The Sea Between Image and Imagination-the Investigation of the Underwater World from the Renaissance to the Age of Enlightenment

A. Ceregato
Institute of Marine Sciences, CNR, Bologna, Italy
alessandro.ceregato@bo.ismar.cnr.it

Abstract

The roots of modern Marine sciences as commonly meant stemmed from the work of Luigi Ferdinando Marsili (Bologna, 1658 - 1730), an eclectic military architect who produced the first "scientific" descriptions of the seabed and its inhabitants. Coeval of the natural philosopher Vallisneri and introduced by Newton to the Royal Society of London, Marsili represents an ideal link between the observation of Nature according to the method developed in the sixteenth century by his co-citizen Ulisse Aldrovandi and the modern oceanographic disciplines. Curiously but perhaps not accidentally, the Institute of Marine Geology of CNR, now incorporated into the ISMAR, was founded by Raimondo Selli in Bologna, Marsili's birthplace and Selli himself named after his ancient precursor one of the most impressive submarine volcanoes of the Mediterranean.

1 Introduction

The modern approach to the history of science (and to history in general) tends to investigate rather the context than finding the "first", the "precursor" or the "father" of a discipline or of a theory. Nonetheless, individual people undoubtedly boosted the evolution of science, or they made a discovery before anybody else, with very diverse outcomes according to many variables.

It is commonly accepted that the development of the marine sciences (the term "oceanography" appeared much later, after the 1872-1876 Challenger expeditions), took place after the work of Luigi Ferdinando Marsili (1658-1730) (Figure 1), in particular from two of his published works, *Osservazioni intorno al Bosforo Tracio* [1] written during his earlier career, and the programmatic *Histoire Physique de la Mer* [2] published in the Netherlands just five years before Marsili's death, at the end of a life entirely spent on the field, through all over the Mediterranean from the Bosporus to Gibraltar. The first work cited above contains analytical results of the investigations on some physical features of the sea performed by Marsili during his first diplomatic mission from Venice to the Ottoman Empire and his return trip to Venice, that can be considered as one of the first oceanographic surveys. The *Histoire Physique* represents somehow the completion of this research, presenting new data on the seawater currents, temperature and salinity, but also descriptions of the seabottom and of the marine organisms [3, 4, 5].

Figure 1: Portrait of Luigi Ferdinando Marsili. (Courtesy of G.B Vai. University of Bologna)

As a matter of fact, the most original element of the approach of Luigi Ferdinando Marsili to investigation and to the dissemination of his observations is due to the application of the scientific method codified some decades earlier by Galilei, Descartes and Bacon, but also to the wide use of the image as a scientific tool, introduced by Ulisse Aldrovandi (Figure 2) in Marsili's hometown Bologna, about a century before.

2 Imagine versus imagination

The combined use of image and text as a tool for describing the natural objects (man included) is well known from the antiquity to medieval treatises, but except of some medical herbals and of particular bestiaries like the *De arte venandi cum avibus* by Emperor Frederick II [6], the role of images was primarily ornamental or symbolic, and their accuracy was poor or even fantastic. Until the Renaissance, most of the written knowledge about nature consisted of a transmittance from generation to generation of a mix of Latin texts, translations from Arabic authors and Arabic versions of Greek literature. These handwritten books were enriched by comments (the "glossae") and sometimes by drawings only occasionally taken from a real model even in the case of depicted herbals or medical treatises; more commonly, texts and images were simply copied from volume to volume. This way of transmission of knowledge favoured the creation of stereotypical, simplified images, whose significance carried rather symbolic significances than real features of the natural objects.

