"A souvenir of undersea landscapes:" underwater photography and the limits of photographic visibility, 1890-1910

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Abstract

The first known attempts to take photographs below the surface of the water were carried out shortly after the appearance of the daguerreotype in 1839. The earliest records date from the 1850s. Towards the end of that century, in order to help advance scientific study of marine life, what are considered to be the first underwater photographs were taken. In these attempts, photography was valued as producing evidence, while at the same time the limits of its range of visibility were debated. Here we compare some European and American experiments, particularly those of biologists Louis Boutan and Jacob Reighard in their studies of marine fauna from 1890 to 1910.

Keywords: underwater photography; photographic visibility; Louis Boutan; Jacob Reighard; Henrique Boiteux.

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When François Arago presented his report on daguerrotypes to the Academy of Sciences in Paris in 1839, he envisaged a wide variety of applications for this new technique. Its range of use was practically infinite and it could be employed to record both the most distant objects – stars and planets in the sky – and the closest and tiniest ones – microscopic organisms. Similarly, the sea, which was already a great theme in literature and also a subject for painters in its own right, was central to the field of photography from the very beginning. Englishman William Henry Fox Talbot (1800-1877), for example, one of the pioneers of this new procedure, took shots of the port of Rouen (in northwestern France) in the early 1840s. Photographers' discovery of the sea kept growing and improving in tandem with improvements in technique: how to make an image appear, transfer it and fix it (Bourhan, 2009, p.295). However, from the very beginning, the nature of this medium made it one of the areas that defied capture by the new technique. Due to its vastness and opacity, the sea, and particularly the deep sea, prevented significant growth in scientific knowledge based solely on personal experience, necessitating indirect methods and standardized instruments in order to observe it (Rozwadowski, 2010, p.522). During the latter half of the nineteenth century, scientific exploration and the installation of undersea telegraph cables linking the different continents brought considerable advances in knowledge. Photography, however, did not benefit from the first steps in scientific oceanography, and the depths explored by different expeditions would remain invisible to the majority of mankind for some time (Bourhan, 2009, p.13-17).

In fact, the first attempts to record images of the ocean depths using the photographic camera date back to the 1850s. In February 1856, William Thompson (1822-1879), carried out what many consider the first recorded attempt to use a photographic camera underwater. [The photograph] was taken in Weymouth Bay, off the south coast of England, in a spot next to a rocky ridge that in ordinary tides remained below the surface of the water; an area of sand, boulders and thick seaweed. In Thompson's experiment, the photograph was taken by lowering the camera down three fathoms, roughly five and a half meters. The camera, which was placed in a custom-built box made of wood and iron, was submerged mounted on a tripod, using a rope.

Thompson envisaged a promising future for this procedure, since it would allow examination of various submerged structures such as underwater rocks, bridge foundations and sand banks, all of which would be of great practical value for the shipping industry and transport. Likewise, the application of photography would lead to advances in important issues in undersea exploration, which up to that point, since it involved long-distance research, was fundamentally based on fossil remains and samples obtained with nets, sounding lines and dredging, or on the observation skills of divers. As Thompson himself put it: "Should a pier of a bridge require to be examined, you have but to suit your camera, and you will obtain a sketch of the pier, with any dilapidations; and the engineer will thus obtain far better information than he could from any report made by a diver" (Thompson, 1856, p.426). Almost four decades later, very similar words were used by French biologist Louis Boutan (1900, p.323), who argued that underwater photography "was called to perform a vital role in industry," since some of these images "could offer [engineers] better information than the most detailed reports of divers."

However, in Thompson's attempt, the box holding the camera could not withstand the pressure and flooded with salt water, which reached the collodion-sensitized plate.[1] Contrary to expectation, the plate was not greatly affected by the salt water, although the result, as he himself pointed out, was only a partial success, a "weak" image. This limitation was not linked so much to the aquatic medium, since "in theory there was no reason why we should not obtain as good an image as we do on land, provided the sea water could be kept from the camera, and that the light was sufficient" (Thompson, 1856, p.425-426), but was considered a result of the photographic apparatus. It was a technological limitation that he hoped would be overcome sooner or later. In this sense, the value granted to photography as evidence was not so much linked to its faithfulness or the degree of accuracy in representing its referent, but to its ability to eliminate human hands from the process of recording and representing the world. By simply pressing a button, or pulling a cord, the photographic machine fixed the image, as seen through the lens, on the light-sensitive plate. This automatism or "mechanical objectivity" (Daston, Galison, 1992, p.82) was the principal virtue of the process.

By fixing images of the world beneath the sea, photography did not broaden mankind's visual field – at least not in the way the microscope and the telescope did – but it did make visible, for those up on the surface, an environment that until then could only be perceived by "indirect methods." In this sense, from the very beginning, the question of visibility was a central one. While on the one hand we could claim that underwater photography allowed the symbolic appropriation of the ocean depths, we should also acknowledge that this process of appropriation was constantly thwarted by the frontiers of photographic visibility underwater. In fact, in this endeavor, photography accompanied the diver, who not only explored the sea's depths but also the limits of visibility (Torma, 2013, p.25). Because water is a denser medium than air, underwater photography was also photography of the aquatic medium. The critical threshold at which light could no longer penetrate this medium defined where photography, and presumably vision, stopped. Undersea photographic equipment developed alongside models of observation, inscription and the essence of vision. Also, acting through them, was a conceptual apparatus that revealed the features of this new visual field and the visible subjects specific to it. The particular effect of underwater photography was not simply to expose things, but to question the medium through which they were exposed (Eigen, 2001a, p.93).

After the first trials carried out by Thompson, different experiments in the area of underwater photography developed rapidly after the 1890s. Mostly performed by naturalists or biologists interested in representing some particular aspect of marine life, these attempts – although sometimes fruitless and unproductive – were more systematic in nature. We will focus here on presenting some of the numerous attempts to take photographs underwater from 1890 to 1910. During this period, especially in Europe and the USA, attempts to take underwater photography by biology researchers spiralled. The most systematic and prolonged of these were carried out by Louis Boutan in France and Jacob Reighard in the United States.

