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Institut Royal des Etudes Stratégiques
Royal Institute for Strategic Studies

# SYMPOSIUM ON THE OCEANS AND THE SEAS

**February 19, 2020**

## SYNTHETIC REPORT

**JANUARY 29, 2021**

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# Foreword

Symposium on the Oceans and the Seas, hosted by the Royal Institute for Strategic Studies (IRES), on February 19, 2020, stems from strong interest for the upcoming "International Decade of Ocean Sciences 2021-2030", scheduled for launch in January 2021. It seeks to contribute to the global debate on ocean sciences development to better comprehend the impact of stress affecting ocean ecosystems and identify sustainable solutions.

This meeting is a part of IRES' ongoing work on global strategic issues, including ocean-related issues, to which IRES devotes its 2021 annual strategic report. These builds-on events previously held by the Institute, including:

- the International Meeting on "The Strait of Gibraltar: Issues, Challenges and Stakeholder Approaches", held on September 24, 2018,
- the International Meeting on "Geostrategic challenges of maritime spaces", held on November 30, 2015,
- the Roundtable presentation of Hassania CHERKAOUI's book "Moroccan and comparative maritime law", held on November 25, 2014.

Along with active contributions from academics spanning a variety of disciplines (e.g. maritime law, marine geology, marine hydrology and oceanography), the meeting was broadly attended by maritime affairs national institution representatives, including the Ministry of Energy, Mines and Environment, the Department of Maritime Fisheries, the Department of National Planning, the Royal Navy, the Royal Center for Remote Sensing (CRTS), the National Office of Hydrocarbons and Mines (ONHYM) and the National Institute of Fisheries Research (INRH).

This symposium sought to identify national maritime issues, current and future, present good national-level practices in maritime management and solutions for sustainable development of marine and coastal areas by 2040. The meeting closed with a set of prospective workshops aimed at prioritizing global and Moroccan issues and discussing potential solutions, as presented throughout the day.

This report is a synthesis of the day's findings, encompassing presentations, debates and workshops.

# Introduction

Oceanic water bodies consist of uninterrupted water expanses surrounding the continents. Physically, they constitute a single "Ocean", although five oceans are distinguishable (Atlantic, Pacific, Indian, Arctic and Southern). This global ocean as a whole, covers 71% of Earth's surface. This continuous oceanic water body effectively enables thermal, hydric and biological exchanges and constitutes a vector for pollution dissemination.

The ocean is global and is a shared heritage to all humanity. Indeed, It effectively:

- serves as a medium of exchange (90% of world trade), communication and globalization,
- provides a substantial portion of human food supply: seafood is the primary source of protein for over one billion people and accounts for 60% of food supply in tropical developing countries,
- is the origin of life and a reservoir of biodiversity and wealth[1],
- is the principal global climate and meteorology regulator because of its ability to absorb CO2 emissions and store and redistribute solar heat,
- absorbs 30% of carbon dioxide through photosynthesis by plant plankton and produces over 50% of the world's oxygen.

Yet, despite oceanographic studies starting as early as 1872 with the Challenger oceanographic expedition[2], much of ocean floors remain unexplored. The Global Status Report on Ocean Sciences[3] highlights worldwide capacity deficiencies in this area.

The first comprehensive global marine assessment, published by the United Nations in 2015[4], showed significant degradation in ocean health, as evidenced by increased tropical cyclone and monsoon frequency, as well as increased acidification and declining oxygen levels.

These phenomena, which are often irreversible and difficult to regulate, severely impact the life and balance of ecosystems (living resources, food chains, reduction of biodiversity), human health and the integrity of infrastructures and physical assets.

For all of these reasons, the United Nations General Assembly proclaimed 2021-2030 as the "International Decade of Ocean Sciences" in its 72nd session in 2017. Launched in January 2021, the initiative seeks to rally both the science community and policy makers to advance ocean science to better comprehend the impact of ongoing stress on our oceans and identify sustainable solutions.

Oceans are everyone's responsibility, as enshrined in international conventions that call on States to ensure its integrity as an ecosystem and protect its biodiversity.

Morocco, a maritime country par excellence, is impacted in more than one way. The country boasts façades on three different marine domains: the Mediterranean Sea, the Strait of Gibraltar and the Atlantic Ocean, spanning 3500 km in length. Nine of the twelve regions outlined in the latest advanced regionalization plan have a coastline[5]. The Exclusive Economic Zone (EEZ)[6] covers over 1 million km2. These maritime areas are the seat of major geopolitical, socio-economic, cultural and historical, environmental, scientific and ecological issues.

This report summarizes the findings of the symposium on the oceans and the seas. It consists of four parts: the first part reviews current and future national maritime issues. The second part presents national good practices in managing marine and coastal areas. The third part identifies avenues and solutions for the sustainable development of these areas. The fourth part presents global and national priority issues and potential solutions.

# 1. Mapping national maritime issues

## 1.1. Geopolitical issues

Morocco is a maritime country, perhaps even a maritime power unaware of itself. Ancient Arabs referred to Morocco as the peninsula of the Orient's Far West. Atlantic, Mediterranean and Gibraltar, the Kingdom enjoys a unique geostrategic position because of its "tri-oceanic" location.

Morocco's maritime territories are of major geostrategic significance and have role to play as key interfaces in a globalized world. These territories bridge a number of geopolitical areas, including the Mediterranean, Europe with 23 coastal states, Africa with 37 coastal states, Latin America with 10 coastal states and North America with 2 coastal states. The Kingdom also faces the Strait of Gibraltar, a crucial global maritime route. Its' exclusive economic zone (EEZ) borders those of Spain, Portugal, Mauritania and Cape Verde. Its Atlantic continental shelf is adjacent to those of Portugal and Spain to the North and to those of Atlantic West African countries to the South.

Security is a concern for Morocco. Indeed, Moroccan maritime areas lie at a crossroads of shipping routes. The country is therefore called upon to prevent and combat: 1) illegal migration; 2) illegal and unauthorized fishing; 3) terrorism and illegal activities (trafficking in drugs, arms and other goods); and 4) oil spills and the discharge of hazardous waste at sea.

Aware of these challenges, Morocco has embarked on a strategy of regional and international cooperation. It actively contributes to a number of international organizations, including UNESCO's Intergovernmental Oceanographic Commission (IOC)[7], where it sits on the Executive Council since 2015, the International Maritime Organization (IMO)[8] where it is a member since 1962. Regularly re-elected as a member of the Council since 2011, it is also active within the Food and Agriculture Organization of the United Nations (FAO), the International Commission for the Conservation of Tuna (ICCAT), the General Fisheries Commission for the Mediterranean (GFCM) and the Fishery Committee for the Eastern Central Atlantic (CECAF).

Morocco ratified a number of international conventions on maritime environment, waste and hazardous chemicals, fauna, flora and environmental protection. It is a State Party to the United Nations Convention on the Law of the Sea (UNCLOS)[9]. In accordance with Article 76 of this Convention, it began the process for extending its continental shelf beyond 200 miles.

Morocco's Permanent Mission to the United Nations submitted a report to this end in July 2015. Morocco also signed or ratified a number of international conventions including:

- the Barcelona Convention and its 7 protocols on the Protection of the Marine Environment and Coastal Regions of the Mediterranean[10],
- the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (F.I.P.O.L.), 1992[11],
- the International Convention for the Prevention of Pollution of the Sea by Oil[12],
- the International Convention on Intervention on the High Seas in Cases of Oil Pollution Casualties[13],
- the Convention on International Regulations for Preventing Collisions at Sea and its annexes[14],
- the United Nations Convention on the Carriage of Goods by Sea (The Hamburg Rules)[15].

Finally, it actively contributes to international efforts to combat global warming via a range of actions, events and programs, including:

- the "Tangier Appeal", for united and decisive action on climate change, signed by His Majesty King Mohammed VI and President François Hollande,
- the implementation of solar and wind energy production projects to account for 52% of installed electrical capacity by 2030 and 52% of energy production by 2050,
- the hosting of the COP 22 in November 2016 in Marrakech,
- climate change mitigation programs and action plans.

Domestically, Morocco strengthened its legal arsenal to assert sovereignty over maritime territories and ensure their regulation. It thus adopted the "Maritime Trade Code" as early as 1919 (Official Bulletin of May 26, 1919 and amendment of August 15, 1930), supplemented and amended by Law No. 16-07 of July 16, 2010 and Law No. 46-12 of April 27, 2016.

Then, in 1973, it enacted Dahir establishing Law 1-73-211 of 26 Moharam 1393 (March 2, 1973) fixing Moroccan territorial water boundaries and exclusive fishing zones, amended and supplemented by Law No. 37. 17 (Official Bulletin of March 30, 2020) and in 1992, the Law on the search for and exploitation of hydrocarbon deposits (Dahir No. 1-91-118 of 27, Official Bulletin No. 4146 of April 15, 1992) later amended and supplemented by Law No. 27-99. It also set out to delimit its maritime territories as follows:

- Decree fixing base lines and geographical coordinates for measuring external limits of maritime spaces (Decree No. 2-15-311 of July 21, 1915),
- Declaration of the 200 nautical mile EEZ (Dahir promulgating Law No. 1-81 of April 8, 1981) as amended and supplemented by Law No. 38.17 (Official Bulletin of March 30, 2020).

Maritime governance still suffers from a range of shortcomings, mainly stemming from dispersion of responsibilities and absence of proper coordination among stakeholders. This calls for creating a regulatory entity to oversee maritime action. **Establishing an inter-ministerial delegation in charge of maritime affairs is therefore advisable**. A truly integrated and comprehensive maritime strategy embracing all facets of maritime State action, strengthening South-South cooperation and developing marine sciences for African integration, is a critical requirement.

## 1.2. Socio-economic issues

Coastal and marine areas of Morocco are vital, they contribute greatly to the country's reputation and economy (fishing, aquaculture, tourism, import/ export, renewable energy production) and are home to substantial investment. Moreover, they will play an even greater role in the future, as evidenced by the number of ongoing projects and challenges ahead.

Maritime routes account for over 95% of global commerce[16]. Port activity reported 137.5 million tons in total traffic and 5.4 million passengers in 2018[17]. It is projected to expand with continued economic integration with Europe and Africa, development of free zones and commercial and industrial logistics, and implementation of major port infrastructure projects in Nador, Kenitra, Safi, Jor Lasfar and Dakhla.

The fishing sector is a significant component of the national economy. It accounts for 2.5% of national GDP and generates 115,605 direct jobs at sea including 113,377 permanent jobs on board fishing vessels and 93,736 jobs on land, along with another 500,000 indirect jobs[18].

- National fishery production amounted to 1,372,000 million tons in 2018 at an average annual growth rate of 2.3% for the 2010-2018 period, equivalent to MAD 11.6 billion in value, at an average annual growth rate of 7.2% for the same period[19]. This productive capacity places Morocco at the top rank in Africa and 13th worldwide for fish production in 2018[20].
- The fish processing industry counts 414 plants, processes 70% of catch and exports 85% of production. Total 2018 production amounted to 723,000 tons for MAD 20 billion in turnover[21].

- The sector serves both domestic and export markets, accounting for 8.2% of total exports and 43% of agri-food exports. Seafood exports, in 2018, reached 723,000 tons for an estimated MAD 22.5 billion. Average annual growth rate for 2010-2018 stands at 6.9%.

The aquaculture sector comprises some twenty farms and five marine aquaculture development stations. The sector produced 510 tons, for a turnover of MAD 21 million in 2016, and employs 250 people[22].

Seaweed harvesting (uncontrolled and intensive) is estimated at 6,950 tons in 2017 with exports of raw red seaweed at 1,520 tons and Agar Agar at 967 tons[23].

Tourism is another priority economic sector. It contributes 7% to GDP and is a significant employer with 550,000 direct jobs in 2019, accounting for nearly 5% of overall employment[24]. Seaside tourism is particularly significant. The coastline, offers substantial opportunities for tourism development, owing to a variety of climates and natural landscapes. It is home to 70% of hotels and is increasingly popular with tourists. The sector continues to grow, although current numbers do not fully live up to Morocco's potential as a tourist attraction. It posted 11.35 million tourists in 2017[25].

Sea water desalination began with the Tarfaya station and a productive capacity of 75$m^3$/day in 1975 and the Boujdour station with a productive capacity of 250m3/day in 1977. The Laayoune station, with a production capacity of 7000$m^3$/day came into service in 1995, followed by a second station with a capacity of 26,000$m^3$/day in 2010 and construction of a new 2600$m^3$/day-capacity station in Boujdour in 2005. The Kingdom then built the Jorf Lasfar station in 2016, with a production capacity of 25 million $m^3$/year, scaling to 40 million $m^3$/year by end 2021. Other stations are planned in Agadir for a production capacity of 275,000 $m^3$/day as well as in Dakhla, Casablanca, Al Hoceima, Nador and Driouech. Seawater desalination is projected to grow and expand to other regions to meet population growth and water shortage risks arising in the event of intensified global warming.

Investment and economic development of Morocco's coastline expanded continuously over recent decades. They are to experience continued sustained growth, both in space and time, because of population growth and heavy urbanization. The coastline concentrates the country's largest urban centers. It includes 45 new urban centers and posts urbanization rates of 69% on the Atlantic coast and 49% on the Mediterranean coast.

It is also home to communication networks and major seaside resorts including Mediterranea Saidia, Mazagan Beach Resort, Mogador Essaouira, Port Lixus and Taghazout Bay, as well as developments in Mar Chica (Nador lagoon), Bouregreg Valley and Rabat corniche. Fishing and aquaculture infrastructure also expanded significantly (2 regional fishing ports, 9 local fishing ports, equipped disembarking points, fishing villages and aquaculture stations), as did traffic and trade (13 commercial ports and 6 marinas).

According to the High Commission for Planning, the coastline is home to 82.6% of industrial production, spanning textiles, leather, chemical and para-chemical industries, food processing, mechanical, metallurgical and electrical industries, as well as oil refining.

## 1.3. Oil exploration issues

The National Office of Hydrocarbons and Mines (ONHYM)[26], charged with the development of the Kingdom's hydrocarbon resources and mines (except phosphates), implemented an enhanced strategy to strengthen hydrocarbon exploration across all Moroccan sedimentary basins, including those offshore.

It is noteworthy that Morocco's offshore of the Atlantic Ocean passive margin covers 400,000 $km^2$ and that of the Mediterranean Sea active margin covers 50,000 $km^2$.

Offshore oil exploration began in the early 1960s and primarily occurs within the 200 nautical mile area of the Atlantic continental shelf. ONHYM currently disposes of an extensive standard format dataset. To date, 44 boreholes were drilled (42 in the Atlantic and 2 in the Mediterranean) over a total area of 94,040 $km^2$. Most of these were drilled in the 1960s off Agadir and Tarfaya.

ONHYM is determinedly exploring Morocco's offshore hydrocarbon potential by means of a strategy based on:

- strengthening world market integration momentum and developing international investors' partnerships to promote hydrocarbon potential,
- conducting surveys and assessments, as well as monitoring and supporting partners (currently five companies operate offshore),
- promoting Morocco's oil potential and encouraging exploration by means of a Hydrocarbon Code[27] and attractive incentives.

On the environmental front, ONHYM ensures compliance with best environmental practices and, where appropriate, site restoration in the event of damage. A set of environmental protection measures is in place to minimize oil exploitation and production operations impacts and mitigate adverse effects on the environment. Impact studies systematically precede project starts, with a specific process for validating and ensuring result-acceptability. Furthermore, preventive measures are in place through ecosystem-based oilfield management.

ONHYM is in charge of preparing technical documentation and contributes to the preparation of the legal arguments as part of the Kingdom's continental shelf extension project[28]. As Morocco ratified the International Convention on the Law of the Sea [29] in 2007[30], it is bound to submit its request for extension of its continental shelf to the United Nations Commission on the Limits of the Continental Shelf[31]. In addition to socio-economic aspects, continental shelf extension is primarily, a geostrategic consideration for Morocco, as it contributes to strengthening its role and position in regional and international affairs.

## 1.4. Historical and cultural issues

The Moroccan coastline is an open-air museum, illustrating Morocco's cultural diversity and rich history, dating back to the Paleolithic age[32]. This land of memory and history boasts exceptional archaeological and historical assets. It is dotted with archeological layers, sites, cities, monuments and objects that testify to human activity and successive civilizations throughout prehistory, antiquity, Islamic and contemporary periods.

Morocco's coastline holds a number of prehistoric sites (the most famous of which being the Hercules and Achekar caves near Tangier) and significant vestiges of Phoenician and Roman occupations during antiquity, such as Chellah, Lexus and Tamuda. It is also rich in monuments and cities built by the different dynasties that followed one another (Idrissid, Almoravid, Almohad, Merinid and Saadian), as well as in vestiges and monuments from the Portuguese (in Boujdour, Agadir, El Jadida, Casablanca and Kenitra) and Spanish occupations (in Tetouan, Ksar Seghir, Tangiers, Asilah and Larache).

These sites, the oldest in North Africa, are exceptional and crucial archaeological archives for both Moroccan prehistory and understanding the development and distribution of human settlements in prehistoric North Africa. Human remains (Homo erectus and Homo sapiens), as well as tools and engravings, help identify prehistoric human groups, relevant chronologies from Lower Paleolithic (Acheulean) to Neolithic as well as behaviors and environmental context of these settlements.

Vestiges of ancient civilizations include the remains of cities, military fortifications and trading posts, monuments, utilitarian and ornamental objects and coins. These have been found across a number of coastal regions (Rebuffat, 1974; de la Martinière, 1912).

