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An overexploited Italian treasure: past and present distribution and exploitation of the precious red coral *Corallium rubrum* (L., 1758) (Cnidaria: Anthozoa)

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Abstract

The aim of this paper is to supply an overview of all historical and recent knowledge on landings, fishing and geographic distribution of the red coral banks along the Italian coasts in order to make a contribution to the conservation and future management of this resource. Along the Italian coasts, the banks have been exploited for millennia, using non-selective trawling gear that was banned in Europe in 1994. Today, harvesting is allowed only by scuba divers and regulated by specific laws. We examined 153 years of history of coral fishing in Italy, from Unification (1861) to 2014. Data about the coralline fleets and the amount of coral landings were recorded for the considered span of time. From a quantitative point of view, the coral fishing in Italy in the last 150 years has been dominated by the sub-fossil coral reservoirs from the Sciacca Banks (Sicily Channel), where an extraordinary amount of 18,000 tons was collected in 34 years (1875–1888 and 1893–1914). This amount represents about 90% of all red coral harvested along the Italian coast in the last 150 years. Excluding this period, the average annual yield was initially around 100 tons, decreasing to 28 tons 100 years later, therefore demonstrating a severe overexploitation of the resource. The great part of the deep red coral banks was abandoned because harvesting was no longer profitable. Nevertheless, quantitative data suggest that red coral banks, even though overexploited, are still widespread along Italian coasts, mainly in shallow waters. These banks show a remarkable persistence although with a generalised shift towards smaller colony sizes and higher density. The time span necessary in recovering the pristine structure, following the end of the fishing activities, appears very long and the populations of several areas might be unable to re-colonise the old and overexploited banks.

Keywords: *Corallium rubrum*, fishery, conservation, Mediterranean Sea

Introduction

Since antiquity, the precious red coral, *Corallium rubrum* (L., 1758), has been an important Mediterranean resource (Bussoletti et al. 2010; Cattaneo-Vietti & Bavestrello 2010; Tsounis et al. 2010), assuming religious and apotropaic meanings as people believed it a good luck charm (Balzano 1838, 1870; Price & Narchi 2015) and even today coral amulets and necklaces are donated to infants and brides as propitiatory ornaments.

Along the Italian coasts, the red coral banks have been exploited for millennia (Figure 1), and coral

branches are still found in both Mediterranean and central-European prehistoric graves (Trasselli 1953; Tescione 1968; Marini & Ferru 1989). Raw corals were found in archaeological remains dating from the 5th century BC to the 1st century AD in the Phoenician settlement of Tharros, in Sardinia (Galasso 2000), an island which still hosts some of the richest banks of the whole Mediterranean Sea.

For centuries, red coral fishermen used trawling gear (the St Andrew's Cross) dating back to the 4th to 3rd centuries BC (Marongiu 1996; Tsounis et al. 2010). During the mid-20th century, the St Andrew's Cross was abandoned in favour of a modified version,

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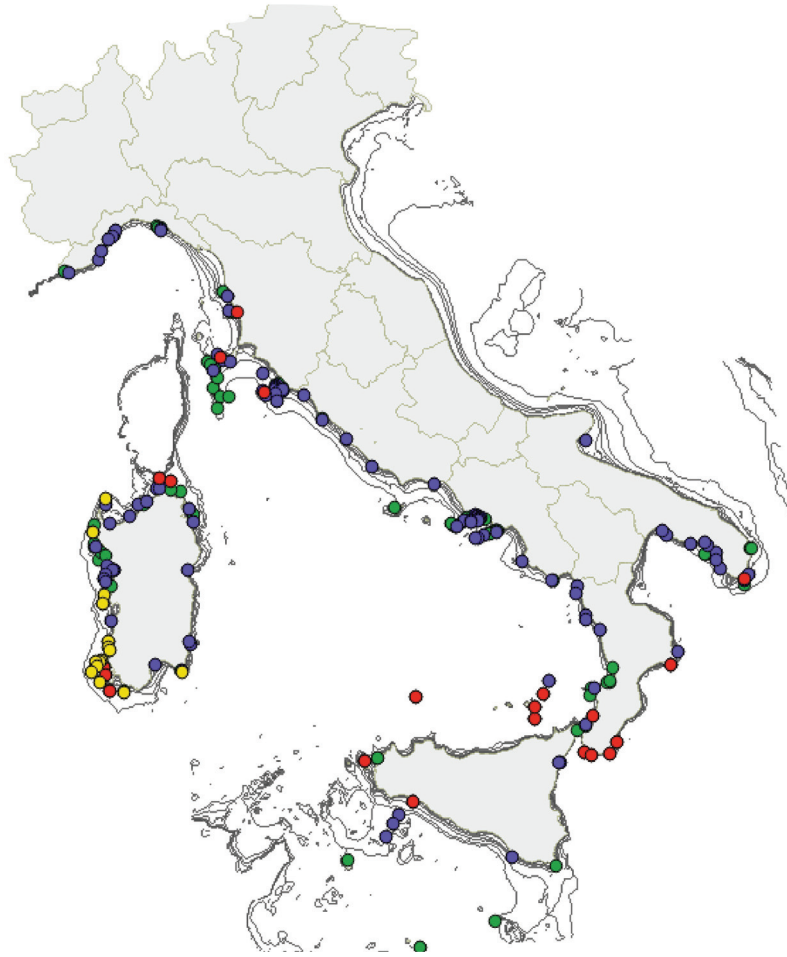


Figure 1. Map of the recorded coral banks exploited during the last 150 years. Red spots: Canestrini (1883). Yellow spots: Parona (1898). Blue spots: Mazzarelli (1915a, b), Mazzarelli and Mazzarelli (1918). Green spots: other authors.

called the “Italian bar”. These kinds of non-selective gears were banned in Sardinia in 1989, and in all of the European Union in 1994 (Council Regulation No. 1626/94). This decision was absolutely necessary as these trawling gears were extremely destructive towards coral populations and their habitats, as recently demonstrated by Remote Operating Vehicle (ROV) evidence of illegal fishery in the Sicily Channel (Cattaneo-Vietti et al. *in press*). On the contrary, harvesting by scuba divers was considered more selective towards colonies of larger sizes and seemed to have a lesser impact on the red coral habitat (Santangelo & Bramanti 2010).

The shallow-water populations (between 15 and 50 m depth), living in caves, crevices and overhangs, were overexploited only by scuba divers who, since the 1950s, were able to pick up colonies in habitats inaccessible to dredging (FAO 1988; Cicogna & Cattaneo-Vietti 1993; Cicogna et al. 1999; Garrabou &

Harmelin 2002; Santangelo et al. 2007; Vielmini 2009; Vielmini et al. 2009; Santangelo & Bramanti 2010; Tsounis et al. 2010; Bramanti et al. 2014).

According to a recommendation of the General Fisheries Commission for the Mediterranean Sea (GFCM 2011), these populations (up to 50 m depth) should be fully protected from exploitation, allowing their extremely slow recovery (Priori et al. 2013; Bavestrello et al. 2014a,b). GFCM established a minimum harvest colony size (7 mm of colony basal diameter) corresponding to an age of 30–35 years (Priori et al. 2013), but each region can issue local regulations, quotas and fishing periods (Cau et al. 2013). Nowadays, the fishing effort in Italy is limited to the deep banks off the Sardinia coast and in Sicily Channel.

Today, several shallow red coral populations dwell in Marine Protected Areas (MPAs) or Marine Reserves (Bergeggi Island, Portofino Promontory,

Argentario Promontory, Montecristo Island, Ischia and Procida islands, Punta Campanella, Caccia Cape, Maddalena Archipelago, Porto Cesareo MPAs) and hence can be considered protected.

Red coral is protected not only by regional and national laws, but also by several international conventions such as Specially Protected Areas of Mediterranean Importance (SPAMI), Annex III; Berna, Annex, III; EU Habitat Directive, Annex V; Barcelona Convention. Recently, *C. rubrum* has been listed as an Endangered species on the International Union for Conservation of Nature (IUCN) national and regional Red List. However, red coral protection remains difficult to realise, because fishing is hardly verifiable, and the yield easily concealable (Santangelo & Bramanti 2010). Moreover, the available data on landings are lacking or underestimated, but it is clear that in the last 100 years, red coral experienced a continuous decrease in landings, and its populations are nearly depleted in several areas (CITES 2007; Tsounis et al. 2013) even due to intense phenomena of mass mortality generally attributed to global warming (Garrabou et al. 2001; Bavestrello et al. 2014a).

