UP AND DOWN ALONG HUMBOLDT CURRENT

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ABSTRACT
Almost two hundred years after the epic scientific expedition conducted in some countries of Central and South America by Alexander von Humboldt, a multi-stage scientific marine voyage tried to follow the flow of the ocean Humboldt current, named after him. The tireless explorer had identified the physical peculiarities and understood the ecological importance of this great marine circulation. The modern expedition confirmed von Humboldt's universally known qualities as an excellent precursor of Ecology in both its aspects: the knowledge of the functioning of natural systems and the effects of human activities on Earth's resources.

KEYWORDS: Alexander von Humboldt, South America, marine biology, Pacific Ocean

Alexander Von Humboldt was a tireless explorer, physicist, geologist, oceanographer, astronomer, meteorologist, botanist. He is considered by the scientific community to be the founding father of climatology and phytogeography. In other words, he can be considered the first true ecologist because he understood the relationships and the deep connections between the living and non-living world and the negative effects of human activity on Earth.

About 200 years after Von Humboldt's explorations in South America, without my realizing it, I found myself retracing the footsteps of the scientist ... no, I'm wrong! It is more correct to say that I found myself following by sea the path of the current which took its name from this great scientist! From Antarctica to the Galapagos sailing along the South American coast to the surface until somehow descending into the ocean depths, from 1997 to 2002.

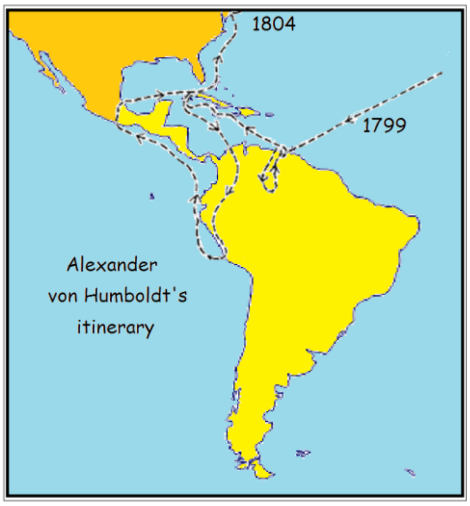

Figure 1. A. von Humboldt's South American expedition.

Before describing my experience, let me summarize, alas rather briefly, the epic expedition of Von Humboldt, which lasted 5 years, from 1799 to 1804.

Figure 2. In addition to Germany, the birthplace of the scientist, the Central and South American countries visited by the scientist during his long expeditions also remember von Humboldt on stamps, paying tribute to this tireless explorer. Here examples from Venezuela, Colombia and Mexico. In Venezuela, in particular, Humboldt achieved awareness of the negative ability of the human beings to alter the delicate balance of Nature. This is evident when describing the climatic problems caused by colonial plantations around Lake Valencia in Venezuela. “When forests are destroyed,” wrote the naturalist, “water sources dry up. Then the river beds turn into streams every time it rains in abundance on the heights ... Floods flow down the hills, flood the parched land and cause devastation throughout the territory”.

Crossing the rain forests of South America, Humboldt could observe the potentially irreversible devastation that human intervention could inflict on ecosystems. And thanks to these travel experiences he understood both the wonderful interconnection of life forms and our ability to destroy it. He pointed out that it was man’s duty and responsibility to understand and respect natural laws: otherwise the risk of damaging the Earth would have become catastrophically real. Prophetic observations for his times, which echo in today’s debates on deforestation and climate change, even though very few people know the modern thinking of Alexander von Humboldt.

Also in Venezuela and Colombia, with the limited means of his time, he sailed on the Orinoco and the Amazon River, mapping the course and identifying the connection between the two basins. For a whole year, he traveled in the central plateau of Mexico and went down into the mining area to the north in order to start the modern geological mapping of that region. He is regarded as the second discoverer of Cuba, where he devoted himself to the collection of samples of flora and fauna. His accuracy in the graphic reproduction of the organisms studied is noteworthy and on this island a National Park, now a World Heritage Site, is named after him.

About his eclectic ability to portray and classify nature, almost 300 plants and over 100 animals, various minerals, and then cities, glaciers, rivers, geysers, bays, even the Humboldtianum Sea on the Moon and asteroids were dedicated to him….. and, of course, also the ocean current subject of this paper.

In Ecuador, he bravely ventured into climbing the Chimborazo volcano which, even though reaching “only” the elevation of 6310 m, was considered at the time the highest mountain of the world. Nevertheless, it can be defined as “the point of the earth’s crust most protruding in space”: due to its equatorial geographical position and taking into account the distance of its top from the center of the Earth. The vegetation belts encountered while ascending this equatorial volcano allowed him to evaluate the differences from what he observed in temperate (Mont Blanc) and in cold areas (Sulitelma, in Lapland). The consequent interpretations of such altitudinal patterns related to latitude laid the foundations of climatology and phytogeography.

The Humboldt Current

The Humboldt Current comes from the coasts of Antarctica and runs northwards along South America, to the border between Peru and Ecuador, where it turn towards the open ocean. It can be compared to an immense river of salt water whose temperature varies between 10 and 18°C depending on the season, identifiable up to 600-1000 km from the coast line and 400 meters deep. It has a flow rate of about 6 million m^3 per second and travels at a speed between 40 and 60 meters per hour.

The current was discovered thanks to the precise thermometric measurements taken by Alexander von Humboldt, who was amazed by the low temperature of the surface waters at those tropical latitudes. And in fact the current cools the sea bringing it to an average temperature of 17-19°C, while at the latitude of Peru, e.g., it should be of about 25-26°C. This thermal anomaly, related to the surfacing process, or to upwelling induced by winds from the mainland which pushes these cold and dense waters towards the sea surface, produces various effects.

The main effect of this current is to create atmospheric conditions characterized by the absence of rainfalls on the coast, and their presence only on the hills. The coastal aridity generates deserts, such as, for example, the well-known Chilean desert of Atacama (with dunes where it is now fortunately forbidden to walk!).