Figure 2: Portrait of Ulisse Aldrovandi (copy from the original by Pelagio Pelagi, early 1800) Courtesy of G.B. Vai. (Photo Mattei-Zannoni, BUB, ASUB)

Starting from the XV century, the strong interaction between art and science and a renewed attention to the physical reality led to an increased accuracy of the images.
The new fame of the *Naturalis Historia* of Pliny and novelties imported from the voyages of exploration explosively expanded the list of terrestrial and marine organisms, forcing the natural philosophers to review the old classifications and try to build a new inventory of the world.
The introduction of printing and of more accurate and analytical illustrations, fed an irreversible process of liberation from the old scholasticism, based on a dogmatic interpretation of Aristotle (filtered from medieval tradition) which conditioned most of the knowledge on nature.
Leonardo Da Vinci (1452-1519), in search of proving a geocentric, "protoscientific" Theory of Earth based on the Neo-Platonist relationship between Man's Microcosm and Nature's Macrocosm, demonstrated that fossils are the remains of ancient organisms that the Deluge could not carry to the highest mountains [7].
At the end of the XV century, Leonardo in Italy and Albrecht Dürer (1471-1528) in Germany, started two different approaches to the figurative description of natural objects: while Leonardo, drawing natural objects and anatomic studies, always tended to represent the dynamism, the continuous transformation of the objects and the relationship between the subject and its context in order to stress their evocative power, on the other hand Dürer isolated the objects to concentrate the analysis on the physical nature of the objects themselves; the best techniques to achieve the finest detail were

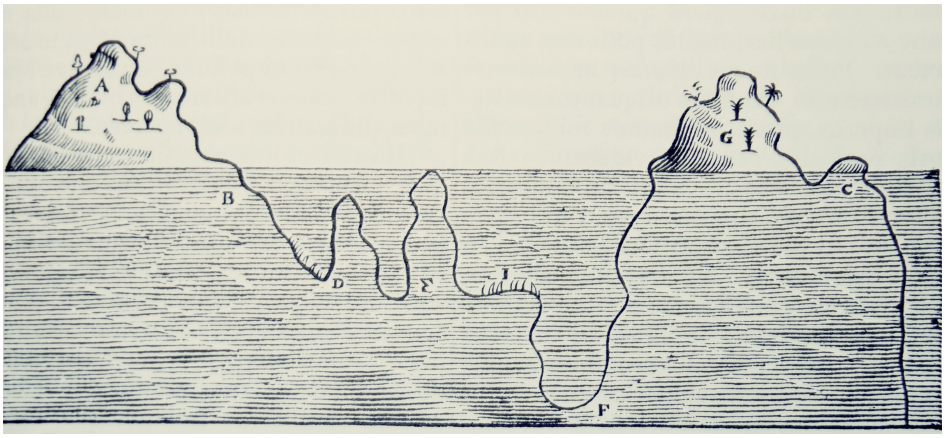

Figure 3: Section of the Earth surface with the hypothetical profile of the seabed. A. Kircher, *Mundus Subterraneus* (III Ed. 1678), Cap. XV, p. 97. G.B. Vai (2004) Ed., Critical reprint by A. Forni Editore. (A. Ceregato, personal archive and photo)

the drawing by ink pen, the engraving and a mix of tempera and watercolors [8].

The new generation of natural philosophers will choose the model proposed by Dürer and his pupils as the best for their descriptions. The Swiss Conrad Gessner (or Gesner;1516-1565) will attempt for first to build an updated inventory of the Three Kingdoms of Nature: Animalia, Plantae and Mineralia. The technique of engraving on wood and later on copper sheets developed by Dürer was immediately adopted for printing the new treatises [9]. The Counter-Reformation limited the freedom of Italian natural philosophers (Galileo Galilei and Giordano Bruno were only the most famous victims), who were denied to venture interpretations dangerously dissonant with the Scriptures, but did not prevent to investigate the "order" of Nature: Ulisse Aldrovandi (Bologna, 1522-1605) set up the first natural history museum at home, a microcosm of Nature tended to show as more comprehensively as possible the diversity of natural objects, animals, plants and minerals and to compose a natural history rich in images as much accurate as possible. For this purpose Aldrovandi created an artistic laboratory within his home museum and invited some of the best illustrators and engravers of his time to take their drawings directly from his specimens; he also acquired and exchanged watercolours and engraved images from his correspondents and collectors as the Archidukes of Tuscany and the Duke of Mantua. He personally maintained for years some artists, and looked at Dürer's legacy when he decided to print his books, so he hired Cornelius Schwindt and Christopher Lederlein (Cristoforo Coriolano) who produced more than 3000 woodcuts at the end of 1598 (i.e. [10]; see also [11] for a complete reference review).