The aim of this paper is to review all historical as well as recent knowledge on landings, fishing and geographic distribution of the red coral banks along the Italian coasts in order to make a contribution to the conservation and future management of this Mediterranean resource.

The bulk of data regarding landings and fisheries' efforts (in terms of number of fishing boats) has been extracted from the grey literature (Ministry Reports, Annals of the Italian Ministries of Agriculture and Industry, and of the Istituto Centrale di Statistica) and publications (Ferrigni 1864; Montelatici 1871; Canestrini & Canestrini 1883; Parona 1883; Ghidiglia 1892; Tescione 1968; Marini & Ferru 1989; Errico & Montanelli 2008; GFCM-FAO 2010; GFCM 2011). Available data from 1978 to present, as reported by several authors (Santangelo et al. 1993; Liverino 1998; Santangelo & Abbiati 2001; Bruckner 2009; Cau et al. 2013; Tsounis et al. 2013), have been extracted from Food and Agricultural Organization (FAO) reports that were, in turn, provided by the red coral *wholesalers and manufacturers* (Cau et al. 2013). Information regarding the bank distribution along the Italian coasts was obtained from Gaetani (1867), Panceri (1871), Targioni-Tozzetti (1880), Colombo (1887), Parona (1898), Lo Bianco (1909), Mazzarelli (1915a,b, 1931), Mazzarelli and Mazzarelli (1918), Peruzi (1923), Scatizzi (1935), Errico and Montanelli (2008), Cattaneo-Vietti and Bavestrello (2010), Gangemi (2011, 2014), Santangelo et al. (2007,

2012), Priori et al. (2013), Bramanti et al. (2014) and Bavestrello et al. (2014b).

Red coral exploitation

Before the 19th century, the only data available regarding red coral exploitation were related to the fleet working in the Sardinia waters. During the 17th century, about 250–300 “coralline” boats coming from Pisa, Genoa, Provence, Marseille, Spain and Naples actively fished coral around the Sardinian Island (Zanetti 1960; Doneddu 1994; Marongiu 1996) and this number increased to 600 units in the mid-18th century, with strong fluctuations according to the more or less favourable periods (from 51 in 1741 to 604 in 1747). In 1759, 256 boats were fishing in Alghero, nine in Bosa, 73 in Castellaragonese (now Castelsardo), 36 in Torres and 29 in Cagliari (Maxia & Valdes 1956). Similar numbers were recorded between 1771 and 1790 (Doneddu 1994).

After the mid-19th century, six different periods in the Italian red coral fishery history have to be considered:

(1) *the pre-Sciaccà period*, before 1875; (2) *the Sciaccà periods* (1875–1888; 1893–1914) corresponding to the discovery and exploitation of the three subfossil coral banks in the Sicily Channel; (3) *the prohibition period*, from 1889 to 1892 when the exploitation of the Sciaccà Banks was stopped by law; (4) *the crisis period* (1915–1945), characterised by negligible activity after the exhaustion of the Sciaccà Banks; (5) *the technological period*, after World War II, when traditional fishermen using powered boats and professional scuba divers operated together until 1989, the year in which the trawled gears were banned in Sardinia; (6) *the regulated period* (from 1990 to present) in which rules and harvesting limitations were applied.

The red coral fishing fleet

In the *pre-Sciaccà period*, 350–400 coralline boats were active along the Italian coast (Statistica del Regno d'Italia 1863; Mazzei-Megale 1880; Liverino 1998; Errico & Montanelli 2008) (Figure 2). The main home harbours were Santa Margherita Ligure (Genoa), Leghorn, Torre del Greco (Naples) and Trapani (Sicily). In Sardinia, hosting the most important fishing grounds, the main harbours were Castellaragonese, Alghero, Bosa and Cagliari.

The Italian fleet developed quickly during the exploitation of the Sciaccà Banks (Parona 1883; Gangemi 2011, 2014). Previously, in fact, only

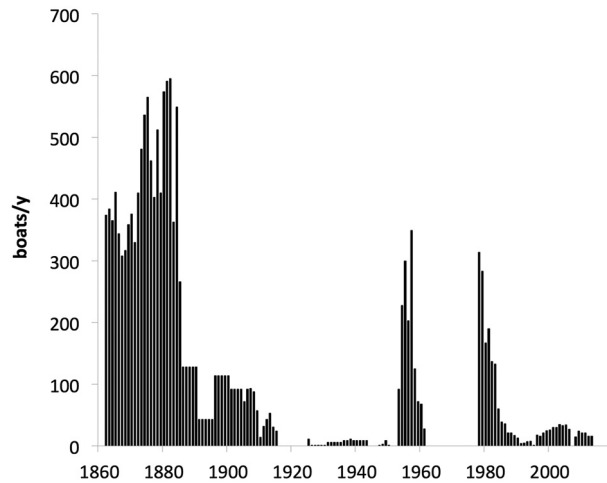


Figure 2. Number of boats employed in coral fishing during the entire studied period.

about 80 coralline boats from Torre del Greco (Naples) were working in the Sicily Channel, at Girgenti (now Porto Empedocle), Mazara del Vallo and Sciacca (Targioni-Tozzetti 1880). After the discovery of the banks, up to 1800 vessels (in 1881, Figure 2) concentrated in the area, neglecting, for several years, the fishing grounds in the other Italian regions, considered less productive. This coral rush lasted only some years with a rapid decrease in the number of employed units (Figure 2). Between 1888 and 1892 (third period), fishing on the Sciacca Banks was prohibited (Ministero dell'Agricoltura, Industria e Commercio 1908), and the fleet dropped to about 40 units, operating mainly in the Tyrrhenian Sea. When harvesting on the Sciacca was again permitted (1893), the number of corallines remained low, never exceeding 120–150 boats (Figure 2).

After the Sciacca period, the fleet was reduced also as a result of other circumstances: the huge availability of raw material due to the Sciacca harvesting, the imports of Japanese coral, the Italian–Turkish war (1911) and World War I. In Alghero, the number of fishing boats dropped to 11 in 1925, to three in 1927, and finally to zero in 1929–1930 (Sechi Copello 1982). The world economic crisis (1929), the Italian politics of those years, inspired to autocracy, and finally the League of Nations sanctions (1935–1936) certainly did not favour the export of luxury goods, such as jewellery, and the red coral industry fell into regression. So, the Italian red coral fishery dramatically dropped (Liverino 1998; Gangemi 2011, 2014) until the end of WWII. After the end of the War, the Italian fleet increased, reaching 350 units in the 1950s, to reduce again at the end

of the 1960s (fifth period). A new increase was recorded around the end of the 1970s (up to 314 corallines in 1978). After this period, the number of boats progressively dropped to 17 in 1989, when the Autonomous Region of Sardinia (ARS) banned ingegno use (sixth period). Finally, when the EU banned all the coral trawling gears in European waters (1994), only eight Italian boats were still operative in Sicily.

Although various attempts to fish red coral using divers were conducted at the beginning of the 20th century in the Gulf of Naples and Sardinia (Mazzarelli 1915a,b; Gangemi 2011, 2014), only in 1954 did scuba divers join the traditional fishermen using the Italian bar. In only a few years, scuba diving became a common activity, and numerous divers started to collect red coral in shallow waters (30–40 m depth) also inside marine caves, a habitat inevitably closed to traditional methods (Fusco 2011). Over the years, the scuba diving technique improved and allowed them to reach deeper banks, more than 100 m depth, also in response to a depletion of red coral populations in shallower waters. The number of diver boats operating mainly in Sardinia and Sicily increased quickly to about 100 units in 1978, stabilising in the following years at around 40 units. In Sardinia, the number is now subject to a quota, ranging between 20 and 30 boats (Figure 3a).

Landings

The *pre-Sciacca period* was characterised by a heavy fishing effort (Figure 2) along the entire Italian coast, landing about 60–140 tons/year (on average, 0.26 tons per boat) (Figures 4 and 5). In this period, Sardinian banks produced the main yield. In the 1860s, of about 79 tons of the coral arrived to Naples, 28.5 tons were fished in Sardinia, 15 tons in Africa, 10 tons in Corse and 25.5 tons from other areas (Tescione 1968). In 1872, 38.5 tons were fished in Sardinia, 15 tons in Africa and 10.5 tons in Corse (Municipio di Torre del Greco 1872). During the 1882 about 2.2 tons were fished in Sardinia where the most productive area was considered to be the waters surrounding the island of Carloforte.

