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Institut Royal des Etudes Stratégiques
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THE OCEAN, A GLOBAL CHALLENGE AND SOLUTION

STRATEGIC REPORT 2022-2023

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PART II: LAND-SEA INTERFACE STAKES

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 :

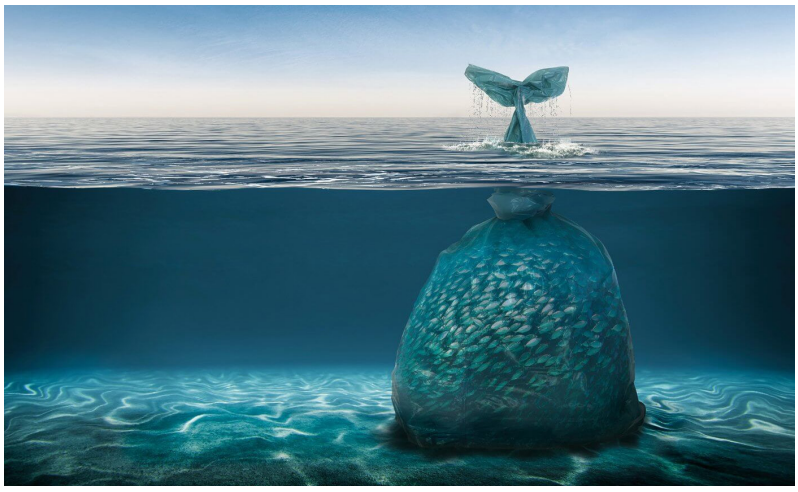
- between two distinct natural components: the Ocean Sphere on the one hand and the rest of the planet on the other (lithosphere*, biosphere*, hydro and cryosphere* and atmosphere*);

- 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, ...).

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.

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

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.

- ✓ 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.

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]

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

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]

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 :

- 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.

- **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.

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

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.

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.

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

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.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