. The stick policy alone cannot suffice, though anti-corruption measures should be stricter and sanctions increased, including at port staff level. As crew indebtedness is often fueled by the hope of acquiring one's own fishing boat, still an expensive undertaking in Morocco, a ''blue bank'' to help finance small-scale fishermen could eventually play an important role.

- The growing importance of on-board electronics and the development of smart ports - port facilities that use information and communication technologies to increase efficiency and ensure security in transshipment operations, with the aim of automating terminals globally - increases the risk of cybercrime, especially for ports such as Tanger Med and Casablanca. Morocco has already taken steps in this direction, including the creation of a General Directorate for Information Systems Security.

A partnership between this institution and Moroccan engineering schools or the possible creation of a Moroccan Institute of Cybercrime could contribute to :

- ✓ training cyber-attack specialists (computer scientists) and engineers in artificial intelligence*, which is faster than humans at detecting this type of threat,
- ✓ continuous training and awareness-raising of professionals in vulnerable companies (especially smart ports) to detect threats and take preventive measures ,
- ✓ centralizing IT equipment required to fight such attacks.

Finally, while these various measures and means of surveillance are directly aimed at protecting Morocco's national territory, international cooperation can also make a significant contribution, notably through the *Blue Justice Initiative* and the Copenhaguen Declaration (*International Declaration on Transnational Organized Crime in the Global Fishing Industry*).

The challenge of a sustainable ocean economy

Aquapreneur* Morocco is a country aware of its development needs and driven by a strong desire to become a new generation post-Anthropocene* ocean economy. This vision starts with recognizing the need to preserve the ocean and its resources in their various forms: seas, land-sea interfaces, exclusive economic zones, high seas, ecosystem, fisheries, genetic, energy and mineral resources...

Aquapreneur* Morocco is not content with protecting: it governs and develops resources and gets as many of its citizens as possible to join in this great growth challenge founded on a new vision of the ocean.

For coordinated ocean governance

Adopting the concept of a sustainable ocean economy (Chapter 1) and the generic development model (chapter 2) detailed in this third part, would lead Morocco to consolidate the systemic governance of its ocean.

To this end, an inter-ministerial Delegation for Ocean Development should be created, directly under the responsibility of the Head of Government, to organize, coordinate and promote ocean development activities throughout the country. Some of its objectives would be :

- Developing an integrated and global ocean strategy based on a systemic understanding of all ocean-related activities (aquaculture*, fishing, import-export, port and naval activities, energy production, tourism, coastal urbanization, etc.), from implementation of international treaties to monitoring of possible national and foreign offenders, and from Ocean Sphere* protection to its sustainable exploitation (definition of thresholds not to be crossed).

- Strengthening coordination of public actor actions, fighting dispersion of competences[374] and better responsiveness to scientific organizations, such as the National Institute for Fisheries Research.

- Developing consultation* among different stakeholders to :

  ✓ ensure smooth transition from a vision of a blue economy with often weak environmental imperatives, to a vision of a sustainable ocean economy, focused on the need for a healthy environment for sound economic activity,

  ✓ implement a consistent policy, integrating concerns of all stakeholders, to accelerate development, promote employment, and improve living conditions for coastal communities.

- Establishing active scientific collaborations with leading countries or institutions to develop scientific tools and methodologies to assess and manage a sustainable ocean economy, with a view to steering this economy (in itinere assessment), as well as establishing a new national accounting system, capable of accounting for the added value generated by a varied ocean economy.

- Contributing, as part of advanced regionalization, to all regions of the Kingdom so as to make the most of the maritime and coastal territorial capital of each.

As indicated in the IRES 2021 Strategic Report "*The time has come to build a new component of governance: a powerful, enlightened State, subject to law and, henceforth, a State of Care. This, a more mature form of the Welfare State, differs from the latter in its moral commitment and mode of action. It does not replace the individual but assists him, does not help him but facilitates him, does not enslave him but serves him. It is a powerful State, but fair, rigorous and transparent. This State of Care must therefore, today, work to protect and restore its maritime heritage for the current and especially future well-being and development of its population*"

Protecting the Ocean Sphere and coastlines

The global land-sea and sea-land interaction is such that Ocean Sphere* protection cannot be limited to the marine territory alone, the merritory (see Part II, Chapter 1). We therefore need to consider integrated solutions, in spatial and process terms, to address the multiple impacts of biodiversity loss*, degradation of ecosystem services and pollution of marine environments.

These solutions should be based on the following process :

- A national inventory of all resources and ecosystem services to better orient resources exploitation strategies and policies aimed at their protection and restoration.

- Conducting a scientific survey of the state of the Moroccan territory and coastal ecotone*, requiring a mapping effort and the collection and analysis of sufficiently detailed environmental data to establish an operational assessment.

- Classification of areas according to status, calling for sanctuarization (no human action), conservation (reasoned use with quotas, limited activities, etc.), or free use with the exception of known environmental nuisances (waste, pollution, predation).

- Establishment of a planned development (territorial or merritorial planning) of the *Coastal and Marine Spatial Planning*, making it possible to protect ecosystem resources, resolve user conflicts, improve coordination and collaboration between institutions and prepare for future ocean uses[375].

- Enshrinement of coastal and marine planning in national legislation, making it binding.

- Position new solutions within this overall framework, while verifying, in addition, for adequacy to the local context (economic, social, cultural).

First exporter of fish in Africa, first producer of sardines in the world, Morocco is rich in marine biological diversity, with over 7830 marine species. From awareness of the need to protect this heritage came, in 2016, a Strategy and a National Action Plan for Biodiversity, which seek to reconcile protection and rational and sustainable use of Moroccan biodiversity* with the following vision: ''*By 2030, biological diversity is conserved, restored, enhanced, and rationally used, ensuring the preservation of services provided by ecosystems, for the benefit of all, while contributing to sustainable development and welfare of Moroccan society*''[376].

This approach is part of a broader environmental consideration and concern for sustainable development, which has given rise to :

- a National Strategy for the Protection of the Environment and Sustainable Development (1995) with a national action plan for the environment and a complete legal arsenal (protected areas, impact studies, air, water, renewable energies, etc.),

- a framework law, the National Charter for the Environment and Sustainable Development, adopted by the Kingdom in 2014, promoting a precautionary approach, the right to a healthy environment, the polluter-pays principle and the individual responsibility of every natural and legal person to protect and enhance the environment[377],

- a new National Strategy for Sustainable Development 2030 in 2017, with several key strategic areas relating to the ocean: ensuring the conservation and rational management of fishery resources*, reconciling tourism development and environmental protection, aligning urban planning with principles of sustainable development, protecting biodiversity*, strengthening conservation policies and improving sustainable coastal management,

- a strategy for creating a network of marine protected areas* for the preservation of resources, rehabilitation of marine ecosystems and sustainability of artisanal fishing with three pilot marine protected areas* covering 750 square kilometers (Alboran, Massa, Mogador) in 2019,

- a law on Strategic Environmental Assessment adopted in 2020[378].

However, despite these commitments, the overall cost of environmental degradation still amounted to 3.5% of GDP in 2014 (3.7% of GDP in 2000) according to the World Bank. In coastal areas, the concentration of tourism, maritime activities and fishing puts ecosystems under pressure, whether fish (sardines, swordfish, cephalopods and white hake) or sandy areas (beach degradation).

These environmental deteriorations would have cost some 2.5 billion dirhams, or 0.27% of GDP in 2014, an assessment considered grossly underestimated, as is that of the reduction in the recreational value of beaches, caused by coastal degradation.

In other words, the instruments exist, but results have yet to demonstrate a decisive advance. The creation of an interministerial delegation for the ocean (see above), supported by offices in coastal regions, could help operationalize these strategies in ocean areas.

Priorities to be implemented, and to be supported by specific intervention missions, should include the following :

- The fight against coastal erosion: according to the World Bank, ''by 2030, 42% of Morocco's coastline will be exposed to severe flooding and erosion'', while ''salinization of coastal aquifers, which will lead to water shortages, could affect the central and eastern coasts of Morocco due to rising sea levels. The situation is already critical in places like Saïdia.

- Measures for the sustainability of fishery resources*: despite the Halieutis Strategy and environmental regulations, such as the ban on bottom trawling in the Mediterranean, overexploitation of these resources for industrial purposes puts them at risk of constant depletion. It is therefore urgent to act effectively and radically against malfishing in Moroccan waters by creating highly protected marine areas in order to restore the marine fauna. Identifying new marine areas should be based on recent scientific data and on implementation of risk warning systems.

- Measures for the sustainability of the seaside tourism sector: fight against the proliferation of invasive species* (*Physalia physalis*, méduses), preserve the sandy coastline (whose rate of disappearance is twice as high as the global average), ensure the quality and availability of drinking water resources.

At the same time, very long-term continuous actions should be taken to :

- restore damaged resources and ecosystems (e.g. cold water corals), develop blue carbon* ecosystems (mangroves, seagrass beds and salt marshes), protect the upwelling* system off Morocco's coast;

- develop the coastal territory and the coastal sea in a perspective not only of protection and sustainable development, but also of resilience against the risks of natural disasters (which currently cost the Kingdom 575 million dollars/year) as a result of rapid urbanization combined with climate change[380] :

  - ✓ urbanization plans that are more consistent with the protection of ecosystems on one hand, and the need to relocate human habitats threatened by coastal erosion and rising sea levels on the other (65% of Morocco's population lives along the coast[381]); in this regard, it would be wise to thoroughly review the Azur plan, which came to an end in 2020 and did not produce expected results ;

- ✓ significantly reduce discharge at sea of urban waste, untreated wastewater (44% in 2020 of urban wastewater[382]) and agricultural and industrial emissions (80% of industries are concentrated along the coast)[383] ;
- ✓ eliminate light pollution* (ban LEDs along coastal cornices) and prohibit the construction of structures that accelerate coastal erosion such as riprap and maritime spurs (rigid hydraulic structures) ;

- reduce the environmental impact of maritime transport, particularly noise* and chemical* pollution, as well as all activities causing environmental degradation.

In summary, despite its inclusion in international commitments for ocean and coastal environment and its extensive legal arsenal, Morocco's commitment to sustainable development is hindered by insufficient implementation[384], combined with increased exposure to climatic events[385] and persistent degradation of ocean environments, the cost of which is still greatly underestimated.

Ensuring sustainable ocean socio-economic development

Morocco has embarked on an ambitious blue economy, supported by the World Bank. However, the dominant discourse around the blue economy, calling for a newBlue Deal[386], although well intentioned, runs the risk of accelerating the industrialization of ocean-related activities and leading to an exponential degradation of the Ocean Sphere*.

For example, the National Ports Strategy (2030) predicts that the annual number of passengers will more than double by 2030, from 3 to 7.6 million.

Similarly, in a context of drought and scarcity of water resources, seawater desalination seems to be a priority activity of the blue economy in Morocco.

A paradigm shift is therefore essential for the blue economy to become a sustainable ocean economy: the question is no longer how to develop the economy from marine resources, but how to develop the economy from what is good for the ocean ?

Port infrastructures, for example, can be improved by minimizing their impact on the coastline and the sea (cf. Ecoports label), lmaritime transport operations can become cleaner (cf. Clean Shipping Coalition), ... Such improvements are necessary but not sufficient. For it is a true vision of the entire system of humanity + Nature, which must allow to recast a new paradigm based on four simple questions :

- What is good for the ocean? (see next section)
- How to finance what is good for the ocean ?
- How to get out of the JEVONS* paradox ?
- How to enable the development of humanity ?

