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## A brief history of the Italian marine biology

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### Abstract

This paper is a short history of Italian marine biology, starting from the mid 16th century. During the Renaissance, a profound curiosity for marine sciences animated the scientific thought and several Italian naturalists started to collect rare and unusual marine items, sometimes acting with little critical sense towards medieval unbelievable legends. The 17th and 18th centuries saw a development of botany and zoology as modern disciplines and Italian scholars started to study the Mediterranean fauna and flora. They became active mainly at the Universities of Trieste, Venice, Palermo, Naples, Rome and Genoa and in other scientific institutions that arose under the different political regimes in which Italy was divided at that time. The Kingdom of Italy, born in 1861 with enormous financial difficulties, was interested in reaching an international scientific limelight: hence, some oceanographic expeditions were organized all around the world with a significant collection of data and specimens. The scientific interest for sea life increased and became at international level at the end of the 19th century, with the foundations of the first shore-based Zoological Stations in Trieste and Naples. At the beginning of the 20th century, intensive studies of inshore benthic communities by dredging and, afterwards by diving, started concurrently with those on structure and dynamics of plankton and fish populations which yielded a significant knowledge of the marine life from the Mediterranean continental platform. After the Second World War, the fundamental studies conducted at the Zoological Station of Naples on genetics, embryology and developmental biology using marine organisms as study models, were spread to different universities, going to constitute an Italian school of experimental embryology of international value. Today, the modern Italian marine biology is increasingly multi-disciplinary, requiring the participation of biochemists, geneticists and mathematicians and it opens up to new frontiers often linked to the global changes.

**Keywords:** *Marine biology, history, Italy, Mediterranean*

### The beginning

Since ancient times, marine life has attracted human interest. Aristotle (384–322 BC) was probably the first to record observations on marine species in his *Historia animalium*, but Romans started to house fish and farm shellfish from the first century BC. In the same time, naturalists produced descriptions and illustrations of marine organisms, often based on paradoxical legends, suitable only to amaze and arouse the people's curiosity. The best example of this was *Naturalis Historia* by the Roman encyclopedist Pliny the Elder (23–79 AD) that offered accounts of the marine life, often without discerning myth from reality (Lindberg et al. 2003), the didactic poem

*Halieutica* on the biology of fishes and on fishery techniques by Oppianus of Corico (II century AD) and *De natura animalium* by Claudius Elianus (165/170–235 AD) who traced Pliny's work.

During the Renaissance, the concept itself of knowledge of Nature changed and a cultural revolution, animated by profound curiosity, invested both the philosophical and the scientific thought. Scholars, animated by an extraordinary fervour of knowledge, started to collect rare and unusual marine items, describing them, sometimes acting with little critical sense towards old and unbelievable legends and superstitions. Extraordinary places were built, the *Cabinets de Merveilles* or *Wunderkammern*, filled with chaotic

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collections of disparate expressions of the natural richness and biodiversity. This was the first moment of the development of the “museum concept” where, ideally, Man attempted to describe the Universe, realizing the whole of its complexity (Lugli 1983). Dozens of dozens of *Cabinets* arose everywhere in Italian Courts, castles and villas as well as in half of Europe. Famous in Italy were those of Medici in Florence, Este in Ferrara, Sforza in Milan and Gonzaga in Mantua. At that time, the *Cabinet of Wonders* by Ferrante Imperato (1550?–1631), apothecary and naturalist in Naples, was well known and appeared in an etching published in 1599 in his *Historia Naturale*. Other “museums” were set up in Verona by Francesco Calzolari (1521?–1600), pupil of Girolamo Fracastoro (1476?–1553), philosopher and doctor of Pope Paulus III, and by Lodovico Moscardo (1611–1681), comprising corals, shells and preserved aquatic creatures.

In this age of changes, Galileo Galilei (1564–1642), the father of modern science, had the courage to support that any hypothesis, even if obvious, should be rationally verified. Thus, the modern science was born, ready to analyse the nature and its manifestations. A new revolutionary vision that permitted to acquire an increasingly in-depth vision of natural phenomena and to test the anticipations of the mind (Lindberg et al. 2003). Perhaps the first great contribution of marine scholars to knowledge must be traced back to scientific and theological debate on the Deluge, the universal flood. At the end of the Middle Ages, the world view was still that of the *Holy Scriptures* and considered Nature as a reflection of the divine plan of the Creation. God created the living beings and Adam gave them a name. The species have always remained the same, unchanged. At best, it was possible to think that some species migrated from another part of the Earth, but not disappeared. The discovery, among other things, of marine fossils on the mountains with shapes that often had nothing to do with the known fauna was clearly in contrast with the Creation. The hypothesis that, in later times to the Creation, some species could appear or disappear questioned the absolute perfection of the divine plan and appeared unacceptable: how a species could disappear, if created by God himself, and especially how a new species could suddenly appear, when the Creation was already occurred? At the beginning of Renaissance, Leonardo da Vinci (1452–1519) suggested that the marine fossils were the remains of organisms lived in a place covered by sea in the past. However, his ideas affected very little to the scientific thinking of his time being written in vernacular, in reality only notes, never organized in a scientific treaty (Ligabue 1977; Gould

2004). So, they did not spread and faded into oblivion for a long time, remaining unknown.

In the same years, Girolamo Fracastoro, argued same hypothesis (Dal Piaz 1922). Also Andrea Cesalpino (1519–1603), a celebrated botanist, conceived that fossil shells had been left on land by the sea, and had concreted into stone during the soil consolidation. Afterwards, Antonio Vallisneri (1661–1730) in *De’ corpi marini, che su’ monti si trovano, della loro origine e dello stato del Mondo avanti ‘l Diluvio, e dopo il Diluvio* (1728) suggested that the presence of the fossil shells found in the mountains was due to the emergence of land formerly covered by the sea, following geophysical uprisings of the Earth’s crust (Contardi 1994). Three centuries before the birth of the modern paleontology, Leonardo, Fracastoro, Cesalpino and Vallisneri, following the Galileo thinking, adopted the scientific method based on the observation of the natural events, the formulation of hypotheses whose tests led to convincing theories. Georges Cuvier (1769–1832), in his *Theorie de la Terre* (1821) explained the disappearance of species with recurrent deluges that led to mass extinctions, followed by new Creations, as Vallisneri suggested by citing the Deluge in his seminal book on marine bodies.

### The pre-encyclopedic spirit

The first movable type printing system introduced by Johannes Gutenberg (1400–1468) allowed to many scholars in Europe to print the reports of their observations, helping to bring up a scientific revolution. Italian scientists, animated by a strong pre-encyclopedic spirit, started to describe the Nature as accurately as possible. Between 1557 and 1558, Ippolito Salviani (1514–1569), protomedicus in Rome, published *Aquatilium animalium Historiae* in which many species were described, also highlighting their habitat and, in some cases, their value as food or drug. In that time, Ulisse Aldrovandi (1522–1605) from Bologna, became a taxonomist ante litteram and can be considered the founder of the modern natural history. In Rome, he collaborated with the French anatomist and naturalist Guillaume Rondelet (1507–1566) who was waiting for the preparation of one of the first modern books of marine zoology, *Libri de piscibus marinis in quibus verae piscium effigies expressae sunt*. Also Aldrovandi began to collect and conserve fish, constituting the first nucleus in a museum that he called “microcosm of nature” and is now widely preserved

at the University of Bologna. Following the example of other European scientists, Aldrovandi conceived the plan of a complete illustration of all plants, animals, and minerals. His book, devoted to the marine organisms, *De piscibus libri V*, published in Bologna in 1613, had a great diffusion throughout Europe and was re-printed several times.

At the end of the 17th century, the Neapolitan Jesuit Nicola Partenio Giannettasio (1648–1715) wrote *Piscatoria et Nautica* (1685) and *Halieutica* (1689), two didactic poems in latin on the marine life and fishing activities (Russo 2016; Schindler 2016).

In Rome, another Jesuit, Filippo Bonanni (1638–1725), published the first scientific work dedicated entirely to molluscs, *Ricreatione dell'occhio e delle mente nell'osservazione delle chioccioline, proposta a' curiosi delle opere della Natura*, whose pictures and descriptions, more or less fanciful, had already appeared in previous treatises.

In the same period Francesco Redi (1626–1698), stating that “there is no life without transmission of life”, demolished the dogma of spontaneous generation and became the founder of experimental biology. Acute descriptor of all living forms, he also devoted himself to the study of many species present in the Tuscan Archipelago waters, subjecting them to accurate anatomical examinations, describing the shape and size of their internal organs.

### The 18th century, the beginning of the marine biology

At the beginning of the 18th century, Count Luigi Ferdinando Marsili (1658–1730) was an eclectic diplomat, great traveler, geographer and oceanographer. During a long stay in Cassis, in Provence (Pérès 1968), he was also interested in marine organisms such as algae, sponges, anthozoans and bryozoans that he described through anatomical tables, sometimes reproducing the dissections of internal organs. In particular, Marsili was fascinated by the red coral: in his *Observations sur l'analyse des plantes marines et principalement du corail rouge* and in *Observations sur les plantes de la mer*, he wrongly recognized the plant nature of the coral (Longhena 1930), entering the debate, then very heated, on the animal or plant properties of many sessile species. In that period, in fact, the “animality” of the red coral was much discussed and for a long time remained unresolved, being believed to be a flower or even a mineral. Firstly, Diacinto Cestoni (1637–1718) and then Vitaliano Donati (1717–1762), observing the polyps meticulously under a microscope, understood the animal nature of the red coral, revealing similarities between this organism with other anthozoans, already

known as marine animals. A discovery unjustly ascribed in 1723 to the Marseilles physician Jean-André Peyssonnel (1694–1759) by Buffon (1707–1788).