A part of four volumes (*Ornithologiae... I, II, III* and *De Animalibus Insectis*) published from 1599 to 1603, the remaining

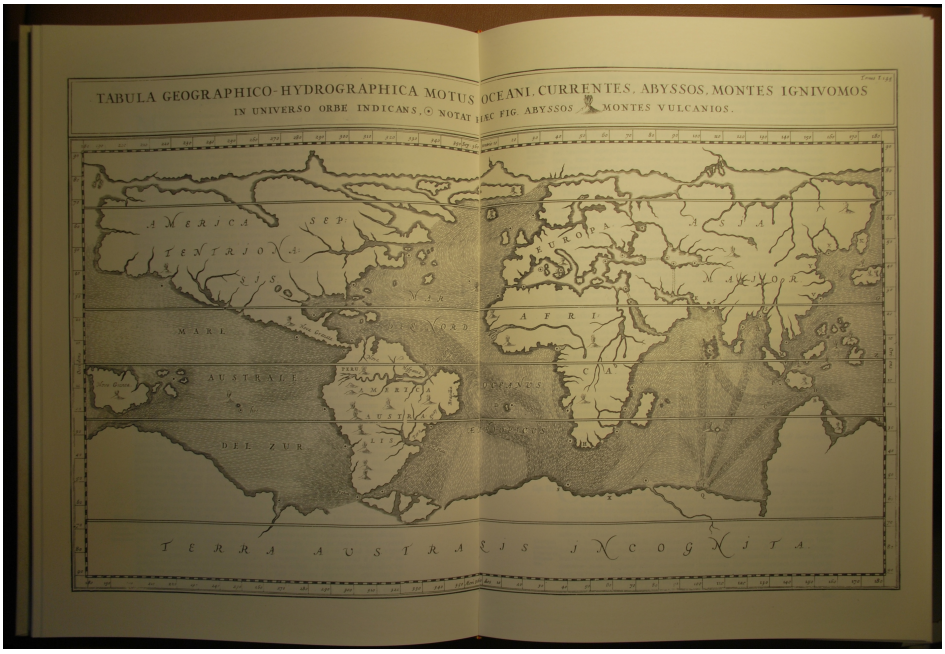

Figure 4: Map of the surface oceanic currents after Athanasius Kircher. Kircher did not perform any direct measurement, differently from what Marsili did some decades later, but it is one earliest attempt of representing the sea currents. From Athanasius Kircher, *Mundus Subterraneus* (III Ed. 1678). Crit. Ed. by G.B. Vai, 2004. A. Forni ed. (A. Ceregato, personal archive and photo)

books of the Ulisse Aldrovandi's *Historia Naturalis* were printed after his death, often remarkably modified by the curators and only one of the planned botanical volumes was published in 1668. According to the common approach of that age, the taxonomy was adapted from those of Aristotle or, as Aldrovandi tended to prefer, from Pliny. Each section included a review of the previous knowledge about a group of natural objects, not only "scientific" descriptions but also symbolic attributes and their eventual pharmaceutical use. The originality of these works was in the personal observations Aldrovandi made directly on the specimens and the accuracy of the images. He also was used to list all the current, popular, foreign names referred to each "species", both within his books and in his collection of more than 2000 colour drawings he used also for his lessons as the first professor of Natural History at the Bologna University.

