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PROFESSIONAL FISHERMEN AS THE GATEWAY TO THE MEDITERRANEAN BATHYAL REALM: TWO CENTURIES OF RESEARCH IN THE LIGURIAN SEA

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ABSTRACT

How did the Mediterranean deep sea become a scientific object? This paper addresses that question through a historical reconstruction of bathyal research in the Ligurian Sea between the early nineteenth and the late twentieth centuries. Rather than attributing the emergence of Mediterranean bathyal ecology solely to scientific discoveries or technological innovations, it demonstrates that the progressive exploration of the deep sea resulted from a long-lasting collaboration between marine zoologists and professional fishermen. From Antoine Risso and Jean-Baptiste Vérany to Raffaele Issel, Enrico Tortonese, Lucia Rossi, Lidia Orsi and Giulio Relini, successive generations of researchers incorporated the practical knowledge and fishing technologies developed by Ligurian fishermen into their scientific investigations. The introduction of mechanised deep-water trawling in 1930 enabled Issel to establish the first systematic programme devoted to Mediterranean bathyal ecology, while the uninterrupted collaboration with the Ligurian fishing communities ensured the continuity of this research tradition for almost two centuries. The study argues that the Ligurian case represents one of the longest documented traditions of collaboration between fishermen and marine biologists in the Mediterranean and shows that the deep sea became scientifically observable through the combined action of technological innovation, empirical fishing knowledge and zoological interpretation. By integrating the history of marine biology with the history of fisheries, the paper offers a new perspective on the emergence of Mediterranean bathyal ecology.

KEY-WORDS: Bathyal ecology**;** History of marine biology; Professional fisheries; Ligurian Sea.

INTRODUCTION

The history of marine biology has traditionally been reconstructed through the succession of scientific discoveries, exploratory expeditions and research institutions. From the great voyages of the nineteenth century to the emergence of modern oceanography, historical accounts have generally emphasised the achievements of individual naturalists, technological innovations, and scientific organisations, (Adler, 2014; Muka, 2021). Comparatively less attention has been devoted to the practical conditions that made those achievements possible, including the collecting practices, fishing technologies and local communities through which marine organisms became available for scientific investigation: the history of marine biology is therefore also the history of the material, technological and social processes through which marine environments became observable as scientific objects (Kohler, 2007; Daston, 2008, 2017).

This problem is particularly evident in the study of bathyal ecosystems. Before the development of systematic deep-sea sampling and modern oceanographic technologies, most of the Mediterranean bathyal environment remained beyond the reach of direct scientific observation (Danovaro et al., 2010). Throughout most of the nineteenth century and the first half of the twentieth century, zoological knowledge of deep Mediterranean faunas depended largely upon organisms obtained through professional fishing activities.

The use of commercial catches as sources of zoological material was by no means a Ligurian innovation. Since classical antiquity, naturalists had relied extensively upon fishermen and fish markets to obtain marine organisms for taxonomic investigation. Renaissance zoologists such as Guillaume Rondelet (1554–1555) and Ulisse Aldrovandi (1638) continued this long-established practice, which remained one of the principal sources of marine specimens well into the nineteenth century. The originality of the Ligurian experience therefore lies not in the use of commercial catches itself, but in the transformation of this ancient zoological practice into one of the longest continuous traditions of bathyal research documented in the Mediterranean.

In fact, among Mediterranean regions, the Ligurian Sea provides an especially suitable case study. The close proximity of the continental slope to the coast favoured the early development of deep-water fisheries (Cattaneo-Vietti et al., 2010). Combined with the continuous technological evolution of fishing practices and the uninterrupted presence of an active zoological community, this created an exceptionally persistent interaction between marine zoologists and professional fishermen. Successive innovations in fishing technology—from deep longlines to mechanised otter trawls and modern fishing vessels—progressively extended access to deeper environments, while marine zoologists repeatedly transformed these new opportunities into scientific investigations.

The present paper examines the historical processes through which the Ligurian bathyal environment became progressively accessible to scientific investigation. By following this tradition from Antoine Risso to Giulio Relini, Lidia Orsi and their research group, this paper demonstrates that the development of bathyal biology in the Ligurian Sea cannot be understood simply as a succession of scientific discoveries. Rather, it represents the gradual construction of a distinctive scientific tradition in which successive technological innovations in deep-water fisheries, the empirical knowledge accumulated by professional fishermen, and the biological interpretation developed by marine zoologists were progressively integrated into a common enterprise of exploration and research (Figure 1).