The notion of blue finance answers the second question. The slowdown in the global economy, predicted by the World Bank for the next few years, prompts us to examine all possible financial resources. In the Moroccan context, blue finance can take on a number of distinct forms:

- The orientation of private and public investments towards guaranteed ''oceanically sustainable'' sectors of activity, which presupposes clearly established criteria, legible priorities and transparent and honest labeling mechanisms,

- Micro-credit (Morocco was the second largest micro-credit market in the Arab world, with 720 million dollars in outstanding loans in 2020[387]), already governed by law n°50-20, that could grant higher ceilings or preferential rates to practitioners of maritime trades, wishing to make their activity more sustainable (less polluting boats, biodegradable fishing nets, ...) or to new entrants in these trades, who would commit to adopt sustainable practices,

- Islamic finance, a market that registered, in 2020 in Morocco, a growth rate of 66%[388],

- *Crowdfunding**, a method of financing projects by the general public, governed by law no. 15.18 that came into force in Morocco in 2021,

- An environmental and more particularly oceanic tax system, fair and incentivizing, which would allow to preserve the environment and rationalize consumption of oceanic resources[389].

These instruments together cover all possible investments in a sustainable ocean economy, from large international aid funds to individual contributions. However, in order to provide maximum benefit to the ocean sector during this start-up phase, these instruments must offer specific advantages and be clearly targeted, accessible to all, with legible indicators, and simplified and swift implementation and transparent and easy evaluation of projects. This could be done through the devolution offices of the Interdepartmental Delegation proposed above.

The paradoxe JEVONS holds that as technological improvements increase the efficiency with which a resource is used, the total consumption of that resource is likely to increase rather than decrease, due to the apparent new availability of the resource[390]. For example, the decrease in fuel consumption per kilometer has not resulted in an overall saving of fuel, but rather an increase because of an increase in the number of kilometers traveled.

Applied to the use of natural resources, this paradox explains the overconsumption of these resources when technology increases their efficiency, hence the need to complement such technological developments with effective demand management policies.

In order for a sustainable ocean economy to overcome this paradox, public policies must be rethought and reoriented based on an essential strategic objective: to put an end to the predatory economy* and to ensure that planetary limits are respected.

To achieve this, a number of axes can be envisaged:

- A circular economy* based on recycling, to reduce the demand for primary natural resources and the volume of waste that ends up in the ocean.

  ✓ For example, with regard to plastic: the accumulated amount of plastic waste in the ocean could double by 2030, a major issue for the future of the ocean and humanity, which also ingests these microplastics. Morocco banned the manufacture and use of plastic bags in 2016 (Law 77-15 and *Zero Mika* campaign). This is a significant but insufficient measure, as plastic waste also includes bottles, fishing equipment, packaging and multiple other objects. In fact, to be truly effective, we should aim simultaneously to :

    - reduce plastic production (it cannot be stopped completely, if only for the health sector),
    - phase out single-use plastics,
    - collect 100% of plastic waste,
    - recycle 60% of collected waste.

Such a policy would launch a **new plastic economy** based on collection and recycling, job creation and the elimination of toxic additives harmful to recycling[391] on one hand, and the production of sustainable alternatives from, for example, seaweed by-products on the other.

To support its action in this area, Morocco could join the *New Plastics Economy Global Commitment* in view of the forthcoming adoption, at the United Nations level, of a legally binding international instrument on plastic pollution, particularly in the marine environment.

- ✓ The recycling economy must also collect, process and reuse as many metals as possible, so as to make the exploitation of seabed ores, an activity that is damaging to the Ocean Sphere*, unnecessary (see above). Morocco is the ninth largest producer of cobalt, and has already begun its transition to the production of cobalt (but also lithium and nickel) from battery recycling. Ship dismantling activities should also contribute to this recycling economy.

- ✓ This approach to economic recovery of waste through recycling also contributes to the fight against poverty and inclusion of the informal economy.

- **An economy based on strong ecological choices to preserve the coastal and marine environment.**

  - ✓ The conditionality of tourism. One of the characteristics of the post-Covid world is the awareness of many countries of the unsustainability of mass tourism. France, l'Italie, India, many islands... more and more countries are limiting access to their natural and cultural heritage, imposing tourist quotas.

It is therefore necessary to determine the maximum capacity of a site based on the carrying capacity of coastal, terrestrial and marine ecosystems. This principle also applies to all maritime activities and coastal urbanization.

Ecotourism is another condition for the development of tourism, as in Costa Rica, which is the global leader. Morocco already has an ecolabel, the Green Key, which should promote sustainable tourism practices in all sectors of the tourism industry (accommodation, transport, catering and visits).

Faced with coastal erosion and water stress, Morocco will have to rethink its tourism industry, which in 2019 represented 7.1% of GDP, 20% of export goods and services revenues, 550,000 direct jobs and as many, if not more, indirect jobs.

- ✓ Sustainable energy. Not all renewable energy is good for the environment. This could be the case for offshore wind power* (see chapter 1), whose installation, operation, maintenance and end of life are environmentally costly.

  The solar energy path that Morocco has embarked on (Solar Plan) can, by developing micro-grids and local off-grid production (decentralized), contribute to providing cheap electricity to different ocean-related artisanal activities (fishing, fish farming and mariculture*).

  It could also enable abandoning energy production methods that are particularly polluting for the ocean, such as the use of hydrocarbons (heavy metals and toxic waste from the extractive industry).

- ✓ Effective waste management. The issue of waste at sea should become a priority, especially in a country with significant tourism ambitions, ranking 7th in terms of plastic waste discharge in the Mediterranean in 2020.

For this, it is necessary to limit the volume of waste (packaging and single-use products, for example), reduce the share of toxic elements in waste, generalize the treatment of wastewater and household waste, and make the treatment of industrial and hazardous waste (such as medical or chemical waste) compulsory through a tax and specific storage, develop a sorting culture based on differentiated waste collection methods (centralized in the city, decentralized in the countryside), involve the tourism, maritime and port industries in collecting and sorting waste, conduct regular waste collection campaigns on the coast.

- ✓ An alternative to desalination. The ecological cost of desalination is not acceptable in a country that cares for the quality of its environment. The current process extracts 1 liter of drinking water at a cost of producing 1.5 liters of brackish water, hot and loaded with salts (of which 141.5 million m3 are discharged into the sea every day, worldwide)[394]. Now, although Morocco has largely adopted drip irrigation, instead of saving water resources, this has increased consumption of water by multiplying irrigated areas, a perfect example of the paradox of JEVONS[395].

Given the growing scarcity of water the Kingdom faces, the first step should be to reduce demand and rationalize consumption. Efforts should focus on agriculture, which uses 85% of Morocco's water resources. Priority should also be given to regulating non-potable water uses and groundwater withdrawals. The reuse of wastewater and the recovery of rainwater should also contribute to significantly reducing the need for desalination.

Consequently, recyclable plastics, ''low-metal'' products, ''low-pollution'' energy, waste treatment, refusing desalination that is harmful to the ocean... are among the many solutions that would enable us to get out of the JEVONS paradox, by limiting the use of resources that feed ''an economy of death'', as opposed to an economy of life[397].

Specifically, how to enable the development of life, both of humanity and of the Ocean Sphere ?

As it stands, human community development depends first and foremost on the availability of the means of survival (food, health), access to basic necessities and ultimately to intangible goods (education, leisure, etc.).

Food security* in Morocco, which includes water supply, is a great challenge for a country whose semi-arid climate gains ground every day. This security is assured by local production, but also by diversifying complementary sources, particularly in a regional proximity perspective.

Morocco is the leading country in terms of marine biodiversity in the Mediterranean region, with a great potential of untapped resources, and with an Atlantic coastline abundant in fish stocks owing to its *upwellings**. It is also the leading country in Africa in terms of fishery production. Its fishing industry processes nearly 70% of coastal fishery catches and exports around 60.8% of its production (2020) to some 100 countries.

Although the Halieutis Strategy has produced encouraging results, with Morocco now ranked 15th worldwide in terms of fishing power[398], the Kingdom's maritime potential is still far from being fully tapped. The focus should now be on :

- developing and implementing new models for fishery resources management* that enable compliance with biological cycles, modernization of artisanal fishing and compensation for under-investment in the sector, such as the Pescomed project (shared management of small-scale fisheries in marine protected areas) ;
- combating the resale of fish from the exclusive economic zone* to trawlers waiting in the international zone (resource drain) ;
- rational and sustainable development, without overexploitation or degradation of resources - supported by international ecolabels and projects such as Medfish – in the following areas :
  - ✓ The industrialization of aquaculture*, a growth relay for the fishery sector where fishing catches are stagnating, tends to unbalance the marine environment (eutrophication*, ... cf. part II). Special efforts should therefore be made to combine environmental sustainability and rational exploitation, especially since 81% of projects submitted by investors are located in the Dakhla-Oued Eddahab region[399].
  - ✓ Seaweed farming offers considerable potential and, first and foremost, an alternative to the gradual disappearance of wild red seaweed in Morocco, which is used to produce agar-agar. It is as urgent to safeguard seaweed beds (algae), which serve as spawning grounds for other species (thus ensuring the sustainability of fish stocks) as to develop a complement to fishing.

Two possible avenues appear promising: a diversified use of cultivated algae based on active ingredients (pharmaceuticals, textiles, cosmetics, etc.) rather than on mass, and the development of carob tree cultivation, whose fruits produce a gelling agent that can be substituted to agar-agar, for which world demand is exploding[400];

- ✓ Permaquaculture* is a natural process combining permaculture and aquaculture*, allowing for example to raise giant and king prawns in a closed environment without pesticides, limiting polluting discharges and water consumption, in the same spirit as the Songhai model[401].

- ✓ Biosaline agriculture*: in a context of soil salinization caused by rising sea levels, the introduction of 19 crops in a saline environment in Foum El Oued (including quinoa and blue panicum) suggests significant developments for this sector in Morocco[402].

- The repositioning of the agri-food sector, a national flagship: indeed, structural water stress will eventually weigh on rainfed crops, the reduced production of which would then be reserved for domestic markets. In such a context, aquaculture* could represent an alternative for Morocco in terms of exportable agro-food supply.

- Finally, the nexus approach (water, food, energy) described in the 2021 Strategic Report: ''Towards a new post-Covid-19 world, should be favored'' .

On a broader economic development level, the sea economy* is capable of making significant contributions, beyond traditional sectors (fishing, shipyards, maritime transport, seaside tourism), through, for example :

- the creation of an Atlantic-Western port network capable of exploiting, routing and receiving different trade flows in the Atlantic zone, in Morocco and along the sub-region, thanks to a pooling of complementarities between the different ports (cooperation rather than competition) once the port of Dakhla Atlantic is completed; this integrated maritime strategy would promote the development of South-South cooperation,

- a niche industry with high added value in the field of information technology applied to marine technologies, from smart ports to onboard electronics, through sensors, plotters, big data analysis systems, automatic systems and other digital systems (production and services) ,

- a local economy based on short circuits, from local distribution (local markets) to local valorization (agri-food) to local financial systems (project financing) ,

- a circular economy* from ship dismantling (metal recovery) to recycling of fishing equipment (plastic and fiber recovery), while taking preventive measures against the negative externalities of these activities ,

- a cultural economy, based on seaside tourism, coastal events (festivals, congresses),

- and, finally, the promise of effective research and development (see next section).

These solutions are in line with United Nations Conference on Trade and Development recommendations to build a sustainable ocean economy and to promote a blue economy, which supports economic growth while preserving ocean heritage.

Developing ocean knowledge

Answering the question ''what is good for the ocean?'' requires improving our scientific and objective knowledge of the ocean in three ways, prior to seeking solutions in this direction.

The development of knowledge: Several fields seem promising enough for Morocco to invest in significantly.

First, in scientific research and engineering, efforts should be focused on three areas :

- Promote ''open science'' (see UNESCO) under a national plan for promoting open access, which would focus on sharing data related to the Ocean Sphere*, open licenses, and provide research infrastructure to accelerate research for sustainable ocean development.

- Strengthen participation in international scientific cooperation, especially in data collection and processing, through the following actions :

  - ✓ Joining the Ocean and Climate Platform and raising awareness among elected officials and regional authorities on the issue of rising sea levels, as in Moulay Bousselham for example (see SEAties).