Apart from Cotta, near the Cave of Hercules and the most important Roman site in the region of Tangier, most sites attest to both Phoenician and Roman occupation. These include: Rusaddir in Melilla, Tamuda in the valley of Oued Martil, Kouass on the right bank of Oued Ghrifa north of Asilah, Zilis, Zilil, Lulia and Constantia, in Dchar Jdid 13km northeast of Asilah, Lixus the oldest city in North Africa near Larache on the right bank of Oued Loukkos, Thamusida near Kenitra on the estuary of Oued Sebou, Sala in Chellah in Rabat, Anfa (today Casablanca), Azama (today Azemmour), Mogador Island near Essaouira and Cerné in Dakhla.

Vestiges of the Islamic period (medinas, kasbahs, citadels, palaces, walls and gates, monuments, mosques, zaouias, medersas, forts, harbors, and lighthouses)[33] are found in many coastal cities: Ksar Seghir, Tangier, Mehdia, Salé, Rabat, Casablanca, El Jadida, Safi, Essaouira and Agadir. They were erected by the Idrissides, the Almoravides, the Almohades, the Merinides, the Ouatassides, the Andalusians, the Saadians and the Alaouites.

Monuments built during the Islamic period, include those of: 1) the Portuguese occupation in Sebta, Ksar Seghir, Tangier, Asilah, Larache, Mehdia, Casablanca, Azemour, El Jadida, Safi, Souira quedima, Essaouira, and Essaouira: Sebta, Ksar Seghir, Tangier, Asilah, Larache, Mehdia, Casablanca, Azemour, El Jadida, Safi, Souira quedima, Essaouira, Agadir and Boujdour and 2) the modern protectorate period with a proliferation of Western architectural styles: Hispano-Moorish, art deco and modern art in the coastal cities under Spanish protectorate (Tetouan, Tangier, Asilah, Larache) and those under French protectorate (Rabat and Casa)

The post-independence period saw the construction of two great monuments under the reign of His Majesty King Hassan II. The Mohammed V Mausoleum in Rabat, both a royal tomb and a place of meditation on the Hassan Tower esplanade on the left bank of Oued Bouregreg. Built in Arab-Andalusian style, it is a jewel of Moroccan architecture and one of Rabat's finest monuments. The Hassan II Mosque, the world's second highest religious building, built, in part (two thirds) on the sea in Casablanca, is both a religious and cultural complex and an architectural masterpiece.

This historical and cultural heritage plays an undeniable socio-economic role. It contributes largely to tourism development in a number of coastal cities that have become leading tourist destinations.

It also plays a role in the cultural influence of Morocco, as history and socio-economic structures combine. Furthermore, beyond its priceless value as part of the country's cultural and historical legacy, this heritage bears witness to the spirit of religious and cultural tolerance that prevailed in Morocco.

This collective memory constantly recalls both the need and value of "living together", and serves as a foundation for present and future development. This heritage is also world heritage. In fact, a number of these monuments are on UNESCO's world heritage list[34].

This cultural and historical heritage, already fragile by its very nature and the wear and tear of time, now faces both the impact of anthropic activities and natural hazards. Quaternary geological sets have yet to yield their full prehistoric and ancient evidence, as archaeological exploration and geological surveys have yet to fully explore Morocco's coastline. Hence, any work for the establishment of new buildings or infrastructures can result in damage and even loss of unstudied and un-interpreted prehistoric and historical remains.

Furthermore, development and growing, and at times anarchic, urbanization as well as coastal sand extraction induces significant sedimentary imbalance. This imbalance could in turn lead to the destruction of cliffs, receding coastlines, subsidence of fixed dunes, migration of sand to the mainland and higher hydrodynamic energy. Finally, yet importantly, coastal risks stemming from global warming, earthquakes and tsunamis, could lead to flooding and erosion.

It is thus urgent to protect and enhance this heritage. Specifically, it is essential to consider cultural and historical issues in coastal sustainable development policy and integrated coastal zone management. To this end, it is recommended to:

- conduct a geo-referenced database survey, including spatialization, historical context, technical characteristics, vulnerability and stakes for all identified heritage sites, and current legislation,
- enhance archaeological, geological and coastal oceanology studies,
- archive this heritage in atlases,
- create local museums in cities with cultural and historical significance as well as a National Museum of the Sea,
- rehabilitate and develop sites to ensure preservation and raise awareness among local populations,

- strengthen and especially enforce legislation and regulations on coastline occupation and development and the protection of cultural and historical heritage sites to ensure these are not destroyed, denatured or submerged in any form of urbanization,
- continue inclusion of sites in national cultural heritage lists[35] and in UNESCO's world heritage list[36].

## 1.5. Environmental risks and challenges

Morocco's coastal areas are both an asset and a handicap. On one hand, they significantly contribute to the country's economy, and on the other, they are vulnerable to natural and anthropogenic risks.

As all coastal and marine environments, ecosystems of Moroccan ocean margins are inherently fragile. Changes in these environments happen not only on a human scale, but in a matter of seconds. Indeed, on the one hand, they depend on a range of interdependent natural factors, and change in one factor can affect all others. On the other hand, ecosystems making-up these environments are very closely interconnected. Consequently, developments in one ecosystem affect all others. Human activity and natural disasters are as many factors accelerating degradation of these environments.

### 1.5.1. Natural risks

Coastal and marine areas face major natural hazards, including: rising sea levels, earthquakes, tsunamis, landslides and corollary gas hydrate mud volcano eruptions. These hazards stem from global warming, geotectonic context of Moroccan oceanic margin and gas hydrates in the substratum of these margins.

#### ➢ Global warming

The Intergovernmental Panel on Climate Change (IPCC) report[37] of October 8, 2018, is more alarming than previous versions. It confirms that global warming is indeed induced by greenhouse gas (GHG) emissions and is rising at a rate of 0.17°C per decade since 1950. Temperatures have already increased 1°C and projected to rise another 1.5°C between 2030 and 2052 and 3°C by the end of the century.

Global warming will cause a global rise in mean sea levels of 26 to 77 cm from 1986-2005 levels by 2100, according to a 2019 IPCC special report[38]. Moreover, TOPEX/POSEIDON[39] data shows accelerated sea level rise, doubling in pace over the past 20 years, to reach 3 mm/year.

IPCC projections also predict an increase in temperature and acidification of ocean waters as well as an intensification of cyclones and a change in ocean currents and upwelling zones.

Global warming would therefore be catastrophic for biodiversity, as well as for human health and survival. Biodiversity and living organism populations are vulnerable to acidification, which results in:

- diminishing levels of carbonates essential for the formation of skeletons and shells,
- disappearance of living organisms with skeletons and limestone shells,
- change in composition and disappearance of zooplankton microorganisms (the base of the food chain).

Rising temperatures also limit the activity of living organisms, which are normally only active within specific temperature ranges. Even when adult forms tolerate large temperature variations, reproduction and development of younger specimens requires more stringent conditions. It is also responsible for rising occurrences of invasive species (jellyfish) and algae blooms, as well as changing timing of phytoplankton blooms, reproduction and migration.

Rising sea levels are responsible for an increase in extreme weather events, changes in ocean flow and bathymetry, coastal erosion, flooding and even coastal and continental loss, changes in the range and spread of marine species, loss of coastal habitats and saline intrusions into freshwater habitats.

Global warming is already underway in Morocco, with the National Directorate of Meteorology[40] reporting a correlation with global temperature increases and showing higher average annual temperatures for all cities since 1971, ranging from 0.8°C in Al Hoceima to 2.6°C in Oujda. It also forecasts a 1 to 1.5°C increase by 2100 in the best case and 4 to 5°C in the worst case.

Morocco's geographical location leaves it doubly vulnerable to global warming. First, vulnerability stemming from increased temperatures, which exacerbates pre-existing physical, ecological and socio-economic stresses, as current climates range from Mediterranean in the North to Saharan in the South. The second is a vulnerability to submersion and flooding.

Climate change impacts are attested to by shorter snow cover durations in mountain areas, temperature peak frequency and intensity of drought periods, warming coastal waters and saline intrusions. They are further evidenced by surges hitting the Atlantic coastline from Tangier to Laayoune in 2014 and damaging homes and tourist and port infrastructure. A World Bank[41] survey of 463 fishermen found a range of impacts, including:

- fewer fishing days due to increased number of storms,
- shifting reproductive seasons,
- dwindling stocks and extinction of some species,
- displacement of small pelagic stocks southward,
- periodic appearance of jellyfish in the Mediterranean (Al-Hoceima, Nador and Larache),
- proliferation of algae (observed in M'diq and Casablanca).

### ➢ Seismic risks and tsunamis

Morocco sits at the northwestern end of the African tectonic plate and, as such, features a complex geodynamic environment with the following characteristics:

- A distensive regime in the Atlantic margin, caused by the divergence between the African and American plates (opening of the Atlantic Ocean) and the South Atlas Fault near Agadir.
- Compressive geodynamic conditions on the Mediterranean margin due to NNW-SSE convergence of the African and Eurasian plates.
- Proximity of the "Azores-Gibraltar" transform fault, which forms the northern limit of the African plate and extends to the Mid-Atlantic Ridge.

This geodynamic context is behind the seismicity of both Atlantic and Mediterranean margins. The Mediterranean margin has moderate seismicity with magnitudes of about 5.4, but can generate numerous aftershocks following a primary tremor. Recent earthquakes in the region of Al-Hoceima are a direct such consequence.

Furthermore, as Morocco is bordered by marine areas, it is not immune to tsunamis triggered by earthquakes at sea. This applies to the North Atlantic shelf, where earthquakes along the Azores-Gibraltar transform fault are generally above seven in magnitude and generate tsunamis.

The review of historical data and analysis of tectonic and geological data indicate that the risk is real[42]. In fact, a number of tsunamis have hit the Mediterranean and Atlantic coasts since 218 BC, the most famous being the Lisbon earthquake of 8.5 to 9 magnitude in 1755, which hit the Atlantic coast of Morocco and the latest the Mediterranean in 2003.

Tsunami impact assessments on the Tangier (Benchekroun et al., 2013) and Atlantic coastlines (Atillah et al., 2011; Mellas et al., 2012), indicate strong tsunami risk exposure along the Rabat-El Jadida urban corridor. The most vulnerable buildings are those in the old medina and on the beach of Rabat. These would suffer significant damage in case of tsunami.

- **Risks of mud volcano reactivation**

Mud volcano activity resulting from gas hydrate expulsion was identified on the Moroccan shelf of the Gulf of Cadiz (Pinheiro et al., 2003; Henriet et al 2006), on the Mediterranean Moroccan shelf (Comas et al. 2003) and on the southern shore of the Strait of Gibraltar (Hamoumi, 2005, 2006). With global warming, the rise in temperature of ocean masses could dissolve and release methane hydrates from seabed mud volcanoes into the atmosphere. Reactivation of these mud volcanoes, in addition to heightened global warming, could produce boulder projections of varying sizes, extensive mud eruptions and landslides, affecting biodiversity.

### 1.5.2. Anthropogenic risks

Morocco is committed to sustainable development since the Rio Summit of 1992. The country chose a strategy of regional and international cooperation and signed or ratified a number of international conventions. Domestically, it opted for a strategy of environmental protection and sustainable development (1995) and a National Action Plan for the Environment (PANE, 2002). It also established a Charter for the Environment and Sustainable Development and a legal arsenal for the protection and enhancement of the environment, including Laws 11-03[43] , 12-03[44], 13-03[45] and 81-12[46].

The 2011 Constitution[47] further enhances this legal arsenal. Morocco also launched a number of environmental and waste management initiatives such as the "Zero Mika" campaign and the enacting of Law n°77-15[48].

Furthermore, Morocco implemented a number of strategies, action plans and programs that include:

- a national strategy for protected areas and wetlands in national parks or classified as Special Interest Biosphere Reserves (SIBE),
- the SNAT and SRAT land use planning schemes, adopted in 2004,
- the Development and Urban Planning Schemes for Coastal Areas (SDAUL),
- the Regional Development Plan (PDR),
- the National Coastal Management Strategy, launched by the Directorate of Land Management,
- the National Littoral Plan in 2017,
- the National Surveillance Program of the Moroccan Mediterranean Coast (MEDPOL),
- the National Emergency Plan and its implementation decree of 2003: a contingency plan to respond to accidental marine hydrocarbon pollution,
- the Industrial Depollution Fund (FODEP), in partnership between the Department of the Environment and German agency KfW,
- the National Program for "Monitoring Bathing Water Quality" (since 1993) and the "Clean Beaches" Initiative set up by the Mohammed VI Foundation for the Protection of the Environment,
- the INRH costal health monitoring network since 1994,
- the Nador lagoon development program,
- programs for the protection of the Oualidia and Dakhla lagoons.

However, this arsenal of institutional measures and actions by public authorities to enhance coastal and marine area management and preservation, while admittedly positive, has yet to effectively curb often-irreversible degradation risks. This for several reasons, including:

- legislation that is often incomplete or difficult to implement for want of application decrees or simply not enforced.
- management by multiple departments with little effective coordination or true "Integrated Coastal Zone Management" (ICZM).

- development project feasibility and impact studies not always based on scientific data (Hamoumi and Irzi, 1999; Hamoumi, 2020b).
- growing and anarchic coastal development and heightened anthropic pressure.

The coastline is in fact 60% urbanized. It concentrates the largest urban centers in the country and saw the emergence of 45 new urban centers. 54% of the population is concentrated on the coast, of which 70% in urban coastal areas, particularly along the Kenitra-El Jadida corridor.

It is home to 70% of hotels and growing numbers of tourists (54.7% of overnight stays). It is also home to major seaside resorts: Mediterranea Saidia, Mazagan Beach Resort, Mogador Essaouira, Port Lixus and Taghazout Bay and developments of the Mar Chica project (site of the lagoon of Nador), the Bouregreg valley and the Rabat Corniche.

The coastline also experienced diversification and expansion in both time and space of human activity including fishing, aquaculture, agriculture, industry and port development. Port infrastructure already comprises 13 commercial ports, 12 regional fishing ports, 9 local fishing ports and 6 marinas, and will expand with 5 new ports planned by 2030: West Nador, Kenitra, Dakhla, Safi and Jorf Lasfar.

Coastal zones are under pressure, causing severe degradation of littoral and marine ecosystems that suffer from sedimentary imbalance and/or pollution. Degradation costs pegged at 0.27% of GDP[49] are largely under-estimated, as a number of polluting factors are not considered.

### ➢ Sedimentary imbalances

Sedimentary imbalances affect coastal areas causing erosion, disappearance of a number of beaches, steadily receding coastline, silting up of harbors, increased desertification and marine water infiltration. A number of scientific studies brought these sedimentary imbalances to light.

Sedimentary imbalances are induced by: 1) Abusive exploitation of sand, 2) Seaside activities and anarchic occupation of dunes and upper beaches, 3) Tourism and port facilities and defense works (jetties, spurs, breakwaters) built with no prior site survey and monitoring (medium and / or long term) of sediment dynamics and hydrodynamics.

### ➢ Anthropic pollution

In addition to industrial pollution from countries on the northern shore of the Mediterranean and pollution of atmospheric origin, coastal and marine areas face liquid, gas and solid discharges from continental pollution and pollution induced by domestic, agricultural, industrial, port, tourism, fishing and dredging activities, all of which have grown and thrived along the coastline over time.

The sea is the main receptacle for wastewater. There are currently but 70 wastewater treatment plants (WWTP); sanitary networks are still insufficient, particularly in rural areas.

Quality assessments of water bodies, sediments and fauna of coastal ecosystems, conducted by a number of universities indicate metallic and organic pollution along the coastline.

Bathing water quality assessments of Moroccan beaches in 2018 [50], show that 27.55% of the 423 samples are of average quality, 1.62% are temporarily polluted and 0.46% are of poor quality. Similarly, 2014 results obtained under an INRH monitoring program[51], indicate persistence of high cadmium levels along the Atlantic coast between El Jadida and Dakhla.

## 1.5.3. Risks of oil spills

Coastal and marine areas are highly exposed to increased pollution from operational discharges and oil spills because of traffic density and increase in the size and average age of ships.

On one hand, they lie in proximity to the oil ports of northern Mediterranean countries. On the other, they are at a crossroads of international shipping and tanker routes from Africa, Europe, America and the Middle East. In addition to the major supply flows to Europe from the Middle East (via the Cape route and the Suez Canal), there are those from North Africa.

Total annual transported hydrocarbon volume in the Mediterranean region stands at 370 million tons, or 20% of world oil transits[52] and at between 400 and 500 million tons along the Atlantic coast[53]. The Strait of Gibraltar, with 350 million tons of oil, gas and chemicals transported by 600 ships daily, is among the most vulnerable areas. There is an average of two accidents per year. There were 32 such accidents between 1979 and 2001 in Moroccan Atlantic and Mediterranean territorial waters and the Spanish maritime waters of Gibraltar and Algesiras, the most note-worthy being those of KHARG V and SEA SPIRIT.

Despite a "National Contingency Plan" for responding to accidental marine pollution by hydrocarbons, it is difficult to develop efficient response and protection strategies in case of an oil spill, as there is little knowledge of factors and variables interacting to disseminate pollution, of trajectories and areas of pollution concentration, and of resources likely impacted, their fragility and resilience.