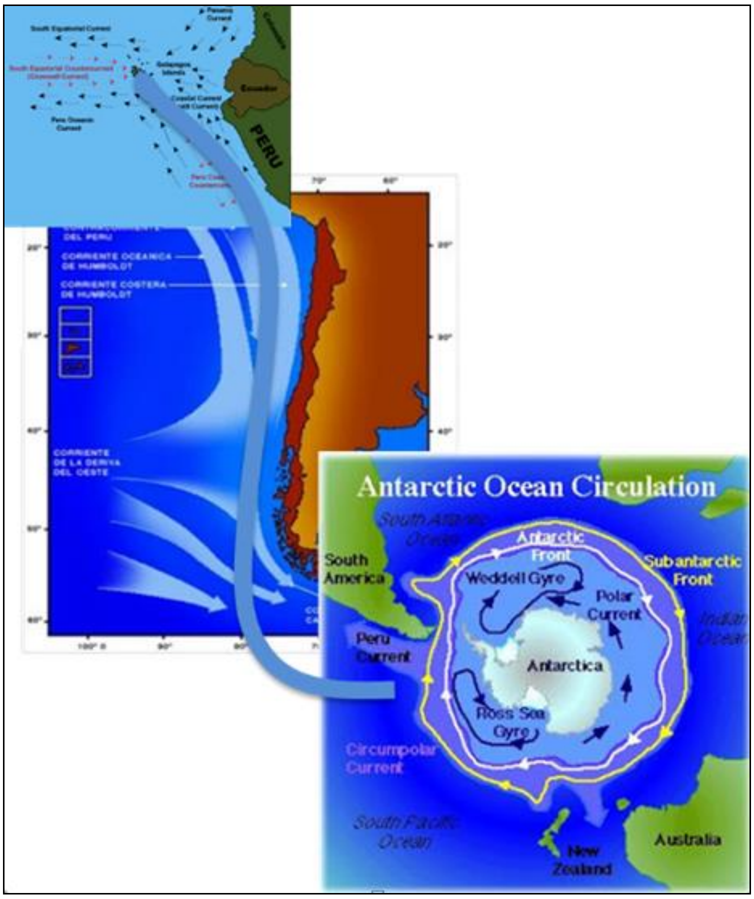

Figure 3. The Humboldt Current.

Figure 4. The Atacama desert.

The second effect is to make the sea very rich in plankton and pelagic fish that feed on it; this is, in turn, prey of piscivorous colonial birds producing guano, of which Humboldt studied the fertilizing properties.

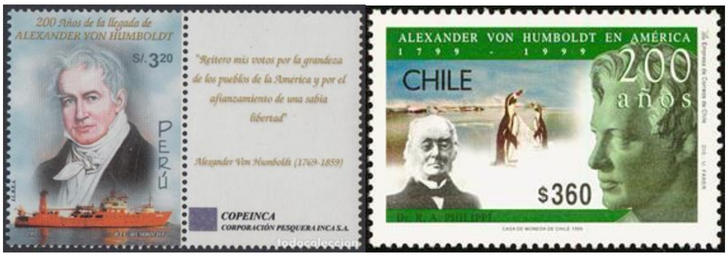

Figure 5. Stamps dedicated to Humboldt from Peru and Chile. Climate and economy of these countries are influenced by the cold coastal current.

Even if von Humboldt has not been physically in Antarctica, allow me to ideally start with my explorations from those frosty regions, chasing the cold flow of the current in order to touch the stages of my research by sea, sailing along the South American coast to the Galapagos on the surface and, in some way, as we will see, going down to the ocean depths.

After the air flight that transfers Italian researchers to Christchurch, New Zealand, it is possible to reach the Italian Antarctic base in two ways. The former is by sea; it takes about 10 days of navigation not always quiet breaking the pack and sometimes opening the way to other boats waiting for an icebreaker to go to the fishing areas. And finally you arrive at the pack ice! The latter is by plane, in a few hours, landing on a strip on the pack!

Figure 6. Ship "Italica".

The scientific activity consisted, among other things, in taking water samples in order to assess the concentration of organic substance and oxygen or in dredging the bottom to sample the organisms that live there; nets were used to catch "ice fish" with the purpose to study the particular physiology that allows them to live at very low temperatures.

The fish that populate the Antarctic Ocean are exceptional organisms, the result of a long evolutionary history that has deeply changed their biological and ecological characteristics to allow their survival in an extreme environment characterized by very cold waters (-1.9° C) and by the presence of ice. Mind that in coastal areas the surface is frozen for most of the year, and that ice also forms on the seabed ("anchor ice"). As a remedy for low temperatures, these fish develop a biological antifreeze in their body capable of "blocking" the growth of ice crystals that can be assumed through gills or with food. Some species (ice fish or white blood fish) do not have hemoglobin or red blood cells. Oxygen, very abundant in the environment due to low temperatures, diffuses at sufficient concentration into the blood through the gills.

Figure 7. Sampling water while pancake ice is forming.

Figure 8. Antarctic organisms. A crinoid, a pycnogonid and an icefish.