- ✓ Developing and perpetuate Morocco's marine science and engineering network, MARSIMER, to promote eco-innovative research.
- ✓ Exploiting the base of bilateral, regional and global mechanisms from which international collaborations can take place, both in the field of scientific cooperation and in that of marine technology transfer.
- ✓ Feed global databases on marine protected areas* and Other effective area-based conservation measures, such as *Protected Planet*, the global platform for communication, exchange, acquisition and analysis of knowledge and data on the status and trends of protected areas.

  Currently, none of the marine protected areas* planned by the Halieutis Strategy are listed on this platform.

- Significantly develop the marine science and technology sector, in general, and oceanography* and marine biology, in particular, as well as oceanology*: it is essential that public policies reflect the latest scientific advances.

  Research in marine biochemistry must be given special attention, given its potential: it allows the exploitation of molecules from marine organisms in fields as varied as pharmacology, cosmetics, fertilizers, food,...

- Investing in practical applications of marine science and engineering and, to this end, directing blue finance towards :

  - ✓ marine biotechnology: this involves using science and technology in the transformation of marine resources for applications in health, cosmetics, agri-food, aquaculture* and the environment ...... This sector is forecast to grow at 6 to 8% per year[403] ,

  - ✓ marine biomimicry*: this approach seeks to draw on the processes of living organisms as a source of sustainable innovation; it entails observing and reproducing the essential properties of marine biological systems in order to develop forms, materials and processes that are innovative, energy-efficient and sustainable,

  - ✓ clean technologies: whether in the field of shipping or ports, these aim to improve the environmental performance of maritime transport (cf. Clean Shipping Coalition), such as new sails for instance, and to reduce harmful emissions in ports (cf. Global Clean Ports),

  - ✓ finally, advanced shipbuilding: Morocco has acquired considerable sectoral expertise in the automotive and aeronautics sectors and is now preparing for similar developments in the shipbuilding industry (clean and intelligent ships); it is essential that research support this effort.

To coordinate such a development program, it may be necessary to create a center of excellence dedicated to national oceanographic research, centralizing data collected and making it available to economic operators in this area.

Then, knowing ''what is good for the ocean'', the State will be able to protect its natural oceanic heritage through suitable regulations, as for cold water corals, and to promote strategies for the sustainable development of its ocean economy according to priorities dictated by Nature and proven facts.

The professionalization of maritime activities: To ensure that R&D results are taken into account in daily activities, it is important to :

- implement professional training courses leading to certification in areas where gaps exist, such as damage control, for example,

- organize a regular update of maritime professions' knowledge (and trainers) according to scientific, technological and normative developments,

- create a streamlined structure for updating and coordinating the core curricula of different training institutes operating in the sector : the Higher Institute of Maritime Studies, the various maritime institutes, ... so as to ensure that the new knowledge is properly incorporated into training.

The development of an oceanic culture: completing such a scientific and technical program requires a critical mass of researchers and professionals attracted by ocean activities. It is therefore opportune to start by raising awareness among Morocco's population of the importance of its natural marine heritage. To develop a true ocean culture, to combat ignorance and ''unsustainable actions'' out of lack of knowledge, the key lies in education, citizen participation and heritage enhancement, as advocated by the Mohammed VI Foundation for Environmental Protection, chaired by Her Royal Highness Princess Lalla Hasnaa.

- Education of future generations begins in kindergarten (*Ocean Litteracy*). Significant educational resources can be made available to teachers, for all age groups, by the international community, thanks to associations such as World Ocean Network and GenOcean (UNESCO). Such awareness would be even more effective if teachers were instructed, nationwide, to work towards building this new relationship with the ocean.

- Practical experience remains the best educational process to develop a strong emotional bond with the ocean, which is an essential condition for a mental revolution that Moroccans need to make in order to better take care of their territory*. Among these experiences :

  - ✓ Learning to swim overcomes an often spontaneous fear of the ocean, practicing water sports (diving, bodyboarding) strengthens self-control. Because knowing how to swim saves lives, all coastal populations should benefit from swimming lessons as part of compulsory schooling.

- ✓ Discovering the ocean's riches through the creation of a national museum to promote Morocco's maritime heritage, the creation of an atlas of Moroccan history through its coastline, and the development of an outreach program (exhibitions, books, films, videos) on Morocco's maritime heritage.

- Citizen action can be mobilized in a number of ways: beach cleaning, collection and sorting of waste on the coast, preservation of archaeological or cultural heritage, experimental projects... The new eco-citizen mobile App Ana Boundif fulfills this need to engage youth in environmental action. At the same time, imams and teachers alike can relay the message that Morocco's future depends on a healthy ocean. International coordination also provides valuable support for citizen mobilization, such as the global Rise Up For Ocean campaign, which measures public engagement.

Finally, improved knowledge of the sea and coastline also leads to greater research, protection and development of Morocco's underwater and coastal archaeological heritage (prehistoric sites, the mythical city of Tighaline, the coastline of Safi, ...). This cultural wealth recalls Morocco's historical and prehistoric richness, testifying to the multiple influences (Phoenician, Roman, Carthaginian, ...), resulting in its cosmopolitanism. This work of archaeological knowledge should also pay tribute to the traditional Berber fishing communities[404], spread along northern Africa, both on the shores of the Mediterranean and along the Atlantic coast, especially in the Souss[405] and Essaouira.

Consequently, for innovative solutions to emerge, new generations of Moroccans need to become aware of the severity of the situation and the urgency of making a change: the Kingdom's territory must not become a dead zone, overexploited and deprived of its biodiversity*. The welfare of everyone and Morocco's development as a whole depend on it.

- To become a great maritime nation of the 21st century, aquapreneur Morocco needs to shift the paradigm away from fast and massive industrialization of maritime activities to a vision more focused on ocean protection and sustainable, balanced use of its resources. To do this, three major challenges must be faced :

- Effect a **revolution in mentalities**, by reconnecting with our maritime roots, promoting our archaeological, historical, cultural and natural heritage, developing ocean literacy* from an early age and ensuring the development and promotion of marine science and engineering.

- Coordinate a **national program** to improve maritime governance, as well as a better connection between science and governance, particularly in risk prevention (sea level rise, erosion, climate).

- Finally, develop **regional and international cooperation** and make Morocco a recognized player in ocean diplomacy.

Conclusion of Part 3

We face a triple planetary crisis. A climate emergency that is killing and displacing ever more people each year. Ecosystems degradation that are escalating the loss of biodiversity and compromising the well-being of more than 3 billion people. And a growing tide of pollution and waste that is costing some 9 million lives a year.

António GUTERRES

As discussed in the first two parts of this strategic report, ocean degradation is caused by global warming, high levels of pollution from human activities and the alarming loss of biodiversity. In the face of this situation, it is imperative to establish more efficient, comprehensive and integrated ocean governance for this common heritage of humanity, based on strong partnerships, enhanced international cooperation and multilateral dialogue.

Raising awareness on a global scale…

A global platform is required that recognizes a shared obligation, clearly defines the responsibilities of each country, and enforces commitments. For global institutions to promote coordination, they must have comprehensive governance structures to make legitimate decisions and represent all of the world's citizens, present and future.

We need to change course – now – and end our senseless and suicidal war against nature.

António GUTERRES

Until this new world order for the ocean is achieved, systemic and comprehensive solutions must be rapidly developed and implemented. They must be free from preconceived ideas and ready-made thinking, such as the concept of blue economy, even if it may seem iconoclastic. They also need to be implemented simultaneously at all possible levels: local, regional and global.

For Morocco's blue revolution

His Majesty King Mohammed VI, keen on developing the maritime dimension of Morocco, has launched, since his Accession to the Throne of His Glorious Ancestors, an ambitious policy of the sea around a three-fold imperative: modernize and develop the Kingdom's port infrastructure (Tangier-Med 1 and 2, Nador-West Med, Dakhla Atlantic), give **new momentum to the fishery sector** while ensuring sustainability of fishery resources* (Halieutis Plan) and **enable Morocco to fully play its role as a "hub",** through high maritime connectivity.

Sustaining these achievements requires:

- systematically conditioning underwater mining, seawater desalination, offshore wind power*... on the use of technologies that benefit ocean ecosystems,
- developing a production model for aquaculture, which has great potential, that is not harmful to ecosystems or human health, such as the Songhai farm,
- rethinking coastal urbanization and developing sustainable beach tourism,
- strengthening immaterial capital in terms of oceanographic and oceanological research and development, not only to protect, or even restore, biodiversity, but to derive high value-added products in the pharmaceutical, cosmetic, agri-food and in all sectors that could benefit from a biomimetic approach.

The oceanic potential of Morocco represents a formidable development challenge, which can only be achieved if a real revolution of mentalities is operated, a revolution that the younger generations are already carrying at the global level.

Take away

The keys to ocean sustainability lie in:

- a generalized awareness of the severity of the situation in which the Ocean Sphere finds itself and of the dangers this situation holds for the future of mankind,
- establishment of a global regulatory and binding framework for the ocean as a common good of humanity,
- rationalization of programs and concentration of energies and funding on the implementation of a clear strategic global vision, ensuring the sustainability of ocean balances,
- gathering and coordinating multiple existing initiatives through a single, effective entity, acting on behalf of all nations through a new governance model.

The Kingdom of Morocco can become one of the first **aquapreneur** states by :

operating a cultural revolution whereby the Moroccan merritory would become a new patrimonial wealth to be protected and used sparingly,

- moving away from the Anthropocene and its predatory economy to better demand management and a widespread and efficient circular economy,
- making ocean resources its best ally to ensure food security, in an alarming context of **climate change**,

- deepening knowledge and skills in all ocean-related activities,
- and sharing these with neighboring countries in a win-win cooperation and mutualisation framework.

A shared consciousness of our global interdependence must give rise to a new common logic, to define and recognize the global commons that support life on Earth — the planetary system that connects us all and on which we all depend.

Restoring our common home: declaration for Stockholm+50

Conclusion

"Climate models predict significant changes in ocean conditions over the next century: warming (virtually certain); ocean acidification (virtually certain); decreased stability of calcite mineral forms (virtually certain); loss of oxygen (very likely); near-surface nutrient depletion (likely) ; decreased net primary productivity (high confidence); reduced fish production (likely); and loss of key ecosystem services (medium confidence) that are important for human well-being and sustainable development" (IPCC,* [Special Report on the Ocean and Cryosphere](), *chapter 5, 2021)*

In summary, the Anthropocene is directly responsible for major and irreversible climate change, the artificialization of much of the Earth's landmass, particularly its coastlines, and the accelerated degradation of the Ocean Sphere, which is a vital contributor to life on Earth through oxygenation of the atmosphere and regulation of the climate.

Whether as a result of climate change* or other direct anthropogenic reasons, the ocean is in serious danger of becoming so unbalanced that it no longer is able to provide the ecosystem functions that sustain life on Earth.

At the same time, in order to develop our material civilization, currently at an impasse as a result of our exponential consumption, we must resort to a more sustainable development, both for the ocean, whose systemic equilibrium we must absolutely protect, and for humanity, which must continue to breathe, feed itself, and move about...

The impetus of the Decade of Ocean Sciences* (UNESCO) has re-launched the mobilization around the Sustainable Development Goal 14 ''Conserve and sustainably use the oceans, seas and marine resources for sustainable development'' and opened the way to global awarenesse.

However, while many citizen movements and local initiatives have taken off, major global industry and institutional actors remain divided between those who are truly committed to the protection and sustainable use of the ocean, those who are ''blue-washing'' themselves in adopting the fashionable discourse of ocean protection and those who persist in ignoring the problem, pursuing destructive activities (overfishing, coastal urbanization, destruction of ecosystems, ...) and even accelerating the industrialization of the ocean.

The year 2022 has proven to be a pivotal year for **global** ocean policy :

- Countless voices (States, citizens, stakeholders) were heard at various international conferences, testifying to the emergence of a will to change things.