In all of these attempts, photography was valued as a producer of evidence, while at the same time the limits of its range of visibility were debated. In this sense, since the process of establishing scientific results almost always requires doing something visible and analyzable, the investigation of communication practices and devices can contribute a great deal to debates on rationality, experimental procedures, observation and representation (Lynch, 1985; Amann, Knorr-Cetina, 1988). Mirroring my own objective in this article, these scientific debates about the concept of visibility were not limited to determining at what depth and distance a photograph could be taken with natural light and when it was necessary to use artificial light. They had opposing stances on the aquatic medium, since some of them considered it an obstacle to proper visualization of the images of submerged objects and organisms, which would be overcome by new technological developments. For others, however, it was an inherent and innate property of underwater photography, the form in which the sea bed and its inhabitants presented themselves to human eyes. If the image obtained was not clear or seemed blurry, that was how underwater vision "really and naturally" developed. Thus, the camera was merely fixing the image of the sea "in reality," so that the question of visibility was enmeshed with the question of objectivity.

Thus we shall see how the differences between the types of apparatus that were constructed and employed, the methods followed and the results obtained all depended largely on the conditions under which the photographs were produced. There was no consensus in the scientific community over the proper way to take photographs underwater. Throughout the period studied here, this practice was referred to in various different ways: "underwater photography;" "undersea photography;" "marine biology photography;" "oceanophotography;" "subaquatic photography;" or "photography of submerged organisms," among others.[2] These differences were not merely terminological, since each of the terms referred to a specific practice. Likewise, the practices themselves were shaped by the material conditions in which they were carried out; in other words, they were related both to the characteristics of the object they sought to represent and to the medium surrounding that object, as well as to the resources available to perform these experiments.

Louis Boutan at the marine station of Banyuls-sur-mer

In the late nineteenth century, marine laboratories or "stations" became very important and more of them grew up along the European coasts as well as in North America and Japan. At the end of the century, these institutions became one of the characteristic sites for biology and zoologyresearch and training, functioning as observatories for aquatic organisms, and their location and even their architecture was part of the scientists' tool kit (García, 2009, p.214). By this time, France was emerging as one of the countries with the most marine research stations and laboratories, with the laboratory at Concarneau being the earliest (Kofoid, 1910, p.89).[3] The second such facility was at Roscoff, also located on the coast of Brittany but on the English Channel, and from then on it became one of the most important zoological research stations created in France. It was founded in 1871 by the biologist Henri de Lacaze-Duthiers (1821-1901) as an adjunct to his zoological laboratory at the Sorbonne University (Caullery, 1950, p.97-99).

This laboratory, however, could only be used for work from March to October, so Lacaze-Duthiers decided to set up a companion one on the Mediterranean for work in the winter months. To that end he chose the seaside town of Banyuls-sur-mer, seven kilometers from the

Spanish border, in the Eastern Pyrenees Department (Département des Pyrénées-Orientales). The marine fauna of this region is particularly rich in corals, sea anemones and mollusks, although wildlife availability was not the major factor in choosing the site of the laboratory. Lacaze-Duthiers had originally planned to establish the station in the town of Port-Vendres,[4] opposite Banyuls, since it possessed a major port and offered the great advantage of protection from the *mistral*, the north wind, which was often very fierce and to which Banyuls is directly exposed. Despite this, the financial support he obtained made him decide in favor of the latter.[5] Construction of the station, which was named the Arago Laboratory, was completed during the winter of 1881-1882. It was in this laboratory that Louis Boutan carried out all his attempts at underwater photography.

Boutan (1859-1934) first arrived in Banyuls in 1886 while he was finishing his doctoral thesis, defended later that year, on the anatomy and development of the mollusk *Fisurella alternata*. In 1888 he became a professor at the University of Lille and four years later, in 1892, he transferred to the Faculty of Sciences in Paris, where he worked as assistant to Professor Henri Lacaze-Duthiers at the Sorbonne (Dossier..., 1929; Thomas, 2005, p.427-428). This post involved working for various months of the year at the research stations in Roscoff and Banyuls, both founded and directed, as we saw earlier, by Lacaze-Duthiers. Boutan had intended to study the development of the mollusk *Haliotis*, also known as "sea ear" or "ear shell," found in abundance in the waters of the Mediterranean. Although in the early stages of development these organisms could easily be studied in the laboratory's aquarium, when they reached adulthood and started to move around freely, they died out *en masse*. So Boutan (1893, p.282-283) decided to go down in a diving suit, encouraged by Lacaze-Duthiers himself.[6]

The descent in a diving suit impressed him so much that, by his own account, it caused him to look for ways to represent and record "exactly" what he saw beneath the sea:

> The strangeness of these undersea landscapes made a very great impression on me, and I thought it regrettable that that I could not translate it except by a description that was more or less accurate, but necessarily incomplete. I would have liked to bring back a more tangible souvenir from these undersea explorations; but it would not have been really possible, however good a diver one was, to do a drawing, even a rough outline, underwater (Boutan, 1893, p.283).

This situation made him consider the possibility of using photography to record what he saw in his underwater forays. He stressed its usefulness for voyages of exploration, on which it was a convenient and reliableaid, allowing "accurate, rigorously faithful reproduction of works of art, monuments, inscriptions etc., encountered along the way. And, this time, the imagination of a draftsman or painter only intervenes to interpret the thing seen" (Boutan, 1900, p.103). He also emphasized the advantages of continuous photomechanical reproduction procedures that allowed infinite reproduction of images, thus constituting a very efficient means of "teaching through seeing" (p.103).

In terms of photography's application specifically to marine research, Boutan imagined it had a promising future, not just as a means of recording but also as an instrument for discovering and testing information already acquired in the field. The main tools used by biologists interested in studying the sea bed had been dredging and sounding lines, which, although they had been perfected and skilfully used by naturalists, were still, according to Boutan (1900, p.133-142), rudimentary instruments working blindly. He pointed out that being able to take photographs under the sea would bring important changes to the situation, solving many of the problems which until that point had only been addressed by more or less justifiable hypotheses (p.322).

Louis Boutan's attempts at undersea photography

The first undersea photography apparatus used by Boutan consisted of a kind of photographic camera known on the commercial market as a "detective camera,"[7] placed inside a hermetically sealed copper box mounted on an iron tripod (see Figure 1). This new dry-plate procedure also profoundly affected the work of amateur photographers, greatly extending the range of subjects that could be photographed. Its speed led to the development of "hand held" cameras that no longer needed to be supported by a tripod, since exposure times were now sufficiently short to allow hand held cameras to take photographs. This led to the rise of the so-called "detective cameras," named for their comparatively discreet appearance and their speed of operation. Some of these cameras were also capable of holding a series of plates that could be exposed in succession, without needing to be manually changed after each exposure (Hannavy, 2008, p.1277-1279).