## 1.6. Scientific and Ecological Issues

Outcrops of quaternary age[54] occur along the littoral in both Atlantic and Mediterranean margins. These sedimentary series are priceless geological assets. They present indisputable scientific value in the study of Morocco's prehistory (see § 1.4) and of Quaternary era geology.

Theses sediments are in fact extremely rich in fauna. Quaternary formations in the Casablanca region include exceptional sequences of universal significance that enabled the Quaternary stratigraphy of North Africa (Lefevre and Raynal, 2002). Sediment records of environmental and/or global parameters are likely best preserved in such deposits, formed over the last 2.6 million years and thus among the youngest geological formations in Earth history. They indeed provide an ideal opportunity to learn about and understand:

- sea level variations, including the Holocene transgression that gave rise to today's shelves and coastal ecosystems,
- climatic changes; the Quaternary period includes several glacial/interglacial cycles over a period of global climate cooling, starting in the late Tertiary period,
- recent tectonics of Morocco's oceanic margins.

The Moroccan coastline also offers a great diversity of ecosystems, constituting priceless natural resources of considerable scientific interest: beaches, rocky coasts (steep coasts, cliffs and capes), bays, estuaries, river mouths, lagoons and marshes, spanning climates that range from Mediterranean in the North to humid Mediterranean in the median part and Saharan (arid) in the South.

A number of these ecosystems are classified as "Sites of Biological and Ecological Interest" (SIBE)[55]. The most notable being the mouth of the Moulouya, the Bou Areg Sebkha, the Cape of Three Forks, Jbel Moussa, Oued Tahaddart, the marshes of Larache, the Merja Oulad Skhar, the Merja Bargha, the Merja Halloufa, the Merja Zerga, Sidi Boughaba, the cliff of Sidi Moussa, the islets of Bou Regreg, the islet of Skhirat, Jorf Lasfar, Sidi Moussa-Oualidia, the dunes of Essaouira, the archipelago of Essaouira, the mouth of Tamri, Cape Ghir, Foum Assaka, the mouth of Oued Drâa, Oued Chebeika, the lagoon of Khnifiss, the tip of Awfist and the Bay of Dakhla.

Moroccan waters also rank among the world's most fish-rich, notably off the Atlantic coastline, where upwellings occur. They feature abundant and diversified biodiversity evidenced by the presence of 7825 species, including 7136 animal forms and 689 plant forms (Menioui, 2001) and by the presence of cold-water coral carbonated mounds. They are also passageways for many migratory species of ecological and economic interest.

The Strait of Gibraltar, declared a "Special Area of Conservation" in 2012[56], is a migration corridor for a number of species of fish (tuna, eel) and marine turtles (green turtle, leatherback and loggerhead turtle). It is also one of only four areas worldwide to observe specific cetaceans including migratory species (fin whale), indigenous (common dolphin, bottlenose dolphin, Tursiops, whale) and semi-indigenous (sperm whale, killer whale). It is also a principal bird migration corridor and a place of passage and stop-over of migratory birds traveling between Europe and Africa and of marine and coastal birds moving between East and West.

The southern and northern shores of the Strait are essential stopover points for breeding, resting, provisioning and feeding for a multitude of migratory birds. They accordingly provide a special place for ornithologists, to observe migratory birds and study the evolution of biodiversity and migratory phenomena. Wetlands all along Morocco's coastline likewise provide an environment of passage and reproduction for migratory birds.

## Focus on cold-water corals

Cold water corals are one of the most striking discoveries of recent decades. First discovered in the late 1970s off the British Isles and then a few years later off Norway. Discoveries have since multiplied and span many regions of the globe.

These bioconstructions are of both socio-economic interest (oil exploration, jewelry) and significant scientific interest. They are in fact valuable paleo climatic indicators, as they quickly respond to climate change.

These species, living over 8000 years, provide an "archive" of mean ocean temperatures. They also constitute genuine ecological niches, as they provide substrate, refuge and food for a diverse fauna of invertebrates and fish.

Morocco's oceanic margins are listed among global cold-water coral biogeographical zones. Cold-water coral carbonate mounds were recently discovered in the Strait of Gibraltar (1994), as well as in Moroccan oceanic margins of the North Atlantic (2002), South Atlantic (2015) and the Mediterranean in Eastern Alboran Province (2006) and Western Alboran Province (2011).

These corals formed in the last glacial period of the Quaternary. Development of these corals was driven by glacio-eustatic fluctuations, resulting from climate variations in the Strait of Gibraltar (Hamoumi, 1997), the Alboran shelf (Fink et al., 2013; Terhzaz et al. , 2018; Terhzaz, 2019; Krengel, 2020) and the North Atlantic shelf (Terhzaz et al. 2018; Terhzaz, 2019).

These cold-water corals hitherto only impacted by human activities: pollution and physical degradation induced by fishing and oil exploration now face the threat of global warming, and can only survive within specific temperature conditions (Freiwald, 2002).

The temperature of Moroccan oceanic margins currently ranges from 4°C to 13°C, which is essential for most coral species. An increase in temperature could therefore be intolerable for these organisms. Specialists estimate that a 3°C increase could triple their appetite and thus result in death should food supplies remain insufficient.

Ocean water acidity, induced by global warming, destroys the skeletons of these organisms. Faced with global warming, the issue of their preservation arises, even more because their very slow growth rates (4 to 25 mm per year) and that their disappearance would seriously harm biodiversity, as they provide refuge and food for a wide range of fauna.

No direct action can be taken to help this ecosystem adapt to global warming in the current state of understanding of coral biology. However, any measure to combat climate change would contribute to their regeneration. It is therefore recommended to conduct studies of these ecosystems to understand their effective extension, biodiversity and that of species that live in symbiosis with them, in addition to genesis and development drivers. Adopting specific national regulations for coral protection and commitment to the United Nations Environment Program (UNEP) 2004 call of on this subject are both highly advisable.

# 2. National maritime area management practices

## 2.1. Preservation of Morocco's marine and coastal environments

The Environment Department of the Ministry of Energy, Mines and Environment recently introduced an arsenal of institutional measures to ensure comprehensive national coastline management, including the National Strategy for the Environment and Sustainable Development (2030)[57].

This strategy gives priority to ocean and coastal matters and aspires to transition to an inclusive, low-carbon economy by 2030 by means of political, institutional, regulatory and financial reforms. It systematically incorporates environmental considerations into the design of all development projects. To this end, it identifies seven major strategic challenges:

- Issue 1: Consolidate sustainable development governance.
- Issue 2: Succeed in the transition to a green economy.
- Issue 3: Improve natural resource management and development and strengthen biodiversity conservation.
- Issue 4: Expedite implementation of the national policy to combat climate change.
- Issue 5: Give special attention to sensitive areas, including oasis areas, mountain areas and the coastline.
- Issue 6: Promote human development and reduce social and territorial inequality.
- Issue 7: Promote a culture of sustainable development.

Axis 22 of Issue 5 focuses specifically on the coastline, it seeks to improve coastal management and development via: 1) the enactment of control measures and sanctions for the Coastal Law, 2) the development of a "National Coastal Plan" and "Regional Coastal Schemes", 3) the enhancement of coastal water quality improvement actions and 4) the upgrading of accidental marine pollution preparedness and response systems.

The Department of Environment also passed a number of laws on the protection and development of marine and coastal ecosystems, including:

- Law n°11-03[58] on the protection and enhancement of the environment, four articles (33 to 36) cover coastline and maritime resources.

- Law n°12-03[59] on environmental impact studies, enabling assessment of direct and indirect effects on the environment in the short, medium and long term.
- Law n° 22- 07[60] on protected areas and particularly on the protection of coastal wetlands.
- Law n°99-12[61] on the National Charter on the Environment and Sustainable Development, which sets out State action on environmental protection and sustainable development.
- Law n°28-02[62] on waste management and disposal.
- Law 81-12[63] on coastal areas.

Goals of the Law on the Coastline are to:

1) preserve the ecological and biological balance of coastal ecosystems,
2) protect natural and cultural heritage, historical, archaeological and ecological sites and natural landscapes,
3) prevent, combat and minimize pollution and coastal degradation and rehabilitate polluted or degraded areas and sites,
4) ensure free public access to the seashore,
5) promote a policy of research and innovation with a view to enhancing coastal areas and resources.

This calls for the elaboration of a comprehensive National Coastal Management Plan and Regional Coastal Schemes.

The National Commission of Integrated Coastal Management[64] recently elaborated and validated The National Coastal Plan (PNL). It revolves around three guiding principles[65]:

- Progressive inter-sectoral integration, enabling coordination between the National Coastal Plan and other strategies, plans and programs.
- Involvement of key stakeholders by incorporating expectations and addressing major issues and challenges.
- Adopting a comprehensive approach for integrated coastal management targeting spatial, temporal and territorial integration.

The National Coastal Plan set six strategic axes:

1) Coastal governance.
2) Development of territorial planning instruments.
3) Protection and prevention of ecosystems from degradation.
4) Coastal zone enhancement.
5) Improving knowledge.
6) Mobilization and capacity building.

Moreover, a monitoring system was developed to assess and monitor plan implementation and progress made towards sustainable coastal development. The assessment relies on three categories of indicators.

- First set of indicators focuses on governance: they measure plan implementation performance and assess coordination among institutional stakeholders.
- Second set of indicators is ecological and environmental: they assess compliance with environmental objectives and actions to better anticipate and manage coastal risks.
- Third set of indicators consists of economic, social and cultural indicators, enabling the assessment of human activity in coastal areas.

Regional Coastal Plans address the territorial implementation of the National Coastline Plan. The first such scheme covers the coastline of the Rabat-Salé-Kenitra Region, and is developed as part of a World Bank technical assistance project. It aims to effectively implement integrated coastal zone management (ICZM) in planning and territorial development processes.

The Department of the Environment initiated two projects as part of ICZM implementation. The first ICZM pilot project[66] was launched in the Oriental Region with the financial support of the Global Environment Facility (GEF).

ICZM objectives include improving coastal natural resources (wetlands and protected areas) conservation and management and strengthening coastal community resilience to climate change.

This pilot project integrated ICZM into the plan of six municipalities and developed guidebooks for these municipalities and management of the mouth of the Moulouya, Site of Biological and Ecological Interest.

The project helped 8,300 people, including 439 women (28%), creating 1,100 jobs, 319 of which are permanent. It also generated ancillary income diversification activities (seaweed farming: 10 to 25% of income, shellfish farming 20 to 25% of income) and artificial reefs that improved population incomes by 50 to 100%.

The second ICZM project was rolled-out in the Rabat-Salé-Kenitra Region, as part of ongoing cooperation with Italy. Currently in its launch phase, this project seeks to develop beekeeping and ecotourism, set up a shellfish farm[67] and establish integrated management of marine and artisanal fishing waste.

The National Laboratory of the Department of the Environment carried out a number of campaigns to combat pollution and preserve the national coastline starting in 2018, along with annual bathing-water quality programs on 45 beaches (20 Mediterranean and 25 Atlantic).

The Association of "Teachers of Life and Earth Sciences" - Tangier instituted the 'Adopt a beach' initiative for marine waste reduction[68]. This enabled:

- implementing ~~of~~ 4 waste collection missions mobilizing 3 boats and 7 divers per mission,
- organizing ~~of~~ 5 awareness and training campaigns for Fnideq port fishermen, pupils, students and local associations,
- organization of awareness and information campaigns encouraging the fishing sector to contribute to the collection of floating marine waste.

In the fight against accidental marine pollution, Morocco adopted a "National Contingency Plan"[69], setting forth activation criteria, establishing command posts at national and local levels and enhancing responder capacity (training, stimulation exercises). This plan aims to:

- organize and coordinate marine pollution prevention and response actions,
- allocate responder tasks and responsibilities and manage compensation claims,
- set up appropriate detection and warning systems,
- foster international cooperation and mutual assistance.

Last, the Department of the Environment recommends generalizing ICZMs sustainable development and preservation of marine and coastal environments, by enforcing and strengthening the ICZM legal arsenal, adopting a National Coastal Plan and development and implementation of Regional Coastal Schemes.

- Set up a marine space management and preservation program to prevent conflicts of use.
- Strengthen the capacities of all stakeholders in coastal zone protection and enhancement.
- Develop and consolidate regional and international cooperation for better coastal management.
- Promote research and innovation for sustainable coastal development.

## 2.2. Good practices in fishing

The fishing sector accounts for a significant proportion of Morocco's economy. It plays a vital role in Morocco's development in terms of job creation, food security and income generation (see § 1.2). Additionally, demand for fishery resources continues to grow substantially at both domestic and international levels, against a backdrop of rising energy costs and intensified climate change impact.

In light of this, the Department of Maritime Fisheries opted for sustainable fisheries and aquaculture management that includes economic, ecological and social viability considerations using a territorial logic.

To this end, Morocco established a legal framework setting out its two-hundred-mile Exclusive Economic Zone[70], territorial waters and exclusive economic zone boundaries[71] and maritime fishing legislation[72]. It also ratified fishing agreements and treaties, including:

- the Regional Convention on Fishing Cooperation among African States bordering the Atlantic Ocean (July 1991),
- the Convention on the Law of the Sea 2007, establishing the sovereign right of States to develop natural resources in accordance with environmental policy and their obligation to protect and preserve maritime environments.

In the area of fishery governance, the Department of Maritime Fisheries chose to plan maritime areas to ensure sustainable utilization of fisheries resources, combining economic, social, environmental and biological aspects[73].

To this end, it drafted management plans, implemented protected marine areas and launched a national program for the installation of artificial reefs, as well as coastal development and fleet upgrading programs.

The Department implemented twenty fisheries management plans through:

- establishment of management units,
- space-time restrictions designed to protect spawning and nursery areas,
- implementation of biological rest periods,
- creation of prohibited fishing areas by fleet type,
- implementation of complementary technical measures, including the institution of "Total Allowable Catches" (TAC) and "Individual Quotas", the regulation of fishing vessels, the setting of market standard sizes and the fight against illicit unreported and unregulated fishing.

Three marine protected areas, in line with long-term nature protection objectives, were established: "MASSA" and "MOGADOR" on the Atlantic coast and "ALBORAN"[74] in Jebha Martil in the Mediterranean. Site selection drew on area biodiversity and habitat importance and on local population acceptance.

Marine protected areas designed are for fishery purposes (MPA-P), in line with International Union for the Conservation of Nature (IUCN) Category VI[75]. They aim to:

- promote fish stock regeneration,
- guarantee sustainability of fish stocks and fisheries,
- protect fragile ecosystems (biodiversity and habitats),
- support traditional livelihoods of local coastal communities,
- strengthen resilience to climate change and environmental challenges,
- enable conflict resolution among stakeholders,
- generate economic value in the coastal zone, by developing alternative activities to relieve some of the pressure on fishing (tourism, recreational fishing, eco-tourism).

A national program for artificial reefs started as part of the sustainable management of fishery resources. The program's aims to: 1) protect traditional fishing areas from illicit and abusive trawling, 2) improve biodiversity, 3) repopulate marine habitats and 4) develop tourist activities (recreational diving, ...). Artisanal reefs were immersed in the marine protected areas of Alboran and Mogador and off Souiria K'Dima, Cala Iris and Sidi Hssaine. Industrial reefs were immersed off Martil and Agadir and semi-artisanal reefs off Boudinar (part of ICZM).

A number of other traditional fishing programs were implemented. The IBHAR[76] program seeks to upgrade and update traditional fisheries and optimize yields. It consists of two sub-programs: the upgrading of coastal and artisanal fishing practices and fleet modernization.

The program to equip traditional boats with thermal containers was implemented to enhance fishing product value and put an end to the use of plastic bags that damage marine ecosystems. It earned Morocco a Best Practices Award for the valorization of seafood products in 2018[77].

The National Program for Coastal Development "PNAL"[78], for the implementation of "developed landing points" and fishing villages, began in 2000. This program aimed at: 1) providing basic infrastructure for fishing activities and 2) creating micro-development poles to generate jobs and growth and mitigate urban migration.

The National Institute of Fisheries Research (INRH) also established an Observatory of Artisanal Fisheries (OHPA)[79]. In the fight against illegal, unreported and unregulated fishing (IUU), Morocco established an administrative entity to coordinate control of fishing activities. This entity is in charge of informing on catch certification, monitoring fishing vessels by satellite (VMS), ensuring compliance with new regulatory provisions for the prevention and control of illegal, unreported and unregulated (IUU)[80] fishing and ensuring physical control. It also launched a Radio Frequency Identification "RFID"[81] Program for artisanal fishing boats, earning an award for "Monitoring Technology" in 2019[82].

The Department of Marine Fisheries also invested in aquaculture[83] as a flagship project for sector sustainability. Coastal planning for aquaculture purposes was conducted by seamlessly integrating aquaculture with other coastal activities to promote the development of a responsible, sustainable and environmentally-friendly aquaculture based on sound ecosystem management.

Last but not least, the Department of Maritime Fisheries launched its "New Fishing Sector Strategy (2020-2030)" that aims to:

- strengthen measures for optimal fishery resource exploitation,
- continue aquaculture development,
- improve fishery competitiveness,
- integrate research, innovation and new technologies as a driver for sector development,
- optimize public action efficiency in the fisheries sector,

- implement Blue Belt, the ocean and climate initiative,
- implement relevant blue economy projects.

## 2.3. Damage survey: maritime expertise worth preserving

Damage Commissariat is specific to the maritime insurance of goods during transport. This instrument, little known to the public, reiterates that seas and oceans are not only a reservoir of wealth, but also a means of communication and, above all, a fantastic medium of exchange, transport and insurance, giving rise to a large and prosperous trade of the invisible.