- Multiple multilateral negotiations have taken place, ranging from the development of a legally binding international instrument to stop plastic pollution, to the reduction of harmful fishing subsidies, to a treaty on marine biodiversity beyond national jurisdiction, to a post-2020 global biodiversity framework... all opportunities to demonstrate the determination of nations to reverse the decline in ocean health.

However, the pace of international decision-making and national implementation, as well as the means of enforcing the rules, do not measure up to the gravity of the situation.

Climate, oceans, biodiversity... the environmental stakes are no longer compatible with the 20th century's modes of development: the Anthropocene and the economy of predation.

What is needed now is a real overhaul of our conception of the world - placing human beings at the heart of Nature and no longer above it - and of our global development model, in favor of a new kind of wealth created by the protection, maintenance and observation of a healthy environment.

Under the leadership of His Majesty King Mohammed VI, the Kingdom of Morocco can become an exemplary witness of such a change in perspective, by recognizing the Ocean Sphere as a common good of humanity, by developing innovative solutions that add value and are not destructive, and by leading a community of oceanic interests capable of advancing the law, knowledge and skills in this area.

Thus, the ocean will not only be a global issue, but will also become the planetary solution to the unsustainability of current development.

Glossary

Abyss: Region that constitutes the floor of the world's oceans, with a depth of between 3,000 meters and 6,000 meters.

Source: *Dictionnaire encyclopédique de l'écologie et des sciences de l'environnement, 2ème édition DUNOD, 2002, p.2.*

Blue acceleration: the expanding drive of capital to industrialize the oceans and the seabed. Economic activity in the oceans is expanding rapidly and significant investments...drive the growth of existing industries as well as the emergence of new ones, covering an increasingly diverse range of activities. The Blue Acceleration ushers in a ''new phase in humanity's relationship with the biosphere, where the ocean is not only critical to sustaining global development trajectories, but is fundamentally altered in the process.''

Source : *"The Blue Acceleration : The Trajectory of Human Expansion into the Ocean," One Earth, vol. 2/1, January 24, 2020 : https://doi.org/10.1016/j.oneear.2019.12.016*

Biosaline agriculture: is the production and growth of plants in groundwater and or/soil rich in salt.

Source: *FAO, 2020, Biosaline agriculture : https://agrovoc.fao.org/browse/agrovoc/fr/page/c_6b250bf9?clang=en*

Marine Protected Areas: ''A protected area is a clearly defined geographical space, recognized, dedicated and managed by any effective means, legal or otherwise, to ensure the long-term conservation of nature and its associated ecosystem services and cultural values.

Source: Geoconfluences. Glossaire, Aires marines protégées, 2021 : http://geoconfluences.ens-lyon.fr/glossaire/aires-marines-protegees-france-monde

Anthropocene: term proposed in 2000 by Josef Crutzen and Eugene Stormer to characterize the current geological epoch, which is marked by the major and growing impact of human activities on the earth and the atmosphere, at all levels, including the global one. The two researchers proposed the end of the 18th century as the starting date of this new era, a period that coincides with the first observations of the effect of human activities on the environment, in connection with the beginning of the industrial revolution.

Source: *CRUTZEN, Josef; STOERMER, Eugene. The "Anthropocene", Global Change Newsletter n° 41, 2000, pp. 17–18.*

Aquaculture: ''Aquaculture is the set of activities of plant cultivation and animal rearing in continental or marine water with a view to improving production, involving individual or legal ownership of the stock being farmed. It includes fish farming (breeding of fish), shellfish farming (breeding of marine shellfish: oysters, mussels, clams, etc.), seaweed farming (cultivation of seaweed) and carcinoculture (breeding of crustaceans, mainly shrimp and crayfish).

Source : National Institute of Statistics and Economic Studies. Aquaculture definition : https://www.insee.fr/fr/metadonnees/definition/c1534

Aquapreneur: This concept refers to all entrepreneurs in water-related sectors.

Source: The water network : https://thewaternetwork.com/_/aquapreneurs/

Atmosphere: is the outermost layer of the Earth, gaseous in nature and therefore constituting the outermost part of the ecosphere.

Source : Dictionnaire encyclopédique de l'écologie et des sciences de l'environnement, 2ème édition DUNOD, 2002, p.52.

Other effective area-based conservation measures (OECMs): these reflect a new conservation approach, distinct from protected areas, where conservation is achieved primarily as a by-product of another form of management.

A definition was agreed upon at the 14th Conference of the Parties to the Convention on Biological Diversity in 2018. It is ''a geographically defined area other than a protected area, which is governed and managed so as to achieve long-term positive and sustainable outcomes for in situ biodiversity conservation, with associated ecosystem functions and services and, where appropriate, cultural, spiritual, social - economic and other locally relevant value.''

Source : The *Biodiversity Information System For Europe :https://biodiversity.europa.eu/protected-areas/other-effective-area-based-conservation-measures*

Common good or the commons: refers to forms of collective use and management of a resource or thing by a community. This notion allows us to move away from the binary alternative between public and private, by focusing more on equal access and the regime of sharing and decision making rather than on ownership. The areas in which the commons can find applications include access to resources, but also to housing and knowledge. The commons are resources that are collectively generated by a community according to a self-defined form of governance.

Source : *Royal Institute for Strategic Studies, Strategic report 2019-2020 : Towards a new development model ; Académie De Versailles ; Centre des ressources en économie gestion, La gouvernance des '' Biens communs* '' au service du ‹› Bien commun ‹› : *https://creg.ac-versailles.fr/la-gouvernance-des-biens-communs-au-service-du-bien-commun*

Biodiversity: all natural environments and life forms (plants, animals, fungi, bacteria, etc.) and their interactions.

Source : *Encyclopedia of the environement, what is biodiversity? : https://www.encyclopedie-environnement.org/vivant/quest-ce-que-la-biodiversite/*

Bioluminescence: it is the production and emission of light by a living organism. This light comes from a chemical reaction of the organism, which transforms chemical energy into light energy. This phenomenon is observed in particular with marine organisms.

Source : *Les horizons : Média d'intelligence écologique https://leshorizons.net/bioluminescence/#:~:text=La%20bioluminescence%2C%20c'est%20la,notamment%20aupr%C3%A8s%20des%20organismes%20marins*

Biomass: this is the mass or weight of a set of living organisms. The biomass of breeders is calculated by multiplying the number of individuals of reproductive age by their weight.

Source : IFREMER. Glossaire, Biomasse : https://peche.ifremer.fr/Glossaire/Glossaire/Biomasse

Biomimicry: The biomimetic approach offers answers inspired by nature. It is therefore about imitating the living, its forms, its materials, its structures or its rules of operation to draw ingenious solutions.

Source : CNRS Le Journal : https://lejournal.cnrs.fr/articles/tous-les-modeles-sont-dans-la-nature

Biosphere: refers to the complex system that constitutes the association on the surface of the planet Earth of environments with unique physico-chemical characteristics: ocean, atmosphere, upper layers of the lithosphere, with which all living beings are associated. The biosphere is therefore defined as the region of the planet in which life is permanently possible and which contains all living beings.

Source : Dictionnaire encyclopédique de l'écologie et des sciences de l'environnement, 2ème édition DUNOD, 2002, p.95.

Blue biotechnologies: Blue biotechnologies are defined as science and technology application to the transformation of marine resources by biotechnology processes and this for applications in the areas of health, cosmetics, agri-food, aquaculture, environment, ...

Source : GUEZENNEC, Jean et all. Les biotechnologies bleues : l'insoupçonnable potentiel de l'invisible, in IFREMER, TAIKONA magazine de la mer, 22 p : https://archimer.ifremer.fr/doc/00414/52540/53353.pdf

Blue Acceleration: ''a race between diverse and often competing interests for ocean food, materials and space''.

Source: JOUFFRAY, Jean-Baptiste et all. The Blue Acceleration: The Trajectory of Human Expansion into the Ocean Crossref, Perspective volume 2, issue 1, p43-54, 2020, doi link: https://doi.org/10.1016/J.ONEEAR.2019.12.016 ; https://www.cell.com/one-earth/fulltext/S2590-3322(19)30275-1

Blue-washing: a term used to describe deceptive marketing that exaggerates a company's commitment to responsible social practices.

Source : *FRIEDERIKE, Vinzenz* et all. Marketing sustainable tourism: the role of value orientation, well-being and credibility, Journal of Sustainable Tourism, August 2019: *https://doi.org/10.1080/09669582.2019.1650750*

Bottom-up: The bottom-up (or sometimes horizontal) approach is when innovations and ideas emanate from the bottom up to be transmitted to other components of the entity under consideration, with the top only playing the role of a transmission belt between the parties, or registry room.

Source: *Geoconfluences. Glossaire,* '' Top down ‹› *et '' bottom up '', 2020 : http://geoconfluences.ens-lyon.fr/glossaire/top-down-et-bottom-up*

Blue carbon: represents the carbon stored by living organisms in marine and coastal ecosystems (mangroves, salt marshes, seagrass beds) and stored in biomass and sediments.

Source : IPCC, 2018: Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report, 543p. doi:10.1017/9781009157940.008. : https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_AnnexI.pdf

Climate change: A variation in the state of the climate observable (by statistical tests, ...) by changes in the mean and/or variability of properties that persists over an extended period of time, typically decades or longer. Climate change may be due to natural internal processes or external forcings, including modulations of solar cycles, volcanic eruptions, or persistent anthropogenic changes in atmospheric composition or land use. In the first article of the UNFCCC, climate change is defined as ''changes in climate which are attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which are in addition to natural climate variability observed over comparable time periods. The Convention thereby distinguishes between climate change attributable to human activities that alter the composition of the atmosphere and climate variability attributable to natural causes.

Source : IPCC, 2018: Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report, 544p. doi:10.1017/9781009157940.008. https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_AnnexI.pdf

Choke point: designates a strategic passage in transportation. Key passages for maritime transport are narrow, shallow bottlenecks, the Achilles heel of the globalized economy. They are straits or channels that entail a limit to ship capacity.

Source : Geoconfluences. Glossaire, Choke point, 2021 : http://geoconfluences.ens-lyon.fr/glossaire/choke-point

Thermohaline circulation or deep ocean circulation: the oceans constantly flow with great currents. This permanent circulation is the ''thermohaline circulation''. In Greek, ''thermos'' means temperature and ''halos'' means salt. These currents are generated and maintained either by differences in temperature or by differences in salinity.
Source : Geoconfluences. Glossaire, Choke point, 2021 : http://geoconfluences.ens-lyon.fr/glossaire/choke-point

Clathrates: nanoporous organic crystals in which water molecules form cages that can encapsulate a large number of molecular species, the topology of the aqueous cages depends on the nature of the guest molecules.

Source : G. A. Jeffrey, in Comprehensive Supramolecular Chemistry, Hydrate Inclusion Compounds, edited by J. L. Atwood, J. E. D. Davies, D. D. Mac-Nicol, and F. Vögtle (Pergamon, Oxford) Vol. 6, p. 757 (1996).

Coccolithophore "Emiliania huxleyi": single-celled calcifying marine algae that play an important role in the oceanic carbon cycle via their cellular processes of photosynthesis (a CO_2 sink) and calcification (a CO_2 source). In contrast to well-studied and satellite-visible surface coccolithophore blooms, the lower photic zone is a poorly understood but potentially important ecological niche for coccolithophores in terms of primary production and carbon transfer to the deep ocean.

Source : Laura Perrin, Ian Probert, Gerald Langer, Giovanni Aloisi. Growth of the coccolithophore Emiliania huxleyi in light- and nutrient-limited batch reactors: relevance for the BIOSOPE deep ecological niche of coccolithophores. Biogeosciences, European Geosciences Union, 2016, 13 (21), pp.5983-6001. 10.5194/bg-13-5983-2016.