The discovery of huge dead red coral deposits off Sciacca triggered a true red coral rush (Rajola 2012). About 18,000 tons of sub-fossil coral were harvested, depleting the banks in about 30 years (Liverino 1998), using a new gear, *la codata* (the tail). This tool consisted of a 200-m-long rope with attached bundles of old nets at regular intervals of 1.5 m, in which coral branches remained entangled (Gangemi

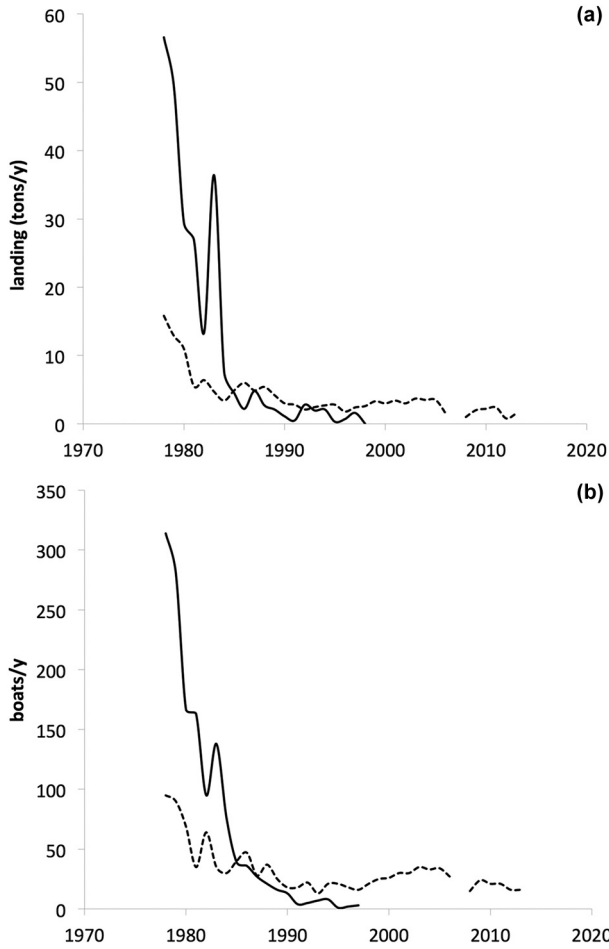


Figure 3. Coral exploitation in the last 35 years. (a) number of vessels employed in coral fishing; (b) amount of coral landed per year. Continuous line, coralline boats; dotted line, scuba-diving boats.

2011, 2014). In this period, the yield reached an average of 2.6 tons/boat/year (Figures 4 and 5). The best harvests occurred in 1880 and 1881 when about 4492 tons and 2630 tons were collected, respectively.

Between 1888 and 1892 (third period), a governmental law suspended the fishing on the banks to regulate the market because the red coral value dramatically fell, due to the exceptional increase of the deal on the market. In this period few boats fished successfully, mainly in the Tyrrhenian Sea, harvesting only 12–36 tons per year (0.45 tons/boat/year) (Figures 4 and 5).

During the fourth period, starting at the end of the red coral rush (1914), few corallines fished, mainly in Sardinia, with landings of about 2 tons/year (0.24 tons/boat/year) (Zanetti 1960) (Figures 4 and 5). Moreover, in that period, the duties on the red coral increased to 10% of the harvested value (Regio

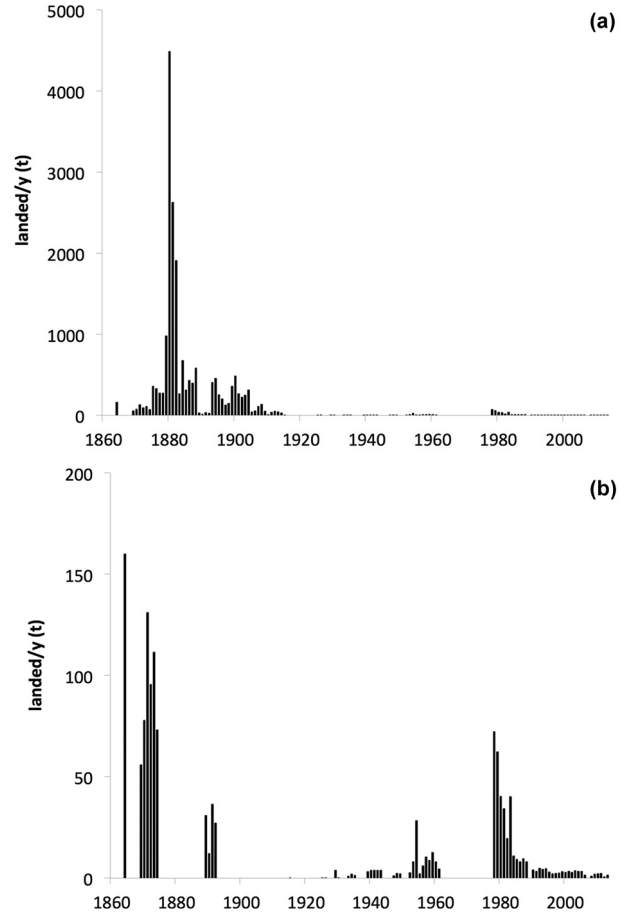


Figure 4. Landed coral per year in the studied period. (a) Data comprising the Sciacca periods; (b) data excluding the Sciacca periods.

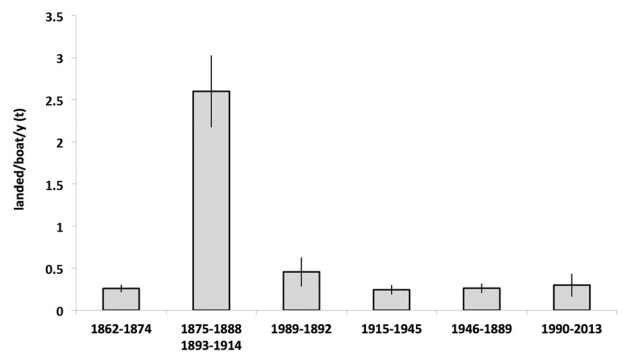


Figure 5. Average amount of coral landed per boat per year (\pm standard error) in the different considered periods of the last 150 years.

Decreto 312/1913), discouraging fishing, which was probably addressed towards the more profitable sponge exploitation (Mazzarelli 1915a,b). However,

exports continued, drawing on the vast reservoir created during the Sciacca period. In 1926, for example, traders exported 6337 tons for a value of 21,320 Italian Lires (Movimento Commerciale del Regno d'Italia 1926). During WWII, the fishing activities were stopped and slowly restarted only after 1948 (Sechi Copello 1982).

The fifth period, from the end of WWII, was characterised by two phases of intense fishing activity. During the 1950s, the average landings reached about 10 tons/year with a very low amount per boat (0.1 tons). Unfortunately, no data are available from 1962 to 1977. In 1978, a second red coral rush started in the Central Mediterranean Sea, with the exploitation of the Skerki Banks (Sicily Channel), at 50 nautical miles (NM) from Marettimo Island, where red coral was found abundant in the 40–50 m depth range. During 1978, 11 tons of coral were harvested by divers in this area (Liverino 1998) and about 3.5 tons of subfossil colonies were collected in the Terribile Bank, discovered in 1983 close to Pantelleria Island (Liverino 1998). In the 1980s, the harvesting was on average 28.7 tons/year (0.25 tons/boat/year) (Figures 4b and 5).

Finally, with the banning of the *ingegno* in the Sardinia waters (1989), harvesting has been limited only to scuba divers, who worked mainly in Sardinia, collecting on average 5.6 tons/year (0.36 tons/boat/year).

In 1996, the Autonomous Region of Sardinia (ARS) started collecting information on catches through the compulsory logbooks filled out by divers at the end of each harvesting season (Cannas et al. 2010, 2011; Follesa et al. 2013; Cau unpublished). In the period 1996–2010, total catches amounted to 37.6 tons (official data from ARS), less than half of what was reported in the FAO datasets (88.5 tons) for the same years.

In 2007, the Sardinian Regional Government decided to forbid red coral harvesting, applying the precautionary principle. In 2006 and 2012–2013, the limitation of the harvesting period and the reduction in the number of authorised divers led to a marked decrease in the annual coral harvest (Figure 3b).

Past and present red coral distribution in the Italian seas

Ligurian Sea

In the Ligurian Sea, red coral harvesting has been historically documented from the Roman Age. Our knowledge about ancient red coral exploitation in this sea is fragmentary, and probably the Ligurian fishermen did not fish a lot in their waters. Along the

western Riviera, Gallo (1888) reported Catalan fishing activities close to the city of Alassio during the 15th century, and some information on fishing activities around the Bordighera village arose from the 19th century (Ricca Di Civezza 1874). This fishing ground off Cape Ampeglio at 112–128 m depth was also reported by Mazzarelli (1915a,b).

