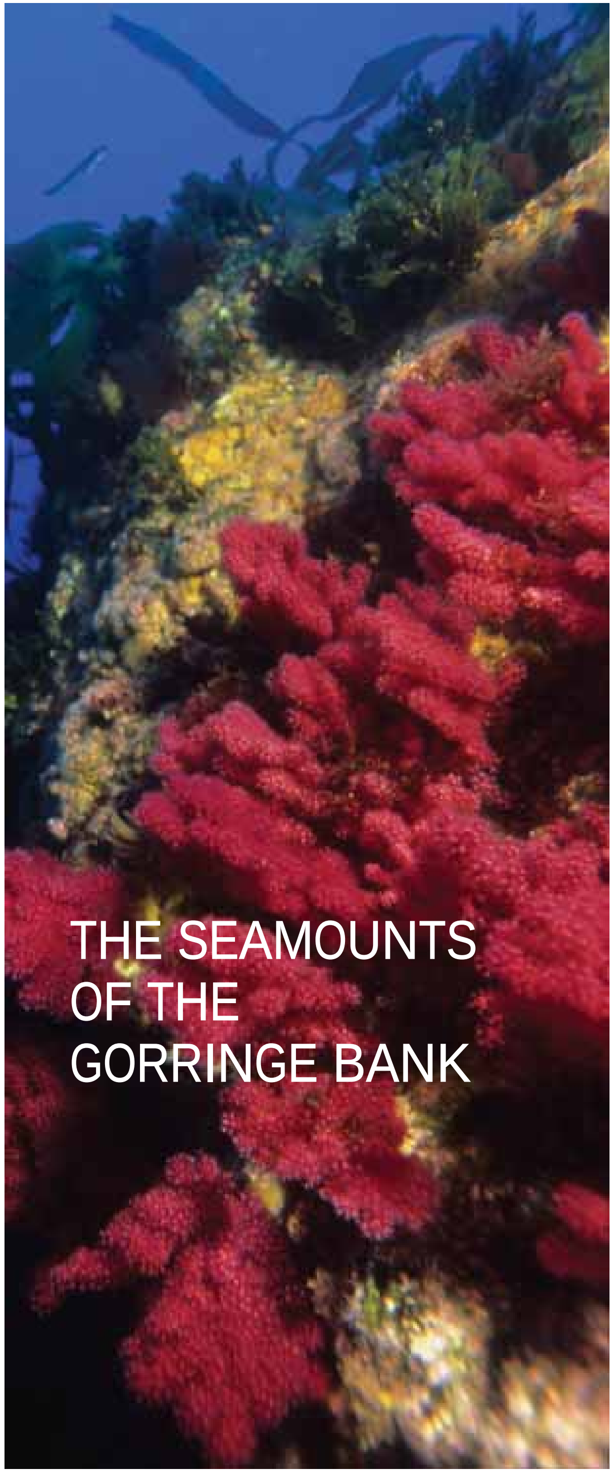


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# THE SEAMOUNTS OF THE GORRINGE BANK

OCEANA

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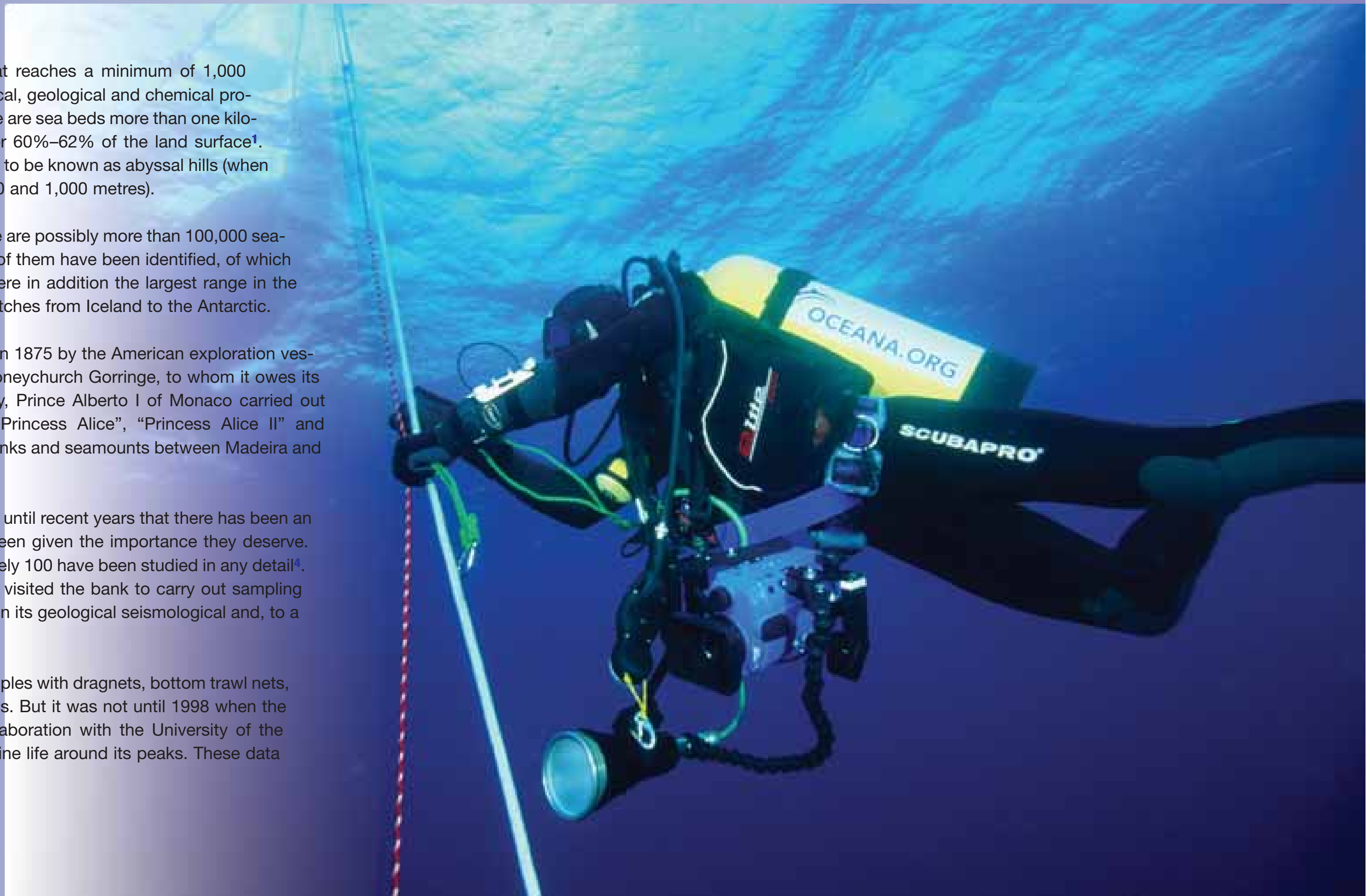
# Introduction




A seamount is regarded as a geological elevation that reaches a minimum of 1,000 metres in height and can consist of very different physical, geological and chemical properties. Therefore, seamounts can only exist where there are sea beds more than one kilometre deep, or, which is one and the same thing, over 60%–62% of the land surface[1]. There are also thousands of smaller elevations that tend to be known as abyssal hills (when they are less than 500 metres) or mounds (between 500 and 1,000 metres).

Whether in isolation or as part of extensive ranges, there are possibly more than 100,000 seamounts around the world[2]. At present, close to 30,000 of them have been identified, of which around 1,000 can be found in the Atlantic Ocean[3], where in addition the largest range in the world can be found; the Mid–Atlantic Ridge, which stretches from Iceland to the Antarctic.

The seamounts of the Gorringe Bank were discovered in 1875 by the American exploration vessel USS Gettysburg, commanded by Captain Henry Honeychurch Gorringe, to whom it owes its name. A few years later, in the early twentieth century, Prince Alberto I of Monaco carried out various studies in the area on board the vessels "Princess Alice", "Princess Alice II" and "Hirondelle II", which gave their names to other large banks and seamounts between Madeira and the Azores.

Despite the large number of seamounts, it has not been until recent years that there has been an increase in scientific studies on them and they have been given the importance they deserve. Today, only 350 seamounts have been sampled and barely 100 have been studied in any detail[4]. In the case of Gorringe, various research vessels have visited the bank to carry out sampling and undertake different tasks of gathering information on its geological seismological and, to a lesser extent, biological history.

Most of the studies have been carried out by taking samples with dragnets, bottom trawl nets, using different sonar systems or even with submersibles. But it was not until 1998 when the Portuguese organisation "Atlantico Selvagem", in collaboration with the University of the Algarve, undertook the first dives to document the marine life around its peaks. These data have led to the publication of various scientific articles.

## Oceana expedition and studies

Recently, in June 2005, Oceana, as part of its transoceanic expedition, visited the Gorringe Bank on board its catamaran the “Ranger” to document the ecosystem of these seamounts in videos and photographs. To do so, it had a team of people consisting of sailors, marine biologists, divers, underwater videographers and underwater photographers.

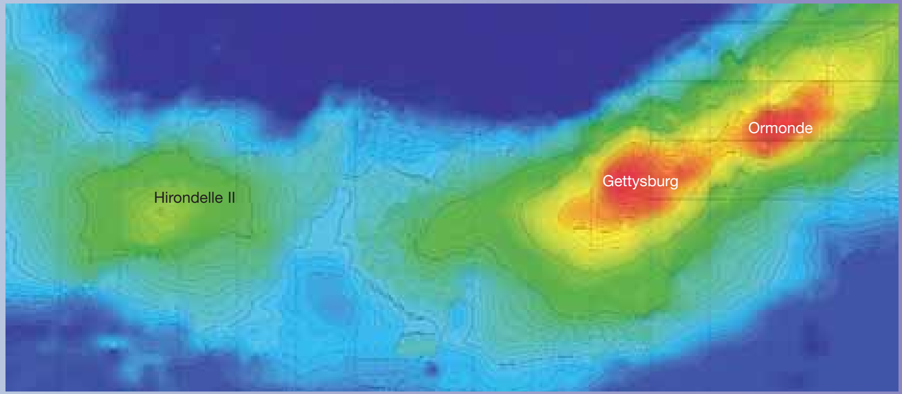
During the time they spent on the Gorringe Bank, they visited two of its main peaks (Gettysburg and Ormonde), where four divers spent around 40 hours underwater. More than one hundred photographs were taken as well as 10 hours of film, and biological samples were taken, particularly algae, for subsequent identification.

In this way, Oceana hopes to contribute to our knowledge of the ecology of the seamounts, provide visual material for dissemination to the general public and promote the protection of vulnerable European habitats.



## Geographical location

The seamounts of the Gorringe Bank or Ridge are located at around 125–150 miles WSW of Cape St. Vincent in Portugal. They cover an area more than 180 kilometres long[5], with two prominent peaks: the Gettysburg (36°31’N, 11°34’W) and the Ormonde (36°42’N, 11°09’W), whose summits are less than 50 metres beneath the surface of the sea, while the base of the seamounts are rooted in the seabed at depths of more than 5,000 metres. Some people also link this range with another smaller seamount to the west of the Bank, known as the Hirondelle II (36°27’N, 12° 52’W), whose peak is around 2,000 metres deep.




These seamounts cover an area of some 9,500 km2 and are distributed in a NE–SW direction within a ridge that extends from southern Portugal to the archipelago of Madeira.

