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Pioneers of Plankton Research: Salvatore Lo Bianco (1860-1910)

Salvatore Lo Bianco (Fig. 1), is little known today but in his time he was an important and remarkable figure in marine biology and especially in plankton ecology. In the early 20th century, he was as famous as leading figures of marine biology such as Alexander Agassiz (of Harvard University) and Anton Dohrn (the founder of the *Zoologische Station Neapel*, now known as *Stazione Zoologica*, and Lo Bianco's employer). The obituary notices of all three, Agassiz, Dohrn and Lo Bianco, were of near identical lengths, and appeared together, in the *Internationale Revue der Gesamten Hydrobiologie und Hydrographie* (W. 1910). Today, Lo Bianco is unknown to most of us likely because he died at the relatively young age of 50 years old, and thus his accomplishments, while important, were not large in number. He also left behind no students to carry on his work. Furthermore, his publications have been cited using an appalling variety of variants of his name: S. Lo Bianco (how he signed his papers), S. LoBianco, S. Lobianco, S.L. Bianco, Bianco, S., and simply Lo Bianco. However, his singular career, and remarkable, but often over-looked contributions to plankton research, are well-worth re-visiting as an inspirational story. From a modest background, he was apprenticed at age 14 as a laboratory assistant by Dohrn in his new Zoological Station and there spent his entire career. Lo Bianco was entirely self-taught, with no formal education in science. He achieved quite notable success through developing new methods and instruments, and taking advantage of opportunities as they presented themselves to produce unique studies.

Here I attempt to shine a light on the neglected story of Salvatore Lo Bianco. First, a biographical sketch will be provided based largely on the accounts of Raffaele (1910), Eisig (1916), and Groeben (1984, 2002, 2005, 2007) and then the major contributions of Lo Bianco to plankton research will be briefly reviewed. These are his development of methods of specimen preservation (Lo Bianco 1890), his studies of deep-water fauna (Lo Bianco 1901, 1903, 1904), and his investigations into the effects of the catastrophic 1906 eruption of Vesuvius on the plankton of the Bay of Naples and surrounding waters (Lo Bianco 1906a,b, 1907). His studies of the deep-water fauna were among the first such studies, and his studies on the effects of volcanic ash, nearly completely ignored, appear to be the first investigations into the effects of volcanic eruptions on a marine ecosystem.