The XVII century is apparently characterized by a paradox: on one hand, it is the age of the Scientific Revolution introduced by Galileo Galilei, Renè Descartes and Francis Bacon, of the experimental methodology, of the discovery of the new order of the Universe, introduced by Galilei and perfected by Newton at the end of the century; on the other hand the Natu-

ral History collections appeared since the Renaissance, from which the new ideas originated, progressively lost their scientific significance in favour of the aesthetic attributes, becoming *Cabinets of Curiosities* (also known as *Wunderkammern*) [12]. From the work of Aldrovandi and Gessner, forgotten the scientific descriptions, the Baroque readers prefer the anedoctal contents, so the old authors will be cited for their descriptions of monsters and drakes: the Aldrovandi's *Monstrorum Historia*, published in 1642 by Bartolomeo Ambrosini, then one of his most appreciated works and largely cited by Athanasius Kircher in his *Mundus Subterraneus* (1664), will be ridiculized a century later by the Enlightened scientists. Nonetheless, some scientists continued to follow the lesson of Aldrovandi, in particular those who were involved in the debate on the nature of fossils and of the structure of the Earth: Fabio Colonna (1567-1640), Niels Stensen (1638-1686) and Agostino Scilla (1629-1700) largely used the images for clarify their observations. Colonna within the *De Glossopetris dissertatio* (1616), demonstrated the organic nature of *Glossopetrae* with a use of images not dissimilar to that of Aldrovandi, Niels Stensen completed the demonstration made by Colonna with a figure of *Canis Carchariae* with a detail of a tooth (following the original Gessner's intuition) and the *Prodromus* (1669) with some simplified figures to describe the different facies of Earth before and after the Deluge [13, 14]. Agostino Scilla, artist rather than scientist titled his most famous work on the real origin of fossils (1670) drawing a frontispiece with two: *La vana speculazione disingannata dal senso* (trad.: the vain speculation disillusioned by the sense), and he accompanied his discussion with accurate figures. Athanasius Kircher described his theories on the *Mundus Subterraneus* through a number of sections of the Earth very imaginative but easy to understand, sometimes populated by the drakes taken from Aldrovandi's works. A few decades later, his hypothesis that the maximum depth of the sea was equal to the highest mountain (Figure 3) influenced the early observations by Marsili. In another chapter of *Mundus Subterraneus* he put one of the first attempts of represent the oceanic currents that is not conceptually so dissimilar from our present charts (Figure 4). If the use of images by natural philosophers is sometimes oscillating between loyalty to the real and the imaginary (the sea is still populated by mysterious sea monsters), in the same years, the development of the cartographic disciplines led to the creation of more reliable maps even in three dimensions, such as those by the Dutch Willem Blaeu (1571-1638) and his sons and the globes made by the Italian Coronelli (1650-1713). Although until the eighteenth century the problem of longitude remains unresolved, maps and nautical books become even more faithful and detailed, and some attempts to describe the seabottom achieved better results. Luigi Ferdinando Marsili, holder of a large collection of natural specimens on the model of that of Ulisse Aldrovandi, immediately understands the importance of considering a good representation as a fundamental tool both for investigation and for dissemination of his observations [15]

3 Towards a new perspective of the Sea

It is easy to imagine how the first area of investigation of the natural philosophers