Within the range, there are also several other geographical features, such as the Ampere seamount (35°00’N, 12°48’W), with a height of 4,700 metres and two peaks at depths of 40–60 metres; the Seine seamount (33°42’N, 22°24’W) which comes up to 86 metres below the surface of the sea; the Coral Patch seamount (34°56’N, 11°57’W), the Hirondelle seamount (36°25’N, 12°57’W) and the Unicorn seamount (34°45’N, 14°30’W); and further to the west, the Josephine Bank (36°45’N, 14°15’W), with various small elevations and one big one at 178 metres beneath the surface. These seamounts can be found flanked by abyssal plains such as the Tagus and the Horseshoe (to the west) and the Seine (to the east).

# 1 Geology

## Geomorphology, topography and petrology

The Gorringe Bank is located in the area where the African and Euro–Asiatic tectonic plates converge and collide, at the eastern extreme of the boundary or fracture zone known as Azores–Gibraltar. For this reason, some studies point to the possibility that these seamounts were created by the thrust of the African plate, generating an overriding effect[6]. More modern studies[7] have proved that the coverage of the sedimentary structure shows that the zone has been tectonically stable since the beginning of the Cretaceous period, while recent discoveries[8] have located the greatest distortions to the south of the Bank, following a sea ridge in a NW–SE direction for almost 300 kilometres, which includes the Ampere and Coral Patch seamounts, which has resulted in this hypothesis being put in doubt.

At the same time, new studies on the area would appear to put these formations back by many millions of years. While argon analysis of the rocks has led to linking the stratum of these seamounts with volcanic eruptions more than 70 million years ago[9], studies carried out with seismic reflection and lateral–sweep sonar methods[10], as well as those based on samples from the Gettysburg seamount[11], which continually produces bioclastic material which is then exported to the great marine depths, would seem to date the formation of these structures to between 145 and 155 million years ago, coinciding with the KimmeridgianTithonian ages of the Upper Jurassic to the Hauterivian of the Lower Cretaceous, which would also seem to be demonstrated by the fossils of Mesozoic cephalopods that have been found. This would make these seamounts some of the oldest in this ocean, specifically dating back to the original creation of the Atlantic following the fragmentation of the Pangaea supercontinent[12].

The terrestrial crust of the sea depths to the west of the Iberian Peninsula is characterised by the presence of superimposed sequences of sedimentary rocks, metaplutonic rocks and serpentinized peridotites[13].

Both at the Gorringe bank and on the terrestrial crust of the sea beds to the west of the Iberian Peninsula, studies have been carried out[14] to explore the geochemical composition of the gabbros and amphibolites, as well as that of the dolerites.

Thanks to the cartography of these seamounts undertaken during the mid–Nineties by the Nautile bathyscaphe, it was corroborated that the surface of Gorringe is made up of recent conglomerates and tholeiitic volcanic lava flows, with some mid–Cretaceous sediments, although there are areas where carbonated rocks are exposed, while in the deeper layers peridotites and gabbros appear[15].

Gorringe has a blanket of pelagic sediments pertaining to the Lower Cretaceous age (Barrenian–Aptian stage)[16]. While the Gettysburg seamount is fundamentally made of serpentinized peridotites and transversal cuts with doleritic dykes, at Ormonde gabbros predominate, with numerous dykes, both doleritic and alkaline[17]. In the case of Gettysburg, the possibility has been put forward that its formation relates to three distinct phases, ranging from a first at 135 million years ago, the second at 110 million years ago and a final one 85 million years ago[18]. Meanwhile, at the peak of Ormonde alkaline rocks have been detected that date back to the period between the Upper Cretaceous and the Palaeocene ages, some 65–70 million years ago[19], but the majority of the Gorringe Bank is dominated by serpentinized peridotites and tholeiitic basalt which is twice as old, which once again puts their appearance and formation back to the lithosphere at the beginning of the Cretaceous period[20].

These characteristics lead us to differentiate Gorringe from the other seamounts located further to the south (Unicorn, Seine, Coral Match, Ampere) and Madeira, which has a greater presence of alkaline basalt rocks and oceanic island basalt (OIB) –except for the peak of Ormonde– which seem to stem from volcanic activity during a long period of time from the end of the Cretaceous to the Miocene Period[21].

In other nearby zones, such as the Josephine bank, it has been proved that the surface of these seamounts is covered by different geological sediments, including basalt rocks, limestone, aggregate, sand and biogenic rocks, while there is barely any information available on the Tore seamount[22]. Some researchers believe that the majority of these seamounts were formed in the Mid–Atlantic Ridge[23], but all the seamounts close to the Azores–Gibraltar Fracture Zone have a similar lithology to the coast of the Iberian Peninsula, which would put them in contact with the continental lithosphere[24].



During the last glacial period, and thanks to the height of their peaks, the current seamounts in the Gorringe bank were actually islands that emerged from the surface[25]. A study on the different shelves that can be found in these seamounts relates them to the glacioeustatic variations caused by the marine transgressions and regressions in the Upper Pleistocene era between 75,000 and 18,000 years ago[26].

## Seismic activity and tsunamis

The majority of tsunamis in the world are generated in the so–called “subduction zones”. In the Atlantic, the most important of these zones are in the Puerto Rico Trench (where the Atlantic reaches its greatest depth at 9,212 metres) and the South Sandwich Trench (8,325 metres). Their smaller size and lesser seismic activities compared to those of the Pacific mean that tsunamis in this ocean are infrequent. However, other tsunamis can be caused by major landslides (e.g. glaciers), volcanic explosions or earthquakes.

One of the zones with the greatest seismic activity in southern Europe[27] is at the ends of the Euro–Asian and African plates, which extend from Gorringe and the Horseshoe Abyssal Plain to the north of Algeria (between longitudes 13ºW and 4ºE). It has been estimated[28] that there is a directional convergence of 140º to 130º and a rate of 2 to 4 mm.a–1. In the opinion of various researchers[29] the presence of different lithospheric influences (Continental and Oceanic Africa, Continental and Oceanic Eurasia–Iberian and Alboran) is the cause of the numerous earthquakes recorded in the area, most of which have a low magnitude[30].


The Gorringe Bank is therefore regarded as one of the areas with the greatest potential for seismic movements[31], and thus the creation of tsunamis, in the Atlantic, and has been the focus of numerous seismological studies[32].

The Gorringe Bank divides the Azores–Gibraltar Fracture Zone in two, with one section in the west, between 24ºW and 13ºW (known as the Gloria Fault) and the other section to the east, between 13ºW and 5ºW, to which this range belongs[33]. This area is also known for having a strong geodic anomaly, magnetic anomalies with a strong positive gravity[34] and as being a North–South convergence zone with a slow rate of 4 millimetres a year[35]. But there is also a more complex seismology in Gorringe, with horizontal pressures and reverse faults[36].

Various gigantic waves have emerged from this bank or its surroundings due to its seismic activity. The largest of these happened on 1 November 1755, when an earthquake of 8.6 on the Richter scale[37] produced at least three waves of more than 10 metres in height which devastated large coastal areas of Portugal, Spain and North Africa, as well as the Macaronesian Islands, and even reached Ireland and the Caribbean. This tsunami has recently been the subject of various reviews and studies[38]. Another huge tsunami occurred in 1969, whose epicentre was between the Gorringe Bank and the Horseshoe Abyssal Plain, also to the south–west of Cape St. Vincent (36.01N, 10.57W), affecting Africa and Europe[39].

Other major tsunamis have occurred in the continuation of this fracture, in both the Gulf of Cadiz and in the Mediterranean, specifically between the Alboran Sea and the coast of Algeria.

But other major tsunamis have been detected in more eastern areas, such as the one detected off the coasts of Calabria and Sicily in 1783[41], or the Strait of Messina in 1908[42].

However, the area with the greatest seismic activity in the Atlantic is the Mid–Atlantic Ridge, where the Euro–Asian and American plates separate, generating a huge number of seamounts and underwater volcanoes, hydrothermal vents and other volcanological phenomena.

Major tsunamis that have affected the south of the Iberian Peninsula[40]

| Year | Origin | Location | Description | Cause | MSK Intensity |
|---|---|---|---|---|---|
| -218 | Cadiz | 36º12'N-07º40'W | Tsunami in Cadiz | Underwater earthquake | |
| -210 | Cadiz | 36º00'N-10º30'W | Cadiz flooded | Underwater earthquake | |
| -60 | SW Portugal | 36º00'N-10º'00'W | Coasts flooded | Underwater earthquake | 9.0 |
| 881 | Cadiz | 36º00'N-08º00'W | Regression of the sea in southern Spain | Underwater earthquake | |
| 1680 | Alboran Sea | 36º30'N-04º24'W | Rise in sea level (5m) in the port of Malaga | Underwater earthquake | 9.0 |
| 1706 | Canary Islands | 28º17'N-16º37'W | Regression/flooding in Garachico | Volcanic eruption | |
| 1755 | SW Portugal | 37º00'N-10º00'W | Catastrophic tsunami in the south of the Iberian Peninsula | Underwater earthquake | 11.0 |
| 1755 | SW Portugal | 37º00'N-10º00'W | Huge inflow and outflow in Gibraltar | Underwater earthquake | |
| 1755 | Coruña | | Inflow/outflow of the sea in La Coruña | Underwater earthquake | |
| 1756 | Balearic Islands | | Coasts flooded | | |
| 1790 | Alboran Sea | 35º42'N-00º36'W | Flooding of the African and Spanish coasts | Earthquake | 10.0 |
| 1804 | Alboran Sea | 6º50'N-02º50'W | Regression of the sea in the province of Almeria | Earthquake | 8.0 |
| 1856 | Algeria | 36º50'N-05º43'E | Regression/flooding of the sea in Jijel | Earthquake | |
| 1856 | Algeria | 36º50'N-05º43'E | Flooding in Jijel and Bougie | Earthquake | 8.0 |
| 1885 | Algeria | | Changes in sea level on the coasts of Algeria | Earthquake | |
| 1891 | Algeria | 36º30'N-01º48'E | Regression of the sea | Earthquake | 9.0 |
| 1954 | Alboran Sea | 36º17'N-31º28'E | Recorded by tide gauges | Landslide due to quake | 10.0 |
| 1969 | Gorringe Bank | 36º01'N-10º57'W | Recorded by tide gauges | Underwater earthquake | 7.0 |
| 1975 | AGFZ | 35º540N-17º36'W | Recorded by tide gauges | Underwater earthquake | 6.0 |
| 1978 | Cadiz | 36º22'N-06º59'W | Recorded by tide gauges | Underwater earthquake | 4.0 |
| 1980 | Algeria | 36º17'N-01º41'E | Recorded by tide gauges | Landslide due to quake | 10.0 |
| 2003 | Algeria | 36º48'N-03º05'E | Damage to boats in the Balearic Islands and coast of the Spanish mainland | Underwater earthquake | 9.5 |
| 2003 | Algeria | 36º48'N-03º37'E | Variation of sea level by 10-15 cm in Mahon and Palma | Underwater earthquake | 2.0 (Spain) |

# 2 Oceanography

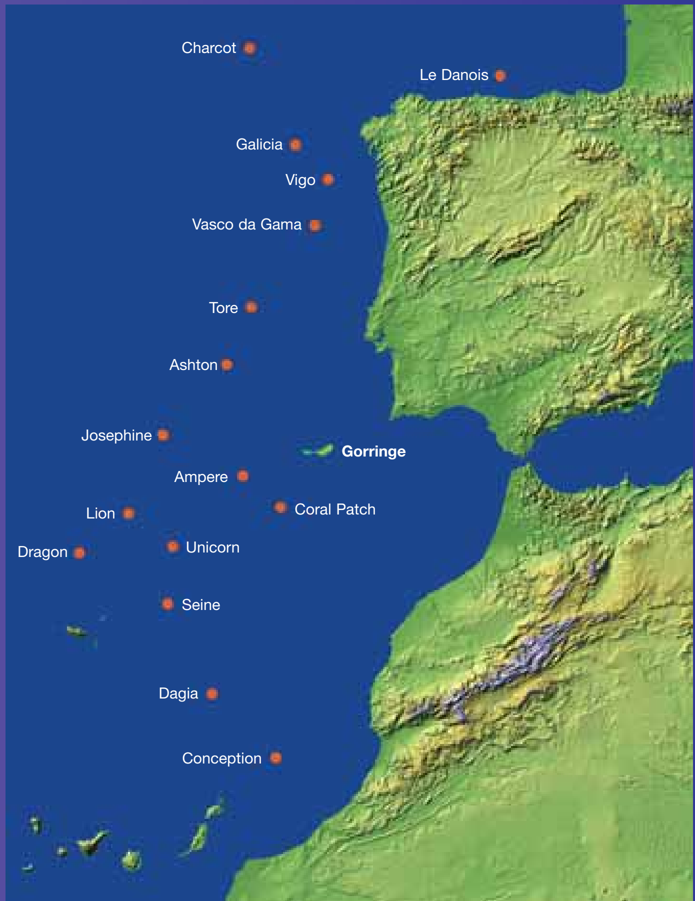
## Currents and seamounts

Seamounts are an obstacle to the free circulation of the oceans. This gives rise to different kinds of phenomena and disturbances, including an increase in the speed of sea currents, upwellings, turbulence, Taylor cones, eddies, and even jets in the zones where the seamounts interact with ocean currents[43].