In 1742, Pope Benedetto XIV, having decided to set up a chair and a museum of natural history in Rome, entrusted Vitaliano Donati to realize it. The plan was sampling fauna, flora and minerals in the Kingdom of the Two Sicilies. Unable to reach Sicily, Donati led a naturalistic campaign between Dalmatia and Albania, whose results, *Della storia naturale marina dell'Adriatico*, were published in Venice (Donati 1750). This essay had a considerable success in Europe and was translated in France and Holland. In the same time, Giovanni Bianchi (1693–1775), also known as Janus Plancus, considered an authority in the field of the Adriatic Sea, published in Venice (1739) *De Conchis minus notis liber, cui accessit specimen aestus reciproci Maris Superi ad littus portumque Arimini* in which several molluscs, forams and other marine organisms from the Northern Adriatic were described. Janus Plancus also had a strong influence on his contemporary Giuseppe Ginanni (1692–1753), naturalist and botanist in Rimini, who dedicated himself to the study of Adriatic fauna and flora (Zampieri 1762; Casellato 2008). Always in Adriatic, Gian Girolamo Zanichelli (1662–1729) reported the presence of a “seacalf” (monk seal) off Rovinj (Zanichelli 1722).

### The Linnean age

The 18th century saw the sudden development of botany and zoology as modern disciplines and several Italian scholars started to study the Mediterranean fauna and flora. In the middle of the 18th century, Karl von Linnaeus (1707–1778) published *Systema naturae* in several editions, adopting the binominal system, laying and determining the foundation of the modern classification of organisms. Above all, Linnaeus imposed the criterion to associate similar things and keep separate different things, indicating the correct way to describe Nature and to understand the complexity of the entire universe. His system held out the promise of a complete catalogue of the living beings, divided into different species on the basis of rational principles.

One of the first to follow Linnaeus principles was the Austro-Italian Giovanni Antonio Scopoli (1723–1788) who entertained an intense correspondence with Linnaeus himself and described several organisms from the Gulf of Trieste, using for the first time in Italy, a binominal nomenclature. In the same years, the University of Sassari was founded (1765) and the Jesuit Francesco Cetti (1726–1778) accepted the chair of sciences. He published a *Storia*

*Naturale di Sardegna* (1774–78), partially dedicated to fish, with continuous references to Aldrovandi's and Linnaeus's works. In Tuscany, Niccolò Gualtieri (1688–1744) published *Index Testarum Conchyliorum, quae adservantur in Museo Nicolai Gualtieri*. His malacological collection was so important that Linnaeus himself used it to describe some types of shellfish.

The most celebrated Italian scientist of that period has been the Jesuit Lazzaro Spallanzani (1729–1799), considered the father of the experimental physiology. Spallanzani, following Redi's biogenesis theory, fought ardently the idea of spontaneous generation with significant experiments, paving the way for Louis Pasteur (1822–1895), father of the microbiology. Moreover, he faced one of the major biological problems of the time: if the embryo had been present inside the egg from the beginning, according to a creationist view, or if the egg substances were indifferentiated and the embryo was produced *ex novo*, as the epigenesis theory claimed. In this debate, Spallanzani suggested the indispensability, but not the participation of the sperm to the formation of the new individual. In any case, he was a forerunner of embryology. He devoted himself also to the study of marine organisms by carrying out, between 1780 and 1785, numerous observations in Portovenere (La Spezia) where he created a small marine laboratory, considered the first in the world, as well as in Istria, Chioggia (Venice), Marseilles, Cyclades and Bosphorus. At Chioggia, Lazzaro Spallanzani stayed for a period, describing many benthic organisms from the Gulf of Venice, also thanks to the drawings of the local naturalist and Abbot Stefano Chierighin (1745–1820), fervent scholar of marine biology and one of the best illustrators of the time (Gibin 1997, 2001). Moreover, Spallanzani studied how sponges feed, demonstrating, once and for all, their animal nature.

In the same age, Giuseppe Saverio Poli (1746–1825) studied the molluscs and cirripeds of the Gulf of Naples. His work, *Testacea utriusque Siciliae eorumque historia et antome tabulis aeneis illustrata*, a description of the molluscs in the Kingdom of Two Sicilies was finally completed by his pupil, Stefano Delle Chiaje (1794–1860).

The Neapolitan Filippo Cavolini (1756–1810), with his *Memorie per servire alla storia dei polipi marini* (1785), entered in a substantially unexplored biological field. In fact, he observed the nutrition, reproduction and regenerative capacities of cnidarian polyps, also highlighting the possibility of grafting between branches of the same colony and the

existence of an axile polarity in these organisms. With *Memoria sulla generazione dei pesci e dei granchi* and *Appendice sulla generazione dei pesci cartilaginei, ossia anfibi respiranti per mezzo delle branchie al modo dei pesci spinosi* (1787), he faced the reproduction in fish and crustaceans and the processes of external fertilization, thinking that in lower invertebrates, such as polyps, all individuals were “mothers” producing fertile eggs, according to the suggestion of Lazzaro Spallanzani that the role of the sperm was only to stimulate and nourish. Another important contribution of Filippo Cavolini to marine biology was the brief *Zosteræ oceanicæ* Linnei anthēsis (1792) where he described flowers and fruits of the seagrass *Posidonia oceanica*, demonstrating its belonging to the vascular plants and not to algae.

In research related to fish reproduction, Italians tried to solve the mystery of eel reproduction, in reality a very complex and much debated puzzle, that intrigued great scientists such as Francesco Redi, Marcello Malpighi (1628–1694) and Lazzaro Spallanzani. In 1733, Antonio Vallisneri in *Opere Fisico-Mediche*, published posthumously in Venice, represented the ovaries of a mature eel from the Lagoon of Comacchio. Also Carlo Mondini (1729–1803) described eel ovaries in 1777, but Lazzaro Spallanzani criticized his conclusions, not considering that he had really identified the female apparatus. Only a century later, in 1875, Simeon de Syrski (1829–1882), working in Trieste, described the male apparatus (the so called Syrski's organ) of the migrating eel, dispelling many imaginative opinions (Pilleri 1980). A year later, also a young Sigmund Freud (1856–1939), thanks to a scholarship, conducted a research on the male reproductive system of the eel. Then, Giovanni Battista Grassi (1854–1925), the parasitologist who played, with Salvatore Calandruccio (1858–1908), an important role in the clarification of the malaria cycle, discovered the metamorphosis process in the eel, understanding that a small transparent fish (called *Leptocephalus brevirostris*) was actually a larval stage of the eel itself. The mystery was finally solved by Johannes Schmidt (1877–1933) during the *Dana Expedition* (1928–1930), with the discovery of the eel spawning site in the Sargasso Sea, in the West Central Atlantic (about 26°N, 60°W). Also in the second half of the 20th century, eel biology aroused the interest of Italian researchers: among them, Umberto D'Ancona (1896–1964), who studied their sexual determination and Bruno Schreiber (1905–1992) who took care of the problems related to its experimental maturation.

### The 19th century, the scientific exploration of the sea

At the end of the 18th century, a large amount of zoological and botanical specimens began to arrive in Europe, when the European countries organized important geographical and oceanographic expeditions, sending ships around the world for scientific reasons and certainly for deeper political, military and commercial purposes. First of all, the Royal Navy. The scientific Societies and National Museums of Natural History, in the meantime established in London, Paris, Wien and Washington, were charged of these studies, favouring the development of young specialists. These great explorations, which lasted through the 19th century and into the 20th century, led to the knowledge of the great biological richness of the oceans.

Although Ferdinando Marsili, with his *Essay physique sur l'histoire de la mer* (1725), has been considered the founder of the modern oceanography, this multidisciplinary science will develop over time in many Nations, excluding Italy: the Italian researchers had to wait for the birth of the Kingdom of Italy (1861) to organize a first scientific expedition over Gibraltar. At the beginning of the 19th century, in fact, the political fragmentation of Italy permitted only some scientific cruises around the peninsula. On the contrary, the foundation of several Universities allowed a wide-ranging scientific policy, favouring an increase in the knowledge of nature. Various largely autonomous disciplines were merged into a new discipline, biology, as Gottfried Reinhold Treviranus (1779–1837) suggested. Although, marine biology must not be considered a separate science: in fact, nearly all the disciplines of biology are represented in it (Fantini 1989). In Italy, marine biologists largely related to their interest of particular botanical, zoological or physiological aspects became active mainly in the Universities of Trieste, Venice, Palermo, Naples, Rome and Genoa and other scientific institutions that arose under the different regimes in which Italy was divided.

### Under the Austro-Hungarian Empire

#### *At Trieste*

Since the beginning of the 19th century, Trieste has had a long tradition in marine biology, that lasted over time (Stenta 1922; Schreiber 1972). As part of a multi-ethnic Empire, Trieste became an attractive center for naturalists and scholars not only from Austria and Germany, but also from Czechoslovakia, Poland and Russia, even earlier than the birth of the

Zoological Station at Naples in 1872. In Trieste, as well as in Naples, however, we cannot speak of a real Italian school of marine biology but, instead, of a Mitteleuropean one, having been these two cities become places of attraction for all the European biological researchers (Ghirardelli 2006).