1. Constructing the Bathyal Mediterranean: Naturalists, Fishermen and the Discovery of the Deep Ligurian Sea (1810–1883)

The first scientific recognition of the Ligurian bathyal environment did not originate from oceanographic expeditions but from the close interaction between naturalists and the fishing communities operating along the coasts of Nice, Villefranche and Genoa. During the early nineteenth century, fishing activities remained closely integrated with the daily life of these coastal towns. Fishing boats were hauled directly onto beaches or small waterfronts, nets were repaired in public spaces, and fish markets were located within the urban centres themselves. This physical proximity created continuous opportunities for contact between fishermen and

naturalists, facilitating the exchange of specimens, observations and practical knowledge. Long before the development of modern marine biology, local fishermen routinely exploited the unusually steep continental slope by means of deep longlines, reaching bathyal fishing grounds situated only a short distance from the coast. Their catches, fishing techniques and accumulated practical experience provided naturalists with both biological material and direct knowledge of an environment that remained largely inaccessible elsewhere in the Mediterranean.

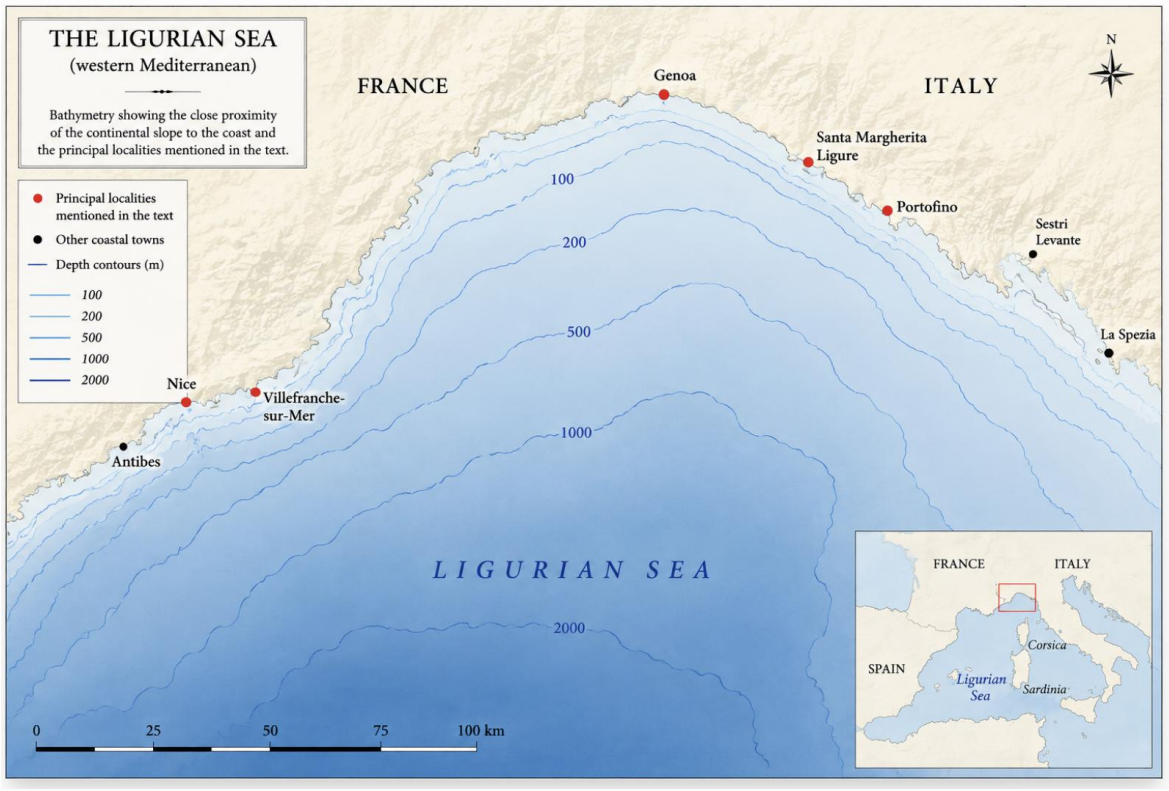

Figure 1. Bathymetry of the Ligurian Sea showing the unusually close proximity of the continental slope to the coast and the principal localities mentioned in the text.