A Damage Commissioner is "an insurance company inspector, in charge of ascertaining damages to insured cargo during transport, preserving insurer recourse against third parties deemed responsible, taking protective measures as dictated by the situation, and to whom the insured is bound to refer to establish such damages, under penalty of claim rejection".

Despite the wide range of Damage Commissioner attributions, the volume of transport insurance expertise missions declined in the last few years. This drop is attributable to external and internal causes.

The three external causes behind this phenomenon are a decrease in claims as a result of improved security and prevention, low national fleet participation in foreign trade transit and national insurance company coverage of Moroccan trade flows. Internal causes slowing the development of this expertise include the absence of statutes regulating the profession and of specific training.

Remedying the decline in damage survey activity calls for developing transport and trade insurance in Morocco, on the one hand, and providing adequate training to operators, on the other. Upgrading the Moroccan trade fleet and instituting compulsory export and import insurance are also a requirement at this level.

It is also useful to invest in training and capacity building. To this end, the following is needed:

- An institute for training damage commissioner, international trade and transport insurance experts.
- Robust and relevant basic training in technical, legal, commercial, banking, customs and other disciplines related to international trade.

- Practical training courses in relevant entities (port and airport authorities, terminals, logistic platforms, courts, banks, transport, handling, insurance, transit, groupage, consignment, transport commission companies...).
- Continuing education and regular assessment to ensure fitness to continue practicing the profession.

# 3. Potential solutions for sustainable impact on maritime and coastal areas

## 3.1. Integrated coastal management, an essential tool for sustainable development

In order to curb and eradicate all forms of abuse and degradation of Moroccan littoral, the administration in charge of land use planning and development[84] adopted a National Land Use Charter that includes planning and development instruments. These are a National Land Use Plan, a Functional Organization and Development Plan and an Urban Development Master Plan, as well as a National Integrated Coastal Management Strategy.

The National Charter for Land Use Planning addresses coastal issues and includes measures for maritime resource development towards sustainable national development. It hinges on the following principles:

- Strict enforcement of applicable laws to combat abuses and violations causing coastal deterioration.
- Establishment of master plans for the development of Morocco's coastline.
- Enactment of specific legislation for coastal areas, clearly defining property rights and determining terms of action in these areas.
- Establishment of a national institution for coastal area planning and development.
- Strengthening coastal areas' basic infrastructure.

The costal component of the National Land Use Plan (SNAT)[85] focuses on national and regional littoral development planning, via:

- detailed definition of urbanization conditions,
- protection mechanisms for vulnerable areas,
- control of marine and littoral resource exploitation activities,

- information on conditions for opening sites to construction and road traffic,
- assuring sea access and sound management of the maritime domain,
- adoption of special measures for the preservation of tourist and urban areas.

Functional Organization and Development Plan (SOFA) provides a framework for the elaboration of urban planning documents and a basis for consultation and consistency for all local actors. It specifically enables:

- management and control urban concentration and competing activities and public prerogatives,
- setting boundaries for urban sprawl and maximum acceptable population pressure,
- ensuring coherence of urban planning documents with the coastal law,
- developing the coastline by developing the interior.

Specifically, the SOFA for the Casablanca-Rabat Central Metropolitan Area for 2006-2025 aims to develop the two cities as part of an integrated vision. It sets out guidelines for: 1) development (business parks and new urbanization), 2) public transport, 3) structuring of central areas with a view to multi-functionality, 4) integration of industrial areas into the urban fabric, and 5) elimination of substandard housing.

The metropolitan development strategy for the Tangier-Tetouan Twin Cities primarily targets incentives for urbanization in the interior of the peninsula, i.e., between the cities of Tangier and Tetuan, and the development and protection of coastal areas.

The Master Plan for Coastal Urban Development (SDAUL) is a planning instrument for the Moroccan coastline that coordinates development actions by all stakeholders. It seeks to preserve, manage and enhance the coastline and surrounding areas as part of a comprehensive approach to harmonize coastal policies. Implementation problems do however exist, notably because of the slowness in drawing up this document and obtaining derogations.

The National Strategy for Integrated Coastal Management is dictated by the need to promote sustainable coastal development, a key strategic asset in the socio-economic and human development of Morocco. It is consistent with: 1) Enforcement of law n° 11-03 on the protection and enhancement of the environment, 2) Land Use Planning guidelines, notably the National Land Use Planning Charter (CNAT) and the National Land Use Planning Scheme (SNAT), and 3) the National Strategy for Sustainable Development (NSSD), and specifically Stake 5, which calls for special attention to vulnerable areas (coastline, oases, mountains).

It is also consistent with international commitments, including:

- ratification by Morocco of the Protocol on Integrated Coastal Zone Management (ICZM) in the Mediterranean, on January 21, 2008,
- sustainable Development Goals: SDG 14[86] and SDG 13[87].

To implement the ICZM approach in Morocco, the Department of territory Planning, in collaboration with the World Bank, initiated a pilot project on the Eastern Mediterranean coastline. This Integrated Coastal Zone Management Project in the Oriental region was designed to:

- strengthen local capacities for ICZM incorporation into planning,
- improve coastal natural resource (forest, wetlands, coastal fisheries, soils, protected areas...) conservation and management,
- strengthen coastal community resilience to climate change, through improved water management and income generating activities.

Project target areas include: 1) the coast of Saïdia-Ras El Ma, including the Ramsar site of the Moulouya River estuary, 2) the rural Municipality of Beni Chiker, including the SIBE of the Cap des Trois Fourches and part of the SIBE of the Gourougou Mountain, 3) the Nador Lagoon, and 4) the rural Municipality of Boudinar, in Driouch province.

Monitoring land use changes between 1992 and 2014, as part of this strategy, highlighted that 50% of the eastern Mediterranean coastal strip is anthropized, mostly by agricultural activities (38.9%) and urbanized surface reached 10.3%, up over 3% from 1992.

On the Atlantic coastline, urbanized surface rate went from 4% to 7% between 1992 and 2014 at the expense of agricultural land primarily, covering 595 $km^2$; natural areas only accounting for 136 $km^2$.

Agricultural land rates fell over 1% (29,000 ha of croplands transformed mostly into urban areas) and irrigated surfaces grew tenfold. Moreover, communal coastal land occupation in 2014, shows strong heterogeneity between North and South of the Atlantic coastline and brings to light 3 major areas:

- The northern regions where natural habitat covers less than 50% of the extensively developed surface area.
- The regions of central Morocco where natural habitat accounts for over 50% of the region's coastal strip surface (Oriental, Souss-Massa).
- The southern regions where natural habitat covers over 90% of land area: desert regions, where artificialization seems limited, while it includes highly vulnerable areas.

A strategic assessment of the coastline was conducted to ensure a degree of balance between territories, with a view to:

- perform a historical and institutional assessment of the management of these areas,
- assess compatibility or conflict of interest between activities and installations,
- identify conditions to improve compatibility and avoid conflicts of interest.

Five coastal areas emerged according to the diversity of potential activities: the Nador lagoon and its eastern extension, Tangier Med, the Greater Casablanca region, Agadir and Dakhla.

- The main potential vocation of the Nador lagoon and its eastward extension is port, urban and tourist development in a sensitive environmental area (lagoon). Related issues include environmental protection, urbanization control, tourism attractiveness, development cluster creation, lagoon depollution, governance and sustainability.
- Tanger Med is a commercial and industrial port. Related issues are environmental protection, promotion of the port offering to ensure sustainable commercial activity, governance, creation of a development hub complete with infrastructure (IZ, highways, railroads), the "land-sea" link and sustainability.

- The coastline of the future Greater Casablanca region, including El Jadida and Jorf Lasfar, has the potential for urban and economic development as primary vocation. Related issues include environmental protection, urbanization control, economic attractiveness, national heritage preservation, governance and sustainability.

- Agadir's main potential vocation is tourism and agro-industrial development. Related issues are environmental protection, urbanization control, tourist attractiveness, governance and sustainability.

- Dakhla's main potential vocation is urban and tourist development in a sensitive desert area and environment (bay). Related issues include environmental protection, coherence between urban planning and fishing, control of urbanization, tourist attractiveness, governance and sustainability.

National stakeholders showed shared commitment for integrated and concerted coastline management towards a common vision on the vocation of different coastal areas to harmonize sectoral policies. Effective strategy implementation however, faces a number of constraints, including:

- delays in adopting Coastal Law implementation decrees, specifically as it relates to inconstructibility along the 100-meter strip or the 2 km setback of transport infrastructure (pre-existing urbanization, coastline configuration, ...),

- the lack of interest, awareness, involvement and prerogatives of rural communities in the management and operation of their littoral which is largely managed by the administration, according to a "major projects" approach,

- expectations on the new role regions are to play in littoral management,

- the too frequent recourse to exemption commissions,

- the lack of means for enforcing the law.

Primary territorial functions for municipalities include agriculture, tourism and industry. Municipalities with an agricultural function are scattered all along the coastline. Agriculture plays an outsize role in the development of a number of local communities, including Bouarg and Madagh in the Oriental region, Ben Mansour, Mnasra and Chouaafa in the Gharb and Loukkos regions, and Inchaden, Massa, Sidi Ouassay, Sidi Bibi and Lqliaa in Souss Massa. The fundamental issue here is the preservation of coastal agriculture given the crying need for land and pressures arising from the spread of other activities at the expense of agricultural land.

Municipalities with a tourist interest are all along the Moroccan coastline, reflecting the country's landscape, archaeological and/or historical heritage. The fundamental issue for these municipalities is to maintain harmony between the preservation of ecosystems, the conservation of heritage and tourism activities.

In industrial communities, the majority of coastal residents are concentrated around manufacturing and service centers providing employment opportunities. The challenge facing these municipalities is to reduce pollution and coastal degradation. Morocco began de-densification along the Kenitra-El Jadida axis towards the South Atlantic coast (Agadir Dakhla) and the Mediterranean coast (Tangier-Oujda) to relieve pressure on a number of polluted areas.

Generally, the following issues and challenges arise:

- Ensure coastal economic and social development in conjunction with the interior regions, without depleting resources. To do this, it is necessary to: 1) maintain economic vitality of the coastal fringe and use it as a springboard for the development of other territories and 2) control the growth of activities along the coast to limit adverse impacts.
- Improve coastal governance through Coastal Law enforcement, arbitration mechanisms, empowerment of municipalities and regional councils.
- Controlling coastal risks: meteorological-oceanic phenomena, storms, rise in sea level.
- Preserve natural capital: biodiversity, landscapes, protected areas (marine and terrestrial), wetlands.
- Develop territorial sustainably through: 1) the control and management of urban concentration and competing activities and public prerogatives, 2) the setting of limits on urban sprawl and maximum permissible pressure levels and 3) the harmonizing and aligning of urban planning documents with the Coastal Law.

Different perspectives of integrated coastal management on actions and measures towards sustainable national coastal development include:

- elaboration of a cartographic atlas,
- establishment of a database specific to the coastline,
- elaboration of development outlines for specific coastal areas,

- proposal of strategic orientations to feed the National Coastal Plan (PNL) review, Regional Territorial Development Scheme (SRAT) and Regional Coastal Schemes to be elaborated over the next five years,
- setting-up a Coastal Observatory.

For an integrated coastal zone management strategy of this type to be efficient and sustainable, it requires:

- better coordination between different planning tools and documents,
- establishment of coastline-specific awareness and education programs,
- eradication of abusive practices and enforcement of the law,
- more balanced demographic expansion on the coast by means of inland magnet centers, to reduce migration to the coast,
- improved observation of coastal dynamics,
- promoting scientific research and innovation in coastal-related fields.

## 3.2. Scientific research and training in marine sciences: an imperative to meet sustainable development challenges and build a blue economy

The Moroccan oceanic margins are of significant scientific interest. They provide an excellent site for modeling the continental shelf and understanding global phenomena (plate tectonics, climate, sea level variations) and ocean circulation.

The Atlantic oceanic margin is passive reflecting successive stages of Atlantic Ocean opening, while the Strait of Gibraltar and Mediterranean oceanic margins are a part of an active margin resulting from the convergence of the African and Eurasian plates. The water bodies of these shelves are different in nature: Mediterranean waters, Atlantic waters and their exchange zone in the Strait of Gibraltar, with a number of oceanographic phenomena and currents: meddies, Canary Current, density currents, upwelling, ... Besides, understanding the sedimentary dynamics of the Atlantic continental shelf constitutes an invaluable scientific contribution. In fact, the only known continental shelf model dominated by superficial oceanic currents is that of South-East Africa.

Ocean shelves are also a prime location for the study of gas hydrate mud volcanoes and associated extreme environments, as well as for understanding the genesis and evolution of cold-water coral carbonate mounds.

These oceanic shelves have therefore always attracted international scientific interest since the early British "Challenger" oceanographic expedition[88]. The shelves have been studied since the late 1960's as part of international programs on geodynamic evolution, sedimentation processes, ocean circulation and global climate variations.

Oil exploration started in these areas in the 1980's. By the end of the 20th century, scientific research regained momentum, after major findings leading to the discovery of gas hydrate mud-volcanoes in 1999 and cold-water coral carbonate mounds in 2002.

Morocco nevertheless lags considerably on coastal and marine ecosystem understanding because critical human and material resource gaps. With the exception of the Strait of Gibraltar shelf, studied extensively as part of the Africa/Europe Fixed Link Project, knowledge of ecosystem functions on other oceanic margins is generally poor.

Academic coastal studies are still localized in both space and time. The studies are often repetitive, and do not build on pre-existing data and findings. Atlantic and Mediterranean shelf data, from studies undertaken as part of past international oceanographic expeditions, are patchy, often outdated and poorly positioned.

Furthermore, data from recent oceanographic surveys, collected using state-of-the-art techniques, with dense grids and accurate positioning, generally cover limited areas and are inaccessible, because they are either confidential (oil exploration) or stored in foreign laboratories.

It is therefore difficult today to precisely analyse circulation patterns, sedimentary transit trajectories, sedimentary dynamics and recent sedimentary cover morphodynamics, as well as topography, lithology, and substratum and non-living resource structural deformation. Similarly, the state and vulnerability of biodiversity are not sufficiently explored. The last census was published over 20 years ago (Menioui, 2001).

Moreover, large project feasibility studies and impact assessments are not always based on recent scientific data and do not include all necessary parameters such as global warming and its consequences.

Additionally, coastal flooding models developed in recent years are not reliable[89]. They are of no use to identify vulnerability and manage risks, as they were elaborated without taking tectonic and subsidence parameters into account. These parameters should not be ignored, in particular in the case of active margins.

The Strait of Gibraltar-Mediterranean Sea is an active margin tied to the NNW-SSE convergence of two tectonic plates: the African plate and the Eurasian plate. Moreover, even the Atlantic margin which is of the passive type, shows evidence of active neo-tectonics in a number of coastal areas:

- Active subsidence in Sebou and Cap Juby areas.
- The South Atlas fault, at the origin of the Agadir earthquake in the 1960s, may reactivate at any time.
- Vertical movements at the origin of a relative uplift, of varying magnitude depending on the region, were recorded during the Quaternary
- The NNW-SSE convergence of the African and Eurasian plates and the Azores-Gibraltar transform fault impact the northern part of the North Moroccan Atlantic margin.

Lastly, in the present state of knowledge of national maritime spaces, areas at high risk of accidental pollution, it is difficult to develop an efficient strategy for prevention, response and protection against oil spills, despite having a national contingency plan[90].

Due to the lack of knowledge on circulation patterns, detailed physiography of seabeds and biodiversity, it is impossible to fully grasp factors and parameters interacting to disseminate pollution and predict trajectories and areas of spill concentration, as well as resources likely to be impacted by pollution, their fragility and resilience.

With regard to human and material resources, beyond the absence of national oceanography centers, the community of academic oceanographers is severely balkanized and only accounts for a small part of the national scientific potential.

University oceanographers also suffer from a crucial lack of: 1) equipment for investigations at sea especially, oceanographic vessels and specific laboratory analyses, and 2) funding for the organization of oceanographic surveys, data processing and the valorization of findings in publications and conferences.

Moreover, national financial support, while still low, is not always allocated according to rigorous scientific criteria. The complexity and slowness of university accounting procedures do not facilitate the management of national and international contracts.

It is therefore urgent to develop and promote ocean sciences, the societal role of which in optimal management of present and future no longer needs to be established. Scientific research and training in marine sciences are essential for the creation of a strong and sustainable blue economy[91].

It is therefore advisable to develop a coherent and relevant strategy to promote scientific research and training in marine sciences, for it would be unrealistic to expect a blue economy in the absence of human, scientific and natural capital (coastal and marine areas and their living and non-living resources).

In addition to establishing of an environmental culture and control and regulatory measures, it is essential to implement federative programs, building on national resources and expertise to support the emergence of an ocean sciences knowledge economy and address new societal needs: environmental control, biodiversity protection, risk management, renewable energy, research on strategic metals, etc.

Marine science development should be part of the Kingdom's African policy, guided by the enlightened strategic vision of His Majesty King Mohammed VI. It also should be conducted as part of international cooperation in accordance with provisions of the International Convention on the Law of the Sea[92].

Scientific research should focus on developing relevant information systems by means of collaborative, comprehensive and rigorous scientific research programs to study the seabed (bedrock and sedimentary cover), water bodies, and living and non-living resources). Programs in ocean science and engineering and climatology should therefore be initiated.