The metal box containing the photographic apparatus was designed by his brother, the engineer Alfred Boutan, and built at the home of the Alvergniat brothers, who were well-known makers of scientific instruments during the second half of the nineteenth century. The box had holes, aligned with both the camera's viewfinder and its lens, and two cranks, one to work the shutter and the other to activate a system that replaced the exposed plate with a new one without having to open the box (Boutan, 1893, p.284).

The upper part was attached to the main part of the box with screws, and the seam between the lid and the box was sealed with rubber. A three-liter "compensation balloon" had been inserted into the upper part in order to withstand the pressure produced by immersion in water. This balloon had been filled with air, so that the pressure of the water on the sides of the balloon would make air pass into the interior of the hermetically sealed box, thus balancing the pressure exerted on its outer walls.

This design was somewhat reminiscent of the proposal by Paul Regnard (1850-1927),[8] who had published his idea for a submersible photographic apparatus for studying the ocean floor shortly before Boutan, in 1891. This apparatus – which was apparently never built – consisted of a round box made up of a copper tube, closed at either end by circular plates of the same material. The upper copper plate was fixed to a copper ring by screws. Inside the box was a camera obscura, whose lens was perpendicular to the ground. On the upper copper plate there was also a connection to a balloon used to counteract the effect of water pressure. Near the lens, Regnard envisaged placing two small batteries to power two Edison lamps to light the scene. The photograph would be taken automatically with the aid of a clockwork mechanism, so that all the operator had to do was submerge the apparatus, wait a few minutes, lift it out of the water and manually replace the exposed plate with a new one before starting over.

This device would serve to represent the layout of the sea bed, the species on it and any other organism that might happen to pass in front of the lens. In order to produce images like these, certain conditions had to be met: the sea floor had to be illuminated, the photographic camera had to be carefully focused, opening and closing for a known length of time, and the camera had to be able to withstand water pressure (Regnard, 1891, p.71-73) (see Figure 2).

Bouton knew about the instrument Regnard had designed, although he thought it had some disadvantages, such as the fact that it offered a “flat view,” similar to that obtained in aerial photography taken from balloons, only allowing representation of the sea bed (Boutan, 1893, p.284-285). Thus, Regnard’s design differed in various ways from the Boutan brothers’. It was clearly a device that would be heavy and bulky. Because of the type of camera used, it required being lowered and raised in and out of the water every time a photo was taken; it could only capture images of the sea bed but it was not completely clear what would be fixed on the plate, somewhat like Thompson’s attempts in 1856.

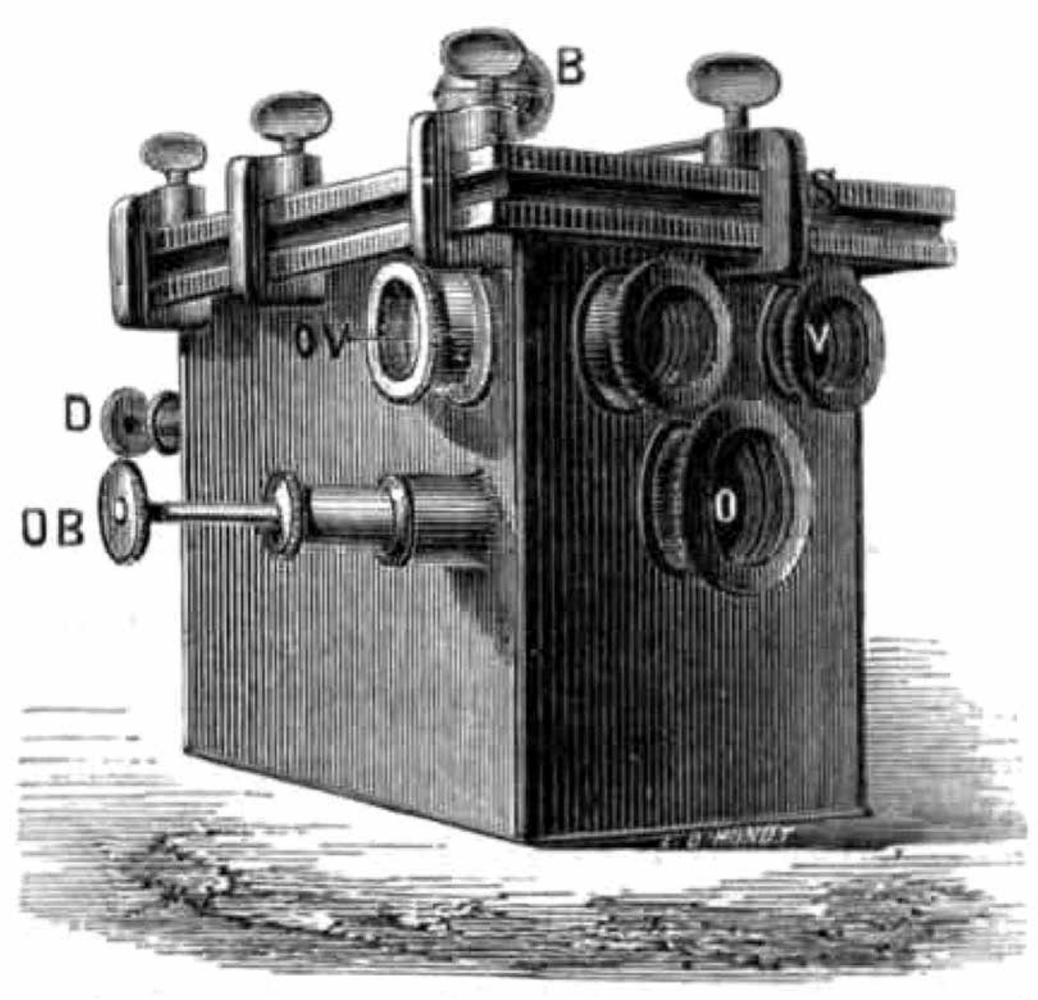

Figure 1: First undersea photography apparatus used at Arago Laboratory in 1893

With this first device, Boutan took what are now considered to be the first underwater photographs in Banyuls bay and the neighboring bay at Troc. These photos were taken at a depth of nine meters, without using artificial light, and thus required an exposure time of around 30 minutes (see Figure 3).

The second apparatus Boutan used represented a completely different concept than the first, since neither the lens nor the camera obscura nor even the photographic plates were protected within a hermetically sealed box but would be directly submerged, with no attempt to insulate them from the water. Boutan assumed, like Thompson, that if these devices worked well out of doors, in air, there was no reason to suppose the opposite would be true if they were submerged in water. The apparatus was built exclusively in the Banyuls laboratories and was finished in late 1896. In this experiment, Boutan realized that the effect of salt water on the plates was very slight when immersion was not prolonged and that, furthermore, this effect could be prevented if the plates were coated ahead of time. A major drawback of this apparatus, for Boutan (1898, p.310-311), was the column of water that entered the camera in between the plate and the lens. Although it was a small amount, its effect was not negligible and it caused a decrease in range for the apparatus.