Water column: "the water column is a concept used in oceanography to describe the physical (temperature, salinity, light penetration) and chemical (pH, dissolved oxygen content, nutrient salts, trace metals...) characteristics of seawater at different depths for a given geographical point. This water column extends from the surface to the bottom of the oceans and can be up to 11 km deep (the Mariana Trench in the Pacific).

Source: Source : CNRS. IFREMER. Geo Ocean. What is the water column? https://www.geo-ocean.fr/en/Science-for-all/Our-classrooms/Hydrothermal-systems/The-water-column

Concertation: refers to a mode of administration or governance in which citizens are consulted in order to debate and enrich a project. It includes a dimension of continuity and follow-up in the development of the project. It makes contradictory exchanges possible and promotes inclusive participation.

Source : REVUE URBAINE. L'analyse préalable : A quoi sert la concertation ? : http://revesurbains.fr/wp-content/uploads/2016/10/Guide-concertation_Lille_complet.pdf

Containerization: the principle of transporting various goods in standardized containers to facilitate transport and handling. Large ports and multimodal platforms have adapted to the standards imposed by containerization: handling systems, adequate storage areas, etc.

Source : GEOCONFLUENCES. Glossaire. Conteneur, conteneurisation, Novembre 2020 : http://geoconfluences.ens-lyon.fr/glossaire/conteneur-conteneurisation

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) or the Washington Convention: international agreement between States, adopted on March 3, 1973 in Washington. '' It aims to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species to which they belong ''.

Source : the Convention on International Trade in Endangered Species of Wild Fauna and Flora. https://cites.org/eng/disc/what.php

Mixing layer (of surface waters): The mixing layer (or mixed layer) is the surface part of the ocean that is stirred by the atmosphere. In the mixed layer, the physical properties of seawater (density, temperature and salinity) remain constant.

Source : IFREMER. Glossaire, milieu_physique, couche de mélange : https://marc.ifremer.fr/glossaire/milieu_physique/couche_de_melange

Antarctic Circumpolar Current: The Antarctic Circumpolar Current is a major ocean current known as the Southern Ocean. It is the only current that circles the Earth and connects the major oceans of our planet.

Source : CENTRE NATIONAL D'ETUDES SPATIALES(CNES). Le courant circumpolaire antarctique COURANT: http://argonautica.jason.oceanobs.com/html/argonautica/fiches/circumpolaire2017_fr.html.

Atlantic Meridional Overturning Current (AMOC): Broad-based ocean circulation that brings warm, salty water into the high latitudes of the North Atlantic, where it cools, releases heat to the atmosphere, and eventually sinks to the deep ocean after a series of complex oceanographic processes. Its impact on climate and biogeochemistry is equally global and complex, particularly due to large-scale atmospheric teleconnection patterns.

Source : Swingedouw D, Houssais M-N, Herbaut C, Blaizot A-C, Devilliers M and Deshayes J (2022) AMOC Recent and Future Trends: A Crucial Role for Oceanic Resolution and Greenland Melting? Front. Clim. 4:838310. doi: 10.3389/fclim.2022.838310.

Population growth: refers to the growth of a population over time.

Source : François. Dictionnaire encyclopédique de l'écologie et des sciences de l'environnement, 2ème édition DUNOD, 2002, pp184-185.

Cryosphere: Region of the ecosphere that consists of polar ice caps and glaciers.

Source : RAMADE, François. Dictionnaire encyclopédique de l'écologie et des sciences de l'environnement, 2ème édition DUNOD, 2002, p.186.

Ocean Decade 2021-2030: ''The United Nations proclaimed the United Nations Decade of Ocean Sciences for Sustainable Development (2021-2030). The initiative aims to mobilize the scientific community, policy makers, industry and civil society around a common agenda of research and technological innovation. The proclamation of the Decade is the culmination of efforts by UNESCO's Intergovernmental Oceanographic Commission to foster international cooperation in ocean sciences.

Source : UN Decade of Ocean Science for Sustainable Development (2021-2030) https://en.unesco.org/underwater-heritage/UN-decade

Ocean deoxygenation: refers to a loss of oxygen in the oceans, which is largely attributed to two main causes: eutrophication due to nutrient runoff from continental areas and nitrogen deposition from fossil fuel use, and warming of ocean waters due to climate change.

Source : Union Internationale pour La Conservation de La Nature (UINCN). Ocean deoxygenation: everyone's problem...summary for policy makers, 2019, 28 p : https://portals.iucn.org/library/sites/library/files/documents/2019-048-Fr-Summ.pdf

Digitalization: Digitalization refers to the use of digital technologies and data, as well as interconnections that give rise to the birth of new activities or the evolution of existing ones.

Source : OCDE.Going Digital: Shaping Policies, Improving Lives, Éditions OCDE, 2019, 168 p : https://doi.org/10.1787/9789264312012-en

E-bomb: is short for ''electromagnetic bomb'' a new generation electromagnetic weapon that was invented in the 1950s. The definition is very broad, but essentially covers all bombs designed to damage targets with a very intense pulse of electromagnetic energy. The main distinction lies in the wavelength of the energy produced by the weapon. This bomb belongs to the so-called direct-energy weapon category - more precisely, to the ''high power microwaves weapon'' (HPM) family. These weapons are capable of producing an electromagnetic pulse (EMI) without a nuclear explosion.

Source : Kopp, Carlo, in Globalsecurity.org, 2003.

White Economy: ''The concept of a white economy is the economy created by young entrepreneurs of startups and digital businesses. Douglas McWilliams, in his book ''The Flat White Economy,'' uses the term white economy to refer to a new concept that is emerging that is focused on the digital world, where startups, small businesses and technology are gaining traction.''

Source : MCWILLIAMS, Douglas. The Flat White Economy : How The Digital Economy is Transforming London and Other Cities of the Future, Overlook Press, 2016, 256 p.

Brown economy: economy based on fossil fuels (coal, oil, gas). This is the economic model implemented and promoted by affluent countries. Impacts of this type of economy are pollution, waste, depletion of non-renewable resources and destruction of the environment.

Source : United Nations Environment Programme (UNEP).

Circular economy: involves producing goods and services in a sustainable manner by limiting the consumption and waste of resources and the production of waste. This model is based on the creation of positive value cycles with each use or reuse of a material or product before final destruction.

Source : National Institute of Circular Economy: https://institut-economie-circulaire.fr/economie-circulaire/

Economy of the sea: ''the economy of the sea refers, as its name indicates, to sectors of activity related to the sea (maritime transport, fishing, offshore wind, marine biotechnology) but also refers to natural assets and ecosystem services from the sea (fisheries resources, shipping lanes, CO_2 absorption, among others).

Source : : The online library of the organization for economic cooperation and development (oecd). the ocean economy in 2030 :https://www.oecd-ilibrary.org/sites/8d846fcdfr/index.html?itemId=/content/component/8d846fcd-fr.

Predatory economy: is a developmental stage of a society's culture, reached when group members adopt a predatory (i.e., rapacious) attitude as a permanent and orthodox spiritual attitude; when struggle has become the dominant feature of a prevailing theory of life; and when common sense comes to judge people and things with a view to combat. The evolution is gradual, since the passage from a peaceful state to predation depends on the development of technical knowledge and use of tools.

Source : Galbraith, J. (2006). La prédation économique moderne : guerre, fraude d›entreprise et cruelle chimère des réformes du marché du travail. A contrario, 4, 90-98. https://doi.org/10.3917/aco.041.98; Thorstein Veblen, Théorie de la classe de loisir, Paris : Gallimard, 1970 (1re éd. américaine : The Theory of the Leisure Class, New York : Macmillan, 1899).

Red economy: the red economy is, according to Gunter PAULI, characterized by waste, indebtedness and unemployment of some for the enrichment of others. This economy ''borrows from everyone and everything, from nature, from humanity, without thinking of repaying one day''.

Source : PAULI, Gunter. L'économie bleue 3.0, Édition revue et Augmentée, L'OBSERVATOIRE, 2019, 496 p.

Green economy: According to the United Nations Environment Programme (UNEP), the green economy is an economy that leads to improved human well-being and social equity, while significantly reducing environmental risks and resource scarcity.

Source : United Nations Environment Programme UNEP, PAULI, Gunter L'économie bleue 3.0, Édition revue et Augmentée, L'OBSERVATOIRE, 2019, 496 p.

Ecotone: Buffer zone enabling the description of complex (and often moving) ecological functions in space and time (or ecological transition zone between two ecosystems).

Source : GARON, David ; GUEGUEN, Jean-Christophe ; RIOULT, Jean-Philippe. Biodiversité et évolution du monde vivant, EDP Sciences, 2013, p. 70 ; Gilles Clément, Manifeste du tiers paysage. Petit livre traitant surtout des écotones comme systèmes écologiques et aussi paysages.

Harmful Algal Blooms: Certain types of phytoplankton produce strong toxins or poisons. When their numbers increase, this is referred to as a ''harmful algal bloom''.

Source : The Pacific Community (SPC) ; LMMA Network, Efflorescences d'algues nuisibles ,Fiche d'information pour les communautés de pêcheurs / 28, 2 p : https://spccfpstore1.blob.core.windows.net/digitallibrary-docs/files/16/16dd62a332cb974770b0496d4861bd3f.pdf?sv=2015-12-11&sr=b&sig=XwbkdiICOevGC7CqnPpH7qoOeVmpDkbSnkCmIJPvfS0%3D&se=2023-03-21T12%3A14%3A15Z&sp=r&rscc=public%2C%20max-age%3D864000%2C%20max-stale%3D86400&rsct=application%2Fpdf&rscd=inline%3B%20filename%3D%22Anon_13_ISFC_28_Harmful_algae_VF.pdf%22

Existential stakes or risks: ''risks that could lead to the extinction of humanity or the collapse of civilization. This reflects the realization that mankind's capacity to cause its own extinction is now effective.

Source : Royal Institute for Strategic Studies, Strategic report 2021 : Towards a new post-COVID-19 World ? . https://www.ires.ma/en/publications-english/general-reports/7653-strategic-report-2021-towards-a-new-post-covid-19-world.html

Invasive species or invasive alien species (IAS): these are species introduced (voluntarily or accidentally) by humans into a new territory outside their natural range, whose establishment and spread threaten ecosystems, habitats or native species with negative consequences on ecological and/or socio-economic and/or health services.

Source : COMITÉ FRANÇAIS DE L'UNION INTERNATIONALE POUR LA CONSERVATION DE LA NATURE, UICN France, Les espèces exotiques envahissantes sur les sites d'entreprises. Livret 1 : Connaissances et recommandations générales, Paris, France, 2015, 40 p : https://uicn.fr/wp-content/uploads/2016/09/UICN_Guide_EEE_entreprises_L1.pdf

Crowdfunding: Or participative financing, was developed in 2008 during the economic and financial crisis. Crowdfunding is a collaborative financing method that allows project leaders to find funding from savers (most often individuals) via Internet platforms. It relies on the dissemination of information and sponsorship through social networks.

Source : HEMDANE Thameur, '' Le crowdfunding, une innovation pour financer le développement du Maroc '', Techniques Financières et Développement, 2016/3-4 (n° 124), p. 27-34. DOI : 10.3917/tfd.124.0027. URL : https://www.cairn.info/revue-techniques-financieres-et-developpement-2016-3-page-27.htm

Geoeconomics: At the intersection of economics and international relations, geoeconomics studies the relationship between power and space, outside of territorial borders.

Source : LOROT, Pascal. '' De la géopolitique à la géoéconomie '', Géoéconomie, 2009/3 (n° 50), p. 9-19. DOI : 10.3917/geoec.050.0009. URL : https://www.cairn.info/revue-geoeconomie-2009-3-page-9.htm

Geomorphology: is a branch of geography that studies landforms, particularly the role of erosion in landscape formation.