At Trieste, Domenico Rossetti De Scander (1774–1842) gathered a large number of lovers of Zoology and Botany in the Società del Gabinetto di Minerva, the most important cultural association in town; meanwhile, the Ferdinand Maximilian Museum of Natural History was founded in 1852. This dedication was opportune since the Archduke Ferdinand Maximilian Habsburg (1832–1867), the unfortunate brother of the Emperor Franz Joseph, was a passionate naturalist and a fervent admirer of Darwin. In the Castle of Miramare, he set up a Zoological Station with an adjoining museum, curated by the German zoologist Karl Vogt (1817–1895) and by the Swiss Eduard Heinrich Graeffe (1833–1916). In 1859, the Austrian Imperial Frigate *SMS Novara*, after completing a two-year research cruise around the world promoted by Ferdinand Maximilian, arrived in Trieste with 26,000 zoological and botanical samples, going to enrich the Natural History Museum of Wien collections. After the tragic death of Maximilian in Mexico, the Miramare samples were transferred to the Museum dedicated to him. The first director of the Museum was the Swiss malacologist Enrico Koch, followed by the Slovene zoologist Enrico Freyer, the Venetian Enrico F. Trois (1838–1918), and, lastly, the Polish Simeon Adamo de Syrski. This last one compiled, in 1870, a calendar of the breeding periods for the marine animals in the Gulf of Trieste and studied the male organ of the eel. De Syrski also placed his attention on the structure and dynamics of the mucilages or algal blooms that even then appeared in the upper Adriatic.

The Estonian Karl Ernst Von Baer (1792–1876), who made the first experiments on ascidian and sea urchin eggs fertilisation (Raineri & Tammiksaar 2013), was among the scientists who visited Trieste. He is considered the father of modern embryology and known for his discover of the eggs within the ovarian follicle in mammals. Other visitors were the German physiologist Johannes Peter Müller (1801–1858) and Adolph Eduard Grube (1812–1880) who classified the annelid collection present in the Natural History Museum. In this period, also the Polish embryologist Alexander O. Kovalevsky (1840–1901) stayed in Trieste. He observed that the formation of the gastrula in the lancelet (*Amphioxus*) followed the same pattern

known for the sea urchin. Moreover, he noted that the lancelet developmental stages, showing a notochord and pharyngeal slits, were similar to those of the ascidians. In other words, Kovalevsky suggested that tunicates have to be considered the closest living invertebrate relatives of vertebrates and should be grouped with the vertebrates as chordates.

Following the early studies of Müller on the lancelet, Kovalevsky highlighted the close phylogeny between it and the vertebrates and after him, the lancelet, for its particular phylogenetic position, became an important model for morphologists and embryologists, being considered a special relict from the ancestral vertebrates: these discoveries raised the hope to understand the steps of vertebrate evolution.

In 1875, the University of Wien inaugurated the Imperial Regia Stazione Didattica e di Osservazione Zoologica di Trieste. Carl Friedrich Claus (1835–1899) from Wien and Franz Eilhard Schulze (1840–1921) from Graz devoted themselves mainly to benthic and pelagic organisms (Specchi 1965). Claus studied the medusae and ctenophores of the Gulf, while Schulze studied sponges and hydroids. In the same period, Adolf Stossich (1824–1900), an Austrian-Italian naturalist worked on the bryozoans from the Kvarner Gulf as well on marine, terrestrial and freshwater molluscs from the Adria region. Between 1868 and 1876, the Austrian corvette *Erzherzog Friedrich* cruised around the world, collecting biological material which enriched also the Imperial Regia Stazione (Stossich 1876). Among the most authoritative scientists who frequented the Station, we have to remember the Russian Ilya Ilyich Mechnikov (1845–1916), pupil of Kovalevsky, father of immunology and Nobel laureate in 1908, who discovered the phagocytosis by the white blood cells in starfish larvae. Always in Trieste, Hans Driesch (1867–1941) carried out fundamental researches on the embryological development of the sea urchin, subsequently conducted at Naples, Jovan Hadži (1884–1972) studied the Hydrozoa, publishing also an important theory on the evolution of the Metazoa, Karl Grobben (1854–1945) and Antoni Wierzejski (1843–1916) the Crustacea.

In the first years of the 20th century, the Stazione was enlarged, had its own resident personnel and was directed by Karl I. Cori from Prague and father of Carl Ferdinand Cori (1896–1984), biochemist and Nobel laureate (1947). In 1915, the Station was closed after Italy's entrance in the war against the Austro-Hungarian Empire, and Valeria Neppi (1877–19??), who had dedicated herself to the study of the Adriatic jellyfish in Trieste, together with G. Stiasny (Neppi & Stiasny 1911), moved to Naples where she continued her studies.

#### *At Rovinj*

The Zoological Garden and Aquarium of Berlin, founded in 1841 by the Frederick William IV (1795–1861), King of Prussia, realised a marine Station in Rovinj (Istria, Croatia) in 1891 with the main purpose of collecting marine organisms for the Aquarium itself. In 1910, the Station concurred to realize an International Institute for Adriatic Studies among the different Adriatic countries, whose aim was to promote common research programs in the Adriatic Sea. Starting from 1911, several scientific cruises, mainly under control of the Kaiser Wilhelm Gesellschaft zur Förderung der Wissenschaften, were organized to study the Adriatic Sea, using small boats as the RVs *Rudolf Virchow*, *Argo*, *Adria*, *Najade*, *Ciclope* and *Montebello* (Relini 2000). Among others, important plankton collections were studied by Valeria Neppi and Adolf Steuer (1879–1943) author of *Planktonkunde* (1910), a textbook used even now by students and scientists for studies of the Adriatic plankton (Zavodnik 1995). After the catastrophe followed the First World War, the Rovinj Station passed under the control of the Italian Regio Comitato Talassografico.

#### *At Chioggia and Venice*

In 1797, Venice lost its political independence, becoming a province of the Austro-Hungarian Empire and remained Austrian until 1866, when it became part of the Kingdom of Italy. At the end of the 18th century, a centre for scholars devoted to marine organisms developed at Chioggia, an important Adriatic fishing port, thanks to Giuseppe Valentino Vianelli (1720–1805), naturalist and poet, known also because he described, for the first time, a fluorescent nereid (Vianelli 1749). Also the literate and naturalist Francesco Grisellini (1717–1787) reported, as results of many observations conducted in the Venice lagoon in his *Observations sur la scolopendre marine luisante et la Baillouwiana*, the fluorescence of some polychaetes, probably belonging to the genus *Chaetopterus*.

Also the Abbot Giuseppe Olivi (1769–1795) took interest in the life of the Gulf of Venice. He described many species, defining the characteristics of the environment in which they lived and also applying a biometric analysis in his best-known work, *Zoologia Adriatica or Catalogo ragionato degli animali del golfo e delle lagune di Venezia* (1796) that was certainly the most important report on the Venice lagoon ecosystem for those times. In the same years, Stefano Andrea Renier (1759–1830), director of the Museum of Natural History of

Padua, attended Chioggia taking care of Adriatic benthos (Renier 1793). He also dedicated himself to the general classification of the animals, proposing a very innovative criterion linked to the increasing complexity of the nervous system.

At Venice, a group of naturalists, gravitating around the *Veneto Institute of Sciences, Letters and Arts* and directed by Gian Domenico Nardo (1802–1877), a pupil of Renier, started to study the lagoon environment. Nardo decisively influenced the Venetian politics in the field of natural sciences for decades, so much so that he was considered the proponent of the union between the 18th century naturalistic group of Chioggia and the 19th century scientific movement in Venice. Herein, Nardo wrote several scientific publications on Venetian and Adriatic algae, invertebrates and fish and reorganized the invertebrate collection at the Imperial Natural Museum in Wien. His most important work, *Descrizione de' crostacei, de' testacei e de' pesci che abitano le lagune e golfo Veneto* (Gibin 2001), was enriched by Chierighin drawings. The volume was the compendium of 40 years of work with a detailed description of 744 species of crustaceans, molluscs, echinoderms and fishes, of which 455 were herein described for the first time. In Venice, marine algologists of that time were Giovanni Zanardini (1804–1878) and Giuseppe Meneghini (1811–1889), while Fortunato Luigi Naccari (1793–1860) and later, Alessandro Pericle Ninni (1837–1892), studied the Adriatic fishes.

### The Papal State

In 1804, under Pope Pius VII (1742–1823), the Department of Zoology of the Pontifical University was founded in Rome: it will be the first nucleus of the Museum of Zoology of the Archiginnasio Romano that will be established in 1850. In 1815, Antonio Bertoloni (1775–1868), pupil of Giovanni Antonio Scopoli, was botanist at the University of Bologna and, among other things, studied the Adriatic algae and, in particular, the specimens collected by Ginanni at Rimini.

Pope Pius IX (1792–1878), elected in 1846, dedicated a certain interest to science. He favored also the work of the Jesuit Angelo Secchi (1818–1878), astronomer and director of the Observatory of the Roman College, who invented the disk that bears his name to measure the transparency of the waters. Father Secchi used it for the first time in 1865 during a scientific cruise organised for measuring the salinity of the Mediterranean deep waters on board of the corvette *Immacolata Concezione*, under the direction of Alessandro Cialdi (1807–1882), chief of the Pope Navy.

In the same years, in Rome, Francesco Castracane degli Antelminelli (1817–1899) is reported as one of the first to introduce microphotography into the study of biology. In fact, his first experiments in applying a camera to a microscope to take pictures of diatoms, his main field of interest, were made as early as 1862. He investigated their structure and physiological functions and, particularly in his last years, their processes of reproduction, also on account of its bearing on some of the problems of biology. He became an internationally renowned expert and was tasked with studying the extensive collection of the diatoms collected during the *Challenger Expedition*, describing 225 species new for the science.

