

Chapter 1

Introduction: Thinking the Future from Now



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1.1 Why a Book on the Alboran Sea?

The Alboran Sea is a region that connects the Atlantic Ocean and the Mediterranean Sea, and is a natural border between Europe and Africa. But it is also a historical compendium of different cultures that extend their influence to the present. Thus, the name “Alboran” seems to come from the Tunisian pirate Al-Borany (Quirosa-Cheyrouze 2007), who used the island of Alboran as a base for his pirate fleet (Gutiérrez-Castillo 2003). Moreover, this region have a remarkable mythological burden that is due to having been considered in historical times as the limit of the known world, and find in it the mythical and legendary columns of Hercules that closed the knowledge Mediterranean during Phoenician, Greek, and Roman periods and called *Fretum Herculeum* and *Fretum Gaditanum* by the Roman, meaning the Strait of Hercules and Strait of Cadiz. The Arabic literature from ancient times named Bab al-Zakak, the door of the alley. Today, all ancient significant names have been replaced by a geographical one, the Strait of Gibraltar. The two columns of Hercules could correspond with two elevations, one in the north, the Gibraltar rock, and one in the south, probably the Hacho mount in Ceuta. The two columns of Hercules remain in the official coat of arms of Spain.

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According to Bernal Casasola (2009) referring to the fishing activity in Alboran, which in the waters of the *Fretum Gaditanum* were carried out ostriculture and the elaboration of fishmeal and other by-products, all during the Late Antiquity. This author also underlines that Opiano in his *Haliéutica*, explains with many details the capture of cetaceans in this region meaning an explicit reference to the presence of whales in western waters of the Mediterranean. Opiano refers to this fishing as a collective action, which is compared to the attack on a city (V, 115–120).

The limits Alboran Sea depend of the geological, geomorphological, hydrological, or biogeographical criteria used (Talamo and Riera 2019), so do not correspond to each other, when using different criteria. According to the International Hydrographic Organization (1953), the limit of the Alboran Sea on the West is a line joining from the tip (Europa Point) of Cap Gibraltar in Europe to the tip of the Península de Almina of Ceuta in Africa (35°54'N 5°18'W), and limit of the East is a line joining from Cabo de Gata (South of Iberian Peninsula, Europe) to Cap Fegalo, near Oran, in Algeria, Africa (35°36'N 1°12'W). However, in a broad sense from a biogeographical point of view the Alboran Sea could include the entire channel of the Strait of Gibraltar to the south of Cabo de Palos in the East (details in Chaps. 2, 6, and 11).

This sea and the related sedimentary basins have been developed by extensional processes in the inner part of an arcuated orogeny, the Betics-Rif ranges, extended both in southern Spain and northern Morocco in relation to the tectonic movements between the African and Eurasian plates. The current tectonic activity is evidenced by the high number of seismic events (Galindo Zaldívar et al. 2018). Seismotectonics and related processes as submarine slides and potential tsunami waves should therefore be considered as several important geohazard factors in this region (Álvarez-Gómez et al. 2011; Macías et al. 2015). Tectonics has generated a complex physiography (Vázquez et al. 2015), which has influenced the circulation of the water masses and the development of an important depositional contouritic system (Ercilla et al. 2016), an example worldwide given the character of this sea as a connection area between different water mass systems.

In a macroecological context, the Alboran Sea is a marine bridge that connects the Mediterranean and Atlantic populations, from microscopic plankton to the big marine mammals. The geological history has determined the presence of several endemisms. Currently, a unique mix of Mediterranean endemisms, boreal, and tropical organisms inhabits this transition zone. The main circulation of the Surface Atlantic Water in the Alboran Sea, characterized by two mesoscale anticyclonic gyres, represents an important hydrodynamic obstacle between its north and south shores. While this oceanographic pattern favors downstream connectivity, i.e., in the west-to-east direction, it constrains the cross-basin shore-to-shore connection. The surface circulation, however, shows frequent instabilities, involving the shedding of submesoscale eddies and filaments, which have realistic chances to cross the sea north to south, transporting biological material from one shore to the other, acting then as a conveyor band. In this context, the Alboran Sea shows rich biodiversity and productivity and, for many decades has been considered as a miniature ocean to study and understand marine structures, processes, and threats. The Alboran Sea

shelters a great variety of natural resources and human activities including fishing, wildlife, research, transport, tourism that historically have been exploited by different countries, mainly by the coastal states. The Alboran Sea represents a regional Mediterranean space where North and South worlds merge, creating a geopolitical region where marine resources and maritime activities should be managed from both national and international perspectives.