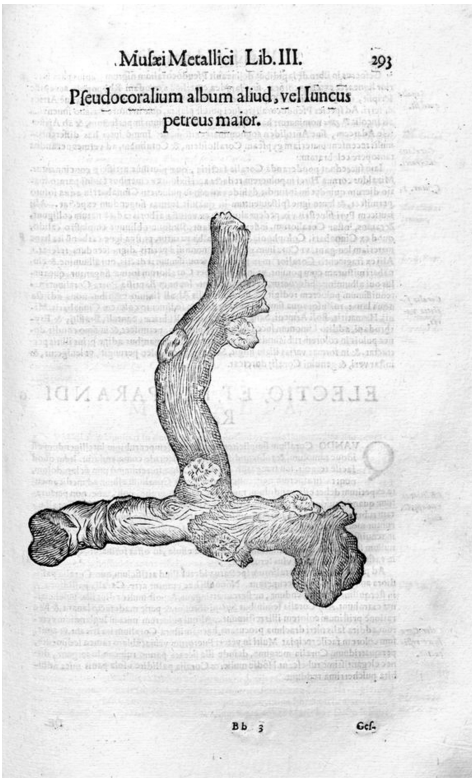

Figure 5: "Pseudocoralium album aliud, seu Iuncus petreus maior" From: Ulisse Aldrovandi (Ed. B. Ambrosini, 1648) *Musaeum Metallicum...* BUB. Fondo Aldrovandi. Courtesy of the Biblioteca Universitaria Bolognese, (Director Dr Biancastella Antonino)

turned to the sea was the ichthyology, or more generally the marine zoology. Introduced by Aristotle and cultivated by scholars from around the Mediterranean, the study of fishes and other marine organisms had a first major boost when the first transoceanic navigators returned back from their explorations with their finds from unknown animals and their rich imaginative and often anecdotal reports on terrible monsters appeared from the oceanic abysses. Nevertheless, the updated classification of marine animals also developed among the stalls of the fishermen, the first attempts of Guillaume Rondelet and scans of his young disciples Paolo Giovio and Ulisse Aldrovandi within the markets of Rome. By these first experiences Aldrovandi will distinguish for the first time between bone and cartilagineous fishes, even if he will not still recognize dolphins and whales as mammals [16]. Meanwhile Georg Bauer (Agricola) and Conrad Gessner began to describe not only the most geological objects but groped their interpretation: they never take the sea, but through their comments on the mainland will begin to ask questions about the nature of

Figure 6: Sketch of the stratigraphic unconformity between a folded substrate (continuing below the sea level) and a soil deposited on its depression.BUB, Fondo Marsili, ms. 90 c.44. Photo A. Ceregato.

the "petrefatti di creature marine" which will culminate in seventeenth-century debate about the nature of fossils, only concluded at the end of the next century. The questions posed by Gessner and Agricola had already been resolved decades ago - but not transmitted - by Leonardo da Vinci, who noted (especially on the famous *Codex Leicester*) even his ideas on the organic nature of fossils and the behavior of water and seabed. Ulisse Aldrovandi devoted a huge space to marine objects, animate and inanimate. It is interesting to extrapolate from his papers the richest correspondence with other collectors along the Adriatic coast. Many of the invertebrates documented in his *De Reliquis Animalibus Exanguibus* (1606) came from the Adriatic coast and from the nets of fishermen from that area. Within his collection of illustrations, we can find rocks colonized by date mussels, squid and dogfish eggs attached to the substrate, a rich repertoire of molluscs typical of sandy bottoms of the Adriatic (i.e. *Chamelea gallina, Pecten jacobeus, Acanthocardia spp., Modiolus sp., Aporrhais pespelecani* and even a branch of the yellow coral *Dendrophyllia cornigera* (Figure 5) [16, 17]. After Aldrovandi the observation and research of a natural order of things, starting point of the founders of modern science such as Descartes, Galileo and Bacon, continues in the seventeenth century through a dichotomy between the collections of "Naturalia et Mirabilia" (the *Wun-*

Figure 7: Sketch of the unconformity between the bodies deposited along the submarine slope and forming sands, gravels and shelly/coral concretions. BUB, Fondo Marsili, Ms. 90 c.45. Photo A. Ceregato.