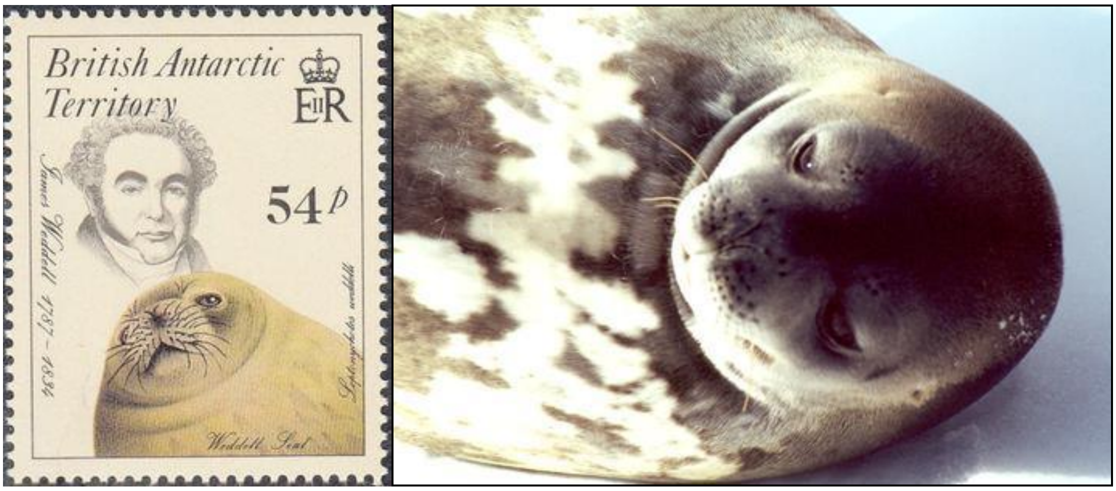

Figure 9. The Weddell Seal (*Leptonychotes weddellii*) is a carnivorous mammal belonging to the Phocidae family. Its name derives from that of Sir James Weddell, British navigator and seal hunter who was the first to describe this species (1820). Weddell seals are widespread in the circumpolar region of the southern hemisphere and along the coasts of Antarctica. The Weddell Seal has steel gray hairs with whitish or yellowish spots spread over the whole body. In summer the colors tend to lighten while in winter they darken. Young individuals do not have spots.

Figure 10. If the pack has not melted, with the help of a giant "corkscrew" holes are opened with the aim to sample the water and planktonic organisms by means of bottles and nets, respectively. Among these are the small crustaceans of the krill, which distribution is strongly influenced by Humboldt current.

Figure 11. An Adelian penguin greets us, the one on the left!....the one on the right is me!

With the arrival of the Antarctic winter we had to leave the continent and abandon these unforgettable landscapes.

Figure 12. The Antarctic seas.

We therefore left the base of Baia Terranova, today named after Mario Zucchelli.

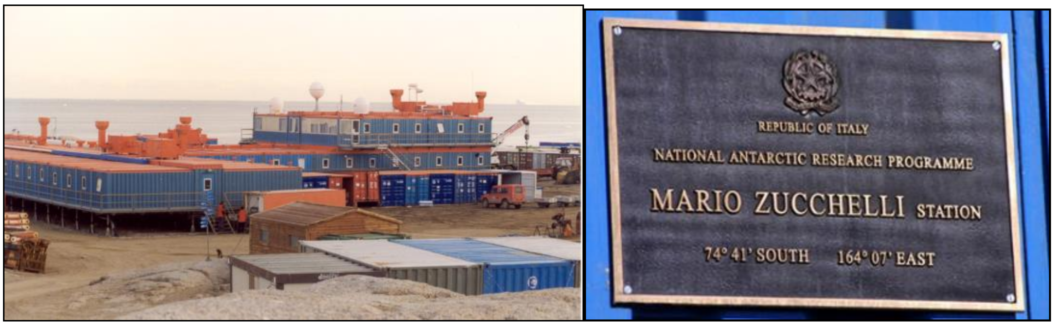

Figure 13. The Antarctic base.

Coasting South America, while Humboldt was moving mainly by land, I was "dragged" by sea, by the current: going up along the Chilean coast, there are two coastal islands, Mocha and Santa Maria.

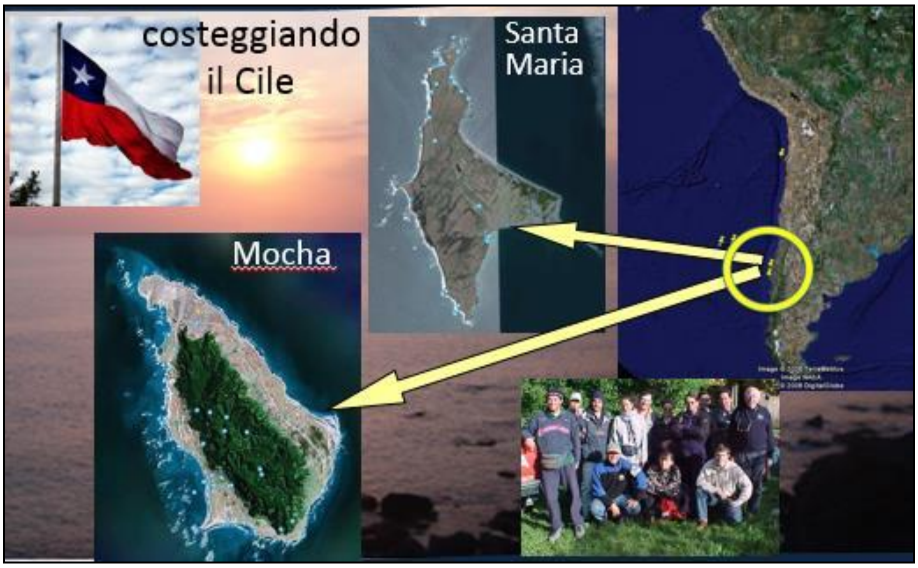

Figure 14. The Chilean coast and its islands Mocha and Santa Maria.

Having to "deal" with limited funds, in order to perform an ecological investigation that could be valid and to provide relevant indications for the proper management of the coastal marine belt, we decided to carry out a simple and cheap sampling, even if complete: the analysis of intertidal area of the beaches, especially the sandy ones, and of their macro-, meio- and microbenthic populations, with particular attention to endemic forms. From the point of view of the "marine" researcher, the fact that the coast of these islands represents the boundary line and, at the same time, the area of contact and possible "invasion" by new living forms is relevant. The analysis of these populations and their dynamics would have allowed us to evaluate the state of health and the future evolution of these ecosystems.

Figure 15. Here technology is not very invasive, as in the time of Von Humboldt: here is Mocha's taxi and the simple boats and traps of the fishermen.

Figure 16. On the quiet beach of Santa Maria it is possible to observe a curious excavator crustacean (*Emerita analoga*), which lives sunken in the sand of the shore, where it reaches impressive densities of over 1000 individuals per square meter. It feeds by collecting with the everted antennas the abundant surface phytoplankton carried by the backwash of the waves that bathe the beach along the whole Chilean and Peruvian coasts. This powerful flow of cold and dense waters of Antarctic origin, fertilize with its huge amount of nutrients these seas making them the most fishy in the world.