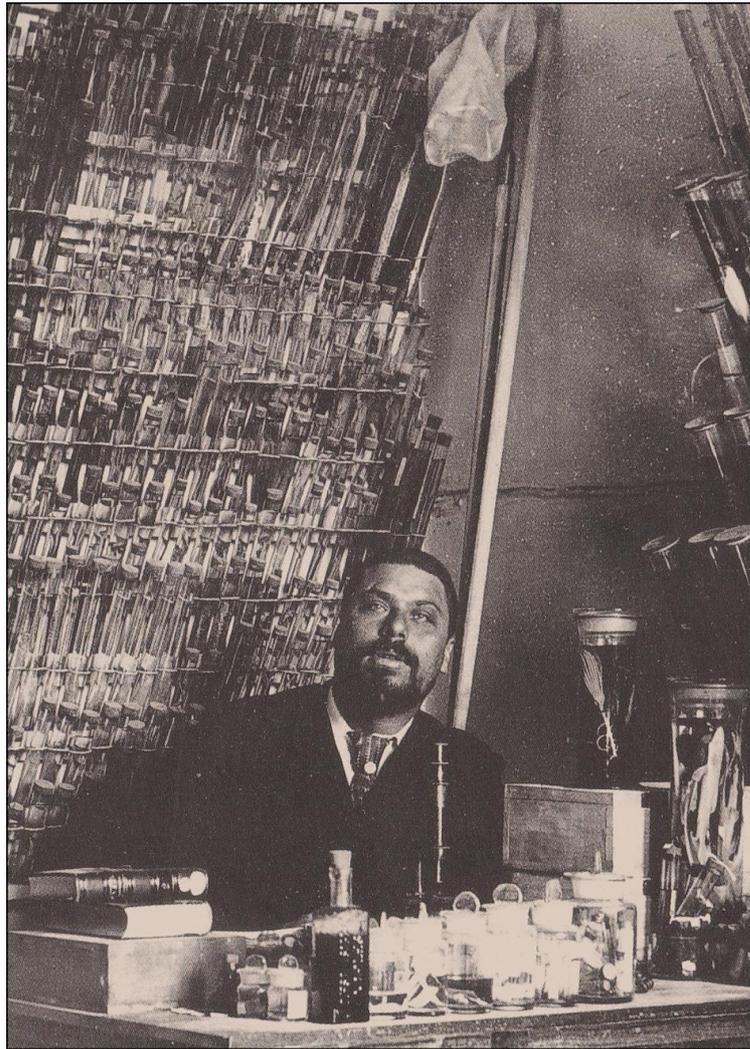


Fig. 1. Salvatore Lo Bianco at his desk in the "Preservation Department" surrounded by preserved specimens, in the Stazione in Naples, Italy, 1889. Image from Wikikimedia. Note the microscope in foreground and the plankton net in the background!

Biographical Sketch

Salvatore Lo Bianco was born on June 10, 1860 to Antonio and Anna Lo Bianco. His father was the doorman of the *Palazzo Torlonia* in Naples where Anton Dohrn, the German naturalist and the founder of the *Zoologischen Station Neapel*, (from here on Stazione), lived from about 1870 to 1874. The young Salvatore Lo Bianco, nicknamed Turillo, was familiar to Dohrn. Dohrn was actually an important figure in Naples. With the financial support of the Berlin Academy of Sciences, the Prussian ministry of Education, and many other institutions and individuals, he founded the Stazione. It was the premier laboratory of marine biology of the time, described in the early 20th century as "the greatest biological station in the world" (Herdman 1901). Although it was not the first marine

station, because of its fame, it was also named "the mother of all marine stations" (Banse 1995). Dohrn had constructed, to his exact specifications, an imposing building housing laboratories and a public aquarium. It was inaugurated in 1873, and shortly thereafter, in 1874, Antonio Lo Bianco asked Dohrn to take on his son, known by his nickname Turillo, as an apprentice in Dohrn's Stazione. Dohrn, having usually seen Turillo with his nose in a book, agreed to take the boy on as an apprentice, and assigned Lo Bianco as an assistant in the Preservation Department. The department was responsible for both the collecting of specimens for scientists at the Stazione, and for display in public aquarium, as well as preparing preserved specimens to be sold to other institutions.

The activity of the Preservation Department, supplying high quality preserved specimens of marine organisms, was a source of prestige for the Stazione, as highlighted by Dohrn in his article announcing his new facility in the journal *Nature* (Dohrn 1873). Sales of specimens to museums and researchers around the world was also a significant source of income, along with entry fees from the aquarium, and fees paid for rental of laboratory facilities (Groeben 2002). Thus, the Preservation Department was of considerable importance.

Lo Bianco, as an apprentice, quickly learned the trade and soon began experimenting with methods of preservation. By 1880, when he was but 20 years old, he had developed fixation protocols to preserve intact, for the first time, delicate specimens of medusa and siphonophores as well designing the containers needed to display the specimens. When the position of Head of the Preservation Department (*Curatore*) became vacant in 1881, Dohrn gave the post to Lo Bianco. A portrait of Lo Bianco at about the time he assumed the direction of the department, and a view of Stazione on the Bay of Naples is shown in Figure 2. By 1883, the department was recognized as having become, under Lo Bianco's direction "one of unusual interest and importance" (Whitman 1883). Lo Bianco himself, largely due to his successes in preservation techniques and prodigious natural history knowledge, was described as "incomparable" (Giard 1889), "genial" (Herdman 1901), "brilliant" (Tschermak 1914), and much later as the remarkable "street urchin turned scientist" (Travaglini 2019). As Hugo Eisig said, when Salvatore Lo Bianco began his career at the Stazione as a 14 year old boy, he was known simply as Turillo, then, as a young man he was known as Don Salvatore, then the respected Signor Salvatore, and finally he was known as Dottore Lo Bianco (Eisig 1916).