Studies should specifically address:

- environmental quality, circulation models, as well as bathymetry and geological mapping of the sea floor,
- qualitative and quantitative assessments of biodiversity and its vulnerability to natural and anthropogenic risks,
- studies on cold-water corals to better understand their actual extension, their biodiversity and that of symbiotic species living with them, as well as factors affecting their genesis and development.

It is also be opportune to develop programs to:

- ensure regular monitoring of coastline and beaches, as well as mapping of vulnerability and areas at risk,

- redesign predictive coastal flooding models for the littoral, factoring all geological and environmental parameters,

- develop studies on marine energy sources, which should constitute a future alternative to polluting energies,

- strengthen socio-economic studies.

In addition, training should target the creation of new marine professions to build a skills pool capable of dealing with globalization, exporting expertise and finally, take part in activities and exploitation of "Zone" resources[93].

Beyond building stakeholder and planner capacities, it is essential to implement adequate training at all levels: Bachelor's degree, Master's degree and Doctoral schools. Training should, on the one hand, enable training of senior technicians, engineers and high-level researchers and, on the other, cover all sea-relevant disciplines: marine geology, marine biology, physical oceanography, chemical oceanography, law, economics, archaeology, history and oceanographic instrumentation.

In conclusion, the promotion of ocean sciences is critical in the face of national and global issues and challenges. It is also more relevant than ever, since the UN proclaimed 2021-2030 as the "Decade of Ocean Sciences for Sustainable Development". Accordingly, it is useful to:

- establish a national authority for coordinating marine science research and training activities,

- design efficient tools and mechanisms for the coordination, planning and assessment of scientific research and training programs,

- implement federative programs (scientific research and training) to integrate various marine science disciplines and build on national know-how and resources,

- create national and African centers for marine and climate sciences and engineering,

- mobilize resources for procuring needed scientific equipment and research operations and valorization,

- strengthen African and international cooperation,

- consolidate national legislation and adopt regulations for the protection of cold-water corals,

- establish an environmental culture and control and regulatory measures particularly with regard to feasibility and impact studies.

## 3.3. The potential of digital geospatial information for mapping and monitoring marine parameters: marine and coastal applications at CRTS

At the Royal Center for Remote Sensing (CRTS)[94], remote sensing and associated technologies are applied to spatial oceanography[95] to support ministerial departments and government agencies in the operational management of socio-economic development projects and programs.

Main operational applications include monitoring and surveillance of marine water quality, sea dynamics, monitoring of sea surface temperatures, upwelling identification and monitoring, development of areas suitable for aquaculture, mapping and analysis of coastal systems and monitoring of marine hazards.

Applications in monitoring of marine water quality parameters include chlorophyll concentration, suspended matter, Diffuse Attenuation Coefficient (Kd 490) and Secchi Disc Depth (SD).

- Spatial mapping of chlorophyll a concentration[96], e.g; the August 2019 CRTS map, enables monitoring of Moroccan ocean water's biological quality.
- The amount of suspended solids (SS) is a very good indicator of the turbidity of coastal and marine waters. It has applications in fisheries and aquaculture and in the assessment of bathing water quality. TSS can be solid and insoluble particles of natural origin (sediments) or polluting particles from urban, agricultural and industrial waste. They cause water turbidity and can thus reduce photosynthesis, disrupt organism respiration and promote the accumulation of organic pollutants and heavy metals in sediments.
- The Diffuse Attenuation Coefficient (Kd 490)[97] is an indicator of water transparency or turbidity at a given wavelength or spectral band. Satellite observation of this coefficient identifies turbid or low transparency marine areas due to the presence of suspended solid particles (mineral, organic) or living organisms, preventing light penetration to deeper layers. The CRTS monitors and maps this coefficient on a monthly basis.
- The Secchi Disc Depth (SD) is an indicator of the maximum depths to which light can penetrate (Secchi depth). It is used to assess marine water quality by highlighting the transparency and clarity of water masses.

Parameters used by the CRTS to monitor sea dynamics include wind characteristics at the sea surface (direction and speed) and sea level height. The extraction of wind data[98] indicates aerological conditions at sea level and determines areas of high or low dynamics. Mapping of the sea level height is conducted using satellite altimetry[99]. Sea level rise distribution in the Atlantic waters of Morocco and seasonal variations of sea level anomalies are excellent parameters for understanding and assessing the impacts of climate change.

Sea surface temperature (SST) is an operationally produced parameter. It describes marine thermal state, on the one hand, and detects and monitors hydrothermal phenomena (upwelling, filaments and drifts, eddies), on the other.

Satellite measurements and mapping of sea surface temperatures are possible with satellite radiometers[100]. The use of radiation-sensitive detectors with a 10µm wavelength detects the radiation emitted by ocean surface and provides surface temperature information.

The CRTS uses space observation data to develop an integrated upwelling characterization system[101] along the Moroccan Atlantic coast that also monitors spatial and temporal dynamics[102]. This program was conducted in partnership with INRH as part of the GERMA project (Gestion des Ressources Marines).

Project approach targeted: 1) Exploitation of space observation data (thermal, chlorophyll), 2) Transformation of images into upwelling indicators and 3) Implementation of applications for operational product development. Operational products generated and made available to users include:

- space-time synthesis product of sea surface temperature (SST)
- chlorophyll a temporal synthesis product,
- upwelling103 and retention index time series; the upwelling index mapping highlighting monthly, seasonal and interannual trends,
- synthetic upwelling product.

Development of areas suitable for aquaculture along the Moroccan coast was carried out in partnership between the CRTS and INRH[104]. The program consisted of two phases.

The first phase focused on extensive ecosystem study of three selected pilot sites: the Bay of Mdiq, the Nador Lagoon and Dakhla Bay. It enabled the development of a Geographic Information System (GIS) and the generation of geographical datasets (maps (topographic, marine, satellite images, turbidity index, sea surface temperature index, physico-chemical parameters of waters, meteorological and socio-economic data) and hydrodynamic models for simulating extreme risk situations and thematic maps.

The second phase focused on developing an analysis model for pre-selecting areas favorable for aquaculture based on potential aquaculture sites screening criteria (FAO, 2010). Criteria used in the model include:

- site characteristics and context: exploitation of the maritime space, terrigenous inputs at sea, sources of pollution, proximity of infrastructures,
- environmental parameters: hydrodynamics, salinity, suspended matter, bottom temperature, bathymetry,
- species' biological needs: salinity, chlorophyll a, oxygen, nitrate, nitrite, ph, suspended matter,
- rearing techniques: floating cages, fixed cages, table rearing, suspended rearing.

Potential zones for aquaculture by species and by farming technique were selected according to specific criteria and applied potential thresholds per criterion. The Mdiq site, for example, was identified as a potential area for intensive fish farming in floating cages (sea bream and sea bass). The multi-criteria analysis: combination of several indicators: SST, TSS, Chl-a, D. Secchi, Bathymetry, helped assess aquaculture potential along the entire Moroccan coastline.

In a different register, multi-date data is used to map and analyze coastal systems to better understand possible coastline changes and degradation. Very High-Resolution imagery (VHR) allows: 1) detailed mapping of land use and monitoring of changes, 2) mapping and monitoring of coastline evolution, 3) mapping of intertidal vegetation cover and 4) quantification of coastal water turbidity.

Remote sensing also enables the monitoring of coastal and marine risks, through the detection and monitoring of marine oil pollution and the assessment of tsunami risks in Morocco.

In the case of oil pollution, satellite data can: 1) detect and identify oil spills on the sea surface, 2) specify the location, area, length and number of fragments of these slicks and 3) monitor impact on the marine environment: proximity of aquaculture parks, protected areas or tourist areas.

Specifically, the RAMSES Project for Monitoring and Detection of Oil Slicks by Satellite Radar Data provides for 1) the implementation of a pilot system for oil slick detection in quasi-real time, 2) an early warning system for relevant authorities (POLWARN), and 3) assistance to and monitoring of offshore operations during response phases (supply of POLINF products).

Tsunami risk assessment in Morocco has two objectives. The first is to develop and test generic approaches to tsunami risk assessment at the Rabat site (SCHEMA project). This led to: 1) the modeling of tsunami hazard integrating all possible scenarios, 2) the mapping of building tsunami vulnerability classes, 3) the assessment of tsunami risk (calculated damage matrix) and 4) the modeling of building damage.

The second objective is the elaboration of a tsunami risk atlas for the main coastal cities of Morocco with maps of: 1) areas potentially affected by tsunami waves: depth and height, 2) types of buildings in flood-prone areas: vulnerability/tsunami levels and 3) building damage levels.

## 4. Prospective workshops: prioritization of global and national issues and potential solutions

The symposium ended with a set of prospective workshops aimed at prioritizing national and global issues and identifying potential solutions to better manage oceans and maritime spaces.

Participants were split into five heterogeneous working groups, each with a rapporteur. These prospective workshops were conducted using a methodology consisting of:

- a brief individual 3-minute reflection to identify issues and potential avenues of solution, with consideration of predefined criteria, namely: 1) magnitude of impact on individuals (health, food) and economic, geopolitical, communication activities, ...) 2) time to implement solutions and 3) perception of urgency,
- around table discussion to allow participants to present perceptions and points of view,
- a debate to decide on priority issues (national and global) and potential solutions.

The five rapporteurs then presented priorities selected by their group in plenary. A synthesis of group findings enabled the identification and prioritization of global and national issues and potential solutions, presented hereunder.

## Global issues

Global issues are primarily environmental (relating mainly to global warming, pollution and loss of marine biodiversity), geopolitical, economic (mainly relating to energy and fisheries resources as well as maritime transport) and, finally, security (illicit trafficking and piracy in particular).

## National issues (in order of priority)

1. National sovereignty as a potential source of conflict.
2. Good maritime governance.
3. Risk management induced by global warming and pollution.
4. State of scientific understanding of marine environment and ecosystems.
5. Heritage preservation.

## Potential solutions (in order of priority)

1. **Improve national maritime governance by establishing an inter-ministerial institution in charge of maritime affairs,** bringing the legal arsenal in line with international conventions and setting up an integrated maritime strategy, including a focus on South-South cooperation.
   - Generalize "Integrated Coastal Zone Management" implementation.
   - Strengthen and, above all, enforce legislation and regulations on coastal occupation and development and on the protection of cultural and historical heritage.
2. **Promote continued research in the marine sciences** by optimizing and pooling research resources available at national level, openly considering a national structure (national agency or center of excellence or observatory) for national oceanographic research and drawing up a detailed maritime map. A number of Moroccan institutions should seize on the United Nations Decade of Ocean Sciences for Sustainable Development (2021-2030) to apply for UNESCO funding.
3. **Enhance heritage value through the creation of a national museum of the sea**, the elaboration of an atlas of Moroccan coastline history, and education, popularization and awareness-raising actions for youth (schools, colleges, high schools and universities) and teachers on the issue of the oceans ("Ocean Literacy").
4. **Consolidate African and international maritime and oceanographic cooperation** to face common challenges, including natural disasters and illicit trafficking at sea.

5. **Strengthen climate change adaptation and mitigation strategies and actions** through risk warning system implementation.
6. **Adopt cold-water coral protection regulations** and commit to the United Nations Environment Program (UNEP) appeal launched on this subject in 2004.
7. **Acquire a large national fleet** and training institute and set-up robust and relevant initial training and quality continuing education programs to develop the activity of damage surveyor.

# Conclusion

Ocean Science Day was a great experience thanks to its topical nature, the diversity and relevance of issues addressed. The meeting provided an opportunity for attendees to take stock of geopolitical, socio-economic, cultural and historical, environmental, scientific and ecological issues pertaining to oceans. It also provided an opportunity to:

- highlight achievements and good practices of attending departments and organizations, as regards marine and coastal areas management,
- present avenues and solutions for managing these areas in a sustainable development context,
- identify and prioritize issues (global and national) and potential solutions.

This meeting also shed the light on gaps and difficulties encountered, including those of current maritime space governance, fragmented among a number of departments with little real coordination. The inadequacy of material and human resources also hinders marine investigations.

These shortcomings are major obstacles to implementing an anticipatory and preventive strategy as well as a coherent and harmonious action for preserving our national coastline over the short, medium and long terms.

# Bibliography


- Achab M., A. EL Arrim, B. EL Moumni, I. EL Hatimi (2007) - Metallic pollution affecting the bay of Tangier and its continental emissaries: anthropic impact, Thalassas, 24 (1): 23-36
- Agnaou M., Nadir M., Ait Alla A., Bazzi Lh., El Alami Z. and Moukrim A. (2017) - Organochlorine pesticides level evaluation in a Morocco Southernwetland: Massa estuary JMES, 2017 Volume 8, Issue 10, pp. 3496-3501. http://www.jmaterenvironsci.com/
- Aguilla, E. González, I., Galán, E. Hamoumi, N, Labriami, M. Y Bloundi, K. (2004) Distribución de elementos traza en sedimentos de la Laguna de Nador (Marruecos). Estudio preliminar. Geotemas 6 (1) pp. 195-198, ISSN 1567 5172
- Ahizoun M, Maire E, Haida S, Darrozes J and Probst J L (2009) - Assessment of shoreline changes in the Kenitra sandy coastal zone, Morocco. Afrique Science 05 (2),184-198
- Ait Lemqeddem Kh, Benjilani H, Damnati B (2017) - Morphodynamic evolution of the coastline in Saïdia and Al Hoceima on the Moroccan Mediterranean coastline. Mediterranean Coastal and Maritime Conference. Edition 4, SPLIT, CROATIA (2017)- http://www.paralia.fr
- Aouiche I., Daoudi L., Harti A., Ziane E. (2015) - Contribution of diachronic study in the spatio-temporal evolution of Agadir Bay (Morocco). J. Mater. Environ. Sci. 6 (11) (2015) 3307-3318
- Amine M, Ouadif L, Baba Kh & Bahi L (2018) - Assessment of the tsunami hazard on Moroccan coasts using numerical modeling. MATEC Web of Conferences 149, 02079 https://doi.org/10.1051/matecconf/201814902079
- Arid H Moudni H, Orbi A, Talbaoui M, Lakhdar Idrissi J, Massik Z, Littaye A, Paoli R. (2005) - Spatial remote sensing and GIS for the integrated management of aquaculture potentialities. GEO OBSERVER N° 14, November 2005 67
- Atillah A, Orbi A. Hilmi K. and Mangin A. (2005) - Operational products of spatial oceanography for the monitoring and analysis of the Moroccan upwelling phenomenon. GEO OBSERVATOR N° 14, November 2005 49,
- Atillah A., El Hadani A., Moudni H., Lesne O., Renou C., Mangin A. ett Rouffi F. (2011) - Tsunami vulnerability and damage assessment in the coastal area of Rabat and Salé, Morocco.Natural Hazards and Earth System Sciences, vol.11, no. 12, pp. 3397-3414.
- Azdi M, Moukrim A, Burgot T, Budzinski H, Chiffoleau J. F, Kaaya A , Zekhnini A, Narbonne et Guarrigues Ph(2006) - Hydrocarbon pollution along Moroccan coasts and BPH activity in the mussel Perna perna. Polycyclic Aromatic Compounds https://www.researchgate.net/publication/44215847
- Banaoui A, Chiffoleau J F, Moukrim A, Burgeot B, Kaaya A, Auger D, Rozuel E (2004 ) - Trace metal distribution in the mussel Perna perna along the Moroccan coast. Marine Pollution Bulletin 48(3-4):385-90

- World Bank and CMI (2011): Climate change adaptation and resilience to natural disasters in North African coastal cities. Summary of the regional study. June 2011. 28p.
- Benbakhta B, Fekhaoui M, El Abidi A,Idrissi L and Lecorre P (2007)- Organochlorine pesticide residues in bivalves and fish in the Moulay Bousselham lagoon (Morocco) - Afrique SCIENCE 03(1) pp. 146 - 168
- Basraoui Y, Zegmout M, Eladdouli J, Demnati S, Chahlaoui A and Chafi A ( 2010) Contribution to the study of the pollution of the coastal zone Saidia/Moulouya, in North Eastern Morocco". Afrique Science, Vol.6, N°3 http://www.afriquescience.info/document.php?id=2044. ISSN 1813-548X.
- Bazairi H., Sghaier Y.R., Benhoussa A., Boutahar L., El Kamcha R., Selfati M., Gerovasileiou V., Baeza J., Castañer V., Martin J., Valriberas E., González R., Maestre M., Espinosa F.&
- Ouerghi (2016)- Morocco: site of Jbel moussa - Mapping of key marine habitats in the Mediterranean and initiation of monitoring networks. Project Haut Commissariat aux Eaux et Forets et à la Lutte contre la Désertification and UNEP/MAP-CAR/ASP. RAC/SPA Publishing - MedKeyHabitats Project, Tunis. 92 p + Annexes
- Benali H., El Moutchou B. (2016a) - Diachronic evolution of the shoreline and occupation of spaces in the coastal area of Ksar Esghir between 1966 and 2005 (Tangier - Morocco). International Journal of Innovation and Applied Studies. Vol. 16 No. 1, pp. 197-209
- Benali H., El Moutchou B. (2016b) - Characterization of the sediment dynamics along the coastal sites of the Ksar Esghir region watershed (Tangier, Morocco). XIVèmes Journées Nationales Génie Côtier - Génie Civil. Paralia pp.153-161
- Benali A, Magueri I I & Salki S (2016) - Impacts of urbanization on the coastline of Safi. In Les littoraux marocains : Changement climatique et stratégies. Paysages géographiques N° 2, Publication of the Faculty of Letters and Humanities Series : Colloques et séminaires. pp. 111-123
- Benbrahim S, Chafik A, Chfiri R, Bouthir FZ, Siefeddine M, Makaoui A (2006) - Etude des facteurs influençant la répartition géographique et temporelle de la contamination des côtes atlantiques marocaines par les me taux lourds: cas du mercure, du plomb et du cadmium. Mar Life 16:37-
- Benchekroun S, Omira R, Baptista M A , El Mouraouah A, Iben Brahim A et Toto E A (2013) - Tsunami impact and vulnerability in the harbour area of Tangier, Morocco. Geomatics, Natural Hazards and Risk, DOI: 10.1080/19475705.2013.858373
- Benata M, Sbai A & Benrbia Kh. (2016) - Consequences of non-rational coastal management: Case of the Saïdia coastline (Eastern Morocco). In Moroccan coastlines: climate change and strategies. Paysages géographiques N° 2, Publication de la Faculté des Lettres et des Sciences Humaines Série : Colloques et séminaires. pp. 125-143