1.2 Thinking the Future from Now

It is widely known that currently the planet is suffering a global change affecting the Alboran Sea, its ecosystems and populations. In this context, it is necessary to set a public baseline of the existing knowledge at present to be able to compare and monitor future changes. This book reviews different aspects of the Alboran Sea to help to understand the present situation from its origin. The first and important step to update a paramount vision on this region is to understand the climatic, geologic and oceanographic, including biochemical cycles, process which conform the rich geodiversity, biodiversity, the productivity, and the sustainable use of the marine resources. The fisheries management system should take into account regularly marine environmental variability to achieve biological sustainability of marine resources and consequently economic security to fishery-dependent stakeholders. Well-funded policy-makers' decisions require a sound scientific-based knowledge of the interaction between the marine environment and commercial stocks. This is because the role of marine environment in the evolution of fish stocks is sometimes even more important than the one played by fishers in the commercial exploitation of them. Finally, we should analyze the different aspects of political context that could affect the management of the resources from the Alboran Sea in the context of climate change. For this reason, and given the knowledge accumulated over the years on both shores of this sea and its resources, an updated review of the current state of knowledge is necessary.

The book could be divided into four blocks (1) oceanographic, geological, and ecological contexts (Chaps. 2–7), (2) biodiversity and ecosystems distribution (Chaps. 8–12), (3) fisheries resources and aquaculture (Chaps. 13–20), and (4) conservation, management, and marine policies (Chaps. 21–25).

1.2.1 *Oceanographic, Geological, and Ecological Contexts*

The first set of chapters corresponds to an introduction to the Alboran Sea from different specialties ranging from aspects related to political geography and legislation, both atmospheric and oceanographic dynamics, and their repercussions on climate, geological evolution, and processes currently dominant in the seabed and ecosystems.

Chapter 2 introduces the different dimensions of this maritime space from a geopolitical and transnational perspective. Legal aspects of geography and the different mentalities of the coastal states are considered in a united context of the North and South worlds, this merged geopolitical thought in the region should be necessary for the correct management of the marine resources and maritime activities.

Chapter 3 offers a general vision of the climatic regional variability in relation to atmospheric processes, which results from the numerous climatic mechanisms affecting the region in the context of north to south and west to east connections, both the large atmospheric circulation in the region and the control by the orography which produces the behavior of the Alboran Sea as a channel for the atmospheric marine boundary layer generating relevant mesoscale disturbances. The oceanographic dynamics is considered in Chap. 4, the Atlantic–Mediterranean waters exchange through the Strait of Gibraltar is the main factor that determines their circulation. The general circulation exhibits a dynamics energy alternating cyclonic and anticyclonic circulation cells. This pattern is forced by tidal dynamics and climatic conditions. Authors demonstrate that these changes affect the temperature and salinity trends of the water masses in the Alboran Sea, both factors to take into account for their impact on climate change at the regional scale and for the management of living resources.

Chapter 5 is devoted to the geodynamic evolution of this region, the dynamics of the Eurasian, African, and Iberian plates from the Upper Jurassic and the opening and closing of related oceanic basins. In this scenario, the westward drift of the Alboran Domain determined the formation of the Betic–Rif–Alboran basin system from the upper Oligocene. The region has been the area of connection between the western (Atlantic) and eastern oceans (initially Tethys and later western Mediterranean Sea) of Iberia. Chapter 6 analyses the seafloor in relation to processes, especially active tectonics, oceanographic and sedimentary dynamics, and their role as geohazards. Tectonic activity is focused between Adra-Cabo de Gata in southern Iberia and Al-Hoceima bay in northern Africa. Two main sedimentary environments are differentiated: shallow and deep margins. The deep environment is characterized by a wide contouritic depositional system and their interaction with turbiditic processes, canyons, landslides, and seamounts.

Finally, Chap. 7 considers the biogeochemical features and dynamics of the Alboran Sea as well as its effects on the marine planktonic community, focusing on the coupling between hydrodynamics, biogeochemistry, and phytoplankton. The Atlantic jet and the upwelling of Mediterranean waters richer in nutrients drive the system, stimulates the growth of phytoplanktons, and enhances the primary production, which makes the Alboran Sea the most productive basin of the Mediterranean Sea.

