# 1.20 The Forbes's Azoic Theory and the Portuguese Zoologists of the 19th Century

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Despite the strong evidence of the existence of life in the sea at great depths since the first decades of the 19th century (Portuguese authors [1812, 1815, 1818]; J. Ross [1819]; J. C. Ross [1847]; among others) the Forbes's azoic theory was curiously accepted by the scientific world and persisted during a considerable period. J. V. Barbosa du Bocage, the best Portuguese zoologist of the 19th century wrote that he became suspicious about the depth limits established by Forbes when he classified a sponge – *Hyalonema lusitanica* – caught by fishermen off Portugal and at a great depth (Bocage [1865, 1871 b]). The azoic theory had such deep roots that Bocage [1871 a, 1871 b] using all his scientific probity only published the depth at which the species was caught (more than 300 fathoms) after getting new specimens, collecting other species at the same region and depth and after the confirmation of his data by Wright [1868]. The papers by the Portuguese ichthyologist F. de Brito Capello (e. g. [1867 a, 1867 b]) stated only for each deep-sea species that they were caught at great depth and did not give any precise depth data. It is difficult to decide if he had no precise data on depth or if he had the azoic theory in mind. The first seems more probable. Portuguese fishermen, that had been fishing deeper than 300 fathoms for centuries, had practically proved the existence of life at great depths well before scientists. Illiterate as they were they did not suffer from scientific obduracy (ef. Merriman [1968]).

Since the beginning of the 19th century there is strong evidence of the existence of life in the deep-sea.

In 1815 the Royal Academy of Sciences of Lisbon published a paper by Constantino Botelho de Lacerda Lobo on the fisheries of the Coast of Algarve in 1790. In his paper he quoted among other data the depths of some fishery grounds, some of them at 125 and 250 fathoms. The greatest depth recorded in his work was 400 fathoms corresponding to the sea of Albufeira where many fishermen worked successfully. Three years before (Lobo [1812]) he had already quoted the depths at which some species were caught (120 fathoms).

In 1818, the Royal Academy of Sciences published again in its memoirs an ichthyological paper (Fig. 1) by an anonymous author entitled "Remarks on some fishes from the sea and rivers from Algarve". It consisted in a paper remarkable for that period in which the species were presented after their systematic position with their scientific names following the system and nomenclature of Linnaeus (what the author called the "Systema dos Peixes de Linneo" (sic)). He also gave the common names and some bibliography concerning the species he recorded namely the work of Artedi and the "Encyclopédie Méthodique" by Bonnaterre.

The editor of the paper added a great amount of footnotes, namely on systematics, based on the work of several authors like Lacepède, Vandelli and Brotero. This ichthyological paper included also data on the areas and fishing periods of the year, fishing gear, economic aspects and fishing depths.

Among the nearly seventy eight species recorded several were currently fished at considerable depths. The sharks *Oxynotus centrina* (L.), *Etmopterus pusillus* (L.) and some rays were recorded at 350, 420 and 550 fathoms, respectively. These depths correspond to the known bathymetric distribution of these species.

Some records of epipelagic species like *Lamna nasus* (Bonnaterre) and *Spicara smaris* (L.), said by the author to be fished at 300 fathoms or more, are certainly misleading. The long lines sent to these depths by fishermen had very probably caugth the animals near the surface. The probable species misidentification is another remark to this text, e. g. *Carcharodon carcharias* (L.) also an epipelagic species is said to be recorded between 175 and 450 fathoms. Its Portuguese common name quoted in this work is *Albafar* or *Albafora* the current modern Portuguese name for *Cetorhinus maximus* (Gunnerus) or *Alopias vulpinus* (Bonnaterre). Furthermore *Carcharodon carcharias* is very certainly only a casual visitor along the Portuguese coast.

In the same year of 1818, during his trip to find the northwest passage between the Atlantic and the Pacific, Sir John Ross [1819] carried out a series of sounding operations at great depth in the Baffin Bay, off Bylot Island. He found a living gorgonocephalus at a depth of which he tought was 1000 fathoms. Other invertebrates were collected at lesser depths along the coast of Baffin Island. As it is known (Rice [1975]; Mills [1983]) the depths quoted by Ross were erroneous (he did not detect the weight hitting the bottom), but he indeed demonstrated the existence of life at 500 to 600 fathoms.