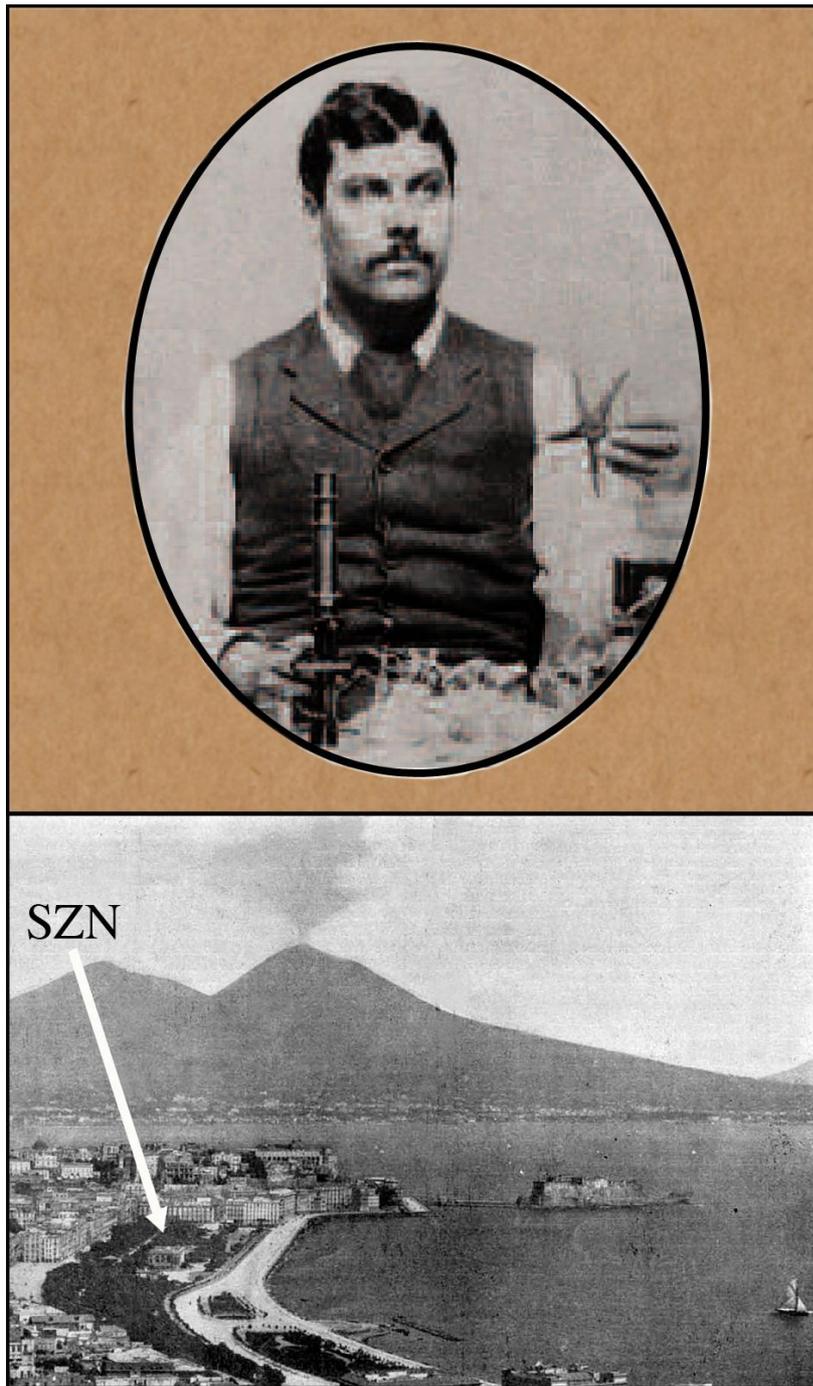


Fig. 2. Top panel shows Salvatore Lo Bianco *ca.* 1880 when assumed the direction of the Department of Preservation at the Stazione then known as *Zoologischen Station zu Neapel*, and now known as the Stazione Zoologica Anton Dohrn Napoli (SZN). The Stazione is shown in the bottom panel, *ca.* 1895, facing the Bay of Naples, with Vesuvius in the background. The top panel image is adapted from Travaglini 2007; the bottom image is adapted from Swingle 1897.