Among the earliest authors to appreciate the scientific importance of this exceptional setting was Antoine Risso. In *Histoire naturelle des principales productions de l'Europe méridionale* (1826), Risso repeatedly emphasised the remarkable bathymetry of the coasts of Nice and Villefranche, where great depths could be reached very close to the shoreline. Rather than treating this simply as a geographical peculiarity, he recognised its biological significance (Bavestrello, 2026). Throughout his work he systematically associated marine organisms with the depths at which they were collected, frequently indicating the bathymetric range of individual species. Such observations represent one of the earliest attempts to interpret Mediterranean marine fauna within a bathymetric framework. For example, he noted that his new species of crab *Dorippe cuvieri* (now *Paromola cuvieri*) lives "*dans les plus grandes profondeurs de la mer*" indicating a depth of collection of 2000 m while *Calypso periculosa* (now *Galathea strigosa*) lives "*dans les trous des rochers profonds*" 500-600 m depth (Risso, 1816).

Equally revealing is Risso's attention to fishing practices themselves. He described in detail the deep longlines employed by the fishermen of Nice for catching sharks and other large fishes, repeatedly linking particular fishing methods with the organisms they captured. For example he stated that his *Squalus nicaeensis* (today accepted as *Dalatias licha* (Bonnaterre, 1788)) "*On la peche à l'hameçon .... à mille mètres de profondeur*" (Risso, 1810). The deep Ligurian Sea first became scientifically observable because it was already being explored daily through the techniques and accumulated experience of professional fishermen.

While Risso had demonstrated the exceptional accessibility of the Ligurian bathyal fauna, Jean-Baptiste Vérany transformed these observations into a more systematic investigation of depth, habitat and species' bathymetric distribution. Vérany's *Catalogo degli invetebrati marini del Golfo di Genova e di Nizza* (1846) and subsequent monographs about cephalopods (1851) contain numerous observations linking species to precise capture depths, fishing localities and bottom characteristics. Organisms such as *Cidaris* are explicitly associated with depths greater than 200 m, while many cephalopods, molluscs and echinoderms are similarly characterised by their bathymetric distribution. For example he described the observations of three specimens of the rare bathypelagic cephalopod *Tremoctopus violaceous* "*pescati in Settembre, in Genova, a circa mille metri di profondità*". Depth had become more than a geomorphological measurement: it was increasingly treated as a biological variable capable of explaining the occurrence of marine organisms.

Perhaps even more significant is Vérany's description of his working methods. In the introduction to his studies on Mediterranean cephalopods (Verany, 1851), he explicitly acknowledged the advice of Franco Andrea Bonelli, professor of zoology at Turin University, who urged him to examine cephalopods immediately after capture, whenever possible while they were still alive. The episode illustrates that zoological knowledge was shaped not only by preserved specimens but also by practical experience concerning the capture, handling and observation of marine organisms.

During the second half of the nineteenth century, this relationship entered a new phase. The scientific cruises of Enrico d'Albertis' cutter *Violante*, documented by the young Decio Vinciguerra (1883), demonstrated both the possibilities and the limitations of contemporary marine exploration. The *Violante* also became a meeting place for some of the leading Italian naturalists of the period, including Enrico Hillyer Gigoli, Giacomo Doria, Raffaello Gestro and Arturo Issel. The presence of the latter is particularly significant, as his son Raffaele would later transform this pioneering phase of exploration into the first systematic programme of Mediterranean bathyal ecology. Interesting was also the presence of Enrico Hillyer Giglioli, who soon afterwards participated as zoologist in the first deep-sea campaign of the survey vessel *Washington* (Giglioli, 1881).

Conventional dredging, attempted during the Violante cruise, proved only partially effective on the steep Ligurian slope. Consequently, the expedition adopted the deep longlines traditionally employed by the fishermen of Cornigliano, successfully operating them at depths approaching 600 m in the so-called *Fossa del Porto*, off the harbour of Genoa. For the first time, fishing technology itself became an explicit component of scientific methodology. The practical knowledge accumulated by generations of fishermen was no longer merely an external source of material but became incorporated directly into zoological investigation. These developments

created the intellectual, methodological and technological foundations upon which Raffaele Issel would subsequently build the Ligurian tradition of Mediterranean bathyal ecology.