In 1841 James Clark Ross [1847], during his expedition to the Antarctic [1839 to 1843], dredged several organisms between 300 and 400 fathoms in the Tasman Sea. Abundant animals were also dredged at 300 fathoms by Goodsir [1845] aboard the HMS *Erebus*, in Davis Strait during the ill-fated arctic expedition (Mills [1983]). Spratt [1849] and Sars [1851] among other authors recorded also the presence of life in the deep-sea.

Edward Forbes, the prominent personality in the study of the sea bottom in the first half of the last century (cf. Rehbock [1979]; Mills [1983]), carried out part of his dredging activity during a year in the Aegean Sea (1841 to 1842). He found that below 130 fathoms the animals became fewer and smaller (Forbes [1844]).

Three years later Spratt and Forbes ([1847], In: Mills [1983]) wrote about the findings in the Aegean Sea:

> "In the deepest parts explored of this abyss, very few species were found, and it seemed as if we were approaching a region that was barren and desert, where there was no more life, unless of minute forms of low organization."

# HISTORIA
E
# MEMORIAS
DA
## ACADEMIA REAL DAS SCIENCIAS
## DE LISBOA.

*Nisi utile est quod facimus, stulta est gloria.*

TOMO V. Parte II.



LISBOA
NA TYPOGRAFIA DA MESMA ACADEMIA.
1818.
*Com licença de SUA MAGESTADE.*


Fig. 1. Frontispice of the "History and Memoirs of the Royal Accademy of Sciences of Lisbon", volume 5, part 2, 1818 and one of the pages of the paper on the fishes of Algarve (Anonymous [1818]) in the same volume.

# ORDEM PRIMEIRA.

## PEIXES CARTILAGINEOS.

*Chondropterygii* e
*Branchiostegi* de Linn.

Barbatanas guarnecidas de cartilagens em vez de ossos.

### §. 1.

### ALBAFAR ou ALBAFORA (*a*).

*Squalus Carcharias* Linn.
Artedi. Gen. 70. Syn. 98.
Bonnaterre Encycl. method. Pl. 7. Fig. 20.

Na costa de Lagos morre este Peixe nos mezes de Maio, Junho, e Julho na *armação*, porém em pequena quantidade, assim como na costa de Tavira, aonde se pesca na distancia de quatro legoas, e na profundidade de 250 braças. Os pescadores de Olhão fazem com os *espinheis* huma grande pescaria deste Peixe na profundidade de 175, 200, 400 e 450 braças d'agoa. Elle faz hum grande damno na *armação*, e tem poucos compradores em fresco; secca-se e depois vai para Hespanha. Aproveitão as entranhas de que tirão azeite em grande quantidade.



(*a*) *Squale Requin.* La Cepede T. 1. pag. 169 da Edição em 4.° o Dr. Vandelli e Nemnich dão-lhe o nome de *Tuberão*, assim lhe chama tambem o Sñr. Brotero. Segundo D. J. Cornide dá-se-lhe igualmente o nome de *Cassarra*, que tanto (diz elle) se parece com o de *Carcharias*.

After Forbes's death, in a work published in 1859, Forbes and Godwin-Austen postulated not only the absence of life or its considerable rarefaction below 300 fathoms but also that the deep-sea was the "finest field" for "submarine discovery".

It is clear that Forbes never rejected completely the existence of life deeper than 300 fathoms but this opinion was dominated by his suggestion that life was absent or much attenuated below 300 fathoms – called the Forbes's azoic theory. It curiously focused the attention of scientists for years, as stressed by Mills [1983].

Anyway some scientists like Wallich and Jeffreys (cf. Mills [1983]) clearly admitted the existence of life in the deep-sea. In Wallich's [1860] remarkable opinion the stressing conditions of the deep-sea – absence of plants, cold, high pressure and darkness – were not a limiting factor to the existence of animal life. On the other hand Jeffreys [1861] suggested that telegraph cables should be protected against boring molluscs.

As it is known the conclusive proof of the existence of life at more than 300 fathoms took place in 1860 when a telegraph cable connecting Sardinia to North Africa was raised from 2000 to 2800 m. Attached to the cable were fixed solitary corals and molluscs (Milne-Edwards [1861]).

Even with all these overwhelming proofs the idea of the azoic zone prevailed for a quarter of a century (cf. Merriman [1968]) and many good scientists were cautious about the matter. Among the reasons justifying the prevalence of the azoic theory were perhaps the following: the stressing conditions known to exist in the deep-sea (although compatible with life in the opinion of Wallich), the respected personality of Forbes, the resistance of prominent scientists like Wyville Thomson (that almost changed his ideas during the cruise of the HMS *Lightning* in 1868) (Merriman [1968]; Mills [1983]), the generally existing scientific and popular resistance to new ideas, and the easy attitude of not accepting what was difficult to prove, with all their psychological aspects. It truly was a question of "scientific and popular obduracy" as Merriman [1968] called it.