We know relatively little about Lo Bianco's private life. He was granted an Honorary Doctoral degree by the University of Naples and began signing his publications 'Doctore' from 1889 onward. He married around 1890 and had

four children. Lo Bianco headed the Preservation Department until his death in April of 1910 at age 50 of a stroke. The Stazione lost Lo Bianco only a few months after it lost its founder and Lo Bianco's mentor of 36 years. Anton Dohrn passed away in September of 1909 at age 68. It appears that the loss of Lo Bianco may have been another hard blow to endure for the Stazione following the death of Dohrn. Boveri (1912) described Lo Bianco's death with the following words: "*Suddenly, this powerful figure whose presence can not be disassociated from the Zoological Station, the friend and helper of all working there, has vanished; as if struck down by a thunderbolt*".

Lo Bianco's Fixation Methods

The methods of fixation that Lo Bianco had developed, sources of much admiration, were jealously guarded by Dohrn to protect the trade in preserved organisms. The story of their release was nicely told by Groeben (2002). According to her account, Dohrn had for many years, steadfastly refused to let Lo Bianco share his protocols, fearful that if others could replicate Lo Bianco's work, then sales of his preserved specimens would decline. Finally, when Victor Hensen was preparing his famous Plankton Expedition (see Dolan, 2021) he asked the Academy of Sciences in Berlin, an early financial supporter of both the Stazione, and the Plankton Expedition, to pressure Dohrn to share Lo Bianco's methods as Hensen wanted to use them during his Plankton Expedition. Thus, Dohrn was faced with a pressure from one of his early financial supporters. Dohrn wrote to the Prussian Ministry of Education, a core financier of the Stazione, complaining that releasing the methods would result in a reduction in income and produce a financial hardship. Eventually, the Kaiser agreed to raise the subsidy given to the Stazione by his Ministry of Education to compensate for the supposed projected reduction in sales of preserved specimens. In reality, as sales of specimens did not decline with the publication of Lo Bianco's methods, the finances of the Stazione actually improved.

Lo Bianco published his methods in 1890 an article in the journal of the Stazione, *Mitteilungen aus der Zoologischen Station zu Neapel* (Lo Bianco 1890). The article began with an introduction by Dohrn in which Dohrn claimed that the methods had not previously been published only because the methods had not until recently been perfected! In the article, Lo Bianco described the different materials and methods he used to preserve different kinds of organisms. He gave individual protocols for large variety of organisms, most from the plankton, including protists (radiolarians and ciliates), medusa, ctenophores, chaetognaths, cladocera, copepods, pteropods and tunicates, sometimes giving a specific protocol for a given species. His methods paper was widely distributed and translated, for example into French (Lo Bianco 1891, 1891-1892) and English (Lo Bianco 1899). Lo Bianco's methods were credited with changing the nature of museum collections around the world (Kofoid 1910). As late as 1963, a new version including an index of methods by taxon, and methods by major taxa, was published (Russell 1963). Many of his protocols included using reagents that are quite toxic, such as osmic acid and mercuric chloride, and are today strictly regulated. No doubt many of Lo Bianco's protocols would be difficult to put into practice today with current rules concerning exposure to toxic chemicals!