- Benomar S, Bouhaimi A, El Hamidi F, Mathieu M, Ouichou A, Moukrim A (2006) - Reproduction cycle of the African mussel Perna perna (Mollusca, Bivalvia) in Agadir Bay: Impact of domestic and industrial wastewater discharges. Biology & Health vol. 6, n° 1, pp. 25-36
- Ben-Ncer A. ( 2019) - Contribution of Prehistoric Archaeology to the knowledge of the History of Morocco. Hespéris-Tamuda LIV (3) (2019): 17-24
- Blinda M., Bellaouchou A, Fekhaoui M., Barcha S E and El Morhit M.(2013) - Evaluation of metallic contamination of sediments and surface waters of the northwestern coast of Morocco. Bulletin de l'Institut Scientifique, Rabat, Section Sciences de la Vie, 2013, n° 35, 43-49.
- Bloundi M. K. (2005). Geochemical study of the Nador lagoon (Eastern Morocco): Impact of anthropogenic factors. Doctoral thesis under joint supervision: Univ. Louis ¨Pasteur, France and Univ. Mohammed V-Agdal, Morocco.
- Bouabdallah M. and Larue J.P. (2009) - Evolution of the Saïdia Bay coastline: Natural dynamics and impact of developments (Eastern Morocco). Revue Physio- Géo, Vol. 3, pp.113-130.
- Bouasria S., Sadki O., Benaabidate L., Boumaggar H. and Hamoumi N. (2007) - Geochemistry and speciation of particulate trace metals in Atlantic coastal sediments between Safi and Souira-Qdima ( Morocco ). Earth and Life, Vol. 2, N°. 1, pp. 1 - 25
- Bouasria S., Sadki O., Benaabidate L., Oummaggard H. & Hamoumi N (2007b) - Geochemistry of heavy metals in the Moroccan Atlantic coastline (area of Safi city). Jour. Black Sea/Mediterranean Environment. Vol 13, pp:73-92. ISSN 1304-950
- Boumeaza T & Saidi1 J (2016 ) - Environmental issues of urbanization on the Mohammedia coastline: what impacts of climate change on urban areas and high-risk industrial sites. In Moroccan coastlines: climate change and strategies. Paysages géographiques N° 2, Published by the Faculté des Lettres et des Sciences Humaines Série : Colloques et séminaires. pp. 145 162
- Boumeaza T, Sbai A., Salmon M., Benata M. and Ozer A. (2010) - Ecological impacts of tourism developments on the coastline of Saïdia, eastern Morocco. Rivages méditerranéens 115 p. 94-102
- Boumhaoud I., Bouzouggar A., Collina-Girard J., Gallin A., Fernandez Ph., and Mouhiddine M. (2020) - The prehistoric origins of Essaouira: archaeological data from the Oued Ksob sector. Hespéris tamuda / Université Mohammed V., Faculté des lettres et des sciences humaines LIV(3):109-118
- Boyauzan A and Irzi Z (2015) - Effects of developments on the morphosedimentary dynamics of the barrier island of the Nador lagoon (North-East Morocco, Oriental region), Revue géographique des pays méditerranéens. No 125, p. 85-94
- Bouzid S, Khannous S, Bouloubassi I, Saliot A, Er-Raioui H. 2011 Assessment of the Mediterranean Moroccan coasts contamination by hydrocarbons (NAH, AH and Alkylbenzenes). Int J Geosci 2 (04) :562-572

- Bouzid S, Andaloussi H, Aboumaria K, Er-Raioui H. (2008) - Urban effluent pollution from the Mghogha flow of the west, margin of the Mediterranean Sea, Morocco. Afr J Environ Sci Technol. 2,116-23.
- Chaibi M., Ait Malek H., Charif A., Ayt Ougougdal M. and Maanan M. (2013) - Study of the evolution of the coastline of El Jadida Bay (Morocco) by photo-interpretation. Africa Science 09(2) 23 - 34 23
- Chaibi M. and Sabatier F. (2010) - Sediment budget of the El Jadida bay coastline (Morocco). Study methods and implications for coastal management. Rev. Méditerranée, n° 115, pp. 117-124
- Chaouay A, Okhrib R, Hilali M, Bazzi1 L,. Chahid A,. Khiri F ( 2017) - Contribution to the study of physicochemical analysis and metallic contamination of seawater from the Agadir coastline (Southern Morocco). J. Mater. Environ. Sci. 7 (8) pp. 2748-2759
- Charrouf L. (1989) - Problems of silting of Moroccan ports on the Atlantic coast. Leur impact sédimentologique sur le littoral. Thesis Univ. Paris Sud, 278.
- Comas, M., Pinheiro, L.M., 2007. Discovery of carbonate mounds in the Alboran Sea: the Melilla mound field. Abstract for the First MAPG International Convention, Conference & Exhibition Marrakech Con-vention Center. 28-31.
- Comas M.C., Soto J.I., Talukder A.R. and TTR-12 Leg 3 (Marsibal-1) Scientific Party (2003) -Discovering active mud volcanoes in the Alboran sea (Western Mediterranean). IOC Workshop Report No. 187, pp. 14-16
- Daghor L, T. Hssaïda T, ChakirS, Slimani H, Mouflih M, Hamoumi N, El Madani F, Ennafah B, Fraikech M & El Bouhmadi K(2016) -Study of dinoflagellate cysts in surface sediments of the Moroccan Atlantic lagoon system Oualidia - Sidi Moussa and the Mediterranean lagoon of Nador. Bulletin de l'Institut Scientifique, Rabat, Section Sciences de la Terre, 2016, n° 38, 1-18. e-ISSN : 2458-7184
- Daghor L, Hssaida T., Hamoumi N., Chakir S., Eneffah B and Fraikch M. (2015) - Response of phytoplankton populations (cysts and vegetative forms) to environmental changes in the lagoons of Sidi Moussa and Oualidia. DOI:10.5150/cmcm.2015.056. Coastal and Maritime Mediterranean Conference EDITION 3, FERRARA, ITALIA (2015) Coastal and Maritime Mediterranean Conference Available online - http://www.paralia.fr
- Daugas J. P., El Idrissi A., Ballouche A., Marinval Ph., Ouchaou B.(2008) - The Early Neolithic in northern Morocco: documentary data, typochronological seriation and genetic hypotheses. Bulletin de la Société préhistorique française, tome 105, n°4, 2008. pp. 787-812
- de Bayles des Hermens R. et Valiou D ( 1979) - Gisement préhistoriques littoraux du Sahara occidental. Etude typologique de l'industrie lithique et des tests décorés. Bulletin de la Société préhistorique française, 76-10-12 (E&T) pp. 445-453
- Debenath A. (2000) - Le peuplement préhistorique du Maroc: données récentes et problèmes L'Anthropologie 104 (2000) 131-145
- de la Martinière H. P. (1912) - History of Morocco, www.cosmovisions.com ChronoMarocAntique

- EL Abdellaoui J.E. and Ozer A. (2007) - Étude diachronique et historique de l'évolution du trait de côte de la baie de Tanger (Maroc). Revue Télédétection, vol. 7, n° 1-2-3-4, p. 157-171.
- El Arrim (2001) - Contribution à l'étude du littoral de la baie de Tanger (Rif Nord occidental-Maroc). Approches sédimentologique, géochimique et impact de la dynamique sédimentaire, Thèse de Doctorat national, Université Abdelmalek Essaadi, Faculté des Sciences et Techniques, Tanger, 150 p.
- El Arrim A., A. Raissouni , M. Wahbi , M. Maatouk , A. Afailal Tribak and B. El Moumni, (2010) - Metallic distribution in waters and sediments of the Tangier Bay coastline. Rif Nord Occidental Morocco, Rapp. Comm. int. Mer Médit, 39, 2010
- El Bouzidi R., Labraimi M. & Zourarah B. (2004) - Morphological evolution and spatio-temporal variability of the longshore drift system in the bay of Tangier (Morocco). J. Afr. Earth Sci. 39, 527-534.
- El Hajraoui M. A and Nespoulet R (Edit) ( 2012 ) - Prehistory of the Rabat-Témara region, Villes et sites archéologiques du Maroc (V.E.S.A.M.) Volume III, Rabat - 2012
- El Hatimi I., Achab M. & El Moumni B. (2002) - Impact of outfalls and canalization on the environment of Tangier Bay: a multidisciplinary approach. Bull. Inst. Sci. sect. Sci. Terre, 24, 49-58.
- El Idrissi A. (2012) - The Neolithic of Morocco: State of the question. Revista del Museu de Gavà, 5, ISSN 1135-3791, 333-341
- El Morhit M, Belghity D, El Morhit A (2013) Metallic contamination in muscle of three fish species in the southern Atlantic coast the Laâyoune (Morocco). Larhyss J 15:21-34
- El Morhit M., Fekhaoui M, Serghini A, El Blidi S, El Abidi A. Yahyaoui A.( 2013) - Typology of water quality in the Loukkos river estuary (Morocco). Larhyss Journal, ISSN 1112-3680, n° 12, January, pp. 7-24
- El Moumni B ; El Arrim A , Maatouk M El Hatimi I., Wahbi M. and Afailal-Tribak A (2002) -Erosion of the Bay of Tangier. In: Erosion littorale en Méditerranée : dynamique, diagnostic et remèdes, CIESM Workshop Series, p. 43-47.
- El Moutchou B., Benali H and Mamouni A. (2014) - Diachronic evolution of the shoreline along the western Moroccan Mediterranean coastlines: case of the coastal sites of Ksar Esghir, Bou Ahmed and Jebha (Morocco). XIIIèmes Journées Nationales Génie Côtier - Génie Civil. Editions Paralia pp.317-324
- El Moutchou. B, El Fadel. L, El Hajjaji. Kh. (2011) - Morphodynamic and morphosedimentary evolution of the Mediterranean coastline of Oued Laou (Tetouan, Morocco). Coastal and Maritime Mediterranean Conference Edition2, Tangier, Morocco Coastal and Maritime Mediterranean Conference. http://www.paralia.fr -pp157-162
- El Mrini A., Maanan M., Anthony E.J. and Taaouati M. (2012a) - An integrated approach to characterize the interaction between coastal morphodynamics, geomorphological setting and human interventions on the Mediterranean beaches of northwestern Morocco. Applied Geography 35 334e344

- El Mrini A., Anthony E.J., Maanan M., Taaouati M. and Nachite D. (2012b) - Beach-dune degradation in a Mediterranean context of strong development pressures, and the missing integrated management perspective Ocean & Coastal Management 69 299 ,306
- Fakhreeddine A. (1990) - Measurements and harmonic analysis of the tides in Asilah, Cap Spartel and Sidi Kankouch. Proceedings of the IIIrd International Symposium on the Europe-Africa Fixed Link through the Strait of Gibraltar, Marrakech. Volume 1 "Site Data", pp. 263-274
- AO. (2010) - . Aquaculture Development 4. An ecosystem approach to aquaculture. Technical Guidelines for Responsible Fisheries No. 5, Supplement 4. Rome, FAO. 63 p.(also available online at www.fao.org/docrep/014/i1750f/i1750f00.htm)
- Fink, H.G., Wienberg, C., De Pol-Holz, R., Wintersteller, P., Hebbeln, D., 2013. Cold-water coral growth in the Alboran Sea related to high productivity during the Late Pleistocene and Holocene. Marine Geology 339, 71-82.
- Foubert, A., Depreiter, D., Beck, T., Maignien, L., Pannemans, B., Frank, N., Blamart, D. Henriet, J.-P., (2008) - Carbonate mounds in a mud volcano province off northwest Morocco: Key to processes and controls. Marine Geology 248 (1-2): 74-96. doi:10.1016/j.margeo.2007.10.012.
- Freiwald, A., 2002. Reef forming cold water corals. In: Wefer, G., Billett, D., Hebbeln, D., Jørgensen, B.B., Schlu¨ ter, M., Van Weering, T. (Eds.), Ocean Margin Systems. Springer-Verlag, Berlin, Heidelberg, pp. 365-385.
- Glogowski, S., Dullo, W.,C., Feldens, P., Liebetrau, V., Von Reumont, J., Hühnerbach, V., Krastel, S., Wynn, R.,B., Flögel, S. 2015. The Eugen Seibold coral mounds offshore western Morocco: oceanographic and bathymetric boundary conditions of a newly discovered cold-water coral province. Geo-Mar Lett. DOI 10.1007/s00367-015-0405-7
- Hakkou M. (2012) - Contribution to the study of the morphosedimentary dynamics of the Bouknadel-Kenitra coastline These of Doctorat National Fac Sc, Univ Ibn Tofail Kenitra p . 266
- Hakkou, M., Castelle, B., Benmohammadi, A., Zourarah, B., (2011)- Wave climate and morphosedimentary characteristics of the Kenitra-Bouknadel sandy coast, Morocco. Environmental Earth Sciences, 64: 1729-1739. DOI: 10.1007/s112665-011-0977-0.
- Hamoumi N (2020a). Human capital and sustainable development in Africa: the levers and programs to target in Geosciences within the framework of Regional Integration. Paper accepted at the Africa Knows! It is time to decolonise minds. Panel D16a : Innovations, new paradigms and knowledge development in North Africa. 20 January 2021. https://www.africaknows.eu/panels/#9412
- Hamoumi N. (2020 b) - Le système des études d'impact sur l'Environnement (EIE) au Maroc : lacunes et dysfonctionnements - Impact sur le développement durable du littoral In Livre collectif : Etudes d'impact et politiques publiques au Maroc. Ed. l'Harmattan Paris. Histoire et Perspectives Méditerranéennes pp. 77-95. Also

published in Revue Marocaine d'Audit et de développement (REMA), 48- June - September 2019, pp. 79-97

- Hamoumi N. (2018a) - The Moroccan margin of the Strait of Gibraltar: State of knowledge - Strategy for protection and enhancement in the framework of sustainable development. Proceedings of the International Meeting: "The Strait of Gibraltar: Issues, Challenges and Stakeholder Approach". Publication of the Royal Institute for Strategic Studies (IRES), pp.82-95
- Hamoumi N. (2018b) - The International Convention on the Law of the Sea (UNCLOS): a lever for the knowledge, protection and enhancement of marine areas of the States Parties. Quid de l'adhésion du Maroc ? In " le Droit de la mer Enjeux et perspective pour le Maroc " Publication Konrad Adenauer Stiftung e.V, pp.19-40
- Hamoumi N. (2015) - The geological knowledge of the Moroccan ocean margins: State of the art - Interest for the valorization and sustainable exploitation of marine resources. Written and oral communication at the National Workshop "Together for an integrated management of Moroccan coastal and marine spaces", 6 June 2015 Rabat
- Hamoumi N. (2014) - When will an efficient strategy for the delimitation of the Moroccan continental shelf be developed. Le Reporter June 2014, https://www.lereporter.ma/frontieres-maritimes-le-maroc-perdra-t-il-ses-droits/
- Hamoumi N (2012) - The lagoon complex of Nador (Morocco): functioning, natural and provoked control, scenarios of future evolution. Paralia, Vol. 5, P. 5.1- 5.14. http:// www.paralia.fr
- Hamoumi N. (2011) - Marine geosciences: an unexploited strategic tool in sustainable development policies in Morocco. Mediterranean Coastal and Maritime Conference, Tangier, Morocco, pp 335-338 (2011), URL http://www.paralia.fr/cmcm/e02-70-hamoumi.pdf
- Hamoumi N. (2008 a) - Les sciences de la mer: un outil stratégique pour le développement durable au Maroc, Revue prospectives universitaires N°1, pp. 199-219 Publication de l'Université Mohammed V-Agdal, Rabat
- Hamoumi N. (2006) - The mud volcanoes of Gulf of Cadiz Moroccan margin and N-W Rif belt: A key for better understanding complex marine -land geology at a regional scale, , in: CIESM (2006). Fluid seepages - mud volcanism in the Mediterranean and adjacent domains, Bologna, 19-22 October 2005. CIESM Workshop Monographs, 29: pp. 79-85.
- Hamoumi N. (2005) - The Flysch Domain of the N-W Alpine Rif Belt, Field guide book "International field workshop in the Rif domain" (Ed. Hamoumi N.), 51 p, 34 figures
- Hamoumi N. (2004), " Les géosciences marines et l'océanographie physique au Maroc : Etat des lieux, Enjeux et défis, Stratégie pour une politique de recherche intégrée ", written and oral communication in Atelier national : Pour une gestion intégrée du domaine maritime marocain, Rabat
- Hamoumi N. (1997) - Les formations coralliaires du Détroit de Gibraltar: Impact sur le Projet Liaison Fixe Europe-Afrique par un tunnel, 22 p., Rapport SNED