### The Kingdom of the Two Sicilies

In the Kingdom of the Two Sicilies, Giosuè Sangiovanni (1775–1849), a pupil of Giuseppe Saverio Poli in Naples and, after the exile in France, of Jean-Baptiste de Lamarck (1744–1829) and Georges Cuvier (1769–1832), founded in Naples in 1811 the Royal Zoological Museum, during the kingdom of the French Gioacchino Murat (1767–1815) (Scillitani et al. 1997). Sangiovanni was professor of zoology and comparative anatomy at the university and his studies were mainly addressed to insects, but also marine invertebrates (*Descrizione di un sistema particolare di organi scoperto nei molluschi cefalopodi e dei fenomeni che ne sono il seguito*, 1819). Similarly, another pupil of Giuseppe Saverio Poli, Stefano Delle Chiaje, developed studies of comparative anatomy of invertebrates (*Memorie sulla storia e notomia degli animali senza vertebre del regno di Napoli*, 1823). The work that gave him greater fame is *Descrizione e notomia degli animali Invertebrati della Sicilia Citeriore* (Delle Chiaje 1841–1844), which includes a vast synthesis of the zoological researches done for over five decades on the invertebrates. In the same years, Oronzo Gabriele Costa (1787–1867) studied various problems of zoology and palaeontology and his *Fauna del Regno di Napoli* (1829–50) was continued by his son Achille (1823–1898) who also published *La pesca nel Golfo di Napoli* (1871), a very interesting inventory of more than one hundred fishing gears selective for a number of species of fishes, molluscs and crustaceans. In 1834, O.G. Costa emphasized that the lancelet (*Amphioxus*) should be placed with the early vertebrates, after that the Russian Peter Simon Pallas (1741–1811) described it as a slug in 1778.

At the University of Palermo, the Dalmatian Pietro Doderlein (1809–1895) devoted himself to study the Sicilian marine fauna (1879), gathered



an almost complete collection of Sicilian fish at the University Museum of Palermo. Moreover, forerunner for those years, he faced some economic aspects of the local fisheries such as the possibility of a pisciculture in Sicily.

### The Kingdom of Sardinia

The town of Nice became part of the Kingdom of Sardinia after the fall of Napoleon and remained under the House of Savoia until 1860. Herein, Giuseppe Antonio Risso (1777–1845) was well known for his *Ichthyologie de Nice* (1810) and for his *Histoire Naturelle de Crustacés des Environs de Nice* (1816) in which reported species living to 640 m in the Gulf of Genoa. These records were among the early to indicate life at such depths, before Edward Forbes (1815–1854) formulated his azoic zone hypothesis, stating that the deep sea below 300 fathoms was entirely devoid of life. Officially, this hypothesis was disproved in the early 1860s, but Risso took concrete evidence 40 years earlier. Still in Nice, Jean-Baptiste Vérany (1800–1865), the founder of the Natural History Museum of Nice (1846) with Jean-Baptiste Barla (1817–1896), was a specialist in cephalopods and in 1836–38 he participated as a naturalist in the expedition of the sailing frigate *Euridice* of the Sardinian Navy sent in South America more for political than scientific purposes. He described the Ligurian marine invertebrates in the compendium *Descrizione di Genova e del Genovesato* published by the Municipality of Genoa (1846), under the direction of the geologist Lorenzo Pareto (1800–1865), foreign minister of the Kingdom of Sardinia in 1848 (Tortonese 1971).

At Genoa in 1803, Domenico Viviani (1772–1840) began professor of botany at the University (Poggi 1981, 2003) and was the first to study the Ligurian macroalgae. In 1806 he also published a *Catalogue des poissons de la rivière de Gènes et du Golfe de la Spezzia*. However, following the decisions taken at the Wien Congress (1815), the Republic of Genoa became part of the Kingdom of Sardinia. His University was closed because of the revolutionary movements of 1821–23 and 1830–35 and fell into a very serious crisis (Pellerano 2013). However, Carlo Alberto Savoia (1798–1849), became King of Sardinia in 1831, promoted the progress of marine sciences in his State and in particular at the University of Genoa. Viviani's successor, Giuseppe De Notaris (1805–1877), mycologist and cryptogamist, continued the study of macroalgae of the Ligurian Sea, describing 125 species, many of which were new to science. Besides, he collaborated

to *Descrizione di Genova e del Genovesato*. His work was continued by his pupil, Francesco Ardissonne (1837–1910), who studied, above all, the marine flora of Acireale in Sicily. In 1889, Giovanni Battista de Toni (1864–1924) worked on *Sylloge algarum omnium hucusque cognitatarum*, an index of all known algae.

### From the unification of Italy (1861) to the first World War (1914–1918)

The Kingdom of Italy, born in 1861, had such socio-economic problems to suggest that investments in marine research were unthinkable. However, it was in the interest of the newborn Nation to appear in the international scientific limelight, demonstrating a good organizational capacity. In the 19th century, the scientific expeditions appeared to be an ideal instrument for combining successfully military and business interests with purely scientific scopes. So, the Italian Government organized a first circumnavigation of the globe in 1865–68 with the pirocorvette *Magenta*, under the scientific responsibility of the zoologist Filippo De Filippi (1814–1867). Unfortunately, he died during the cruise in Hong Kong and all the zoological and botanical specimens, destined to the Museum of Natural History of Turin, were reorganized by his pupil Enrico Hillyer Giglioli (1845–1909) (Vinciguerra 1910; Parona 1911).

In 1867, the Natural History Museum of Genoa was founded (Poggi 2017) thanks to the efforts of Giacomo Doria (1840–1913) and between 1877 and 1879, Captain Enrico Alberto D'Albertis (1846–1932) aboard the cutter *Violante* carried out dredgings to collect marine organisms. In the following years, D'Albertis conducted thalassographic campaigns with the cutters *Violante* and *Corsaro*, collecting scientific material that enriched the collections of the Museum (Issel 1913). At that time, with the construction of the first steam ships, it became possible to dredge even deeper, exploring an environment that, until few years earlier, was completely unknown: the deep sea. Between 1868 and 1880, several scientific cruises were conducted mainly in the Atlantic and the well-advertised and enormous success of the *Challenger Expedition* (1872–74) encouraged similar ventures in Mediterranean, a basin practically ignored because was believed that it did not host any abyssal fauna. Giglioli was of the opposite opinion and led a cruise in 1881–83 from the Tyrrhenian Sea to Bosphorus using the steamer *Washington*, collecting at great depths, up to 3,630 m, species typical of the abyssal fauna. The discovery of this fauna aroused a great impression at the congress of the International Geographical Union held in Venice (1881).

Between 1871 and 1885, the steam corvette *Vettor Pisani* made four cruises around the world (Della Croce 1993), mainly for economical and political purposes. In the last cruise (1882–85), the ship was equipped with a small zoological cabinet, whose head was the lieutenant of vessel Gaetano Chierchia (1850–1922). Before departure, he spent several months training at the Naples Station to study the basic principles of classification and the most important methods of sampling and preservation. His collection was made available to the Zoological Station (Groeben 1988). One of the most important contributions to biological oceanography by the *Vettor Pisani* cruise was the realisation of a plankton net by the captain Giuseppe Palumbo (1840–1913) which was opened and closed in depth by messengers, thus allowing the catch of deep plankton for the first time.

In the same period, the ichthyologist Decio Vinciguerra (1856–1934) from the Natural History Museum of Genoa participated to the *Spedizione Antartica Italiana* (Italian Antarctic Expedition), funded by Argentina, planned and coordinated by Giacomo Bove (1852–1887). The initial purpose was to reach Antarctica, but because of a number of logistical problems, especially the sinking of the schooner *San José*, the plan was scaled down and the expedition was limited to Tierra del Fuego and Patagonia, where Vinciguerra made valuable collections and observations on the fauna and its distribution in this region (Poggi 2017).

In Sicily, Andrea Aradas (1810–1882) publishing *Conchigliologia marina di Sicilia* (Aradas & Benoit 1872–1876), became one of the most important malacologists of the 19th century. Another very important Sicilian malacologist with a large and significant scientific production was Tommaso di Maria Allery marquis of Monterosato (1841–1927), who also brought together the most important malacological collection of Two Sicilies Kingdom as those of Giuseppe Antonio Brugnone (1819–1884) and Nicola Tiberi (1820–1885), who was the first to study marine remains from Pompei excavations, publishing *Le conchiglie pompeiane* (1879). Another important malacologist in that period was the Piedmontese Cesare Maria Tapparone-Canefri (1838–1891) who studied the molluscan fauna from Red Sea and Mauritius.

Despite the economic difficulties facing Italy, natural sciences had a period of great development in the second half of the 19th century: in 1888 the Italian Botanical Society was founded in Florence and in 1900 the Italian Zoological Union in Pavia. Moreover, in 1872, the Hydrographic Office of the

Royal Italian Navy had been founded in Genoa. Its first director, Giovanni Battista Magnaghi (1839–1902), conducted several hydrographic campaigns in the Mediterranean between 1878 and 1888 on board the steamer *Washington*.

In 1909, on the initiative of the Italian Prime Minister Luigi Luzzati (1841–1927), the Minister of the Navy, Admiral Pasquale Leonardi Cattolica (1854–1924), the scientists Vito Volterra (1860–1940) and Giovanni Battista Grassi (1854–1925), the Italian Royal Talassographic Commission (Regio Comitato Talassografico Italiano) was instituted to improve the knowledge of the national seas, mainly in relation to fishing activities and shipping industry (D'Ancona 1956). The same Admiral Pasquale Leonardi Cattolica in 1920 founded in Naples the Regio Istituto Superiore Navale, today Parthenope University, an university devoted to the sea studies (Amirante 2003).

In the same period, a Fisheries Consult Commission was instituted to address the major problems related to the exploitation of the marine resources. In fact, although already Spallanzani in 1783 had denounced the destructive effects for marine habitats of some fishing gears, only at the beginning of the 20th century, a political interest for the biological resources and their management arose. The problems of the national fisheries and the socio-economic conditions of the fishermen began to be addressed at ministerial level. Arturo Issel (1842–1922), geologist and malacologist at the University of Genoa, Decio Vinciguerra from the Museum of Natural History of Genoa and Director of the Aquarium in Rome, Salvatore Lo Bianco (1860–1910) from the Zoological Station of Naples, Sebastiano Richiardi (1834–1904) from the University of Pisa and David Levi-Morenos (1863–1933) from the Venice Lega Navale and expert in fish farming, were called to join to this Commission.