derkammern) and research based on experiment and observation that, with regard to the geology, will see the first assertion of the cornerstones of the modern discipline with Steno and Colonna at the beginning of a century that will be shut down, just at the time of Marsili, with the major debates on Theory of the Earth and the nature of fossils, and with the development of dissemination until the *Encyclopédie*, twenty years after Marsili's death. As previously seen, The preconditions for the Marsili's insight are ultimately given by the results of natural philosophy, collectionism and the birth of the great academies and scientific societies through which the scientific method, developed between the late sixteenth and seventeenth century, comes to be the only possible epistemological approach to investigate the physical world. During his formative years, Marsili also because his military career, received an irregular instruction and he never achieved a graduation even if he attended many courses at the Bologna and Padua Universities, but he formed his own cultural background by the friendship with the most active scientists of his hometown: Geminiano Montanari and Marcello Malpighi among others. His most formative training was given by direct experiences and observations made since his earliest diplomatic missions in the Ottoman empire and in the Balkans [1, 2, 3, 18, 4, 5]. He knew the works by Steno and Scilla and he had direct contacts with Johann Jakob Scheuchzer and Antonio Vallisneri Sr. who

Figure 8: *Corallium rubrum*. Original specimen figured in *Hist. Phys. de la Mer*, T. XXVIII. Museum of Zoology, Bologna. Courtesy Bruno Sabelli, Photo A. Ceregato.

unvealed to him the first discoveries on the structure of mountains and their stratigraphy, but he also was very influenced by the works of physics like Hooke, Newton and by the John Woodward's theory of the Deluge. He was not really an eclectic intellectual, but more a passionated military technician who investigated as many aspects as possible of the territories and seas he visited for diplomatic or military purposes. In the second part of his life he devoted all his energies to the creation of an Instituto Scientiarum based on the model of the foreign Academies of Science but also following the way indicated by his predecessor Aldrovandi, that is stimulating the interaction between art and science, mixing together the Institute with the Clementine Academy of Arts and reforming the obsolete University of Bologna introducing the experimental method. He did not see his project completely realized, even if it was formally ratified during the period 1709-1712, because of the opposition of the old teachers and of the Bolognese Senate who did not give the necessary funds because of the concurrent poverty of the town. In spite of all that, he left to the Institute a huge collection of natural and archaeological specimens, some fundamental books on marine sciences and geology and a rich library. During his scientific activity, Marsili intro-

Figure 9: *Corallium rubrum*. Detail from *Hist. Phys. de la Mer* (Dutch Ed., 1785), T. XXVIII. BUB, Fondo Marsili. Photo A. Ceregato.

duced the experimental method for measuring many oceanological parameters and drew sections and profiles of the seabottoms from a modern point of view (Figure 6,7). He did not recognized the real nature of the corals but his descriptions of *Corallium rubrum* (Figure 8,9), and deep water madreporarians, such as *Dendrophyllia cornigera* and *Madrepora Oculata* (Figure 10) were cited for a long time after the final taxonomic placement of the Cnidaria. He made many descriptions on the benthic environments and on the anatomy and the behaviour of marine organisms. As Vai [19] noted, he had some remarkable insights on that process we today know as isostasy. Lacking of regular academic training he always needed help to translate his texts in Latin or in French (later the great Dutch naturalist Boerhaave translated the whole *Histoire Physique* for a new edition printed by the Company of Indies), but after three centuries the recent literature returned him the right role in the history of science. Count Marsili, engineer and military, by its own admission only an occasional frequenter of the Humanae Litterae, had better luck at the Académie de France than in his hometown. Two centuries later, tells Renzo Sartori, Raimondo Selli returns a double tribute to Marsili founded in Bologna, the Institute of Marine Geology and dedicate one of the largest underwater volcanoes in the Mediterranean ([3], Vai, pers. comm.).

Figure 10: Complete specimens and details of *Dendrophyllia cornigera* and *Madrepora oculata*. Detail from *Hist. Phys. de la Mer* (Dutch Ed., 1785), T. XXX. BUB, Fondo Marsili. Photo A. Ceregato.

4 Acknowledgements

I am indebted to dr Laura Miani and dr Maria Cristina Bacchi (Biblioteca Universitaria Bolognese) for their kindness and their helpful suggestions concerning the manuscripts by Marsili. Thanks are due also to the Director of the BUB, dr Biancastella Antonino, and to the Director of the Museum of Zoology of the Bologna University, prof Bruno Sabelli, for the permission of taking photographs of the Marsili's collections for this work. Prof Gian Battista Vai, Director of the Museum of Geology G. Capellini (University of Bologna), friendly let me free to dig into his personal archive. This is the ISMAR CNR contribution n. 1674.