Issel (1884) and Parona (1898) indicated coral populations from other localities both along the western (Vado, Bergeggi Island, Noli, Spotorno, Capo di Caprazoppa, Gallinara Island, Porto Maurizio) and eastern Ligurian coast (Portofino Promontory and La Spezia). According to Mazzarelli (1915a,b), the fishing activity in the cities of Noli and Spotorno expired 30 years before his observations, while the reports of the banks around La Spezia (Parona 1898) have to be considered wrong.

The shallow banks along the Portofino Promontory cliffs hosted the first pioneer scuba diving activities conducted since the 1940s, and the harvesting was intense. Today, the Portofino population is well known (Marchetti 1965; Cattaneo-Vietti & Bavestrello 2010; Bramanti et al. 2014; Bavestrello et al. 2014a) and protected inside the Portofino MPA. After 20 years of protection, it shows a slow recovery (Bramanti et al. 2014; Bavestrello et al. 2014b).

Today, the Ligurian deep populations (from 70 to 120 m depth) appear severely fragmented and scattered, growing on isolated outcrops with low colony densities. In the western Ligurian Sea the largest population, exploited until the 1980s, is present on the Maledetti Bank, off Bergeggi Island, a rocky shoal extending from 54 to 75 m depth nowadays included in a Site of Community Importance. Another population, characterised by low densities, is recorded in the Bordighera Canyon, around 100 m depth. Smaller populations, with densities of few col m^{-2} , are still recorded in the Banco delle Vedove, off Cervo, Gobbe dei Cammelli (Riva Ligure), Canyons of Lua and Arma di Taggia, and other deep outcrops, off Noli, Spotorno and Finalmarina, all sites linked to a hypothetical historical harvest. In the eastern Ligurian Sea, along the Portofino Promontory, only two deep banks (Punta del Faro and Isuela shoals) are known (Figure 1).

Tuscany and Tuscany Archipelago

Shallow, dense red coral populations are scattered along the Tuscany coast from the Meloria Shoal, Calafuria (Leghorn) to Vada shoals (Errico & Montanelli 2008 and references therein). In particular, the Calafuria population has been extensively studied in terms of demography, recruitment, early

growth rates and genetics (Abbiati et al. 1993; Santangelo & Abbiati 2001; Santangelo et al. 2007, 2012). Similarly, the distribution, size/age ratio, and sexual structure of a population living between 60 and 90 m NW off Elba Island, subject to historical and recent harvesting, have been also analysed (Priori et al. 2013, 2015). Overall, this population appears to be recovering, after past and recent exploitation (Angiolillo et al. 2015).

Fishing grounds, even in shallow waters between 30 and 55 m depth, were historically reported in Elba Island, from Fonza Cape, to Calamita Cape and Mezzo Canale Shoal as well as in the Formiche di Grosseto shoals, and generally all around the whole Tuscany Archipelago (Giannutri, Montecristo, Pianosa and Giglio islands) (Canestrini & Canestrini 1883; Issel 1884; Mazzarelli 1915a,b, 1931; Barletta et al. 1968; Abbiati et al. 1993; Errico & Montanelli 2008; Priori et al. 2013; Angiolillo et al. 2015).

Regarding the deeper banks, several red coral populations were found at depths ranging between 60 and 120 m around the Tuscany Archipelago. At Montecristo Island, an area subjected to a long protection period (about 30 years), the richest population was found, surviving to the *ingegno* and scuba diving fishing activities, which operated in this area until the 1980s.

In the other explored banks of the area, between Formiche di Montecristo and Pianosa Island, red coral was always present, but the majority of the colonies showed small sizes and low densities.

Finally, the Argentario Promontory is an area rich in small and scattered populations present in shallow waters in several localities (Mazzarelli 1915a,b, 1931; Scatizzi 1935), which endured heavy fishing pressure in the 1950s and 1960s. Tuscany, in fact, hosted pioneeristic scuba diving harvesting activities from the 1950s (Liverino 1998), while the coralline boats operated until 1983, largely determining the depletion of the banks of commercial interest (Figure 1).

Latium

At the dawn of the scuba diving activities (1950–1960), small shoals were exploited at Montalto di Castro up to 60 m depth, as well as off Santa Marinella (Capo Linaro) (Liverino 1998). Historically, Mazzarelli (1931) recorded a shoal 1 km long, 5 NM off Civitavecchia harbour and others along the Circeo Promontory. Small shoals are present at 5 NM SSW off Gaeta harbour, at 48–65 m depth (Mazzarelli 1915a,b).

Around the Ponza Archipelago, Neapolitan fishermen have collected coral from the 16th century (Marini & Ferru 1989) to today, and some information is available on the presence of red coral in this archipelago (M. Bo, pers. comm.) (Figure 1).

Sardinia Island

Sardinia hosts the most important red coral grounds of the Italian coasts, traditionally harvested since the Phoenician Age (Zanetti 1946, 1960; Sechi Copello 1982).

Data from the first part of the 19th century are scarce, given that two royal decrees (1824 and 1846) removed taxes and hence liberalised coral fishing in Sardinia (Maxia & Valdes 1956).

Gaetani (1867) reported on fishing grounds from Figari Cape to Tavolara Island. Other banks were recorded around the Maddalena Archipelago, where fishermen from Torre del Greco (Naples) fished until 1879 with scarce results. However, Mazzarelli (1915a, b) described additional, still rich banks, on the eastern coast, near Aranci Gulf, between Figari Cape and Tavolara Island between 80 and 300 m depth. Today, red coral around the Tavolara Island is very rare.

The Strait of Bonifacio and the Asinara Island represent important fishing areas hosting large banks, some of which measure several square kilometres. Along the coast from Testa Cape to Castelsardo, banks are located about 10 NM off the coast (Parona 1883). Today, Santa Teresa di Gallura and Vignola are the most important fishing harbours of the region.

Other important banks are present along the entire coast of the Asinara Island. Along the western coasts of the island, between 2 and 15 km offshore, a large bank runs south for 40 km to Argentiera Cape.

Near Alghero, coral was found almost continuously along the coast, and particularly abundant South of Alghero (from Mareggio Cape to Mal di Ventre Island), on average at a distance of 4 NM off the coast (Parona 1883).

In the 1950s and 1960s, scuba divers exploited red coral populations growing inside the submarine caves of Caccia Cape (Liverino 1998) and the Pulice Bank, 40 NM off Caccia Cape, being overall 10 NM long and 5 NM wide (Marini & Ferru 1989). Near Bosa, the coral banks were at a distance of 5–12 NM off the coast and 87–140 m depth (Parona 1883), while Liverino (1998) reported that around the Mal di Ventre Island, 4.2 tons of good coral were harvested in only 15 days in 1964.

Along the southernmost coasts of the Island, rich banks are found around St. Pietro and St. Antiaco,

known from 1599 (Parona 1883). At Carloforte, the main banks were located at a depth ranging from 60 to 150 m, 10–12 NM off the coast, while Mazzarelli (1915a,b) recorded about 20 banks between 70 and 140 m depth. The Toro and Teulada Cape shoals were among the most productive. Finally, coral banks were recorded on the eastern side of the Gulf of Cagliari: Fortezza Vecchia (near Carbonara Cape) and Cavoli Island shoals (Parona 1883).

The red coral along the eastern coast of the island is very scattered and never reached the wide distribution and richness characterising that of the western coast. Since 1882, the coral banks in front of Porto Corallo and Muravera, 10 NM off the Flumendosa river mouth, have been completely depleted by overfishing (Mazzarelli 1915a,b). At the end of the 19th century, Parona (1883) described a particularly intense and destructive fishing activity in this area (Figure 1).

Gulfs of Naples and Salerno

Already Cavolini (1785) and Costa (1858, 1871) described fishing activities close Naples, mainly between Vico Equense and Sorrento. Banks were recorded from the Pampano shoal, to the North of Capri Island and off Massa Lubrense. Balzano (1859) reported fishing grounds immediately off Naples (Castello dell'Ovo), Vico Equense and Capri. Lo Bianco (1909) signaled red coral banks, the so-called “corallere”, everywhere in the Gulf of Naples, where he used to collect colonies 35 cm high and 30 cm wide. A complete survey was conducted by Mazzarelli and Mazzarelli (1918), who described 22 productive banks. These populations were heavily harvested and depleted during the 19th century and in the early years of the 20th century: Colombo (1887) found almost no living red coral inside the Gulf. According to Liverino (1998), during and immediately after WWII, some attempts to harvest coral in the Gulf were made, but with poor results: over 60 years later, the red coral banks are still strongly suffering (Bavestrello et al. 2014b; Angiolillo et al. 2015).