Source : Geoconfluences. Glossaire, Géomorphologie, Avril 2021 : http://geoconfluences.ens-lyon.fr/glossaire/geomorphologie#:~:text=La%20g%C3%A9omorphologie%20est%20une%20branche,dans%20la%20formation%20des%20paysages

Integrated Coastal Zone Management (ICZM): This concept is fairly recent (1980-1990). Contrary to previous approaches that were based on specific sectors of the economy, ICZM is an approach to governance that integrates all sectors of activity that affect the coastal zone and its resources, and that simultaneously considers social, economic and environmental aspects. ICZM implies the creation of a new level of governance at the heart of which lies civil society participation.

Source : VANDERLINDEN, Paul. La gestion intégrée de la zone côtière , in Université Virtuelle Environnement et Développement durable (UVED) : https://ressources.uved.fr/Grains_Module3/GIZC/site/html/GIZC/GIZC.html

Ocean gyre: An ocean gyre is a large system of circular ocean currents formed by global winds and forces created by the Earth's rotation. There are three main types of ocean gyres: tropical, subtropical and subpolar.

Source : NATIONAL GEOGRAPHIC. Ocean Gyre: https://education.nationalgeographic.org/resource/ocean-gyre

Great Acceleration (of human activities): period from the 1950s onwards during which all socio-economic trends (demography, consumption, industrial production) accelerated significantly.

Source : ANTROPOCENE : https://www.anthropocene.info/great-acceleration.php

Hinterland: land area linked to the port by major communication networks. The hinterland is the area of attraction and continental service of the port, in economic terms. It is also the continental market area.

Source : GEOCONFLUENCES. Glossaire, Arrière-pays et avant-pays (hinterland, foreland), Mars 2021 :

http://geoconfluences.ens-lyon.fr/glossaire/arriere-pays-et-avant-pays-hinterland-foreland#:~:text=L'arri%C3%A8re%2Dpays%20(hinterland,son%20aire%20de%20march%C3%A9%20continentale

Hypoxia: Hypoxia in marine waters - a lack of dissolved oxygen - is a growing problem that can have serious impacts on marine environments and ecosystems. Oxygen depletion in seawater is currently considered one of the likely consequences of global warming, as warmer water contains less oxygen. Hypoxia can occur naturally. It can also be exacerbated by human activity or caused directly by it.

Source : Governement of Canada, Hypoxia: https://www.dfo-mpo.gc.ca/oceans/publications/soto-rceo/2012/page03-eng.html

Shipbuilding industry: all activities involved in the design, construction, repair and maintenance of ships.

Source : OBSERVATOIRE DE LA PARITAIRE DE LA METALLURGIE. Naval & Énergies Marines Renouvelables : https://www.observatoire-metallurgie.fr/secteurs/naval-energies-marines-renouvelables#:~:text=L'industrie%20navale%20fran%C3%A7aise%20regroupe,et%20la%20maintenance%20des%20navires.

Artificial intelligence: refers to the ability of a machine to reproduce human-related behaviors, such as reasoning, planning and creativity..

Source : European Parliament. Artificial intelligence: definition and use : https://www.europarl.europa.eu/news/fr/headlines/society/20200827STO85804/intelligence-artificielle-definition-et-utilisation

Interface: Zone of contact between two differentiated spaces that generates exchange processes between them.

Source : GEOCONFLUENCES. Glossaire. Interface : http://geoconfluences.ens-lyon.fr/glossaire/interface-1

Internet of Things: is a network of objects with clear identifiers, equipped with intelligent software, fitted with sensors and constantly connected to the internet. It enables these objects to exchange information with the manufacturer, the operator or other objects connected to the internet. It makes physical objects detectable and allows them to be controlled remotely, via the Internet, thus enhancing the integration between IT systems and the physical world. The economic world as well as technical experts agree on the exponential increase in the number of objects connected to the Internet.

Source : RAYES, Ammar ; SALAM, Samer. Internet of Things: From hype to reality – The road to digitization (2nde edition), Cham (Suisse), Springer, 2019, pp. 1-3.

Intertidal: Tidal is an adjective designating that which is relative to the tide. Intertidal means that which is located between low and high tide, i.e. the band also called the foreshore.

Source : GEOCONFLUENCES. Glossaire, Tidal, intertidal : http://geoconfluences.ens-lyon.fr/glossaire/tidal

Overshoot Day: Calculated by the Global Footprint Network, this day marks the date by which humanity has consumed (ecological footprint) all the resources that the Earth can replenish in a single year (biocapacity).

Source : World Wildlife Fund Canada: https://www.wwf.fr/sites/default/files/doc-2019-05/20190509_WWF-EU-Overshoot-Day-Living-Beyond-Nature-Limits_Report_WWF-min.pdf

Blue Amazon: The concept of Blue Amazon was coined by Admiral Roberto de Guimaraes Carvalho in an article in 2004. The Blue Amazon (Amazônia Azul) is the Brazilian maritime space (Comissão Interministerial) that matches the surface of the Amazon forest (Amazônia Verde). The primary focus of this concept is the exploration and exploitation of natural resources as well as their legal and, if necessary, military protection.

Source : Folha de Sao Paulo, www1.folha.uol.com.br/fsp/opiniao/fz2502200409.htm ; GOMES DO CRAVO BARROS Jorge ; BARROS-PLATIAU Ana Flávia ; COSTA DE OLIVEIRA Carina et al. '' '' Amazonie bleue '' et projection brésilienne sur l'avenir '', Outre-Terre, 2015/1 (N° 42), p. 204-212. DOI : 10.3917/oute1.042.0204. URL : https://www.cairn.info/revue-outre-terre2-2015-1-page-204.htm

Lithosphere: Surface region of the Earth's crust, about 20 km thick, made up of hardened layers, except in areas of magma intrusion in the asthenosphere.

Source : RAMADE, François. Dictionnaire encyclopédique de l'écologie et des sciences de l'environnement, 2ème édition DUNOD, 2002, p.463.

Coastalization: ''Coastalization is a process of concentration of populations and human activities along or near the coastline. The contemporary attraction of occupied coastlines is at the origin of an increasing densification of developments and of competition or conflicts between activities and actors. These activities complement or exclude each other''.

Source : GEOCONFLUENCES. Glossaire, Littoralisation : http://geoconfluences.ens-lyon.fr/glossaire/littoralisation-ou-maritimisation#:~:text=La%20littoralisation%20est%20un%20processus,ou%20%C3%A0%20proximit%C3%A9%20des%20littoraux.

Seafarers: The term seafarers refers to persons employed, engaged or working in any capacity on board a ship. A distinction should be made between seafarers and non-seafarers. Salaried or non-salaried seafarers are seafarers engaged in an activity directly related to the operation of the vessel. While non seafarers represent personnel carrying out a professional activity on board more than 45 days of embarkation, continuous or not, over a period of six consecutive months.

Source : Observatoire des Droits des Marins. Fiches pratiques. Droit du travail maritime. Gens de la mer :https://www.obs-droits marins.fr/fiches_pratiques/droit_du_travail_maritime.html?idFiche=21

Eutrophication: Eutrophication is one of the most common alterations of continental and marine waters. Triggered by excessive nutrient inputs, eutrophication phenomena result in exacerbated productivity of aquatic ecosystems. The most well-known manifestations are toxic cyanobacteria blooms in lakes and rivers, as well as green macro-algae blooms in coastal areas. These phenomena generate major disruptions of aquatic ecosystems and have impacts on associated goods and services, on related economic activities and on human health.

Source : Expertise scientifique collective Eutrophisation, 2017. L'eutrophisation : manifestations, causes, conséquences et prédictibilité. Rapport d'Expertise scientifique collective, Rapport CNRS- Ifremer-INRA-Irstea (France), 1283 p : https://mycore.core-cloud.net/index.php/s/5PpOueQDXwdrXqt#pdfviewer

Freedom of navigation: The right of all vessels, boats, timber trains and other means of transport by water to circulate freely over the entire navigable area of the waterway, on condition that they comply with the stipulations of the present regulations and, where appropriate, with the supplementary or implementing requirements which shall be established by bordering States.

Source : l'article 2 de la résolution adoptée le 14 octobre 1934 lors de la session de Paris ; MUBIALA, Mutoy. Chapitre 4. La liberté de navigation In : L'évolution du droit des cours d'eau internationaux à la lumière de l'expérience africaine, notamment dans le bassin du Congo/Zaïre [en ligne]. Genève : Graduate Institute Publications, 1995 (généré le 21 septembre 2022). Disponible sur Internet : <http://books.openedition.org/iheid/1550>. ISBN : 9782940549221. DOI : https://doi.org/10.4000/books.iheid.1550

Haliotropism: is composed of ''Halios'' which refers to the sea and haliotropism means to turn towards the sea and be attracted by it. This phenomenon has transformed the coastline from an empty territory to a crowded one.

Source : CORLAY, Jean-Pierre. Géographie sociale, géographie du littoral, Norois, 1995, pp. 247-265 : https://www.persee.fr/doc/noroi_0029-182x_1995_num_165_1_6623

Heliotropism: this term refers to the attraction the sun exerts on populations that relocate.

Source : BRUNET,Roger.Les mots de la géographie, Reclus-La Documentation Française, 1993, 470 p.

The French Research Institute for Exploitation of the Sea (IFREMER) is a public institution founded in 1984, with an industrial and commercial character (EPIC), placed under the joint supervision of the Ministries of Higher Education and Research and of the Environment, Energy and the Sea. It contributes, through its work and expertise, to the knowledge of the oceans and their resources, to the monitoring of the marine environment and the coastline and to the sustainable development of maritime activities. It has laboratories in some twenty sites in the three major oceans: the Indian, the Atlantic and the Pacific. On behalf of the State, it operates the French Oceanographic Fleet for the benefit of the national scientific community.

Source : IFREMER : https://wwz.ifremer.fr/L-institut

IPBES: is the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. It is an independent intergovernmental body established by States to strengthen the science-policy interface of biodiversity and ecosystem services for the conservation and sustainable use of biodiversity.

Source : INTERGOVERNMENTAL SCIENCE-POLICY PLATFORM ON BIODIVERSITY AND ECOSYSTEM SERVICES : https://ipbes.net/fr/node/40

Mariculture: Mariculture is often defined as marine aquaculture. Some researchers limit mariculture to the cultivation of marine plants and animals in the ocean itself. While others also include brackish water species and include cultivation methods that take place in salt and brackish waters that are not located in the ocean.

Source : European Environmental agency (EEA) : https://www.eea.europa.eu/help/glossary/eea-glossary/mariculture ; SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSITY. (2004). Solutions for sustainable mariculture-avoiding the adverse effects of mariculture on biological diversity, CBD Technical Series N°. 12 2004

Maritimization: process leading to the increased exploitation of sea and ocean resources and the expansion of trade by sea, in connection with globalization.

Source : GEOCONFLUENCES. Glossaire, Maritimisation : http://geoconfluences.ens-lyon.fr/glossaire/maritimisation

Maritime globalization: implies general ideas of common good, of world heritage to be preserved, of the beneficial necessity to join forces to exploit wealth, share resources and technologies. [...].

Source : L'AMIRAL DUFOURCQ, Jean. Cité par MOTTE, Martin .In '' La mer, entre mondialisation et fragmentation ''. Prospective et stratégie vol 8, no 1, 2017, p .57-70. https://www.cairn.info/revue-prospective-et-strategie-2017-1-page-57.htm

MENA (Middle East and North Africa): is the acronym used to designate a region of the world comprising North Africa and the Middle East.

Source: WORD BANK: https://www.worldbank.org/en/region/mena

Mercator Ocean: is a non-profit corporation, founded and funded by the five major French institutions involved in operational oceanography: CNRS (Centre National de la Recherche Scientifique), Ifremer (Institut Français de Recherche pour l'Exploitation de la Mer), IRD (Institut de Recherche pour le Développement), Météo-France and SHOM (Service Hydrographique et Océanographique de la Marine Nationale). It is in the process of becoming an intergovernmental organization, providing oceanographic-based services of general interest, focused on the conservation and sustainable use of oceans, seas and marine resources. This organization has developed complex ocean simulation systems (numerical models) based on ocean observational data (satellite and in situ) that are capable of describing, analyzing and forecasting the physical and biogeochemical state of the ocean at any time, at the surface or at depth, on a large scale or for a specific area, in real or delayed time.