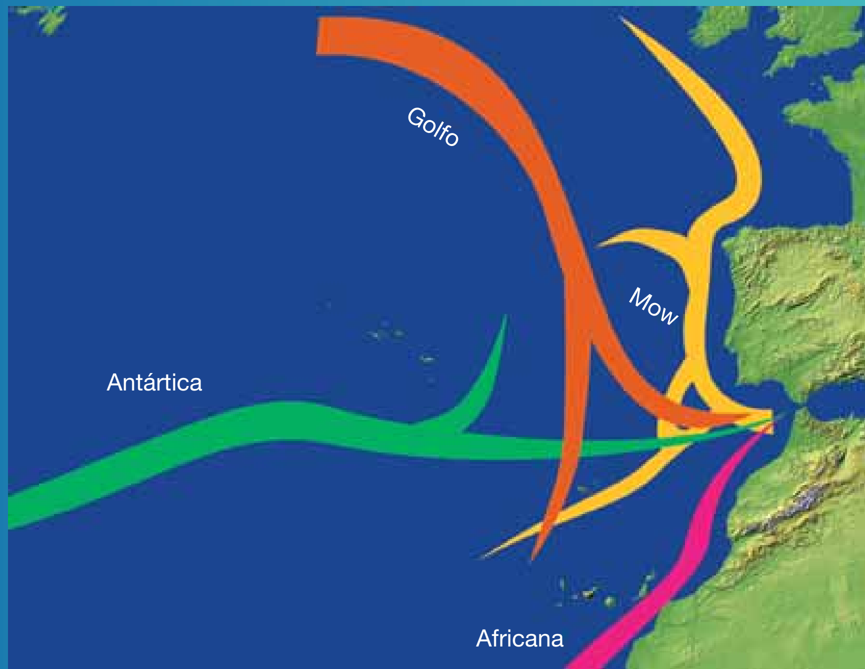
Sea currents in the areas with the greatest depths tend to be very slow, not exceeding a few centimetres per second[44]. But when they come into contact with an obstacle, such as a seamount, the mass of water accelerates due to the "Venturi Effect", reaching a speed of 25 centimetres per second[45]. It is also known that there are benthic storms at these great ocean depths, something common to areas of both the North and South Atlantic[46].

The behaviour of ocean currents when they come into contact with seamounts can also be influenced by the topography. Thus while at the Great Meteor seamount (to the south of the Azores on the Mid–Atlantic Ridge at 30°00'N 28°30'W) there are Taylor cones and calm areas with isolated water masses[47] –possibly due to the wide plateau on its peak– at the Ampere seamount the upwellings are more active[48].

These variations in the movement of water masses have also been detected on the Gorringe Bank; around its seamounts there is an extensive anticyclonic eddy associated with the lifting of nutrients from the rich deep water, giving rise to high concentrations of nitrates and chlorophyll in the shallow waters[49], which encourages the development of a wealth of flora and fauna on the peaks of these seamounts. It is known that part of the life on these seamounts depends upon the constant supply of nutrients from the superficial layers. In the North Atlantic, the primary annual productivity in oceanic waters is between 45 and 125 g C/$m^2$, being much richer in the northern part than the southern[50].




These effects, generated by the topography of the seamounts, mean that they have become oasis of life compared to their surroundings, which tend to feature a much lower biomass and diversity. Meanwhile, this supply of nutrients contrasts with the generalised oligotrophy of deep waters, where only the supply of food from the superficial layers, or the chemosynthetic production of habitats, such as hydrothermal vents and gas seepage, allow the existence of relatively abundant biomasses[51].



## The Mediterranean influence

The area in which the Gorringe Bank is found, as well as the Gulf of Cadiz and adjacent areas, are characterised by the entry of Mediterranean waters through the Strait of Gibraltar[52].

In the Mediterranean, evaporation is higher than the input of fresh water from rivers or the rainfall it receives. This means that the mass of Mediterranean water is very dense (the density of water depends upon its temperature and salinity) and in the area of the Strait of Gibraltar this generates thermohaline circulation[53]. When this mass of Mediterranean water collides with the less dense water from the Atlantic, it passes through the Strait of Gibraltar underneath the mass of Atlantic water. This current from the Mediterranean is known as the Mediterranean Outflow Water (MOW). As the MOW leaves Gibraltar towards the Atlantic, it is diluted until it reaches a state of neutral buoyancy between the western part of this gulf and the south–western waters of Portugal at a depth of some 1,000–1,200 metres[54]. This plume or tongue of warmer, saltier water, which carries more than 50,000 km$^3$ a year[55], reaches its maximum speed of 0.3 metres per second to the south of Portugal (between 08°30'W and 09°45'W)[56].

Most of the Mediterranean outflow seems to be concentrated at between 800 and 1,500 metres (up to 66%), although a notable percentage is dispersed below these depths (22%) and another part reaches the most superficial layers (around 18%), especially to the south of parallel 38°N[57].

Different studies[58] have demonstrated the huge influence that certain seamounts close to the Iberian Peninsula can have on the Mediterranean outflow, detecting that some of the main routes along which these waters flow are around these topographical features. Once the water has left the Gulf of Cadiz, the Mediterranean outflow heads in two main directions[59]. One is to the west, towards the Gorringe Bank, and the other is to the north, via the Iberian continental shelf until it reaches Galicia. There, part of this water heads for the more northerly zones via Cape Finisterre, until it reaches the British Isles (where it can be detected in the large deep–sea coral reefs of the Porcupine Seabight to the south–west of Ireland). A second branch of the MOW heads to the west, crossing the Galician Bank (where other large deep–sea coral reefs can be found). The coincidence of these salty currents with the distribution of some of the main deep–sea coral reefs in Europe has led scientists to associate the distribution and existence of these reefs with the Mediterranean influence[60].

The bulk of this Mediterranean water clearly seems to flow towards the west. Meanwhile, other researchers have corroborated that a large proportion of these salty masses that reach the Gorringe Bank subsequently take a northerly direction until they combine with the branch that stretches along Galicia, while others continue their journey towards the more westerly zones of the Atlantic[61]. Some of this water even enters the Cantabrian Sea[62].

This current of Mediterranean water generates meddies that travel large distances, as far as the Gorringe Bank and subsequently spreading across the North Atlantic, reaching distant areas to the north, south and west[63] by means of the Coriolis force and interactions with the topography[64].

### *—Meddies—*

Meddies are solid masses of water with an anticyclonic rotation up to 50 kilometres in diameter and a vertical extension of up to 200 metres[65] which are formed to the south–west of Portugal, particularly in the Portimao Canyon[66] and have an average lifespan of 1.7 years[67], although some can remain active for almost 5 years[68]. The relief of the Gorringe seamounts represents an obstacle to the trajectory of eddies and the Mediterranean outflow, which gives rise to the formation or destruction of meddies[69]. On other occasions, the meddies that have formed opposite Cape St. Vincent head in a southerly direction until they reach the seamounts of Gettysburg and Ormonde[70], even reaching the Great Meteor seamount more than 400 miles to the west of the Canary Islands and Madeira[71]. It is estimated that around 15–20 meddies are formed between the south of Portugal and the Gorringe Bank each year[72], which would allow almost 30 to exist simultaneously in the North–East Atlantic[73].

## The Atlantic influence

With regard to superficial currents, the area in which the Gorringe Bank is located (like the whole of western Europe and the north of Africa) is strongly influenced by the Gulf Stream, particularly by one of its branches known as the Azores Current.

Around the 45ºW meridian, the Gulf Stream divides, forming the Azores Current[74]. This current heads in a south–easterly direction until it crosses the Mid–Atlantic Ridge and reaches the coasts of southern Europe and northern Africa, and ends up mixing with the segment coming from the Mediterranean in the areas close to the south of Portugal[75], and also with the tropical current rising up from the African shelf[76]. At the same time, the Gulf Stream divides into three more branches which flow towards the south until reaching the Canary Current and subsequently to the west to the North Equatorial Current[77].

The maximum speed of the Gulf Stream has been estimated at around 100 centimetres per second[78], and the volume of water it moves depends upon the area, with an average of around 30 Sverdrup. Meanwhile, the width of the Azores Current jet is around 150 kilometres wide and 1,000 metres deep, moving at a speed of some 40–50 centimetres per second[79] and carrying around 10–12 Sverdrup in the Gorringe area[80]. The width, direction, speed and transport capacity of these currents can vary depending either interannually or seasonally and can form countercurrents and cyclonic or anticyclonic eddies[81].

When the mass of water of the Azores Current and the Mediterranean outflow meet, the high salinity and thus density of the latter drops rapidly[82], but its transport capacity, 0.7 Sverdrup as it leaves the Strait of Gibraltar, is tripled or quadrupled when it reaches a buoyancy equilibrium at a depth of approximately 1,000 metres to the south of Portugal[83].

## Other currents

But these are not the only currents that influence these seamounts. Cold Antarctic waters (2ºC), rich in nutrients (but with a low oxygen content when they reach this northerly area), also reach these latitudes via the depths of the Mid–Atlantic Ridge, having reached the Iberian Basin and the West Gorringe Bank via Discovery Gap with a Sverdrup transport of 0.55[84].

Despite the numerous studies carried out on the movements of water masses in the North Atlantic, there are still many questions to be answered on the interactions between the different currents, and between these currents and the topography[85].

## Oxygen levels

Despite the fact that ocean water tends to have oxygen levels close to saturation point, some waters, at depths of between 100 and 1,200 metres, can have minimum levels of oxygen, or hypoxia, as has been corroborated off West Africa[86]. These phenomena can also occur in deep water, including anoxic areas[87]. And although the concentrations of oxygen in the depths of the sea vary between <1 and 7 ml/l[88], the low temperatures allow for gases to dissolve more easily, which enables oxygen levels of 4%–6% to be reached in the majority of the aphotic zone, while in photic zones this could be 3.5%[89]. The vertical movements of the masses of ocean water also have a considerable influence on renewing oxygen at greater than normal depths.