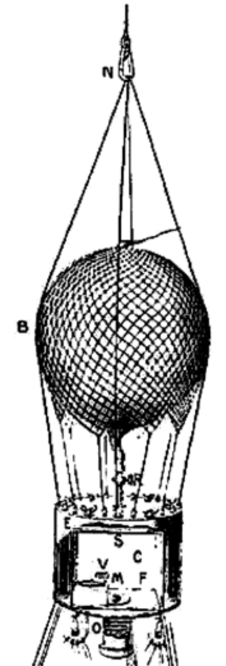

Figure 2: "Proposed device for photographing the sea bed or any other inaccessible cavity" (Regnard, 1891, p.72)

This made him consider the need to use a third apparatus, similar in design to the first. An iron box, hermetically sealed, held the lens and the plate. The photographic apparatus this time was a camera for photographic plates measuring 18 x 24cm, with a frame capable of carrying six plates that could be exchanged by operating a lever from the outside, just like the first apparatus. Compared to the metal box it was so heavy and bulky that it required three men to maneuver it. It also had a kind of visor intended to reduce reflections from higher up in the water, which, according to Boutan (1898, p.321-323), acted like thousands of mirrors pointing in different directions, which could detract from the clarity of the image (see Figure 4).

Instead of using a simple lens with a fixed focus set at a predetermined distance, as he had done the first time, on this occasion he used a symmetrical anastigmatic lens manufactured by the Darlot company.[9] In order to work, this lens needed to be carefully focused, which was not possible on the sea bed. Thus, Boutan designed a special procedure. Using a block and tackle that crossed the dock where the station's boat was moored when it needed repairs, the camera was secured and lowered a few centimeters into the water. Once in position, the camera had to be focused at the desired distance on a white screen

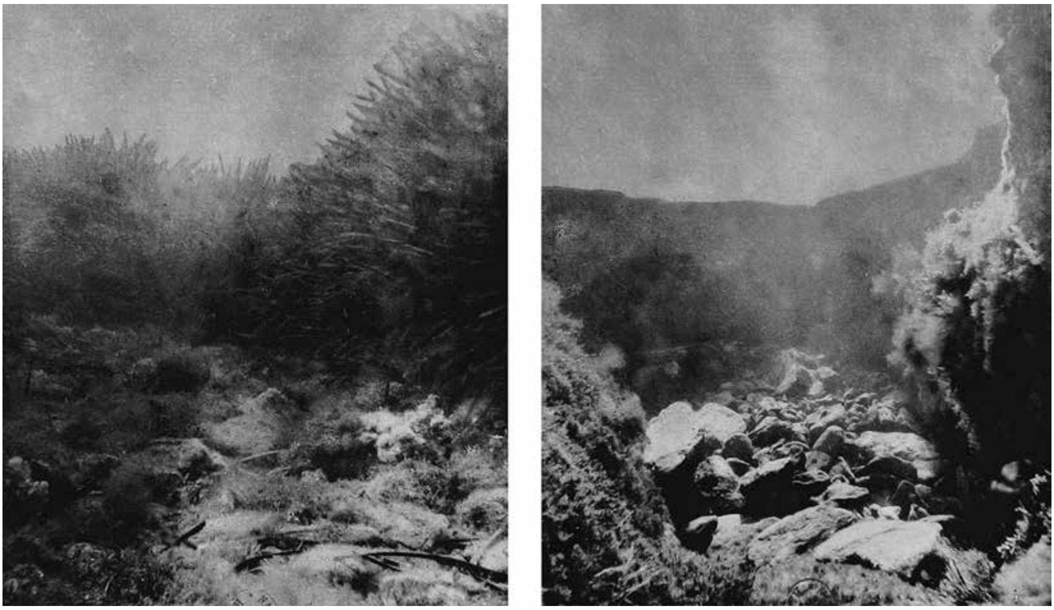

Figure 3: "Undersea landscapes taken in the vicinity of Arago Laboratory" (Boutan, 1893, pl.XVIII)

bearing an inscription, which had been submerged ahead of time in the dock. This operation required the help of about ten people.

In this third case, one of the main differences lay in the fact that the boat itself became part of the photographic device, charging electric batteries and lights that would be used to take the negative, the camera and even a dark room, set up specially in the boat's hold.

Here it is interesting to note that Boutan (1900, p.186) describes the bottom of the sea using landscape conventions intended to refer to and represent scenes on dry land. Thus, the "undersea landscapes" to which he refers at various points in his writings included "underwater meadows" and "lush vegetation," whose appearance was "reminiscent of plants from tropical countries."

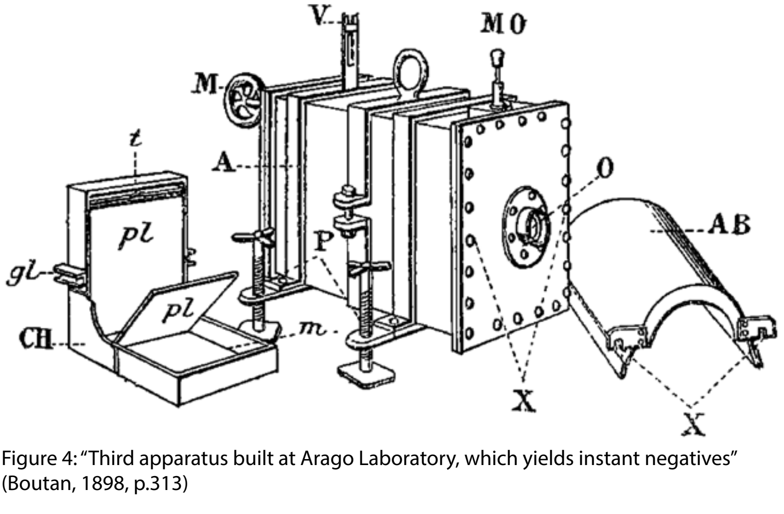

Figure 4: "Third apparatus built at Arago Laboratory, which yields instant negatives" (Boutan, 1898, p.313)

Despite the analogies that can be traced, the differences between the two devices were significant and, as Boutan noted, had a great effect on the photographic results they yielded. His negatives had a serious flaw, despite their picturesque nature: the foregrounds clearly lacked depth. Also, among the better photos, the "landscape" seems to be a relatively short distance away. Also, he himself acknowledged that the photographs obtained via his method "are a weak and partial translation of the landscape that the diver sees before his eyes." Despite all his efforts and the variations in exposure times, he was not able to improve on the final result.