Also in the Gulf of Salerno, the presence of coral has been historically documented (Balzano 1859; Colombo 1887; Mazzarelli & Mazzarelli 1918), but its distribution is highly fragmented and characterised by small populations, already deeply exploited in the 19th century. Fishing grounds were reported around and off the Li Galli Islands and along the Amalfi Coast, between Punta Campanella and Capo di Conca, until 200 m depth (Bavestrello et al. 2014b; Angiolillo et al. 2015). According to

Peruzy (1923), the red coral found off the city of Positano was of bad quality, due to its yellowish colour, and the harvesting was not profitable. Moreover, Mazzarelli (1915a,b) and Mazzarelli and Mazzarelli (1918) ascertained the total collapse of the banks off Punta Licosa, in the southern end of the Gulf of Salerno, between 45 and 135 m depth.

Finally, pioneer scuba divers harvested good amounts of red coral inside several submarine caves at Palinuro Cape from the 1950s (Fusco 2011). Nowadays, these caves are protected, but red coral populations still have difficulties in recovering. In contrast, out of the caves, a rich population, hosting colonies over 20 cm in height, has been recently recorded (Fabio Barbieri pers. comm.).

No information is today available regarding fishing activities in the Gulf of Naples and Salerno (Figure 1).

Tyrrhenian Calabria

In the 19th century, fishing grounds were reported off Praia d'Aieta, Scalea, Cetraro (Bonifati Cape) and Paola (Mazzarelli 1915a,b). The southernmost good fishing grounds were reported between Tropea (Vaticano Cape) and Scilla (Gaetani 1867; Canestrini & Canestrini 1883; Mazzarelli 1915a,b; Liverino 1998).

No information is today available regarding recent fishing activities in this area (Figure 1).

Ionian coasts

In the mid-19th century, good amounts of red coral were fished from Spartivento Cape to Colonne Cape (Gaetani 1867). Although the Calabrian fishermen were inexperienced in this type of fishing, within a few years, they obtained about 1.7 tons of coral from the area (Gaetani 1867). According to Balzano (1859), important banks were exploited off Roccella Ionica and Soverato villages, as well as off Rizzuto and Colonne Capes. Other banks were exploited at 4 NM off St Pietro and St Paolo Islands (Taranto) (Mazzarelli 1915a,b) all the way to Santa Maria di Leuca (Ristola Point, 90 m depth).

Today, small red coral banks are reported at 60–75 m depth at Santa Caterina, 7 NM off W Gallipoli, at Santa Maria di Leuca, 3 NM off the coast, and at Campomarino, 5 NM off coast, towards East. Other banks are reported close to Porto Cesareo (Corriero et al. 2012). No information is today available regarding recent legal fishing activities in this area (Figure 1).

Sicily and Sicily Channel

In the mid-19th century, Calabrian fishermen harvested coral at Vulcano, Lipari and Basiluzzo in the Aeolian Islands (Panceri 1871), where at present, only small shallow populations are still recorded. Scatizzi (1935) reported good fishing from Ustica Island, while other main historical Sicilian fishing grounds were off San Vito Lo Capo, Trapani and around the Egadi Archipelago (mainly off Levanzo Island), where, according to Liverino (1998), several professional scuba divers operated with success in the 1970s. No information is today available regarding fishing activities in these areas, and a recent survey (2011) revealed only small, sparse colonies (G. Santangelo pers. comm.). Probably, in the past, these localities were only the starting point of the fishing campaigns in the Sicily Channel, Skerki Banks and Tabarka (Tunisia) waters, where much richer populations were reported (Canestrini & Canestrini 1883).

The main historical red coral fishery grounds were, in fact, in the Sicily Channel, where about 80 coralline boats from Torre del Greco worked in the mid-19th century from Empedocle to Sciacca harbours (Targioni-Tozzetti 1880). On May 1875, the first huge deposit of dead coral was discovered approximately 16 NM off Sciacca (37°20'3"N, 12°48'7"E), at depths ranging from 150 to 200 m. This bank was 2.5 NM long and 2 NM wide (Mazzarelli 1915a,b). Two other deposits were found in the following years on August 1878 and January 1880, at 37°14'7"N, 12°43'3"E (24 NM off Sciacca) and at 37°5'N, 12°36'3"E (33 NM off Sciacca), respectively. These discoveries determined a real "coral rush" and between 1875 and 1914, about 18,000 tons of sub-fossil red coral were harvested and the banks quickly depleted (Liverino 1998; Rajola 2012). A new bank of sub-fossil red coral, called "Terribile", was discovered in 1983 close to Pantelleria Island, but the quality of coral was really poor and the activity on the bank was quickly abandoned (Liverino 1998). Living banks were exploited off Gela on 1963 and today several others are still exploited in the Sicily Channel, off Ragusa (Cattaneo-Vietti et al. *in press*) (Figure 1).

Discussion

In this study, we examined 153 years of history of coral fishing in Italy, from Unification (1861) to 2014. In this span of time, we have recorded data about the coralline fleet (as number of boats) for 121 years (79% of the considered period) and the amount of coral landed for 107 years (70% of the considered

period). For 32 years we have no data. The first important knowledge gap, in the period 1916–1924, overlapped with WWI and the years immediately following. However, it is highly probable that, in these years, no boats were launched for coral fishing. Similarly, the two-year gap in the period 1944–1945 was due to the extremely difficult period during WWII. The most important gap of data was, instead, from 1962 to 1976. In this span of time, it is very likely that the harvesting was active, but data were not recorded.

Red coral has been harvested for hundreds of years along the Italian coast, firstly with artisanal gears and, in the second half of the 20th century, by scuba diving. Italy hosted and still hosts important banks, generally heavily overexploited up to the end of the 19th century (Parona 1883; Colombo 1887; Mazzarelli 1915a,b; Mazzarelli & Mazzarelli 1918). However, from 1979 to 1983, a period particularly favourable for coral fishing due to the re-discovery of the Skerki Banks in the Sicily Channel, the landing data showed that, with respect to harvesting in the whole Mediterranean of about 70–100 tons/year (Cau et al. 2013; Bruckner 2014), the Italian production reached an average of 40 tons/year. Practically, more than half of all coral fished in the Mediterranean basin in the last few years of the 20th century came from Italian banks, although we cannot discriminate easily the catches that occurred on the Italian continental platform and those obtained by Italian fishermen scuba-divers along the North African coasts. Therefore, we must be very careful in drawing conclusions from these data sets that, at most, have to be regarded as pure estimates.

The coral fishing in Italy in the last 150 years has been dominated by the sub-fossil coral banks of Sciacca (Sicily Channel), where an extraordinary amount of 18,000 tons was collected in only 34 years (1875–1888 and 1893–1914), reaching an annual average of 530 tons. This represents about 90% of all red coral harvested along the Italian coast in the last 150 years. If, in the same span of time, we exclude the Sciacca periods, only about 2000 tons of living red coral were harvested in the remaining fishing grounds, for an annual average of 29 tons. The Sciacca amounts are not ascertainable and are probably questionable to some extent: in fact, Mazzarelli (1915a,b) suggested that the Sciacca Banks produced "only" 4662 tons in the period 1883–1912. However, it is unquestionable that this period was exceptional, probably unrepeatable, but at the same time extremely negative for the red coral trade. The raw material from Sciacca saturated the market for at least 50 years, determining, de facto, the fall in price and the consequent decline of all fishing activities (Gangemi 2011, 2014).

Excluding the Sciacca period, it can be observed that, in the mid-19th century, the average annual yield was around 100 tons, decreasing to 28 tons 100 years later, therefore demonstrating a severe over-exploitation of the resource. On the other hand, the annual yield per boat did not seem to change in all the considered period: in the mid-19th century, it was, on average, 0.25 tons/boat/year and remained the same at the end of the 20th century.

This scenario has to be interpreted in light of a significant reduction of the number of launched boats as well as in the progressive retirement of the fishing fleet from the majority of the Italian banks. Today, the fishing is limited to only Sardinia and Sicily Channel, while the banks off Liguria, Tuscany Archipelago, Latium, Gulfs of Naples and Salerno, Calabria, and Ionian Sea, that once produced a significant amount of red coral, have been abandoned because the yields have become negligible. For example: in the period 1978–1997, the coralline and scuba-diver yields from the Tuscany Archipelago and Gulf of Naples reached, on average, 1.8 tons/year: only 6.9% of the amount collected in the Sardinia waters in the same period (Liverino 1998).

