Check against delivery

Marine Research in the Middle of the Atlantic Ocean: tools for proper management

By: Frederico Cardigos

Before arriving to the government of the Azores, since six months ago, I was a marine biology researcher in the middle of the Atlantic Ocean at the Department of Oceanography and Fisheries of the University of the Azores. I was a PhD student under the supervision of Professor Ricardo Serrão Santos. I was specializing on marine invasive macro species. On the last few years, I worked under contract through several research projects, including some funded by European Programs, such as MAST and Framework Program 6. In those projects I mainly had to do the link between the needs of the research scientists and the developers of new technological tools for marine investigation. This approach gave the opportunity of closely observe the different approaches for marine research and to have access to the results of completely different teams, using complementary methodologies. At the same time, representing the University of the Azores, I was involved in several international meetings, to coordinate work to understand and protect the marine environment, such as Oslo-Paris Convention meetings or MARBEF European network of excellence.

Administratively, **the Azores** are an autonomous region of the Portuguese republic with 300 hundred thousand proud Portuguese citizens. Geographically, the Azores are located in the middle of the North Atlantic. The archipelago has nine islands spread over the largest mountain chain in the world, the Mid Atlantic Ridge. The average depth of this area is quite high. This fact, allied to the large distance from the mainland shelf, justifies the apparent poverty of marine productivity in the Azores. Both, the number of marine species and the yearly fish captures are comparatively low when confronted to the mainland or Icelandic numbers. But, in the other hand, one million square kilometres of Exclusive Economic Zone, through which some of the biggest existing species migrate, and the presence of exotic habitats such as the deep sea hydrothermal vents forces us to carefully look to this sensitive environment and to try to find the correct measures of marine management.

In the Azores, **we are concerned** and we want to know the marine environment in detail. Using some of the most advanced tools, we were able to develop our knowledge. Of course, dozens of scientific papers were published and the endogenous scientific knowledge is recognised trough the permanent development of partnerships. IFREMER, Woods Hole Oceanographic Institute and National Institute of Oceanography in India are three examples of the list with more than one hundred institutions that, all around the world develop, in cooperation, work in the Azores and with the Azores.

Nowadays, the **University is an instrumental institution** that provides the Government of the Azores with the results needed for a correct management. This information is used to determine the fish quotas, to decide on the correct fishing procedures, to implement the management rules used for sensitive environments and other. Besides the more practical approach of the marine research, the University also performs fundamental investigation.

In the mid-Atlantic mission accomplished two years ago by the new Norwegian research vessel "GO Sars", we were allowed to see species for which we do not know even the kingdom! It is a common place to say the lunar surface is better known than the bottom of the sea. It is common, but the sad part is that it is still true. The area actually studied in the deep-sea is as big as few football fields. Some estimates point to 10 million macro benthic species and 100 million meio-benthos species. Satellites, and other XX century instruments, are unable to observe the deep-sea. Remote Operated Vehicles and Submarines are expensive and able to see only a few meters around them. This is quite modest when we are referring to almost three quarters of the earth surface. 90% of the biosphere is ocean which means that the space available for life is 170 times wider in the Ocean than in the other biotopes. Besides marine life, the bottom of the open ocean is also very rich. The deep-sea possesses 100 million tonnes of poly-metallic sulphides and large quantities of Manganese nodules.

The large part of the **deep-sea** is constituted by abyssal plateaux with sandy or muddy bottom. Commonly, these are areas with low productivity, mainly because it is dependent on the natural production that comes from the first meters of the Ocean, but incredible high micro biodiversity. The available energy and the macro species diversity are low. At other places, such as ridges, seamounts, canyons and hydrothermal vents things are different. In

the deep-sea organic matter has a density of 1 gram per square meter, and in the hydrothermal vents the figure increases up to 20 kilograms in the same area, twenty thousand times more.

Biological developments on the study of the species existing in the **deep sea hydrothermal vents** allowed us to better understand the adaptations that were mandatory to survive in one of the most extreme environment of the plant earth. Concentration of metals and other lethal elements would kill a mammal in only a few minutes. The pressure is so high that would immediately smash a human being that would imagine diving at these depths. Even worst for life development than the high temperature is the contrast of temperatures that, in these locations, can vary from several hundred degrees, near the vents, to less than 5 centigrade in only a few centimetres distance. In the deep-sea hydrothermal vents there are no sun light, and the production of organic material relies not on the sun, but on the chemical mediation. If you are able to imagine all this, you are simultaneously in the chemosynthetic realm and, also, in the same environment that gave birth to all life on planet earth. What an opportunity to marine scientists!