In Boutan's opinion, the reason for this failure lay not in the operation of the camera but in the photographic apparatus itself. With a better apparatus, the operator could

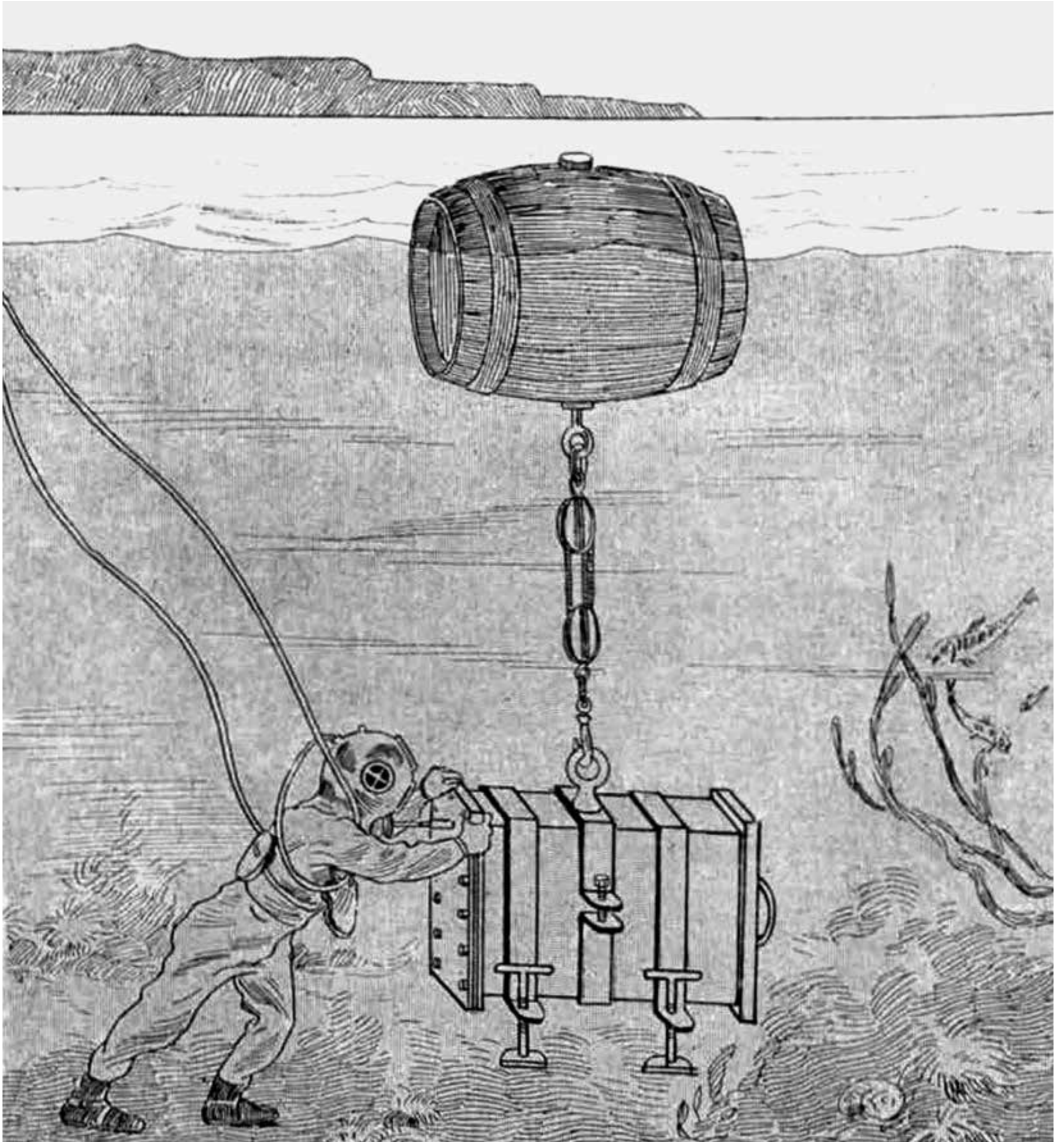

Figure 5: "Maneuvering the apparatus with the aid of the float manipulated by the diver below the water" (Boutan, 1900, p.198)

regulate the focus of the lens with greater precision and thus obtain a greater depth of field, representing "more faithfully the spectacle before his eyes" (Boutan, 1893, p.313). One of the first disadvantages confronting the underwater photographer was marine silt, which lent the "landscape" a uniform gray shade, making it impossible to bring out the contrast between the different fields. Thus the negatives obtained were necessarily dull. The second drawback, which was even more serious, was the clouding of the medium inevitably caused the diver's movements (Boutan, 1893, p.309-311). Even in the calmest conditions, the tide was noticeable constantly making the vegetation sway, which made the image blurry, requiring the camera diaphragm size to be decreased in order to obtain a clearer picture, which in turn reduced the amount of light entering and necessitated increasing the exposure times in order to obtain an impression on the photographic plate (Boutan, 1900, p.189).

Of all the obstacles Boutan encountered, the one which caused him the most concern in all his experiments – and which was also related to visibility – was lighting. The deeper one went, the longer the exposure time needed, thanks to the decrease in light. However, he noted that the water depth was not the only element in play; there was also the state of the atmosphere and the position of the sun, in other words, the light intensity of solar radiation after passing through the air could modify, and even double, the exposure time. He tried lighting the scenes both with natural and artificial light, in the latter case using magnesium as well as electric lamps. He even tried to maximize the use of sunlight via mirrors operated from the boat that could direct the sun's rays, sending them down to the area below the water.

At the time he tested the first photographic camera design, Boutan used an artificial lighting system designed by electrical engineer Chaufour, modified with the help of Joseph David (1869-1922), a mechanic at Arago Laboratory. With this magnesium flashbulb the results did not meet expectations, yielding "weak" and "mediocre" photographs that Boutan (1900, p.232-237) attributed to the fine magnesium dust left floating in the atmosphere of the lamp after the flash activated. In the experiments Boutan carried out in 1895, 1896 and 1897, he sought to take instantant photographs underwater without the aid of artificial light, using only a diaphragm with a larger aperture,[10] which allowed him to increase the amount of light that would leave an impression on the plate. He did photography tests at different depths, trying to determine the maximum limit at which it was possible to take photographs. He sought to determine to what extent the sun's "photogenic" light power decreased as the layer of water between the sun and the object increased in width (Boutan, 1898, p.307).