The severe reduction of the fishing areas, yields and colony size following the overexploitation (Tsounis et al. 2010) were not the only causes of the decline and further crisis of the coralline activity: in fact, the Japanese red coral import and, overall, the huge amount of raw material from the Sciacca deposits were of such a magnitude that the need for a continuous supply was made less urgent.

Finally, the scuba divers determined the last detriment for the coralline fleet: in fact, from an economical point of view, putting into commission a coralline boat was not comparable with the cost of a scuba-diving boat, while the production was about the same. Consequently, the increasing competition with divers led to the decline of the coralline fishing activities, long before the legal prohibitions of the trawling gear.

Conclusions

Today the harvesting of red coral in Italy is regulated by specific laws at the local level in Sardinia and Tuscany, leading to significant reductions in the selling and processing of the red coral resource (Stampacchia 2010).

Red coral banks, even though overexploited, are still widespread along the entire Italian coast, mainly in shallow waters, where populations show a remarkable persistence with a generalised shift

towards smaller colony sizes and higher density populations (Santangelo & Abbiati 2001; Tsounis et al. 2006; Santangelo & Bramanti 2010). These populations, mainly inside MPAs, represent an important attraction for recreational divers (Bramanti et al. 2011). The recovery time of these populations appears very long: only 30 years after the last exploitations and 15 years following integral protection, the Portofino MPA shallow-water population seems to be on track to achieve the structure it had in the 1950s, when the heavy harvesting started (Bavestrello et al. 2009, 2014a).

Unfortunately, there are still few data available on the recovery capacity of the deeper overexploited banks: we do not know if these banks, no more exploited, are lost forever, but we can suppose that their recovery capacity could be critical. A representative example is that of the historical red coral banks of the Gulf of Naples, largely unrecovered nowadays (Bavestrello et al. 2014a). The Mediterranean red coral shows a slow resilience due to the limited larval diffusion potential (Costantini et al. 2007; Ledoux et al. 2010), high post-settlement mortality (Cerrano et al. 2001), low growth rates and reproductive output that increases with size (Garrabou & Harmelin 2002; Santangelo et al. 2004, 2012; Bramanti et al. 2007, 2014; Gallmetzer et al. 2010; Linares et al. 2010; Priori et al. 2013). Moreover, the overexploitation has certainly favoured a higher genetic separation within and among coral populations, leading to a decreased genetic diversity (Costantini et al. 2007). The time span necessary for recovering the pristine structure, following the end of the fishing activities, appears very long, and the populations of several areas, once overexploited, might be unable to re-colonise the banks. Indeed, the continuous action of the *ingegno* on a bank seems to have an extensive destructive consequence on the population, differently from the previously hypothesised random impact (Cattaneo-Vietti et al. *in press*). At present, information on the position and status (density and population structure) of the commercial red coral banks is being updated in Sardinia (Pedoni et al. 2009; Follesa et al. 2010). These data represent a baseline to understand what the fate of the Mediterranean red coral deep banks will be.

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References

- Abbiati M, Santangelo G, Novelli S. 1993. Genetic variation within and between two Tyrrhenian populations of the Mediterranean alcyonarian *Corallium rubrum*. *Marine Ecology Progress Series* 95:245–250. doi:10.3354/meps095245.
- Angiolillo M, Gori A, Canese S, Bo M, Priori C, Bavestrello G, Salvati E, Fabrizio E, Greenacre M, Santangelo G. 2015. Distribution and population structure of deep-dwelling red coral in the Northwest Mediterranean. *Marine Ecology* 1:1–17. doi:10.1111/maec.12274.
- Balzano P. 1838. Del corallo, della sua pesca e della sua industria nelle Due Sicilie. *Annali Civili* 32:1–69.
- Balzano P. 1859. Della origine e storia del corallo, della sua pesca, ed incremento che potrebbe questa ricevere. *Giurisprudenza Amministrativa*. pp. 71–110
- Balzano P. 1870. Il corallo e la sua pesca. Trattato sui coralli di Pietro Balzano. Codice corallino del 1790. Regolamento sulla pesca del corallo del 1856. Tipografia del Giornale di Napoli. 165 pp.
- Barletta G, Marchetti R, Vighi M. 1968. Ricerche sul corallo rosso (parte IV): Ulteriori osservazioni sulla distribuzione del corallo rosso nel Tirreno. *Istituto Lombardo (Rendiconti Scientifici)* B102:119–144.
- Bavestrello G, Bo M, Bertolino M, Betti F, Cattaneo-Vietti R. 2014a. Long-term comparison of structure and dynamics of the red coral metapopulation of the Portofino Promontory (Ligurian Sea): A case-study for a Marine Protected Area in the Mediterranean Sea. *Marine Ecology*. doi:10.1111/maec.12235.
- Bavestrello G, Bo M, Canese S, Sandulli R, Cattaneo-Vietti R. 2014b. The red coral populations of the Gulfs of Naples and Salerno: Human impact and deep mass mortalities. *Italian Journal of Zoology* 81:552–563. doi:10.1080/11250003.2014.950349.
- Bavestrello G, Cerrano C, Cattaneo-Vietti R. 2009. Biological interactions affecting the growth rates of red coral (*Corallium rubrum*) colonies. In: Pergent-Martini C, Bricchet M, editors. Proceedings of the 1st symposium on conservation of the coralligenous bio-concretions. Tunis: RAC/SPA. pp. 53–58.
- Bramanti L, Rossi S, Tsounis G, Gili JM, Santangelo G. 2007. Settlement and early survival of red coral on artificial substrates in different geographic areas: Some clues for demography and restoration. *Hydrobiologia* 580:219–224. doi:10.1007/s10750-006-0452-1.
- Bramanti L, Vielmini I, Rossi S, Stolfi S, Santangelo G. 2011. Involvement of recreational scuba divers in emblematic species monitoring: The case of Mediterranean red coral (*Corallium rubrum*). *Journal for Nature Conservation* 19:312–318. doi:10.1016/j.jnc.2011.05.004.
- Bramanti L, Vielmini I, Rossi S, Tsounis G, Iannelli M, Cattaneo-Vietti R, Priori C, Santangelo G. 2014. Demographic parameters of two populations of red coral (*Corallium rubrum* L. 1758) in the North Western Mediterranean. *Marine Biology* 161:1015–1026. doi:10.1007/s00227-013-2383-5.
- Bruckner AW. 2009. Rate and extent of decline in *Corallium* (pink and red coral) populations: existing data meet the requirements for a CITES Appendix II listing. *Marine Ecology Progress Series* 397:319–332. doi:10.3354/meps08110.
- Bruckner AW. 2014. Advances in management of precious corals in the family Corallidae: Are new measures adequate? *Current Opinion in Environmental Sustainability* 7:1–8. doi:10.1016/j.cosust.2013.11.024.
- Bussoletti E, Cottingham D, Bruckner AW, Roberts G, Sandulli R, editors. 2010. Proceedings of the international workshop on red coral science. Management, and trade: Lessons from the Mediterranean. Silver Spring, MD: NOAA Technical Memorandum CRCP-13. pp. 1–233.
- Canestrini G, Canestrini R. 1883. Il corallo. *Annali Industria e Commercio* (1882). Rome: Ministero Agricoltura, Industria, Commercio.
- Cannas R, Caocci F, Follesa MC, Grazioli E, Pedoni C, Pesci P, Sacco F, Cau A. 2010. Multidisciplinary data on the status of red coral (*Corallium rubrum*) resource in Sardinian seas (central western Mediterranean). In: Bussoletti E, Cottingham D, Bruckner A, Roberts G, Sandulli R, editors. Proceedings of the international workshop on red coral science, management, and trade: Lessons from the Mediterranean. Silver Spring, MD: NOAA Technical Memorandum CRCP-13. pp. 1–233.
- Cannas R, Caocci F, Follesa MC, Pedoni C, Pendugiu AA, Pesci P, Sacco F, Cau A. 2011. The red coral resource in Sardinian seas: A multidisciplinary survey on *Corallium rubrum* populations. *Studi Trentini di Scienze Naturali* 89:9–18.
- Cattaneo-Vietti R, Bavestrello G. 2010. Sustainable use and conservation of precious corals in the Mediterranean. In: Iwasaki N, editor. *Biohistory of precious corals*. Tokyo: Tokai University Press. pp. 1–364.
- Cattaneo-Vietti R, Bavestrello G, Bo M, Canese S, Andaloro F. in press. Illegal fisheries evidences on a deep red coral bank in the Sicily Channel. *Aquatic Conservation: Marine and Freshwater Ecosystems*.
- Cau A, Cannas R, Sacco F, Follesa MC. 2013. Adaptive management plan for red coral (*Corallium rubrum*) in the GFCM competence area. Report of the 38th session of the General Fisheries Commission for the Mediterranean (GFCM). Appendix I.
- Cavolini F. 1785. Memorie per servire alla storia de' polipi. Napoli. 279 pp.
- Cerrano C, Bavestrello G, Bianchi CN, Calcinaì B, Cattaneo-Vietti R, Morri C, Sarà M. 2001. The role of sponge bioerosion in Mediterranean coralligenous accretion. In: Faranda FM, Guglielmo L, Spezie G, editors. *Mediterranean ecosystems: Structures and processes*. Milan: Springer-Verlag. pp. 235–240.
- Cicogna F, Bavestrello G, Cattaneo-Vietti R. 1999. Red coral and other Mediterranean octocorals: Biology and protection. Roma: Ministero per le Politiche Agricole. pp. 1–238.
- Cicogna F, Cattaneo-Vietti R. 1993. Red coral in the Mediterranean Sea, art, history and science. Roma: Ministero delle Risorse Agricole, Alimentari e Forestali. pp. 1–263.
- CITES. 2007. Consideration of the proposals for Amendment of Appendices I and II. CoP 14, Proposal 21. In: Convention on International Trade in Endangered species of wild Fauna and Flora. 14th Meeting of the Conference of the Parties. Geneva: CITES. pp. 1–23.
- Colombo A. 1887. La fauna sottomarina del Golfo di Napoli. *Rivista Marittima*, Roma 20:1–107.
- Corriero G, Mercurio M, Cardone F, Longo C. 2012. Studio della biodiversità del coralligeno profondo pugliese, con particolare riguardo alla *facies* a corallo rosso. CeRB Edizioni, Bari. 24 pp.
- Costa A. 1871. La pesca nel Golfo di Napoli. *Memorie Regio Istituto d'Incoraggiamento* 7(2). Tipografia Nobile, Napoli. 105 pp.
- Costa OG. 1858. Fauna del Regno di Napoli. Vol. 11. Naples: Tipografia Azzolino and Compagno.