As I said before, the Azores are located over the mid Atlantic Ridge, but in a very particular part of this Ridge. Here, besides the American plateaux, we also have the conjunction of the Euro-Asiatic with the African plateaux. This is one the few places on earth where a triple junction exists. The geological activity is, therefore, quite high, and fissures break on the crust as the plates try to accommodate the growth of the Ocean. These fissures allow the marine water to approach the magmatic chambers of the mantle, to heat, ascend, and return to the Ocean floor where the precipitation of the mantle elements creates beautiful chimneys that are crowded with marine life.

Here, benthic species that survive this misfortune are able to use all these drawbacks in their competitive advantage. Hydrothermal species may incorporate bacteria that synergistically provide food and receive shelter, these species may get ride of high metal concentrations and they may even adjust their DNA! Imagine the possibilities of using this for the benefit of mankind? What medicines could be developed? What biochemical processes where lost during evolution that may still be available in the deep-sea vents?

The next question could be “but why should we study them in the Azores?” Yes, one may do it in any place that is near to a triple junction, has a

laboratory with all the devices to develop the studies and that possesses a team specialized in eco-toxicology and other marine subjects. In the Azores, we are only at 10 hours distance of a triple junction, we have LabHorta, a place where deep-sea species may be maintained during several months and a dozen of PhDs specialized in deep sea studies. One can do it anywhere, but it certainly easier to do it in the Azores, after we have developed the acoustic retrievable deep-sea cages.

Besides deep sea hydrothermal vents, the sea around the Azores also possesses other very interesting ecosystems. Among those, I would like to call your attention to the **seamounts**. These structures are much more complex than what we could imagine at a first glance. There are clues leading us to a higher fish concentration over the seamounts. As these structures are relatively isolated over the sea-bottom, certain specialized species also developed there. There are several species endemic to seamounts. The cruel part is that usually the seamounts are small and they are also very sensitive. Impact caused by anthropogenic activity was ignored and it is hidden in the deep and isolation of the seamounts. Present or future activities, related to mining, gas and oil extraction, CO2 sinking, have to be planned in order to predict and minimize potential impacts.

The **seamounts and the deep-sea** are under stress. Only this justifies the increasing number of deep-sea species and habitats that are present in the international red-lists. It is today well known that species of the deep are less resilient than others. This happens because they have a slower growth, late maturity, high longevity, and populations are discontinuous. Proper action has to be putted in place, allowing for the correct management. Unfortunately, this is not compatible with the lack of jurisdiction of the high seas.

The oceans, particularly the deep sea where considered with **infinite capacity to dilute any substance** making them harmless. The oceans were elected for o long time as the dumping and disposal site for a wide range of substances, such as radioactive, heavy metals, garbage and others. The threats for marine life that this represented are now well known, and there has been important changes on anthropogenic disposal of harmless substances at the sea floor. But now, another potential threat is arising: carbon sequestration. Disposal of CO2 in deep sea geological formations is being envisaged and experimental studies are being conducted. Difficulties at this stage seem to steer apart the exact balance of damages and benefits.

Some of the envisaged problems are the induced pH changes, with the almost certainty of the decrease of around 0.1 in the next 100 years. Also, the ecosystems at such depths are very sensitive to changes in biogeochemistry and the consequences in those deep-sea ecosystems are not completely known, but, almost surely, not very positive...

No one knows for sure what will happen in the atmosphere with the global climate change. If that is true for the well known atmosphere, imagine the degree of uncertainty for the deep-sea? One might expect and increase in dissolved CO2, which will then result in the acidification of oceanic waters. Key marine organisms, such as corals and some plankton species, will have difficulty maintaining their external calcium carbonate skeletons, and in higher latitudes this may occur within decades. Elevated CO2 partial pressures will affect the physiology of many marine species. This will be coupled with expected CO2 sequestration on the deep sub-seabed.