Later he was able to attempt photographs using electric light. He managed to do this thanks to the help of Deloncle (1856-1922),[11] who offered to provide Boutan with all the necessary apparatus for obtaining the electrical batteries needed, which would be submerged along with the photographic apparatus. In exchange, Deloncle requested that a certain number of the photographs he obtained be projected at the Palace of Optics at the Universal Exhibition in Paris in 1900 (Boutan, 1900; Eigen, 2001a, 2001b). Preparations for the electric light device were completed by August 1899. Chaufour had to run a steam engine for over seventy hours to charge the batteries. Trials of these lights took place in a large pool four meters long by two meters wide. The idea was to set the lamps to converge at the same point for a given photograph, although this goal was not altogether achieved. The total weight of the various pieces of apparatus and tackle used for the experiment was 500-600 kilograms (Boutan, 1900, p.250-253).

The experiment was carried out at night, under the assumption that the same result should be obtained regardless of the depth to which the photographic apparatus was submerged, since the battery for producing light, which would be submerged at the same time as the photographic apparatus, would function under the same conditions and provide the same light intensity (Boutan, 1900, p.256). They took the photo of a group of *Gorgonia* (sea whips or sea fans), at a depth of six meters. Boutan wrote that photographs of objects that were shot with the aid of electric light stood out in more relief and their outlines were clearer. Since the background was not lit up, they were projected onto a kind of black screen.

Trials of deep-sea photography with the aid of electric light were the last carried out by Boutan. After the publication of his book *Photographie sous-marine et les progrès de la photographie* (Undersea Photography and the Progress of Photography), at the time of the Universal Exhibition in Paris in 1900, there is no evidence of any further publications by Boutan on this topic nor on the use of this technique in his subsequent research. After his stay at Banyuls, Boutan moved to Roscoff, working on commercial pearl production. Later we find him at the marine biology station in Algeria, where he continued working mainly in marine studies.

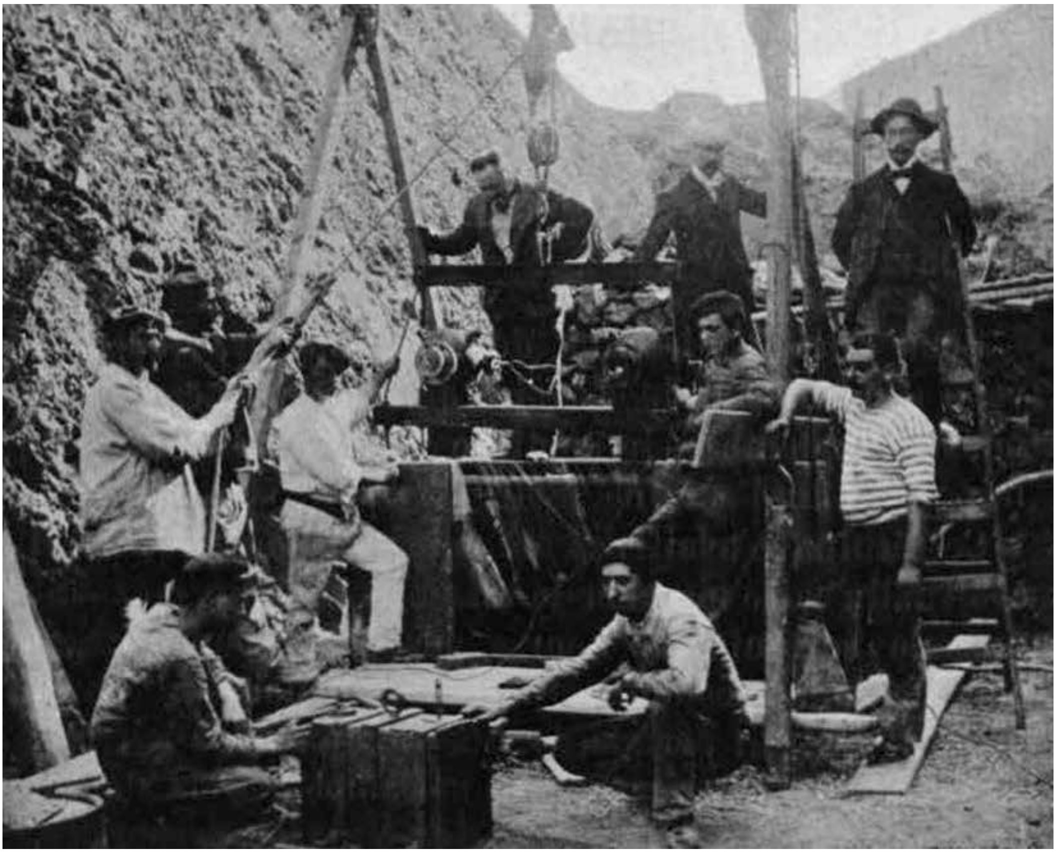

Figure 6: "Testing the lamps in a pool filled with sea water" (Boutan, 1900, p.250)

Underwater photography in America

Various biologists attempted to represent life in the aquatic medium using photography both before, during and after Boutan's trials. However, very few of these attempts could be strictly described as underwater photography, since they involved images of marine animals taken without submerging the camera, either in the field or in public or private aquariums. Within this latter group, we can include the photographs taken by Paul Fabre-Domergue (1861-1940) at the French marine research station at Concarneau (Fabre-Domergue, 1899), J. E. Rombouts in Amsterdam during the 1880s (Cohen, 1889, p.51) and Francis Ward in Scotland (Ward, 1910, 1911, 1920). We could also add work carried out in the field that did not involve immersing the camera in water, such as the images of Australian coral reefs taken by the British naturalist William Saville-Kent (1893, p.41) in the early 1890s, with his "vertical photography method" or those taken by French astronomer Lucien Rudaux (1874-1947) (Rudaux, 1908).

The only two trials that could strictly be described as underwater photography were carried out in the Americas. One of them was undertaken almost entirely by a Brazilian sailor at almost the same time as Boutan's attempts. Around 1898, Brazilian Henrique Adolfo Boiteux (1862-1945), who was a naval captain at the time, designed and built what he decided to call a "photographic diving suit." Besides the metal helmet, he made a waterproof suit and boots with lead soles to aid immersion and walking on the sea bed; to this outfit he added an incandescent lamp and a photographic camera, both of which were held in a box attached to the upper part of the helmet. This camera was fixed to the suit in a hermetically sealed box, with glass openings at the height of the viewfinder and the lens, which was moved with the aid of a screw going through the box. The light beam was pointed at a reflector that directed it through a glass pane and the lamp was powered by a dynamo or generator on board a ship.