- Hamoumi N and Terhzaz L. (2016) - Cold water corals of the Moroccan ocean margins: A biodiversity seriously threatened by global warming. Proceedings International Symposium on Climate Change New approaches, new technologies, new opportunities Involvement of Moroccans from here and elsewhere" organized by the "Council of the Moroccan Community Abroad on November 11 and 12, 2016 in Marrakech
- Hamoumi N. and Irzi Z. (1999) - Les aménagements côtiers: problèmes et enseignements - Cas du littoral méditerranéen oriental, Actes de la 3ème Rencontre Hydrodynamique marine 99, Casa, 12 p.
- Hamoumi N., Hssaida T., Terhzaz L.etHazim M. E. (2011) - Control and evolution of the ecological environments of Nador lagoon (Morocco). Mediterranean Coastal and Maritime Conference, Tangier, Morocco, pp 181-184 (2011), URL: http://www.paralia.fr/cmcm/e02-39-hamoumi.pdf
- Hannou E K (2003) - Land use planning and coastal development: case of the northern part of Morocco. TS7 Coastal Zone Management. 2nd FIG Regional Conference Marrakech, Morocco, December 2-5. www.fig.net/resources/proceedings/fig_proceedings/morocco/proceedings/TS7/TS7_1_hannou.pdf
- Hebbeln, D., Wienberg, C., Beuck, L., Freiwald, A., Wintersteller, P., cruise participants, 2009. Report and preliminary results of RV POSEIDON cruise POS 385 "coldwater corals of the Alboran Sea (western Mediterranean Sea). Faro-Toulon, May 29-June 16 2009. Reports of the Dep. of Geos. University of Bremen (No. 273, 79 pp.).
- Henriet, J.P.; Hamoumi, N.; Ivanov, M.; Pinheiro, L.; Suzyumov, A.; Swennen, R.; Blinova, V.; Bouimetarhan, I.; De Boever, E.; Depreiter, D.; Foubert, A.; Kozlova, E.; Maignien, L.; Poort, J.; Van Rensbergen, P.; Van Rooij, D. (2006). The mud volcano province on the Atlantic Moroccan margin: Towards a natural laboratory for joint European-Maghreb research, in: CIESM (2006). Fluid seepages - mud volcanism in the Mediterranean and adjacent domains, Bologna, 19-22 October 2005. CIESM Workshop Monographs, 29: pp. 21-26. ISSN 1726-5886
- Hilal A (2016 ) - Moroccan coastal space between pressures of the present and demands of the future: the case of the Essaouira coastline (Morocco). Cinq Continents Volume 6, Number 13, pp. 79-100
- Idrissi. M, Hourimeche A, Rey V and Chagdali. M ( 2004) - Impact of coastal installations on the evolution of the coastline of Mohammedia (Morocco). VIIIème Journées Nationales Génie Civil - Génie Côtier, Compiègne, 7-9 September 2004. Pp789-796
- Irzi Z., Kadiri H. & Hamoumi N. (1997) - Hydrology and morphodynamics of the barrier island of the Nador lagoon, eastern Mediterranean coast, Morocco Book of abstracts, 6ème Congrès Français de Sédimentologie, Montpellier Publ. ASF, Paris, n°27, pp.149 -150

- Kaabouden F., Baptista A., Iben Brahim A., El Mouraouah A. and Toto A. (2009) - On the moroccan tsunami catalog. Natural Hazards and Earth System Sciences, vol. 9, n° 4, p. 1227-1236
- Kaaya A, Najimi S, Ribera D, Narbonne J F & Moukrim A (1999) - Characterization of Glutathione S-Transferases (GST) Activities in Perna perna and Mytilus galloprovincialis Used as a Biomarker of Pollution in the Agadir Marine Bay (South of Morocco). Bull. Environ. Contam. Toxicol. (1999) 62:623-629
- Kalloul, S., Hamid, W., Maanan, M., Robin, M., Sayouty, E.H., Zourarah, B., 2012. Source contributions to heavy metal fluxes into the Loukous Estuary (Moroccan Atlantic Coast). J. Coastal Res. 28 (1), 174-183.
- Kalloul, S., Hamid, W., Maanan, M., Robin, M., Sayouty, E.H.and Zourarah, B. (2012) - Source contributions to heavy metal fluxes into the Loukous Estuary (Moroccan Atlantic Coast). J. Coastal Res. 28 (1), 174-183.
- Khalfaoui O, Dezileau L, Degeai J P , Snoussi M ( 2019) - Reconstruction of past marine submersion events (storms and tsunamis) on the North Atlantic coast of Morocco. Natural Hazards and Earth System Sciences Discussions, 1-14
- Khouakhi A, Snoussi M, Niazi S & Raji O (2012) - The Geographic Information System (GIS): a tool for the assessment of land at risk of coastal flooding related to climate change. Case of the coastline of Mohammedia. Travaux de l'Institut Scientifique, Rabat, Geology & Physical Geography series, n°23, p. 1-8.
- Krengel T. (2020) 550,000 years of marine climate variability in the western Mediterranean Sea revealed by cold-water corals . Phd thesis faculty of natural sciences and mathematics Heidelberg University Germany
- Lefévre D. and Raynal J. P.- Les formations plio-pleistocènes de Casablanca et la chronostratigraphie du Quaternaire marin du Maroc revisitées. Quaternary 13, (1), 2002 p. 9-21)
- Louaya, A. and Hamoumi (2016) - Apport de la télédétection dans l'étude de l'évolution morphodynamique du complexe lagunaire de Nador (Maroc) au cours des 40 années passée XIVièmes Journées nationales Génie côtier Génie civil, Toulon. Paralia, p. 381-388, http://www.paralia.fr
- Louaya A. And Hamoumi N. (2011) - Impact des aménagements sur la morphodynamique du complexe lagunaire de Nador, Maroc Conférence Méditerranéenne Côtière et Maritime, Tanger, Maroc, pp 211-214 (2011), URL: http://www.paralia.fr/cmcm/e02-45-louaya.pdf ISSN 1760-8716
- Louaya A et Hamoumi N (2006)- Application de la télédétection à l'étude de la géomorphologie et de la morphodynamique du complexe lagunaire de Nador (Projet COLASU ICA36CT-2002-10012), Géo Observateur N° 15, pp.51-65
- Maanan, M., Ruiz-Fernández, A.-C., Maanan, M., Fattal, P., Zourarah, B., Sahabi, M., (2014a) -. A long-term record of land use change impacts on lagoonal sediments (Oualidia lagoon, Morocco). Int. J. Sediment Res. 29 (1), 1-10. MacDonald, D.D., Ingersoll, C.G., Berger, T.A., 2000. Development and

- Maanan M, Saddik M, Maanan M, Chaibi M, Assobhei O, Zourarah B (2014b)- Environmental and ecological risk assessment of heavy metals in sediments of Nador lagoon, Morocco.. Ecological Indicators 48 (2014) 616-626
- Maanan, M., Landesman, C., Maanan, M., Zourarah, B., Fattal, P., Sahabi, M., (2013) -. Evaluation of the anthropogenic influx of metal and metalloid contaminants into the Moulay Bousselham lagoon Morocco, using chemometric methods coupled to geographical information systems. Environ. Sci. Pollut. Res. 20, 4729-4741.
- Mansoum. M, (1994) - La baie d'Agadir : impacts des aménagements sur l'évolution géomorphologique du littoral. Doctoral thesis, Brest, 349p.
- Mansoum. M, 2013: Prospective mapping of the evolution of the coastline of Essaouira. Publication, Revue de la Faculté des Lettres et Sciences Humaines Saïs-Fès, N°25, pp: 43-62.
- Mansoum M ( 2016) - The management of coastal erosion in Morocco. In Les littoraux marocains : Changement climatique et stratégies. Paysages géographiques N° 2, Publication de la Faculté des Lettres et des Sciences Humaines Série : Colloques et séminaires. pp. 31-62
- Mellas S., Leone F., Omira R., Gherardi M., Baptista M.A., Zourarah B., Péroche M. and Lagahé E. (2012). Tsunami risk in Morocco: modeling and assessment using a first set of exposure indicators for the Atlantic coastline. Physio-Geo, 6, 119-139. 6.
- Menioui M (2001) Marine and coastal biodiversity, in Strategy and action plan for the conservation and use of biodiversity. Department of the Environment/UNEP. pp. 1-21.
- Minoubi A, Elkhalidi Kh, Chaibi M, Zourarah B, Ayt Ougougdal M, Poizot E & Mear Y (2018) - Impact of port structures on the evolution of the coastline of the bay of Safi (Atlantic coastline-Morocco), Revue Marocaine de Géomorphologie. N°2. pp 18- 35.
- Mouzouri. M & Irzi. Z (2011) - Evolution and morpho-dynamics of the coastal plain of Saidia (Mediterranean coastline of North-East Morocco) during the period 1958-2006. 5ulletin de l'Institut Scientifique, Rabat, section Sciences de la Terre, , n°33, p. 65-76.
- Nachite, D., El Moutchou, B., Anfuso, G., Benavente, J., Bello, E. and Macías, A. (2004) - Morphology and recent evolution of the coastline between Fnideq and M'diq (Tétouan, NE Morocco). Geogaceta, 35, 43e46
- Nadir M, Agnaou M, Idardare Z, Chahid A, Bouzid T.and Moukrim A (2015) - Impact study of M'zar submarine emissary (Agadir Bay, Morocco): Trace metals accumulation (Cd, Pb and Hg) and biochemical response of marine MolluskDonax trunculus(Linnaeus, 1758). J. Mater. Environ. Sci. 6 (8) p. 2292-2300
- Nekkal F., Linstädter J., Aouraghe H. and Bougariane B. (2015) -Ifri Ouzabour:The extreme extension of the cardial culture on the southern Mediterranean coast (Eastern Rif, Morocco). Bulletin de l'Institut Scientifique, Rabat, Section Sciences de la Terre, 2015, n° 37, 55-76.
- Nespoulet R., Debenath A., El Hajraoui A., Michel P., Campmas E., Oujaa A., Ben-Ncer A., Lacombe J.P., Amani F., Stoetzel E.& Boudad L. (2008) - Le contexte

archéologique des restes humains atériens de la région de Rabat-Témara (Maroc): Apport des fouilles des grottes d'El Mnasra et d'El Harhoura. Proceedings RQM4, Oujda, 356-375

- Nespoulet R and El Hajraoui A (2015)- Les grottes de Rabat-Témara, une référence pour la 6ème extinction? Travaux de l'Institut Scientifique, Série Générale, N° 8, 151-167
- Niazi. S, 2007. Assessment of the impacts of climate change and sea level rise on the Tetouan coastline (Western Mediterranean of Morocco): Vulnerability and Adaptation. Thesis Doctorat d'Etat, es-sciences Univ. Mohammed V, Fac. Sci. Rabat, 232 p
- Oueslati A.( 2014) - The "Great Dune of Tangier" (Northern Moroccan coastline): an example of disappearance of a natural entity of landscape and environmental interest. Physical Geography and Environment Varia Vol. 8 pp 251-272
- Pinheiro L.M., Ivanov M. K., Sautkin A., Akhmaninov G., Magalhaes V. H., Volkonskaya A., Monteiro J. H., Somoza L., Gardner J., Hamoumi N. and Cunha M. R. (2003) - Corrigendum to "Mud volcanism in the Gulf Of cadiz: results from the TTR-10 cruise. Marine Geology 195 (2003) pp. 131-151
- Raynal J.P., Sbihi-Alaoui F.Z. and Mohib A. (2010) - Bilan des recherches récentes sur le Paléolithique de Casablanca (Maroc). Nouvelles de l'archéologie no120-121
- Rebuffat R (1974) - Vestiges antiques sur la côte occidentale de l'Afrique au sud de Rabat. In: Antiquités africaines, T 8, pp. 25-49. https://www.persee.fr/doc/antaf_0066-4871_1974_num_8_1_943
- Renou C, Lesne O, Mangin A, Rouffi F, Atillah A, El Hadani D and Moudni H. (2011) - Tsunami hazard assessment in the coastal area of Rabat and Sale, Morocco. Nat Hazards Earth. Syst Sci. 11:2181-2191.
- Ruiz, F., Abad, M., Olias, M., Galan, E., Gonzalez, I., Aguila, E., Hamoumi, N., Pulido, I., Cantano, M., 2006. The present environmental scenario of the Nador Lagoon (Morocco). Environ. Res. 102, 215-229.
- Saidi A, Sbai A, Mouadili O, El mahdaoui M (2016) - The Cap de l'Eau coastline between fragility of the physical environment and impact of anthropogenic pressures (North-East Morocco). In Moroccan coastlines: climate change and strategies. Paysages géographiques N° 2, Published by la Faculté des Lettres et des Sciences Humaines Série : Colloques et séminaires. pp. 177 -191
- Salim F Z, M. Y. El Habti, Kh. Lech-Hab Ben Hamman, A. Raissouni & A. El Arrim (2018) - Application of a Geomatics Approach for the Diachronic Study of the Meditterannean Coastline Case of Tangier Bay, International Journal of Geosciences, 9, 320-336
- Salmon M, Boumeaza T., Sbai A., Ben Atta M., Et Ozer A., (2010), L'érosion des côtes meubles de l'extrême nord-est du Maroc, Bulletin de la Société Géographique de Liège, no 54, p. 97-106.
- Sbai A & Lasgaa H (2012)- Vulnerability and impacts of risks associated with sea level rise in the coastal plain of Saidia - Cap de l'Eau (North-East Morocco). XIIèmes

Journées Nationales Génie Côtier - Génie Civil, Cherbourg, June 12-14, 2012. Editions Paralia CFL. http://www.paralia.fr

- Sbai F, Labraimi M., Haddane M (2004) - Evaluation of coastline recession on a portion of the Moroccan Atlantic coastline of Mohammedia. PANGEA n° 41/42 Communications
- Sbai A, Benata M, Lasgaa H, Saidi A, Benrbia Kh (2011) - Study of the erosion of the soft coasts of North-East Morocco. Mediterranean Coastal and Maritime Conference, http://www.paralia.fr
- Sedrati M and Anthony E. J. (2007) - A brief overview of plan-shape disequilibrium in embayed beaches: Tangier bay (Morocco). Revue géographique des pays med, pp. 125-130
- Shimkus K. M., Esteras M., Bahmad A., Murdmaa I., Sandoval J. & Izquierdo N. 1995. Submarine geological studies of the Gibraltar Strait (Rift-Argus Campaign), IV Coloquio Internacional sobre el enkace fijo del Estrecho de Gibraltar , Tomo II, 377 -412
- Siba A,, Eljaafari S, Mokhtari F (2018) - Bacterial and toxic pollution in industrial and domestic discharge waters of the Atlantic coastline (Casablanca East- Morocco). European Scientific Journal, Vol.14, No.12. DOI:10.19044/esj.2018.v14n12p283
- Skounti A (2011) - Le patrimoine marocain. https://www.academia.edu/4139147/Le_Patrimoine_in_Le_Monitor_2011
- Snoussi M., Ouchani T., Khouakhi A., Niang-Diop I. (2009): Impacts of sealevel rise on the Moroccan coastal zone: Quantifying coastal erosion and flooding in the Tangier Bay. Geomorphology, Elsevier 107 (2009) 32-40
- Snoussi M., Ouchani T., Niazi S. (2008). Vulnerability assessment of the impact of sea- level rise and flooding on the Moroccan coast: The case of the Mediterranean eastern zone. Estuarine, Coastal and Shelf Science, Vol. 77, pp 206-213. doi:10.1016/j.ecss.2007.09.024
- Snoussi. M, & Long, B. (2002) - Historical evolution of Tangier Bay and attempts at rehabilitation. Ciesm Workshop Series N°18, Monaco,pp.43-47
- Stitou M, Dolores Galindo M, El Mai H (2010)- Tangier, Les cahiers de la recherche de l'Université Abdelmalek Essaadi 1 (4-5) pp. 39-48
- Stoetzel E., Patrick M., Nespoulet R. & El Hajraoui M. A (2007) - Les environnements holocènes du littoral atlantique du Maroc.exemple des petits et grands vertébrés en contexte archéologique provenant de la grotte d'El Harhoura 2, région de Temara Emmanuelle Quaternaire,18, (4), p. 299-307
- Tahiri L, Bennasser L, Idrissi L, Fekhaoui M , El Abidi A, Mouradi A (2005) - Metal contamination of Mytilus galloprovincialis and sediments in the Bouregreg Estuary (Morocco). Water Quality Research Journal of Canada 40(1):111-119
- Terhzaz, L., 2019. Étude sédimentologique et géochimique des monts carbonatés de la marge marocaine méditerranéenne et de la marge marocaine Nord-Atlantique (Golfe de Cadix), Thèse de doctorat, Faculté des Sciences Rabat, Université Mohammed V, 280p.