Source : MERCATOR OCEAN INTERNATIONAL. L'organisation : https://www.mercator-ocean.eu/about-mercator-ocean-international/

Micronutrients: compounds present in food, ingested in quantities of less than 1g/day and which are not a significant source of energy. They are essential because they are not synthesized by the body and perform essential biological functions. They include vitamins, minerals and trace elements.

Source : ESNOUF, Catherine ; FIORAMONTI, Jean ; LAURIOUX, bruno (dir). L'alimentation à découvert, CNRS Éditions, Paris, 19 Octobre 2017, Glossaire, p.303-313 , DOI : 10.4000/books.editionscnrs.10226 : https://books.openedition.org/editionscnrs/10521?lang=fr

New Silk Roads (BRI): a strategic Chinese project aimed at economically connecting China to Europe by integrating the spaces of Central Asia through a vast network of road and rail corridors. This term (Belt and Road Initiative or BRI in English) replaced in 2017, in the official terminology, the expression ''One Road, One Belt''. This project includes more than 68 countries with a total of 4.4 billion inhabitants, representing nearly 40% of the world's gross domestic product (GDP).

Source : GEOCONFLUENCES. Glossaire, Routes de la soie, nouvelle route de la soie : http://geoconfluences.ens-lyon.fr/glossaire/routes-de-la-soie

Sustainable Development Goals (SDGs): also known as the Global Goals, were adopted by the United Nations in 2015. They are a global call to action to eradicate poverty, protect the Planet and ensure that all people live in peace and prosperity by 2030. The 17 SDGs are integrated - recognizing that interventions in one area will affect outcomes in others and that development must balance social, economic and environmental aspects.

Source : United Nations Development Programme, What are the Sustainable Development Goals? https://www.undp.org/sustainable-development-goals

Oceanography: ''Oceanography is a science that studies the seas and oceans, their limits and their interactions with the air, the seabed, the continents and the living organisms''.

Source : MÉDIATHÈQUE DE LA CITÉ DE LA MER DE CHERBOURG. Dossier thématique. Avril 2012, p.4 : https://mediathequedelamer.com/wp-content/uploads/dossier-oceanographie.pdf.

High seas: all parts of the sea outside the territorial sea or internal waters of a State. The high seas being open to all nations, no State may legitimately claim to submit any part of them to its sovereignty. Freedom of the high seas is exercised under the conditions determined by the present articles and by other rules of international law. It comprises in particular, for the States bordering or not the sea: the freedom of navigation; the freedom of fishing; the freedom to lay submarine cables and pipelines; the freedom to fly over it.

Source : Convention sur la haute mer. 1958, Genève. http://www.fortunes-de-mer.com/documents%20pdf/legislation/Internationale/Convention%20Haute%20Mer%201958%20FR.pdf.

Oceanology: term formed from -ocean and -logy. Neologism dating from 1966. ''Methods, scientific and technical operations implemented for the exploration, economic exploitation or protection of the oceans. ''Oceanology'' sometimes corresponds to the definition of applied oceanography (for services, industries), ... Others explain that oceanology, as opposed to oceanography, is not only to describe the ocean but to understand its mechanisms''.

Source : MÉDIATHÈQUE DE LA CITÉ DE LA MER DE CHERBOURG. Dossier thématique. Avril 2012 : https://mediathequedelamer.com/wp-content/uploads/dossier-oceanographie.pdf ; CHOMEL DE VARAGNE, Bruno. L›océanologie : La recherche et la mer, La documentation française, 1974, 280 p ; DE VARAGNES, Bruno Chomel. L'océanologie : La recherche et la mer, - Paris : La documentation française, 1974 (La documentation française illustrée ; 280), 95p.

Ocean Sphere: Term created in 1949 by the Russian V.N. Stepanov, which means the so-called global ocean that includes all the oceans and seas. It covers both hemispheres in a heterogeneous way, that is to say 70,8 % of the surface of the Earth (representing 97 % of the water on Earth).

Source : TOUCHART, Laurent ; BARTOUT,Pascal. FAUT-IL CONCEVOIR UNE LIMNOSPHÈRE ?, '' L'Information géographiqueIn Armand Colin,pp.77-107 : https://www.cairn.info/revue-l-information-geographique-2018-2-page-77.htm

Offshore: term that refers to activities that take place at sea, without being related to fishing or maritime transport.

Source : LE MANUEL NUMERIQUE MAX. Géographie Tle, Lexique, Offshore : https://manuelnumeriquemax.belin.education/geographie-terminale/topics/geo-tle-t6c01-332-a_lexique

OMZ: oxygen minimum zone, also called hypoxic or ''dead zone'': ocean volume, at medium depth, in which the oxygen content remains very low, even too low to sustain life.

Source : CAROL ,M Lalli,; PARSONS, Timothée R. Océanographie biologique : une introduction. Oxford. ISBN 0-7506-2742-5, 1993 : http://www.sisal.unam.mx/labeco/LAB_ECOLOGIA/OF_files/54210854-Biological-Oceanography-an-Introduction.pdf

Regional Comprehensive Economic Partnership (RCEP): The Asia-Pacific Comprehensive Economic Partnership Agreement (RCEP) is set to become the largest free trade area in terms of economic weight. Designed to further integrate the economies of Southeast and Northeast Asia, the RCEP establishes strict requirements for customs procedures, processes and performance.

Source : ORGANISATION MONDIALE DES DOUANES. Panorama, L'accord global de partenariat économique régional en Asie-Pacifique (RCEP) sous la perspective douanière

https://mag.wcoomd.org/fr/magazine/omd-actu-96/rcep-from-a-customs-perspective/

Illegal Unreported and Unregulated Fishing (IUU): is a general term, which includes:

Fishing and related activities conducted in violation of national, regional and international laws.

Non-reporting, misreporting or underreporting of information on fishing operations and catches.

Fishing by ''stateless'' vessels.

Fishing in areas covered by regional fisheries management organizations (RFMOs) by non-parties.

Fishing activities that are not regulated by States and cannot be easily monitored and accounted for

Source : Food and Agriculture Organisation of the United Nations, La pêche illicite, non déclarée et non réglementée, 4 p : https://www.fao.org/3/i6069f/i6069f.pdf

Permaquaculture: is an integrated and evolutionary cultivation system inspired by natural ecosystems. It is also an ethical approach and a philosophy based on 3 pillars: ''taking care of the Earth, taking care of humans and sharing resources fairly''.

Source : SARTHOU,Jean-Pierre. Permaculture, in Dictionnaire d'agroécologie : https://dicoagroecologie.fr/dictionnaire/permaculture/

Small Island Developing States (SIDS): include individual countries with common characteristics and vulnerabilities such as insularity, geographic remoteness, and small size of economy, population, and area. These factors combine to make it clear that functional, reliable, sustainable, and resilient transportation systems - particularly maritime and air - are critical to the development and survival of these countries.

Source : CONSEIL DU COMMERCE ET DU DÉVELOPPEMENT COMMISSION DU COMMERCE ET DU DEVELOPPEMENT : https://unctad.org/system/files/official-document/cimem7d8_fr.pdf

Phytoplankton: ''Phytoplankton (from the Greek ''phyton'' or plant) is the group of planktonic organisms belonging to the plant kingdom, of very small or microscopic size, which live suspended in water. Specifically, it is the marine and freshwater plant community that floats freely in the water and includes many species of microalgae and cyanobacteria.

Source : PHENOMER. IFREMER. Glossaire, Phytoplancton : https://www.phenomer.org/Informations/Pratique/Glossaire/Phytoplancton

Photosynthesis: Process by which plants and certain bacteria use solar energy to synthesize organic molecules from carbon dioxide and water.

Source : ACTU ENVIRONNEMENT. Dictionnaire de l'environnement : https://www.actu-environnement.com/ae/dictionnaire_environnement/definition/photosynthese.php4

Piracy: According to the International Convention on the Law of the Sea, an act of piracy refers to any unlawful act of violence or depredation committed by the crew or passengers of a ship against another ship, on the high seas or in a place not under the jurisdiction of any State.

Source : L'ORGANISAITON MARITIME INTERNATIONALE :

https://www.imo.org/fr/OurWork/Security/Pages/PiracyArmedRobberydefault.aspx

Pisciculture: is a method of raising freshwater fish for consumption.

Source : RAMADE, François. Dictionnaire encyclopédique de l'écologie et des sciences de l'environnement, 2ème édition DUNOD, 2002, p.627.

Light pollution: Light pollution is an anthropogenic phenomenon associated with the development of urbanization and human activities and which involves artificial light. From an ecologist's point of view, light pollution refers to artificial light that degrades natural light cycles (day/night cycles and seasons), modifies the nocturnal component of the environment, i.e. the illumination of the environment, and consequently impacts the behavior, biological rhythms and physiological functions of living organisms and ecosystems.

Source : ENCYCLOPÉDIE DE L'ENVIRONNEMENT : https://www.encyclopedie-environnement.org/vivant/limpact-ecologique-de-pollution-lumineuse/

Chemical pollution: this is pollution generated by unwanted chemical substances in the environment as a result of human activities - agricultural, industrial or urban. Chemical pollutants include pesticides, endocrine disruptors, plastics, drug residues and other emerging pollutants... As they cannot be eliminated by the ecosystem, these pollutants have an impact on humans as well as on fauna and flora. The most frequently observed chemical pollution comes from the use of hydrocarbons, solvents or pesticides; but one must also consider gaseous pollutants that alter the atmosphere and ozone layer, thus accelerating climate change. According to a study published in January 2022 in Environmental Science & Technology, the planetary limit of chemical pollution has been crossed, exposing mankind to brutal changes in its environment.

Source : NOVETHIC. Lexique, pollution chimique : https://www.novethic.fr/lexique/detail/pollution-chimique.html

Noise pollution: Noise pollution affects the physical and mental health of people, as well as the lives of urban animals. According to some findings of the World Health Organization (WHO), noise is the second most important environmental factor causing health problems, right behind the impact of air pollution (particles).

Source : European Environment Agency Environmental noise in Europe, 2020, 104 p : https://www.eea.europa.eu/publications/environmental-noise-in-europe

Prochlorococcus: The single-celled marine cyanobacterium Prochlorococcus is the most abundant photosynthetic organism on Earth. These microbes are adapted to oxygen-rich, nutrient-poor oceanic conditions, with a fundamental divergence between high-light and low-light ecotypes.

Source : ULLOA, Osvaldo ; HENDRIQUEZ-CASTILLO, Carlos ; RAMIREZ-FLANDES, Salvador ; STEPHANAUSKAS,Ramunas. The cyanobacterium Prochlorococcus has divergent light-harvesting antennae and may have evolved in a low-oxygen ocean, Massachusetts Institute of Technology, Cambridge, March 11, 2021 : https://doi.org/10.1073/pnas.2025638118 ;PENNISI, Elizabeth ; Meet the obscure microbe that influences climate, ocean ecosystems, and perhaps even evolution, March 9, 2017, In American Association for the Advancement of Science : https://www.science.org/content/article/meet-obscure-microbe-influences-climate-ocean-ecosystems-and-perhaps-even-evolution.

Primary production: synthesis of organic compounds by plants and microbes, on land or in the ocean, mainly by photosynthesis using light and carbon dioxide (CO_2) as energy and carbon sources respectively. It can also occur by chemosynthesis, using chemical energy, for example in deep sea vents.

Source : IPCC, 2019: Annex I: Glossary [van Diemen, R. (ed.)]. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems In press : https://www.ipcc.ch/site/assets/uploads/sites/4/2019/11/11_Annex-I-Glossary.pdf.