Boiteux's experiments in this field were reported in some French publications that specialized in photography (La photographie..., 1898, p.35) and, apparently, he himself described and explained the results of his invention in a text whose whereabouts is now unknown (Fontes, s.d.). Although further discussion of Boiteux's "photographic diving suit" is beyond the scope of the current article, he does represent a potential line of research into the history of underwater photography in South America.

The other, more well-known experiments carried out on the American continent were done in the early 1900sby biologist Jacob Ellsworth Reighard (1861-1942) at the marine research station at Tortugas on the Florida peninsula. Reighard was a professor of zoology at the University of Michigan from 1895-1927 and in charge of the Michigan Fish Commission from 1890-1894, while from 1898-1902 he was director of a biological survey of the Great Lakes for the US Commission of Fish and Fisheries. During this time, Reighard was head of one of the country's most active aquatic ecology research centers.[12]

Due to eyesight problems, he gave up laboratory work in order to do field research on fish behavior (Bocking, 1990, p.495). In 1907 he published an article describing his experiences photographing fish in their natural habitat. In it, he pointed out that up until then photography had been of limited use for representing marine organisms and that even though there were excellent photographs of animals kept in aquariums under more or less artificial conditions, work beyond that had been scarce. He, on the other hand, sought to photograph aquatic organisms not merely in their native element but also in their natural element, under normal conditions, so as to show how they could be photographed bringing the camera out into the field, doing for aquatic animals what had been done for birds and other land creatures. Reighard was aware of Boutan's research and publications on undersea photography, and he preferred to use the term "subaquatic photography," since this included photography in both freshand salt water (Reighard, 1908, p.43-51).

In order to take photographs underwater, Reighard used a camera that could carry up to twelve 13x18cm plates, which he placed in a custom-built galvanized steel box. He did not use a diving suit, since according to him conditions were such that photographs could be taken from the surface. Thus, he was surprised that Boutan did not use a reflecting camera when trying to find a way of focusing his camera underwater. According to Reighard, if he had put a camera of this kind in a sealed metal box in such a way that it could be operated from the outside, he would have had a portable apparatus that could work as fast underwater as on land (Reighard, 1908, p.62).

In these "reflecting" cameras, light comes in via the lens, is reflected onto a mirror – thus the name – and then reaches the viewfinder, as seen in Figure 7. Boutan's cameras had a "direct viewfinder" (see Figure 1) instead of this mechanism. This type of viewfinder was not mounted on the same axis as the camera lens, so that what the photographer could see was not exactly the same image captured by the lens, leading to what is known as "parallax error." Also, the reflecting system allowed Reighard to focus each of his photographs, thus his surprise that Boutan had not used it, since it had been available since the mid-1880s.[13] The reflecting system, besides eliminating parallax error, had a further advantage, as in the case of a camera like the one in Figure 7. It allowed the operator to position himself above the camera itself, meaning that in shallow depths of water, such as the places where Reighard worked, there was no need to submerge oneself entirely in order to take photographs, because instant photographs could be taken with natural light, and the focus could be adjusted at will; all of which was an improvement on what Boutan had done (compare Figures 1 and 7).

Despite this difference in the type of camera used, Reighard encountered fairly similar difficulties to the ones Boutan had described earlier. Firstly, he says that cloudy water imposed a limit on underwater photography in the same way that fog, rain or partial darkness restricted photography outdoors. Therefore, the water needed to be as clear as possible, free of apparent particles in suspension. In order to take instant shots, the water needed to be free of the red tint often present in freshwater lakes and rivers, since that tone acts as a color screen and greatly extends the necessary exposure time (Reighard, 1908, p.66).

Thus he states that it was impossible to photograph objects at a considerable distance underwater. The reason for this distance limitation is probably double; on the one hand the cloudiness of the medium, the fact that even in the clearest waters there were many bodies in suspension that interfered with the range of visibility. On the other, one had to take into account the reflection of light on the surface of the water, which, according to Reighard, would also cause objects to appear flattened, without depth or roundness.

However, the lack of range and the flatness of the images combined with weak contrast, so characteristic of underwater photography, were not in Reighard's view really defects but rather "truthful representations" of the conditions in which these photographs were obtained. Thus, his position on the limitations differed, for example, from Boutan's. What might seem like a defect to a photographer not familiar with underwater landscapes was really an achievement for the artist or naturalist since it would show "things as they are" (Reighard, 1908, p.67).

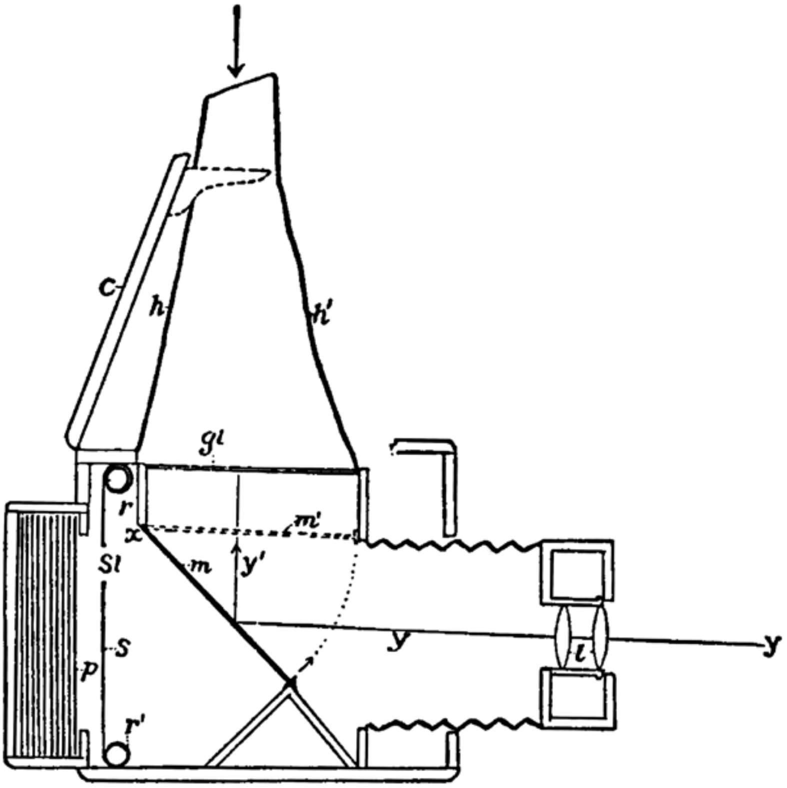

Figure 7: "A reflecting camera shown in section, with magazine plate holder attached, *gl*, ground glass; *h h'*, hood; *l*, lens; *m*, mirror in position during focusing; *m'*, mirror, showing position during exposure; *p*, sensitive plate; *r* and *r'*, rollers of focal plane shutter; *s*, the shutter; *sl*, slot in shutter; *x*, hinge on which mirror turns; *y y y'*, ray of light traversing the lens and reflected from the mirror to the ground glass" (Reighard, 1908, p.60)