1.2.2 Biodiversity and Ecosystems Distribution

The second block of chapters addresses biodiversity and endemism in different ecosystems. Chapter 8 reviews the taxonomic, origin, history, and current conservation status of seaweeds and seagrasses populations. Chapter 9 offers a general overview of benthic habitats, as well as their associated biota from the Alboran Sea. Some of these habitats host very complex communities in comparison to similar ones that are located northwards in the Atlantic Ocean or eastwards in the Mediterranean Sea and the current conservation status of those habitats. Chapter 10 reviews the importance of invertebrates as the main components of Alboran Sea biodiversity, also include an analysis of current conservation status. Chapters 8, 9, and 10, together, provide an in-depth review of the status of benthic habitats, as well as of habitat-building species from the Alboran Sea. Chapter 11 analyses the biogeographical aspects (both historical and macroecological) that have favored a high biodiversity of species in the Alboran Sea. Chapter 12 is dedicated to patterns of linkage or isolation, which determine the very development and abundance of certain species within the Alboran Sea. Thus, the oceanographic peculiarities of the Alboran Sea are linked with the biological cycles of some species to explain these patterns.

1.2.3 Fisheries Resources and Aquaculture

Due to the high biodiversity of the region and high productivity, there is an important fishery activity in the area since historical times. The third block of chapters reviews the fisheries in the region.

Chapter 13 analyze the main causes of the decline of small pelagic fishes from the Alboran Sea. Chapters 14 and 15 are dedicated to the artisanal fisheries in Spain, northern Alboran Sea, and Morocco, southern part, analyzing the traditional gears deeply rooted in the region and the main target species, an essential element of coastal communities' activity, revenues, and culture. Currently, landings of sardine and anchovy in northern Alboran are low. Chapter 16 put the focus on the small pelagic fisheries of two species, Sardine and Anchovy, in the Northern Alboran Sea exploited by a Spanish purse seiner fleet based in a long historical series of landings from the 1940s to the present.

Chapter 17 revises main tuna fisheries carried out in Alboran currently by Morocco and Spain, and the effect of climatic oscillation such as the North Atlantic Oscillation on the tuna fisheries.

Demersal resources and their exploitation are reviewed in Chap. 18, based on the high biodiversity of the Alboran Sea, due to the confluence of fauna from the Atlantic and the Mediterranean biogeographic regions.

Blackspot seabream (*Pagellus bogaraveo*), an important commercially exploited fish for the Spanish and Moroccan fleets that operate in the Strait of Gibraltar is

analyzed in Chapter 19. Chapter 20 raises the starting and current situation of industrial aquaculture in Morocco and Spain.

1.2.4 Conservation, Management, and Marine Policies

The last set of chapters addresses the aspects of resource management and conservation, as well as other economic, historical, and social aspects. Thus, the Alboran Sea is a relevant hotspot for marine megafauna (i.e., large pelagic sharks, sea turtles, seabirds, and marine mammals), which connected the Atlantic and the Mediterranean Sea. The overlap between various human activities—such as marine traffic or fisheries on the northern and southern coasts—as well as pollution entail the capture or mortality of marine megafauna. Chapter 21 reviews research approaches that could provide suggestions for the effective management of large marine megafauna.

In a framework of Driver-Pressure-State-Impact-Response in fishery management, and considering main driver a need for social and economic development in the region, Chap. 22 aims to analyze the socioeconomics of Alboran Sea fisheries as one of the main pressure over fish stocks and insight on fisheries management of the area in the context of an Ecosystem-Based Management Approach accounting for marine environmental conditions (climate variability and global warming) that influences the Alboran Sea ecosystem and consequently, fisheries.

Chapter 23 provided a historical review of the fishery on the Spanish sea coast since the conquest of the area by the Spanish Catholic Kings, until the twentieth century, and the beginning of marine research.

Chapter 24 reflects on lessons learned, gaps, and needs in marine research and provided with main actions to advance in international collaboration in ocean science, technology, and governance and harness its potential to meet societal needs, address global challenges, and drive sustainable development.

Finally, Chapter 25 reviews the Marine Protected Areas (MPAs), Key Biodiversity Areas (KBAs), and other preserved areas and provides a deep description of the existing habitats and species, and the tools used to the surveillance and mitigation against impacts.

1.3 The Future We Wish: Final Remarks

In bilateral or multilateral frameworks, international cooperation in the Alboran Sea and the Strait of Gibraltar regions aiming the scientific knowledge, conservation, and sustainable development has been constant during the last decades in the region. From the initial marine research activities carried out by Prince Albert I of Monaco and his team at the end of the nineteenth century, latterly followed during the twentieth century by the Spanish scientists from the IEO (Fig. 1.1) commanded by Odón de Buen, the subsequent international interest by different countries in doing