At the University of Genoa, Corrado Parona (1848–1922) eminent parasitologist and among the main supporters of the theory of evolution, studied, among other things, the cetaceans of the Ligurian Sea and was commissioned by the Ministry of Agriculture to evaluate the Italian fisheries and in particular the fishing of red tuna and red coral in Sardinia. With Parona, the fishery studies were born in Italy. Already in 1898, in fact, he denounced the destructive effects of some fishing gears, going in this against the thought that Thomas H. Huxley (1825–1895) had expressed during his opening speech at the Fisheries Exhibition of London in 1882. For Huxley, many

fishery resources were inexhaustible due to the enormous reproductive potential of the species and the absolutely insignificant catches. History proved that he was wrong.

In those years, Ligurian sea-farmers, after having tried in vain to develop an oyster farming, built the first mussel farm in 1887–1888 in the Gulf of La Spezia (Ligurian Sea), according to the reports by Arturo Issel (1842–1922) and Davide Carazzi (1858–1923), who indicated this Gulf as particularly suitable (Carazzi 1893).

Still in Genoa, Giovanni Canestrini (1835–1900), future translator of the Darwin's works, conducted ichthyological researches that were continued by Decio Vinciguerra (Gestro 1935) while Salvatore Trinchese (1836–1897), firstly in Genoa, then in Bologna and finally in Naples, studied not only the systematics of the opisthobranchs, a group of gastropods, but began to shift his interest in the physiology of the nervous system (Cimino 1989), as was already happening for many zoologists in Germany and France.

In the same years in Naples, Giuseppe Mazzarelli (1870–1946) provided a detailed assessment of the red coral banks in the Gulf of Naples, evaluating the disastrous effects of fishing with the Italian bar on the benthic communities (Mazzarelli & Mazzarelli 1918; Cattaneo-Vietti et al. 2016).

### **The Zoological Station of Naples, a separate case**

In 1859 Charles R. Darwin (1809–1882) caused one of the major cultural revolutions of all times publishing *On the Origin of Species by means of Natural Selection, or Preservation of Favoured Races in the Struggle for Life*. His ideas spread rapidly also in Italy and Michele Lessona (1823–1894) became the most passionate popularizer of the theory of evolution. However it was a Prussian, Anton Dohrn (1840–1909), a keen supporter of Darwinian theory to give a decisive push to the evolution ideas in Italy and in all international scientific world. In 1868, he obtained his habilitation in Jena and dedicated himself exclusively to the study of phylogenetic problems, inspired by his friend and tutor Ernst Haeckel (1834–1919). Thinking that the first steps of biological evolution should be sought in the marine life, Dohrn and his friend and fellow student at Jena, the cossak and assistant of Haeckel, Nicholai Miklukho-Maclay (1846–1888), in 1868 conceived of the idea of a global network of zoological stations (Groeben 1982), in which scientists could visit various stations around the world, collect material, and conduct research in fully equipped laboratories.

After the first experiences of Janette Villepreux-Power (1794–1872) in the city of Messina, who build up traps (named “cages à la Power”) to maintain and observing living of marine organisms (very famous became their observations on the secretion and function of the argonaut shell), Dohrn decided to place in the Strait of Messina the first of these stations, consisting of two rented rooms, but the absence of a library and of trained personnel made this option discarded.

At the University of Naples, Paolo Panceri (1833–1877), the director of the Museum of Comparative Anatomy, was interested in various aspects of marine biology, from the fertilization in the lancelet to bioluminescence. He organised the International Maritime Exposition of 1871 and this gave Dohrn the opportunity to meet him in 1870 and to explain his project to build in Naples a marine station. After the success of the Exposition and thanks to the endorsement of Panceri, in 1872 the Municipality of Naples came to meet Dohrn, offering a free space in the Villa Comunale where Dohrn was able to realize his private institution. So, the Zoological Station of Naples was born thanks to the crucial support of the scientists of the university.

The decisive idea of Dohrn was to connect the laboratories with a public Aquarium and to sell preserved animals to public and private institutions so that fees would cover some of the running costs and also pay a permanent assistant. In addition, equipped work spaces were annually leased to universities, scientific institutions and governments, including the Italian State, which in turn made them available to their researchers (Groeben 2002). Although it was not the first, in fact the Laboratoire Maritime of Concarneau had been founded in 1859 and those established in Sevastopol in 1871 and Roscoff a year later, the institution created by Dohrn achieved in few years an international reputation due to the “network of stations” concept.

1872 was a crucial year for marine studies: in the same year, in fact, the *HMS Challenger* sailed from Portsmouth to study, all around the world, the physics and chemistry of sea water, the nature of the bottom deposits and the distribution of life, especially in deep ocean. Although the expedition lasted 1,000 days and covered more than 68,000 nautical miles, it never entered the Mediterranean, a sea considered of little interest at that time. Dohrn was not of the same opinion: the *Challenger* cruise marked the beginning of the modern oceanography, but the marine biologists needed to access to living

organisms, studying not only their morphology, but also their physiology and development. According to Dohrn, zoology and embryology had to convert into evolutionary developmental biology, connecting phylogeny with the homologies observed in the first stages of animal development. Above all, scientists needed an institution where to pursue their own projects and ideas in support of the Darwinian theory, inside laboratories freed from the national, philosophical or disciplinary frontiers and equipped with rich libraries. The facilities offered in Naples were exceptional for the time: not only aquaria and avant-garde microscopes, but also the possibility of obtaining biological material thanks to the sampling made by fishermen, and also divers. In 1879, in fact, the Italian Navy loaned a scaphander diving apparatus to the Station and the botanist Gottfried Berthold (1854–1937) and the zoologist August Weismann (1834–1914) made several diving excursions (Groeben 1982).

Among the first of Dohrn's collaborator, Paolo Panceri was interested in various aspects of marine biology, from the fertilization in the lancelet to bioluminescence.

Also Carlo Emery (1848–1925), who will become one of the most famous European entomologists, began to frequent the Station in 1875, studying, among other things, bioluminescence, a subject which Umberto Pierantoni (1876–1959) studied later, theorising the hereditary physiological symbiosis (1909) and becoming one of the father of the endosymbiosis theory together with its pupil, Paolo Buchner (1886–1978). In the same years, Federico Raffaele (1862–1937) stayed several times at the Station studying embryology and larval development in fish and Davide Carazzi studied the embryology of some marine molluscs, improving histological preparations.

Salvatore Lo Bianco was custodian and tutor of the Zoological Station. Son of the porter in Palazzo Torlonia at Mergellina where Dohrn lived, Lo Bianco was an extraordinary self-taught who soon became an acute observer of marine biological processes. Between 1888 and 1909, he published *Notizie biologiche riguardanti specialmente il periodo di maturità sessuale degli animali del Golfo di Napoli* (Lo Bianco 1909). Great attention also received his publication *Metodi usati nella Stazione Zoologica per la conservazione degli animali marini* (Lo Bianco 1890), translated into various languages. The material collected by Lo Bianco was the basis for the impressive monograph *Uova, larve e stadi giovanili di Teleostei*, edited in three volumes from 1931 to 1956 by a group of Italian scholars headed by Umberto D'Ancona.

Between 1900 and 1902, Friedrich Alfred Krupp (1854–1902), with the help of Salvatore Lo Bianco, was carrying out a major project of the exploration of the Mediterranean whose first results, *Pelagische Tiefseefischerei der "Maja" in der Umgebung von Capri*, were published in Jena in 1904. Unfortunately, the sudden Krupp's death truncated the project.

In the Dohrn's thought, the Zoological Station did not have to have in-house research programs and therefore the different laboratories reflected the major interests of the visiting scientists. Research was focused on the descriptions of marine organisms, their structures, functions and habits, following the traditional studies of the 19th century as well as to the studies of the physiological processes of life, looking for evidences to support the theory of evolution. To support this theory, it was necessary to find the missing link between inorganic and organic matter or at least very primitive forms of life. And this could not be found but at sea.

In 1868 Huxley, studying an old sample of mud from the Atlantic seafloor taken 11 years before, discovered an albuminous slime which he thought could be traced back to the primordial slime, a protoplasm from which all life had originated. Huxley named it *Bathybius haeckelii*, in honor of Ernst Haeckel who theorized the existence of the primordial slime thanks to which simple organic compounds were created from non-living inorganic molecules through physical and chemical reactions. It was actually a precipitate of calcium sulfate from the seawater that was reacted with the preservative alcohol, as shown a few years later. However, the search for the primordial ooze, the meeting point between inanimate and animated matter, involved many famous biologists of the end of the century. At Naples, Francesco Saverio Monticelli (1863–1927), in search of an intermediate form of life, found in the aquarium an ameboid organism, *Treptoplax reptans*, which considered an ancestral metazoan. However, this has never been seen since its original description (1896), and now is assumed to be a synonymous of the currently only one species, *Trichoplax adhaerens* Schultze 1883, ascribed to the phylum Placozoa.

Burdened by the lack of systematic studies on the Mediterranean marine fauna and flora, Dohrn developed a monumental illustrated work on the morphological and systematic investigations of the Gulf organisms, the *Fauna und Flora des Golfes von Neapel* project, dealing with the morphology, development, systematics or ecology of a peculiar taxon. Disappointed by the quality of scientific

illustrations accompanying many of the monographs, Dohrn also hired professional artists to create illustrations for the works and each monograph became famous for the precision and beauty of its plates. Several Italians were called to collaborate: Antonio Della Valle (1850–1935) an expert in amphipods and ascidiaceans, Umberto Pierantoni with a monograph on Archiannelids belonging to the genus *Protodrilus*, Angelo Andres (1851–1934) for the actinians. Raffaello Valiante (1850–1934) described the *Cystoseira* of the Gulf and Giuseppe Jatta (1860–1903) the cephalopods, Giovanni Battista Grassi the chaetognaths, and Carlo Emery (1848–1925) published a monograph regarding the fish genus *Fierasfer* (= *Carapus*) from the Gulf, describing their larval forms and studying the etology of these holothurian-inhabiting species.