Let me briefly summarize the results of the survey on the Mocha and Santa Maria islands. The analysis of the macro- and meio-benthic population of the intertidal zone (rather wide vertical excursion: 1.5 m) showed that the abundance and composition of these communities can be significantly influenced by the quantity and quality of the organic matter present in the sandy sediment, as well as by the hydrodynamic conditions (currents and exposure to waves). These factors affect environmental characteristics, such as grain size, humidity, temperature, slope of the beach. It has been observed that, at least up to a certain level, the abundance, biomass and wealth of species of the meiofauna are supported by the organic matter even on beaches heavily exposed to the action of the waves (larger granules, greater slope of the beach and short wave area). The macro-fauna, instead, appears more sensitive to intense hydrodynamic phenomena.

But with my own eyes I've seen how the quiet of these coastal islands can be disrupted by an impressive marine phenomenon, which represents tangible proof of how rich the Humboldt current can be. As a result of winds from the continent, the deep flow of the current can rise to the surface due to the well-known phenomenon of upwelling, dragging the organisms that feed on the phytoplankton of the water column. After we left the krill in the cold Antarctic waters under the pack, we witnessed an impressive and curious scene at the same time: the euphausiacea appeared again, beached in tons on the shore of the sandy island of Santa Maria. The huge amount of food resources brought to the surface from the sea depths immediately found a multitude of opportunistic seagulls users.

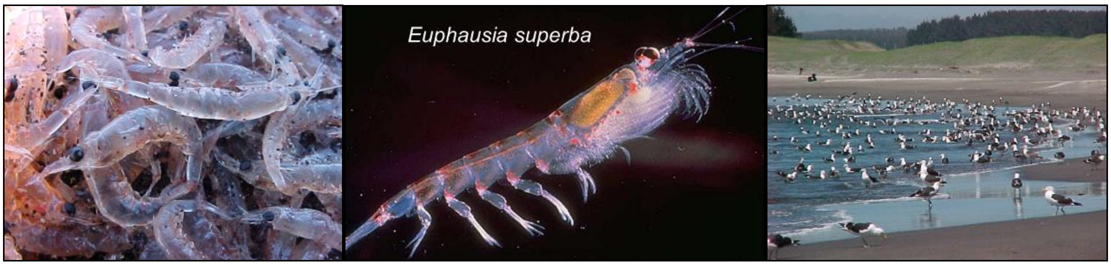

Figure 17. Effects of the upwelling or the rise of deep water masses along the coast due to the effect of currents. Important in this regard may be the transfer of organic matter from the deep sea to the surface and on the beaches. During the sampling of Santa Maria we witnessed the beaching of huge quantities of krill and other deep-sea marine organisms that enriched the sand of the beach with organic substance and represented an important source of food for a colony of seagulls.

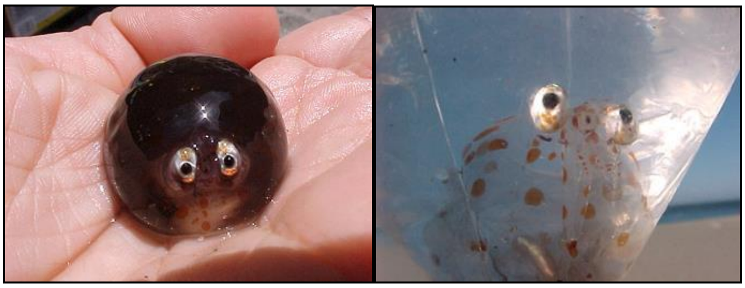

Figure 18. The provenance from the depths is testified by a curious «object», which after some time turned out to be a glass squid (*Teuthowenia pellucida*), which shows a perfect mimicry in depth, where it usually lives and where it owes its survival to transparency, but which instead remains tragically exposed in the shoreline. The Cranchiidae family collects about sixty species of "glass squid". Thanks to their transparency, these animals manage to escape the voracity of predators from the ocean floor. Also called "glass squid", it is an animal that plays an ecologically very important role in the seas of the southern hemisphere of the Earth (especially in New Zealand). It has bright organs near the eyes, to have an improved vision in dark environments, and has the particular ability to roll up like a hedgehog taking the shape of a ball, probably for defensive purposes, since it is a prey sought after by many marine creatures such as goblin sharks, whales and sperm whales.

Figure 19. Examples of the degrading action of man on the natural environments predicted by Humboldt in the year 2000: plastic waste (Santa Maria) and the transformation of the forest along the coast for the needs of the paper mills (Concepcion).

Then we left the coast line to check if the Humboldt current can also have effects in the open ocean about 400 miles (670 Km) off Valparaiso and we visited the islands of the Juan Fernandez archipelago (more famous as Robinson Crusoe Islands), so far away that they are still largely unknown.

Figure 20 The Chilean coast and its oceanic islands.

These volcanic environments arouse great interest because they are places where the degree of alteration of habitats due to human action is still limited: they have been declared a Chilean National Park since 1935 and became a UNESCO biosphere reserve since 1977. It is especially in these places that aspects related to biodiversity, speciation and biogeographical issues, so dear to Humboldt, can be scientifically assessed. These are priority objectives worldwide, since they are related to the conservation of nature and its renewable resources. The knowledge of these sites is very limited for several reasons (in particular it is difficult to find the funds): therefore, each new scientific investigation can improve a still too limited knowledge.

In particular, as regards the islands, it is of great importance the possibility of comparing the environmental characteristics of sites which have long been heavily populated and usually very studied (islands and coasts of inland seas, such as the Mediterranean Sea), with what can be found in environments very little investigated and scarcely impacted by man. This is particularly true, of course, for some oceanic islands, such as those of the Juan Fernandez archipelago.

We embarked on “Abate Molina”, an oceanographic ship named after Juan Ignacio Molina (1740-1829), a Jesuit who preceded von Humboldt by a generation. He was a naturalist, botanist, zoologist and geographer too. Forty years before Darwin he proposed his theory of gradual evolution. On the other hand, he supposed the possible sedimentary origin of basalt, which had been found both on the Andes and on the Chilean coast, without traces of lava effusions. This hypothesis was categorically denied by Humboldt who correctly determined the volcanic origin of those rocks. His statement on the volcanic origin of the rocks that were sometimes considered sedimentary deposits of water, was an essential contribution to the elimination of erroneous opinions. With this the so-called neptunism hypothesis was completely archived.