The Ligurian experience also offers an interesting perspective on one of the central debates in nineteenth-century marine biology. Edward Forbes' celebrated Azoic Hypothesis (1843) according to which animal life disappeared below about 300 fathoms, largely reflected the technical limitations of contemporary dredging rather than the actual distribution of deep-sea organisms (Anderson & Rice Anderson, 2006). By contrast, the exceptional bathymetry of the Ligurian coast and the long-established collaboration with professional fishermen enabled Mediterranean zoologists to obtain deep-water organisms routinely from depths that remained inaccessible to most contemporary naturalists. Long before systematic oceanographic expeditions documented the richness of deep-sea life, the Ligurian tradition had already shown, through professional fishing, that the Mediterranean bathyal realm constituted a rich and scientifically accessible biological environment (Forbes, 1844; Anderson & Rice, 2006).

2. From Technological Innovation to Bathyal Ecology

At the beginning of the twentieth century, Italian fisheries were widely regarded as technologically backward compared with those of other European countries. In his influential report presented at the National Fisheries Congress held in Genoa in 1910, Giuseppe Rocco argued that the future development of Italian fisheries required the modernisation of fishing techniques and, above all, the extension of fishing activities beyond the traditional fishing grounds (Rocco, 1910; Pellerano, 2014).

Giuseppe Rocco's proposals found their first concrete expression in the Ligurian Sea during the second half of the 1920s, when profound technological innovations transformed commercial fisheries. The introduction of motor-powered vessels equipped with mechanical winches, allowed otter trawls to be operated routinely beyond 200 m depth, opening extensive sectors of the upper continental slope that had previously remained largely inaccessible (Brian, 1931; Issel, 1932). In the spring of 1930, these technological innovations made possible the commercial exploitation of the deep-water shrimp grounds off the Ligurian coast. Among the first fishing communities to exploit these new grounds was that of Santa Margherita Ligure where particularly active was the action of Giovanni Battista Paccagnella (Baicin) with his newly built motor fishing vessel "*Avvenire*".

The first catches revealed extraordinarily rich populations of the deep-water shrimps *Aristeus antennatus* and *Aristeomorpha foliacea*, (Figure 2) together with a remarkable diversity of bathyal organisms that had previously been known almost exclusively from occasional captures (Brian, 1931; Issel, 1932). As Alessandro Brian later recalled, the new fishery immediately transformed the Genoa fish market into the principal interface between the Ligurian bathyal environment and zoological research, providing an uninterrupted flow of deep-water material to the Institute of Zoology (Brian, 1931).

Raffaele Issel (Figure 3), Director of the Institute of Zoology of the University of Genoa from 1923 to 1937 (Pellerano, 2013), immediately recognised that the newly accessible fishing grounds offered an unprecedented opportunity to investigate the Mediterranean bathyal environment as an ecological system. Rather than regarding the new catches simply as a

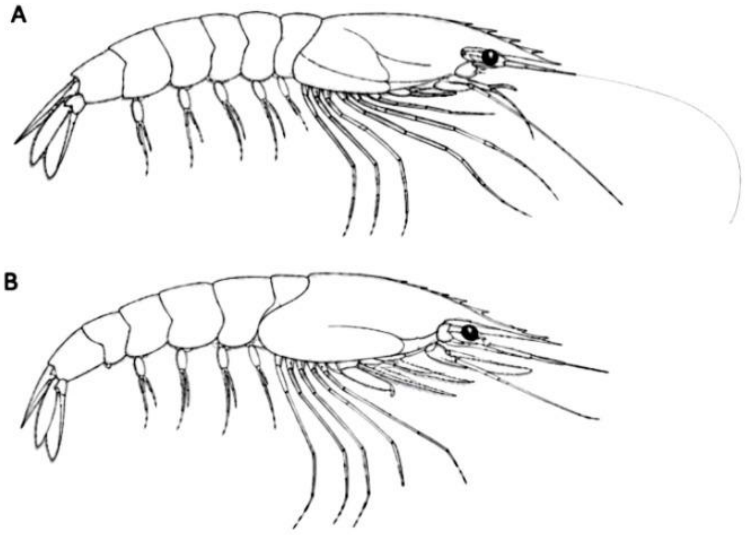

Figure 2. *Aristeus antennatus* (Risso, 1816) and *Aristaeomorpha foliacea* (Risso, 1827). Modified from Brian (1941).