In just a few years, the most experimental aspects quickly took over, thanks to the implementation of the methods to study the development and the embryology, using sea urchins, ascidians and other marine organisms. The zoologists thus converted themselves in embryologists, connecting phylogeny with homologies between the germ layers of embryos, and foreshadowing evolutionary development biology. Artificial insemination and parthenogenesis, hybridisation, first segmentation and embryonic stage development became the most important research fields.

In 150 years, the best biologists of their time, including 19 Nobel laureates in Medicine or in Chemistry, worked at Naples for longer or shorter periods and gave a significant boost to the development of science, laying the foundations of the modern biology (Groeben & De Sio 2006). Not all can be considered true marine biologists, but biologists who used marine organisms to understand problems of more general interest. It is beyond this brief note to examine all the researches carried out in Naples, mostly by international researchers. However, it is enough to remember the names of August Weismann (1834–1914), Nicolaus Kleinberg (1842–1897), Wilhelm Roux (1850–1924), Francis Maitland Balfour (1851–1882), Albrecht Kossel (1853–1927), Jacques Loeb (1859–1924), Theodor Boveri (1862–1915), Thomas Hunt Morgan (1866–1945), Curt Alfred Herbst (1866–1946), Hans Driesch (1867–1941), Otto Loewi (1873–1961), Otto Heinrich Warburg (1883–1970), Friedrich Baltzer (1884–1974), Otto Fritz Meyerhof (1884–1951), Ernst Scharrer (1905–1965), Jean Louis Auguste Brachet (1909–1988), Bernard Katz (1911–2003), Ricardo Miledi (1927–2017) to

understand the importance that this institution had in the 20th century world biology.

In 1915, Italy plunged into the First World War and Reinhard Dohrn (1880–1962), son of the founder of the Zoological Station and director of the institution, was forced to repatriate and the management of the Station was entrusted to Francesco Saverio Monticelli who appointed Umberto Pierantoni as director of the zoological department (Montalenti 1960). He started to study the morphology and physiology of the light organs of various marine species, demonstrating that the photogenic substance was, in several cases, a culture of luminescent bacteria, confirming so the hypothesis of the symbiotic nature of the bioluminescence. The physiologist Filippo Bottazzi (1867–1941), one of the fathers of Italian biochemistry, was the responsible of the physiological department from 1915 to 1923. His studies on the role of the sarcoplasm in muscle contraction and on the osmotic pressure were of such importance that he received several Nobel Prize nominations. The results of this work supported the fascinating hypothesis that the vertebrate body fluids were nothing that the original environment, the sea water, made internal by the biological organization.

After the war, in 1924, the great philosopher Benedetto Croce (1866–1952), Italian Ministry of Education, wanted the Zoological Station to return under the responsibility of the Dohrn family. The Dohrn's extraordinary and innovative insights opened up Naples to the international research, with important consequences for the Italian biologists who had the opportunity to get in touch with researchers and issues of great scientific thickness.

In the post-war years, neurobiology exploded and squids, octopuses and aplisies became extraordinary models of study. Silvestro Baglioni (1876–1957), a pupil of Bottazzi, demonstrated the importance of the fish swim bladder as a sense organ and analyzed the function of the *Torpedo* electric organ as well as the olfactory, visual and tactile organ senses of numerous cephalopods and fish. Under the guidance of Bottazzi, Gaetano Quagliariello (1883–1957), at the beginning of his career that led him to become Rector of the University of Naples and senator of the Republic, carried out research on the blood pH of marine vertebrates and invertebrates. In 1935, Francesco Paolo Mazza (1905–1943), collaborating with Zénon-Marcel Bacq (1903–1983), demonstrated the presence of acetylcholine in the optical ganglia of the octopus, thus providing a fundamental data for the understanding of the chemical transmission of the nervous signal. Enrico

Sereni (1901–1931), working on the peripheral nervous system of cephalopods, demonstrated the squid giant axon's function in collaboration with John Z. Young (1907–1997).

### The fascist period and the beginning of the applied marine biology

The collapse of the Central Powers at the end of the First World War led to an inevitable crisis both in Trieste and Rovinj Stations. In 1920, the Regio Comitato Talassografico Italiano did not consider appropriate a reconstitution of the Zoological Station in Trieste, instead going to establish a Talassographic Institute that did not address biological topics.

The few Italian biologists who worked in Trieste before the war moved to the Rovinj Station or in Naples. In fact, the marine Station of Rovinj (formerly, the Zoologischen Station der Berliner Aquarium founded in 1891) remained operative thanks also to the activity of Raffaele Issel (1878–1936) who was director from 1920 to 1924, when Massimo Sella (1886–1959), a pupil of Giovanni Battista Grassi, took over as director. In 1930, thanks to an agreement between the Regio Comitato Talassografico and the Kaiser Wilhelm Gesellschaft zur Förderung der Wissenschaften in Berlin, the Italian-German Institute of Marine Biology was born. A common leadership of the Institute was decided with two co-directors: Massimo Sella, appointed by the R. Comitato Talassografico and Adolf Steuer, professor at the University of Innsbruck, appointed by the German side. After the Second World War, the Institute di Rovinj will be the Center for Marine Research as part of the Ruđer Bošković Institute in Zagreb (Croatia), while a part of his historical collections were preserved at the Hydrobiological Station of the Department of Biology (University of Padova) in Chioggia (Turchetto et al. 2008).

Massimo Sella was an eclectic researcher: he introduced *Gambusia holbrooki* in Istria to fight malaria, worked on the sponges in Lybia and holoturians fisheries in Adriatic as well as on the migration and life of eels and bluefin tuna (Sella 1912; Lucu & Sella Marsoni 2013). In particular, he suggested that tuna migrate every year from the Atlantic to the Mediterranean through the Strait of Gibraltar for spawning and that the migration route was along the African coast (Sella 1929).

One of the most distinguished researchers who worked in Rovinj was Aristocle Vátova (1897–1992) (Dalla Venezia 1993). He devoted himself to the quali-

quantitative study of the benthic fauna of the Leme Canal using the Petersen grab (Vátova 1928), a method applied for the first time in the Mediterranean and particularly effective for evaluating biomass and secondary production of soft bottoms. In the following years, he expanded his analysis to a large part of the Adriatic (Vátova 1949), laying the foundations for the knowledge of the distribution of the Mediterranean soft-bottom communities. In 1943, he left Rovinj, and stayed at the Hydrobiological Station of the University of Padua in Chioggia, founded in 1941 by D'Ancona (Gibin 2013). At Venice, he was able to reconstruct a centre for marine biological research that later gave rise to the Istituto di Biologia del Mare (later directed by Umberto D'Ancona). In 1955, Vátova moved to the Institute of Marine Biology of Taranto.

After the First World War, other research institutes, in addition to the Zoological Station of Naples and the Italian-German Institute of Marine Biology in Rovinj, were active in marine biology: the R. Thalassographic Institute of Messina, the R. Central Laboratory of Hydrobiology of Rome (Panella 1994) and the R. Institute of Marine Biology of Taranto which were largely addressed to applied research for developing the marine resources (Cecere & Mellea 2009).

In 1916, the R. Thalassographic Institute of Messina was established in an area of great interest for the marine biology studies (Cavaliere et al. 1999). The Strait of Messina is, in fact, the meeting point between two basins (Ionian and Tyrrhenian Sea) characterized by different physical-chemical characteristics that, among other things, determine tidal differences of almost 30 cm, facilitating strong currents and upwellings with occasional strandings of many mesopelagic organisms.

Luigi Sanzo (1874–1940), director of the Institute, conducted important works of comparative anatomy, physiology and embryology, especially on eggs, larvae and juvenile stages of marine teleosts (Spartà 1941). Among those of considerable economic importance for the fishery, it is worth mentioning his studies on the bluefin tuna (*Thunnus thynnus*), the swordfish (*Xiphias gladius*), the albacore (*Thunnus alalunga*) and the Atlantic bonito (*Sarda sarda*).

At Taranto, a new R. Institute of Marine Biology was founded in 1914 and his director, Attilio Cerruti (1879–1956), developed studies of mariculture and, in particular, promoted mussel farming (*Mytilus galloprovincialis*) (Cerruti 1967), an historical activity in the Mar Piccolo of Taranto (Cecere & Mellea 2009).

In the 20–30' years of the 20th century, the Government gave particular attention to the pelagic and demersal fish stocks management, with more interest in developing the product than in its preservation. Under this vision, Gustavo Brunelli (1881–1960) as director of the Fisheries Office of the Ministry of Agriculture and of the R. Central Laboratory of Hydrobiology in Rome, unfortunately favoured the development of the trawling fishery everywhere and in particular in the Sicily Channel, a choice whose negative consequences will last over time.

In Genoa, Raffaele Issel, even in the narrowness of a small laboratory on the cliff of Quarto dei Mille founded in 1911 (Issel 1914a), completed important observations on the biology of rock pool organisms (Issel 1914b) and began to take an interest in zooplankton (Remotti 1936). In the same period, he published *Biologia Marina* for Hoepli publisher, the first Italian textbook on the subject, particularly dedicated to the Mediterranean problematics (Issel 1918). Together with Renato Santucci (1896–1957), an expert of decapods, and Alessandro Brian (1873–1969), a specialist of copepods (Brian 1921; Carli & Bruzzone 1970; Guiglia & Cattaneo 1972), he faced many issues related to the Ligurian Sea, also taking care of the bathyal communities and of problems related to the trawling fisheries (Issel 1930; Santucci 1931). This team was also accompanied by Achille Forti (1878–1937), an algologist specialist in diatoms who became a leader in Europe (Forti 1922, 1924).