The general crises over the fisheries in the shallow areas has conducted, in the 80's and 90's, to a sudden exploitation of the deeper areas. Quite rapidly the Australian and the New Zealand trawlers have severely explored the orange rough stocks. Besides direct captures, Matthew Gianni in 2004 also stressed the indirect and dramatic impact over accessory resources. Trawlers scratching the sea bottom, clean the cold corals and deep-sea sponges, some of them with over 1000 years old. Some scientists say that especially the suspension feeders, as cold corals and sponges, might never recuperate after being collected. They are too slow growers and one might have to wait several hundred years to get to the initial condition.

Generally speaking, over 50% of the fish stocks are near the limit of exploitation, while other 25% are already over-exploited. No past, actual or future exploited deep-sea fish stock is commercially viable at the actual level of fisheries.

The fisheries using **trawling nets or other kind of nets** are the most problematic for the sea bottom. Even lost nets, called ghost nets, are still a huge problem. Glover and Smith in 2003 mentioned that oil and gas extraction have rules that evaluate and minimize the negative impacts over sensitive ecosystems. In the other hand, future activities, including the perforation for hydrocarbon extraction or marine soil mining might be a future threat. These are new activities and precautionary rules have to be

implemented before starting the industrial activity. Impact assessment should be carefully done.

By any strange reason, lost material in the bottom of the sea, such as a fish spine, shark tooth, or a fragment of a volcanic rock, tend to aggregate manganese, nickel, cobalt, manganese, cooper, gold, silver, titanium and zinc among others. The **manganese nodules**, as they are called, are among the slowest growing mineral deposits. According to Verlaan in 1992, it takes one million years to grow two centimetres. Manganese, nickel and cobalt quantities are probably higher in the sea than the terrestrial reserves. Several authors have studied carefully the impact of manganese collection, but, as far as we are aware, no one studied the impact of the sediment plume that falls from the extraction devices.

Another potential resource of the deep-sea is the **methane hydrate** extraction. Will this be the fuel of the future? No one knows for sure, but a lot of study is being carried out. Methane hydrate mounds are crystal structures of methane and water that form under conditions of low temperature and high pressure. In some places of the sea bottom, a solid layer of crystals of methane hydrate extends from the sea floor down hundreds of meters. The quantity of carbon stored here is more than twice the available carbon in the oil fields. About 60% of all bacteria on Earth live in sub-seafloor sediments and hydrates constitute a unique deep bacterial habitat. Myriads of one to two inch long polychaete worms can be seen living on and in the surface of the hydrates.

Non-planned extraction activity may immediately lead to ecological disequilibria, economical losses and, in the worst scenarios, extinctions. So, how can one manage such sensitive and rich areas? The answer has been pin pointed by dozens of authors, and is simply to carefully study each stock before initiating exploration. To use nets without fisheries biologist planning is the same has mining, because the stocks will collapse. Usually, traditional fishing, using a very low fishing effort is the easy and often correct answer. As mentioned by Glover & Smith in 2003, industrial fisheries in the deep-sea is considered as non-renewable. Doing small scale studies seems also a correct approach. And it is possible. After studying it, some areas of the deep-sea were observed to quickly recuperate even after trawling.

In the sea around the Azores, in our Economic Exclusive Zone, we have several seamounts and, as the Azores do not have a continental plateaux, the

seamounts are crucial for the seafood supply in these islands. To prevent any misuse, after sea trials scientists suggested to quit any project using trawling nets in the Archipelago. As the local authorities considered it imperative, it is now impossible to use those nets in an extensive area of the Azores. This was afterwards put in regulation by the EC. While this was done, the same new common fisheries policy decided to increase the fishing effort in 430% for swordfish fishery in the waters under their jurisdiction, thus creating an unevaluated impact on by-catch species like the IUCN endangered sea-turtles and blue-sharks.

The littoral, the closest marine part to the islands is, of course, also the one over more stress. Every person wants to benefit from these clean and blue waters. We understand, but rules, suggested by scientific researchers had to be putted in place in order to use them, but in a sustainable level. And these are not empty words. In the shores of the Azores is only possible to use long-line fishing methods at distances more than three miles offshore.

Marine mammals are often regarded has one of the main group of species and they are under careful management. In the former days, we also hunted them. Nowadays, direct exploration, including provoking any harm to these animals is not allowed. Nevertheless, it is possible to explore them in terms of tourism. Whale watching is today an industry that brings more than 20 thousand persons to the Azores each year. That is, more or less, ten per cent of the overall tourism. Scientists were inquisitive about these animals. Several interesting studies were performed including species lists, feeding behaviour, general behaviour, interaction between marine mammals and tourist activities among several others. The work then carried out was used to produce a law for whale watching activities that made jurisprudence in other Portuguese initiatives.