Fig. 1.1 Ancient fishing boat from the 1930s of the twentieth century in the Port of Malaga. Source: Own funds of the Oceanographic Center of Malaga (IEO)

research in the area, in particular the “¿Dónde va? Experiment” during the twentieth century, with the participation of an international team co-directed by the United States and Spain, or the recently Morocco’s incorporation into the scientific arena in the region mainly through the creation of a research center in Nador and another in Tangier. This book comes to fill a tremendous gap in the synthesis of more than a century of multilateral research. Nevertheless, a challenge for sustainability science and sustainable development of a region is to promote new perspectives in the interaction between scientists and the other actors involved in the governance process. Science–Policy Interfaces (SPI), as social processes oriented toward the collaboration between scientists, decision makers, and the general public to enrich environmental governance, is revealed as an adequate approach (López Rodríguez 2016). SPI based on shared projects, joint declarations, and shared experiences are a common value in the Alboran region with several examples (Dónde va Group 1984; Kinder et al. 1983), an international consortium that studied the circulation of the western Alboran Sea and the Strait of Gibraltar, the adoption of the Intercontinental Biosphere Reserve of the Mediterranean in Andalusia (Spain)—Morocco (Molina Vázquez and Villa Díaz 2008) to establish a cooperation channel between the two countries, putting common efforts into the promotion of a model toward sustainable development favouring the preservation of the shared ecosystems, the I International Meeting on Conservation and Sustainable Development in the Alboran Sea held in

Malaga in 2007 and ratified in 2009 at the second edition of the meeting, held in the city of Oujda (Morocco) producing the Oujda Declaration (Robles 2010) to promote the creation of the “Alboran Network for Sustainable Development” to support a permanent surveillance system in the form of an Observatory for Conservation and Sustainable Development in the Alboran region, and the subsequent Alboran Poctefex Project (of the Cross-Border Cooperation Program, Spain—External Borders of the European Union).

Other scientific and management experiences involve other countries connected to the Alboran area with similar problems and solutions. Currently, new international programs, governance organizations, and other operators are putting their attention into the Alboran Sea region, an area that is not only a favorable region for cooperation but sometimes used as an example, although a realistic approach shows us the difficulties for the participation of some stakeholders in some participative process (Twomey and O’Mahony 2019).

As an example of where we go, the approach, cooperation, stakeholder’s involvement, sharing knowledge, and improving capacities, the FAO regional project COPEMED (Coordination to Support Fisheries Management in the Western and Central Mediterranean) implemented in 1986, currently in its second phase, could be useful. COPEMED aims to strengthen technical and scientific capacities for fisheries assessment and management in the central and western Mediterranean, taking into account environmental, biological, economical, social, and institutional considerations. To this end, it promotes scientific cooperation among the coastal nations through common methodologies, standardized data-gathering as well as joint multidisciplinary analyses. Countries involved in COPEMED are EU and non-EU and three countries, Algeria, Morocco, and Spain, sharing the Alboran Sea are members of the project. The current phase of COPEMED started in 2008 aiming to build on the achievements of the first phase of the project (1996–2005) while strengthening an established framework of international cooperation, which fosters subregional approaches in fisheries research and management. The Project aims to maintain the sustainability of marine fisheries in the central and western Mediterranean Sea, taking into consideration environmental, biological, economical, and social issues, and aims to promote scientific cooperation among the coastal nations through coordinated scientific investigations and data gathering as well as joint multidisciplinary analyses. The Project will support national and regional fisheries management processes and take advantage of the scientific multidisciplinary knowledge that was developed during the first phase. The Project is reducing the differences in fisheries management between northern and southern countries of the region and tries to encourage a subregional approach in fisheries research and management.

The fishery research institutions of the region and the national management bodies benefit from the work of the Project. They will be in a better position to formulate fishery management and development strategies based on sound multidisciplinary knowledge of the sector. The national fisheries departments will be able to perform multidisciplinary data collections and analyses that will be used to formulate fisheries policies. There are mutual benefits for all concerned because of

the strong cooperation among nations and with the General Fisheries Commission for the Mediterranean (GFCM) that will result. The ultimate beneficiary is the fishery sector—from resource users to the various stakeholders—which will rely on responsible and sustainable fisheries development and management.

Until the present, COPEMED has made progress in encouraging collaboration among national and regional scientific and fisheries management institutions, and has had a positive effect in the subregion and beyond.

To improve regional cooperation, recently the General Fisheries Commission for the Mediterranean (FAO-GFCM) adopted subregional structures to improve the management of fishery exploited resources. To such a new approach, a new office was created in Málaga (Spain) for the purposes of the Subregional Committee for the Western Mediterranean (SRC-WM).

Other examples of international cooperation (projects carried out by GFCM, FAO or UICN-Med does in Alboran Sea), can serve as regional incentives and to show the way forward. It is the joint effort, respect to the others, collaboration, and international cooperation that will allow us to create the necessary synergies for a common future.

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