The father of the fishing science in Italy was Umberto D'Ancona from Rijeka, who spent large part of his life at the University of Padua (Ghirardelli 1989). In 1926, he started to analyse carefully fishery trends in the Upper Adriatic between 1905 and 1923 and the effects of the reduced fishing efforts on the stocks when were suspended during the First World War (1915–18) (D'Ancona 1926; Fortibuoni et al. 2017). Contrary to expectations, the biological balance had shifted in favour of the carnivorous predators as the planktophagous fish had not increased in numbers, but their predators had increased. D'Ancona interpreted these data as indicating a return to a state of natural equilibrium, favoured by the cessation of human interference, concluding that a moderate fishing activity determined a marine biological balance much more favorable for the human economy than the natural one. In other words, a moderate catch of high predators, such as dolphins, would have a positive effect on the commercial stock. His results inspired Vito Volterra, a pioneer of mathematical biology of international fame, which led to the

formulation of the Lotka-Volterra predator-prey model, and supported the economic importance of the dolphin bounty hunting in Italy to reduce the effect of these predators on the fish populations (D'Ancona 1942; Meliadoro et al. *in press*). In those years, in fact, dolphins were considered to be very voracious, seen as direct competitors for the resources and consequently identified as harmful and pest species, deserving a systematic extermination (Volterra 1926).

Between 1922 and 1923, Francesco Vercelli (1883–1952), director of the Institute of Geophysics in Trieste, organized several oceanographic cruises in the Strait of Messina using the R/V *Marsili* of the Italian Navy. In the same years, the Hydrographic Institute of Genoa armed the R/V *Ammiraglio Magnaghi* who was in service from 1918 to 1938, realizing important hydro-oceanographic expeditions in the Sicily Channel and in the Red Sea, to which the naturalist Pietro Parenzan (1902–1992) participated. Subsequently, Parenzan devoted himself to the study of the benthic fauna of the Adriatic and the Ionian Sea and founded the Marine Biology Station of Porto Cesareo in 1966 (Parenzan 1986; Fanelli & Rubino 2002).

Unfortunately, in 1938 some Italian biologists were indelibly stained by signing the *Manifesto della Razza* to support the fascist racial laws, but no marine biologists appeared among signatories. However Umberto Pierantoni, author of *The race in the human species. Races and civilizations* (1940) was part of a restricted Commission that in 1942 tried to amend the document, explaining the racial differences more from a historical and cultural point of view than on a scientific level (Israel 2007).

### **The second post-war period and the experimental marine biology**

After the Second World War, between 1947 and 1955, the Istituto Nazionale di Studi Talassografici of the National Research Council (CNR) was found, as the direct heir of the former R. Comitato Talassografico, to promote thalassographical investigations along the Italian seas. Its offices and laboratories were settled in Venice. Moreover, in the '60s of the last century, the National Research Council established other research centers linked to the study of the marine environment such as the Institute of Fishing Technology in Ancona and that concerning the Biological Exploitation of the Lagoons in Lesina, in Apulia. In the same years, the CNR armed a ship, the RV *Bannock*, followed by another smaller one, the RV *Marsili*. Thanks to

these vessels, numerous research campaigns were conducted, especially in the Mediterranean.

From a more strict biological point of view, the research fields developed at the Zoological Station of Naples before the war slowly spread to different universities, where different aspects of the reproductive biology and development were studied, using marine organisms as study models. In Pisa, Guido Bacci (1912–1980) studied sexuality in molluscs, echinoderms and polychaetes and, in particular, the hermaphroditism, marking a decisive turning point on the knowledge of this problem. Statistical data on the sexuality in *Patella* and *Calyptrea* showed, for the first time, the importance of the sexual variability in hermaphrodite populations and led to the theory of polyfactorial sex determination. Subsequent research on *Ophryotrocha* polychaetes in controlled environments, experimentally confirmed the validity of such theories. In the same years, Arturo Bolognari (1917–1981) in Messina studied the sexual inversion in *Halotis lamellosa* and the biochemical processes involved before and after the fertilization in the sexual cells of the echinoderms.

However, Naples remained still one of the world capitals of the experimental embryology. In fifties and sixties, Mario Salfi (1900–1970) started to study the asexual reproduction by budding in tunicates, when Giuseppe Reverberi (1901–1988), professor of Zoology at the University of Palermo, became the Director of a Center for Biological Studies of CNR hosted in the Zoological Station. Studying the embryonic development in ascidians, Reverberi recognized the impossibility of drawing a net line between the regulatory and the mosaic development. Following his studies, cell development began to be interpreted in terms of molecular interactions, with biochemical, biophysical and immunological methods, while the molecular model of regulation of gene expression, based on repression and induction, suggested new interpretations of development, as a process control in time of expression of a predetermined program in the fertilized egg. In addition, Reverberi resumed the classical studies of Baltzer on the phenotypical sex determination in *Bonellia*, testing the effect of various chemical substances, mechanical and environmental interferences (food availability, presence of dominant individuals of the same sex) as well as several symbiotic parasites for understanding the mechanisms of the parasitic castration, especially in isopods.

Always in Naples, Silvio Ranzi (1902–1996), before being professor of zoology at the University

of Milan, was oriented in comparative embryology and development biology, studying the growth of Selachian embryos in ovipara, ovovipara and vivipara species. He found a correlation between the growth of the embryo, the uterus histophysiology and different organs of the mother and produced evidence that aquatic eggs take mineral ions from environmental water (Cigada Leonardi & De Bernardi 1997). In the same period, Francesco Ghirelli (1916–2002) employed cephalopods to develop the knowledge of the physiology and biochemistry of hemocyanins and cephalotoxin from salivary glands of cephalopods, while Giuseppe Montalenti (1904–1990), a pupil of Federico Raffaele in Rome, and Alberto Monroy (1913–1986) started to study genetics, mutagenesis and neurosecretion, becoming protagonists of the Italian experimental biology. After the Second World War, the laboratories of the Station returned to be frequented by international researchers as James Dewey Watson (1928–) and Maurice Wilkins (1916–2004), pioneers of the DNA structure studies. Just in Naples in the spring of 1951, during a speech by Wilkins on the molecular structure of DNA, Watson decided to collaborate with him.

In that period, Giuseppe Montalenti addressed his studies on the physiology of the fertilization and in particular the experimental activation of echinoderm eggs at the Marine Biological Laboratory in Woods Hole and later at the Zoological Station. In Naples, he was called to cover the first chair of Genetics in Italy, where he continued his studies on genetics, reproduction and evolution of sexuality. Alberto Monroy with A. Tyler (1906–1968), a student of T.H. Morgan and among the world's leading fertilization scholars, studied the chemical changes during the fecundation in the sea-urchin and the mechanisms put in place to avoid the polyspermia, also demonstrating that, during oogenesis, the ribosomal expression is blocked by particular proteins, then eliminated during the different phases of the embryonal development.

Thanks to the Zoological Station, young Italian researchers have had the opportunity to stay for long periods abroad, especially in the United States (Montalenti 1969). During these stages, they acquired an international scientific experience and when they come back in Italy they were often able to form research groups with a new, different mentality. Bruno Battaglia (1923–2011) began to deal with evolutionary genetics attending the major specialists of the sector. Applying to the harpacticoid *Tisbe reticulata* populations the same genetic techniques previously used on *Drosophila* by Thomas



H. Morgan, Battaglia studied the inheritance of the characters, demonstrating the genetic control of the chromatic polymorphisms in the Venice Lagoon population and the existence of a balanced polymorphism based on the selective advantage of the heterozygosis for the first time in a marine environment. In 1962, at the University of Trieste, Elvezio Ghirardelli (1918–2007) gave new impetus to the research of the zooplankton and in particular in the study of the chaetognates that are still a subject of discussion as regards the systematic position, affinity and evolution. To this phylum, he dedicated a monograph (Ghirardelli & Gamulin 2004).

At Messina, Sebastiano Genovese (1926–1983) started to study the marine microbial ecology and in particular the photosynthetic sulfur bacteria. He subsequently became director of the Zoological Station of Naples. Cesare F. Sacchi (1926–2016) devoted himself to the study of the ecology and the morphological variability of the intertidal gastropods of the genus *Littorina* and the structure and dynamics of the lagoon populations. Giuseppe Cognetti (1974), still in Naples, devoted himself to the study of polychaetes and their reproductive processes.

The hybridization process in calcisponges was the first field of interest of Michele Sarà (1926–2006) at the Station Biologique of Roscoff. Later, after the experiences at the Zoological Station of Naples and at the Universities of Naples, Bari and then at the University of Genoa, he studied the taxonomy of sponges, working often with Gustavo Pulitzer-Finali (1915–2006), and the endosymbiosis among bacteria, zooxanthellae and sponges as producers of evolutionary novelties. In marine ecology, he faced the structure of the sponge communities in terms of competition and cooperation, paying more attention to the cooperation processes and overturned the traditional vision according to which the structure of benthic populations was strictly regulated by competitive phenomena. In 1974, he published, with Giuseppe Cognetti, *Biologia Marina*, a reference textbook also for university students.

In 1969, the Italian Society of Marine Biology (SIBM) was founded in Livorno, on the initiative of Guido Bacci (Relini 2000). The first president was Giuseppe Montalenti. At the same time, the Italian Association of Oceanology and Limnology (AIOL) was born in 1972, under the presidency of the marine geologist Raimondo Selli (1916–1983). The main goals of these associations were respectively in-depth analysis of issues related to marine biology, oceanography and limnology, exchanging opinions and experiences. In particular, SIBM,

with the collaboration of a huge number of specialists, published a complete checklist of the Italian marine fauna and flora (Relini 2008, 2010).