The Preservation Department was responsible not only for specimen preparation, but also for supplying freshly caught organisms for use by the scientists working at Stazione. Visiting scientists were amazed to learn that they simply had to inform the Department what was desired and usually it would be delivered to their laboratory space. Local fisherman knew that if something odd appeared in their catch, it might be purchased by the scientist of the Preservation Department who would want to know exactly where and how it was captured. Consequently, through the years, Lo Bianco acquired a very wide knowledge of the forms found in local waters, where they are found, and when they are found in what condition, or life-cycle stage. Everyone, fishermen and scientists alike, deferred to Lo Bianco's judgment as to the identity of a given specimen (Dean 1893). The regular sampling conducted allowed him to put together developmental series from occasional occurrences. One example is the development of the eggs and larva of the rare deep-sea ribbonfish occasionally found in the plankton samples. The series shown in Fig. 3 are specimens of eggs and larvae from sampling in February of 1906, May 1907, October 1906, and January 1907.

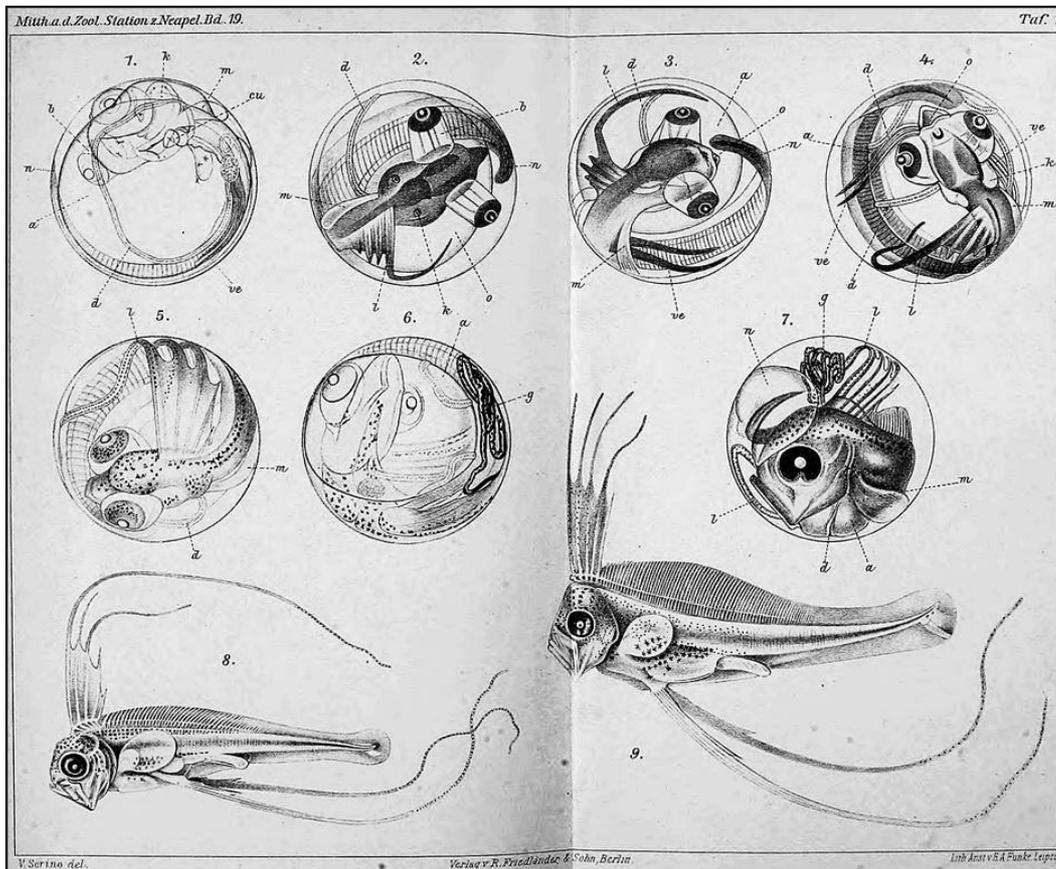


Fig. 3 Development stages of the eggs and larvae of the deep sea Ribbonfish from Lo Bianco 1909a. The different developmental stages were occasional finds in net tows made in 1906 and 1907.