Primary productivity: The synthesis of organic compounds by plants and microbes, on land or in the ocean, primarily by photosynthesis using light and carbon dioxide (CO2) as sources of energy and carbon respectively. It can also occur through chemosynthesis, using chemical energy, e.g., in deep sea vents.

Source : IPCC, 2019: Annex I: Glossary [van Diemen, R. (ed.)]. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems in press: https://www.ipcc.ch/site/assets/uploads/sites/4/2019/11/11_Annex-I-Glossary.pdf.

Port grabbing: grabbing of ports by foreign powers: analogous to land grabbing.

Source : PROGRAMME JUSTICE AGRAIRE DU TRANSNATIONAL INSTITUTE (TNI) ; MASIFUNDISE DEVELOPMENT TRUST ET AFRIKA KONTAKT : http://worldfishers.org/wp-content/uploads/2014/08/The_Global_Ocean_Grab-FR.pdf

Ocean research: means any lawful study, research or other scientific activity, whether basic or applied, designed to increase knowledge of the marine environment for the benefit of mankind as a whole, which is not undertaken directly for industrial or economic purposes and which does not substantially alter the surface or subsoil of the seabed and does not substantially affect the marine environment;

Source : Law insider, marine scientific research definition : https://www.lawinsider.com/dictionary/marine-scientific-research.

Fishery resources: fishery resources are composed of stocks exploited by fishing and those resulting from aquaculture activities.

Source : L'UNIVERSITÉ VIRTUELLE ENVIRONNEMENT ET DÉVELOPPEMENT DURABLE (UVED). Introduction à l'économie de l'environnement et des ressources naturelles, le cas emblématique des ressources halieutiques : https://ressources.fondation-uved.fr/introecoUVED/html/c2_p22_1.html

Ocean Sciences: ''aim to understand complex social-ecological systems and services at different scales, through observations and collaborative, multidisciplinary research''.

*Source : UNESCO. INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (COI-UNESCO). Global ocean science report: the current status of ocean science around the world; executive summary 2017, 19 p: https://unesdoc.unesco.org/ark:/48223/pf0000249373_fre**

Food security: Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

Souce : Food and Agriculture Organization (FAO), Les concepts de sécurité alimentaire et leur aptitude à répondre aux défis posés par la croissance urbaine : https://www.fao.org/3/ab788f/ab788f07.htm

Shoreface: is a transition zone between the continental shelf and the shoreline, where waves (especially long-period waves) begin to strongly interact with the seabed.

Source : HAMON-KERIVEL, Klervi ; COOPER, Andrew ; JACKSON, Derek ; Sedrati, Mouncef ; GUISADO PINTADO, Emilia. Shoreface mesoscale morphodynamics: A review. Earth-Science Reviews, Elsevier, 2020, 209, pp.103330. ff10.1016/j.earscirev.2020.103330ff. ffhal-02944352f : https://hal.archives-ouvertes.fr/hal-02944352/document

Subsidiarity: A principle according to which powers are delegated to the level most relevant for effective action. The general meaning and purpose of the principle of subsidiarity lies in the granting of a certain degree of independence to a subordinate authority vis-à-vis an authority at a higher level, in particular a local authority vis-à-vis the central power. It is therefore a question of sharing competences between different levels of power, a principle that constitutes the institutional foundation of states with a federal structure.

Source : BRODHAG, Christian et all. Dictionnaire du développement durable, AFNOR,2004, p.213.

Top-down: The top-down approach reflects a traditional understanding of power. Orders come from above and are implemented at each level by a subordinate authority.

Source : GEOCONFLUENCES. Glossaire, '' Top down '' et '' bottom up '',2020 : http://geoconfluences.ens-lyon.fr/glossaire/top-down-et-bottom-up

Mass tourism: emerged as a result of the generalization of paid vacations in many industrialized countries, the growth of purchasing power in the 1960s allowing the ''masses'' to travel and support the economic sector of tourism.

Source : MERCIER, Mathieu. SITE PÉDAGOGIQUE. Territoire touristique L'apparition du tourisme de masse : https://sites.google.com/view/muniverssocial/g%C3%A9ographie-et-%C3%A9ducation-%C3%A0-la-citoyennet%C3%A9/territoire-r%C3%A9gional-le-tourisme

Turbidity: ''Turbidity is a measure of water clarity. It describes the amount of light scattered or blocked by particles floating in the water. These particles give the water an opaque or cloudy appearance.

Source : DataStream. Un guide de surveillance de la qualité de L'eau. La turbidité, 2021, 2 p : https://datastream.cdn.prismic.io/datastream/9f7fd899-0728-47fd-9892-3f66dab05f5f_Turbidite.pdf

Upwelling: ''upwelling of deep waters to compensate for a deficit of surface waters. This phenomenon occurs primarily in tropical waters and is caused by trade winds and strong cold currents whose combined action pushes coastal waters offshore. The upwelling causes an influx of mineral nutrients, which explains the fertility of surface waters in plankton and small pelagics such as anchovy and sardine.''

Source : IFREMER. Glossaire : https://wwz.ifremer.fr/peche/Glossaire/Glossaire/Upwelling

Ocean Heat Waves: Marines Heat Waves (MHW) unusual warming of sea surface temperatures and surface layers of large marine areas.

Source : Frölicher, T. L., Fischer, E. M. & Gruber, N. Nature, 15 August 2018 :doi:https://doi.org/10.1038/d41586-018-05978-1

VFloating cities (VLFS): Faced with an ever-increasing world population, rising sea levels and threats to ecosystems, cities must find new alternatives, such as floating cities. According to UN-Habitat, ''a floating city is an aquatic city of some 10,000 inhabitants, fully modular, eco-responsible and autonomous in terms of food and energy. It is capable of withstanding any type of natural disaster (floods, tsunamis and category 5 hurricanes). ''The floating city concept is built around hexagonal platforms of 20,000 square meters, each of which can accommodate 300 residents.'' ''A floating city is not a luxury, it is a necessity'' for island countries whose very existence is threatened by global warming and rising oceans.

Source : NATIONAL GEOGRAPHIC. Les villes flottantes seront-elles la solution à la crise du logement mondiale ? : https://www.nationalgeographic.fr/environnement/les-villes-flottantes-seront-elles-la-solution-a-la-crise-du-logement-mondiale;

Mud volcanoes and pockmarks: surface expression of mud originating at depth. Depending on the geometry of the conduit and the physical properties of the extrusive, the structure may be a dome or a low topographic relief view.

Source : Mazzini, Adriano; Etiope, Giuseppe (May 2017). ''Mud volcanism: An updated review''. Earth-Science Reviews. 168: 81–112. Bibcode:2017ESRv..168...81M. doi:10.1016/j.earscirev.2017.03.001. hdl:10852/61234.

Exclusive economic zone (EEZ) : a strip of sea beyond and adjacent to the territorial sea, extending up to 200 nautical miles from the baselines. In this zone, the coastal State has full sovereignty and jurisdiction for the purpose of exploration and management as well as for the purpose of economic exploitation of the natural resources (living or non-living) of the waters above and below the seabed".

Source : SENAT. Les zones économiques exclusives ultramarines : le moment de vérité, ANNEXE 2 : GLOSSAIRE RELATIF À LA DÉFINITION DES DÉLIMITATIONS MARITIMES (Convention des Nations Unies sur le droit de la mer du 10 décembre 1982) : https://www.senat.fr/rap/r13-430/r13-43011.html.

Intertidal zone: the zone between the high tide and low tide, also referred to as the foreshore, seashore, or littoral zone. The intertidal zone is hence an environment where seawater and air are interchanged repeatedly from the constant breaking and receding of waves.

Soure : Source : Futura Science, Estran : qu'est-ce que c'est ? : https://sciencetrends.com/intertidal-zone-littoral-zone-ephemeral-habitat/.

Subtidal zone: The intertidal zone is an ecosystem found on the marine coastline, where a multitude of shoreline organisms survive the shifts from high to low tide. It is located on marine coasts, including rocky shores and sandy beaches. The intertidal zone experiences two different states: one at low tide when it is exposed to the air and one at high tide when it is submerged in water. The area is completely submerged by the tide once or twice a day.

Source : National Oceanic and Atmospheric Administration U.S. Department of Commerce (NOAA) : https://oceanservice.noaa.gov/facts/intertidal-zone.html. ; NATIONAL GEOGRAPHIC. Intertidal Zone : https://education.nationalgeographic.org/resource/intertidal-zone.

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9. La zone économique exclusive (ZEE) est située entre la ligne de base et 200 miles (soit 370 kilomètres). L'Etat côtier à des droits souverains sur sa ZEE (CNUDM) aux fins :1) d'exploration, d'exploitation et de gestion des ressources naturelles biologiques et non biologiques des eaux, des fonds marins et de leur sous-sol, 2) d'activités d'exploration, d'exploitation à des fins économiques (production d'énergie à partir des courants et des vents) et 3) de la recherche scientifique marine et l'installation d'ouvrages et d'iles artificielles

10. Le plateau continental comprend les fonds marins et leur sous-sol au-delà de la mer territoriale et jusqu'au rebord de la marge continentale. La ratification de la CNUDM accorde aux Etats côtiers le droit de présenter à la Commission des limites du plateau continental des Nations Unies, dans un délai de dix ans maximums, une demande d'extension de leur plateau continental au-delà de 200 miles marins, mais ne dépassant pas les 350 miles

11. La Convention des Nations Unies sur le Droit de la mer (CNUDM/ United Nations Convention on the law of the sea /UNCLOS), adoptée le 10 décembre 1982 à Montégo Bay et entrée en vigueur le 16 novembre 1994 https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_f.pdf

12. https://geobon.org/bons/thematic-bon/mbon/

13. EurOBIS (https://www.eurobis.org/about): Système européen d'information sur la biodiversité des océans. C'est une base de données biogéographique marine en ligne qui compile des données sur toutes les créatures marines vivantes. Les principaux objectifs d'EurOBIS sont de centraliser les données biogéographiques largement dispersées sur les espèces marines collectées par les institutions européennes et de rendre ces données librement disponibles et facilement accessibles.

14. Aphia et WoRMS https://www.marinespecies.org Aphia permet des interactions entre ses propres données taxonomiques et ceux d'autres bases de données biogéographiques. La gestion interne de la base de données permet une utilisation aisée d'un contenu spécifique - qu'il soit global, régional ou thématique

15. Directrice générale **de l'UNESCO** qui dirige l'initiative Décennie des sciences océaniques au service du développement durable (2021-2030).

16. Ils figurent parmi les principales conclusions du rapport mondial de l'UNESCO/COI sur l'état des lieux des Sciences océaniques.

17. L'atmosphère est la couche gazeuse qui enveloppe certains astres, l'atmosphère terrestre appelée également air se compose de diazote (78%), dioxygène (21%) et d'autres gaz tel que : l'argon le dioxyde de carbone. L'atmosphère joue un rôle essentiel dans la protection de la vie sur Terre par l'absorption partielle des UV, le réchauffement de la surface terrestre (effet de serre) et la réduction des écarts de température entre le jour et la nuit.

18. La cryosphère englobe : les inlandsis (calottes polaires), les plateformes glaciaires, la glace de mer (banquise), le pergélisol les glaciers de montagne, les manteaux neigeux continentaux et la neige saisonnière.

19. Les biomes terrestres sont au nombre de sept : la toundra, la taïga, la forêt tempérée, la prairie tempérée, la savane tropicale, le désert et la forêt tropicale.

20. La lithospère correspond à l'enveloppe solide de la Terre elle est constituée par la croute terrestre et une partie du manteau supérieur.

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32. Pluricellulaires et consommateurs d'autres êtres vivants.

33. Pluricellulaires et capables de synthétiser leur propre matière organique (photosynthèse).

34. Pluri- ou unicellulaires incluant les champignons et les levures et décomposeurs d'autres êtres vivants.

35. Organismes unicellulaires qui peuvent fonctionner soit comme des plantes, soit comme des animaux.

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