At the half of 20th century, the use of the first oxygen rebreathers and, afterwards, of the Self-Contained Underwater Breathing Apparatus (SCUBA) opened a new road of exploration to marine biologists who used largely this technique. Although Filippo Cavolini in 1785 employed a diving bell to observe the benthos in the Gulf of Naples (Riedl 1980) and the Zoological Station used divers to collect biological material as early as the end of the 19th century, only after WWII this practice spread in the scientific world, although at the beginning was considered to be of exclusive pleasure and viewed with suspicion by the academic world. Also at the Zoological Station of Naples, at the end of the '40 years of the past century, the first underwater researchers were received with distrust. Rupert Riedl (1925–2005), from the Zoologisches Institut der Universität in Wien and a pioneer of the scientific diving, remembered in 1978: “in those days the establishment was represented by Reinhard Dohrn (1888–1962), Anton's son: he told me that I could not disturb a scientific institute, like the Zoological Station, asking for funding for a sports activity” (Riedl 1978).

In reality, the diving for studying the Mediterranean benthic communities opened up unexpected horizons and its impact on marine ecology can be compared to that of the electron microscope in cell biology. Scientific diving was born in France (Drach 1948) and permitted to explore easily hard bottoms and inaccessible environments. In 1952, Riedl organized the *Österreichischen Tyrrhenia-Expedition* (AA.VV 1959) during which the study of submerged caves started, thanks to scuba diving (Riedl 1978). Sandro Ruffo (1915–2010), from the Natural History Museum of Verona and an amphipod expert, participated in this project, unique among the Italians. In 1963, Riedl edited the monograph *Fauna und Flora der Adria*, calling to collaborate for the sponges Michele Sarà, unique Italian.

Scientific diving spread rapidly in Italy. In 1957, Enrico Tortonese (1911–1987), director of the Natural History Museum of Genoa, used divers for taking coralligenous samples from hard bottoms (Pastorino & Canu 1965) for describing the coralligenous habitat present along the Portofino Promontory (Tortonese 1958, 1961, 1962, 1963) while a young diver, Roberto Marchetti (1930–1995), before devoting himself to the study of freshwater ecology and toxicology, studied the red coral

populations present in the Ligurian and Tyrrhenian seas (Marchetti 1965a, 1965b).

Tortonese was mainly an ichthyologist and an expert in echinoderms and also published, among other things, three volumes of the *Fauna d'Italia* dedicated to fish (Tortonese 1956a, 1970, 1975) and one to echinoderms (Tortonese 1956b). His research contributed not only to knowledge of the fauna of the Mediterranean, but also Red Sea, Black Sea and North Eastern Atlantic.

In 1957, Enrico Tortonese organized a meeting in Genoa with the leading experts of the European benthos, including Jean-Marie Pérès (1915–1998), the future author, together with Jacques Picard, of the *Nouveau Manuel de Bionomie Benthique* (1964). During the meeting, the definitions of the bionomic levels inside the littoral benthic domain were fixed, taking into account light intensity as the main discriminating factor. While the French school saw in the sun-light the variable that explained the vertical distribution of the benthic organisms, the austrian Riedl, working also in the Gulf of Naples, gave more relevance to the role of water movement. Consequently, he introduced in Italy the importance to study marine caves, an environment where it was possible to distinguish and study separately the role of these two variables. So, marine caves became, at the end of the '70s, an important field of study for the Italian marine biologists to which the Laboratory of Ecology of the Benthos of the Zoological Station of Naples and the Institute of Zoology of the University of Genoa devoted themselves. In 1978, Fabio Cicogna (1926–2008) founded the CLEM (Centro Lubrense Esplorazioni Marine), a non-profit organisation for the promotion of the marine sciences. In those years, Cicogna organised workshops and field activities to favour the study of the marine caves, the protection of the red coral and date mussel populations, as well as the establishment of marine protected areas along the Italian coasts (Russo & Cicogna 1991; Cicogna & Cattaneo-Vietti 1993; Cicogna et al. 1999, 2003) and was the founder and first president of the Hydrozoan Society (Bouillon et al. 1987).

In the decade 1970–80, the newly organised Benthic Ecology and Biological Oceanography laboratories of the Zoological Station developed several ecological studies, including researches on the relations between the chemical-physical factors and the living populations as well as on plant and animal communities. In particular, Lucia Mazzella (1947–1999) devoted herself to the study of the *Posidonia oceanica* ecosystem, Donato Marino (1947–2002) and Bruno Scotto di Carlo

(1939–1988) studied the spatio-temporal distribution of the phyto- and zooplankton respectively, and Eugenio Fresi (1943–2010) introduced the most advanced multivariate statistical techniques for the analysis of ecological data in the Italian marine biology (Boero & Fresi 1986; Gambi & Russo 2011). In the same period, Giuseppe Giaccone (1936–2018) at the University of Catania made a substantial contribution to the knowledge of the brown algae *Cystoseira*, a group of great importance for the Mediterranean benthic bionomy, often using diving techniques. During those years, a wide development of the marine ecology and ecotoxicology occurred as answer to the increasingly evident environmental degradation processes also thanks to marine biologists as Aristeo Renzoni (1929–2011) at the University of Siena and Norberto Della Croce (1926–2011) and Francesco Faranda (1933–2011) at the University of Genoa.

In the period 1976–81, CNR promoted a national scientific project, called *Oceanography and Sea Bottoms*, which produced important results in several fields of the marine biology, from benthic and planktonic studies to fisheries and sea farming. During those years, a wide development of the marine ecology and ecotoxicology occurred as answer to the increasingly evident environmental degradation processes. Since 1958, the National Committee for Nuclear Research (CNRN, then became CNEN in 1960 and finally ENEA in 1982) in Fiascherino (Lerici) and subsequently in Santa Teresa, always close La Spezia, started to study the distribution and circulation of radioactive pollutants, in a period in which nuclear tests were carried out in the atmosphere. Later, it devoted itself to understanding the physical, chemical and biological variables at sea and their changes driven by natural or human effects.

One of the main problems of the pollution concerned eutrophication of the Upper Adriatic, whose acute effects occurred as early as 1975. Richard Albert Vollenweider (1922–2007) devoted himself from 1978 to 2004 not only to study the phenomenon but, above all, to find its causes. His work allowed the Center for Marine and Oceanographic Research Structure Daphne of Cesenatico to develop programs for monitoring dystrophic phenomena, harmful algal blooms and mucilage events, still in progress.

In experimental marine biology, at the end of the 70' years of the past century, new perspectives arised to the light of the modern evolutionary developmental biology (Evo-Devo) no longer driven by studies on the morphological comparisons between embryos, but more on molecular processes. In

these years, new chemoecological approaches permitted to analyse organismal patterns of natural products in terms of predators and prey, allies and competitors relationships and also to identify several substances of pharmacological interest produced by marine organisms, mainly sponges and nudibranchs (Fattorusso & Tagliatela-Scafati 2008).

In ecology, the study of the marine ecosystems in relation to the global change effects, centered on the marine biodiversity and particularly on complex ecosystems such as seagrasses and coralligenous communities which became fundamental. Despite the arbitrary nature of each category, several new field of interest were open e.g., land- or atmosphere-waters interactions, the role of the hydrological fronts and plankton production, the benthic-pelagic coupling, as well as in field manipulation studies to support ecological theories.

In deep waters, the main lines of the biological research concerned the evaluation of biomass and secondary production, the flow of organic matter and, in particular, how its energy value changes. Other fields of interest were the role of the bacterial activity in mud bottoms and the role of resting stages as banks of biological variability.

World climate is never static and periods of warming and cooling are likely to continue as they did during the Pleistocene, affecting the structure of habitats and the dynamics of the populations. Although, the increasing levels of the atmospheric CO<sub>2</sub>, started with the Industrial Revolution, now interact with Mediterranean waters and could bring to unexpected effects on the entire ecosystem (Ryland 2000). In this age of changes, it is also important to develop long-term studies that allow us to highlight possible changes in the Mediterranean ecosystems over time and the effects of human impacts that cause loss of species and habitats also with an introduction of alien species which can devastate native species and habitats. Consequently, even in an era of molecular biology, the marine organisms continue to offer a great field of interest and a unique tool to evaluate the effect of the human impacts on the structure and dynamics of the communities, the positive/negative relationships in terms of competition and cooperation among interacting populations as well as the consequences of the global change. At the end of the last century, the mechanisms that underlie the participation of microorganisms (bacteria and viruses) in marine food webs and biogeochemical cycles started to be investigated, also for understanding how marine ecosystems might respond to global change.

In the '80-90s, the need to define methods of protection of the littoral marine environment and the sea

resources become more pressing and the Italian Government promoted the creation and management of 46 MPAs along the Italian coasts with two laws (no. 979/82 "Dispositions on the defence of the sea" and no. 394/91 "Frame-law on the protected areas") (Cattaneo-Vietti & Tunesi 2007). This gave impetus to new research especially in assessing the impact of human activity on the structure and dynamics of coastal populations. At the same time, thanks to an agreement between Italy, Monaco and France, the Pelagos Sanctuary, better known as the Sanctuary for Marine Mammal (Italian Law no. 391 of 11 October 2001), covering a surface area of 87,000 km<sup>2</sup> largely in the Ligurian Sea, was instituted to protect, above all, the populations of cetaceans living in this area (Notarbartolo Di Sciara et al. 2008).

At the end of the last century, also thanks to international research programs such as the *National Antarctic Program* (PNRA), established in 1985, many Italian marine biologists have had the opportunity to work on topics previously little investigated and known. Few years later (1994), the Interuniversity Consortium for Marine Sciences (CoNISMa) was born under the drive of Francesco M. Faranda, professor of ecology at the University of Genoa. Thanks to this institution, researchers of 32 universities from around Italy have had the opportunity to participate in projects of national and international interest. However, in the 70-80 years, the Italian marine biologists mainly have developed researches linked to pollution problems, fishing impacts and marine protected areas management, often turning into monitoring activities, which have culturally impoverished the scientific research at sea.

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