Figure 21. On the Chilean stamp, the abbot is even depicted with Humboldt.

We started from the port of Valparaiso, towards the alignment of submarine volcanoes that ends with the three emerged islands of the archipelago, Santa Clara, Robinson and Selkirk. We sampled a first submerged volcano at 400 meters below the sea surface, Mount Gamma, which, in alignment, represents the oldest manifestation of a particular phenomenon of thermal lifting that occurs in the oceanic crust belonging to the Nazca plate. The islands of the archipelago would be nothing more than the most recent geological manifestation on the surface (the closest island, Robinson, is between 4.2 and 3.8 million years old and the small Santa Clara is dated 5.8 million years; Selkirk, farthest away is the youngest (2.4 – 1 million years old) of the processions of volcanic mountains, which form in correspondence with the flow of the oceanic crust over the mantle “hot spots”, a sort of hot plumes extended hundreds of kilometers.

The formation of the volcanic islands of the archipelago, so distant and so different in genesis from the volcanoes of the Andean cordillera, is however linked to the drift movement of the continents, driven by the creation of a new oceanic crust in the mid-ocean ridge and the subsequent sliding due to the convective motion of the mantle below, according to the well-known theory formulated by another great German scientist, Alfred Wegener (1880-1930), polar researcher, geophysicist and meteorologist.

In correspondence with these reliefs, a bathy probe and sampling bottles were lowered to obtain chemical and physical data about the water column; a core drill was used to collect the bottom bacteria and finally a rock dredger was towed to sample sessile organisms. Then, we continued sailing along the alignment of the volcanoes to reach Robinson Crusoe.

Figure 22. Bear fur seals (*Arctocephalus philippii*) of Juan Fernandez intrigued by our research. A bear fur seal that reproduces on the Juan Fernandez islands, off the coast of Chile. It is the second smallest species of pinnipede (the closely related bear fur seal of the Galapagos is even smaller). Discovered by the navigator Juan Fernández in the sixteenth century, this seal became in the following century the target of seal hunters. At the beginning of the twentieth century it had become almost extinct, with only 200 specimens remaining, but since it was placed under protection, its number has grown rapidly. There are now believed to be 10,000 around these islands.

Our aim was to verify whether the dispersal of the plankton organisms, and in particular the “leaf” (phyllosomial) larvae of the lobsters, was favored by the Humboldt current; the same lobsters (*Jasus frontalis*) that we eat fresh in Italy, imported by air in one day directly from the South American countries.

Figure 23. …..and finally Robinson! The town and the “Robinson caves” where it is told the pirates hided their treasure. Simple boats with two bows to facilitate maneuvers in the imposing waves of the Pacific ocean and traps used here to catch lobsters *J. frontalis*.

The island of Robinson Crusoe (formerly Masatierra), about 96 square kilometers and colonized only in 1877, has about 750 inhabitants, all in the town of San Juan Bautista. The highest elevation (950 m) is the Cerro el Yunque. The island, of clear volcanic origin, is between 3.1 and 4 million years old. Its isolation has resulted in numerous animal and plant endemism.

The nearby and small Santa Clara, without fresh water, is uninhabited; the landing is very difficult; it is the oldest in the archipelago (4 million years old).

Figure 24. Signposts and the statue of Selkirk. National Park since 1935 and UNESCO World Biosphere Reserve since 1977. The real treasure of this archipelago is not the gold of the pirates who may have reached the islands, but the natural resources, endemism and biodiversity. *Dendroseris litoralis*.

As mentioned above, in Robinson we were looking for lobster *J. frontalis* larvae. During the day with nets and at night with bright traps. Also in Selkirk we carried out research concerning the plankton organisms and in particular the “leaf” (phyllosomial) larvae of the lobsters, a resource carefully exploited by fishermen who reside in the two major islands.

Figure 25. Approximately 180 km far from Robinson. On Alejandro Selkirk (formerly Masafuera), 50 square kilometers, the highest point is the 1650-meter Cerro los Inocentes. This island emerged 1.3-0.85 million years ago. A small group of houses (Colonia Quebrada Las Casas) is occupied only 6-7 months a year for lobster fishing.

Figure 26. A stormy sea welcomes us. An inaccessible coast with complicated landing.

Figure 27. An endemic starfish characterized by a large central disk from which a large number of short arms branch off (at least 25): evidently useful in areas of greater dynamism, such as intertidal areas. The *Heliaster* genus includes seven species living in the coastal waters of the eastern Pacific: only *H. canopus* lives in the archipelago. It is certainly not the only organism that "has a good time" on the outcropping rocks…the clingfish, or climber fish (*Sicyases brevirostris)*: the sucker derives from the modification of the pectoral and pelvic fins. In the intertidal it manages to remain attached to the slippery rocks covered with algae which it feeds even under the most intense waves. "There are several purposes for it: one is they are able to stick to rocks when they're in the intertidal battered by waves. So it keeps them still in high-energy environments". The "suckers" work on the same principle as the surface of the fingers of the geckos through the finest fragmentation of the surface itself.

Figure 28. Also in Selkirk zooplanktonic sampling was carried out to deepen the knowledge of the larval forms of the lobster *J. frontalis*, a resource carefully exploited by fishermen who reside in the two major islands.

The results of our studies there seem to exclude the possibility that the Humboldt current is involved in the transport and diffusion off the lobster larvae even if the windy climate of the two islands is certainly influenced by the surface water temperature, which is in turn affected by the Humboldt current. Therefore, far from the Chilean coast the effect of any upwelling seems negligible compared to another type of surface current that affects both Selkirk and Robinson, isolated reliefs in the open ocean. The current is partly started by surface vortices induced by the friction of the wind on the water when the latter encounters an elevated and sudden obstacle, just like the two volcanic islands of the archipelago. These whirlpools were named Karman, in honor of Theodore von Karman (1881-1963), Hungarian physicist and aerospace engineer (regarded as the father of supersonic flight). Remember, however, that a certain "Leonardo" already studied vortices in a stream 500 years ago!