- Costantini F, Fauvelot C, Abbiati M. 2007. Fine-scale genetic structuring in *Corallium rubrum*: Evidence of inbreeding and limited effective larval dispersal. *Marine Ecology Progress Series* 340:109–119. doi:10.3354/meps340109.
- Doneddu G. 1994. La pesca del corallo tra alti profitti e progetti inattuati (sec. 18°). In: Mattone A, Sanna P, editors. Alghero, la Catalogna, il Mediterraneo: Storia di una città e di una minoranza catalana in Italia (14°–20° secolo). Sassari: Gallizzi Ed.
- Errico C, Montanelli M. 2008. Il corallo. Pisa: Ed. Felici.
- FAO. 1988. GFCM technical consultation on red coral of the Mediterranean. FAO Fish Report 413:1–159.
- Ferrigni PC. 1864. La pesca e la lavorazione del corallo in Italia. Relazione degli Armatori in Livorno all'On. Sig. Ministro di Agricoltura, Industria e commercio. Livorno: Ed. V. Sardi.
- Follesa MC, Cannas R, Cau A, Pedoni C, Pesci P, Cau A. 2013. Deep-water red coral from the Island of Sardinia (north-western Mediterranean): A local example of sustainable management. *Marine and Freshwater Research* 64:706–715. doi:10.1071/MF12235.
- Follesa MC, Cannas R, Ortu A, Pedoni C, Pesci P, Porcu C, Sacco F, Cau A. 2010. The status of red coral (*Corallium rubrum*) resource in the Northern and Western coasts of Sardinia. GFCM - General Fisheries Commission for the Mediterranean, Transversal Workshop on Red Coral, 16–17 September 2010, Alghero.
- Fusco L. 2011. Corallo Rosso. Napoli: Ed. Idelson-Gnocchi. pp. 1–271.
- Gaetani G. 1867. Il corallo nella Provincia di Reggio di Calabria. Relazione alla Camera di Commercio ed Arti per l'Esposizione Universale di Parigi. Reggio Calabria.
- Galasso M. 2000. Pesca del *Corallium rubrum* in Sardegna nell'antichità: Materiali e strumenti. L'Africa romana Atti del XIV Convegno di Studi Sassari, 7–10 Dicembre 2000.
- Gallmetzer I, Haselmair A, Velimirov B. 2010. Slow growth and early sexual maturity: Bane and boon for the red coral *Corallium rubrum*. *Estuarine, Coastal and Shelf Science* 90:1–10. doi:10.1016/j.ecss.2010.04.018.
- Gallo IR. 1888. Storia della Città di Alassio. Chiavari: Tipografia G. Esposito. pp. 1–259.
- Gangemi M. 2011. La pesca nel Mezzogiorno tra Otto e Novecento: Tonnare, pesci, spugne e coralli. Bari: Cacucci Ed. pp. 1–214.
- Gangemi M. 2014. Pesche speciali in Sicilia tra Otto e Novecento. Tonno, corallo, spugne, sardelle e alacce nei compartimenti marittimi di Trapani e Porto Empedocle. In: Doneddu G, Fiori A, editors. La pesca in Italia tra età moderna e contemporanea. Produzione, mercato, consumo. Sassari: Editrice Democratica Sarda.
- Garrabou J, Harmelin JG. 2002. A 20-year study on life-history traits of a harvested, long lived temperate coral in the NW Mediterranean: Insights into conservation and management needs. *Journal of Animal Ecology* 71:966–978. doi:10.1046/j.1365-2656.2002.00661.x.
- Garrabou J, Perez T, Sartoretto S, Harmelin JG. 2001. Mass mortality event in red coral *Corallium rubrum* populations in the Provence region (France, NW Mediterranean). *Marine Ecology Progress Series* 217:263–272. doi:10.3354/meps217263.
- GFCM. 2011. Report of the second transversal workshop on red coral Ajaccio (Corse), 5–7 October 2011. Rome: FAO, Headquarters.
- GFCM-FAO. 2010. Report of the transversal workshop on red coral Alghero (Sardinia), 16–17 September 2010, Italy. Rome: General Fisheries Commission for the Mediterranean – Commission Générale des Pêches pour la Méditerranée.
- Ghidiglia C. 1892. L'industria del corallo e la sua computisteria. Bologna: Tip. Fava e Garagnani.
- Issel A. 1884. Il Corallo. In: Giglioli EH, Issel A, editors. Pelagos, Saggi sulla vita e sui prodotti del mare. Genova: Tip. Istituto de Sordomuti.
- Ledoux J-B, Garrabou J, Bianchimani O, Drap P, Féral J-P, Aurelle D. 2010. Fine-scale genetic structure and inferences on population biology in the threatened Mediterranean red coral, *Corallium rubrum*. *Molecular Ecology* 19:4204–4216. doi:10.1111/mec.2010.19.issue-19.
- Linares C, Bianchimani O, Torrents O, Marschal C, Drap P, Garrabou J. 2010. Marine protected areas and the conservation of long-lived marine invertebrates: The Mediterranean red coral. *Marine Ecology Progress Series* 402:69–79. doi:10.3354/meps08436.
- Liverino B. 1998. Il corallo dalle origini ai nostri giorni. Napoli: Arte Grafica Ed. pp. 1–276.
- Lo Bianco S. 1909. Notizie biologiche riguardanti specialmente il periodo di maturità sessuale degli animali del Golfo di Napoli. *Mitthmeer Zoological Station Naples* 19:35–761.
- Marchetti R. 1965. Ricerche sul corallo rosso della costa ligure e toscana. II. Il Promontorio di Portofino. *Rendiconti dell'Istituto Lombardo di Scienze e Lettere B* 99:279–316.
- Marini M, Ferru ML. 1989. Il corallo. Storia della pesca e della lavorazione in Sardegna e nel Mediterraneo. Cagliari: Tema. pp. 1–246.
- Marongiu C. 1996. La pesca del corallo in Sardegna XIII–XVIII. In: VI Settimana della Cultura Scientifica. Sassari: Università degli Studi di Sassari.
- Maxia AOM, Valdes T. 1956. Documenti inediti sulla pesca del corallo in Sardegna nei secoli XVII e XVIII Cagliari economica. Cagliari: Camera di Commercio, Industria e Agricoltura.
- Mazzarelli G. 1915a. Banchi di corallo esplorati dalla R. Nave “Volta” nell'estate del 1913. *Annali dell'Industria*. Roma: Ministero di Agricoltura, Industria e Commercio. pp. 1–173.
- Mazzarelli G. 1915b. Risultati della campagna della R. Nave “Volta” eseguita nell'estate 1913 per la esplorazione dei banchi di corallo dei mari italiani. *Rivista Pesca Idrobiologia*, Roma 10:1–3.
- Mazzarelli G. 1931. La pesca del corallo. In: La pesca nei mari e nelle acque interne d'Italia. II. Roma: Istituto Poligrafico dello Stato. pp. 406–415.
- Mazzarelli G, Mazzarelli G. 1918. Prime indagini sui banchi di corallo del Golfo di Napoli. *Annali Idrobiologia e Pesca*, Pavia 1:1–42.
- Mazzei-Megale G. 1880. L'industria del corallo in Torre del Greco. Notizie economico-statistiche sulla pesca e sulla lavorazione del corallo esercitata dai torresi. Napoli: Tip. dei Comuni.
- Ministero dell'Agricoltura, Industria e Commercio. 1908. Divieto della pesca del corallo in alcuni mesi dell'anno. Atti sessione dicembre 1906. Roma: Commissione Consultiva per la Pesca. pp. 20–37.
- Montelatici P. 1871. Relacion sobre la pesca del coral en Italia. Livorno.
- Movimento Commerciale del Regno d'Italia. 1926. Roma: Ministero delle Finanze.
- Municipio di Torre del Greco. 1872. Relazione. *Annali del Ministero di Agricoltura* 1:212.
- Panceri P. 1871. Il corallo considerato come specie animale e come prodotto industriale. Napoli: L'Esposizione Internazionale Marittima. pp.10–14.
- Parona C. 1883. Il corallo in Sardegna: Relazione presentata a S. E. il Ministro di Agricoltura, Industria e Commercio. Rome.