# 3 Biology

Seamounts have been regarded as "stepping stones" or areas of species expansion. The particular hydrology and the currents caused by the topography of seamounts turn them into hotspots of marine life. This allows the development of unique ecosystems and huge benthic communities of fish and suspensivorous species (including scleractinian corals, antipatharian corals, gorgonias and sponges) that are different from those found in the surrounding areas[90], which tend to have a much lower biomass and diversity.

It is believed that the huge concentration of plankton around seamounts is due to the effect (sometimes combined) of upwellings and Taylor cones[91]. When these cones occur over shallow seamounts, they can increase primary production by providing the euphotic zone and the highest levels of the trophic chain with solar energy[92], while working as a plankton retention system in the vicinity of the seamounts[93].

It is well–known that the waters at depths of more than 4,000 metres, such as those at the base of the Gorringe seamounts, can have very low temperatures (even below 1ºC), although they tend to be very rich in nutrients, much of which has accumulated from the "snowfall" of organic material from the superficial layers[94].

The vertical distribution encouraged by seamounts not only facilitates the existence of different habitats and species but also a different bathymetric distribution of same–species juveniles and adults (bathymetric ontogenic migration), which tend to prefer different depths, this being the case of the different redfish (Sebastes spp.), grenadiers (Coryphaenoides rupestris) and Baird's slickhead (Alepocephalus bairdii), which, when they reach adult age, head for deeper waters[95].

The potential of these vertical migrations of organisms to transfer nutrients from shallow to deep waters, or vice versa, together with the snowfall of animal and plant detritus that concentrates over them helps seamounts to engender rich communities and high levels of biomass[96].

But the sheer importance of having a substrate in the middle of the ocean where marine life can anchor itself can be easily understood if we bear in mind that 98% of the marine species in existence live on or within a few metres of the sea bed[97].

The peaks of most of the seamounts in the world are several hundred or thousand metres beneath the surface of the sea, which prevents any photosynthetic communities from settling on them. However, in the case of the Gorringe Bank, the shallowness of its peaks means that dense and rich communities of algae and cnidaria with zooxanthellae can develop, which makes them some of the seamounts studied up to the present day with the greatest biodiversity and habitats, as they range from the euphotic to the abyssal zone, giving rise to an incredibly varied range of habitats and species.

Poriferae tend to establish themselves on the hard substrates, such as the giant sea sponges found on the Ampere seamount[98].

In the fine sand substrates of some Atlantic seamounts, urochordates have been gathered that were initially thought to be endemic to the Josephine Bank[99], such as the ascidian Seriocarpa rhizoides, but which have been found recently on other nearby seamounts and as far away as the Strait of Gibraltar[100].

Regrettably, studies on the biology of the seamounts of the Gorringe Bank are quite a lot scarcer than studies on their geology or seismology. Most of the data available on these locations is limited to a few scientific expeditions undertaken in recent years, which have gathered information mainly on ichthyologic fauna, molluscs and other invertebrates.



## Endemism and Biodiversity

The tremendous productivity of these geographical features means that they can be used by migratory species or those with a wide area of distribution as places for feeding or spending key periods in their lifecycles, such as mating and reproduction. Various species at different biological phases (larva, juvenile, adult or reproductive) may visit these marine oases, guided by one of the oceanic currents that cross them. Indeed, it is known that the long–living orange roughy (Hoplostethus atlanticus) undertakes migrations of thousands of kilometres to lay its eggs on seamounts[101].

The importance of seamounts in giving life to endemisms is determined by the history of the tectonic plates and by their function as zones for recolonising and extending species[102]. Some seamounts or groups of seamounts can be isolated from the rest and from the surrounding water because of the currents around them[103]. These currents can also, in certain cases, prevent the dispersion of larvae from the seamounts to other places[104], thus resulting in the appearance of endemisms. This phenomenon is totally contrary to the cosmopolitan distribution of the majority of species in the depths of the sea, which generally have a greater area of distribution the deeper they live, as the environmental conditions at this level are similar in every ocean and they do not come across any determining obstacles[105].

The large number of endemic species found on many seamounts makes them "hotspots" or centres of biodiversity. In the seamounts of the South Pacific, the percentage of endemisms reaches between 30% and 52%[106] of the species identified. In the North Atlantic, this percentage falls to less than 10%[107], although the lack of detailed studies on many of them could be the reason behind this lower endemicity. Indeed, the seamount that can be regarded as the most studied in this area, the Great Meteor, has 9% of endimisms in the case of fish alone[108].

Seamounts that rise up to shallow waters tend to concentrate cosmopolitan or similar species to those found in their vicinity[109]. This could be the reason why a large number of endemisms have not been found on the Gorringe Bank, though on the other hand this region may have a much more important role as a zone for extending and recolonising species than the deeper seamounts[110]. Thus all the species of molluscs identified on the Gorringe Bank can also be found in the Macaronesian archipelagos, the waters of the Iberian Peninsula or in the Mediterranean[111]. In general, the number of endemisms found on the seamounts between the Iberian Peninsula and the Macaronesian archipelagos is still low, but then the studies on flora and fauna are also limited. Two examples of apparently unique species to this zone are the hydrozoa Pseudoplumaria sabinae, and most particularly the discovery of a pycnogonid or pantopod that was previously unknown to science, the Austrodecus conifer[112], whose genus has not been mentioned before in connection with the North Atlantic.

Marine mammals are also regular visitors to these areas. This can be seen on the Formigas Bank in the Azores, where various species of cetaceans congregate, including bottlenose dolphins (Tursiops truncatus), common dolphins (Delphinus delphis), striped dolphins (Stenella frontalis) and pilot whales (Globicephala melas)[113]; around the Davidson seamount in the Pacific off California, where Dall's porpoises (Phocenoides dalli), sperm whales (Physeter macrocephalus) and orca or killer whales (Orcinus orca)[114] congregate, and around the Bowie seamount off British Columbia, where sperm whales, Steller sea lions (Eumetopias jubatus) and various species of dolphins and seabirds can be observed[115].



The importance of seamounts to deep–sea sharks is unknown, but the almost total absence on the continental slope of newborns and juveniles from the main species of deep–sea sharks caught by European fleets has led to the hypothesis being put forward that the seamounts of the Mid–Atlantic Ridge and others in the region may be reproduction zones for these animals[116]. This lack of juvenile deep–sea sharks in coastal waters in not exclusive to the Atlantic, as the same phenomenon has been observed in Japanese waters[117].

Given the characteristics of certain gastropod larvae, which can drift across the oceans for months, covering huge distances[118], they are capable of recolonising areas very far away from their usual area of distribution. In fact, on the Ormonde seamount, 56% of the prosobranches found lead a planktonic life[119].

It is striking that the malacological fauna found on the Gorringe Bank has more in common with the Mediterranean Sea than with other adjacent Atlantic waters. In fact, 93.5% of the species identified there can also be found in the Mediterranean, and some of them cannot be found anywhere else in the Atlantic apart from these seamounts[120]. It is also worth mentioning that despite their proximity to the African continent, only 29% of the species of molluscs on the Gorringe Bank are also found in the waters of Morocco and Mauritania, a percentage more similar to their affinity with Scandinavian species, with which they share 22.6%. However, similarities with the waters of Madeira (77.4%) and the Canary Islands (80.6%) are much greater. They even have a greater affinity with more northerly species, reaching 54.8% in the case of the Azores and up to 58.1% when compared with Galicia and the Cantabrian Sea[121].

The lack of nutrients and animal life in the Mediterranean waters that enter the Atlantic through the Strait of Gibraltar, and which in the Gorringe area will be at depths of around 1,000 metres, cannot affect the photic zone of these seamounts, which is where these molluscs were collected148. For this reason, the closer affinity with the Mediterranean area is attributed to the lack of studies made of the Portuguese coast, which could increase the percentage of similarities with species on the Gorringe Bank. However, the presence of endemic Mediterranean species (or at least mentioned only in connection with that sea) such as the red gorgonia (Paramuricea clavata), buccinidae (Chauvetia mamillata) and the rissoidae (Alvania zylensis), may signify a much greater influence that what is believed.

This Mediterranean significance has also been corroborated in studies on hydrozoa found on both the Gorringe seamounts and others in the vicinity. On the French expedition "SEAMOUNT 1", 20 species of haleciidae and plumulariidae were identified, of which ten were of Atlantic–Mediterranean distribution, six were cosmopolitan, four corresponded to Atlantic species from adjacent areas, and one was endemic to these seamounts[122].

On the other hand, the brachiopod crustaceans found on the seamounts located in the most southerly or westerly positions, such as Great Meteor, Atlantis, Plato and Tyro, have shown greater affinity with the Mauritanian biogeographic region, while species that are common in the Iberian Peninsula or even the Canary Islands and Madeira do not seem to be present[123].

Greater disparities have been found in other seamounts, this being the case of the seamounts known as the Nasca/Sala and Gomez Chain in Chilean waters, where the species found have a much greater affinity with those in the Indian and West Pacific oceans than with the south–eastern Pacific ocean where they are found[124].

In the case of the seamounts on the Madagascar Ridge, the fauna found there shows much greater similarities with those of Australia and New Zealand, including two deep–sea sharks (Parmaturus macmillani and Proscymnodon plunketi) which up until then had only been found in the South Pacific[125].

Another noteworthy fact is the huge taxonomic variety of ichthyologic fauna found on seamounts; despite the fact that the number of species identified barely represents 2%–3% of those existing in the oceans of the world, their taxonomic diversity is exceptionally high, representing between 25% and almost 50% in the case of known families and orders respectively[126].



To get an idea of the vast lack of knowledge on the biota of seamounts, we simply need to know that of the most frequently–studied taxonomic group, invertebrates, only 3%–4% of them have been evaluated[127].

Work on flora on seamounts even more scarce, if possible, but some discoveries are throwing up very interesting data. In fact, the photosynthetic plant discovered at the greatest depth (268 metres) is a red encrusting alga and was found on a seamount close to the island of San Salvador in the Bahamas[128].

## List of species

With the information provided in this report from "in situ" studies and the bibliographic compilation, the Gorringe seamounts can now represent almost 150 different species, which makes them, after the Great Meteor, the second seamount in the North Atlantic with the largest number of known taxons.

During this expedition, some 50 different species of flora and fauna have been preliminarily identified. Thirty-six of these are mentioned and documented for the first time, in terms of both Gorringe itself and the seamounts of the North-East Atlantic.