succession of remarkable or rare species, Issel conceived a coordinated research programme devoted to the structure, composition and biological functioning of the "*scampi grounds*" (Issel, 1930, 1932). This programme, initiated with *La biologia del fondo a "scampi" nel Mare Ligure* (Issel, 1930) and synthesised in his ecological overview of the deep fauna of the Gulf of Genoa (Issel, 1932), marks the birth of systematic bathyal ecology in the Mediterranean. Issel organised the work of his collaborators around complementary lines of investigation within a single coordinated research programme. Alessandro Brian concentrated on the biology and ecology of the commercially important deep-water shrimps (Brian, 1931, 1941), Renato Santucci specialised in reptant decapods and the biology of the Norway lobster *Nephrops norvegicus* (Santucci, 1930, 1932a, 1933), while Issel himself focused primarily on fishes and cephalopods, integrating the results into a broader ecological interpretation of the Ligurian bathyal fauna (Issel, 1932).

Within this framework, commercial fisheries became fully integrated into scientific methodology. Brian no longer relied on isolated specimens but analysed the continuous flow of material arriving at the Genoa fish market, combining fishermen's observations with biological investigations to reconstruct the geographical distribution, seasonal abundance and feeding ecology of the principal bathyal crustaceans (Brian, 1931, 1936, 1938, 1941). Likewise, Santucci examined thousands of specimens collected over only two years and maintained living animals in the aquarium of the Quarto Marine Laboratory (Pellerano, 2014), where behaviour, moulting and feeding could be investigated experimentally (Santucci, 1930, 1932a, 1932c, 1933). Commercial fishing had thus evolved into a permanent system of biological sampling capable of supporting ecological and experimental research rather than merely taxonomic description (Issel, 1932).

The success of Issel's programme depended not only on technological innovation but also on the establishment of stable relationships with the Ligurian fishing communities. Santucci actively promoted contacts with fishermen, delivering lectures to the fishing community of Santa Margherita Ligure and encouraging the voluntary donation of biologically interesting material to the laboratory (Bavestrello et al., 2024). More importantly, the programme established a durable

network of collaboration between the University of Genoa and the Ligurian fishing communities, a tradition that would survive the interruption of the Second World War and provide the foundation for the renewed bathyal investigations of the following decades.

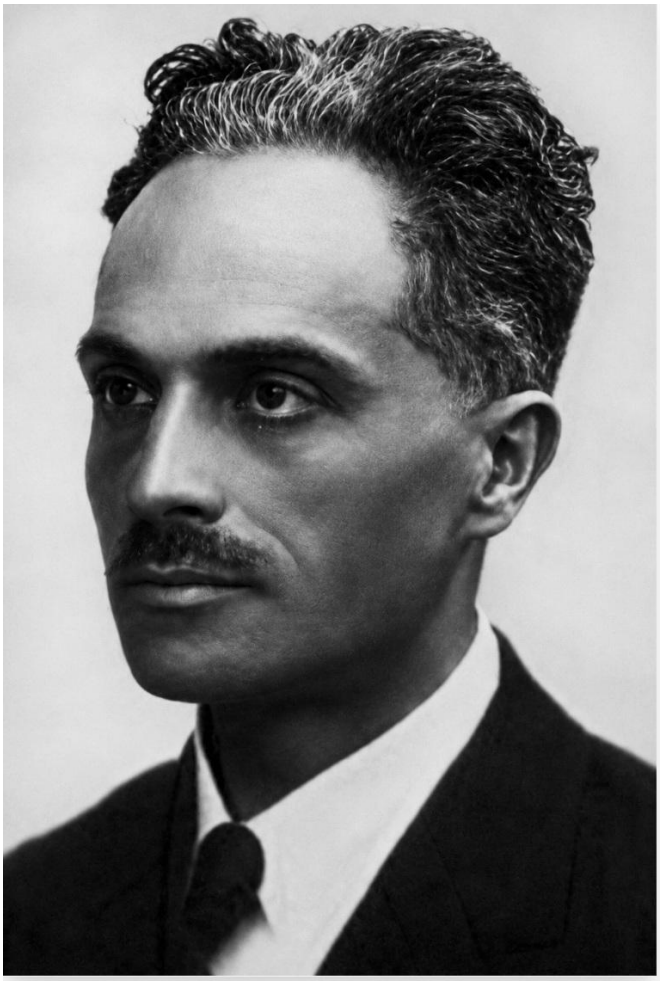

Figure 3. Raffaele Issel, Director of Zoological Institute of the University of Genoa.