Lo Bianco put the extensive natural history knowledge that he had thus acquired to good use, not only in arranging for the collection of organisms for visiting scientists, but also to produce massive valuable works of synthesis documenting

the seasonality of the reproductive states of organisms, including many of the plankton, in articles published as a series of articles between 1888 and 1911 (the last post-mortem) the first three under the same title: "*Notizie biologiche riguardanti specialmente il periodo di maturità sessuale degli animali del golfo di Napoli*" (Lo Bianco 1888, 1889, 1909b) and a review published shortly after his death with the title "*L'influenza dell' ambiente sul periodo riproduttivo degli animali marini*" (Lo Bianco 1911). These articles, which total 464 pages, have been cited hundreds of times (according to Google Scholar). The last, posthumous publication, incorporated data from two remarkable, and today largely neglected, studies of the fauna of the deep sea considered in some detail below.

The Deep Sea Studies of Salvatore Lo Bianco

By the early 1900's, it was well established that the bottom of the oceans, were not as first thought, void of life, but were inhabited by a surprising variety of benthic organisms. However, in the early 1900's, there was disagreement concerning the existence of deep-sea pelagic organisms. Alexander Agassiz held the view that there was no fauna deep in the water column based on his sampling in the Pacific and the Atlantic, and the opposite view was held by Carl Chun (Mills 1980). Chun had found that certain species of radiolaria and siphonophores were endemic to deep waters, in the Mediterranean based on sampling, done with the close collaboration of the Stazione staff, near the island of Capri (Chun 1887). Agassiz sharply disputed Chun's findings (Agassiz 1888). Thus, when a wealthy German, the arms manufacturer Friedrich Alfred Krupp, who spent much of his time in Capri, and was known to Dohrn, offered to carry out deep-water sampling with his yacht, the offer was accepted as an opportunity to confirm Chun's results.

Lo Bianco was charged by Dohrn with the "scientific direction" of Krupp's sampling, including the choices and installation of equipment as well as analyzing the samples obtained. The first cruises were those using Krupp's yacht the *Maja* (also spelled *Maia* or *Maya*), a steam-powered 25 m boat. It was equipped with a 500 μm mesh net, 3.6 m long with a mouth of 95 cm, and 2000 m of cable. It was used to sample deep waters in the vicinity of Capri in April 1901, and 58 samples were obtained, including 17 samples from depths of 500 - 1500 meters. This first season sampling was considered a preliminary study by Lo Bianco and his analyses, consisting mostly of a list of the taxa found in each sampling, was published in December 1901 (Lo Bianco 1901). A few years later, a new version was published as a book with illustrations of all the organisms found in the *Maia* samples in 41 plates (Lo Bianco 1904). Two of the striking plates from Lo Bianco's book showing some of the deep-sea plankton are shown in Figure 4.