Species of fauna and flora found on the Gorringe Bank (in green the species corroborated by the Oceana Ranger expedition and in red the new species mentioned for this location by Oceana):

**FAUNA**

**Reptiles**
Caretta caretta

**Seabirds**
Hydrobates pelagicus
Oceanodroma castro

**Fish**
Abudefduf luridus (1)
Anthias anthias (1)
Aphanophus carbo (6)
Arnoglossus imperialis (6)
Balistes carolinensis (1)
Canthigaster rostrata*
Capros aper (6)
Centolabrus trutta
Chromis limbata
Coris julis (1)
Kyphosus sectatrix
Labrus bergylta (1)
Lepidopus caudatus (3)
Lepidorhombus boscii (6)
Macroramphosus scolopax (6)
Manta birostris (1)
Mola mola
Muraena angusti
Phycis sp (6)
Raja maderensis (6)
Remora remora (1)
Sarda sarda (6)
Seriola dumerlii (1)
Seriola rivoliana (1)
Serranus atricauda (1)
Sphyraena viridensis (1)
Symphodus mediterraneus
Thalassoma pavo (1)
Torpedo marmorata (1)
Torpedo torpedo (6)

**Crustaceans**
Maja brachydactyla*
Metaverruca recta (7)
Necora puber
Scylarides latus
Verruca stroemia (2)

**Annelids**
Hermodice carunculata

**Hydrozoa**
Aglaophenia sp.
Aglaophenia tubiformis (5)
Aglaophenia tubulifera (5)
Antennella secundaria (5)
Cladocarpus elongatus (5)
Halecium beanii (5)
Halecium tenellum (5)
Halecium sessile (5)
Kirchenpaueria bonnevieae (5)
Kirchenpaueria pinnata (5)
Lytocarpia myriophyllum (5)
Nemertesia antennina (5)
Obelia geniculata*
Plumularia setacea (5)
Pseudoplumularia sabinae (5)
Sertularella gayi*
Streptocaulus corneliusi (5)

**Porifera**
Asconema setubalense (7)
Spongia officinalis
Clathrina sp.
Chondrosia reniformis
Ciocalypta penicillus*
Halichondria aurantiaca*

**Siphonophora**
Velella velella

**Molluscs**
Alvania cancellata (4)
Alvania zylensis (4)
Arca tetragona (4)
Bathyarca philippiana (7)
Bittium latreillii (4)
Bolma rugosa (4)
Calliostoma conulus (4)
Calliostoma zizyphinum
Capulus ungaricus (4)
Cavolinia inflexa (4)
Cerithiopsis sp. (4)
Chama gryphoides (4,7)
Chauvetia mamillata (4)
Coralliophila brevis (4)
Coraliophila meyendorfii (4)
Crassopleura maravignae (4)
Diodora graeca (4)
Emarginula tenera (4)
Epitonium pulchellum (4)
Gibberula sp. (4)
Glycymeris glycymeris (7)
Gouldia minima (4)
Haliotis tuberculata (4)
Hiatella arctica (7)
Hiatella rugosa (4)
Hypselodoris picta (4)
Jujubinus exasperatus (4)
Lamellaria latens (4)
Lima lima (4)
Limopsis minuta (7)
Manzonia crispa (4)
Megathyris detruncata (7)
Neopycnodonte cohlear (7)
Odostomella doliotum (4)
Philippia hybrida (4)
Plagiocardium papillosum (4)
Raphitoma sp. (4)
Similiphora similior (4)
Spondylus gussonii (7)
Stenosarina davidsoni (7)
Striarca lactea (4)
Tectura virginia(4)
Trichomusculus semigranatus (4)
Trivia pulex (4)

**Echinoderms**
Centrostephanus longispinus (7)
Cidaris cidaris (7)
Echinocyamus grandiporus (7)
Echinocyamus pusillus (7)
Genocidaris maculata (7)
Holothuria forskali
Ophiomyces sp. (7)
Sphaerechinus granularis (7)

**Anthozoa**
Astroides calycularis
Aulocyathus atlanticus (6)
Caryophyllia abyssorum (6)
Caryopjyllia smithii (6)
Corynactis viridis
Deltocyathus eccentricus (6)
Deltocyathus moseleyi (6)
Dendrophyllia cornigera (6)
Desmophyllum dianthus (6)
Flabellum alabastrum (6)
Flabellum chuni (6)
Lophelia pertusa (6)
Madracis pharensis (6)
Paracyathus pulchellus (6)
Paramuricea clavata
Peponocyathus folliculus (6)
Stenocyathus nobilis (6)
Stenocyathus vermiformes (6)
Villogorgia bebrycoides (6)

**FLORA (algas)**

**Brown**
Arthrocladia villosa
Dyctiopteris membranacea
Dyctiota dichotomo
Halopteris filicina*
Laminaria ochroleuca
Saccorhiza polyschides
Sporochnus pedunculatus
Zonaria tournefortii

**Green**
Valonia utricularis
Valonia aegagropila*

**Red**
Acrosorium uncinatum
Aglaothamnion sepositum*
Botryocladia ardreana*
Callophyllis lacinata
Cryptopleura ramosa
Halymenia floresia
Halymenia sp.
Kallymenia reniformes*
Laurencia obtusa*
Lithophyllum incrustans
Lithophyllum stictaeforme*
Mesophyllum alternans
Palmaria palmata
Peyssonnelia inamoena*
Plocamium cartilagineum
Porphyra leucosticta
Rhodophyllis divaricata*
Sebdenia monardiana
Titanoderma sp.

* Genus identified, specie unequivocal confirmation pending.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©NOAA. A large catch of fish from Gorringe Bank. Plate VII, print 5. In: "Results of the Scientific Campaigns of the Prince of Monaco." Vol. 89. 1910.



## Peculiarities of some of the species on the Gorringe Bank

The lists in this study have not included the discoveries of the first explorations carried out at the beginning of the twentieth century (which, as can be seen in the above picture –in which some fish can be identified, such as scombridae, tuna, triglidae and a Mediterranean moray (Muraena helena) and, possibly, some streaked gurnards or blue-mouth redfish (Helicolenus dactylopterus)–, would increase the number of species found on these seamounts), nor those pending publication, this being the case of polychaeates and cirripeds found on recent oceanographic campaigns, such as the Seamount 1 and Seamount 2, amongst others, whose initial results have been made public while this work was being undertaken.

Lepidopus caudatus: the specimens collected on previous explorations[129] in the Gorringe area seem to have more in common with the populations in the South Atlantic than with closer ones, such as those in the Azores, particularly in terms of the number of counts in the vertebral and dorsal regions.

On the Great Meteor seamount, three types of fish were studied, and the conclusion was reached that they were different to those found in the closest continental waters[130]. The seamounts seem to encourage this isolation, which can give rise to unique peculiarities, such as those mentioned for the Lepidopus caudatus.

Manzonia crispa: this gastropod mollusc was believed to be exclusive to the islands of Madeira[131]. With its discovery at Gorringe, its area of distribution has expanded towards the North–East Atlantic[132].

Paramuricea clavata: up until now, it was regarded as a species endemic to the Mediterranean, mainly the western part[133]. Its discovery on Gorringe Bank extends its area of distribution by several hundred kilometres.

Pseudoplumaria sabinae: this hydrozoa is an endemism known only on the seamounts of Gorringe and Ampere[134].

## —Description of the ecosystem observed—

The communities of brown algae or kelp forests formed by Laminaria ochroleuca and Saccorhiza polyschides are characteristic of southern Europe and particularly the Iberian Peninsula (as far as the east of the Cantabrian Sea[135]) and in the western part of the Mediterranean Sea with an Atlantic influence, such as the Alboran Sea[136]. The composition and diversity of the kelp forests found on Gorringe's peaks are very similar to those of the Alboran Sea and Gibraltar Strait[137].

While Saccorhiza polyschides is very widespread throughout Europe and North Africa (from Norway[138] to Ghana[139]), Laminaria ochroleuca is only found from Cornwall (south–west of Great Britain) to Morocco and Mauritania[140], although recently it has also been mentioned in Namibia[141]. However, Saccorhiza is an infrequently found species in the Macaronesian archipelagos, although it can be found in the Canary Islands[142].

Despite the fact that Laminaria ochroleuca is habitual on the Iberian coasts[143], there are very few data on the presence of this alga in the Macaronesian archipelago, except for on seamounts such as the Formigas Bank in the Azores[144] or in some areas of the Canary Islands[145].

The kelp "forests" observed on both the peaks of the Gorringe Bank were predominated by Laminaria ochroleuca, which formed more dense communities, amongst which could be found some more dispersed examples of Saccorhiza polyschides. Beneath them, like an "undergrowth", various brown and red algae were growing, predominantly Zonaria tournefortii, frequently accompanied by Dyctiopteris membranacea, as well as suspensivorous invertebrates, especially porifera and cnidaria, together with echinoderms and crustaceans.

In areas where the rock was more exposed, and over the hapterons of the laminaria, Rhodophyceaea algae and the odd colony of green Valoniaceae algae could be found. And on some of the red algae, hydrozoa were growing like epibionts.

These communities, dominated by Zonaria tournefortii, which could be found on both peaks of the Gorringe bank, formed notably thick blankets of vegetation, generating dense concentrations similar to those of Cystoseira spp. found in other parts of the Atlantic and Mediterranean[146].

In the steeper areas, more exposed to currents, or even in the rock fissures, there were alcyonacea, but these tended to be small or medium in size.

The Iberian–Macaronesian–Mediterranean zone (including the seamounts in this area) is one of the areas with the greatest diversity of alcyonacea in the North Atlantic. Indeed, some 89 species have been counted[147]. With regard to the genus Paramuricea, this has only been detected on three seamounts[148]: Paramuricea placomus on Great Meteor, Paramuricea candida on Plato, and the Mediterranean red gorgonia (Paramuricea clavata) which is mentioned in this work on the Gorringe Bank.

With regard to ichthyologic fauna, the most widespread species is the rainbow wrasse (Coris julis), with hundreds of examples a short distance from the benthos, while other very frequently–found species were amberjacks, mainly Seriola rivoliana, although some examples of Seriola dumerilii were also found.

In lesser numbers, but also common, were triggerfish (Balistes carolinensis) and ornate wrasse (Thalassoma pavo).



Amongst the dense blanket of vegetation, fish remains could be found, with considerable numbers of blacktail combers (Serranus atricauda) and ballan wrasse (Labrus bergylta). There were also species characteristic of the Macaronesian region such as the Canary damsel (Abudefduf luridus) and the Atlantic damselfish (Chromis limbata).

The only batoids found (spotted torpedos –Torpedo marmorata) displayed characteristic behaviour, appearing in numerous groups, one on top of the other.

Other pelagic fish, such as the Bermuda chub (Kyphosus sectatrix) or Atlantic bonitos (Sarda sarda), appeared on other occasions alongside the amberjacks. The chub is a fish more characteristic of the Western Atlantic, from the Caribbean to Bermuda[149], although it can also be found in North African waters, around Madeira and, more rarely, in the Mediterranean.

Small, unidentified pelagic fish, but possibly clupeiforms, were also spotted in the area. With regard to large pelagic species, only a large ocean sunfish (Mola mola) measuring between 1.5 and 2 metres in length was seen, which remained on the surface for a few minutes less than half a mile from the peak of Ormonde.

On the surface of the sea, numerous by–the–wind–sailors (Velella velella), most of which were dead and just displayed their "sail", drifted along with the current. We were also able to observe various layings by non–identified cephalopods.

The most common seabirds in the area are petrels (Procellariidae), which feed on the abundant plankton and the remains of organisms floating on the surface.

The one turtle found was spotted at less than 10 miles to the north east of Ormonde, this being a very large sub–adult loggerhead turtle (Caretta caretta) which was resting on the surface of the sea.

In general, both the fauna and flora present on the Gorringe bank is characteristic of the North–East Atlantic (particularly the area between the Iberian, Mediterranean, Macaronesian and North African areas), with the presence of some species that are widespread in the Atlantic, such as the triggerfish (Balistes carolinensis), the Atlantic bonito (Sarda sarda), and other cosmopolitan species such as amberjacks (Seriola spp.), chlorophyceaea Valoniaceae algae and different rhodophyceae.