In this context it is not surprising that the Portuguese zoologist José Vicente Barbosa du Bocage [1823 to 1907] (Fig. 2) had the same kind of hesitations. Bocage was by far the most distinguished Portuguese zoologist of the last century. He is considered to be the founder of Zoology in Portugal as a modern and scientific discipline (Ribeiro [1904]; Sacarrão [1953, 1968]). In 1862 the Zoological section of the National Museum of Natural History was created and under his impulse the museum was very much enriched with material coming from overseas. Having received a degree in Medicine he became Professor of Zoology and taught at the Polytechnic School in Lisbon in which the National Museum was settled. His vast scientific activity covered all the vertebrate groups from mammals to fishes, with remarkable works on the ornithology and herpetology of Angola. He also published on sponges and on the life at the great depths of the ocean. He was a Peer and spent part of his life in politics, being Minister of Navy and Overseas and Foreign Affairs, Deputy and State adviser.

Fig. 2. J. V. Barbosa du Bocage [1823 to 1907]

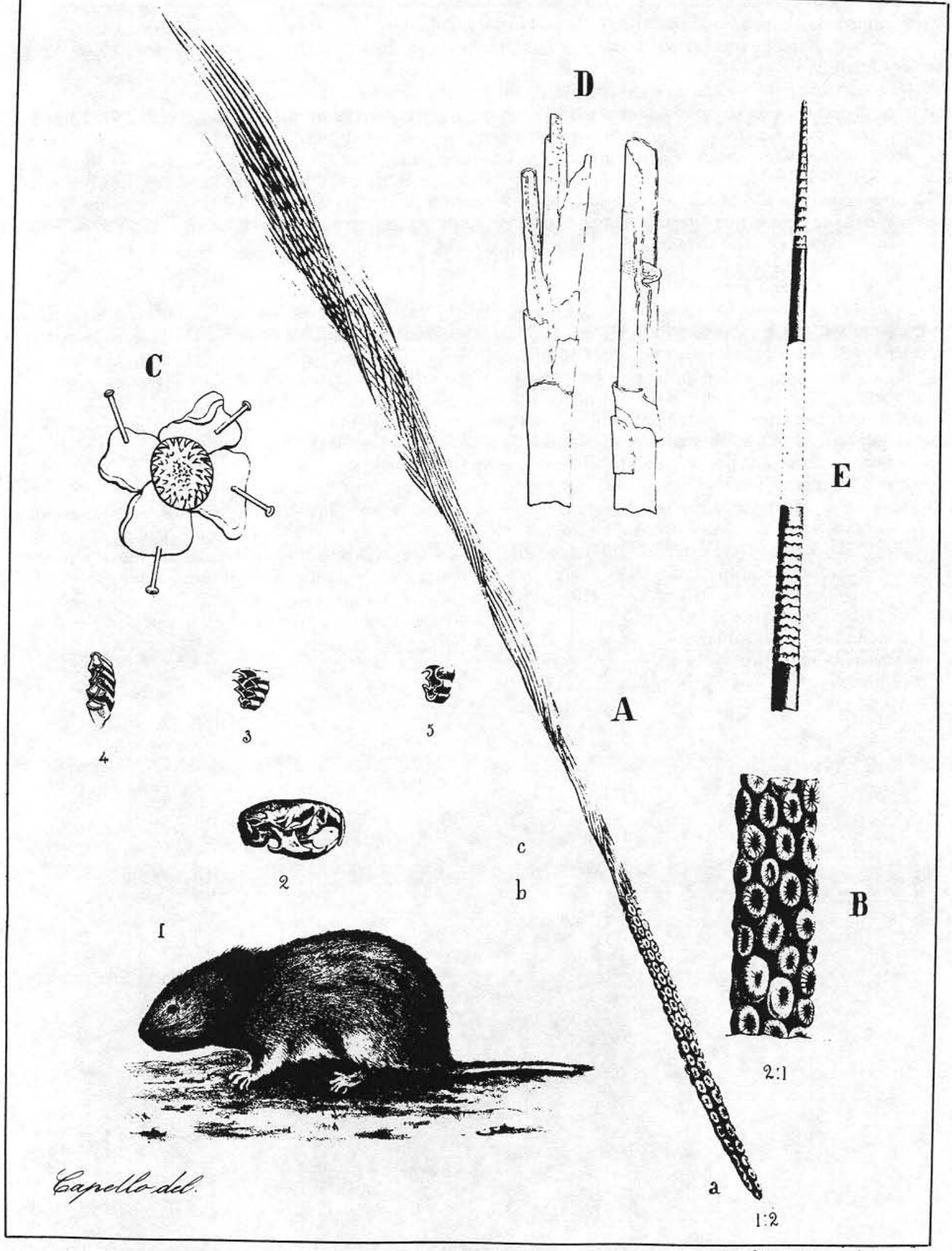


Fig. 3. The plate representing *Hyalonema lusitanica* described by Bocage [1865]:
A – The long spicules with attached polyps
B – The polyps
C – An open polyp
D – E – Details of the spicules

In June 1863 Bocage received a "zoophyte" sent by Mr. Gamito, the Chief officer of the customs of Setubal. The organism was caught by fishermen's long lines during shark fishing, far from the coast and at a "considerable depth" as Bocage [1865] quoted. He called it *Hyalonema lusitanica* and it was later demonstrated that it was a sponge. He actually described a bundle of long sponge spicules (63 cm long) having in its upper extremity a fixed agglomeration of polyps (cf. Fig. 3). In the diagnosis he included the characteristics of the polyps and number of tentacles.

In an additional note to his paper, Bocage [1865] recorded another specimen of *Hyalonema*, collected at "great depth" between 600 and 700 fathoms according to Mr. Gamito. This specimen had no more polyps but probably the true portion of the living sponge (cf. description by Bocage [1865]). These specimens of *Hyalonema lusitanica* existing at the Museu Bocage in Lisbon were destroyed by a fire in 1978, as practically the whole museum (cf. Saldanha [1978]) and now it is impossible to know exactly the nature of the organism Bocage described in his additional note.

We have to stress that by that time the origin of the long spicules was a controversial subject. Gray and Brandt believed it originated from the polyps and Valenciennes from the sponges that were generally found with them (Bocage [1865]).