3. The Renewal of the Ligurian Bathyal Tradition

The Second World War brought to an end the intensive research programme established by Raffaele Issel, Brian and Santucci. Nevertheless, it did not interrupt the network of relationships that had developed between marine zoologists and the Ligurian fishing communities. During the following decades this network survived through different scientific traditions, preserving complementary aspects of the earlier programme and eventually allowing the renewal of systematic bathyal research.

A central role in this continuity was played by Enrico Tortonese, Director of the Museo Civico di Storia Naturale “Giacomo Doria” from 1955 onwards and former student of Decio Vinciguerra (Sarà, 1987). Unlike Issel, whose principal objective had been the ecological organisation of bathyal communities, Tortonese remained essentially an ichthyologist and zoogeographer. His interest focused on the rare and poorly known fishes regularly brought ashore

by deep-water fishermen, which formed the basis of a long series of systematic investigations on the Ligurian ichthyofauna (Tortonese, 1958, 1960, 1962, Tortonese E. & Relini-Orsi L. 1970). Although his scientific objectives differed substantially from those of Issel, Tortonese maintained the practical relationships with professional fishermen that had characterised the Ligurian school since the 1930s.

At the same time, the tradition initiated by Issel found its most direct continuation in the work of Lucia Rossi. Her study of the bathyal fauna of the eastern Ligurian Riviera represented the first substantial investigation of deep-water communities carried out after the Second World War (Rossi, 1958). Rather than developing a quantitative ecological programme, Rossi adopted a predominantly faunistic and bionomic approach, documenting the composition of bathyal assemblages and the distribution of their characteristic species. Her investigations, conducted aboard Benedetto Paccagnella's motor trawler Lavoratore II, also constitute the earliest documented collaboration between Paccagnella and marine zoologists (Rossi, 1958).

A new phase began at the start of the 1970s. Lidia Orsi of the University of Genoa entered bathyal research through her collaboration with Tortonese on rare deep-water fishes collected by commercial fishermen (Tortonese & Relini-Orsi, 1970). Her earliest publications remained firmly rooted in the ichthyological tradition established by Vinciguerra and maintained by Tortonese, focusing on new records and uncommon bathyal species (Relini-Orsi & Relini, 1970, 1972a).

The collaboration between Lidia Orsi and Giulio Relini gave rise to a new research programme devoted not only to the discovery of unusual species but also to the structure, dynamics and exploitation of bathyal ecosystems. Introducing their study of bathyal decapods, Relini and Relini-Orsi observed that only in a few Italian regions did the continuity of marine investigations permit meaningful comparisons between contemporary bathyal communities and observations made more than forty years earlier. They explicitly referred to Issel's programme on the scampi grounds as the historical basis for their own investigations (Relini-Orsi & Relini, 1972b). The renewal of Ligurian bathyal research therefore represented not the beginning of a new scientific tradition but the continuation of an existing one under new methodological and ecological perspectives.

A decisive contribution to this renewed phase of research was provided by Benedetto Paccagnella. Son of Giovanni Battista ("Baicin"), one of the pioneers of the Ligurian deep-water shrimp fishery, Benedetto inherited not only exceptional technical expertise but also an intimate knowledge of the bathyal fishing grounds accumulated through decades of family experience. His collaboration with marine zoologists extended over more than thirty years, first with Lucia Rossi and later with Lidia Orsi, Giulio Relini, Tecla Zunini Sertorio and other members of the University of Genoa (Rossi, 1958; Relini-Orsi & Relini, 1972b; Zunini Sertorio et al., 1974).

Unlike earlier fishermen, whose principal role had been to provide specimens or facilitate access to fishing grounds, Paccagnella became an active participant in the scientific process. His detailed knowledge of bathymetry, seasonal changes, fishing techniques and species distributions contributed directly to the planning of sampling campaigns and to the interpretation of ecological observations. The exceptional nature of this collaboration was repeatedly acknowledged by the zoologists with whom he worked and reached its highest formal recognition when he was included as co-author of a technical scientific report (Zunini Sertorio, Della Croce & Paccagnella, 1974).