The following table gives a list of the species found on the Gorringe Bank which can also be found on other banks and seamounts in the North–East Atlantic, from the Bay of Biscay to the north of the Canary Islands, including the Eratosthenes seamount in the Mediterranean[150].

| Species | Seamount |
|---|---|
| Aglaophenia tubulifera | Ampere, Josephine |
| Antenilla secundaria | Ampere |
| Anthias anthias | Josephine, Meteor |
| Aphanopus carbo | Meteor |
| Arca tetragona | Josephine |
| Arnoglossus imperialis | Josephine |
| Asconema setubalenses | Ampere, Josephine |
| Aulocyathus atlanticus | Cruiser, Hyeres, Le Danois |
| Bathyarca philippiana | Erathostenes, Josephine |
| Capros aper | Josephine, Meteor |
| Caryophillia abyssorum | Atlantis |
| Caryophillia smithii | Conception |
| Centrostephanus longispinus | Ampere, Conception, Dacia, Josephine, Meteor, Seine |
| Cidaris cidaris | Antialtair, Atlantis, Cruiser, Galicia, Hyeres, Josephine, Plato, Tyro |
| Cladocarpus elongatus | Galicia |
| Deltocyathus eccentricus | Atlantis, Josephine |
| Deltocyathus moseleyi | Atlantis, Cruiser, Josephine, Le Danois, Meteor |
| Dendrophyllia cornigera | Ampere, Josephine, Le Danois |
| Desmophyllum dianthus | Eratosthenes |
| Echinocyamus grandiporus | Antialtair, Atlantis, Cruiser, Hyeres, Josephine, Meteor, Plato, Tyro |
| Echinocyamus pusillus | Ampere, Cruiser, Meteor |
| Flabellum alabastrum | Atlantis, Cruiser, Josephine |
| Flabellum chuni | Atlantis, Cruiser Hyeres, Josephine, Meteor |
| Genocidaris maculata | Atlantis, Cruiser, Josephine |
| Halecium tenellum | Seine |
| Kirchenpaueria bonnevieae | Ampere |
| Kirchenpaueria pinnata | Galicia |
| Lepidopues caudatus | Josephine, Meteor |
| Limopsis minuta | Atlantis, Cruiser, Hyeres, Josephine, Meteor |
| Lophelia pertusa | Atlantis, Conception, Meteor, Plato |
| Lytiocarpia myriophyllum | Ampere |
| Macroramphosus scolopax | Josephine |
| Megathyris detruncata | Ampere |
| Metaverruca recta | Atlantis, Josephine, Meteor |
| Nemertesia antennina | Ampere, Seine |
| Paracyathus pulchellus | Ampere, Josephine |
| Peponocyathus foliculus | Josephine |
| Plumularia setacea | Ampere |
| Pseudoplumaria sabinae | Ampere |
| Raja maderensis | Meteor |
| Sphaerechinus granularis | Conception, Dacia |
| Spondylus gussonii | Atlantis, Hyeres, Josephine, Meteor, Plato |
| Stenocyathus vermiformis | Josephine, Le Danois |
| Stenosarina davidsoni | Atlantis |
| Streptocaulus corneliusi | Ampere, Josephine |
| Villogorgia bebrycoides | Josephine |



Despite the disparity of data between some seamounts and others, which does not allow for a proper evaluation of the similarities between them, certain echinoderms seem to be the most common species in every location. Also, the presence of reef–forming corals such as Lophelia pertusa, and certain species of molluscs appear over and over again.

The similarities of the Gorringe biota with other seamounts in the area are as follows:

| Seamount | Coincident species | Total documented | Percentage of similarity |
|---|---|---|---|
| Ampere | 13 | 26 | 50% |
| Antialtair | 2 | 5 | 40% |
| Atlantis | 13 | 59 | 22% |
| Conception | 3 | 11 | 27% |
| Cruiser | 9 | 34 | 26% |
| Dacia | 2 | 2 | 100% |
| Erathostenes | 2 | 23 | 9% |
| Galicia | 2 | 5 | 40% |
| Hyeres | 6 | 19 | 32% |
| Josephine | 26 | 96 | 27% |
| Le Danois | 4 | 16 | 25% |
| Meteor | 14 | 185 | 8% |
| Plato | 4 | 17 | 24% |
| Seine | 3 | 12 | 25% |
| Tyro | 2 | 5 | 40% |

In total, 47 of the species of fauna and flora on the Gorringe Bank coincide with the 325 species documented on the other seamounts: i.e., less than 15%.

# 4 Threats to the biodiversity of the Gorringe Bank: fishing

Although it has been proved that life can emerge in even the most extreme locations, the biomass is, generally speaking, much greater in places that provide it with a more favourable environment. Thus many species concentrate in areas such as seamounts, canyons and other marine topographical features where the greater speed of currents prevents the accumulation of sediments and facilitates the upwelling of nutrients[151].

Portugal allows fishing over all the seamounts to the south of Portugal, including the seamounts of the Gorringe Bank, Seine, Josephine, Ampere and Dacia[152], by vessels from the mainland as well as from the islands of Madeira.

Although we do not know the true scope of the fishing effort carried out in the area, or what fishing techniques and gear are most regularly used, during the time that Oceana was working in this area, buoys marking fishing pots for crustaceans could be seen to the south of the Ormonde seamount.

Given the importance of suspensivorous species to seamounts, trawling results in a huge amount of accidental catches of these creatures, as well as those that use the structures formed by them as habitats[153]. This means that the habitats formed or participated in by gorgonias, corals and sponges are significantly affected. We should not forget that sea beds with gorgonias give shelter to a multitude of species of invertebrates and vertebrates[154]; in communities of porifera, more than 130 different species associated with them have been found[155], and that in deep–sea coral reefs, mainly formed by Lophelia pertusa, more than 800 different species have been counted[156].

Despite the relatively short time that bottom trawling has been taking place in deep waters (it started at the end of the Sixties[157]), the damage it has caused is already very evident and today their nets are already reaching depths of 2,000 metres[158]. Studies on the impact of trawl nets on deep–sea ecosystems and seamounts are sufficiently explicit when it comes to demonstrating the damage caused by this kind of fishing. On the sea mounds in Australia, it was proven that areas where fishing did not take place showed between 46% and 106% more species and between 200% and 720% more biomass[159]. In studies carried out to the north–east of Great Britain, the scars left by bottom trawlers were already visible in up to 12% of sea beds photographed at depths of between 700 and 1,300 metres[160].

It is believed that some of the most sought–after species by the fishing industry, such as the orange roughy, which live in the areas around seamounts, require considerable oceanic production estimated at 10 times more than the area they occupy[161].

It is believed that deep–sea sharks could be the group of fish that has declined the most in different parts of the North Atlantic from the impact of fishing[162], given their tremendous vulnerability. This is of particular concern for this species group, which is normally long–living with a low reproduction and growth rate, as 35% of the condrichthyans that exist in the world are confined to deep waters[163]. Even more so if we bear in mind that before the 1980s, deep–sea shark fisheries were almost non–existent in Europe as a whole[164].

Longevity studies on some of the main species of sharks caught in these fisheries have proven that they are very long–living species with a very low reproduction rate[165]. In the case of the leafscale gulper shark (Centrophorus squamosus), it can reach up to 70 years old[166].

Research on Australian seamounts has shown that the areas where intensive bottom trawling has taken place has left exposed rock in 95% of its extension, while in areas where fishing had not taken place this only came to 10%[167].

Many of the species that live on seamounts, particularly those that live at great depths, evince characteristics that make them particularly vulnerable: great longevity, low reproduction and low growth rate. In other words, the fall within the classification of K–strategy species: those that experience difficulties in recovering their populations in the event of overexploitation[168]. Generally speaking, deep–sea species mature at a very advanced age[169].

In addition to this, unique distribution patterns and habitats, isolation or the impossibility of dispersing larvae, and endemicity or differences between some of the species on seamounts from other populations in the same region, make them unique species and thus at high risk of overexploitation or even extinction[170]. With regard to habitats, their physical destruction by bottom trawling gear or other human activities can make their recovery impossible, or it can take thousands of years[171].

There are countless examples of this vulnerability. From vertebrates such as the orange roughy (Hoplostethus atlanticus), which can live to more than 125 years old[172] and not become sexually mature until the age of 30[173] or the bluemouth redfish (Helicolenus dactylopterus) which can exceed 40 years of age[174], to the cold–water corals and gorgonias such as Lophelia pertusa and Primnoa resedaeformis, whose colonies can live to more than 200 and up to 500 years old respectively[175], while the reefs they create can have taken more than 8,000 years to build[176].

The impact of bottom trawling on these reefs and colonies of cnidaria can be devastating, as demonstrated by studies carried out in Alaska, which came to the conclusion that a single bottom trawler is capable of dragging up almost 1,000 kilos of gorgonias and deep–sea corals from the sea bed in a single cast[177]. Or in Norway, where it is estimated that between 30% and 50% of all their coral reefs have already been damaged or destroyed[178]. Even the corals and gorgonias that survive the onslaught of the bottom trawlers can show damage in the long term. This has been corroborated in Alaska, where on sampling a community of alcyonacea coral that had been damaged seven years earlier, almost 25% of the surviving colonies had lost between 80% and 99% of their branches[179].

There are many doubts about the possibility of there being commercial deep–sea fisheries that are both economically viable and sustainable at the same time. To avoid the overexploitation of some of these species, such low catch levels have been proposed (this being the case of the orange roughy for which a stock recovery of barely 2.5% a year would only allow catches of barely 1%–2% of its virgin biomass per year[180]), making any kind of exploitation practically unviable. For this reason, many deep–sea fisheries are based on exhausting stocks one after the other and on searching for new fishing grounds to exhaust, this being the case of the blue ling (Molva dypterigia)[181].

ICES has already warned that many species of deep–sea fish are overexploited or exhausted[182]. A recent article[183], published on the website of this scientific institution left no room for doubt on the poor state of these stocks and pointed out the huge fall in species such as the blue ling (Molva dypterigia), the grenadier (Coryphaenoides rupestres), the orange roughy (Hoplostethus atlanticus), the ling (Molva molva) and the tusk (Brosme brosme). In the case of these last two species, the CPUE (catch per unit effort) has fallen by 70% in the waters of the northern and western British Isles since the 1970s. For this reason, an immediate reduction in the catches of these species has been proposed.

Numerous studies have warned about the impact of bottom trawling over seamounts and other vulnerable ecosystems, including the decline of target species and the destruction of slow–growing benthic species[184]. And hundreds of scientists have called for a ban on bottom trawling over these ecosystems[185].

Despite the fact that it is known that almost one thousand species of demersal fish are caught in deep waters by trawl nets[186], only a few dozen of these species have any commercial use[187]. This means that the rest are discarded.

There are many examples of the lack of selectivity and the impact on both targeted and non–targeted species in these fisheries of the North–East Atlantic. In the Rockall Trough it is normal to catch some 40 to 50 different species of benthopelagic fish in casts made by bottom trawlers[188], the majority of which are of no commercial interest. To the west of Ireland, in one single three–hour fishing session, a bottom trawler working at between 840 and 1,300 metres caught 14 different commercial species and an unknown number of other species, including corals and sponges[189]. In the French fleet's grenadier fishery (Coryphaenoides rupestris) in the North Atlantic, some 48.5% of catches are discarded[190]. On the Galician Bank, an experimental bottom–trawling fishery working at depths of between 600 and 1,200 metres caught 86 different species of fish, as well as around twenty invertebrates[191]. And in the Mediterranean, discards produced by deep–sea crustacean bottom trawlers reaches 50%, including between 100 and 150 different discarded non–target species[192].

Many deep–sea fisheries have shown evident overexploitation or exhaustion of stocks in just a few years. At Rockall Trough, to the north of the British Isles, the CPUE for the main deep–sea species has fallen by 50% in just five years[193]. But this trend has become generalised in many parts of the world. Reductions and/or major changes to the composition of stocks have also been found in the seamounts of New Zealand, Japan and Australia[194], amongst others. The orange roughy (Hoplostethus atllanticus) is one of the most evident examples of catches that are totally unsustainable for stocks. In Australia[195], their populations may have decreased by between 57% and 93% in just 15 years of exploitation, and could now be at just 7%–13%, and in Namibia[196] it is believed they are below 10% of the biomass that existed before fishing started less than 20 years ago.