C. G. Ehrenberg, who was among those scientists accepting life in the deep-sea (Merriman [1968]) denied Bocage's finding under the zoological aspect (Bocage [1867]). In a letter addressed to J. E. Gray in May 2, 1867, Bocage [1867] wrote about a letter received from Ehrenberg:

> "He persists in believing me the victim of a mystification, and in regarding the Hyalonemas as artifical products manufactured by the Japanese" (!).

He also transcribes the letter of Ehrenberg:

> "I am convinced that the officer of customs who procured you these specimens has been deceived by some dealer in objects of natural history, or by travellers coming from Japan, and who have invented the fishery of these bodies near Setubal. It has been possible to *place beyond doubt the presence of cotton threads for the attachment of the different pieces;* there are also on the surface fibres of wool coloured red and green, certainly belonging to some old sailor's garment. The resemblance of this specimen to one of Brandt's figures is so striking, that is impossible for me to believe that bodies so alike on all their parts can occur both in the Sea of Japan and in that of Portugal, or that these forms could be constructed in a manner so identical in the midst of circumstances so widely separated." (Bocage [1867])

This letter points out well how incipient the fundamentals of biogeography were by that time.

Bocage [1867] argued that natural history dealers did not exist in Portugal and that never in the memory of man a ship was seen coming from China or Japan entering the little harbour of Setubal! He replied to Ehrenberg sustaining the seriousness of his finding – the seven specimens he got were given to him by honest people in different periods – 1863, 1864 and 1865, and they came precisely in the season of sharkfishing off Setubal. In his letter to Gray he also commented with indignation the non existence of cotton threads attaching the spicules, as Ehrenberg noted.

In a second letter to Gray [June 15, 1867] Bocage [1867] complained about the doubts of Ehrenberg on the "habitat of *Hyalonema lusitanicum*", and he carefully explained how the specimens (one of which was in the collection of the British Museum) were obtained. What Ehrenberg had in mind was certainly more the geographical situation of the findings than the bathymetric data. As a matter of fact, ten years before [1857], Ehrenberg wrote in a letter to Maury: "... I hold firmely to the opinion of stationary life at the bottom of the deep-sea" (Merriman [1968]).

In 1871 Bocage published another paper on sponges, this time on *Holtenia carpenteri* found attached to the hooks of the long lines that the fishermen of Setubal used to catch deep-sea sharks. This sponge came from the same place and depth (450 to 500 fathoms and more) as *Hyalonema lusitanica*.