References

[1] L.F. Marsili. Osservazioni intorno al Bosforo Tracio overo Canale di Costantinopoli Rappresentate in lettera ala Sacra Reale Maestà di Cristina Regina di Svezia da Luigi Ferdinando Marsili. pages 1–10, 1681.

[2] L.F. Marsili. Histoire Physique de la Mer. Ouvrage enrichi de figures dessinées d'après le Naturel. pages 1–173, 1725.

[3] R. Sartori. Luigi Ferdinando Marsili, founding father of oceanography. *Four Centuries of the Word Geology. Ulisse Aldrovandi 1603 in Bologna.*, pages 169–177, 2003.

[4] A. Lodovisi. Luigi Ferdinando Marsili e l'Olanda. page 239, 2006.

[5] N. Pinardi. Misurare il mare. Luigi Ferdinando Marsili nell'Egeo e nel Bosforo 1679-1680. page 83, 2009.

[6] Federico II di Svevia. L'Universo degli Uccelli - Il trattato di ornitologia del grande imperatore naturalista. (Critical edition of De arte venandi cum avibus, from various manuscripts, sec. XIII). pages 1–231, 1988.

[7] S.J. Gould. I Fossili di Leonardo e il Pony di Sofia. (Orig.: Leonardo's mountains of Clams and the Diet of Worms). pages 1–448, 2004.

[8] L. Tongiorgi Tomasi. L'immagine naturalistica: tecnica e invenzione. In: Natura-Cultura. L'interpretazione del mondo fisico nei testi e nelle immagini. Atti del Convegno Internazionale di Studi, Mantova, 5-8- Ottobre 1996. pages 133–151, 2000.

[9] C.M. Pyle. Art as science: scientific illustration, 1490–1670 in drawing, woodcut and copper plate. *Endeavour*, 24(2):69–75, 2000.

[10] G. Olmi. Il museo o "microcosmo di natura". In: Natura Picta. Ulisse Aldrovandi. pages 19–37, 2007.

[11] M. Folia Campos and C. Magnani. Bibliografia su Ulisse Aldrovandi. In: Natura Picta - Ulisse Aldrovandi. pages 620–660, 2007.

[12] M. Beretta. Storia Materiale della Scienza. Dal Libro ai Laboratori. pages 1–336, 2002.

[13] N. Morello. The question on the nature of fossils in the 16th and 17th centuries. In: Four Centuries of the Word Geology. Ulisse Aldrovandi 1603 in Bologna. pages 127–152, 2003.

[14] N. Morello. Steno, the fossils, the Rocks, and the calendar of the Earth. In: The Origins of Geology in Italy. *GSA Special Paper*, 411:81–94, 2006.

[15] G. Olmi. L'illustrazione naturalistica nelle opere di Luigi Ferdinando Marsigli. In: Natura-Cultura. L'interpretazione del mondo fisico nei testi e nelle immagini. Atti del Convegno Internazionale di Studi, Mantova, 5-8- Ottobre 1996. pages 255–303, 2000.

[16] P. Tongiorgi. Dalle profondità dei mari del XVI secolo. In: Natura Picta - Ulisse Aldrovandi. pages 89–93, 2007.

[17] W.D.I. Rolfe and A. Ceregato. “A fossilized nut?”: a drawing from Aldrovandi in the Paper Museum of Cassiano dal Pozzo. *Archives of natural history*, 36(1):160–163, 2009.

[18] B. Soffientino and M.E.Q. Pilson. The Bosporus Strait - A Special Place in the History of Oceanography. *Oceanography*, 18(2):17–23, 2005.

[19] G.B. Vai. Isostasy in Luigi Ferdinando Marsili’s manuscripts. In: The Origins of Geology in Italy. 411:95–127, 2006.