And there are even more extreme cases of collapse, such as the fishery of the deep–sea red crab (Chaceon affinis), which started in 1988 on the Galician Bank (some 200 miles to the west of Galicia). In just five years, catches rocketed from 0.9 tonnes to 11.5 tonnes in 1994. In 1997 there were no catches and the fishery closed[197]. In other parts of the world, such as the seamounts to the north–west of Hawaii in the Pacific, similar situations have been experienced. For example, in the pelagic armorhead fishery (Pseudopentaceros wheeleri), catches of 30,000 tonnes were achieved in just a few years, but in 1977 this fell to 3,500 and has never recovered[198].

A recent study[199] to estimate the level of vulnerability of the species that are found around seamounts compared to other fish reached compelling conclusions. Species that use seamounts, particularly those that congregate there, are much more long–living, have a lower natural mortality and a very low capacity for recovery and response to disturbances, and this is demonstrated by the significant reductions in their populations in barely a few decades of fishing. The result of this study gave a maximum level of acceptable, sustainable catches for exploiting these species as just 5% of their biomass.



A large proportion of the deep–sea fishing effort centres on these geographical features. While the species at the abyssal sea floor tend to be fish with bland flesh and big, loosely–attached scales due to the weakness of the sea currents there, for quite the opposite reason, the species on the seamounts have much more robust bodies. This means that while the former have little marketable value[200], those from the seamounts are much more sought–after internationally.

Both kinds of fish are very vulnerable to overexploitation, as the former tend to suffer serious damage when caught and even if they manage to escape from the nets many of them do not survive[201] (and these escapes from the nets can be more than 80% in terms of numbers and more than 40% in terms of weight[202]), the latter depend strongly on primary marine production and the availability of food thanks to vertically–migrating species[203], as these fish tend to have a very defined zoning process and spread themselves bathymetrically in a very uniform way[204].

Generally speaking, regardless of whether the creatures manage to escape from the nets or not, or whether they are discarded or not, the mortality of species caught from the great depths is very high[205].

The change in pressure experienced by fish caught at great depths when they are brought up to the surface means that they burst or are deformed by the expansion of the swim bladder and their internal gases. This means that, apart from very rare occasions, the mortality of these discards is 100%[206].

But although bottom trawling has the greatest impact, it is not the only form of fishing that damages coral. Longlining, fixed gillnets or any other system of fishing that comes into contact with the sea bed has the potential to damage these communities. Between the Gulf of Alaska and the Aleutian Islands, where there are extensive "forests" of corals and sponges, deep–sea longlining can accidentally "catch" coral on 0.1% of their hooks[207]. Although this percentage may seem small, every year hundreds of thousands of hooks are cast, so the cumulative impact can be very considerable.

# 5 Conclusions and proposals

ICES was already saying in 2002 that "the most effective way of mitigating the effect of trawling on these habitats is to close such areas to fishing." and that "the only proven method of preventing damage to deep–water biogenic reefs from fishing activities is through spatial closures to towed gear that potentially impacts the bottom[208]".

A few years earlier it had pointed out that "In the light of the environmental sensitivity of the deep–sea floor, a general trawl ban for the deep–sea seems sensible and possible for some fisheries and/or areas. As a short term step for the implementation of such measures, zonation systems to prevent expansion of trawl fisheries into new areas should be instituted as quickly as possible. Gear limitation to longlines should be considered[209]".

Oceana would like to state its total agreement with the opinions and proposals put forward by the ICES and reiterate the need for them to be implemented urgently.

Furthermore, OSPAR defined as "sensitive habitats" those which, if negatively affected by human activities, could only recover in a 5–25 year period, while "very sensitive habitats" are those which need an even higher period of time in which to recover. In this way, it set the criteria for selecting protected marine areas and zones closed to human activities on the high seas and great sea depths[210]. It is more than evident that the Gorringe seamounts, as well as other seamounts and all the biogenic reefs in Europe, fall within these criteria. OSPAR has also included seamounts and deep–sea corals on its list of endangered habitats[211].

The European Commission has also recognised the importance and vulnerability of these habitats, as demonstrated by its adoption of urgent measures, under article 7 of Regulation 2371/2002 of December 2002[212], protecting areas such as the Darwin Mounds in the Exclusive Economic Zone (EEZ) of the United Kingdom, and the proposal to protect the sea beds of the archipelagos of the Azores, Madeira and the Canary Islands against bottom trawling[213]. Furthermore, Directive 92/43/EC[214] regards the ecosystems of deep–sea areas as habitats of community interest and includes "reefs" in annex I.

In annex II the Directive also includes some of the species found on these seamounts, such as the loggerhead turtle (Caretta caretta); in annex IV the long–spined sea urchin (Centrostephanus longispinus), and in annex V the Mediterranean slipper lobster (Scyllarides latus).

Other international agreements[215] to which European countries are signatories also include on their lists some of the species found there; in its annex II, the Berne Convention enumerates all the hydrobatidae and the loggerhead turtle, while the Bonn Convention features this reptile in annex I.

Other species on the seamounts are only given protection if they are found in the Mediterranean. This is the case of Laminaria ochroeluca and Lithophyllum lichenoides which can be found in annex I, and the long–spined sea urchin in annex II of the Berne Convention.

This is not forgetting the different resolutions and recommendations of the United Nations[216] via UNICPOLOS, the Convention on Biological Diversity, or its General Assembly, amongst others, to protect seamounts, deep–sea coral reefs and other vulnerable ecosystems.

It is evident that the importance of the seamounts of the Gorringe Bank and their habitats and the species they shelter are worthy of special protection status. But it is also evident that in terms of marine protection matters, European legislation is very deficient and needs to be improved urgently.

Oceana therefore proposes the revision of the annexes of the European Habitats Directive to include all threatened and vulnerable ecosystems, habitats and species. As a first step, the following should be included in these:

– Seamounts
– Carbonated mounds
– Hydrothermal vents
– Underwater canyons
– Marine phanerogam meadows
– Coralligenous communities
– Maerl beds
– Kelp or laminaria forests
– Deep–sea coral reefs
– Sponge communities
– Reefs of annelid polychaetes (i.e. sabellidae)
– Mollusc reefs (i.e. vermetids and mytilids)
– Communities of Cystoseria sp.
– Other vulnerable communities of environmental importance, especially all biogenic reefs and algae “forests”.

Also, it should immediately adopt as its own the annexes of other conventions with partial or total competencies in the marine environment, such as the Barcelona Convention, the Berne Convention, the Bonn Convention, the Oslo–Paris Convention, etc.

The Gorringe seamounts possess unique aspects that make them worthy of the utmost interest:

–It is a mountainous massif that originated at the beginning of the formation of the Atlantic Ocean;
–It is the only European seamount with such a wide range of habitats, ranging from abyssal zones at depths of more than 5,000 metres to the euphotic zone.
–It could be a unique example of the combination of Mediterranean, Atlantic–Iberian, North African and Macaronesian flora and fauna.
–Its state of conservation is still very good, and it is of great interest not only from an environmental point of view but also from seismological and geological perspectives, amongst others.

All in all, the characteristics of the Gorringe seamounts meant that this natural seascape is of exceptionally high value, and should not only be a protected area but could easily be the first exclusively marine National Park in Europe and the world.

# GLOSSARY

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| Abiotic | Inanimate, nor deriving from living beings. The lifeless component of the ecosystem. A place where life is impossible. |
| Abyssal | Applies to the area between the depths of 4,000 and 6,000 metres and to the organisms that live in these depths. |
| Aphotic | The part of the water column where sunlight does not penetrate, usually beneath 200 metres. |
| Anaerobic | All respiratory processes that do not require oxygen. |
| Annelid | Worm with a long cylindrical body, segmented in the form of rings. |
| Amphibolite | Metamorphic rock, formed basically from amphiboles and plagioclase with a massive texture and dark green colour, usually as a result of the metamorphosis of basic igneous rocks. |
| Anoxia | Absence of oxygen. |
| Anthozoa | Or Anthozoan. Animal from the cnidaria family which has the appearance of a flower, with a cylindrical body and a mouth surrounded by tentacles; such as corals and anemones. |
| Anthropic | Resulting from human activity. |
| Bottom trawling | A fishing technique using a net in the shape of a sack which is dragged along the sea bed by one or two boats, together with weights, chains and metal doors. |
| Augite | Pyroxene which is characterised by a monoclinical crystalline structure in dark green or black. |
| Autotrophe | Organism capable of synthesising its own food from inorganic sources, which is the case with the majority of green plants and some bacteria. |
| Basalt | Fine-grained basic volcanic rock, formed mainly from plagioclase and pyroxene. Basalts constitute 90% of rocks. |
| Bathymetry | Branch of oceanography that deals with measuring the depth of oceans, seas and lakes. |
| Batoids | Order of elasmobranch fish, characterised by a flattened body with the pectoral fins fused to the sides of their heads, with the branchial opening on the ventral surface, such as rays or fantails. |
| Benthic | Relating to organisms that live on or over the sea bed, whether fixed or mobile. |
| Benthopelagic | Fish that live and feed close to the sea bed and in intermediate waters close to the surface, such as hake and grenadiers. |
| Biodiversity | Ecological diversity and diversity of life; variety and variability of organisms and ecological complexes in a specific area. |
| Biogenic | Formed or created by living organisms. |
| Biomass | Amount of living material present at a specific time and place. |
| Biota | Group of species or organisms of fauna and flora which live in or are characteristic of a specific habitat. |
| Bivalve | A creature belonging to the group of molluscs whose shell is formed by two articulated sections, such as mussels or clams. |



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| Accidental catch | Organisms caught during fishing operations of which they are not the target. These could be different species from what are being sought, or specimens of the target species that are smaller than permitted. |
| Cetacean | Order of mammals that live in the water whose extremities have evolved into fins, such as whales and dolphins. |
| Thermohaline circulation | Currents caused by temperature and salinity variations. |
| Cirriped | Hermaphrodite marine crustacean whose larva is free-swimming; in its adult state, it lives attached to underwater objects, e.g. barnacles. |
| Chlorophyll | Plant pigments formed by a long chain of carbons, hydrogen, oxygen, nitrogen and a magnesium molecule, chlorophyll alpha ($C_{55}H_{72}O_5N_4Mg$) and beta ($C_{55}H_{70}O_6N_4Mg$). |
| Cnidaria | Group of animals, generally marine ones, also known as coelenterates. They are characterised by their stinging cells or cnidoblasts. It includes jellyfish, corals, anemones, etc. |
| Community | All animal or plant populations that interact in a specific place and time. |
| Condrichthyans | Class of fauna that includes all cartilaginous fish such as sharks, rays (elasmobranches) and chimerae (holocephali). |
| Taylor cones | Taylor cones or columns are sea currents that make an object move in a rotatory flow, pulling it through a column of fluid parallel to the axis of rotation. |
| Corallinaceae | Family of red algae from the Corallinales order, characterised by their calcium carbonate excretions. This gives them their “stony” appearance, similar to corals. |
| Current | Horizontal movement of water in the form of a “river” within a general circulatory system. |
| Crust | This is the most solid outer layer of the Earth, positioned above the mantle, and is the superficial part of the lithosphere. |
| Cosmopolitan | Organisms that are widely distributed in the different regions of the world. |
| Cretaceous | Geological period belonging to the Mesozoic era, approximately 145 to 70 million years ago. |
| Crustacean | Class of arthropod with branchial respiration with two pairs of antennae, compound eyes, a body mostly covered by a shell, whose metamorphosis passes through the larval phases of nauplius, mysis and zoea. This includes crabs, prawns, amphipods, etc. |
| Demersal | Relating to organisms which, opposite to pelagic organisms, live close to the bottom of the sea. |
| Detritus | Organic remains produced by the decomposition of plants and animals. |
| Dinoflagellates | Group of unicellular microscopic or very small algae, classified as protists. Dinoflagellates include endosymbiotic species (zooxanthellae), ecto- and endoparasitic species, bioluminescent species and toxic algal bloom species. |
| Dispersion | The ability of a population or species to colonise new habitats. |
| Dolerites | Rough, granular basalt rocks. The most common dolerites are ophytic, resulting from the crystallisation of the feldspar before the augite. |
| Ecosystem | Group of organisms from different species which interact between themselves and with the environment in which they live. Or the integration of biocenosis and biotype. |