However, the larvae also arrive on the Masafuera island, creating the thriving and careful fishing of lobsters.

Eight years after our visit to the islands, the tranquility of life led by the inhabitants of this archipelago was swept away by a dramatic event. While von Humboldt’s current constantly laps the islands, a sudden tsunami wave triggered by an earthquake in the Chilean region of Bio Bio deadly hit them on February 27, 2010.

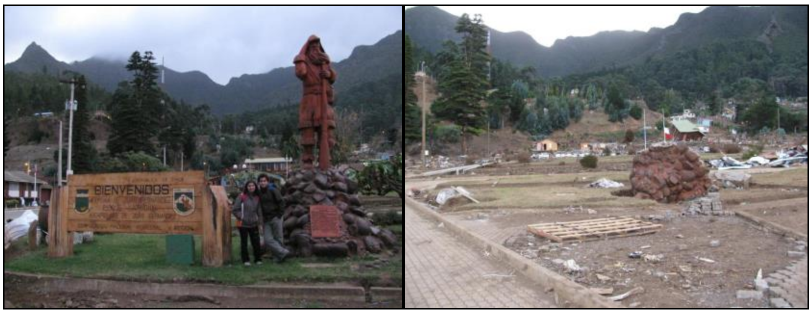

Figure 29. Juan Fernandez. On the right the destruction due to tsunami in 2010.

Left the surface waters of the open sea, we descended into the depths. Our aim was to understand how did our current act in depth. The low temperature between 0 and 2° C of the abyssal ocean depths along the South American margin certainly did not depend on the cold Humboldt current. Its physical and ecological importance is heavily felt in even at thousands of meters below the surface. How? In 1997 we reached the Atacama Trench, about 160 km away from the coast of Chile, thanks to an apparently “crazy” expedition (Atacama Trench International Expedition) which allowed to drop some large traps tied to a “thin” umbilical cord 11 kilometers long. Identical “economic” care guided the realization of the complex scientific campaign in the Atacama Trench, where the maximum depth recorded in the trench (8000 meters) was almost reached: we stopped at 7800 m!

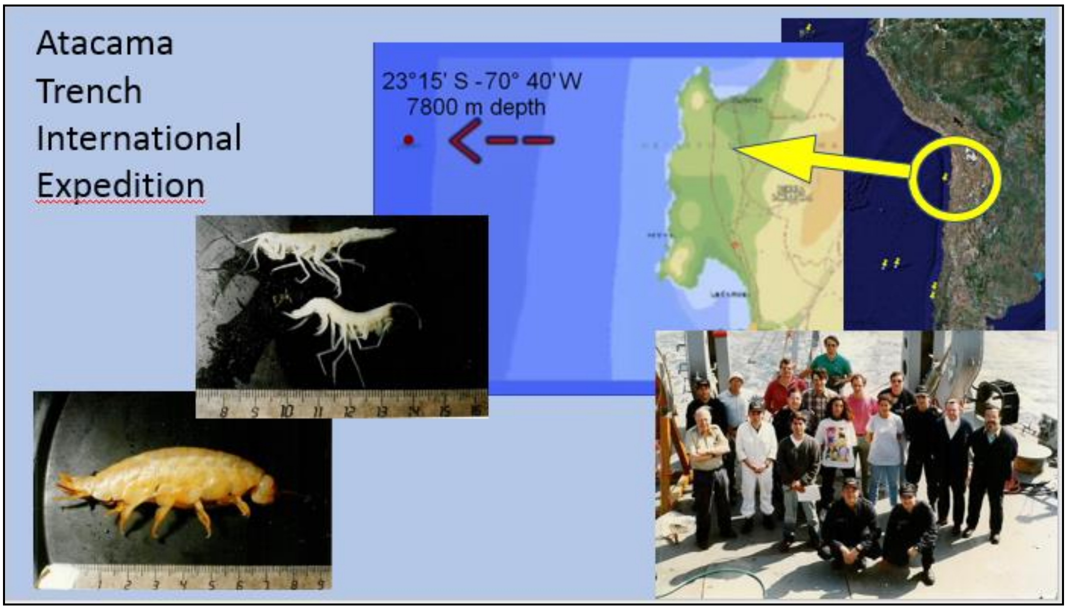

Figure 30. ATIE – Atacama Trench International Expedition.

Very few investigations have been carried out there and, with the ATIE, for the first time, the Italian scientific community faced the exploration of ocean trenches and great wonder and disbelief about its relatively low costs was manifested by British researchers from Southampton Oceanography Centre when they received the samples we collected, knowing the data of our expedition and the huge number of organisms (over 1000) brought to the surface. The cost-effectiveness of the investigation is attributable to having brought simple traps to a depth of 7800 meters, as well as a complex automatic core drilling machine, using a very long polypropylene rope, a floating material weightless in water. This allowed the recovery of the instruments with the winches of the relatively modest tonnage vessel made available by the "Armada" of Chile, an operation that would have been impossible with the use of the too much heavy steel oceanographic cables normally used.

Observations and sampling were aimed at:

- study bathyal, abyssal and hadal fauna;
- investigate the deep-sea benthic microbial communities;
- analyze qualitative and quantitative characteristics of the sedimentary organic matter (pelagic - benthic coupling);
- study distribution, ecology and biodiversity of meio- and macro- benthic fauna of the deep waters (biodiversity and ecosystem stability);
- assess the mineralogical and sedimentological characteristics of deep-sea faunal habitats.

We embarked on a ship of the Chilean Navy named after the military hydrographer Vidal Gormaz (1837-1907), who was also a geographer, meteorologist, astronomer and explorer of the Chilean coasts, and, moreover, of the river and lake systems of the South. We assembled our traps and when we reached the abyss, we lowered the automatic sediment corer which allowed us to determine a low bacterial density compared to other sites and an abundance of accumulated organic matter, typically phytopigments, capable of supporting the abundant biomass of the higher trophic levels.

Figure 31. The expedition included studying hadal fauna, deep-sea microbial communities, the quantity and quality of sedimented organic matter….And a careful preparation in Italy of the sampling equipment, self-built and modular once arrived in Chile was also necessary to save on enterprise costs!