Through this long process, the relationship between marine zoologists and professional fishermen reached its highest level of integration. What had begun during the nineteenth century as the occasional acquisition of unusual specimens, and had evolved during the Issel period into a structured collaboration supporting ecological investigations, finally became a genuine scientific partnership in which research questions, sampling strategies and biological interpretation were developed through the continuous interaction between academic researchers and experienced fishermen. The modern Ligurian tradition of bathyal research therefore emerged not as the achievement of individual scientists, but as the product of a long-standing community of practice linking successive generations of zoologists with the fishing families whose knowledge made the Mediterranean deep sea continuously accessible to science.

CONCLUSIONS

The history of bathyal research in the Ligurian Sea reveals a pattern that has received little attention in the historiography of marine biology. The development of scientific knowledge depended not only on technological innovation or on the work of individual zoologists, but also on the progressive construction of a stable community linking academic researchers with professional fishermen. Throughout almost two centuries, this collaboration evolved from the occasional acquisition of unusual specimens into a long-term scientific partnership that fundamentally shaped the scientific exploration of the Mediterranean deep sea.

During the early nineteenth century, fishermen enabled naturalists such as Risso and Vérany to obtain organisms from depths that remained inaccessible to conventional collecting methods. The cruises of the *Violante* represented a decisive methodological transition, demonstrating that fishing techniques themselves could become scientific instruments. The introduction of commercial deep-water trawling in the spring of 1930 created an unprecedented opportunity that was immediately recognised by Raffaele Issel, who transformed the new fisheries into the first systematic programme of Mediterranean bathyal ecology (Brian, 1931; Issel, 1930, 1932). His research group established not only an innovative scientific agenda but also a durable network of collaboration between the University of Genoa and the Ligurian fishing communities.

Unlike many scientific initiatives that disappeared with their founders, this network survived the interruption caused by the Second World War. Through different institutional settings and scientific perspectives, the relationships established with professional fishermen were maintained by Enrico Tortonese, continued through Lucia Rossi's faunistic and bionomic investigations of Ligurian bathyal communities, and subsequently renewed by Lidia Orsi and Giulio Relini (Rossi, 1958; Relini-Orsi & Relini, 1972). Their work inaugurated a new phase of quantitative ecological research made possible by the exceptional collaboration of Benedetto Paccagnella, whose contribution represented the highest level of integration ever achieved between scientific investigation and professional fishing.

Relini et al. (1986) and Relini (2007) explicitly recognised the continuity of Ligurian bathyal research, tracing this tradition back to the pioneering programme established by Issel and his collaborators. The present study extends this historical perspective by demonstrating that the roots of this scientific tradition reach much further back, to the first decades of the nineteenth century, when the collaboration between naturalists and professional fishermen began with Risso

and Vérany and was subsequently strengthened through the *Violante* expeditions. The continuity of this collaboration made it possible not only to discover the bathyal fauna but also to compare ecological conditions over several decades, providing one of the earliest historical reconstructions of long-term changes in Mediterranean deep-water communities (Relini-Orsi & Relini, 1972).

Among the Mediterranean regions documented to date, no other case exhibits a comparably continuous and well-documented tradition of collaboration between successive generations of marine zoologists and professional fishermen. Elsewhere, important contributions to the knowledge of deep-water faunas undoubtedly resulted from major oceanographic expeditions or local fishing activities. In the Ligurian Sea, however, the relationship between fishermen and marine biologists developed into a stable scientific tradition extending across successive generations of researchers and fishing families.

The Ligurian experience therefore demonstrates that the emergence of Mediterranean bathyal ecology cannot be understood solely as the consequence of scientific ideas or technological progress. It was equally the product of a long-lasting alliance between different forms of knowledge: the theoretical and institutional framework provided by marine zoologists and the practical experience accumulated by generations of professional fishermen. Together, they transformed the Ligurian Sea into one of the longest continuously investigated bathyal regions of the Mediterranean and showed that the history of marine biology is inseparable from the history of the fishing communities whose knowledge made the deep sea progressively accessible to science.

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