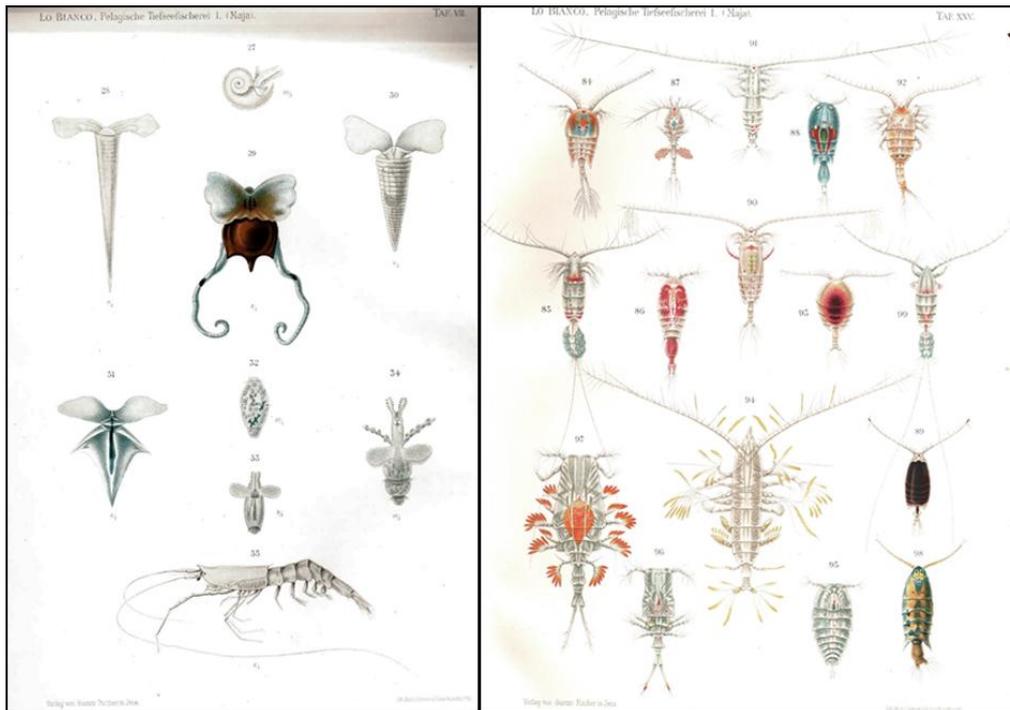


Fig. 4 Plate 7 (Pteropods) and plate 35 (Copepods) illustrating some of the organisms of the plankton from Lo Bianco's 1904 book on the results of 'deep-sea fishing' conducted with *Maia* in 1901 (Lo Bianco 1904).

The second sampling was done with a larger vessel, the 50 m steamer the *Puritan*, which Krupp had brought to Capri from England. The ship was equipped with a custom-made closing plankton net and 3000 m of cable. Net tows were conducted between February and May of 1902 in the region of Capri and also between Corsica and Monaco. Lo Bianco himself took part in many of the sampling trips carried out with the *Puritan*. Plankton samples were collected at various depths between the surface and about 2 Km depth. Further studies of deep-sea fauna were planned by Lo Bianco and Krupp for 1903 but never materialized as Krupp passed away in 1903. Krupp was eulogized by Lo Bianco in the report on the cruises with the *Puritan* (Lo Bianco 1903) and at length by Otto Zacharias, who noted Krupp's interest in deep-sea fauna as well as both marine and freshwater plankton (Zacharias 1903).

Lo Bianco's analysis of the samples led him to propose a scheme of vertical zonation of the water column based on daytime illumination. In his scheme, the water column consists of the well-lit zone extending from the surface to a depth of about 30 meters inhabited by the "Pheoplankton", a shadow zone extending from 30 meters to about 500 m depth, inhabited by the "Knephoplankton", and the completely dark sea below 500 m depth inhabited by the "Skotoplankton". He recognized that some species appeared to be found throughout the water column and for these he proposed the term "Pantheplankton". Lo Bianco largely confirmed Chun's finding of relatively abundant and diverse deep-water faunas.

Lo Bianco's light-based scheme of depth distributions was one of several that had been proposed by the early 20th century based largely on finding distinct assemblages of organisms in different depth strata and these were largely simply descriptive without suggesting a mechanism that governed vertical distributions (Russell 1927). In contrast to the other schemes, Lo Bianco's scheme was based on the abiotic variable of light. It should be noted that the period in which sampling was carried out using the *Puritan*, in February to May, was a period in which the water column was likely well-mixed to great depths with weak to non-existent vertical gradients in abiotic variables other than light, such as temperature, salinity and nutrients. Lo Bianco's light-based scheme immediately drew some attention (Anon. 1903), and did find some advocates (e.g., Damas & Koefoed 1907).

Lo Bianco's study of the effects of the eruption of Vesuvius in April 1906

Vesuvius has a very long history of eruptions (e.g. Carlino 2021), but the 1906 eruption of Vesuvius was the first to be followed in near-real time by the media (Chester et al., 2015). People around the world saw dramatic images of the eruptions such as those shown in Figure 5. Based on the many contemporary accounts (e.g., Hobbs 1906; Lorenzo 1906; Michael 1906), Chester et al. (2015) reconstructed the eruption events that are briefly summarized below.