Together, seven traps of various shapes descended with baits and chemical lights at a depth of at least 6000 meters. At that depth, over a thousand specimens of organisms that live in total darkness and in the cold of the abyss have been captured, attracted by lights and baits. They were above all amphipod crustaceans that feed on particles which rain from above and in particular the remains of marine animals. Totally, 942 specimens of amphipods belonging to 13 different species were collected. Almost 450 specimens of a necrophage amphipod that is one of the most widespread organisms in the oceans, *Eurythenes gryllus*, were attracted in the traps equipped with bait and light source, representing the deepest worldwide record known at the time! This species lives confined in low temperature environments and therefore in the abysses at low latitudes but also at the surface in the polar seas. The particular importance of our collection was ascertained after the analysis of the demographic composition of the samples in the laboratory. Only three males were present; the other specimens were immature females belonging to a single growth stage. In addition, the size ratios between the different morphological characters measured resulted to be outside the variability known for the *E. gryllus*. These facts suggested the Southampton specialists that in the Atacama Trench this panoceanic animal is facing an incipient speciation.

How the Humboldt current that flows much above them influence these abyssal amphipods? At the latitude of Atacama, the current still retains a wealth of nutrients capable of supporting a rich planktonic community, such as the large masses of krill that we have previously seen beached on the island of Santa Maria. The presence of this plankton is seasonal and dependent on the clash between the cold Humboldt and the warm Pacific current. This immense availability of food attracts gigantic fin whales and humpback whales, the cetaceans that make one of the longest migrations, from their breeding areas to the feeding ones.

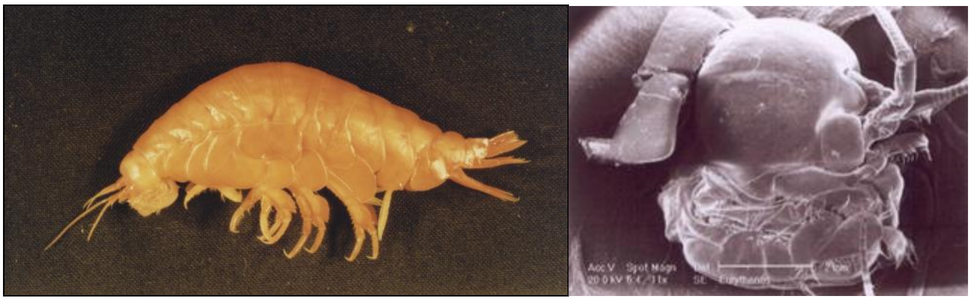

Figure 32. *Eurythenes gryllus* and detail of the mouthparts suitable for sectioning very long bites.

The natural cycle of life requires that occasionally some of these giant mammals die during migrations along the coasts of South America. The remains thus descend towards the bottom where the community of voracious scavengers, mainly the large amphipods sampled from our traps, are waiting as vultures not far from the ocean bottom for what rains from above. Therefore, these organisms must thank the current for such abundant food (it has been estimated that several months are required to consume all that meat).

Ultimately, Chile and Peru owe their economic wealth to the current, through small pelagic fishing, and the export of guano, produced by flourishing piscivorous birds. We wanted to verify if further north, towards the Equator, the Humboldt current was still relevant. So, we reached the Galapagos archipelago off the coast of Ecuador.

Figure 33. Galapagos Islands.

Coming back to von Humboldt, we already mentioned that in Ecuador he ventured in an attempt to reach the domed peak of the imposing Chimborazo at over 6300 meters, climbing with absolutely inadequate equipment, abandoned by the porters terrified by the difficulty of the climb and stopping only 300 meters from the top, unable to continue through a huge crevasse. More modestly I limited myself to reaching the capital of Ecuador, Quito, at almost 3000 meters above sea level…..by plane though!

Galapagos can be reached by a ship from Guayaquil on the Ecuadorian coast or flying from Quito, located not far from parallel 0.

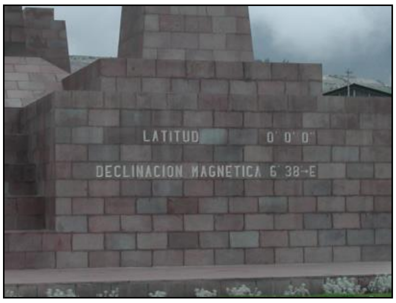

Figure 34. In Quito I was also able to visit, with my expedition companions, the ideal geographical line drawn by the zero parallel!

This archipelago is about 1300 km away from South America in the Pacific Ocean, and on each of the over 100 islands and islets that make up the archipelago there are endemic animal and plant communities, absolutely unique and peculiar. Our main task was the sampling of meiofauna (nematodes and copepods) and the bacteria associated with it, in order to identify endemic forms.

Figure 35. For endemism and biodiversity, the Galapagos are second to none: marine iguanas vegetarian and absolutely harmless, despite the uneasy aspect; giant turtles, for which the Galapagos are famous, but now reduced in number and enclosed in fences in the inhabited islands to protect their slowness from the intrusiveness of tourists; crabs that protect themselves from tourists by running away quickly. Their color is bright red, but there is even a black version that blends better with the black volcanic rocks.

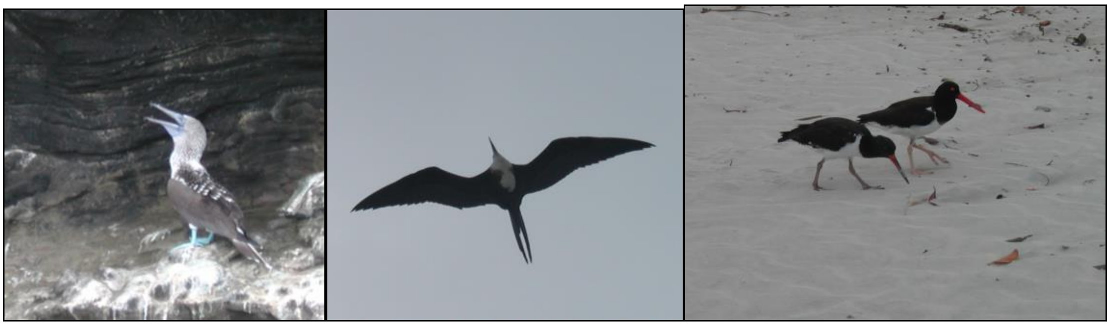

Figure 36. The extreme variety of bird species.