Figure 8: "Fig.1 – Photograph of subaquatic life taken with submerged camera; Fig 21 – Using the camera inside a hermetically sealed box" (Reighard, 1909, p.129)

Final considerations

The experiments referred to in this article took place at a time of enormous, rapid change in the photography industry, which allowed people to come up with and test new uses and applications for the medium. The various trials carried out by Boutan should be seen not only within the context of this biologist's quest to find and perfect the most appropriate ways and tools to fix images of the underwater medium on photographic plates. We should also stress the way he managed to make efficient use of the materials and human resources available to him at Arago Laboratory; not just for designing, building, testing and perfecting his different types of equipment for underwater photography but also for publishing the results of his experiments in the journal *Archives de Zoologie Genérale et Experiméntale*. He also took advantage of his social network, appealing to relatives, friends and colleagues for the expertise and funding he needed to achieve his goals. Thus, Boutan was able to take photographs not only by going underwater himself with the camera but also from the surface, in the aquarium, with natural light, artificial magnesium light, electric light etc.

He himself interpreted the often negative or mediocre results of his experiments as technical limitations of the process of taking photographs, which would be overcome in the future thanks to the technological advances that would surely happen in a field that was, as we have seen, constantly developing and evolving. Although Boutan, as we mentioned at the outset, saw photography as a medium capable of "objectively" fixing the visible world, he also understood that it could be perfected, especially in terms of undersea photography. Thus his concept of it is subtly different to the biologist Jacob Reighard's concept of this type of photography. For Reighard, the lack of distance, the "flatness" of objects and the lack of clarity of the images due to the cloudiness of the aquatic medium was not an imperfection. On the contrary, these images "reflected the aquatic medium" as it appeared to the human eye. As he emphasized, in "subaquatic landscapes" the opalescence of the background concealed many mysteries while also lending a characteristic beauty. Thus, a photograph that did not manage to show this lacked character. However, he acknowledged that this feature, which was clearly valuable from an artistic point of view, did represent a limitation for underwater photographs intended for scientific use.

NOTES

[1] Collodion was a photographic process in use from 1855-1880. It involved a sticky substance produced by dissolving flash cotton (ordinary cotton wool, soaked in nitric and sulfuric acid) in a mixture of alcohol and ether. This was then poured onto a glass plate, which was sensitized by dipping it into a silver [nitrate] bath, and the plate was exposed inside the camera while still moist. The image had to be revealed immediately after the photograph was taken. This meant that the process required cumbersome equipment in order to reveal the photographs in situ. It was much faster that the calotype process, since it reduced exposure time to seconds instead of minutes, and it was less expensive to reproduce than the daguerreotype. It also yielded higher-quality negatives than hitherto (Hannavy, 2008, p.55-56).

[2] Throughout the text the terms "underwater photography" or "subaquatic photography" will be used, since they are broader in nature, including photos taken in fresh water as well as in the sea.

[3] This laboratory had been established on the Atlantic coast in Brittany in 1859 by Victor Coste, a professor at the Collège de France, well-known for his work on mammalian and human embryology.

[4] Lacaze-Duthiers' vision of zoology, which was based on general zoology, combined different approaches, mainly comparative morphology and a study on embryogenesis, with an emphasis on experimentation

and fieldwork (Debaz, 2005, p.138-139). Besides the stations at Roscoff and Banyuls-sur-mer, he founded a specialist journal, the *Archives de Zoologie Expérimentale et Générale*, which published the research carried at at the two stations, and in which Boutan published the first reports of his experiences with underwater photography.

[5] The town council offered a site for the laboratory, 12 thousand francs for immediate use and an income of five hundred francs a year for twenty years. Mr. Thomas, a wealthy neighbor, pledged 250 francs a year for 10 years along with a boat; the council of the Département des Pyrénées Occidentales offered twenty thousand francs to build the laboratory, and subscriptions were also received from various citizens in the neighboring region, which was an important wine producer (Dimmock, 1883, p.556).

[6] Indeed, Lacaze-Duthiers was a disciple and colleague of the famous French biologist Alphonse Milne-Edwards, who embarked on various marine research projects using a diving suit in the 1840s.

[7] Although instant photographs were actually produced during the 1860s, it was not until the much more sensitive dry gelatin-bromide plates were introduced at the end of the 1870s that this practice became widespread, allowing people to explore motion photography, beginning with the work of Eadweard Muybridge (1830-1904) in the United States, Étienne Jules Marey (1830-1904) in France and Ottomar Anschütz (1846-1907) in Germany (Hannavy, 2008, p.40-43).

[8] Regnard received a doctorate in medicine in Paris in 1878, specializing in anatomy and physiology. He became a member of the Physiology Institute at the Sorbonne in 1875, and of the French Academy of Medicine in 1895. He was one of the leading disciples of Paul Bert (1833-1886), professor of zoology and comparative physiology at the University of the Sorbonne. Bert did important research on the physiological effects of air pressure as well as on respiration and asphyxia, and was interested in diving.

[9] These lenses gave greater light and clarity as well as better correction of distortion.

[10] An adjustable shutter that regulates the amount of light entering the photographic camera.

[11] A member of parliament in France and the administrator of the Optics Society (Société de l'Optique), Deloncle was one of the main figures behind the building of the giant telescope (60m long and 1.25m in circumference – the largest ever built) that was exhibited at this event.

[12] Reighard, however, did not consider himself an ecologist but [believed] his mission was to create a unified science of biology. Emulating European aquatic research, he set up a research station modelled on the main marine stations, and also sought to keep his research independent of practical concerns (Bocking, 1990, p.462).

[13] Reighard states that this type of camera was already on sale in New York in 1886 and that the seller had a representative in Paris, where it was also advertised (Reighard, 1908, p. 62).

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