The horizons that **marine research** opens are too wide for us to see or even imagine their limits. It is a responsibility to maintain the values hidden in the dark deep blue shadows and it is an opportunity to discover solutions to problems that we even did not met yet.

Europe had a crucial role in the protection of the marine environment of the Azores. It was only after the Bird and, afterwards, the Habitats Directive were published that the marine environment protection achieved the importance that, today, we certainly recognize. The Azorean environment orientated people have no doubt about the importance of the European

Union in catalyzing the awareness over nature problems, sensibility and solutions. Nowadays, I must say, the Azores citizens have overcome the initial ignorance and now they are very proactive in the protection of the marine environment. In my opinion, which, of course, is suspicious, we are now much more conservative than Europe.

We certainly do not understand the hesitation in integrating the Fisheries Common Policy inside the Marine Directive. It is mandatory that, once and forever, extraction is under a precautionary approach. Sustainable ecological approaches have to lead the extraction, or else extraction will conduct to economical drawbacks and, in the worst scenario extinctions. How can one Directive interfere in the definition of the Good Ecological Status without interfering in the worst conditioner? If the Marine Directive is the environmental "pillar" of the European Maritime Policy after June 2007 how can the Fisheries Common Policy to be out of its scope?
In the impact assessment of the Marine Directive the word "deep-sea" was written once and, in the other hand, "coastal" was written 43 times.
"Seabed" was written 6 times and always related with shallow habitats.
"Ultra-peripheral or outermost regions" were referred once.
At the 11th International Deep-Sea Biology Symposium, scientists from around the World discussed issues relating to deep ocean management and the contribution that scientific research should make to the debate. The conclusion was that policies for the management of deep-sea ecosystems, within areas of national jurisdiction, have generally used regulations developed for shallow water systems. In some cases these are not appropriate for the deep-sea. In the Azores, the deep-sea represents 95% of the one million square kilometres of EEZ. We are certainly concerned with the deep-sea.

Five European **funded** LIFE Projects were instrumental to obtain the knowledge to classify, study and develop management plans for the Azorean Natura 2000 sites. It was not very expensive in terms of European budget, but it allowed for the international teams to develop crucial work that was afterwards decoded to one new species, to around fourty peer-reviewed scientific papers, 38 management plans and hundred and fifty reports. It was a lot of work and a lot knowledge.

Under the **Oslo-Paris Convention**, we have proposed, and it was accepted and submitted by Portugal, the classification of six places. Those places have been carefully monitored by Portugal with the cooperation of several

European Countries. One of the proposed areas, Rainbow hydrothermal vent, is already outside the Portuguese EEZ. This was not enough reason to turn our back to the appropriate study, management and protection.

I have to admit that we have the ambition to directly contribute to the study and management of the sea around Azores. We really want to have a direct interference in the protection of the largest EEZ of the European Union countries. We want to do that because our EEZ is part of us. Is part of our body and mind and we believe that, with the cooperation of everyone that has a positive approach, we are the best positioned to, under the scope of the Azores, help to review the Natura 2000 network and related Directives. For us, it is extremely important that the marine Directive takes into account the open ocean, the deep-sea, their species and habitats at the same level as the coastal ones. Saying that, I also have to admit that the 300 hundred thousands persons that live in the nine islands do not have the necessary budget to, alone, implement the necessary tools to define and monitor the Good Environmental Status of the Azores Sea. First studies pointed to one annual budget over 30 million euros to implement the Marine Directive. To your information, the annual budget for all the environment activities in the Azores is 20 million euros. We certainly do not have the money to do it. We need a Marine Directive with a financial wing to correctly fund the initiatives that will be mandatory.

Finally, I would like to stress that the Azores scientists and managers have always been and will always be available to help to find the best decisions. We are located in the North Atlantic, over the Mid Atlantic Ridge, we may do the bridge between Ireland and other northern countries with Macaronesian islands of Madeira, Canaries, until Cape Vert. I acknowledge Professor Ricardo Serrão Santos, from the University of the Azores, Ms Maria Pitta and Ms Patrícia Simões of the Government of the Azores for the enormous contribution that they gave for this talk.

Thank you!