Figure 37. The bears seals: they too, as we have seen in Antarctica with the Weddell seals, let themselves be approached without fear; at least the females! The Galápagos Bear Seal (*Arctocephalus galapagoensis*) is the smallest of all the seals. It reproduces on these eastern Pacific islands, and is therefore the only bear fur seal to reproduce in tropical waters. They spend more time out of the water than almost any other pinnipede.

Figure 38. The "variety" is also vegetable. Just one example: the "prickly pears" here are trees and form woods, well protected by their thorns! And finally the "mangroves": impressive forests on the edge of the beaches: they build a border environment and at the same time a link between land and sea. The tangle of their roots retains sediment and prevents erosion of the beaches.

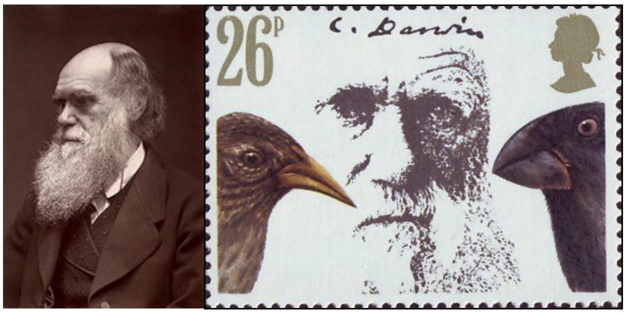

Figure 39. These islands were made famous for the exploration of another great naturalist scientist, Charles Darwin (1809-1882), to whom we owe the statement of the theory of evolution. Also for him the honor of the stamp! He published his theory in the book "The origin of species by natural selection" (1859), which is his best-known work. He collected much of the data on which he based his theory during a trip around the world on the ship HMS Beagle (which got its name from a dog breed, fortunately), and in particular during his stop in the Galápagos Islands.

We were hosted at the Scientific Station named after Darwin, on the island of Santa Cruz, together with the usual visitors, including the descendants of his famous finches observed in 1835.

Figure 40. We observed that Darwin's finches certainly have specialized bills to select the juicy insects… but they also like the pieces of bread given by the park goers.

Figure 41. The serene tranquility that transpired during the brief acclimatization on land in Quito, gave way to fatigue and stress when we reached the beaches of some islands of the archipelago by sea.

Figure 42. We sampled the meiofauna during low tide under the equatorial sun at 45° C, having as our only companions the marine iguanas which, however, can seek shelter in sand lairs and also an alien organism now “extinct”!

What’s hotter than the equator? But why then am I ending my paper on Humboldt cold current right here in the Galapagos? Apart from the cultural affinity between Humboldt and Darwin, what kind of link can ever exist between the icy Antarctica where we started sailing and the very hot Equator, our point of arrival? And could this bond be represented by the powerful Humboldt current? Well, yes!

If you remember, we left Antarctica greeted by an Adelian penguin and coincidentally, the first animal we met and photographed while enjoying the sun on the coast of Bartolomé Island is a Galapagos penguin!

Figure 43. The Galapagos penguin represented on an Ecuadorian stamp!

This extremely resistant endemic bird is the only penguin found north of the Equator and can overwinter “in the heat” by exploiting the strength and richness of nourishment that the current carries for almost 90 degrees of latitude! It is the most “northern” component of the black band penguins or, rather, a ... “gang” of penguins...? In fact, it is a close relative of the Humboldt penguin, which lives along the Chilean and Peruvian coasts, of the Magellanic penguin which also populates the Atlantic coasts of South America, and of the Cape penguin, who instead prefers South Africa and the current of the Benguela!

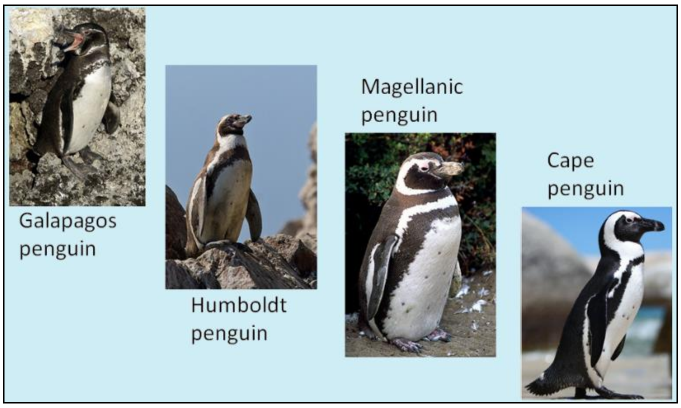

Figure 44. The “gang” of penguins

However, they are mainly present along the southernmost coasts of South America and Africa washed by the cold Antarctic currents, while our penguin goes further north: it is endemic to the Galapagos and can bear the heat of the Equator because the waters of the current which invests the archipelago, after a journey of almost 90 degrees latitude, still maintain an optimal temperature and a load of nutrients sufficient to support its precious trophic reserve of planktonic shrimps.

Figure 45. Now it’s up to the small sea lions of the Galapagos to greet us and meet us somewhere else in the ocean.

At the end of this long marine pursuit of von Humboldt’s tracks, let me express a personal consideration: given the extreme and necessary specialization required by modern scientific research, probably there will no longer be figures of great scientists such as those who have been remembered now and who in the past dealt in all fields with an insight of nature in its various physical, geological, geographic and biological aspects.

I would have liked to participate, even as a simple spectator, in one of the expeditions conducted by von Humboldt 200 years ago, when some natural laws still had to be theorized and the causes of the most impressive natural phenomena explained.

Aware of the tiredness I generated in you readers, just for completeness I add that 25 years after the expedition to South America, the tireless von Humboldt left for a long scientific journey to Russia … and 20 years from my expeditions are still not gone. So you are safe from my next one!

DOI: 10.15167/2612-2960/BELS2020.2.1.1229