Fig. 4. Photographs of the Mount Vesuvius ash ejections and ash clouds during the 1906 eruption. The top panel image is from the volcano observatory, located about 3 Km from Vesuvius, on April 16th (image from Anon. 1929). The middle panel image is from a distant elevated point with the Stazione (SZN) visible in the foreground (image from Barasotto et al. 2015). The bottom panel shows the volcanic ash cloud as it appeared near the sea surface (image from Lorenzo 1906).

The first phase of the 1906 eruption began on April 4th with tremors and deposits of dark grey ash falling as far as Naples. On April 7th, a loud explosion was heard with spatter, ash and lapilli ejected up to 2 km in the atmosphere. The second phase was from April 8 to the 11th and included mass ejections resulting in ash accumulations of over a meter depth, causing the collapse of buildings resulting in heavy casualties. The third phase began on April 9th with deposits of brown ash followed by ejections of grey ash. From April 14th ejections were of white ash and diminished gradually until April 22nd. Thus, the volcano ejected different types of ash over a period of about three weeks.

Lo Bianco's study of the effects of ash deposits began with a laboratory experiment. He subjected small fish taken from the aquarium to additions of ash of the various types that had fallen, and without ash, then observed them over a 48 h period. He found that the fish showed no apparent ill effects with exposure to ash! In stark contrast, the resumption of field sampling in the Bay of Naples, beginning on April 10th, showed drastic changes in the plankton compared to before the eruption. A plankton net tow from 20 m yielded nearly no catch. Two weeks earlier, the typical dense populations of diatoms and copepods had been found. The same day, a deep water tow was made four Km offshore at 100 m depth. It recovered a black mass of mucus, ash and dead and dying organisms. By the 14th of April, net tows from 20 m depth in the Bay yielded a variety of forms but still no diatoms. A net tow three km offshore at 50 m depth recovered again mucus masses covered in ash. On the 17th of April tows were made in clear water about eight Km offshore and recovered normal catches. Periodic rainstorms carried ash from the shore into the Bay resulting in obvious turbidity. It was not until the end of May, several weeks after the eruption of Vesuvius, that conditions in the Bay returned to normal and the planctivorous sardines returned as well.

Lo Bianco's work on the effects of the ash deposits on the marine life (Lo Bianco 1906a,b; 1907) appear to be the first observations of the effects of a volcanic eruption on planktonic organisms. As Lo Bianco pointed out, he was uniquely placed to evaluate the effects of the eruption given the accumulated knowledge of the local marine flora and fauna based on near daily sampling over the years (Lo Bianco 1907). His study did not go completely unnoticed at the time, it was, for example, summarized in Steuer's *Planktonkunde* (Steuer 1910). However, the Vesuvius publications have been largely overlooked and cited, for example, only with regard to his report of mass mortality of fish and benthic organisms (i.e., Brongersma-Sanders 1957). Oddly enough, the effects of volcanic ash deposits on plankton have, in recent years, been given a fair amount of attention as possible fertilization events (e.g., Browning et al. 2014; Weinbauer et al. 2017). In contrast, Lo Bianco's account is evidence that volcanic ash deposits can have a powerful ballast effect, effectively clearing the water column of planktonic organisms. This particular phenomenon does not appear to have been considered in any of the modern works considering volcanic ash as possibly fertilizing surface layer phytoplankton assemblages.

Conclusion

Although Lo Bianco is not well known to plankton researchers today, his name is perhaps familiar to some taxonomists of marine invertebrates. Because of his studies and service to researchers working at the Stazione, Lob Bianco had many species named for him. Fittingly, the first two species named for him, and still recognized as valid, were from the plankton of the Bay of Naples: a tintinnid ciliate, *Tintinnopsis lobiancoi* named by Daday (Daday 1887), and a copepod, *Pontella lobiancoi* named by Giesbrecht for Lo Bianco (Canu 1888). Hopefully with this essay Lo Bianco will be remembered by us as among the first to have developed methods of fixation to allow many to actually see the beauty of planktonic organisms. He was also among the first to call attention to deep sea plankton and he was the first to document the devastating effects of volcanic ash on the plankton. Salvatore Lo Bianco well deserves to be remembered by plankton researchers.

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