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| Ecotype | Breed or subspecies adapted to a particular type of environmental condition. |
| Eddies | Eddies are circular currents of water that are faster and narrower that those around them, with specific physical and chemical properties. They can reach several hundred kilometres in diameter. They can either be anticyclonic (when they go in a clockwise direction) or cyclonic (anticlockwise). |
| Venturi Effect | Acceleration that takes place to a fluid when its flow is tightened or constricted. |
| Elasmobranch | Class of vertebrates that includes sharks and rays. Almost exclusively marine. |
| Endemism | Organism that can only be found in a specific region. |
| Epibiont | A non-parasitic organism that lives at least one phase of its life cycle on top of another, larger, organism. |
| Epiphyte | Organism that lives on the surface of a plant or alga, getting support but not food. |
| Echinoderm | A marine animal with a calcareous skeleton and spines. Its body is divided into five radially symmetric sections, e.g. holothuria, starfish and sea urchins. |
| Sciophile | Organism that grows predominantly in shaded areas. |
| Species | Taxonomic classification ranking below genus defining related organisms capable of interbreeding. |
| Spines | Bony radials that support some fins. |
| Phanerogam | Upright plant that produces flower and fruit. |
| Feldspar | Minerals from the silicate group. They are made of silicon and oxygen plus other components. They are the essential components of endogenous and metamorphic rocks. |
| Phytoplankton | Microscopic plant organisms that float in aquatic ecosystems. |
| Formation | Fundamental lithostratigraphic unit. Body of rocks identified by their lithological characteristics and stratigraphic position. |
| Oceanic Trench | A very deep linear depression located at the base of some continental slopes. |
| Photophile | Organism that prefers to settle in well-lit areas. |
| Photosynthesis | A metabolic process whereby plants transform inorganic compounds into organic matter (food), releasing oxygen and using energy from sunlight. The simplified equation of the process is: CO2 + H20 à M.Org. + 02 |
| Coriolis Force | The Coriolis Force is produced by the rotation of the Earth, which tends to divert the trajectory of objects over a surface; to the right in the northern hemisphere and to the left in the southern. |
| Gabbros | Igneous rocks with a basalt composition. |
| Gastropod | Class of molluscs whose body is covered by a spiral shell, such as snails. |
| Genus | Taxonomic classification between species and family; a group of very similar species. |
| Gnesis | A metamorphic rock with notable foliation and granitoid composition, generated by high level regional metamorphosis. |
| Gonads | Sexual organs responsible for producing gametes. |



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| Granite | Acid plutonic rock with quartz, potassium feldspar, plagioclase and mica. 10 - 65 % of its feldspars are plagioclase and 5 - 100 % are anorthite. |
| Habitat | Place and type of environment in which organisms live. It can be geographical, physical, chemical or biological. |
| Hapteron | Cylindrical structure or modified branch which serves to anchor the alga in the substrate. |
| Hydrozoa | Or hydrozoaria. Animal from the cnidaria or coelenterates group which, throughout its life, has a polyp or jellyfish shape. |
| Jets | Jets are turbulent streams of water that form when waters with different densities come into contact, which may give rise to eddies. |
| Larva | Period in the development cycle of certain animals between embryo and adult. |
| Lithosphere | The external, solid, rigid layer of the Earth above the asthenosphere. The lithosphere encompasses the continental and oceanic crusts and the most superficial part of the mantle (lithospheric) above the asthenosphere, to which the crust is mechanically joined. It generally occupies the first 50 to 100 kilometres. |
| Abyssal plain | A plain on the ocean floor at great depths. |
| Malacologic | The part of zoology that studies molluscs. |
| Bioclastic material | Sedimentary rocks, predominantly made up of bioclasts (the name given to any fossil element, whether whole or fragmented, of animal or plant origin, whether transported or not). |
| Meddies | Meddies are eddies of Mediterranean water and thus have greater salinity and a higher temperature. |
| Metamorphism | Series of processes whereby an original rock changes its mineralogy and structure, managing to form a new rock from the effects of pressure and/or temperature without the original rock completely melting. |
| Methane | This is the simplest hydrocarbon, the product of anaerobic decomposition. |
| Mollusc | Class of animals with a soft, non-segmented body generally protected by a shell, such as snails, clams or octopus. |
| Nutrient | Any organic, inorganic or ionic compound used mainly for the nutrition of primary producers (algae and microalgae). |
| Longlining | Fishing gear consisting of a main fishing line from which other secondary lines hang at intervals, with baited hooks at the ends. |
| Pantopod | Sea spiders. Arthropods about which there are many doubts as to their taxonomic classification. Previously they were considered to be part of the chelicerata family (spiders, scorpions, horseshoe crabs, etc.) but today they are given a separate classification. |
| Pelagic | Organism that lives in a column or mass of water, whether swimming or floating. |
| Peridotites | Igneous rocks of predominantly dark minerals consisting of around 75% ferromagnesium silicates and plagioclase feldspars. |
| Phylum | Taxonomic classification between kingdom and class. |

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| Pinniped | Any member of the different aquatic mammal families with fins, from the Carnivorous order. There are three families: Odobenidae (walruses), Phocidae (seals without external ears) and Otariidae (seals with ears). |
| Plankton | A group of small organisms that live suspended in water and constitute the first link in the trophic network. It includes protozoic creatures, larvae (zooplankton) and unicellular algae (phytoplankton). |
| Continental Shelf | The submerged edge of the continent that extends from the coastline (0 m) to a depth of up to 200 metres. |
| Population | Group of individuals from the same species that are found in a specific habitat and operate as a reproductive community. |
| Polychaete | Animals from the annelid group that live in the sea and whose bodies are covered in bristles of setae. They can form huge colonies and live inside tubes. |
| Porifera | The phylum to which sponges belong. A creature characterised by having pores on the outside of its body which communicate with its interior by a system of canals to allow for feeding and respiration. Its skeleton is made up of specula or elastic fibres. |
| Productivity | The capacity of plants to produce organic matter, or the quantity of matter produced by a surface or volume unit in a given time. |
| Pycnogonid | See pantopod. |
| Setae | Bristle made up mainly of chitin. |
| Chemosynthesis | Process and capacity of certain bacteria to form organic compounds, based on inorganic substances, without the presence of sunlight. |
| Regression | Backward movement of the coastline due to a drop in the sea level. |
| Kingdom | The broadest taxonomic classification, which consist of phyla or divisions. Five kingdoms are recognised: Monera, Protista, Fungi, Plantae and Animalia. |
| Rock | A natural aggregate of individual minerals. Rocks are classified by origin as: magmatic rocks, which originate from the consolidation of magma inside the crust (plutonic) or on the exterior (volcanic); sedimentary, originating from the diagenesis of sediments resulting from the processes of meteorisation, transport and deposit; and metamorphic, which result from the action of pressure, temperature and fluids (metamorphic processes) on any type of pre-existing rock. |
| Tholeiitic rock | The is a basalt rock oversaturated in silica, which is characterised by having a paragenesis formed by calcium plagioclase, augite and pigeonite, with interstitial glass or a fine-grained matrix made up of quartz and feldspar intergrowths. |
| Metaplutonic rocks | Metamorphic plutonic igneous rocks made up mainly of gneis-granite and metagabbros. |
| Sedimentation | Process whereby substances in suspension are deposited on the sea bed. It is also the deposit of particles that have been previously eroded and transported by external geological agents from a generating parent area to a reception area or sedimentary basin. |
| Serpentinization | Process of hydrothermal change whereby mineral silicates rich in magnesium (such as peridotites) are converted or replaced by serpentine minerals. |



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| Siphonophore | Floating colonies of coelenterates made up of polyps that develop different functions, for example Physalia, or Portuguese man-of-war. |
| Overriding | Process whereby a tectonic plate rises up over another one due to the movement of plates. |
| Sound | Instrument to measure the depth of water underneath a vessel. |
| Stock | Fraction of the population susceptible to exploitation. |
| Upsurge | The ascent of nutrient-rich deep water due to the effect of regular winds along the coast. |
| Suspensivorous | Animals that feed by capturing or filtering the food they find suspended in the water column, such as corals and sponges. |
| Substrate | The stratum or solid matter on which an organism moves or to which it is attached. |
| Sverdrup | Unit of measurement of water flow. One Sverdrup is equivalent to one million cubic metres per second. The general average of the Gulf Stream is 30 million m3-s, while the Azores Current is three times lower (10 million m3-s). |
| Continental Slope | An underwater area with a strong incline located between the continental shelf and the abyssal plain. The main slope of the deep oceanic basin. It encompasses the entire incline from the lower edge of the shelf to where the ocean floor begins. |
| Taxon | Group of organisms to which a name is given for their classification. In principle, any taxonomic range is a taxon. |
| Thermocline | This is the transition zone of the ocean where the sea temperature drops rapidly downwards, with little increase in depth. It is a thin layer of water lying between the warmer surface water and the colder deep water. It is characterised by the rapid change in temperature of one degree or more per metre of depth. |
| Topography | The characteristics of the surface of a terrain. |
| Benthic storms | Episodes of strong currents in the depths of the ocean. It has been suggested that these currents occur when: a) there is an eddy or strong surface current; b) there is a strong and continuous deep current; c) there are easily re-suspendable sediments. They can achieve speeds of more than 25 cm/s2, with speeds of even 43 cm/s2 having been recorded in the Greenland Sea. |
| Transgression | Movement of the coastline inland due to a rise in the sea level. |
| Upwelling | Changes in the sea level due to glacial and interglacial periods. |
| Volcanism or Tholeiitic Magmatism | Characterised by low alkaline and titanium values. Typical of zones on the Mid-Atlantic Ridge, and those known as “flood basalts” or “plateau basalts” which constitute huge accumulations of lava that have emerged on the surface at very specific times in the history of the Earth. |
| Subduction zone | Zone where a tectonic plate has sunk beneath another (zone of destruction of the oceanic crust). |
| Dysphotic zone | Zone in the water column where light penetration is not sufficient for organisms to carry out photosynthesis but is sufficient to produce a response in organisms. This normally goes from depths of 100-200 metres to more than 1,000 metres. |

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| Exclusive Economic Zone (EEZ) | A maritime area that extends to 200 nautical miles from the base line (represented by the low-tide line of the coast), over which the coastal nation has sovereignty rights to explore, exploit, conserve and administer all the natural resources in the waters, sea bed and marine subsoil, as well as jurisdiction over scientific research, protection of the marine environment and the establishment and use of artificial islands. |
| Euphotic Zone | Zone in the water column where sufficient light enters for intensive photosynthesis to take place, to the extent that over-saturation of oxygen can occur. |
| Photic Zone | Zone in the water column where sunlight penetrates. |
| Zooxanthellae | Dinoflagellates or unicellular microscopic photophile algae that live in symbiosis in the tissues of certain invertebrates such as corals, gorgonias, anemones, sponges, molluscs, etc. |



Fotography by Oceana / Juan Carlos Calvín Calvo

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