In the very same volume of the "Journal de Sciencias Mathematicas, Physicas e Naturaes", Bocage [1871 b] published his comments on "animal life in the great depths of the ocean". He wrote that the idea of the non existence of life below 300 fathoms had been generally accepted till recent years (this was in 1871) because it was supposed that life was incompatible with high pressure and complete darkness. Even with several proofs in contrary to this the idea had deep roots and any contradictory record was considered erroneous.

Bocage also wrote that by that time [1871] the existence of life deeper than 500 fathoms had been demonstrated for three years. He justified then why he did not give the precise depth where his first specimen of *Hyalonema* was caught, mentioning only "living at very great depths". He pointed out that even with the unanimous testimony of the fishermen about the depths where specimens of *Hyalonema* were caught he thought they were exaggerating and that naturally this animal lived in lesser depths than those fixed by Forbes as a limit to animal life.

This example illustrates for Portugal the widespread "scientific obduracy". Bocage's doubts make him invite Perceval Wright from Dublin to dredge the bottoms where *Hyalonema* was usually caught off Setubal. In the beginning of his "Notes on Deep-Sea Dredging" Wright [1868] stated his conviction about the existence of life in the deep-sea. The paper dealt nearly totally with his experience off the Portuguese coast following the invitation of Prof. Bocage.

He carried with him a "medium-sized naturalist's dredge" (for which he paid "duty while passing through Spain") and went to the sea in an "open sail-boat with a crew of eight men", about 600 fathoms of rope the dredge, lots of hooks and bait, and provisions for a couple of days". The dredge was sent down with 480 fathoms of rope with 30 more for slack. It was drawn for the distance of about a mile along the bottom.

The dredge was hauled by hand and it was found to be full of mud and with a big quantity of the long spicules of *Hyalonema*. A perfect specimen of *Hyalonema* "rewarded my first attempt at dredging at such a depth" as quoted by Wright.

He was also surprised by finding sharks *(Centroscymnus coelolepis* Bocage and Capello, 1864) at these depths, that were fished with long lines from the boat he was using. He concluded that:

> "I think there can be no reasonable doubt that they were inhabitants of the same great depth as the *Hyalonema* and that, on being dragged up through such a weight of water, they were completely asphyxiated" (!).

Wright did not only catch *Hyalonema lusitanica* and *Centroscymnus coelolepis* but also *Chiasmodon niger* Johnson.

Furthermore Bocage gave him a specimen of a gorgonarian collected in the same place as the previous species, that Wright [1868] called *"Keratoisis Grayii"*.

Bocage [1871 b] was fully satisfied with the results obtained by Wright. For him they represented the end of his hesitations with clear proofs about the depths (more than 450 fathoms) at which several animals lived, many of them of "high organisation", that he quoted has "one of the most remarkable facts of zoological geography".

Another Portuguese zoologist Félix de Brito Capello [1828 to 1879] (Fig. 4) was a fine ichthyologist. After leaving his military profession and spending a period in the tropics he became a naturalist at the "Museum of Lisbon". In 1864 he described the deep-sea shark *Centroscymnus coelolepis* in collaboration with Bocage (Bocage and Capello [1864]). He also published in Crustaceans and Arachnids.

Capello [1868 a, 1868 b, 1870] stated in his papers that several species of fishes like those belonging to the genus *Centrophorus, Pseudotriakis, Chimaera* and *Aphanopus* lived at "great depths" without giving any precise data. It is difficult to decide if he had no precise data on depths or if he had the azoic theory in mind. The first seems more probable.

Without any possibility to work at sea on a research ship, because there was none in Portugal of the middle of the last century, the Portuguese zoologists had to study the material caught by fishermen. That these men had developed deep-sea fishing with long lines off on different areas of the Portuguese coast for a long time. This kind of fishing enabled them to attain depths of 1200 m and to collect living animals there (as those presented to Bocage and Capello).

Fig. 4. Félix de Brito Capello [1828 to 1879]

King Carlos of Portugal, a pioneer in European Oceanography (Saldanha [1980]) commented the fact (Bragança [1897]) that forty years before it was generally accepted that marine life ceased at a depth of more or less 500 m and by that same time the Portuguese fishermen had solved the problem or enlarged the bathymetric limits to life as they were fishing with their long lines deeper than the quoted limit.

Knowing nothing about science they had pratically solved their survival problem. Very fortunately for them – illiterate as they were – they did not suffer from scientific obduracy.

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