- Terhzaz, L., Hamoumi N., Spezzaferri, S., Lotfi EL M., Henriet, J.P., (2018) - Monticules carbonatés de la marge méditerranéenne marocaine : Faciès et contrôles environnementaux, Comptes Rendus Geoscience, 350, 212-221p.
- Terhzaz, L., Van Weering, T., de Haas, H., Mienis F. et Hamoumi, N. (2007) -. Coraux d'eau froide et biote associé de l'escarpement de Pen Duick (Golfe de Cadix). Actes de " The First MAPG International Convention, Conference & Exhibition ",
- Vandorpe, T, Wienberg, C., Hebbeln, D., Van Den Berghe, M., Gaide, S, Wintersteller, P &Van Rooiji, D (2017) Multiple generations of buried cold-water coral mounds since the Early-Middle Pleistocene Transition in the Atlantic Moroccan Coral Province, southern Gulf of Cádiz. Paléogéographie, paléoclimatologie, paléoécologie, 485, p.293-304.
- Van Rooij, D., Blamart, D., De Mol, L., Mienis, F. Pirlet, H., Wehrmann, L.M., Barbieri, R. Maignien, L., Templer, S.P. De Haas, H., Hebbeln, D., Frank, N., Larmagnat, S., Stadnitskaia, A., Stivaletta, N. Van Weering, T. Zhang, Y, Hamoumi, N., Cnudde, V. Duyck, P., Henriet, J.-P. & l'équipe de bord du MiCROSYSTEMS MD 169. (2011) - Cold-water coral mounds on the Pen Duick Escarpment, Gulf of Cadiz: the MiCROSYSTEMS approach. Marine Geology, 282(1-2), 102-117.
- Wienberg, C., Hebbeln, D., Fink, H; G., Mienis, F, Dorschel, B., Vertino, A., López Correa, M., et Freiwald, A., 2009. Scleractinian cold-water corals in the Gulf of Cádiz-First clues about their spatial and temporal distribution Deep Sea Research Part I: Oceanographic Research Papers 56 (10): 1873 93. doi:10.1016/j.dsr.2009.05.016

# Reference notes

[1] Ocean & Climate Platform (https://ocean-climate.org/?page_id=2020)
[2] The first global oceanographic expedition on board British corvette HMS Challenger between 1872 and 1876
[3] Global ocean science report: the current status of ocean science around the world, UNESCO, 2017, 978-92-3-100226-7, 978-92-3-000067-7 (kor)
[4] World Ocean Assessment I, https://www.un.org/regularprocess/content/first-world-ocean-assessment
[5] http://www.regionalisationavancee.ma
[6] Law n° 1-81 instituting an exclusive economic zone of 200 nautical miles off the Moroccan coast, Dahir n° 1-81-179 of 3 Jumada II 1401 (8 April 1981), Law n° 37.17 modifying and completing the Dahir bearing law n°1.73.211 of 26 Moharrem 1393 (2 March 1973) fixing the limit of territorial waters and Law n° 38.17 modifying and completing law n°1.81 instituting an exclusive economic zone of 200 nautical miles off the Moroccan coast.
[7] http://www.unesco.org/new/fr/natural-sciences/ioc-oceans/about-us
[8] United Nations body in charge of ensuring the safety and security of maritime transport and preventing marine pollution from ships
[9] Official Gazette n° 5714 of March 5, 2009- Dahir n° 1-04-134 of 17 joumada I 1429 (May 23, 2008)
[10] Ratified by Morocco on February 15, 1980
[11] Dahir n° 1-93-103 of 25 rabii I 1421 (28 June 2000), B.O. n° 4832 of 21 September 2000
[12] Dahir n° 1-88-519 of 8 chaabane 1389 (20 October 1969), Official Bulletin n° 2997 of 08/04/1970 (8 April 1970).
[13] Dahir n° 1-76-12 of 26 safar 1397 (February 16, 1977), Official Bulletin n° 3554 of 2 safar 1401 (December 10, 1980).
[14] Dahir n° 1-77-187 of 29 rebia II 1399 (March 28, 1979), Official Bulletin n° 3564 of 12 rebia II 1401 (February 18, 1981).
[15] Dahir n° 1-84-21 of 11 rebia I 1407 (November 14, 1986), Official Bulletin n° 3953 of 19 hija 1408 (August 3, 1988).
[16] Directorate of Studies and Financial Forecasts, Ministry of Economy and Finance, Morocco, (2016) - Maritime transport of goods in Morocco: Evolution and outlook.
[17] Port activities: year 2018 - http://www.equipement.gov.ma/ports
[18] 2018 Activity Report of the Department of Maritime Fisheries, Ministry of Agriculture, Maritime Fisheries, Rural Development and Water and Forests, Kingdom of Morocco
[19] Ibid 19
[20] FAO (2018)- The State of World Fisheries and Aquaculture - Achieving the Sustainable Development Goals. Rome
[21] Ibid 19
[22] Ministry of Economy and Finance, Morocco and Agency for the Development of Aquaculture ANDA (2018) - Moroccan marine aquaculture: Potential and need for development. https://www.finances.gov.ma/
[23] Jaouhari Mehdi - la Vie éco 26 july 2017 - https://www.lavieeco.com/news/economie/algues-marines
[24] Tourism in figures - https://www.tourisme.gov.ma/fr/tourisme-en-chiffres/chiffres-cles
[25] Ministry of Tourism - - http://www.tourisme.gov.ma
[26] http://www.onhym.com/office/onhym-en-bref
[27] Law n°21-90 amended and completed by Law n°27- 99, http://www.onhym.com/pdf/Code_Hydrocarbures
[28] Articles 76 to 85 (Part VI) of UNCLOS define the continental shelf in the legal sense, the modalities of its extension and the obligations of coastal States.
[29] The United Nations Convention on the Law of the Sea (UNCLOS) adopted on December 10, 1982 in Montego Bay and entered into force on November 16, 1994.
[30] he convention entered into force in Morocco on June 31, 2007 (B0 n° 5714 of March 5, 2009-Dahir n° 1-04-134 of 17 Joumada I 1429, May 23, 2008).
[31] Ratification of UNCLOS grants coastal States the right to submit a request for the extension of the continental shelf beyond 200 nautical miles, but not exceeding 350 miles, supported and justified by legal and scientific arguments (Article 76, Part VI).
[32] The Paleolithic is the first and longest period of prehistory that began 3.3 million years ago

[33] Kingdom of Morocco, Ministry of Culture, Youth and Sports, Department of Culture. Portal of the Moroccan cultural heritage. http://www.patrimoineculturel.ma/
and List of Morocco's listed monuments
https://fr.wikipedia.org/wiki/Projet:Maroc/Liste_des_monuments_class
[34] UNESCO World Heritage Centre - Morocco, Properties inscribed on the World Heritage List https://whc.unesco.org/fr/etatsparties/ma
[35] Kingdom of Morocco, Ministry of Culture, Youth and Sports, Department of Culture. Monuments, sites and areas classified as "National Heritage".
https://www.minculture.gov.ma/fr/?p=373
[36] Ibid 35
[37] http://www.ipcc.ch/report/sr15/
[38] IPCC (2019) - Special Report on the consequences of global warming of 1.5°C above pre-industrial levels and associated global greenhouse gas emission trajectories, in the context of strengthening the global response to climate change, sustainable development and poverty reduction. WMO/UNEP
[39] https://fr.wikipedia.org/wiki/%C3%89l%C3%A9vation_du_niveau_de_la_mer
[40] In Yousra Jaa (2019) Exclusive Global warming in Morocco: the latest figures. Medias 24 https://www.medias24.com/exclusif-les-derniers-chiffres-du-rechauffement-climatique
[41] Kingdom of Morocco, Climate Change and the Fisheries Sector: Impacts and Recommendations, 2013, Morocco Climate Change Strategy Analytical Support Program P-ESW 113768, Strategy Note n. 3
[42] Renou, et al, 2011 ; Amine et al., 2018 ; Kaabouben et al., 2009
[43] Law n°11-03 on the protection and development of the environment, Dahir n°1-03-59 of 10rabii I 1424 (12 May 2003) (BO n°5118 of 19/06/2003, page 500)
[44] Law n°12-03 relating to the impact studies on the environment promulgated by the dahir n°1-03-60 of 10 rabii I 1424 (12 May 2003), Official Gazette n°5118 of 19/06/2003, page 507
[45] Law nº 13-03 relating to the fight against air pollution, Dahir nº 1-03-61
[46] Law n° 81-12 relating to the littoral, Dahir n° 1-15-87 of 29 ramadan 1436 (16 July 2015) Official Gazette n° 6404 - lem Moharrem 1437 (15-10-2015)
[47] The Constitution of the Kingdom of Morocco. Dahir n° 1-11-91 of 27 chaabane 1432 (29 July 2011), Official Gazette n° 5964 bis of 28 chaabane 1432 (30/07/2011)
[48] Law n°77-15 prohibiting the manufacture, import, export, marketing and use of plastic bags. Dahir n° 1-15-148 of 25 safar 1437 (7 December 2015) Official Gazette n° 6422 5 rabii I 1437 (17-12-2015) 5 rabii I 1437 (17-12-2015)
[49] World Bank (2014).
[50] National Report, 2018, Secretariat of State in charge of Sustainable Development
[51] INRH (2015) - Bulletin de surveillance sanitaire des zones de production conchylicole
[52] GREENPEACE (2007).
[53] Kupper Claire and Vaghi Margaux. Mapping oil in West Africa. GRIP Analysis Note, January 14, 2014, Brussels. http://www.grip.org/fr/node/1158
[54] The Quaternary is a geological period that includes the Pleistocene (2.6 Ma to 10,000 years ago) and the Holocene (10,000 years ago to the present). It is when humans first appeared
[55] http://ma.chm-cbd.net/manag_cons/esp_prot/sibe_ma/sibe_lit
56 Network of Natura 2000 sites for the Mediterranean biogeographical region
[57] Stratégie Nationale de Développement Durable 2030, Executive Summary, October, 2017, https://www.environnement.gov.ma/PDFs/publication/Rapport_Stratégie_Nationale
[58] Law n°11-03 on the protection and development of the environment, Dahir n°1-03-59 of 10rabii I 1424 (12 May 2003) ( Official Bulletin n°5118 of 19/06/2003, page 500)
[59] Law n°12-03 on environmental impact studies promulgated by dahir n°1-03-60 of 10 rabii I 1424 (12 May 2003), Official Gazette n°5118 of 19/06/2003, page 507
[60] The law n° 22- 07, Official Gazette n° 5866 of August 19, 2010
[61] Dahir n° 1-14-09 of 4 joumada I 1435 (March 6, 2014) enacting law n° 22- 07, Official Gazette n° 6240 of 18 joumada I 1435 - March 20, 2014
[62] Law 28-00, Official Gazette n°5480 of December 7, 2006
[63] Law n° 81-12, Dahir n° 1-15-87 of 29 ramadan 1436 (July 16, 2015) Official Gazette N° 6404 - lèr Moharrem 1437 (15-10-2015)

[64] National Commission for Integrated Coastal Management provided for in Article 5 of Law 81-12, in charge of advising on the draft national coastal plan. decree no. 2-15-769 of 3 rabii I 1437 (15 December 2015)

[65] Defined by the Coastal Law 81-12 and confirmed by international best practices.

[66] This project is part of the large Regional Program for Sustainable Development in the Mediterranean "SUSTAINABLE MED" in http://gizc.environnement.gov.ma/projet-gizc-dans-la-region-de-loriental/description-du-projet

[67] Intended for the breeding of shellfish such as hollow oysters, mussels, flat oysters, cockles and clams

[68] Conducted as part of the agreement concluded in 2018 between the Program for the Assessment and Control of Marine and Coastal Pollution in the Mediterranean Region (MED POL) in https://www.iucn.org/fr/content/programme-dévaluation-et-de-maitrise-de-la-pollution-marine-et-côtière-dans-la-région.

[69] Decree No. 95-717 of November 22, 1996, supplemented by Prime Ministerial Enforcement Order No. 3-300 of July 16, 2003

[70] Article 3 - Dahir n° 1.81.179 of 3 joumada II 1401 (April 8, 1981) enacting Law n° 1-81 instituting an exclusive economic zone of two hundred miles off the Moroccan coast. Amended and completed by Law n°38.17, Official Bulletin of March 30, 2020

[71] Decree n° 2-75-311 of 11 Rejeb 1395 (July 21, 1975) determining bay closure lines of the Moroccan shoreline and geographical coordinates of territorial water boundaries and the exclusive economic zone (August 1975). Completed and amended by Law 37.17, Official Bulletin of March 30, 2020

[72] The exercise of fishing rights is exclusively reserved in the EEZ to vessels flying the Moroccan flag or operated by Moroccan natural or legal persons in accordance with the procedures and under the sanctions provided for in the Dahir providing Law No. 1-73-255 of 27 Chaoual 1393 (November 23, 1973) establishing maritime fishing regulations. Official Gazette n° 3187

[73] Decree 2-18-722 of September 2019 on the development and management plans for fisheries, which enabled a transition from a management logic by species or group of species to a management of the maritime space by considering stock distribution and the distribution of the various fishing trades to ensure efficient sharing of fishing effort

[74] The National Park of Al Hoceima with 19,600 ha of marine area was designated a "Specially Protected Area of Mediterranean Importance (SPAMI)" (2009) and 10 sites of biological and ecological interest.

[75] This category aims to protect specific species or habitats, often through active management intervention (e.g., protection of critical benthic habitats from trawling or dredging). Marine protected areas (MPAs) for specific species or groups may be categorized as category IV sanctuaries for seabirds, turtles or sharks.

[76] http://www.mpm.gov.ma/wps/portal/PortalI-MPM/ACCUEIL/Ibhar

[77] At the High Level Meeting on Artisanal Fisheries in the Mediterranean and Black Sea Malta - 2018

[78] http://www.mpm.gov.ma/wps/portal/!ut/p/b1/04_Sj9

79 The National Institute of Fisheries Research: http://www.inrh.ma/

[80] Law No. 15-12 (Official Bulletin, 2014-06-05, No. 6262, pp. 3476-3485) , Decree No. 2-17-456 (Official Bulletin, 2018-04-05, No. 6662, pp. 701-703) and Decree No. 2-17-455 (Official Bulletin, 2018-05-17, No. 6674, pp. 1228-1230)

[81] http://www.mpm.gov.ma/wps/portal/PortalI-MPM

[82] On occasion of the International Day for the Fight against Illegal, Unreported and Unregulated Fishing, organized by the Food and Agriculture Organization of the United Nations in Marrakech in June 2019

[83] https://www.anda.gov.ma/

[84] Ministère de l'Aménagement du Territoire national, de l'Urbanisme, de l'Habitat et de la Politique de la ville, Secrétariat Général, Direction de l'Aménagement du Territoire.

[85] This strategic planning document completed in 2002 covers all the country's territory and runs over 25 years. It consists of a series of diagnostic reports and graphic documents (maps) defining basic planning principles, as well as functionalization and governance modalities of the strategic orientations it advocates.

[86] MDG 14 aims to conserve and sustainably use oceans, seas and marine resources for sustainable development. United Nations Development Programme: https://www.un.org/sustainabledevelopment/fr/campaigns

[87] MDG 13 calls for urgent action to address climate change and its impacts. United Nations Development Programme

https://www.un.org/sustainabledevelopment/fr/campaigns

[88] The Challenger expedition circumnavigated the globe between 1872-1876, kicking off marine science.
[89] Niazi, 2007; Snoussi et al, 2008; Snoussi et al, 2009; World Bank, 2011; Khouakhi et al, 2012 and Sbai & Lasgaa, 2012
[90] National Contingency Plan to combat accidental marine pollution by hydrocarbons Decree No. 95 717 of 22 November 1996
[91] Hamoumi, 2004 ; 2008 ; 2011 ; 2012 ; 2014 ; 2015 ; 2018a ; 2018b ; 2020b
[92] The United Nations Convention on the Law of the Sea (UNCLOS), adopted in 1982, entered into force in 1994. Provisions of parts XI, XII, XIII, XIV, set obligations to: promote international cooperation in marine scientific research, guarantee the right of coastal States to take part in research projects and be represented on board oceanographic vessels and other research facilities (without obligation to participate in project costs) and benefit from the transfer of marine technology as part of bilateral, regional and multilateral programs.
[93] Deep Ocean Domains as Common Heritage of Mankind, Part XI of the International Convention on the Law of the Sea (UNCLOS)
[94] https://crts.gov.ma/
[95] https://crts.gov.ma/thematiques/oceanographie
[96] Satellite optical sensors enable observation of chlorophyll a in surface waters
[97] Diffuse attenuation results from the absorption and scattering of photons by particulate and dissolved matter in water columns
[98] Wind measurements over oceans using space-based techniques are key to understanding ocean circulation dynamics, which drives the Earth's climate and involves important interactions between ocean and atmosphere
[99] The altimetry technique is based on the measurement of the instantaneous sea level using a radar that reflects waves off the sea surface. Sea level is deduced from the distance between the satellite and the sea surface, obtained from measuring the round-trip time of radar waves. Satellites enable the monitoring of global mean sea level with an altimeter accuracy under 4 cm
[100] Radiometers onboard satellites are now so powerful that they provide Earth surface thermal data by day and night, and allow the mapping of sea surface temperatures on a meso-scale.
[101] Upwellings are marine currents that allow the ascent of cold, nutrient-laden bottom waters. This oceanographic phenomenon occurs to compensate for the vacuum created when surface ocean waters are pushed offshore by strong winds blowing from the Earth. Upwellings promote the proliferation of small pelagic fish.
[102] Atillah et al. 2005
[103] The upwelling index is the difference between the maximum temperature recorded offshore and the minimum temperature along the same parallel. It provides information on the presence or absence of cold water upwelling along the coast and on its intensity. It also allows monitoring the spatiotemporal evolution of the upwelling in detail, with a global view of the entire Moroccan coast for different seasons and years.
[104] Arid et al. 2005