- Parona C. 1898. La Pesca Marittima in Liguria. Genova: Angelo Ciminago Ed.
- Pedoni C, Follesa MC, Cannas R, Matta G, Pesci P, Cau A. 2009. Preliminary data on red coral (*Corallium rubrum*) population of Sardinian Sea (Western Mediterranean). In: Pergent-Martini C, Bricchet M, editors. Proceedings of the 1st symposium on conservation of the coralligenous bio-concretions. Tunis: RAC/SPA. pp. 230–232.
- Peruzy L. 1923. Il corallo e la sua industria. Napoli: Gaspare Casella Ed. pp. 1–79.
- Price LL, Narchi NE. 2015. Ethnobiology of *Corallium rubrum*: Protection, healing, medicine, and magic. In: Narchi NE, Price LL, editors. Ethnobiology of Corals and Coral Reefs. Chapter 5. Switzerland: Springer International Publishing. pp. 73–86.
- Priori C, Erra F, Angiolillo M, Santangelo G. 2015. Effects of gastropod predation on the reproductive output of an over-exploited deep octocoral. *Coral Reefs* 34:59–63. doi:10.1007/s00338-014-1223-5.
- Priori C, Mastascusa V, Erra F, Angiolillo M, Canese S, Santangelo G. 2013. Demography of deep-dwelling red coral populations: Age and reproductive structure of a highly valued marine species. *Estuarine Coastal and Shelf Science* 118:43–49. doi:10.1016/j.ecss.2012.12.011.
- Rajola G. 2012. Mistero Sciacca. Storia di un corallo di altri tempi. Torre del Greco: Edizioni Scientifiche e Artistiche. 258 pp.
- Ricca Di Civezza L. 1874. Viaggio da Genova a Nizza, ossia descrizione con notizie storiche, di statistica ed estetica e d'arti e di lettere, scritte da un ligure, nel 1865. Firenze.
- Santangelo G, Abbiati M. 2001. Red coral: Conservation and management of an overexploited mediterranean species. *Aquatic Conservation: Marine and Freshwater Ecosystems* 11:253–259. doi:10.1002/(ISSN)1099-0755.
- Santangelo G, Abbiati M, Giannini F, Cicogna F. 1993. Red coral fishing trends in the western Mediterranean Sea during the period 1981–1991. *Scientia Marina* 57:139–143.
- Santangelo G, Bramanti L. 2010. Quantifying the decline in *Corallium rubrum* populations. *Marine Ecology Progress Series* 418:295–297. doi:10.3354/meps08897.
- Santangelo G, Bramanti L, Iannelli M. 2007. Population dynamics and conservation biology of the over-exploited Mediterranean red coral. *Journal of Theoretical Biology* 244:416–423. doi:10.1016/j.jtbi.2006.08.027.
- Santangelo G, Bramanti L, Rossi S, Tsounis G, Vielmini I, Lott C, Gili JM. 2012. Patterns of variation in recruitment and post-recruitment processes of the Mediterranean precious gorgonian coral *Corallium rubrum*. *Journal of Experimental Marine Biology and Ecology* 411:7–13. doi:10.1016/j.jembe.2011.10.030.
- Santangelo G, Maggi E, Bramanti L, Bongiorno L. 2004. Demography of the over-exploited Mediterranean red coral (*Corallium rubrum* L. 1758). *Scientia Marina* 68:199–204. doi:10.3989/scimar.2004.68s1.
- Scatizzi I. 1935. La pesca del corallo. *Bollettino Pesca Piscicoltura e Idrobiologia* 11:706–726.
- Sechi Copello B. 1982. Storia di Alghero e del suo territorio (dal Neolitico al 1720). Bastiò: Ed. Alghero.
- Stampacchia P. 2010. Il comparto del corallo di Torre del Greco. In: Bussoletti E, Cottingham D, Bruckner AR, Roberts G, Sandulli R, editors. Proceedings of the international workshop on red coral science, management, and trade: Lessons from the Mediterranean. Silver Spring, MD: NOAA Technical Memorandum CRCP-13. pp.121–122.
- Statistica del Regno d'Italia. 1863. Ministero d'agricoltura, industria e commercio, Direzione di statistica. Torino: Tipografia letteraria. pp. 1–195.
- Targioni-Tozzetti A. 1880. Rapporto a Sua Eccellenza il Ministro di Agricoltura, Industria e Commercio sulla Mostra Internazionale di Pesca tenuta a Berlino nel 1880. Vol. 38. Roma: Annali del Ministro di Agricoltura, Industria e Commercio.
- Tescione G. 1968. Italiani alla pesca del corallo. 2nd ed. Napoli: F. Fiorentino Ed. pp. 1–506.
- Trasselli C. 1953. La pesca nella provincia di Trapani. Trapani: Arti Grafiche Corrao.
- Tsounis G, Rossi S, Bramanti L, Santangelo G. 2013. Management hurdles for sustainable harvesting of *Corallium rubrum*. *Marine Policy* 39:361–364. doi:10.1016/j.marpol.2012.12.010.
- Tsounis G, Rossi S, Gili J-M, Arntz W. 2006. Population structure of an exploited benthic cnidarian: The case study of red coral (*Corallium rubrum* L.). *Marine Biology* 149:1059–1070. doi:10.1007/s00227-006-0302-8.
- Tsounis G, Rossi S, Grigg RW, Santangelo G, Bramanti L, Gili JM. 2010. The exploitation and conservation of precious corals. *Oceanography and Marine Biology: An Annual Review* 48:161–212.
- Vielmini I. 2009. Population structure of *Corallium rubrum* (L. 1758) in different geographic areas. PhD Thesis, University of Pisa. 109 pp.
- Vielmini I, Bramanti L, Tsounis G, Rossi S, Gili JM, Cattaneo-Vietti R, Santangelo G. 2009. *Corallium rubrum* age structure determination. In: Bussoletti E, Cottigham D, Bruckner AW, Roberts G, Sandulli R, editors. Proceedings of the international workshop: Red coral science, management and trading: Lessons from the Mediterranean. Silver Spring, MD: NOAA Technical Memorandum CRCP-13. pp. 179–182.
- Zanetti G. 1946. La legislazione sarda relativa all'industria corallina e la pesca del corallo in Sardegna. *Studi Sarsaresi* 1 (Giurisprudenza):20. Università di Sassari.
- Zanetti G. 1960. La pesca del corallo in Sardegna. *Cuadernos de Historia*. Zaragoza: Jeronimo Zurita. pp. 10–11.